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Datum · *Date:* 06.08.2021
Bearbeiter · *Attending to this matter: Alexander Sysoev*
Ihr Zeichen · *Your Reference:*
Ihr Datum · *Your Date:*

Dear Regulatory Authority,

Ericsson Austria welcomes the opportunity to respond to the RTR consultation on the 2021-26 Spectrum Release Plan and follows this process with the high interest and ambition to contribute to the digitalization in Austria.

Please, find below in this document our responses to the questions raised within this consultancy request.

Being a leading manufacturer of 5G technology, Ericsson Austria is fully committed and open to support 5G roll-out in Austria.

Best Regards
Ericsson Austria GmbH

Ericsson Austria GmbH
Ernst-Melchior-Gasse 24
1020 Vienna
Austria

Tel: +43 1 811 00 0
Fax: +43 1 811 00 699
www.ericsson.com
DVR: 0556840

PNB Paribas Fortis SA/NV
Herengracht 595-1017 CE Amsterdam
P.O. Box 10042 – 1001 EA Amsterdam
BIC/Swift Code: BNPANL2A
IBAN: NL58BNPA0227686624

VAT: ATU 14 75 10 08
Reg no.: FN 64141a, Handelsgericht Wien
ARA license no.: 6626
GLN: 9008390054000

1 Chapter 1

Frage 1.1.:

Wie sehen Sie die Markt- und Verkehrsentwicklung im Bereich der mobilen und drahtlosen Breitbanddienste in den nächsten 5 Jahren (welche prozentuelle Steigerung des Datenvolumens pro Jahr für die nächsten fünf Jahre erwarten Sie)? Welche durchschnittlichen Datenraten für Endkunden erwarten Sie für Mobilfunk und drahtlose Breitbanddienste? Werden Home Broadband Dienste in Österreich weiter die Nachfrage treiben? Welche 5G-Dienste/5G-Use-Cases (eMBB, URLLC, etc.) werden in diesem Zeitraum an Bedeutung gewinnen? Gibt es spezifische Frequenz- bänder, die für die Erbringung dieser Dienste essentiell sind (z.B. 26 GHz-Band)? Bitte begründen Sie Ihre Antwort.

[Ericsson Response]: According to the latest Ericsson Mobility Report[1], global traffic levels hit 38 exabytes per month at the end of 2019, with a projected fourfold increase to 160 exabytes per month expected by 2025.

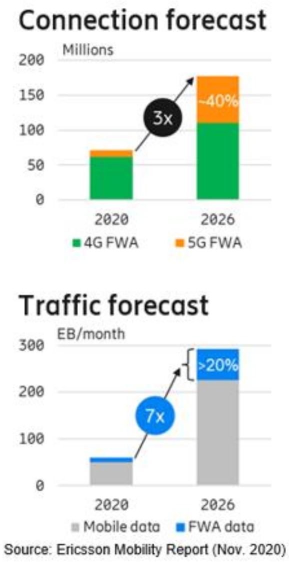

Figure 1. Traffic and connection forecast as per Ericsson Mobility Report.

Over 70 percent of all service providers are now offering fixed wireless access (FWA) services. Connections are forecast to exceed 180 million by the end of 2026, accounting for more than 20 percent of total mobile network data traffic globally. FWA data traffic represented around 15 percent of global mobile network data traffic by the end of 2020. This is projected to grow 7 times to reach 64EB in 2026, accounting for more than 20 percent of total mobile network data traffic globally.

[1] https://www.ericsson.com/en/mobility-report/reports/june-2021

As for FWA in the broadband connections context: there are approximately 2 billion households in the world. By the end of 2020, approximately 1.2 billion (60 percent) had a fixed broadband connection, and by the end of 2026 this will reach approximately 1.5 billion (around 70 percent). FWA will thenrepresent 12 percent of all fixed broadband connections. However, it is worth mentioning that FWA is also seen as a replacement option for 250 million existing DSL connections.

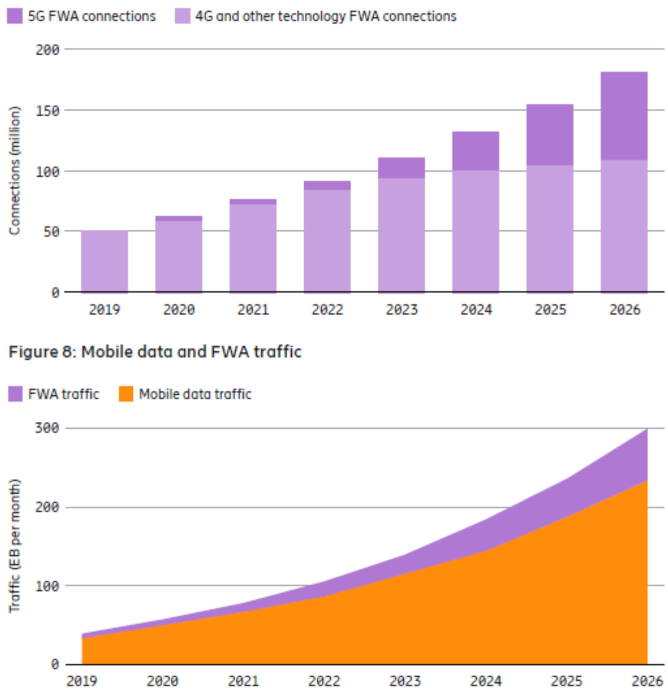

Figure 2. Mobile data and FWA traffic as per Ericsson Mobility Report.

Ericsson suggests to refer to the trusted studies weighting the 5G investments and assessment of cost to benefit ratios without sticking to only one group of the use cases, but rather a set of different use cases across different verticals.

Analysys Mason[2] have quantified the economics benefits of "full 5G" for Austria and identified where gaps in coverage may be expected. Key takeaways include:

- The total economic benefit from full 5G deployment across Austria is estimated at €11.2 billion, at a cost of €0.9 billion, a benefit to cost ratio of 13
- While commercial 5G rollout will cover Austria's entire population by 2025, this only refers to low frequency (700MHz) coverage for enhanced mobile broadband
- Full 5G (3.5GHz) commercial coverage will only cover around a third of Austria's population and 2% of its area by 2025, but is vital for digital transformation of verticals and public services

[2] https://www.analysysmason.com/consulting-redirect/reports/filling-europes-5g-coverage-gaps/

To ensure full 5G is deployed wherever it is required, the study estimates that matched funding of €0.5 billion in private and public funding is required.

Full 5G would make a major difference for Austria's rural areas, generating €8.4 billion in benefits for a cost of €0.5 billion, a benefit to cost ratio of 17.

Full 5G here refers to the required mixture of low frequency (700MHz) and mid-band (3.5GHz) coverage needed to enable all of 5G's potential use cases, including agriculture, manufacturing, rail and roads.

The innovative new use cases that 5G will bring to general public as well as industry have been defined in three broad categories under 3GPP's SMARTER (Study on New Services and Markets Technology Enablers) project. One of these, enhanced mobile broadband (eMBB), represents a continuing evolution from LTE, which can already provide mobile broadband speeds in the gigabits and can deliver high quality of service (QoS) internet access in previously challenging or prohibitive conditions. The need for higher bandwidth, greater connectivity and lower latency in critical applications has already outstripped LTE's capacity as more and more devices connect to networks around the world.

Other major use cases for 5G — ultrareliable low-latency communications (URLLC) and massive machine-type communications (mMTC) — work together with eMBB to satisfy the requirements of new wireless networks. With these facilities in place, networks can support massive IoT and mission-critical applications in manufacturing, military deployments, healthcare and emergency response. As 5G eMBB becomes widely available, several sub-use cases will be possible to deliver such as: Hot spots (eMBB can enhance broadband access in densely populated areas such as high-rise buildings and crowded city centers), Broadband everywhere (technologies like FWA), Public transportation (broadband access on high-speed trains), Smart offices (high-bandwidth connections in environments with heavy data traffic) , large-scale events (concerts and sporting events), enhanced multimedia (seamless streaming of 4K video and augmented reality.)

These three capabilities solve issues with bandwidth, latency and density that have limited LTE's capabilities in, for example, autonomous vehicles, automated manufacturing, smart city infrastructure Ultimately, the goals set for 5G point toward seamless coverage with a connection density of up to one million connections per square kilometer, peak data transfer rates in the tens of gigabits per second and latency of 1 millisecond.

High-band (mmWave) is best prepared for Industry 4.0 and above-mentioned major 5G use cases in terms of best performance (unpresented peak rate and user experience), slim size and power consumption, ultra-low latency and high reliability, especially in crowded areas and entertainment events/hotspots.

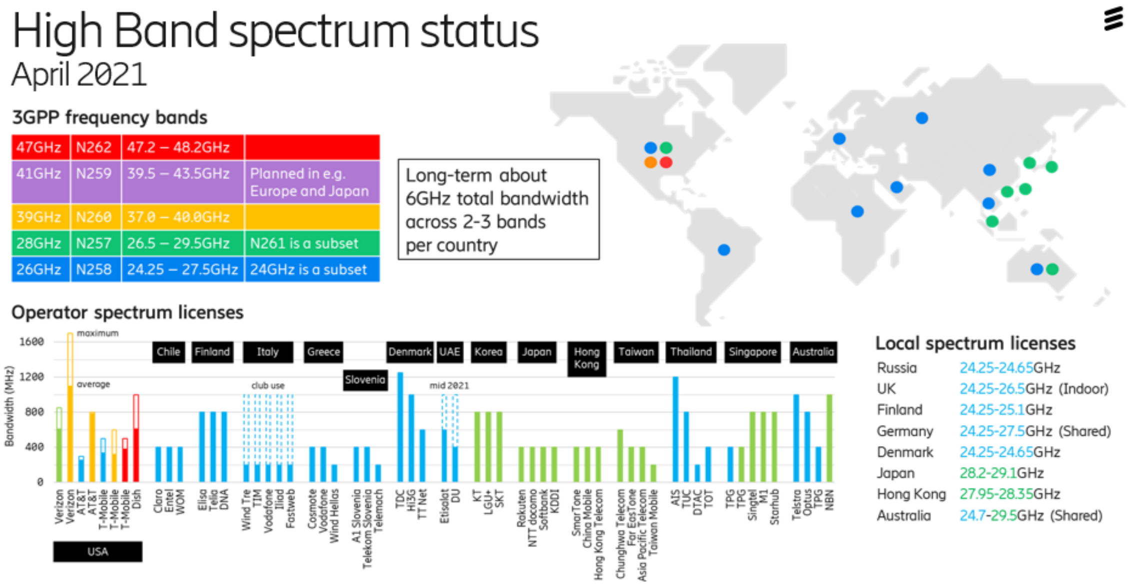

Figure 3. High-band spectrum status, April 2021.

International harmonization of spectrum bands is critical for the development of 5G, including for mmWave ranges. The ITU World Radiocommunication Conference 2019[3] (WRC-19) agreed that the ranges 24.25-27.5 GHz (n258) and 37-43.5GHz (n260 and n259) should be globally identified for 5G.

The US market is the 5G mmWave frontrunner and has already auctioned a total of 5000 MHz bandwidth across four mmWave frequency bands. The rest of the world is expected to begin by offering one mmWave band (n257 or n258), while awarding additional mmWave bands at a later stage. In the longer term, about 6GHz of total bandwidth is expected per country across two to three different bands.

The recommendation is to award 800 MHz per service provider in the initial mmWave band (n257 or n258). However, some countries have only managed to make a subset of a band available in the first stage, e.g. 26.5-27.5GHz in some European countries. The global status is typically 400 to 800MHz per service provider.

Frage 1.2.:

Erwarten Sie in den nächsten 5 Jahren Kapazitätsengpässe in ihrem Netzwerk? Wenn ja, in welchen Gebieten erwarten Sie in den nächsten 5 Jahren Kapazitätsengpässe? Wann sind zur Vermeidung dieser Kapazitätsengpässe weitere Frequenzen erforderlich? Sehen Sie die 26 GHz-Frequenzen als geeignet an, um erwartete Kapazitätsengpässe zu beseitigen?

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[3] https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.14-2019-PDF-E.pdf

[Ericsson Response]: Ericsson is the leader in mobile technologies including 5G providing the technology to our customers, mobile service providers, who are responsible for the roll-out, development and maintainance of their networks. Having said this, Ericsson sees it impossible answering the question of bottlenecks in the networks.

Ericsson sees 5G New Radio (NR) on 26GHz to be another valuable frequency layer in a mobile service provider's existing heterogenous (multi-layered) network. 26GHz deployments on both existing grids and new Small Cell sites, supporting both outdoor and indoor deployments, enabling consumer and vertical enterprise solutions are expected.

Ericsson strongly advocates the 26GHz band to be authorised via national exclusive licenced spectrum (with potential to support commercial sub-leasing to other industries). National licences have been key to the success of mobile services. Whilst licence exempt regimes could be considered for other bands for 5G, it is believed that such an approach for this band would create uncertainty and potential delay 5G service take up.

The possibility for local licencing (or other schemes to support industrials usage, e.g. Land boundary authorisation) is an option for the 26GHz band, however Ericsson believes that this should be reserved for consideration when the full 26GHz band is released, and the licencing restricted to a small portion of the frequency band (not in the 26.5-27.5GHz range).

26GHz is a part of a broader 5G toolset, and the suitability of the spectrum for different deployments will depend very much upon the technical conditions, the authorisation approach, and the eventual size of the allocations to the licence holders. Ericsson recommends ensuring that the proposed authorisation regime supports individual licence holders to acquire up to 800MHz of contiguous spectrum. The larger the frequency bandwidth the greater the ability to overcome some of the propagation challenges of this band.

Ericsson expects to see 26GHz deployed both on the existing grid in areas of high mobile broadband demand, as well as on small cells (both indoor and outdoor). Studies for different cities have shown that mmWave spectrum (combined with both 3.4-3.8GHz and existing lower LTE bands such as 800/1800MHz) can present a big opportunity to deliver outdoor Gigabit speeds utilizing existing roof top sites, potentially solve the capacity issue in outdoor hotspots, removing the challenges of finding sites for small cells, potentially off-load existing 4G bands as well as 3.5 GHz NR, improving end user performance at cell edge (i.e. indoor), support a user experience of 100Mbps UL and 1.5Gbps DL in 30% of area with smartphone type devices.

Ericsson does not expect to see a widescale deployment of 26HGz for contiguous coverage across rural areas. However, it is expected to see spotty deployments of 26GHz in specific locations to support various industrial use cases both outdoors and indoors.

Additionally, Ericsson expects to see 26GHz utilised for Fixed Wireless Access, and used as a last drop solution for rural communities, suburban estates as well as urban developments.

Frage 1.3.:

Erwarten Sie in den nächsten 5 Jahren den Eintritt eines weiteren bundesweiten Mobilfunknetzbetreibers in den Mobilfunkmarkt? Erwarten Sie den Markteintritt weiterer drahtloser regionaler Breitbandanbieter in den nächsten 5 Jahren? In welchen Regionen?

[Ericsson Response]: 5G will give service providers the possibility to improve their existing consumer business and to address previously untapped value chains in the digitalization of industries. The new technology opens up new opportunities in new ecosystems. Together with our partners we are continuously testing, learning and pushing the boundaries of how 5G can meet the diverse needs now and of the future.

As said, the rollout of 5G is opening up a wealth of new opportunities for service providers beyond their traditional markets. However, to successfully capture them, an organizational transformation must take place, so that service providers can evolve their traditional role and enhance their position in the value chain.

During the transition to 5G service providers need to plan for the strategic evolution of their value chain role. Ericsson foresees service providers playing three distinct roles in the 5G-enabled world. These roles allow service providers to provide increasing value from 5G network infrastructure, from offering tailored connectivity solutions and digital 5G platforms to building their own processes and offers including massive IoT.

- Role 1: the traditional network developer. In this role, service providers act solely as a mobile connectivity provider by offering solutions such as mobile internet and communication services, and it’s mainly business as usual. Here, service providers’ 5G business models are mostly consumer-focused and their role in the IoT ecosystem is limited.
- Role 2: the service enabler. In the service enabler role, the service provider extends its services by leveraging additional capabilities such as cloud, edge and IoT enablement – shifting focus to enterprise customers. At this stage, the service provider is an enabler for 5G and IoT and acts as a supplier of customized connectivity and platform services.
- Role 3: the service creator. In the third role in the value chain service providers transition from being a connectivity and platform provider to creating new digital services and collaborating beyond telecoms to establish digital value systems. At this point, service providers will partner with a wide ecosystem of suppliers to deliver new services all the way up to full IoT solutions.

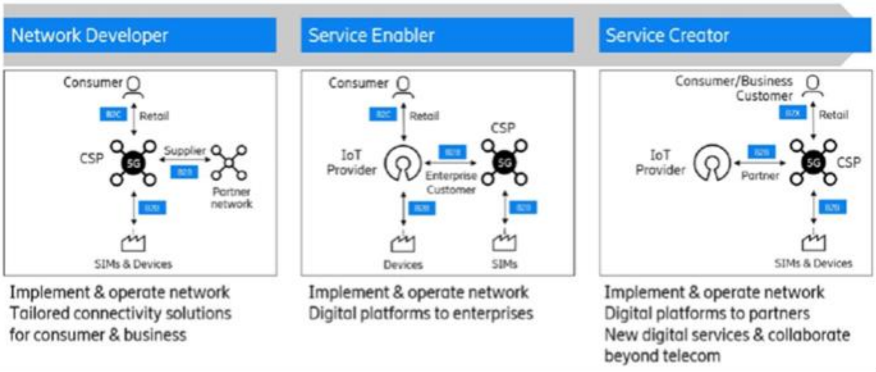

Figure 4. Possible roles for the Mobile Service Providers in 5G era.

This figure above shows examples of the typical business models enabled by the three CSP roles. The combined opportunity for those roles is expected to reach USD 700 billion annually by 2030, but deciding on which role to take on over time will be challenging.

With that in mind, we forecast that if new entrants will come to the mobile telecommunications market, they would rather focus on the broader value chain while the existing service providers are still in the transformation phase. To support this statement, there are few examples worldwide where new national service providers start with low-cost entry, however they bring the innovations into their value chain very quickly. To name the companies – Tele2 (Russia) or Dish (United States).

Frage 1.4.:

Wie definieren Sie „Vertical Industries“? Welche Bedeutung werden einzelne 5G Vertical Industries in den nächsten 5 Jahren haben? Welche Player werden in Zusammenhang mit Vertical Industries eine wichtige Rolle spielen (Unternehmen aus dem Vertical Industry Sector, Mobilfunkbetreiber, drahtlose Breitbandanbieter, Aggregatoren, Ausrüster, Systemlieferanten, andere ICT Unternehmen, etc.)? Welche Kommunikationsdienste / Use Cases / Vertical-Industry-Lösungen werden in Zusammenhang mit Vertical Industries Bedeutung erlangen? Welche Bedeutung haben in diesem Zusammenhang private 5G Networks?

[Ericsson Response]: 5G will create an ecosystem for technical and business innovation involving vertical markets and highlights the opportunities for service providers across 10 key industries: manufacturing, automotive, energy and utilities, public safety, healthcare, media and entertainment, public transport, financial services, retail and agriculture. Industry digitalization investments will generate an estimated USD 1.307 billion revenue opportunity for telecom service providers by 2026. Telecom service providers can profit from an additional 36 percent revenue potential by 2026 from 5G-enabled market opportunities

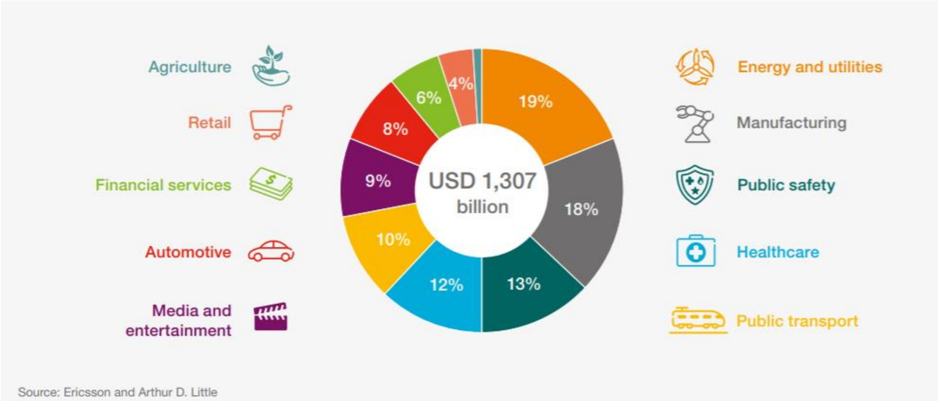

Figure 5. 5G-enabled industry digitalization revenues for ICT players, 2026

In our recently released report, Network slicing: Top 10 use cases to target, Ericsson and Arthur D. Little[4] analyzed more than 70 external market reports about the global digitalization of industries and also reviewed more than 400 digital use cases from 70 industries and took a deeper look into one or two use cases in each industry.

The report found there are many things for CSPs to consider when they are selecting their target industry segments and corresponding use cases. Firstly, there needs to be a solid enterprise strategy around which industries or verticals to target. To successfully offer services to industries or enterprises will require both a good understanding of their needs and market realities, as well as the other players operating in their eco system.

CSPs also need to understand which industries are more likely to maximize business impact.

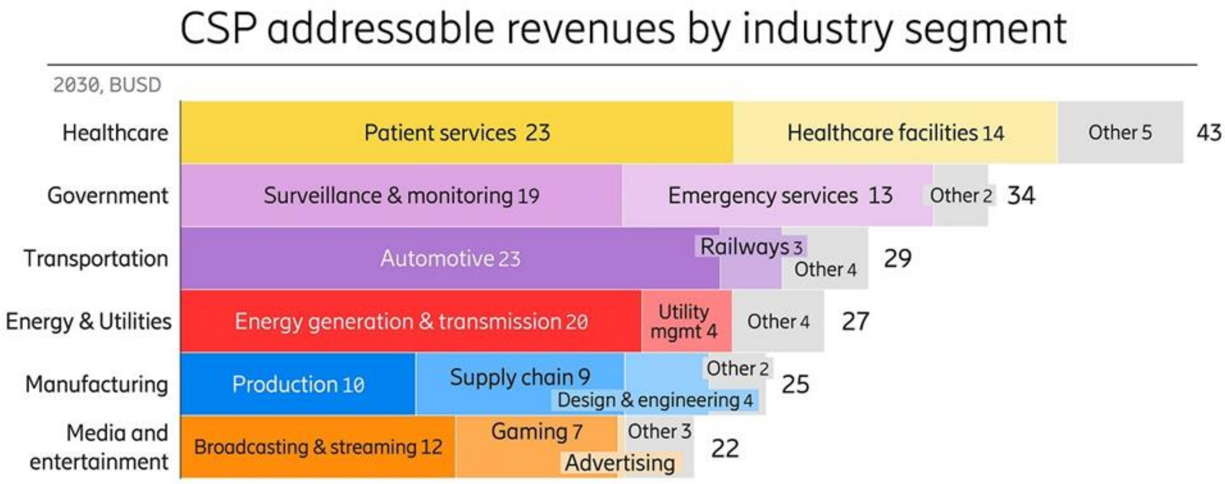

Figure 6. Each industry is usually dominated by two to three segments

Our findings - the top industries for network slicing: ultimately, our research discovered that six top industries, (see figure above) account for 90 percent of the addressable revenues, summing up to some USD 200 billion for CSPs. In turn, these can be divided into several

[4] https://www.ericsson.com/en/5g/5g-for-business/5g-for-business-a-2030-market-compass

industry segments, e.g. transportation could be split up into automotive and railway services. Manufacturing could be split into production and supply chain etc.

Automotive. A USD 23 Billion opportunity for CSPs and one of the largest industry segments. This is an industry where the need for high availability and low latency will pave the way for CSPs to help facilitate use cases, including teleoperated driving, coordinated groups of platooning vehicles, automated lane change and real-time situational awareness.

CSPs' could essentially take two roles in the value chain - either as a network developer or service creator. As a service creator the CSP would engage in activities like reselling devices, application platform provisioning, data monetization or offering support. Generally, as service creators the market potential grows significantly, but it requires the capability to broaden the scope of the offerings and have a go-to-market approach.

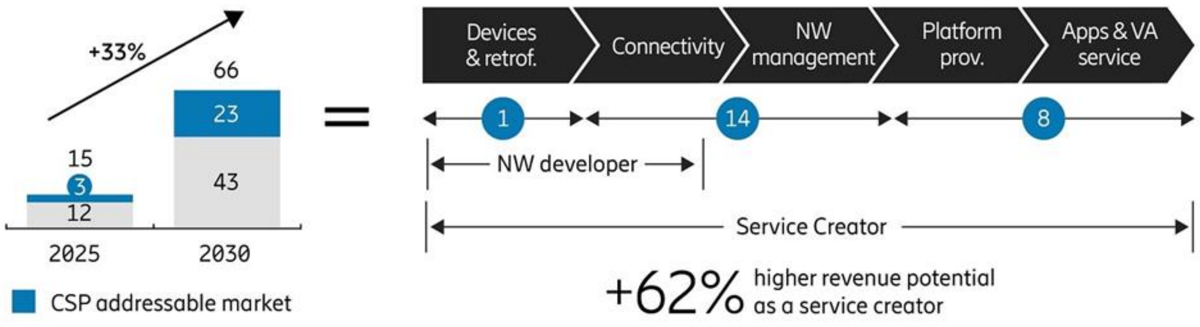

Figure 7. The role as service creator in automotive offers a significantly higher revenue

Healthcare. This is addressable market for CSPs with patient services expected to grow from USD 6 Billion in 2025 to USD 23 Billion in 2030.The patient services industry is composed of hospitals and various healthcare players that provide mobile healthcare services to patients. This is certainly a growing industry. The percentage of the population over 60 continues to grow and is forecasted to rise from 13.5% of the population in 2020 to 21% by 2025. Use cases like remote treatment in emergencies, precision medicine and rehabilitation robotics and many more will evolve.

Manufacturing. The production segment will see strong growth of 36 percent compound annual growth rate (CAGR) from 2025 to 2030. The manufacturing production segment consists of several players that are focused on the preparation, processing and fabrication of goods from raw materials. A key growth driver is the rapid technological adoption and demand for mass customization. Consumers and enterprises want more personalized production of goods, which adds additional value and creates a larger addressable market. Key use cases include augmented reality (AR) devices that will enable improved quality inspection and diagnosis for maintenance workers, technicians and service providers throughout a plant, as well as remote controlled robots and 3D video-driven interaction between collaborative robots and humans. With a network slice, the CSP can guarantee the level of throughput, reliability and control required through quality of service (QoS), for example collaborative robots.

Broadcasting and streaming. This is a fast-growing industry. Consumer spending on ultra-high definition (UHD), virtual reality and 360-degree video is expected to grow at a 35 percent CAGR through 2023. The ways in which people produce, distribute and consume entertainment content is rapidly changing. There are a number of near-term uses cases in the industry that network slicing can enable, such as, remote broadcast and production. For example, network slicing would enable most of the personnel involved in the live broadcast of an event control cameras, mix and edit content and change views on the fly, even if they are working from a location hundreds or thousands of miles away from the event. This is because the ultra-low latency of a network slice combined with its quality of service, can provide the required reliability and throughput to enable real-time control of cameras. Since CSPs can deploy slices globally at a predictable cost, broadcasters can now produce niche events that were not previously economically viable. 5G will provide better coverage than fixed solutions, and a network slices ability to isolate traffic could be configured to meet the broadcaster's specific security needs.

The energy generation and transmission sector. consists of various players that are managing, producing and supplying energy. This includes the generation of energy from fuel sources and distribution. New regulatory policies and directives are encouraging and stimulating the adoption of clean energy generation and consumption. High reliability is critical to ensure real-time control especially in case of a malfunction. Growing amounts of data will need to be analyzed in real time and over large geographical areas.

For CSPs, typical customers include small and medium-sized energy companies and power plants. By 2030, slicing-enabled revenue is expected to approach USD 46 billion and the addressable revenue will reach USD 20 billion.

The four main energy generation and transmission near term use cases include:

- Virtual power plants
- Connected remote windfarms
- Cellular push-to-video
- Grid voltage monitoring

Many enterprises have the ambition for new innovative connectivity solutions but face complex challenges when integrating these into their operation. Therefore it is important to raise awareness about an already existing ecosystem that gives enterprises and CSPs access to partners who can help raise productivity by combining 4G or 5G cellular connectivity with innovative devices to connect to the network, software to manage processes, and system integrators to bring it all together. Ericsson has a partner program with a focus on enabling and accelerating the Industry 4.0 ecosystem:

- Device & Hardware: Cisco, Cradlepoint, Dell EMC, D-link, HPE,…

- Software & applications: Crosser, Hexagon, SAP, Hitachi, …
- Professional Services: AFRY, Ambra, Altran, Capgemini, …

For full list of Industry 4.0 Partners can be found in a link in footnote[5].

The most notable new verticals solutions and deployment scenarios addressed in 3GPP Releases 16 and 17 of 5G New Radio (NR) are in the areas of:

- Integrated access and backhaul (IAB)
- NR in unlicensed spectrum
- Features related to Industrial Internet of Things (IIoT) and ultra-reliable low latency communication (URLLC)
- Intelligent transportation systems (ITS) and vehicle-to-anything (V2X) communications
- Positioning

Integrated access and backhauling IAB. Provides an alternative to fiber backhaul by extending NR to support wireless backhaul. As a result, it is possible to use NR for a wireless link from central locations to distributed cell sites and between cell sites. This can simplify the deployment of small cells, for example, and be useful for temporary deployments for special events or emergency situations. IAB can be used in any frequency band in which NR can operate. However, it is anticipated that mm-wave spectrum will be the most relevant spectrum for the backhaul link. Furthermore, the access link may either operate in the same frequency band as the backhaul link (known as inband operation) or by using a separate frequency band (out-of-band operation).

New Radio in unlicensed spectrum. Spectrum availability is essential to wireless communication, and the large amount of spectrum available in unlicensed bands is attractive for increasing data rates and capacity for 3GPP systems. To exploit this spectrum resource, release 16 enables NR operation in unlicensed spectrum, targeting the 5GHz and 6GHz unlicensed bands. It supports both standalone operation, where no licensed spectrum is necessary, and licensed-assisted operation, where a carrier in licensed spectrum aids the connection setup. This greatly adds to deployment flexibility compared with LTE, where only licensed-assisted operation is supported. Operation in unlicensed spectrum is dependent on several key principles including ultra-lean transmission and use of the flexible NR frame structure.

Channel access mechanisms based on listenbefore-talk (LBT) are probably the most obvious area of enhancement in release 16. NR largely reuses the same LBT mechanism as defined for Wi-Fi and LTE in unlicensed spectrum. Interestingly, it was demonstrated during

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[5] https://www.ericsson.com/en/industry4-0/partners

standardization that replacing one Wi-Fi network with an NR network can lead to improved performance for the remaining Wi-Fi networks as well as for the NR network itself.

Industrial IoT and ultra-reliable low-latency communication. The IIOT is a major vertical focus area for NR release 16. To widen the set of potential IIoT use cases and support increased demand for new use cases such as factory automation, electrical power distribution and the transport industry, release 16 includes latency and reliability enhancements that build on the already very low air-interface latency and high reliability provided by release 15. Support for time-sensitive networking (TSN), where very accurate time synchronization is essential, is also introduced. Figure below illustrates TSN integration in 5G NR.

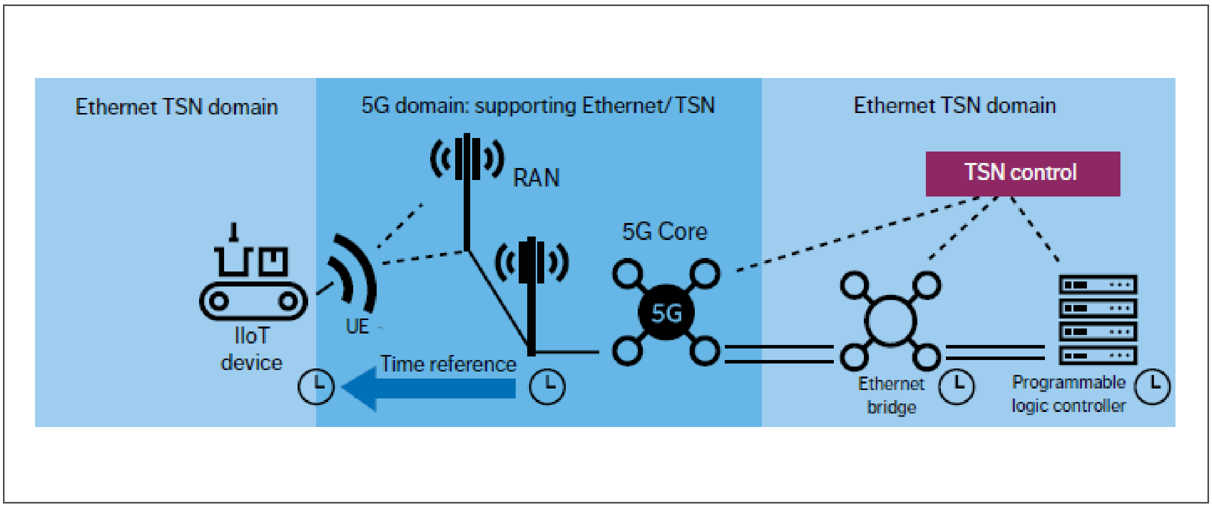

Figure 3 Overview of the TSN integration

Figure 8. The overview of time-sensitive integration

Although many of the URLLC-related improvements are small in themselves, taken together they significantly enhance NR in the area of URLLC. The inter-UE downlink (DL) preemption that is already supported in release 15 is extended in release 16 to include the UL, such that a UE's previously scheduled lower-priority UL transmission can be preempted (that is, cancelled) by another UE's higher-priority UL transmission. Release 16 also supports standardized handling of intra-EU UL resource conflicts.

To reduce latency, release 16 supports more frequent control-channel monitoring. Furthermore, for both UL configured grant and DL semi-persistent scheduling, multiple configurations can be active simultaneously to support multiple services. These enhancements are especially useful in combination with TSN traffic, where the traffic pattern is known to the base station.

Intelligent transportation systems and vehicle-to-anything communications. ITS, which provide a range of transport and traffic-management services, are another major vertical focus area in release 16. Among other benefits, ITS solutions improve traffic safety as well as reducing traffic congestion, fuel consumption and environmental impacts. To facilitate ITS, communication is required not only between vehicles and the fixed infrastructure but also between vehicles. Currently, 25 use cases for advanced V2X communications have been defined, including vehicle platooning and cooperative communication using extended sensors. In release 15, communication with fixed infrastructure is provided by the access-link interface between the base station and the UE.

Release 16[6] adds the option of the NR sidelink (PC5), which can operate in in-coverage, out-of-coverage and partial-coverage scenarios, utilizing all NR frequency bands. It supports unicast, groupcast and broadcast communication, and hybrid automatic repeat request (hybrid-ARQ) retransmissions can be used for scenarios that require more robust communication. Groups can be either configured or formed, and the group members communicate using groupcast transmissions. A truck platoon, for example, could be configured using dedicated hybrid-ARQ signaling between the receivers and transmitter, or formed in a dynamic manner based on the distance between the transmitter and receiver(s).

Positioning. For many years, UE positioning has been accomplished with Global Navigation Satellite Systems assisted by cellular networks. This approach provides accurate positioning but is typically limited to outdoor areas with satellite visibility. There is currently a range of applications that requires accurate positioning not only outdoors but also indoors. Architecture-wise, NR positioning is based on the use of a location server, similar to LTE. The location server collects and distributes information related to positioning (UE capabilities, assistance data, measurements, position estimates and so on) to the other entities involved in the positioning procedures. A range of positioning methods, both DL-based and UL-based, are used separately or in combination to meet the accuracy requirements for different scenarios.

As industrial digitalization accelerates, so does the demand for the advanced connectivity that private cellular networks can deliver and that liberates industrial enterprises to unlock the potential of automation, control, and exponential growth.

Manufacturing, ports, airports, oil & gas, mining and energy plants are some enterprise sectors enabling innovative new use cases with a private cellular network. A private cellular network is an on-premise network deployed for an enterprise's exclusive use and unique requirements.

The main benefits of Private Networks

- Guaranteed coverage is the most apparent benefit. It is assured in the enterprise’s operations area, both indoors and outdoors as required, through a dedicated spectrum, even in remote locations, such as in mining or offshore oil rigs.
- Security and encryption are vital and of the strongest standards since Private Networks are based on cellular technology. This offers high levels of security as 3GPP standards are closely adhered to across vendors, and the private nature of this solution ensures that all data stays on-premises.

[6] https://www.3gpp.org/release-16

- Ensured capacity is an essential feature, as a private network removes any contention with other network users, making it possible to guarantee network performance, such as uplink and downlink bit rates and latency.
- Retained control due to Private Networks enabling enterprises to determine and control how resources are utilized, and how traffic is prioritized, is a further advantage
- Critical reliability is assured as private networks are based on LTE/5G technology, which offers performance and enables applications that cannot be accommodated by Wi-Fi, such as mission-critical communication services and ultra-high definition video surveillance.
- Predictable and ensured low latency is another important feature. It is a requirement for many IoT applications that rely on timebound communications, where delays can result in a catastrophic failure, such as for critical control of remote devices like heavy machinery.
- High data speeds for communication compared to narrowband Land Mobile Radio systems, which suffer from capacity restraints, are also offered. This is ideal for video and high-resolution imagery, desirable in many industry segments.

Ericsson has a complete portfolio for local cellular connectivity with 4G and 5G dedicated networks supplying reliable, secure, low latency, and high-performance connectivity tailored to industrial demands. We can offer a comprehensive solution to address specific industry needs through our value-adding partner ecosystem of validated industry experts, telecom service providers, and system integrators.

Telecom service providers / Communication Service Providers (CSPs) entering the enterprise market can benefit from Ericsson's understanding of enterprise needs, a strong enterprise portfolio, and successful private cellular networks deployments. Ericsson makes it easy for CSPs to connect with enterprises and offer them an end-to-end, secure, and reliable dedicated network that can be deployed fully private and on-premise, or in any integration with the telecom network.

Ericsson's Dedicated Networks portfolio consists of:

- Industry Connect, an easy and secure off-the-shelf, ready for resell, private network product with Ericsson pre-selected components. It is a plug & play, pre-packaged and pre-integrated connectivity in a box solution for limited coverage areas in fully private (i.e., on-premise) deployment mode.
- Private Networks is a flexible and tailorable private cellular network offering. CSPs decide what they want to focus on in their network and how to differentiate their offering to enterprise customers. Together with Ericsson and their business team, we can address the desired use cases and build a unique private network solution. Private Networks can be deployed in fully private (i.e., on-premise) and in hybrid deployment mode (i.e., integrated with CSP network) from small to wide coverage areas for any industry.

- Ericsson Private 5G is a wireless networking product providing high-speed, secure 4G and 5G connectivity that is easy-to-order, install and manage developed for industrial use, ensuring sensitive data remains secure and onsite. As your business grows, Ericsson Private 5G offers a range of deployment sizes, ranging from small, medium, large, to extra-large, to support your unique situation with seamless evolution and upgradability.

As part of efforts on the industrial private wireless front, Ericsson's involved in the 5G-Industry Campus Europe. With an outdoor private network covering 1 square kilometer and an indoor setup of almost 7,000 square meters, it's Europe's largest industrial 5G research network. Niels König, Coordinator 5G-Industry Campus Europe, Fraunhofer Institute for Production Technology IPT, in a statement said that private 5G networks are highly attractive to tackle challenges of production.Ericsson has also implemented 5G private network in its own smart factory in Texas, which increased productivity and helped implement safety protocols.

Frage 1.5.:

Welche der in der vorigen Frage genannten Kommunikationsdienste / Use Cases / Vertical Industry können langfristig durch traditionelle öffentliche Kommunikations-netzbetreiber wie Mobilfunkbetreiber/regionalen Breitbandanbietern auf Basis von bundesweiten/regionalen Nutzungsrechten (zB durch spezifische „Slices“) erbracht werden und welche nicht? Bitte begründen Sie genau, warum dies der Fall ist. Welche spezifischen Anforderungen machen den Unterschied (öffentliche versus private Nutzung, technische Anforderungen, etc.)? Welche geografischen Gebiete sind für diese Dienste relevant (Nutzung in Gebäuden wie z.B. Fertigungsanlagen, Einkaufszentren, Industrieproduktionsstätten, Forschungs-Campus, etc.)? Handelt es sich vorwiegend um Indoor-Dienste (Indoor-Campus) oder auch Outdoor-Dienste (Outdoor-Campus), die sich auf Liegenschaften des Nachfragers beschränken (z.B. Industrieunternehmen)? Schätzen Sie bitte die durchschnittliche Fläche eines Campus-Netzwerkes (z.B. 100 x 100 Meter)? Welche maximale Fläche kann ein Campus-Netzwerk einnehmen?

[Ericsson Response]: The flexible spectrum assets of CSPs enable them to address industry needs in the best possible ways, even in countries with locally licensed spectrum for industries. Different frequency bands have complementary characteristics, with low bands being ideal for coverage and availability and having the most diverse device support (though with typically smaller bandwidths than mid bands), mid bands offering significantly improved capacity with a good balance of coverage, and high bands delivering a major capacity boost (though with limited coverage).

For TDD bands, there are trade-offs to consider between capacity, latency, and coverage, depending on the choice of the TDD transmission pattern. Additionally, when using a TDD band, an important aspect is synchronized TDD patterns with respect to networks on the same or adjacent spectrum. mmWave bands have better isolation than sub-6 GHz due to the radio wave propagation characteristics and, consequently, have relatively relaxed TDD coexistence constraints.

Figure below shows the benefits of leveraging the flexible spectrum assets of CSPs to deliver optimal results in terms of performance, diversified use cases, system capacity, and indoor/outdoor coverage, with or without local spectrum. In most regions, locally licensed spectrum is in mmWave bands, sub-6GHz TDD bands, or both mmWave and sub-6GHz TDD bands. Leveraging CSPs' spectrum assets with complementary characteristics can provide major benefits, including improved coverage and availability, Cat-M/NB-IoT access, and low latency. For local spectrum in the sub-6GHz TDD band range, CSP mmWave bands can also potentially boost capacity and reduce latency. As another benefit, CSPs can leverage their public spectrum assets to provide premium MBB and voice services to industries. For its part, 5G inter-band carrier aggregation can also be employed as a powerful tool by dynamically routing traffic through different carriers (across CSP spectrum and local spectrum), achieving the best trade-offs in terms of coverage, reliability, latency, spectral efficiency, and capacity.

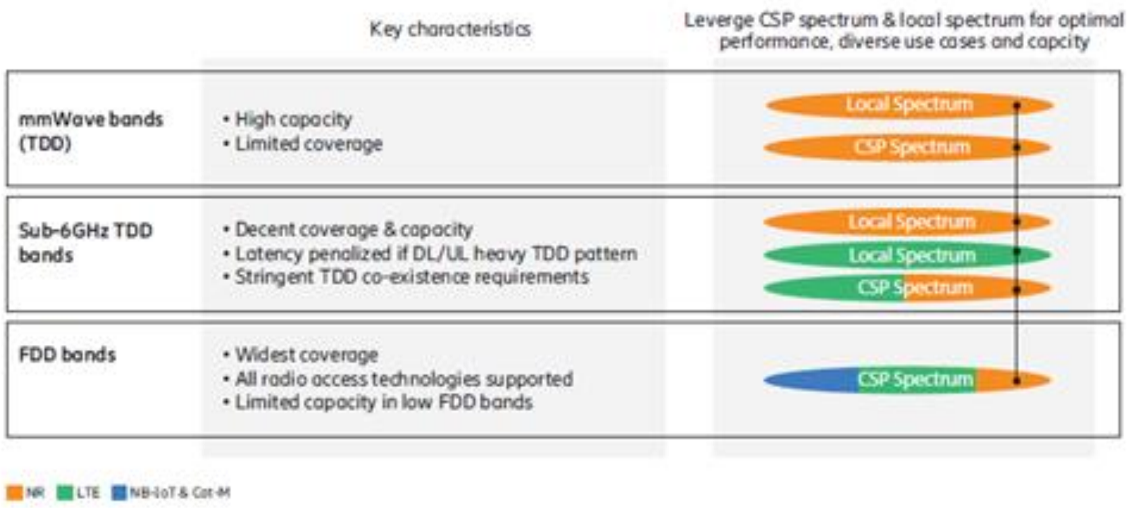

Figure 9. The dependency between CSP and localized spectrum on different bands.

Depending on industry strategies regarding what operations are core to their businesses and kept in-house (as opposed to those bought as a service), cellular networks can be deployed in various ways by a communications service provider. Broadly speaking, there are two main network deployment concepts for addressing industrial connectivity needs:

- non-public networks (NPNs) in conjunction with public networks (PNs), where network resources are shared between public and non-public users
- standalone non-public networks, where independent standalone networks are deployed for non-public use

Deploying a non-public network in conjunction with a public network allows reuse of network infrastructure, efficient utilization of spectrum, and seamless mobility. The network infrastructure can be deployed inside or outside an enterprise's premises in part or in its entirety and can be shared between public and non-public users. There are three ways of realizing this:

- shared RAN, where RAN is shared between public and non-public users while the rest of a network's components are kept segregated (all non-public data and control traffic stays within an enterprise's logical premise)
- shared radio access and control plane, where a core network control plane is hosted in a public network in addition to the shared RAN (non-public user data remains local while control traffic leaves the enterprise's premises, allowing seamless roaming of non-public users)
- non-public networks hosted by public networks, where non-public user data leaves the enterprise's premises while still allowing the enterprise to obtain dedicated resources from a CSP's infrastructure (for example, through end-to-end dedicated network resources across radio, transport, and core networks) with a service-level agreement (in which scenario a CSP can also deploy radio access nodes inside the enterprise's premises for radio coverage and performance reasons)

CSP skill and experience in designing, building, managing, and maintaining cellular networks can be instrumental in the success of industries as well as in ensuring that their dedicated networks interoperate perfectly with adjacent public networks. With this in mind, the recommendation is that CSPs develop new business models addressing long-term investment horizon of industries as well as their need for quality and operational independence. These new business models must also ensure the availability of spectrum for the duration of a production facility's lifetime as well as the freedom to change suppliers of services at reasonable intervals. Accommodating these requirements, CSPs will likely remove one of the major concerns for industries considering choosing the 3GPP-licensed technology path.

Locally licensed spectrum principles. Allocating licensed spectrum for wide-area services to a limited number of CSPs has proven successful and cost-efficient through the well-functioning market and competitive services it has generated for consumers, with 3GPP network coverage serving roughly 95 percent of the world's population. Widearea spectrum for industries would lead to the underutilization and fragmentation of spectrum and thus the loss of its efficiency. As for locally licensed spectrum, the situation is different, as deployments are typically made on private property and frequently indoors, where the availability of competing indoor offerings is not naturally secured.

Ericsson proposes that if countries decide to dedicate locally licensed spectrum, an idea defined as the "real estate principle" should be the preferred principle to apply when doing so. In short, this refers to linking a priority right to acquire a local license to the real estate ownership (or tenant, depending on national prerequisites). This simple principle meets the three requirements mentioned earlier of having predictable spectrum access, avoiding rewarding first movers, and ensuring availability of unused local spectrum. The real estate principle offers predictable access to spectrum over time as well as a sustained possibility for late entrants to acquire local spectrum and still leaves unused spectrum available for short- or medium-term use by third parties.

Some additional examples of the benefits associated with the real estate ownership principle include that the legal principles surrounding real estate are established, well defined and understood, and digitized in most if not all countries. The logical connection needed in order to be able to dispose of spectrum on owned property is also easily understood and fits the need for local high-performance systems. Leasing of locally licensed spectrum should be allowed to ensure access to spectrum in all scenarios. In a real estate ownership model, it should be possible for a CSP to offer services to the industry on the estate using the reserved spectrum. Most industries will want the operation to be handled by a third party, and, since some of the appealing services offered by CSPs (such as, for example, roaming, wide-area mobility, voice/IMS, and so on) are services optimized in their service offerings, it is particularly natural for the real estate owner to allow a CSP to operate the given service in places where there will typically be three or so networks serving the public and one logical IoT network operating (such as in an airport or hospital).

A CSP can here easily handle the local IoT network as a combined network, and the CSP should then also be allowed to use the dedicated local spectrum for public services (following the real estate owner’s consent as well as the condition that all traditional requirements for public service be fulfilled).

Another major advantage is that the administration of real estate-based licenses can be very simple following this principle, as the real estate owner must simply accept the responsibility to fulfill conditions for use and (presumably) pay an initial plus an annual fee for the local license part of the spectrum, avoiding a complicated and time-consuming auctioning procedure in the process. The industries can then start planning and deploying equipment as soon as the sub-band is identified, and the regulatory decision made. For this model to succeed, spectrum management systems will be needed to automatically manage large amounts of local licenses as well as regulatory conditions. One such system with these and other capabilities is the evolved licensed shared access (eLSA) approach (based on the already standardized LSA system) being standardized in ETSI RRS.

Spectrum not yet claimed by the real estate owner can also be offered to CSPs and third parties for a limited time (for example, for sports events or concerts where temporarily increased coverage or capacity is needed), but only as long as sufficient safety margins are kept to fully guarantee existing local licenses are not interfered with.

Campus Networks are small, local networks dedicated to a set geographical area. They can cover anywhere from a few hundred square meters indoors to a few square kilometers outdoors. Locations include factory shop floors, logistics centers, venues, airports, ports, oil and gas campuses and power plants. According to Arthur D. Little[7] the requirements depend on the type of campus and they differentiate between four types, which differ in coverage

[7] https://www.adlittle.com/sites/default/files/viewpoints/adl_private_campus_networks-min_0.pdf

(in/outdoor, on/off premise, local/distributed), purpose, connectivity quality requirements, and connected devices:

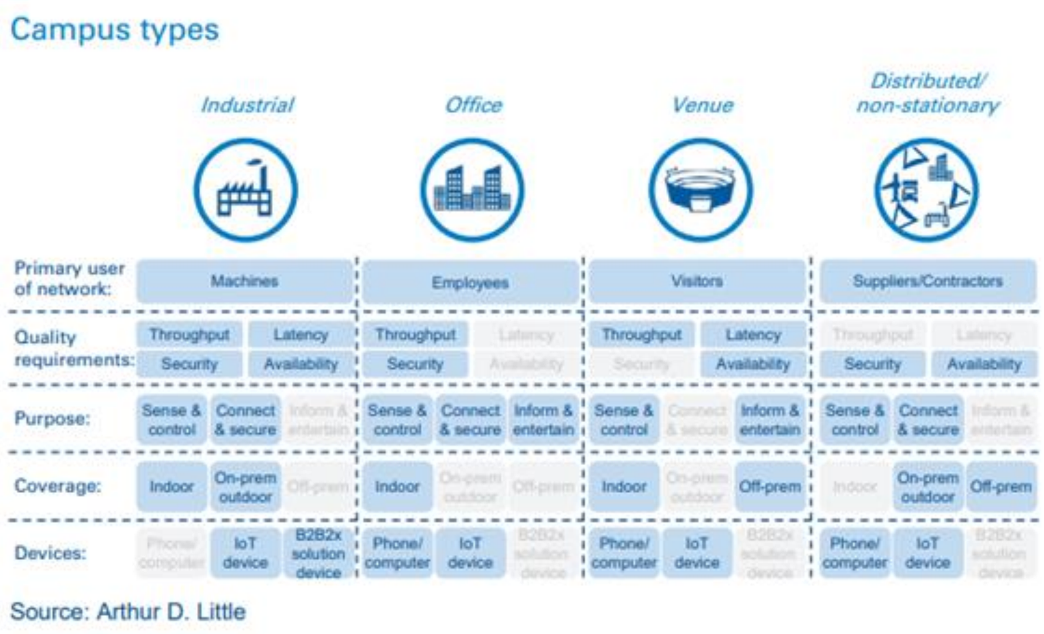

Figure 10. The model with different types of the Campus networks.

Frage 1.6.:

Welche Anforderungen ergeben sich aufgrund der Vertical Industries für die zukünftige Vergabe von Frequenzen? Gibt es Frequenzbänder, die von zentraler Bedeutung für diese Industriezweige sind? Wann sollten diese Frequenzen vergeben werden? Welche im Kapitel 2 genannten Frequenzbänder haben keine Bedeutung für diese Industriezweige?

[Ericsson Response]: Unlike MBB, the industries' connectivity needs are extremely diverse. So, to realize cellular connectivity for all industries in a systematic way, we at Ericsson have defined four IoT connectivity segments that can efficiently co-exist in a single 5G network. These include:

- Massive IoT, with connectivity targeting a massive number of low-cost, narrow-bandwidth devices with extreme coverage and long battery life capabilities. The massive IoT ecosystem is based on narrowband IoT (NB-IoT) and LTE category M (Cat-M) access with tens of millions of commercial users in 2020, operating in FDD bands. Common use cases include various types of low-cost sensors, meters, actuators, trackers, and wearables.
- Broadband IoT, for connectivity providing much higher data rates and lower latencies than massive IoT while enabling extended device battery life and coverage for devices

with significantly wider bandwidth than Massive IoT devices. Based on a wide range of LTE device categories (LTE Cat-1 and above) in frequency division duplexing (FDD) and time division duplexing (TDD) bands, broadband IoT has more than 500 million users globally. Broadband IoT usage is presently dominated by vehicles, wearables, gadgets, cameras, sensors, actuators, and trackers.

- Critical IoT connectivity, delivering time-critical communication for data delivery within specific latency targets with required guarantee levels. Critical IoT will be introduced in all 5G bands alongside the advanced time-critical communication capabilities of 5G NR, which will be further enhanced with 5G core (5GC). It includes 5G's most powerful, ultra-reliable and/or ultra-low latency features. Typical time-critical use cases include cloud-based AR/VR, cloud robotics, autonomous vehicles, real-time fault prevention, haptic feedback, real-time control, and the coordination of machines and processes.
- Industrial automation IoT, enabling the seamless integration of cellular connectivity into the wired industrial infrastructure used for real-time advanced automation. It includes capabilities for integrating 5G systems with real-time Ethernet and time-sensitive networking (TSN). These capabilities mandate 5G NR and 5GC.

The IoT connectivity segments have a cost-effective, smooth, and future-proof evolution intended to accelerate adoption in the ecosystem and minimize the total cost of ownership (TCO). As depicted in Figure below, each IoT segment addresses a distinct set of connectivity requirements across various industry verticals.

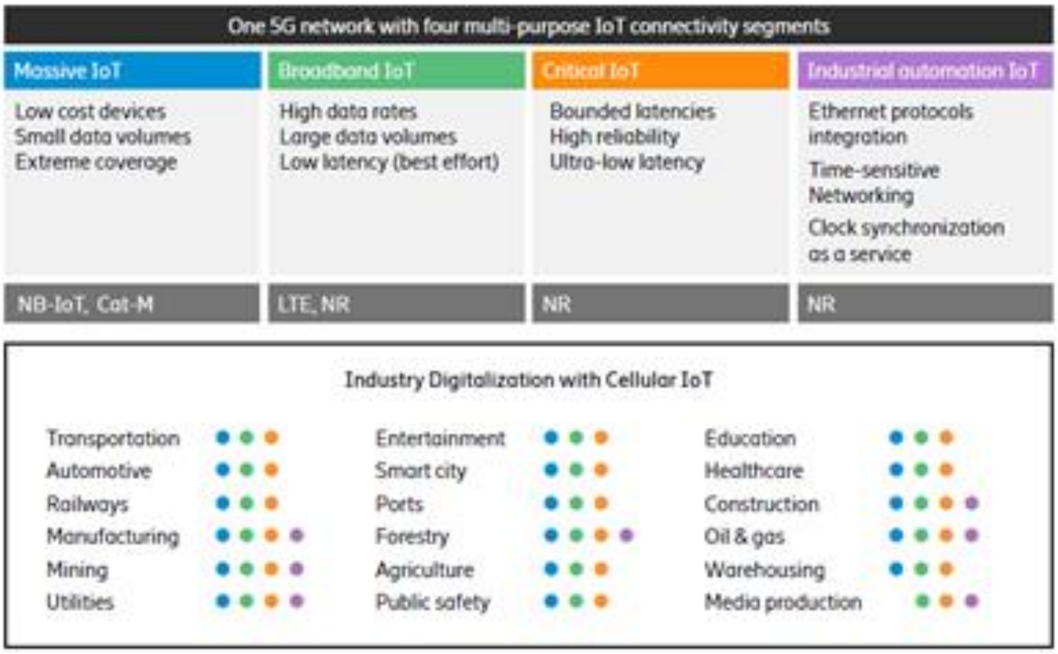

Figure 11. The model with Internet of Things separation.

Answering the second half of the question doesn't have a straight-forward approach, while the first and the minimum definition over there is the joint industry understanding that 5G is seen as the powerful tool to support the digitalization of various verticals. Through dedicated industry 5G networks – doesn't really matter if those are approached directly or via communication service providers – the promises of so called Industry 4.0 can be fulfilled and significant efficiency and quality potentials in industrial production can be achieved. New products and services, innovations, new digitalization potentials – all those could be developed and tested in a real industrial environment.

Then next step is perhaps a reference to the different countries' example and experience, in line with the challenges we have expressed in other responses of this document. In Germany, for example, this approach is already being taken in the 3.7 GHz range, which is expected to strengthen the industrial location there[8].

In general – referring to the experience from other countries - we see the following frequencies being considered for the localized dedicated industry spectrum[9]:

- 2.3 GHz
- 2600 MHz
- 3.4 - 3.8 GHz and 3.8 - 4.2 GHz
- 26 GHz

Whatever frequency resource is considered by RTR for the localized spectrum (if at all), the importance of avoiding the interference and harmonization of the spectrum are expected to become even more valid and crucial.

Frage 1.7.:

Sehen Sie eine Notwendigkeit, maßgeschneiderte Vergabeverfahren für Vertical-Industry-Lösungen zu entwickeln (z.B. lokale Lizenzierung, Reservierung eines Teils des Spektrums, etc.)? Falls ja: In welchem Band? Welche Frequenzmenge sollte dafür genutzt werden?

[Ericsson Response]: Setting spectrum aside for local or vertical usage in priority 5G bands (i.e. 3.5/26/28 GHz) could jeopardize the success of public 5G services and may waste spectrum. Approaches like spectrum leasing are typically better options in these situations. For mmWave local spectrum licenses is becoming quite common for some different reasons:

- the large amount of spectrum is in some countries deemed sufficient to also reserve some for local or vertical use

[8] https://www.bundesnetzagentur.de/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OeffentlicheNetze/LokaleNetze/lokalenetze-node.html

[9] https://www.gsma.com/spectrum/wp-content/uploads/2020/11/Mobile-Networks-for-Industry-Verticals.pdf

- part of the spectrum need to be restricted to local use in some countries (indoor or shared use):
- “Indoor” restricted to low power indoor use to not interfere with incumbent (wide) use of the band
- “Shared” restricted to areas where it does not interfere with incumbent (local) use of the band
- there are also models where mmWave spectrum is auctioned in primary areas, while locally licensed in more remote areas

Some examples of “spectrum licenses” models:

- USA: Tiered spectrum; most common available to all on environmental sensing ability; the mmWave spectrum is auctioned per County or Partial Economic Area (PEA). The “average” in the figure is the population weighted average bandwidth of all areas, while the “maximum” is the largest for any area. Only spectrum licensees with large average bandwidths are included, i.e. with nearly US wide assets.
- Italy: “club use” is a model where each of the five licensees (each holding 200MHz) can use all awarded spectrum (up to 1000MHz) in areas where it is not used by the other licensees
- Germany, Sweden, Finland, France, Denmark and Norway– local industry spectrum awarded per land/property or lease through CSP
- Japan – awarded to land-owner, leaser or contractor offering communication services; divided indoor vs outdoor by power restrictions
- Czech Republic – Price set by pre-defined formula – annual cost 20 MHz for factory plant 500*500m2 ~ 190 Euro
- U.K – Midband and mmWave spectrum offered on pre-defined formula

Options for local industries to operate on licensed spectrum supporting long-term investments:

- Sign a Service Level Agreement (SLA) with Communication Service Provider (CSP) owning licensed spectrum
- The CSP provides local services to the industry with their network implementations including local deployments where needed
- Responsibility & operational agreements between CSP and industry
- All spectrum ranges could be available
- Lease Spectrum locally from a CSP
- Mandatory leasing proposed in some countries, allowing long term lease essential
- Regulators may set aside some spectrum for local licenses

- Needs to be designed for industries and be very local, e.g. real-estate based and harmonized with global frequency bands for device eco system availability
- Interference protection between local industry and wide area CSP use of spectrum
- Avoid spectrum hoarding and un-used spectrum
- Typically one or two range(s) in midband and mmW band, may not cater for all use cases

Answers to the question of which band and what amount of spectrum are given in responses to question 1.7 and subsequent questions in other chapters.

Frage 1.8.:

Sollen Frequenzen für Vertical Industries direkt an Industrieunternehmen oder ihre Partner vergeben werden oder soll die Vergabe offen für alle Interessenten sein?

[Ericsson Response]: Some countries have begun to consider licensed spectrum as part of industrial digitalization and industrial applications. Germany, for example, allocated local licensed spectrum in 3700–3800 MHz band range to industries for their applications already in 2019, while Japan similarly announced the allocation of the 28 GHz band[10]. Other countries, like France and Italy, are looking primarily at allocating spectrum to CSPs, who then need to ensure the availability of spectrum for industries. The approaches taken differ widely between regulators, and the allocated bands are in many cases shared with incumbents.

Regarding the locally licensed spectrum considered by administrations, these diverse allocations pose challenges to building a device ecosystem for industrial applications. Device chipsets need to be supported not only by an ecosystem of traditional mobile broadband (MBB) devices but also by an ecosystem that includes industrial devices of varying complexity on different spectrum bands. These ecosystems, however, are still under formation. In tables below, a snapshot can be found of the spectrum allocations and regulatory discussions on assignment of spectrum dedicated for industrial applications at the time of April 2021.

[10] https://www.tele.soumu.go.jp/resource/e/search/myuse/use0303/batch.pdf

Table 1. Mid-band spectrum for the industry

Country	Spectrum (MHz)	LTE/NR band	Mode of operation	Bandwidth	Comments
Chile	3750–3800	B43/n78	TDD	50 MHz	Allocation postponed
China	5925–7125	TBD	TDD	TBD	Under investigation
Croatia	3410-3800	n78	TDD	90-100 MHz	Allocation 2021
Czech Republic	3400–3600	n78	TDD	2*20 MHz	Allocated in 2020 to two CSPs with a leasing option
Denmark	3740-3800	B43/n78	TDD	60 MHz	Considering allocation to CSPs with a leasing option
Finland	2300–2320 3400–3800	B40 B42/B43/n78	TDD	20 MHz TBD	Available 2020 Allocated in 2018 to CSPs with a leasing option
France	2575–2615 3490–3800	B38 B42/B43/n78	TDD	40 MHz 4x50 MHz	Available 2019 Allocated in 2020 to four CSPs with a leasing option
Germany	3700–3800	B43/n78	TDD	100 MHz	Available 2019
Japan	2575–2595 4600–4900	B41 n79	TDD	20 MHz 300 MHz	Available 2019 Available 2020
Netherlands	3410–3450, 3750–3800	B42/B43/n78	TDD	40+50 MHz	Available with restrictions. New regulation by 2022
Norway	3400–3800	B43/n78	TDD	TBD	Considering allocation to CSPs with a leasing option
Poland	3400–3800	B42/B43/n78	TDD	80 MHz	Considering allocation

Table 1. Mid-band spectrum for the industry

Country	Spectrum (MHz)	LTE/NR band	Mode of operation	Bandwidth	Comments
Sweden	3720–3800	B43/n78	TDD	80 MHz	Considering allocation
UK	1781.7-1785/1876.7-1880, 2390-2400, 3800-4200	B3, B40, n77	FDD + TDD	3+3, 10, 400 MHz	Available 2019
US	3550–3700	B48/n48	TDD	<150 MHz	Available 2020

Table 2. High-band spectrum for industry

Country	Spectrum	NR Band	Bandwidth	Comments
Australia	24.25–27.5 GHz	n258	TBD	Considering allocation
Brazil	27.5–27.9 GHz	n257	400 MHz	Considering allocation
Croatia	24.25–27.5 GHz	n258	TBD	Considering allocation
Finland	24.25–25.1 GHz	n258	850 MHz	Considering allocation
Germany	24.5–27.5 GHz	n258	800 MHz	Available 2021
Hong Kong	27.95–28.35 GHz	n257/n261	400 MHz	Available 2019
Italy	26.5–27.5 GHz	n258	TBD	Available through sharing with CSPs
Japan	28.2–28.3 GHz, 28.3–29.1 GHz	n257/n261	100MHz + 800 MHz	Available 2020
Malaysia	26.5–28.1 GHz	n257/n261	TBD	Considering allocation
Republic of Korea	28.9-29.5 GHz	n257	TBD	Considering allocation
Sweden	24.25–25.1 GHz	n258	850 MHz	Considering allocation
UK	24.25–26.5 GHz	n258	<2.25 GHz	Available 2019

Figure 12. The snapshots of the different frequency strategies from country to country.

Regulators and policy makers have a different set of challenges. In countries that have decided (or are planning to decide) on locally licensed industry spectrum, regulators and policymakers must find an easyto-understand and cost-efficient model for its regulation. If implementing locally licensed spectrum for industry purposes, they must ensure that its utilization is efficient. Additionally, it is important to note that the way in which licensed spectrum is managed within countries also impacts the appeal of the 3GPP path. When licensed spectrum is offered locally with the objective of satisfying the needs of industries, a few basic requirements should be fulfilled as to how this is offered.

These requirements include that:

- Access to spectrum must be predictable over a long period of time to support uninterrupted operation and major investments in production processes and industrial facilities having a lifecycle of typically 15–20 years.
- Schemes awarding excessive first-mover advantages should be avoided so that industries or other players do not block spectrum through spectrum hoarding.
- Local spectrum not yet licensed to industries should be kept available to increase spectrum utilization efficiency for spectrum license holders (such as CSPs), though with a sufficient safety margin to ensure that existing local networks are not subject to interference. It should be noted that radio network providers and device makers can potentially face challenges with developing solutions for unique frequency bands unless the availability of devices and an ecosystem are factored into the decision of dedicating frequencies for locally licensed spectrum.

Frage 1.9.:

Gibt es wettbewerblich relevante Themen, wie etwa eine Abschottung vom Zugang zu Frequenzen, im Rahmen der hier im Spectrum Release Plan genannten Bänder? Wer hätte dazu die Fähigkeit und den Anreiz und welcher Effekt auf den Wettbewerb würde sich dadurch ergeben?

[Ericsson Response]: This question is hard for Ericsson to comment given that Ericsson is not in the telecommunication business in a role of communication service provider. Ericsson also agrees that full potential of 5G can be unlocked and realized at a condition that fair and trustul competition principles are realized during the spectrum auction process.

At the same time, worth mentioning that in some of the countries there were legal and financial disputes about the idea of „spectrum foreclosure“ when the specific service provider intends to bid for the spectrum in order to keep the frequency resources outside of the competition and / or prevent the competitors from acquiring the licenses for the additional spectrum. However comes the question of having the evidence to actually foreclose the spectrum – it is a legal, justice and financial question of how to prove a foreclosure attempt.

One possibility still to minimize even the theoretical risk of the foreclosure of the spectrum is to follow the principle of equal promoting the economical value of the 5G across the different service providers or other actors considered by the regulator, rather than allowing a certain single player to acquire and concentrate the majority of the frequency resources. At the same time, following such strategy and approach has a down-side – this is about setting the artifical limits to a particular actors on the market while the investment intention of those players are real and serious. More over, industry practice shows that buying and then selling out particular licenses is a normal practice by the certain players of the mobile industry, this is just a part of the strategy that has much more components in place.

There has been recently a discussion in North American market regarding the topic of the „spectrum foreclosure“, some links to follow are provided in the footnotes[11][12].

Besides, there has been a serios debate in some other markets defining the way to address a distinct spectrum concentration concerns. Besides setting a clear deployment and investment proof conditions – which RTR is well experienced given the previous auctions – we see some of the regulators also setting aside a certain in-band cap. Over the link in footnote one could find an example of such framework implementations recommended for mid-band auctions in Canada[13]. Such set-aside approach however would be fair to assess in order to justify any impact on outcomes of the auction with such in-band security.

Having said above, we believe that a complex assessment of multiple precaution but also post-auction actions is required including setting non-foreclosure frameworks, but also the investment commitment measurements by the new entrants.

Frage 1.10.:

Gibt es im Bezug zu Infrastructure Sharing relevante Themen? Das Positionspapier wurde primär für Bänder im letzten Spectrum Release Plan 2016 und damit für Bänder unter 4 GHz formuliert. Welche Regelungen wären für Frequenzen deutlich über 4 GHz aus Ihrer Sicht angemessen?

[Ericsson Response]: Unlike previous generations of Radio Access Network (RAN) standards, which were deployed as stand-alone networks, 5G NR is designed from the start to interwork fully with existing 4G LTE networks. While this provides a high degree of continuity and seamless experience for users, it also demands careful planning in order to minimize risk to existing services. To provide a great customer experience, most of today's 5G deployments rely on mid-band and it is critical for Communications Service Providers to optimize these deployments to get maximum benefits. Following topics have to be addressed by service providers and are required for a successful solution:

- What are the challenges on mid-band deployment and how could they be solved in a cloud infrastructure?
- How can we leverage the design philosophy and in-depth experience from the RAN System into Cloud RAN?
- What are the implications of differences in processing need between low-band and mid-band?

Solving the mid-band coverage challenge. 5G mid-band runs on wide band Time Division Duplex (TDD) spectrum below 6GHz delivering the high capacity promised by 5G. However,

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[11] http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-12-119A1.pdf
[12] https://www.law.cornell.edu/uscode/text/47/309
[13] https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/SLPB-002-19-Reply-Shaw.pdf/$FILE/SLPB-002-19-Reply-Shaw.pdf

due to shorter wavelengths, it provides less coverage compared to low-band. The limiting factor is the uplink and Ericsson has two main solutions to address this challenge – Uplink Booster and 5G carrier aggregation. Uplink Booster is an innovative solution available in Ericsson Radio System today, that increases coverage on 5G mid-band by moving the uplink beamforming processing from the baseband to the massive MIMO radios, where it runs on Ericsson Many-Core Architecture (EMCA). This creates up to 10dB gain, equivalent to a 3.7x extension of coverage area, improved uplink throughput and higher spectral efficiency. Carrier aggregation in 5G is another powerful solution in the Ericsson portfolio. Our resolution is to decouple the downlink from the uplink, keeping the downlink data on the mid-band while the uplink data, and the control plane, are moved to the low-band. In simple words, when combining mid-band with low-band, the uplink, which is normally weaker, will reach the base station on low-band 5G, which travels longer. And the 5G mid-band signal will travel as far as the base station allows, ensuring also an extended coverage, without any limitation from a weaker signal from the user equipment. This has two primary benefits:

- Coverage increases with low-band's longer reach, adding 7dB gain, translating to extend the coverage area by 2.5x, compared to dual connectivity deployments.
- The overall network capacity increases about 27 percent, due to the extended mid-band coverage, so we can also offload traffic on to the mid-band.

Processing for mid-band compared to low-band. The processing needed for a fully loaded, low-band cell on a commercial-off-the-shelf (COTS) server, excluding processing for operating system and common functions, is roughly 1 core. Comparing to a fully loaded, mid-band cell without any accelerator this would be about 16 cores. The difference in processing volume comes from the amount of data produced and consumed in the mid-band system, differences in bandwidth, layers and traffic models. It is roughly 20 times larger in downlink compared to a low-band cell. A pure soft x86 based implementation for mid-band is not commercially viable in a deployment scenario in line with expected traffic growth due to this massive processing need. However, offloading processing of certain layer 1 functions to more specialized hardware, so-called accelerators, will make RAN on cloud infrastructure viable also for mid-band. Choice of accelerators is a strategic decision and depends on communications service provider´s deployments and traffic scenarios.

Further regulation recommendations and experiences for the bands above 4 GHz are shared throughout the whole document.

2 Chapter 2

Frage 2.1.:

Für welche Nutzungsformen, Geschäftsmodelle und Technologien werden diese Frequenzen voraussichtlich genutzt werden? Welche Bedeutung wird Inband-Backhauling spielen? Kann Inband-Backhauling ein Ersatz in bestimmten Gebieten (z.B. in der Stadt) für den FDD-Richtfunk für die Anbindung von Basisstationen sein (siehe dazu weiter oben)? Bitte begründen Sie Ihre Antwort.

[Ericsson Response]: For enhanced mobile broadband use cases such as multi-player gaming, AR gaming and rich video streaming. Higher downlink speeds will also expand opportunities for communications service providers to bring fixed wireless access to consumers, with cellular mmWave connectivity of up to four times faster than fiber.

Generally speaking, mm-wave bands like the 26GHz band which has been identified by the EU as one of the 5G pioneer bands, support use cases that require high bandwidth and very low network latency.

For device makers, it is key that the mm-wave bands to be used for 5G deployment are harmonized in order to support the required economies of scale.

According to Qualcomm's statements[14], "millimeter wave (mmWave) without a doubt will be one of the key spectrums used in 5G… by 2021, all leading economies will have millimeter wave deployed, and as you think of the use cases beyond smartphones, millimeter wave is required". Verizon in the US, believes for the mm-wave bands that "…that's where the transformative [5G] use cases happen."

For Cellular Service Providers, it is essential that they are able to obtain big contiguous chunks of spectrum in this band in order to be able to offer Private Network services and related industrial applications to various industries, which are expected to be one of the most important uses of this band.

Experience from the US, who has been one of the world's frontrunners in both 5G deployments and in the use of mm-wave band for 5G, shows that Fixed Wireless Access has been the primary use case at launch, but more innovative uses, such as for industry 4.0 etc. are expected in the near future. So far, Italy is the only EU country which has licensed the 26 GHz band and Italian service providers also intend to use it mainly for offering Fixed Wireless Access services, i.e. as a substitute of expensive fiber rollouts for offering ultrafast broadband service in e.g. rural areas, where fiber coverage may not be commercially viable, as well as for dedicated indoor coverage for e.g. private networks for industrial and other

[14] https://www.qualcomm.com/news/releases/2021/04/13/qualcomm-announces-successful-data-calls-using-5g-mmwave-and-sub-6-ghz

IOT-related applications requiring very low latency and/or very high throughput. An example of how Telecom Italia thinks about the use of the 26GHz band, can be found in footnote[15].

Back in October 2019, the French telecom regulator Arcep has approved the first eleven initiatives to trial 5G technology using the 26 GHz band[16], in the following key areas:

- logistics (smart ports, multimodal transport management, traceability), smart city (smart buildings),
- mobility (in-station services for trains or passengers) or
- covering sporting events.

Other projects have a broader target and plan on hosting any kind of innovative enterprise.

According to the European Commission's Implementing Decision for the harmonization of the radio spectrum in the 26 GHz band[17], this band is destined for "enhanced, dense wireless broadband". According to this Decision, the 26 GHz frequency band offers the highest amount of spectrum and thus the largest capacity of all three 'pioneer bands' as these have been identified by the EC. New types of applications, that require gigabit speeds and large bandwidth are expected to make most use of this band, like e.g. connecting objects and devices, Enhanced Mobile Broadband (eMBB), services for high capacity (Fixed Wireless Access (FWA), high-definition video communications, virtual, augmented and mixed realities. It is expected that progressive adoption of this band by 5G service providers will initially be focused on congested hot-spots, major transport paths and industrial sites.

Services expected to use mm-wave bands are the following (ref. "Study on using mm-wave bands for the deployment of the 5G ecosystem in the European Union"[18]):

- Enhanced Mobile Broadband (eMBB) to smart phone users is expected to be the primary use case for high band 5G for most service providers. High Band 5G will target specific deployments where the needs for high capacity and speed eMBB are largest.
- Fixed Wireless Access (FWA) can provide connectivity for households and SMEs, possible to be implemented with LTE and further boosted by 5G. FWA can be very capacity demanding and by using fixed locations and outdoor CPE, it becomes possible to provide capacity needed by using large amount of spectrum available at high band.
- High Band 5G is well suited to deliver high capacity low latency wireless connectivity for industry automation. High band offers high speed, high capacity and can provide

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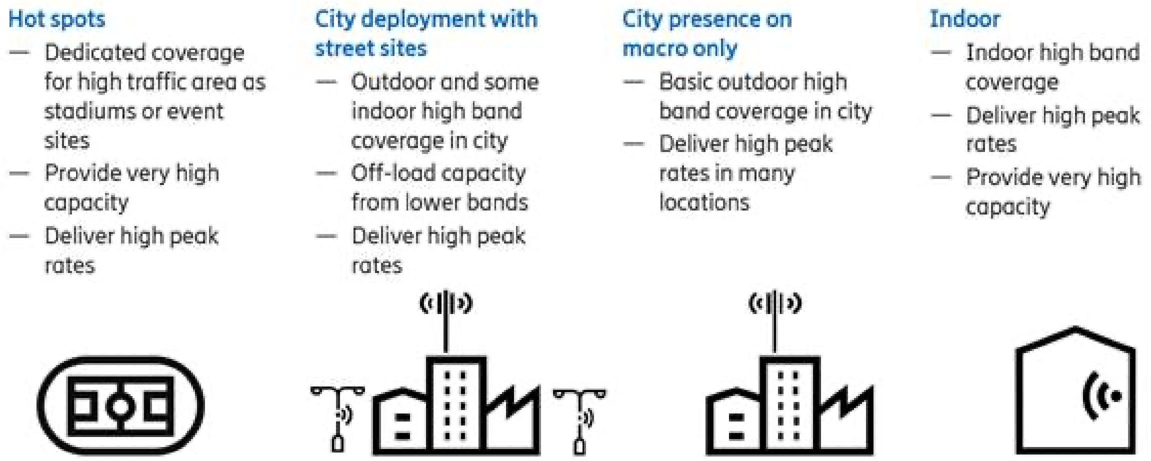
15 https://www.gruppotim.it/en/press-archive/corporate/2020/PR-TIM-5G-overcame-the-2-Gbps-speed-a-new-European-record-080120.html
16 https://www.arcep.fr/uploads/tx_gspublication/Report-5G-issues-challenges-march2017.pdf
17 https://digital-strategy.ec.europa.eu/en/news/european-commission-harmonise-last-pioneer-frequency-band-needed-5g-deployment
18 https://www.bruegel.org/wp-content/uploads/2019/10/KK0319410ENN.en_.pdf

for low latency radio interface. The limited radio propagation of high band can allow for radio coverage to be concealed to specific locations. In some countries high band spectrum allocations are designated to industry applications.

- Services for vertical sectors including automotive (V2X: Vehicle-to-everything, autonomous cars), other transportation (trains and buses), manufacturing / industrial automation, energy grid communications, smart cities, and medical applications.
- Integrated access backhauling (IAB). IAB will use high band 5G spectrum and radio nodes for backhaul together with access removing the cost and hazel to install fixed backhaul to new sites. The large spectrum allocations on high band allow for enough capacity for both backhaul and access. High band IAB can provide backhaul for high band access as well as for radios on lower bands. Major savings can be achieved by removing backhaul cost and quicker installation of new site can be reached by using IAB. IAB is still being standardized and is not ready for commercial offers yet. Ericsson is in explorational phase of IAB solution right now - HW vise our current product can support that but the SW needs to be developed. It will be developed based on how the mmW market will be evolving. As an example current commercial deployments in US using street poles and rooftops are all based on fiberoptics which is most common for suburban environments. So we do not see the market demand in IAB in close future.



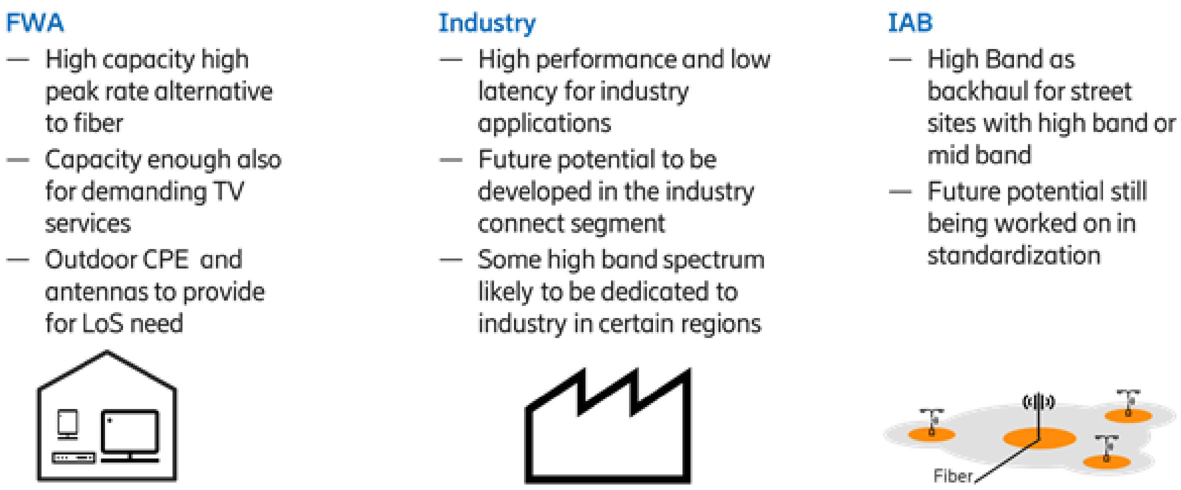


Figure 13. Primarily use cases for forecasted in mm-waves.

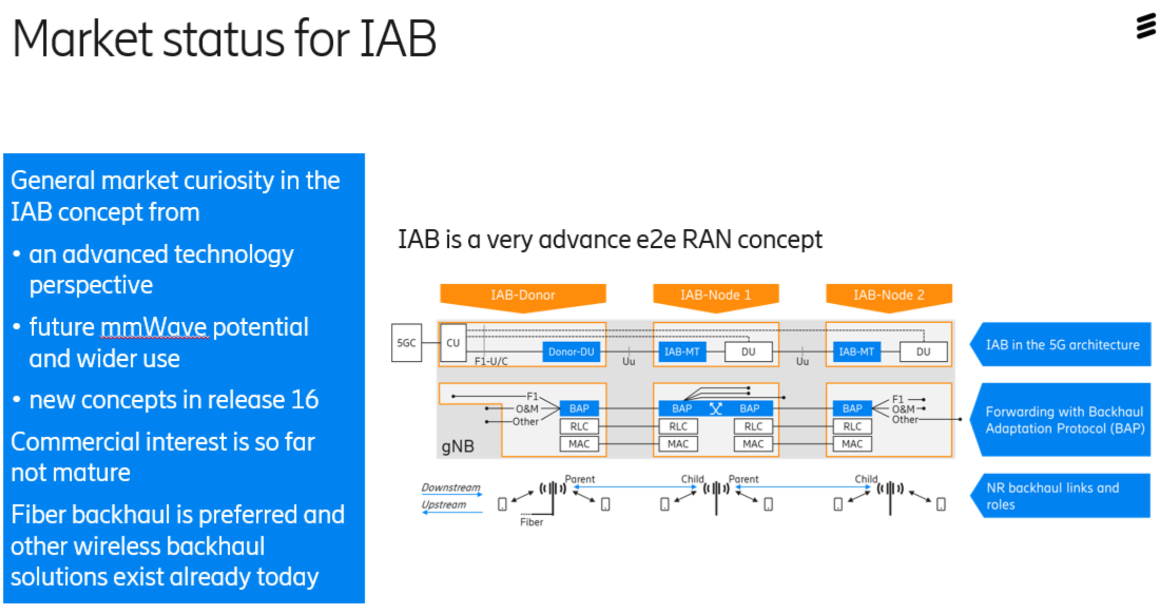


Figure 14. Market status for IAB as seen by Ericsson.

Frage 2.2.:

Wann erwarten Sie, dass Endgeräte und Technologien/Eco-Systems zur Verfügung stehen werden? Für welchen Teil des Bandes erwarten Sie zu welchem Zeitpunkt Endgeräte und Technologien?

[Ericsson Response]: Terminal equipment with mmW 5G support is already available. Devices with full b257 support are widely sold in US market – both smartphones and CPEs. iPhone 12 have the mmW support limited to US market so far. NR band 258 which is the main target mmW 5G band for Europe is being allocated in countries like Italy, Greece, Germany, UK, Denmark and others. China is planning of commercial deployments in b258 starting 2022. We suspect many devices both from smartphone (mobile broadband and eMBB use cases) and CPE (FWA use case) form factor will be available near time with b258 support[19].

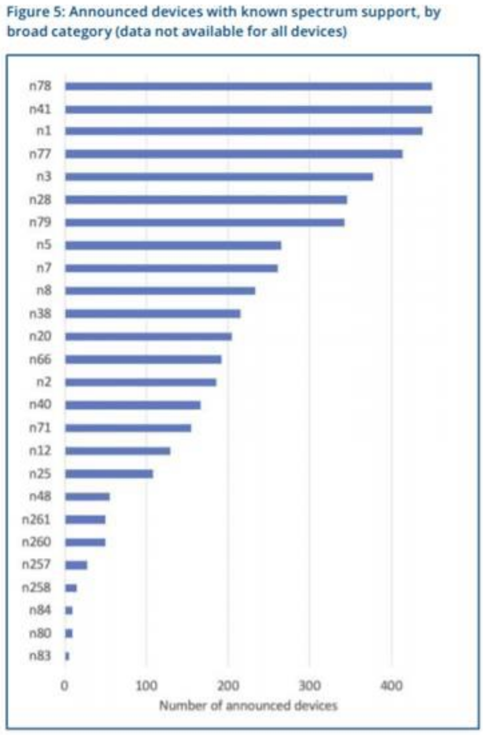


Figure 15. Ecosystem maturity for the milimeter wave range.

Frage 2.3.:

Welche Bedeutung wird die Anbindung von Basisstationen durch Richtfunk (FDD-RF) in den nächsten Jahren in städtischen und in ländlichen Gebieten haben? Ist dafür eine dauerhafte oder längerfristige Nutzung dieses Bandes für Richtfunk erforderlich? In ganz Österreich oder nur in ländlichen Gebieten? Welche der in Tabelle 3 dargestellten Option (R1 bis R6) soll in Bezug auf die bestehende Richtfunknutzung gewählt werden? Bei Mehrfachauswahl, bitte nennen und reihen Sie ihre präferierten Optionen. Kennen Sie eine bessere Option? Welcher Bandplan soll gewählt werden? Bitte begründen Sie ihre Antworten.

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[19] https://gsacom.com/paper/5g-devices-executive-summary-july-2021/

[Ericsson Response]: Question might be not understood properly, but in general talking about base station connectivity topic in relation to the FDD FS, we expect a growing demand for both point-to-point backhaul solutions and IAB as complementary across all possible geographical locations. Besides, IAB can be considered as a good alternative for the high-band spectrum. Removing backhaul cost is very situational dependent (i.e., existing base station connectivity via backhaul or not, fiber lease costs, E-Band spectrum costs, etc.), Ericsson's suggestion is to look at this together with the RAN spectrum and via angle of new services creation.

With regards to the shared spectrum release options R1-R6, Ericsson suggests to consider the recommendations of relevant ECC reports[20] and sees options R1 to R3 as less radical.

Frage 2.4.:

Wann soll dieses Band Ihrer Meinung nach vergeben werden? Soll das Band in zwei oder mehreren Schritten und mit unterschiedlichen Bewilligungsmodellen vergeben werden (Optionen G1 bis G4)? Soll das Band partitioniert werden? Sollen für high demand areas (HDA) und low demand areas (LDA) getrennte Bewilligungsverfahren genutzt werden (individuelle Nutzungsrechte mit Auswahlverfahren in HDA und lokale Lizenzierung in LDA)? Bitte begründen Sie ihre Antworten.

[Ericsson Response]: Ericsson sees 26 GHz as an important band for service providers, but notes with some concern that Europe risks delaying the rollout of 5G in higher frequency bands significantly compared to the driving countries, such as the US, Japan and Korea. In these countries, such frequency bands have been made available and in some cases have already started to be used with further acceleration throughout the next few years. Therefore, Ericsson advocates allocating 26 GHz for outdoor use in high capacity areas much earlier than 2026.

The band 26 GHz is very much capable of delivering close to wireline speeds with the low latency, but there is a specialty with the band connected to high propagation losses that sets certain challenges of the wide usage connected to the low spectrum bands. 5G on 26 GHz will be a TDD based system. It is important to consider in the planning of geographic spectrum areas the boundary conditions and interference that may be present. Synchronization between allocated spectrum blocks within the 26 GHz band must be considered to ensure efficient use of the spectrum. As with the 3.6 GHz band, where synchronization requirements were defined, a similar approach may be required for the 26 GHz band.

What this means from the regulation perspective. The very high propagation mentioned above in reality means that the coverage that is reachable by the means of this band would only be a small percentage of the land mass, even if considering densification of the cells. There is a number of potential options to mitigate this challenge, but – as said above – the coverage area would be lower compared to the low-bands. Besides, the amount of bandwidth available with

[20] https://efis.cept.org/views2/fixedservicerecommendations.jsp

the spectrum is noticeably higher – over 2 GHz of bandwidth compared with several hundreds of MHz in the mid band and less than 100 MHz available in low bands.

What this means from the service provider perspective. We sense that wide usage of this band across the all areas would be challenging for service providers – it should be seen as the capacity booster in already congested areas. Given also mentioned propagation loss, going into the wide coverage with high obligations from service provider towards the regulator, would mean for the service provider a high cost of the network deployment.

Having said this, Ericsson proposes to consider those aspects from both regulation and also addressable usage areas perspective.

First – to identify the so called high demand and low demand areas (HDA and LDA). Having such split in place, should give the service providers several options – consider the roll-out of 26 GHz as the capacity booster in HDA and consider the harmonization of the spectrum resource in LDA depending on the service provider convenience.

Second – to define the most appopriate and suitable licensing model that doesn't introduce the complexity for either service provider or regulator, and has a clear purpose to benefit the society in Austria with the broader usage of 5G. Ericsson is not in a fair position to make any recommendation, however we could share that some of the regulators worldwide consider also additions to regular spectrum licenses such as apparatus and class licensing that are subject for the differentiation between mentioned HDA and LDA.

Frage 2.5.:

Welche Frequenzmenge muss ein Betreiber mindestens erwerben, um die Frequenzen in diesem Band effizient nutzen zu können? Welche use cases treiben diesen Mindestbedarf? Sehen Sie diesbezüglich regionale Unterschiede (z.B. in verkehrsreichen Zentren in den Städten versus rurale Gebiete)? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: From a technology point of view, we recommend contiguous spectrum awards in blocks of a minimum of 400-500 MHz per licensee. The reason for this is that in mmW the most challenging part is the propagation losses and because of this modulation higher that 64QAM and too many simultaneous data layers cannot be used effectively keeping the coverage good enough for commercial deployments. Our recommendation is to award approximately 1 GHz of contiguous spectrum per licensee. Non-contiguous spectral blocks should be avoided as much as possible since this may limit the availability of device ecosystem and make both devices and infrastructure more complex and costly to provide. Interesting to note that there are countries, such as South Korea which have awarded 800 MHz per licensee in this band. Both GSMA, in their 5G spectrum public policy position[21], as well as GSA[22] recommend around 1 GHz spectrum per licensee in this band.

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[21] https://www.gsma.com/spectrum/wp-content/uploads/2021/04/5G-Spectrum-Positions.pdf
[22] https://gsacom.com/technology/spectrum/

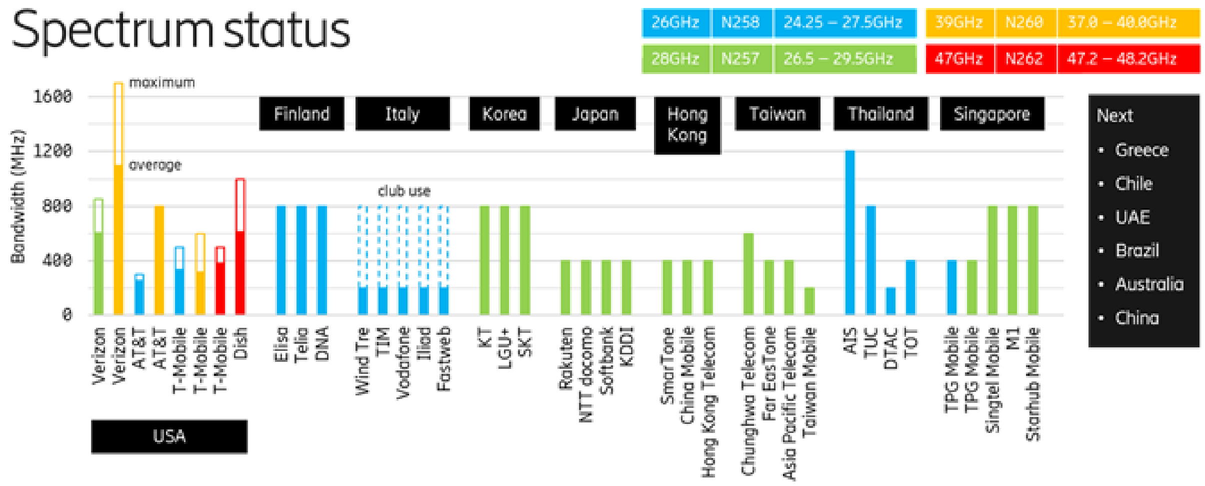

Figure 16. Spectrum status across different service providers in different countries.

Frage 2.6.:

Welches betreiberübergreifende Synchronisations-Schema halten Sie für dieses Band geeignet? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Same as for mid band TDD 5G deployment. Time and phase synchronization is needed across service providers and networks. unless enough geographical/frequency separation or isolation (indoor-outdoor), following ECC Report 307[23].

Frage 2.7.:

Welche Frequenzmenge sollte ein Betreiber in diesem Band maximal erwerben dürfen bzw. ab welcher Frequenzmenge ist eine effiziente Frequenznutzung nicht mehr gegeben? Bitte begründen Sie Ihre Antwort.

[Ericsson Response]: The Ericsson recommendation is to allocate at least 1GHz of contiguous spectrum per service provider (also the GSA and GSMA recommendations are in this range), 400Mhz-800Mhz could be a sub-optimal range. There is no commercial chipsets or devices available yet to support more than 800Mhz in the DL so far. And with less than 400MHz the max user throughput is less than 2.1Gbps limiting cell capacity.

Frage 2.8.:

Besteht aus Ihrer Sicht die Gefahr der Abschottung von oder der Behinderung beim Zugang zu Frequenznutzungsrechten in diesem Band? Bei welchen nachgelagerten Diensten bzw. auf welchem Markt? Wer hätte dazu die Fähigkeit und den Anreiz und

[23] https://docdb.cept.org/document/13859

welcher Effekt auf den Wettbewerb würde sich dadurch ergeben? Bitte begründen Sie Ihre Antwort.

[Ericsson Response]: Band 258 is defined as NR band in 3GPP, harmonized in CEPT and globally identified for IMT by ITU-R. So we do not see such risk coming.

Frage 2.9.:

Sind Sie am Erwerb von Frequenzen in diesem Band interessiert? Wenn ja, welche Frequenzmenge (minimal/maximal) planen Sie zu erwerben? Wenn ja, in welchen Gebieten wollen Sie die Frequenzen nutzen? Bitte begründen Sie den Bedarf.

[Ericsson Response]: This is an unfair for Ericsson to give any response to this question by being a technology leader and provider, but not a service provider. We believe that the most effective approach and go-to-market model for industry for the time being is the cooperation and collaboration between the service providers and vendors, while all involved actors focus on their strengths and part of the value chain. Having said this, we advocate and urge service providers and regulators to speed up the 5G roll-out as the tool to digitalize society and stimulate the economy. Such acceleration clearly requires innovative solutions, approaches and collaborations across the borders.

Frage 2.10.:

Stimmen Sie überein, dass das gesamten Band für die bundesweite Nutzung von Mobilfunkdiensten vorgesehen werden soll? Oder sollen in bestimmten ländlichen Gebieten – in denen Mobilfunkbetreiber die Frequenzen nicht nutzen werden – auch alternative Nutzungsmöglichkeiten vorgesehen werden?

[Ericsson Response]: Ericsson recommends to have this band reserved for nationwide usage, this includes rural areas. Mid-bands are critical in urban/sub-urban areas and can play a key role in busy rural villages as well, for example to address rural connectivity FWA or in major transport paths to add capacity to the basic coverage layer by low bands. Another use case if Industry 4.0 in large factories – see the responses in chapter 1 for more details.

Frage 2.11.:

Wann soll dieses Band Ihrer Meinung nach vergeben werden? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Ericsson is fully committed to supporting all the necessary bands that are foreseen to be used for successfully deploying 5G technology in different markets, in accordance with market demand. The first requests that have been registered from the market, are for TDD in the 3.4-3.8 GHz band and subsequently for FDD in 700MHz band.

2600 MHz bands are considered to be mature bands already for LTE and should in general be given the highest priority to be licensed in support of the evolution to 5G, provided there is relevant market interest from service providers. Whatever the licensing process that will be followed, it will be important for the regulator to ensure that each licensee has contiguous spectrum allocations to improve spectrum efficiency and access to a large device ecosystem.

Frage 2.12.:

Soll das gesamte Band einheitlich als TDD-Band vergeben werden? Bitte begründen - Sie ihre Antwort.

[Ericsson Response]: This is a strategic question that needs to take into account several dimensions – overall spectrum strategy and coverage against capacity coverage.

As it has been already indicated by Ericsson in this document, we recommend to have multi-layer network where all the layers have their own set of characteristics and benefits.

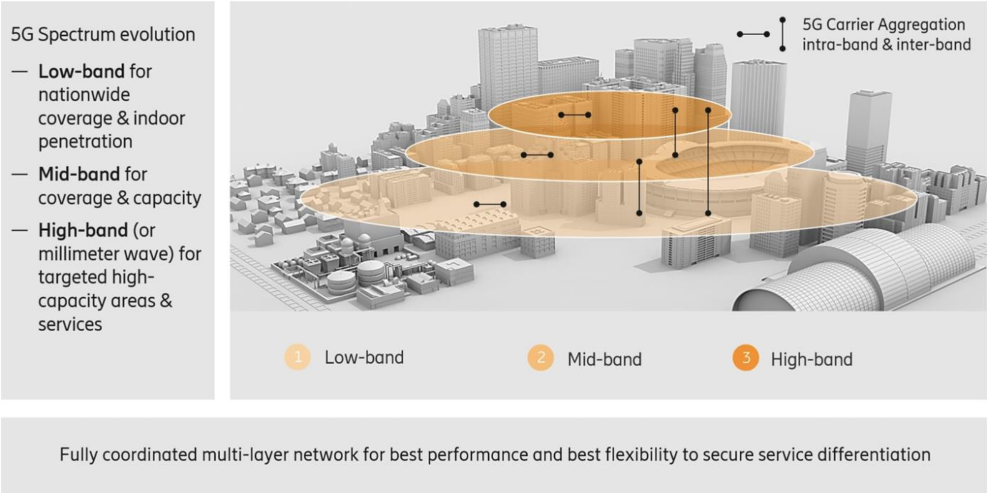

Figure 17. 5G Spectrum evolution over the different bands.

5G low-band (below 7GHz frequency division duplex, commonly FDD) is the most commonly deployed band. It provides a wide coverage area because it has a lower frequency. However, it is limited in capacity. 5G mid-band (below 7GHz, time division duplex, commonly TDD) is the sweet spot for 5G deployments. It has a higher bandwidth and capacity compared to the low-band. However, its uplink coverage is more limited than the low-band. 5G high-band or millimeter wave (above 24GHz) delivers unprecedented peak rates and low latency but comes with poorer uplink coverage compared to both the mid- and low-bands.

There is a certain difference between TDD and FDD approaches. FDD system transmits on a continuous basis, which allows to achieve cell edge rates farther from the base station. Hence, the number of of base stations required to achieve a given area of coverage is reduced. Hence, the FDD system requires lower cost baseline including the operating expenses. At the same time, TDD system use the unpaired spectrum when paired in simply not available. So, in very general and high-level approximation, FDD is believed to provide with better coverage compared to TDD, while TDD is argued to equip the network with better capacity.

To support the wide range of 5G deployment scenarios from large cells with sub-1GHz carrier frequency up to millimeter wave deployments with very wide spectrum allocations, 5G supports a flexible numerology. This flexible numerology allows a range of subcarrier spacing (SCS) from 15kHz to 240kHz with different slot lengths. In comparison, LTE only supports a fixed 15kHz subcarrier spacing and a fixed slot length of 1 millisecond (ms). Given the diversity of spectrum available globally, it is essential that we aggregate the different frequency bands using 5G Carrier Aggregation. This is done to improve cell coverage and deliver higher peak rates.

Having said this, what we suggest to consider is FDD/TDD carrier aggreation that allows to combine TDD with FDD spectrum in order to improve the overall i.e., high-band TDD coverage and downlink throughput. By activating inter-band NR carrier aggregation, the cell coverage area of mid-band TDD extends by a 2.5 factor. That equals a 25% increase in the population covered. With inter-band NR carrier aggregation activated, network capacity increases; the result of extended coverage is higher offload from FDD, higher user throughput at the cell edge, and increased capacity.

Such combination in general would allow service providers and regulator to reach higher average speeds in line with better 5G coverage. An illustrative example of 5G coverage improvement is provided below.

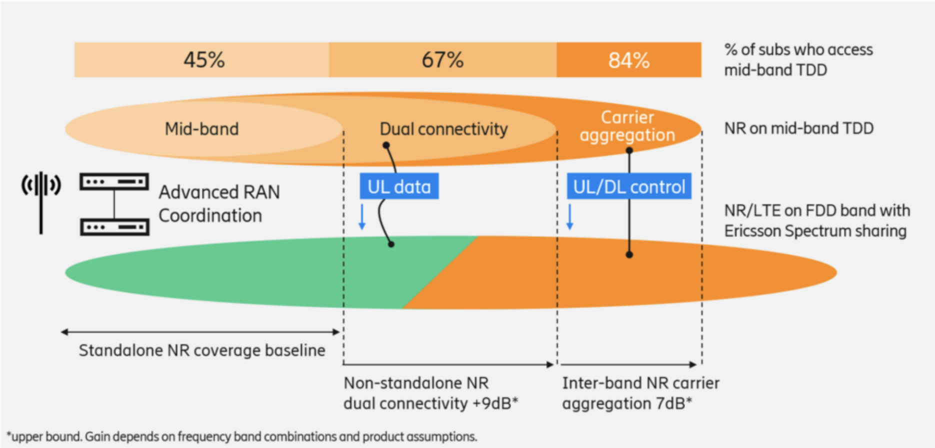

Figure 18. Ilustration of FDD/TDD carrier aggregation.

Frage 2.13.:

Soll im Fall einer früheren Vergabe auch die Umstellung auf TDD vor 31.12.2026 erfolgen?

[Ericsson Response]: See the response provided in an answer to question 2.12.

Frage 2.14.:

Im Fall einer gemischten FDD/TDD-Vergabe: Welche Schutzabstände wären aus heutiger Sicht zwischen FDD und TDD am gleichen Standort notwendig? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Ericsson recommends to consider this not only from FDD/TDD mixture, but from the mixture of technologies to a great extend because relevant guardbands would be required in order to ensure separation between different technologies at different service providers. A concrete example – imagine that 3.5 GHz is split in blocks of 10 MHz and service provider uses two slots for LTE deployment, while at the same time another service provider invests into 5G on the same band. The only way to prevent the interference here would be to keep a sufficient guard band (in this specific example, could be as high as two slots or 20 MHz), hence the best approach here would be to auction 3.5 GHz with the wider block and manage the guard bands accordingly. Having said this, we recommend that first step here should be a definition of the channel bandwidth that is granted to service providers as part of the auction process.

It is true that compared to LTE, the size of the guard band for 5G is drastically different. At the same time, the key aspects to consider here are the technology guard bands (described above) and inter-service provider guard bands. The later one is significantly improved in 5G due to digital filtering enabled by technology as such, but still the mixture of FDD and TDD needs to be taken into account here. For such mixed-numerology systems, industry recommends to consider so called inter-numerology intereference (INI) characteristics in order to reduce the amount of the wasted spectrum. To be more precise – several simulations have been showing that best results are reached when the channels with the minimum SCS ratio are organized adjacent to each other with a common cyclic prefix. Which is possible to reach with syncronized operations of TDD networks on service providers side.

Frage 2.15.:

Für den Fall, dass die bestehenden Frequenzabkommen mit den Nachbarstaaten auf Grund der geänderten Nutzungssituation (reine TDD-Nutzung) angepasst werden müssen, in wie weit würde sich eine vorübergehende benachteiligte Grenzsituation auf den Betrieb und Ausbau in den jeweiligen Grenzgebieten auswirken? In wie weit könnten Betreiberabsprachen (hier zumindest zeitlich vorübergehende) Lösungen für die Nutzungen im Grenzgebiet sein?

[Ericsson Response]: Ericsson in general sees a complexity with moving from one duplex mode to another. There are various migration techniques and methodologies that exist here – usage of the guard bands and filters, different antennas directions and some others. Still those methods are far away from the being efficient for the usage of the spectrum, plus have a certain cost tag associated with them, which makes the usage of the band more complex on the service provider side.

Another problematic thing here is the frame structure view that might vary from one service provider to another across the borders. Still if this path is selected, we recommend to consider a list of practical advices from GSMA to get those implemented at the borders[24]:

- Localised change of frame structure (i.e. indoor usage).
- Network optimisation (such as base station location, antenna direction, and power limits).
- Protection of 4G systems should take into account their real deployment (i.e. take into account that they are mainly fixed wireless access systems).
- Downlink blanking where service providers, on both sides of the border, agree to stop the use of some of their downlink slots when the other service providers are using an uplink slot. Although, this will impact performance and may not be built in to all equipment, especially legacy 4G.
- A step-by-step migration based on the regional timings of 5G deployments and 4G migrations.
- Migrate 4G networks to a different band or to 5G technology.
- Commercial agreement between 5G service providers and incumbent 4G service providers (including acquisitions, re-farming, and reprogramming).
- Reduce capacity near the borders, i.e. by only using a part of allocated spectrum.
- Use alternative bands within the cross border area (including existing bands, mmWaves, additional new/temporary frequencies, or LSA in a different band).
- Avoid co-channel use and aim to have service providers only using adjacent channels – temporaryband plan at the border.
- Use club licences, spectrum and infrastructure sharing along borders.

We see it critical to engage communication service providers in this discussion.

To summarize Ericsson’s view here – we don’t recommended migrating to TDD, but continue with FDD/TDD n7/38:

- TDD n41 requires synchronization (phase and time) unless enough geographical separation. This is not needed in the case of FDD. This includes national synchronization and cross border.
- RTR should consider carefully what the neighboring countries are deploying. If the neighboring countries also have the same FDD/TDD it is better to continue using the same to avoid cross border issues (mixing FDD and TDD in the same frequencies).

[24] https://www.gsma.com/spectrum/wp-content/uploads/2021/03/5G-TDD-Synchronisation-QA.pdf

- 5G NR ecosystem exists for all bands n7/38 and n41, so this continuing with n7/38 will not be an issue from that perspective
- Old LTE devices developed for Europe may not include B41, which may present an issue for service providers since they will not be able to address these devices

Frage 2.16.:

Welche Frequenzmenge muss ein Mobilfunkbetreiber/ggf. anderer Nutzer mindestens erwerben, um die Frequenzen in diesem Band effizient nutzen zu können? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Ericsson‘s recommendation in general is to consider spectrum awards and renewal of spectrum to be reasonably priced and allocated, so to allow for meaningful network deployments addressing the digitalization policy objectives. Having said this, we believe that for 5G to be able to support the full range of use cases, awarded national licenses should include spectrum in low-, mid- and high-bands as these frequency ranges have different characteristics.

Spectrum regulation should aim for attaining harmonized and unrestrictive regulatory conditions for 5G for the different frequency ranges – low (e.g. 600, 700 MHz), mid (e.g. 3.3-4.2 GHz, 4.4-5 GHz) and high bands (e,g. 26 GHz, 28 GHz, 39 GHz).

Spectrum in the low-bands 450 MHz, 600 MHz and 700 MHz bands is needed to connect the unconnected and to increase geographical network coverage and to ensure a successful introduction of IoT solutions. A minimum of 2x10MHz in these ranges is needed.

For initial deployments, a minimum of 100 MHz of contiguous mid-band spectrum within the 3300 – 4200 MHz and 4400-5000 MHz bands (and in some countries 2600 MHz), and around 1 GHz of contiguous high-band (mmWave) spectrum within the 26 GHz, 28 GHz per licensee are needed. Later, additional spectrum in these ranges will be needed.

While a minimum of 100 MHz of contiguous mid-band spectrum may be enough to cope with the spectrum needs by 2021, additional spectrum is needed in the 2025-2030 timeframe.

There are various consulting studies pointing that ”the total mid-band spectrum needs (between 1500-7125 MHz), when averaged over 35 cities worldwide, is estimated to be 2,020 MHz in the 2025-2030 time frame“ to deliver the 5G vision of user experienced mobile data rates of 100 Mbit/s in the downlink and 50 Mbit/s in the uplink across the city, i.e. citywide “speed coverage”, for a range of human and non-human communications and to deliver smart cities in an economically feasible manner.

This additional spectrum will also bring key benefits outside the cities, in particular to bridge the digital divide between urban and rural areas as it can increase capacity in small towns and villages for home broadband. This becomes of particular importance in low income countries, where affordability is critical and FWA is the fastest way to get citizens “online”. Connectivity needs in major transport paths will also profit from this additional spectrum.

The requirements for additional mid-band spectrum will differ among countries, considering national spectrum usage as well as amount of currently allocated spectrum for 5G, i.e. the less licensed spectrum today will turn into a larger demand for additional mid-band spectrum. Spectrum in the mid-bands include 2.3 GHz, 2.6 GHZ, 3.3-4.2 GHz, 4.4-5 GHz and 5925-7125 MHz.

Contiguous spectrum blocks will remain critical in the future, i.e. minimum contiguous blocks of 100 MHz. Nationwide licensing will remain critical to ensure efficient usage of spectrum, e.g. MBB, transport, cameras can be addressed seamlessly within the city while outside the city the spectrum can be used by industries, FWA or along major roads as required.

Frage 2.17.:

Welche Frequenzmenge sollte ein Betreiber in diesem Band maximal erwerben dürfen bzw. ab welcher Frequenzmenge ist eine effiziente Frequenznutzung nicht mehr gegeben? Bitte begründen Sie Ihre Antwort.

[Ericsson Response]: See the response provided in an answer to question 2.16.

Frage 2.18.:

Sind Sie am Erwerb von Frequenzen in diesem Band interessiert? Wenn ja, welche Frequenzmenge (minimal/maximal) planen Sie zu erwerben? Wenn ja, in welchen Gebieten wollen Sie die Frequenzen nutzen? Bitte begründen Sie den Bedarf.

[Ericsson Response]: This is an unfair for Ericsson to give any response to this question by being a technology leader and provider, but not a service provider. We believe that the most effective approach and go-to-market model for industry for the time being is the cooperation and collaboration between the service providers and vendors, while all involved actors focus on their strengths and part of the value chain. Having said this, we advocate and urge service providers and regulators to speed up the 5G roll-out as the tool to digitalize society and stimulate the economy. Such acceleration clearly requires innovative solutions, approaches and collaborations across the borders.

Frage 2.19.:

Für welche Nutzungsformen, Geschäftsmodelle und Technologien werden die Restfrequenzen aus dem Bereich 3,4-3,8 GHz voraussichtlich genutzt werden? Gibt es in den verfügbaren Regionen einen Bedarf für die Nutzung der Frequenzen für private Netzwerke (Campus-Netzwerke)?

[Ericsson Response]: 5G performance in terms of robustness, capacity, latency and data rate has been recognized to offer unprecedented potentials for industries, harbors, hospitals and other local enterprises striving for a higher level of automation and dataflow as well as lower costs.

Some nations have therefore indicated that parts of the spectrum made available for IMT 2020 will be offered locally or regionally in a way that promotes industrial and other enterprise licensees rather than nation-wide service providers licensees only.

More details are provided in a section related to the local spectrum sharing. In summary, Ericsson see the following regarding global availability of 5G spectrum for industries. This spectrum is being assigned either:

- On a dedicated and exclusive basis for industries "Local licensing" (e.g. 3700-3800 MHz in Germany), or
- On a non-exclusive basis allowing for instance non-industrial use of the spectrum as well as industrial use (e.g. 26 GHz in UK and Italy), or
- Through mobile service providers' leasing of parts of their acquired spectrum. The known cases so far are France and Finland's 3.5 GHz band that is currently licensed to service providers but with the requirement that, upon requests, they must offer industries either local service or the possibility to lease local spectrum.
- Note that unlicensed spectrum could also be used by industries, however it will not allow meeting the stringent URLLC requirements required for some IIoT applications.

Concerning the concrete band, Ericsson's view is that:

- 3.4 – 3.8 GHz should be reserved for nationwide MNOs, as this is the core mid-band for 5G. We see very high auction prices in some other countries indicating the spectrum scarcity caused by not providing the entire range to MNOs.

Frage 2.20.:

Wann sollen die restlichen Frequenzen dieses Bandes Ihrer Meinung nach vergeben werden? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Ericsson recommends deploying the 2.3 GHz and 3.4-3.8 GHz allocation as soon as possible. With substantial progress in 5G in many parts of the world, Austria cannot afford to fall behind. Therefore, Ericsson recommends that a plan for the timely release of spectrum in the frequency bands mentioned above is in place, noting the sequence of mid-, high- and low-frequency ranges, in synchronization with the development of respective ecosystems. Not only Austrian Customers will benefit from 5G, Austria will also be able to keep pace with other countries in the development and deployment of 5G.

Frage 2.21.:

Welche Frequenzmenge muss ein Betreiber mindestens erwerben, um die Frequenzen in diesem Band effizient nutzen zu können? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Ericsson‘s recommendation in general is to consider spectrum awards and renewal of spectrum to be reasonably priced and allocated, so to allow for meaningful network deployments addressing the digitalization policy objectives. Having said this, we believe that for 5G to be able to support the full range of use cases, awarded national licenses should include spectrum in low-, mid- and high-bands as these frequency ranges have different characteristics.

Spectrum regulation should aim for attaining harmonized and unrestrictive regulatory conditions for 5G for the different frequency ranges[25] – low (e.g. 600, 700 MHz), mid (e.g. 3.3-4.2 GHz, 4.4-5 GHz) and high bands (e,g. 26 GHz, 28 GHz, 39 GHz).

Spectrum in the low-bands 450 MHz, 600 MHz and 700 MHz bands is needed to connect the unconnected and to increase geographical network coverage and to ensure a successful introduction of IoT solutions. A minimum of 2x10MHz in these ranges is needed.

For initial deployments, a minimum of 100 MHz of contiguous mid-band spectrum within the 3300 – 4200 MHz and 4400-5000 MHz bands (and in some countries 2600 MHz), and around 1 GHz of contiguous high-band (mmWave) spectrum within the 26 GHz, 28 GHz per licensee are needed. Later, additional spectrum in these ranges will be needed.

While a minimum of 100 MHz of contiguous mid-band spectrum may be enough to cope with the spectrum needs by 2021, additional spectrum is needed in the 2025-2030 timeframe.

There are various consulting studies pointing that ”the total mid-band spectrum needs (between 1500-7125 MHz), when averaged over 35 cities worldwide, is estimated to be 2,020 MHz in the 2025-2030 time frame“ to deliver the 5G vision of user experienced mobile data rates of 100 Mbit/s in the downlink and 50 Mbit/s in the uplink across the city, i.e. citywide “speed coverage”, for a range of human and non-human communications and to deliver smart cities in an economically feasible manner.

This additional spectrum will also bring key benefits outside the cities, in particular to bridge the digital divide between urban and rural areas as it can increase capacity in small towns and villages for home broadband. This becomes of particular importance in low income countries, where affordability is critical and FWA is the fastest way to get citizens “online”. Connectivity needs in major transport paths will also profit from this additional spectrum.

The requirements for additional mid-band spectrum will differ among countries, considering national spectrum usage as well as amount of currently allocated spectrum for 5G, i.e. the less licensed spectrum today will turn into a larger demand for additional mid-band spectrum. Spectrum in the mid-bands include 2.3 GHz, 2.6 GHZ, 3.3-4.2 GHz, 4.4-5 GHz and 5925-7125 MHz.

Contiguous spectrum blocks will remain critical in the future, i.e. minimum contiguous blocks of 100 MHz. Nationwide licensing will remain critical to ensure efficient usage of spectrum, e.g. MBB, transport, cameras can be addressed seamlessly within the city while outside the city the spectrum can be used by industries, FWA or along major roads as required.

[25] https://www.gsma.com/spectrum/5g-spectrum-guide/

In relation to mmWave, the RSPG (Radio Spectrum Policy Group) recommended that EU member states should make a “sufficiently large portion (e.g. 1GHz)” of the band available in response to market demand by 2020 and onwards[26]. There are also different studies done by Ericsson in cooperation with few consulting companies summarizing the status, cost and benefits of 5G mmWave in Europe and the importance of releasing this spectrum for Europe’s economy[27].

Frage 2.22.:

Sind Sie am Erwerb von Frequenzen in diesem Band interessiert? Wenn ja, welche Frequenzmenge (minimal/maximal) planen Sie in den einzelnen Regionen, in denen Frequenzen noch verfügbarsind, zu erwerben? Wenn ja, in welchen Gebieten wollen Sie die Frequenzen nutzen? Bitte begründen Sie den Bedarf.

[Ericsson Response]: This is an unfair for Ericsson to give any response to this question by being a technology leader and provider, but not a service provider. We believe that the most effective approach and go-to-market model for industry for the time being is the cooperation and collaboration between the service providers and vendors, while all involved actors focus on their strengths and part of the value chain. Having said this, we advocate and urge service providers and regulators to speed up the 5G roll-out as the tool to digitalize society and stimulate the economy. Such acceleration clearly requires innovative solutions, approaches and collaborations across the borders.

Frage 2.23.:

Besteht aus Ihrer Sicht die Gefahr der Abschottung von oder der Behinderung beim Zugang zu Frequenznutzungsrechten in diesem Band? Bei welchen nachgelagerten Diensten bzw. auf welchem Markt? Wer hätte dazu die Fähigkeit und den Anreiz und welcher Effekt auf den Wettbewerb würde sich dadurch ergeben? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Ericsson sees the uncertainty regarding the commercial use as the major obstruction to consider using the spectrum in 26 GHz. And it is important to mention that this uncertainty is not unique when it comes to the certain frequency resource, but rather common challenge across different available frequencies. In order to address this concern, we see it important to find the most relevant regulation model as well as to mitigate different technical challenges that are made vocal.

When it comes to the technical conditions of this spectrum’s usage, we propose to avoid reference to the compatability studies in the regulation references, but also consider the need

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[26] https://rspg-spectrum.eu/wp-content/uploads/2019/10/RSPG19-036final-Final_Report_WG_on_5G.pdf
[27] https://www.gsma.com/spectrum/resources/5g-mid-band-spectrum-needs-vision-2030/

to avoid emission restriction while both rather set impractical limits, rather than valuable recommendations.

When it comes to the regulational conditions of this spectrum's usage, we propose to factor the already mentioned HDA and LDA analysis, define the sufficient bandwidth and make it available from the very beginning, and finally also redefine the obligations towards the service providers.

Frage 2.24.:

Stimmen Sie überein, dass das Band –gemeinsam über ein Sharing-Konzept mit der Legacy-Nutzung - für Mobilfunkdienste genutzt werden soll?

[Ericsson Response]: Ericsson agrees with RTR to use this Band for Mobile Services and sees the 2,3-GHz Band as an important Band for 3GPP-Technologies which use the TDD Access mode.

Static geographical sharing of this Band for example, would be ideal for industrial automations and/or critical business applications

Frage 2.25.:

Welche Form der Koexistenz mit Legacy-Nutzung halten Sie für zielführend? (a) Vergabe nur jenes Teils des Bandes, der mehr oder weniger bundesweit vergeben werden kann. (b) Statisches Sharing-Modell mit der Vergabe auch von Frequenzen, die signifikanten geografischen Einschränkungen (Exklusions-Zonen) unterliegen. (c) Dynamische Sharing-Modelle (z.B. LSA). Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Offering long term licensed spectrum on regional or local level can open up for licensing contradicting to the purpose of making scarce spectrum available for the good of society. These side effects include:

- Geographic cherry-picking, offering local coverage only but no coverage in less attractive areas. This constitutes the opposite to the coverage requirements as frequently used in Nation Wide Licensing to secure coverage in areas that are less commercially attractive.
- Spectrum Hoarding or speculations in spectrum holdings, where services are never offered unless the license is eventually bought by, and transferred to, an MNO. "Use it or lose it" regulations may be applied but has proven difficult and time-consuming to enforce.
- Fragmentation of spectrum leading to less efficient use of valuable spectrum, as "1+1 >2" when it comes to bandwidth.
- Excessive first mover advantage, where the first to acquire regional/local spectrum will block future users within the area.

Dynamic Spectrum Allocation means that spectrum is allocated to different networks dynamically on e.g. daily basis based on availability. Do not confuse DSA with Dynamic Spectrum Sharing (DSS) used to mix e.g. 4G and 5G in the same sub-band. 5G offers unprecedented robustness and guaranteed latency and bandwidth in both private and public networks. This however presupposes that spectrum bandwidth and interference is guaranteed over time. Interference between neighbouring installations can easily be limited either by inherent RAN functions, when MNOs operate the networks, or through bi-lateral agreements between the service providers. These agreements are not practically possible if service providers are dynamically moved between different sub-bands, and thereby dynamically get new neighbours.

Ericsson advocates some form of expansion and coverage rate requirements to counter speculation in the spectrum and to keep the spectrum idle. We believe this can benefit the adoption of 5G and the new technologies it enables, which in turn can be a driving force for digitization and innovation.

Frage 2.26.:

Wann soll dieses Band Ihrer Meinung nach vergeben werden? Bitte begründen Sie ihre Antwort.

[Ericsson Response]: Ericsson recommends deploying the 2.3 GHz and 3.4-3.8 GHz allocation as soon as possible.

With substantial progress in 5G in many parts of the world, Austria cannot afford to fall behind. Therefore, Ericsson recommends that a plan for the timely release of spectrum in the frequency bands mentioned above is in place, noting the sequence of mid-, high- and low-frequency ranges, in synchronization with the development of respective ecosystems. Not only Austrian Customers will benefit from 5G, Austria will also be able to keep pace with other countries in the development and deployment of 5G.

Frage 2.27.:

Im Falle eines statischen Sharing-Modells: Wäre eine Einschränkung in der Form, dass in Gebieten, in denen keine 2300 MHz-Basisstationen vorhanden sind, weiterhin eine temporäre Nutzung für Funkkameras zulässig ist – und vom Zuteilungsinhaber zu tolerieren ist– für Sie akzeptabel? Würden durch eine derartige Einschränkung Nachteile für eine Mobilfunknutzung entstehen? Falls es geografische Nutzungseinschränkungen geben sollten, in welchen Gebieten würden Sie die 2300 MHz-Frequenzen jedenfalls gerne nutzen?

[Ericsson Response]: Ericsson is not able to provide fair comments here while this question is rather relevant for the service providers.

However from other countries‘ experience we could share that for some of the frequencies, including the 2300 MHz range, the regulator applies so called low power and medium power licensing mechanism that might be considered by RTR for the further evaluation and implementation.

So called, low power licence will authorise companies to deploy as many base stations as they need within a distance of 50 metres radius, centred on a coordinate provided to the regulator when they apply for the licence. This gives the flexibility to move the base stations around within the licensed area without requiring further coordination by regulator. Moreover, we have seen the differentiation when it comes to the low power license being applied for the indoor and outdoor usage of the base stations. In comparison to the low power license, the so called medium power licence will authorise only a single base station.

Some regulators also outline the out of channel and in-band and / or out-of-band emissions limits for the shared access per antenna. This needs to be defined by RTR taking into account the theoretical and practical technical conditions and restrictions.

Frage 2.28.:

Im Falle dynamischer Sharing-Modelle: Welche Anforderungen hätten Sie an temporäre örtliche Einschränkungen? In welcher Form sollten diese festgelegt bzw. im Anlassfall kommuniziert werden? Wie kurzfristig könnte eine Einschränkung des Nutzungsgebiets durchgeführt werden? Wie könnten realistische Bedingungen für eine Nutzung aussehen? Wäre zur Vermeidung komplexer Sharingbedingungen die reine „Indoor-Nutzung“ einzelner Kanäle oder in geografisch eingeschränkten Bereichen eine Option?

[Ericsson Response]: See the response provided in an answer to question 2.27.

Frage 2.29.:

Welche Frequenzmenge muss ein Betreiber mindestens erwerben, um die Frequenzen in diesem Band effizient nutzen zu können?

[Ericsson Response]: Our general recommendation is to consider a sufficient bandwidth to be available from the very beginning to support and provoke the commercial usage across the different verticals and use cases. However there are good references provided by the physics.

Every generation of mobile communications has been associated with higher data rates compared to its previous generation. The requirements on peak data rate have been defined for 5G as 20 Gbps for downlink and 10 Gbps for uplink. For the downlink, it is seen that the peak data rate is 17.5 Gbps for a 400 MHz-wide component carrier. Aggregating two such component carriers with a total bandwidth of 800 MHz exceeds the ITU-R requirement with a peak data rate of 35 Gbps. For the uplink, the peak data rate on one 400 MHz component carrier is 9.4 Gbps. Aggregating two such component carriers likewise gives a peak data rate well beyond 10 Gbps.

The requirements on peak spectral efficiency are 30 bps/Hz for downlink and 15 bps/Hz for uplink. Efficiencies of up to 44 bps/Hz are achieved on the downlink. Similarly, uplink peak spectral efficiencies of up to 24 bps/Hz are achieved. These metrics are met by using higher modulation schemes, such as 256QAM (both in downlink and uplink), and several data transmission streams or layers (eight layers in downlink and four in the uplink).

When it comes to the requirements on experienced data rates, they are defined to be 100 Mbps for downlink and 50 Mbps for uplink. These are to be obtained in the fifth percentile in the dense urban scenario. The evaluations show that the requirements can be reached assuming a bandwidth of 317 MHz.

The requirements in fifth percentile user spectral efficiency and average spectral efficiency are scenario dependent. Results for all scenarios — fifth percentile and average, downlink and uplink — are above the requirements.

The requirement on area traffic capacity is 10 Mbps/m2 for downlink in the in the indoor hotspot scenario. Results indicate that 10 Mbps/m2 is reached with a spectrum allocation of 219 MHz.

It is seen that several NR configurations can support the requirement on bandwidths of 100 MHz and above, with the largest component carrier having a bandwidth of 400 MHz. NR can support carrier aggregation (CA) of up to 16 component carriers, offering support for signals in excess of 1 GHz.

To support mobility in NR, there is a requirement of supporting 1.5 bps/Hz, which should be supported for combinations of normalized data rates and terminal speeds at the median uplink signal-to-interference-plus-noise ratio (SINR). It is seen that for all scenarios, the median SINR is higher than what is needed to reach the required normalized data rates. Furthermore, there is also a requirement on the mobility interruption time, defined as the shortest time duration, supported by the system during which a user terminal cannot exchange user plane packets with any base station during transitions. The requirement on mobility interruption time is 0 ms and, for NR, the requirement is fulfilled with intra-cell beam mobility or with carrier aggregation.

Hence, from Ericsson perspective we see an optimum bandwidths of at least 400MHz per service provider.

There is a number of different approaches taken worldwide and in Europe with regards to, for an instance, 26 GHz spectrum, but we see it common to consider at least a range of 1 to 1.2 GHz being available to service providers by the regulators.

Frage 2.30.:

Welche Frequenzmenge sollte ein Betreiber in diesem Band maximal erwerben dürfen bzw. ab welcher Frequenzmenge ist eine effiziente Frequenznutzung nicht mehr gegeben?

[Ericsson Response]: See the response provided in an answer to question 2.29.

Frage 2.31.:

Sind Sie am Erwerb von Frequenzen in diesem Band interessiert? Wenn ja, welche Frequenzmenge (minimal/maximal) planen Sie zu erwerben? Wenn ja, in welchen Gebieten wollen Sie die Frequenzen nutzen? Bitte begründen Sie den Bedarf.

[Ericsson Response]: This is an unfair for Ericsson to give any response to this question by being a technology leader and provider, but not a service provider. We believe that the most effective approach and go-to-market model for industry for the time being is the cooperation and collaboration between the service providers and vendors, while all involved actors focus on their strengths and part of the value chain. Having said this, we advocate and urge service providers and regulators to speed up the 5G roll-out as the tool to digitalize society and stimulate the economy. Such acceleration clearly requires innovative solutions, approaches and collaborations across the borders.

Frage 2.32.:

Soll das 42 GHz Band für eine Nutzung für ECS (Mobilfunk und Breitband) unter harmonisierten Nutzungsbedingungen angestrebt werden? Bitte begründen Sie die Antwort.

[Ericsson Response]: Ericsson sees a high potential in the usage of milimeter wave bands, including 42 GHz. This band is considered ideal for providing 5G services due to the fact that they offer wide spectrum bands that can enable hight speed traffic with low latency, exactly what is required by future applications.

There are few important worldwide milestones to consider – first is FCC in US proposed making 42 GHz band available for flexible wireless use[28] (back in 2018), second is that government in China allowed to use 42 GHz for trial purposed (back in 2017). Some other countries consider studies related to the use of 42 GHz to be completed during 2021 (i.e., Japan, India). Given that this spectrum has been widely approached during WRC-19, it is expected further spectrum resource allocation and CEPT to provide further harmonized technical conditions during 2021 already[29].

An interesting reference to Germany – part of the spectrum within 40.5 and 43.5 GHz is being used by the satellite services, while upper sub-band has been allocated to the mobile services. Once WRC work is finished, the expectation is that the band of 40.5 – 42.5 can be additionally allocated to the mobile services.

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[28] https://www.fcc.gov/5G
[29] https://www.qualcomm.com/media/documents/files/spectrum-for-4g-and-5g.pdf

Frage 2.33.:

Soll das 6 GHz–Band (zumindest über 6425 MHz abhängig von internationalen Entwicklungen) für eine Nutzung für ECS (Mobilfunk und Breitband) unter harmonisierten Nutzungsbedingungen angestrebt werden? Zu welchem Zeitpunkt sollte dieses Band vergeben werden? Bitte begründen Sie die Antwort.

[Ericsson Response]: The use of 6GHz spectrum is currently under study in different parts of the world[30]. This spectrum is currently used by fixed links and other services. In the USA, the Federal Communications Commission published a Report and Order in April 2020 opening the 5925 – 7125 MHz band for unlicensed use. Doing so adds 1,200MHz of additional bandwidth for unlicensed technologies including Wi-Fi 6 and 5G NR-U. In Europe, technical analysis is ongoing for 5925 – 6425 MHz, regarding potential indoor use considering protection of incumbents and potential application of geo-location databases.

Several researches[31] supported by both Ericsson and GSMA indicate that an additional up to 2 GHz of mid-band spectrum is required to meet the IMT-2020 indications for uplink and downlink – 100 Mbps and 50 Mbps – in a high-capacity coverage on a metropolitan level. Delivering on this goal will be challenging without licensed 6 GHz spectrum for 5G. Therefore, the proposals from GSMA were to make at least 6425-7125 MHz available for licenses 5G and depending on the countries incumbency consider opening the lower half of 6GHz range on a license-exempt basis following the technological neutrality.

Lastly, countries that are opening up bigger slices of the “mid-band” spectrum to 5G will enable both speed and range needed for networks based on this fast-emerging, next generation technology.

Frage 2.34.:

Welche Auswirkung hätte die Vergabe eines Frequenzbandes über 6425 MHz für die Bedeutung und Nutzung des 26 GHz-Bandes?

[Ericsson Response]: Ericsson sees no direct connection in opening the 6 GHz band for the licensing and the use of the 26 GHz band. Both serve the ambition to improve, extend and make the roll-out of 5G mobile networks for the best of the economy and society.

Frage 2.35.:

Welche Bedeutung hat das 60 GHz-Band mit den aktuellen Bedingungen, und nicht-exklusiver Verfügbarkeit (derzeit europaweit generell bewilligt) für eine Breitband-Nutzung, wie sehen Sie den zeitlichen Bedarf? Bitte begründen Sie die Antwort.

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30 https://www.gsma.com/newsroom/press-release/gsma-calls-on-governments-to-license-6-ghz-to-power-5g/
31 https://techmonitor.ai/policy/6-ghz-for-all

[Ericsson Response]: Ericsson in general sees that a very wide range of bands from 13 – 86 GHz has been broadly discussed by the industries for 5G above 6 GHz access and proponents of backhaul have expressed interest up to 110 GHz.

From a perspective of the physical aspects of the technoligies needed to make 5G millimetre wave antennas and devices, we believe that ecosystem will be rapidly growing in the next years, more details are given in the sections related to the milimeterwave bands. We also believe that for short distances the physical limitations such as the absorption effects are not a limiting factor up to at least 100 GHz.

Propagation of the 60 GHz band is the line-of-sight. This band contains an oxygen absorption peak leading to the license exempt. Due to the physical specifics, there is a need for strong beamforming, the interference environment is less a concern here. What is however underestimated by this moment of time is the steering algorythms for the antennas as they require an extra verification for the usage with 5G.

At the same time, so called WiGig systems has been developed for this range leveraging on the low cost silicon technologies. The band of 60 GHz would have been the most suitable application for the high-speed indoor use cases.

Frage 2.36.:

Sollen weitere Bänder für eine Nutzung für ECS (Mobilfunk und Breitband) unter harmonisierten Nutzungsbedingungen angestrebt werden? Welche? Zu welchem Zeitpunkt? Bitte begründen Sie die Antwort.

[Ericsson Response]: The New Radio (NR) according to 3GPP specifications, includes both traditional but also the new bands that are specially designed for this technology. The channel bandwidth supported ranges from 5 to 100 MHz for the low and mid-bands, while can vary from 100 MHz and up to 1 GHz in the mm-wave bands. As it has been said in responses to several other questions, the best capabilities of 5G are realized once the wider channels are used. We also see different countries as well as ITU moving into the direction of the highest possible channel bandwidth allocated per service provider. Besides the spectrum allocation of the largest possible contiguous blocks, it is also possible to consider the usage of the carrier aggregation across both TDD and FDD bands in order to find a right balance between the capacity and coverage.

It is very important that 5G roll-out is further accelerated and the scale effect is applied. Multiple researches have been indicating the ambition therefore to grow with new bands targetting the rural areas, hence additional low and mid-bands. We see a growing interest to the usage of part of UHF frequencies, while also in US T-Mobile is actively using 600 MHz (this case is widely discussed in the Ericsson Mobility Report dated from June 2021[32]). We see a huge potential with the usage of 5925-7125 MHz for licensed 5G, even though a careful assessment of coexistence with incumbers would be required. Those bands – UHF, below 1

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[32] https://www.ericsson.com/en/mobility-report/articles/t-mobile-5g-spectrum

GHz, sub 6 GHz range, 66-71 GHz – are part of the wide WC-23 discussions. Therefore, it is important that also from harmonization perspective local decisions are informed by the studies and considerations coming from WC-23.

Even though, this is out of the scope of this question, but besides, there is a number of studies and researches (some of them are running by the regulators such as OfCom) regarding the use of V-Band and higher frequencies. Those studies are rather theoretical now, but could be considered for the longer future too.

Frage 2.37.:

Wann sollen diese Bänder vergeben werden? Stimmen Sie zu, dass diese Bänder nicht Teil des aktuellen Spectrum-Release-Plans 2021 - 2026 sein sollten? Bitte begründen Sie die Antwort.

[Ericsson Response]: Ericsson can't give any firm recommendation as the Spectrum-Release-Plans are individual for all the countries and governments taking into account multiple factors valid both locally and at a global level. What can be somehow attempted to be predicted is that after the consultations concluded at WC-23 the harmonization and usage of new spectrum is cleared. Referring to an experience of both WC-15 and WC-19, there were and there are many early adopters and hence same is well predicted for WC-23[33]. Therefore having those bands as part of 2021-2026 Release Plan is recommended.

At the same time, we would like to highlight few important things here:

- The commercial conditions raised during the auction processes should not jeopardize and negatively impact the roll-out of 5G, otherwise neither coverage nor speed expectations are really fullfiled.
- The spectrum allocations and auctions should be seen from the overall harmonization perspective, otherwise there are risks of having the spectrum wasted.
- The governments and regulatory authorities should consider the overall spectrum policy being encouraged for service providers to make a long-term investments.
- The authorities are important to be engaged in the international harmonization processes while this speeds up the scale effect of the 5G roll-out.

[33] https://www.gsma.com/spectrum/wp-content/uploads/2021/04/WRC-23-IMT-Agenda-Items.pdf

3 Chapter 3

Frage 3.1.:

Bitte geben Sie für jedes Band des Spectrum Release Plans eine Einschätzung des Nutzungsgebiets für unterschiedliche in Frage kommende Anwendungen (Mobilfunk, FWA, private Netzwerke, etc.) ab.

[Ericsson Response]: By deploying a 5G network across all three types of spectrum bands, service providers can unlock a wider range of use case possibilities[34].

Low-band 5G spectrum has a historic background by being used for legacy voice and MBB services, hence comes from a mix of re-farmed spectrum from early mobile generations (1G, 2G) and previously unused bands. This type of spectrum is suitable for building out a foundation for 5G coverage. Besides, these bands are suitable for the so called wide-area outside coverage as well for the indoor coverage required for enhanced MBB services and outdoor to indoor comminication of the machines.

Mid-band spectrum covers the 1–6GHz bands and includes existing 3G/4G bands, as well as new spectrum licensed for mobile services. The increase in capacity comes from the use of wider bands, and higher 5G coverage and capacity per band are enabled by new radio technologies. Channel bandwidth of 50 MHz to 100 MHz allows to enable capacity-driven and latency-driven use cases for enhanced MBB and critical machine type communication. Can be seen as the complementation to low-band in order to improve the capacity and efficiency.

High-band spectrum is completely new for 5G and enables the launch of services with high performance in dedicated zones. The coverage for 5G services in this spectrum band is less than the coverage provided by low- and mid-band spectrum, but serves larger zones than Wi-Fi hotspots. These include popular, crowded areas and hotspots with large numbers of smartphone users, for example stadiums or other large indoor events.

Low latency characteristics of high bands will improve surveillance and video streaming, everywhere AR/VR for enhanced onling gaming experiences, and the evolution of the 5G smart factory. Within the wider framework of Industry 4.0, the 5G smart factory will help accelerate 5G deployment, create a substantial number of jobs, and usher in a promising new era of technological advancement.

Enhanced fixed wireless access is another growing source of revenue potential. Deploying dedicated sites for mobile broadband with the new available spectrum is quickly becoming an achievable business case, exploiting the high capacity and low latency characteristics of 5G mmWave and fixed wireless access. As fixed wireless access can be highly demanding of capacity resources, high bands are an attractive choice for supplying the required capacity with 400MHz-800MHz of spectrum.

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[34] https://www.gsma.com/spectrum/5g-spectrum-guide/

Industrial and enterprise connectivity are expected to generate significant long-term revenue streams for service providers. The limited radio propagation of the high bands allows decent radio coverage to be contained within specific locations. In some countries, high-band spectrum allocations are being chosen for the next wave of Industry 4.0 applications, where wireless connectivity offers the necessary flexibility for installations and applications, and where low latency can be sustained.

Frage 3.2.:

Welche Versorgungsgebiete planen Sie für ihr jeweils eigenes Geschäftsmodell in den unterschiedlichen Bändern? Bitte beschreiben Sie auch das Geschäftsmodell.

[Ericsson Response]: This is an unfair for Ericsson to give any response to ths question. We believe that the most effective approach and go-to-market model for industry for the time being is the cooperation and collaboration between the service providers and vendors, while all involved actors focus on their strengths and part of the value chain. Having said this, we advocate and urge service providers and regulators to speed up the 5G roll-out as the tool to digitalize society and stimulate the economy. Such acceleration clearly requires innovative solutions, approaches and collaborations across the borders.

Frage 3.3.:

Wie sehen Sie generell das Potenzial der gemeinsamen Nutzung von Frequenzen für die Bänder des Spectrum Release Plans? Welche Voraussetzungen müssen gegeben sein, um diese Modelle zu nutzen? Welche generellen Barrieren sehen Sie?

[Ericsson Response]: Spectrum is the resource that mobile technologies depend on, and availability of spectrum for mobile services is affected by differences in public policy in various countries. As may be expected, spectrum is generally scarce due to two reasons: 1) the higher use of spectrum for various services in developed nations, and 2) the relative degree of governmental control on spectrum allocations in emerging markets.

Roughly 600-700 MHz of spectrum has been allocated in the most developed nations for mobile services years back, and since then the spectrum requirements needed to meet traffic growth predictions were ranged between 1340 MHz and 1960 GHz. Needless to say, the required amount of spectrum is scarcely available for exclusive allocation to mobile services in the region below 6 GHz, where most systems operate, and is even more difficult to identify in bands below 3 GHz that are more suited for coverage.

3GPP defines in the standards the practices for an easy and smooth migration from LTE bands to NR usage by allowing LTE and NR to share the same carriers[35]. Given that ecosystem of the NR devices is growing over the time across the different spectrum bands, Ericsson finds

[35] https://www.3gpp.org/dss

important to follow the industry best and standard practices. Some good experiences regarding the sharing models is covered in responses to questions 3.4 and 3.5.

Summarizing our recommendations here, we definitely see a considerable interest in the shared use of spectrum, however the spectrum sharing itself can't be done in the isolation, an important step for the authorities here would be first to clear the bands relocating the services in favor of having the target 5G bands cleared. Spectrum sharing can be second step to be done here, when clearing a band is not possible for different reasons. This summary goes in line with GSMA recommendation suggesting to have a harmonized spectrum and prime bands being cleared[36]. There are few industry practices done in this direction like for an instance the clearing of C-band spectrum by FCC[37].

Frage 3.4.:

Für welche Bänder und unter welchen Bedingungen könnten die oben genannten Sharing-Konzepte (Club-use-Modell, Use-it-or-share-it-Modell, LSA, etc.) eingesetzt werden? Welche der angesprochenen Sharing-Modelle sollen Ihrer Meinung nach für welches Band genutzt werden? Wie müssen die technischen und ökonomischen Rahmenbedingungen gestaltet werden? Bitte begründen Sie ihre Antwort. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: The classic models of spectrum allocation for mobile services favoured by regulators have typically been[38]: 1) dedicated or exclusive allocations via auction of spectrum, or 2) unlicensed horizontal allocation for short range and Local Area Network (LAN) uses. Referring to the EU experience and regulation, sharing the bands in EU can be done in two ways: the so called CUS (or Collective Use of Spectrum) model or the so called LSA (or Licensed Shared Access) approach.

As it is seen now, the industry is sticking more to the usage of LSA, specifically in the 2.3-2.4 GHz band. LSA is defined as binary sharing that gives the shared spectrum access rights that are guaranteed by the regulator which is making it possible to have the predictabe quality of service via fullfilment of specific sharing conditions in a band. In comparison to CUS, where legislation regime is low, this makes the interference management as the responsibility of the authority by setting the access conditions.

Regulators worldwide are very keen on innovation in cognitive radio techniques that can improve spectrum utilization by various techniques such as spectrum sensing, the use of geolocation databases, time based sharing between orthogonal use cases etc. In general, it must be noted that spectrum utilization does not necessarily improve spectral efficiency. Utility is a macro-economic concept, whereas spectrum efficiency is an engineering measurement of the effectiveness with which a resource owner is able to communicate data.

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[36] https://www.gsma.com/spectrum/resources/5g-spectrum-positions/
[37] https://docs.fcc.gov/public/attachments/DOC-364655A1.pdf
[38] https://www.gsma.com/spectrum/wp-content/uploads/2021/06/Spectrum-Sharing-Positions.pdf

Improved spectrum utilization benefits the national product in indirect ways, and can improve the number of uses for the spectrum supply. Exclusive partitioning of spectrum will typically result in lower utilization, but greater direct productive output, assuming healthy competition between spectrum owners. An extreme focus on spectrum utilization leads to solutions like Wi-Fi or White Space use, where secondary users are free to use spectrum when the primary user is not likely to be interfered.

As spectrum availability decreases further, service providers with differing load characteristics may want to either mutually rent or pool their spectrum resources for simultaneous use of their networks.

	Peer-to-peer coordination protocol	Horizontal spectrum manager	Dynamic Channel Selection	Geo-location database	Wi-Fi sharing mode
Primary licensed shared	Yes, preferred	Yes, alternative when centralized solution preferred	Yes, enabler for peer-to-peer coordination	If required by regulation	
LSA	Maybe, for evolved LSA (LSA spectrum pool)	Maybe, for evolved LSA (LSA spectrum pool), when centralized solution preferred	Maybe, depending on LSA implementation details	Yes	
Unlicensed	Yes, for optimized sharing between networks of same type		If required by regulation	If required by regulation	Yes

Table 1. Spectrum Sharing Models.

Several scenarios of spectrum sharing are possible. For example, in the case of the 2.4 GHz band, unlicensed use of the spectrum has created a variety of coexistence scenarios where Wi-Fi, Zigbee, Bluetooth, DECT and other systems freely use the band. However, it is well known that in congested environments, networks can undergo severe outages due to the inability of uncoordinated networks to coexist. This situation occurs in vertical sharing between unrelated technologies and horizontal sharing between systems operating with the same air interfaces.

Since we see a growing interest in evolved LSA, it is reasonable to assume that a nominal architecture has a database in the regulatory domain. We further assume that each service provider has its own LSA Controller for local spectrum management. Beyond this, based on the type of control exercised on the use of spectrum, the architectural options may be listed as follows: database directed control (repository or hierarchical), LSA controller based (with nominal or distributed architecture), hybrid conctrol (with direct database for unmanaged networks and LSA controller for managed networks). The details of how LSA sharing could be established are provided in the response to the next question.

To summarise the benefits of LSA – it is frequency agnostic, it can address digital divide via spectrum sharing with guaranteed quality between the mobile providers and incumbents, it can help therefore to speed us the usage of certain bands for the mobile broadband reasons and, finally, it can speed up the allocations of 5G.

Frage 3.5.:

Wie soll Ihrer Meinung nach Sharing institutionell etabliert werden (Definition und Durchsetzung der Sharing-Regeln, Koordination, Implementierung Datenbanken): Sollen Betreiber auf privatrechtlicher Basis, die zuständige Behörde oder ein unabhängiger Dritter (Spectrum Manager) diese Aufgabe übernehmen? Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: As said above, there are several architectures related to LSA based sharing and usage of any of them carries certain regulation, rules, coordination and implementation aspects[39].

In hierarchal architecture, repository is responsible for channel assignments to service providers and reassignment of resources. LSA controller directs self-organizing network procedures. From sensing perspective, service provider to repository via geographical polygons or outage indications. From access nodes to LSA controller, the median C/I, 10%-ile or 90%-ile C/I in the coverage area. From coordination perspective, orthogonalization (frequency and space, contention based for time), coding and rate control (frequency hopping or direct sequence spreading), load control.

Repository controlled architecture is fully centralized in which repository controls all spectrum assignments. Access nodes (ANs) in each network communicate via ISP gateway (GW) their location, air interface and location. ANs perform sensing and report measured interference in terms of average C/I and RSSI to the repository. In addition, ANs, can send re-assignment request to obtain new frequency in case, for example, the measured averaged interference is high. Based on the information obtained from AN, the repository can perform channel assignments, decide on transmit power levels and channel reassignments. At the expense of the high information exchange overhead, the repository can perform fully centralized spectrum allocation. The preference is for spatially orthogonal assignments as

[39] https://ieeexplore.ieee.org/document/6817803

long as bandwidth is sufficient. Once congestion occurs and not enough bandwidth is available, overlapping channels can be assigned resulting in interference. Dynamic adjustments can be performed based on cooperative sensing.

The nominal architecture involves communication between LSA controllers for system-specific communication between service provider networks. This is a partially decentralized architecture in which trepository controls spectrum assignments and protects service provider assets. The difference from the hierarchical architecture is that there exists a direct communication between LSA controllers.

The distributed architecture has no regulatory domain. In this architecture, LSA controllers have integrated database and there is no real-time regulatory involvement. Instead, repository functions are distributed to LSA controllers. In this case, there is no incumbent and the spectrum pooling approach is purely horizontal. Control architecture is similar to nominal.

The hybrid architecture has the features of the repository controlled and nominal architectures. In the hybrid architecture, there is a mixture of open access systems and managed systems. In this case, managed systems have optional inter-LSA control I/F. Both hierarchical and nominal architectures are possible. Open access systems individually controlled by repository using general authorized access.

Table below provides the summary of the different architecture models and the relevant regulatory and coordination aspects.

	Repository	Hierarchical	Nominal
Architecture	Centralized	No inter-service provider interface	LSA controllers communicate
Simplicity	Simple	Moderate	Complex
Sensing latency	High latency for common backhaul, low for dedicated	Low latency for dedicated Controller to repository link	Lowest possible latency for between service providers
Three tier SAS compatibility	Automatic	Possible; repository duplicates LSA Controller functionality	Possible; repository duplicates LSA Controller functionality
Horizontal sharing	Incompatible and irrational	Compatible	Compatible and ideal
Multi-RAT compatibility	Yes	Yes	Complex
AI types	Contention, dedicated	Contention, dedicated, scheduled	Scheduled

Table 2. SLA Architectural Models.

To enable LSA between service providers, for any of the architectures discussed above, coordination of the spectrum that is shared among service providers needs to be performed.

There are various, well known methods for spectrum sharing that can be used here. We divide them in two groups as follows[40]:

1. User scheduling:

User scheduling can be performed by repository, LSA controller or ANs, depending on the underlying architecture. For example, in the repository controlled architecture, user scheduling is performed by repository. Different scheduling approaches can be applied. User scheduling can be viewed as a (more general) network utility optimization problem for which efficient techniques to find solutions exist. It is also related to the downlink MIMO scheduling problem. When enough resources are available, frequency orthogonalization among interfering users is preferable (for example, inter-cell interference coordination (ICIC)). Other scheduling approaches include: time scheduling, rate control, etc.

2. Signal processing techniques:

Different signal processing techniques for reducing interference can be applied by ANs and/or users. Such techniques include: interference cancellation, beamforming, zero forcing, coding, interference alignment. We note that different schemes require different amount of channel state information (CSI), The right choice of the scheme will depend on the CSI and the processing capabilities that are available. For example, interference cancellation requires the knowledge of 1) channel coding and modulation of the interferer 2) channel state information from the interferer. Note that the interfer in this case is in the network of another service provider.

The information flow between repository, LSA controllers, ANs and users should be supported in the network to enable spectrum coordination, for the nominal and hierarchical architectures, however the detailed flow description is out of this response scope.

Frage 3.6.:

Kennen Sie andere Sharing-Modelle, die für die genannten Bänder genutzt werden könnten? Bitte beschreiben Sie diese. Bitte geben Sie an, für welche Bänder und für welchen Zweck sie genutzt werden können. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: We rather see an evolution of the band sharing models in relation to the FDD and TDD spectrum sharing, where the focus and usage of FDD band sharing is proven technically, commercially and in real practice[41].

Technically spectrum sharing in TDD is possible, Ericsson is investigating based on discussions and input from service providers related to the needs, requirements and timing. However in practical no effective TDD spectrum sharing available now and near future.

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[40] https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-SM.2404-2017-PDF-E.pdf
[41] https://www.itu.int/en/ITU-T/Workshops-and-Seminars/standardization/20200203/Documents/Peter_%20Ogundele_Presentation.pdf

Technical potential needs further evaluation with regards to standardization, implementation and device support. Spectrum sharing in TDD specific bands is still under study phase and exact development plans to be communicated later.

It is fair however to say that the main benefit of TDD should give the flexibility of TDD spectrum usage for LTE and NR based on traffic demand. However, since FDD bands and TDD bands have different tasks and advantages, demand on flexibility of spectrum usage might be different.

Benefits of TDD DSS can be seen in certain scenarios during NR sunrise (Introduce NR on existing TDD LTE bands) and LTE sunset (phasing out LTE). More obvious gain should be seen towards LTE sunset rather than NR sunrise. Different from FDD DSS which is extremely important from very beginning to enable the coverage advantage of FDD bands.

Current TDD spectrum sharing will initially be on carrier level. One part of spectrum dedicated to NR (20Mhz), another part of spectrum dedicated to LTE (20 MHz or eventually 10 Mhz) and then the shared spectrum will be given to the single RAT at the time. At least 20MHz should be located as shared spectrum. The switch between LTE and NR are within several seconds and minute level.

It is possible for NR new band which (will be) well specified in 3GPP with eco-system support, New baseband and new radio which are powerful enough may be needed considering the complexity of TDD DSS. For most of existing TDD bands, due to late requirements and lack of common driven force in the echo system, the effort is unaffordable although technically possible.

Carrier level sharing is unique for TDD. The principals for TDD spectrum sharing are based on LTE cells to be muted and unmuted allowing resources to be dynamically allocated between LTE and NR. LTE cell: On (unmuted) without any NR <-> Off (muted) with increased bandwidth for NR. NR cell: NR partitioning of resources is changed by LTE cells mute and unmute and by that changing the bandwidth available for NR.

For PRB level sharing, it is more complicated than FDD, considering the bigger bandwidth and different numerology between LTE and NR. Rel 16 standardized physical layer components will be needed, which means not only Rel16 UE support is required, but also the challenges on how to handle the legacy Rel15 UEs in the PRB/TTI Sharing capable network.

Supporting pictures regarding potential usage of spectrum sharing on TDD bands and implementation of spectrum sharing in TDD bands are below.

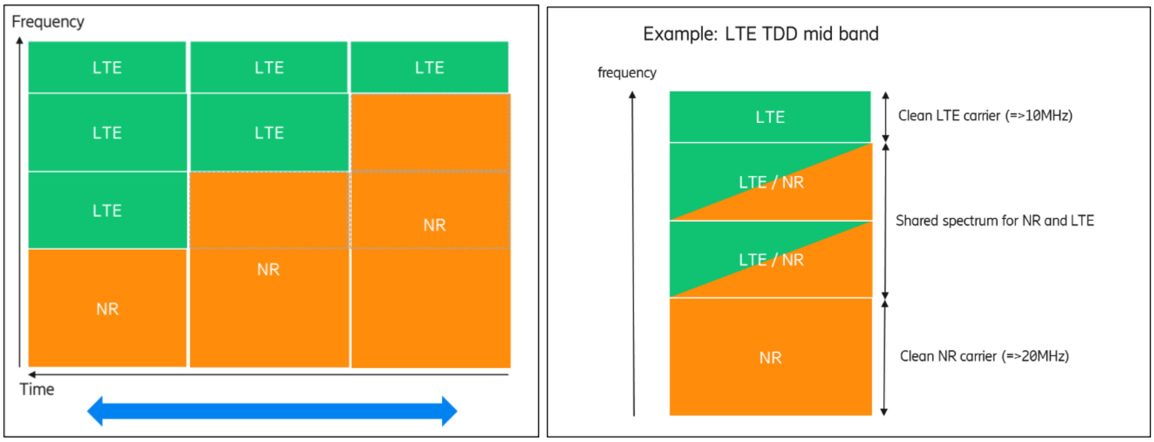

Figure 19. Ilustration of spectrum sharing on TDD bands.

Frage 3.7.:

Bewerten Sie bitte die unterschiedlichen Bewilligungsmodelle in Bezug auf die Frequenzen des Spectrum Release Plans und die Anwendungen, die ihrer Meinung nach für die betroffenen Frequenzen relevant sind. Welche Vorteile und Nachteile sehen Sie? Bitte begründen Sie die Antwort und verweisen Sie auf die jeweiligen Anwendungen. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: Spectrum management or spectrum release plan is about efficient use of scarce resources and allocation of new spectrum to highest societal benefit. It is also about global or regional coordination and harmonization of spectrum usage to decrease cost of technology by increasing economies of scale hereby maximizing the affordability for all users.

Some few bullets below outline Ericsson's spectrum position[42] and could be seen as non-binding suggestions to the government, regulator and the mobile service providers.

There is a need for spectrum harmonization between countries planning early 5G deployment. Having said this, clearing prime bands should have been a priority including award of up to 100 MHz of spectrum in mid-bands and up to 800 MHz of spectrum in mm-wave bands. The further steps should support the scale of the 5G and hence involvement of more spectrum in 3.5 GHz, 6 GHz and 40 GHz.

In order to ensure a wide coverage together with a mass variety of the different use cases, it is recommended to consider 5G spectrum allocation across low, mid and high bands. Low-bands in this case focus on the widespread coverage including various indoor and outdoor locations (such as rural and / or sub-urban areas). Once the government has a target to consider a wide focus on the broadband connectivity, this should be seen as a primary target.

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[42] https://www.ericsson.com/en/public-policy-and-government-affairs/optimizing-spectrum

Mid-band spectrum offers already a fair mix of the the coverage and capacity benefits enabled by 5G technology. We see a focus here on 3.4 GHz, however a refarming in the bands of 1500 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz is seen as an opportunity to meet the growing demand in 5G which further on can be supported with the usage of spectrum up to 4.2 GHz, 4.8 GHz and 6 GHz. What is important to indicate here is a globalized approach of the governments and regulator bodies towards the hardmoniszation of mid- and low-bands in order to secure the long-term growth of the 5G services. High-band is recommended for the deployments focusing on advanced use cases primarity in the city areas where the ultra-high broandband speed can be of a great value.

Ericsson recommendation is to treat 5G radio access network as the fully coordinatred multi-layer entity addressing the wide variety of the use cases, but also the healthy mix of the different bands. The picture below outlines the approach.

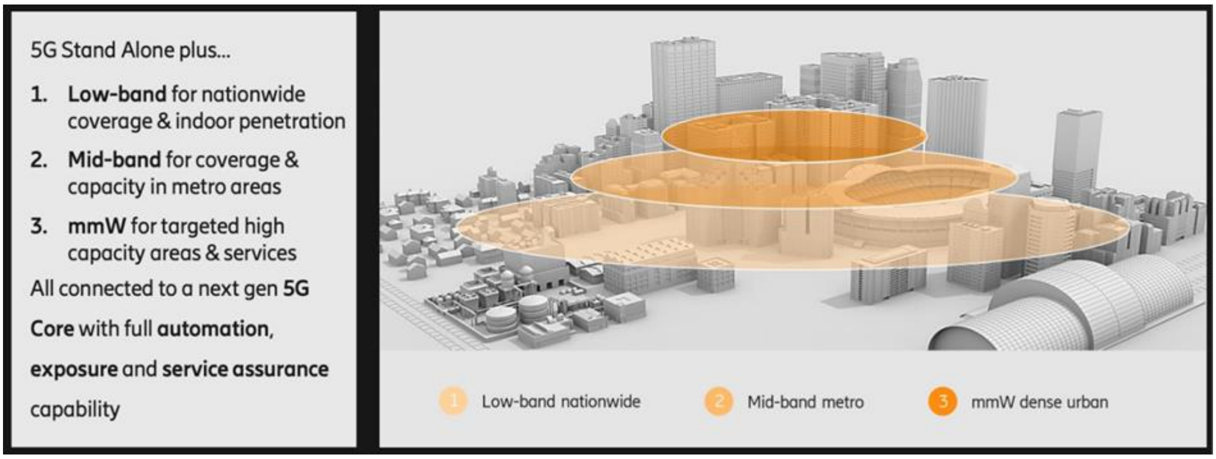

Figure 20. Combination of different bands being used for 5G SA.

Spectrum sharing can be seen as the complementary approach towards speeding up the 5G roll-out. However, it is important to assess the benefits of FDD spectrum sharing against TDD spectrum sharing where certain complexity and immaturity of the ecosystem on the TDD side prevail the benefits of the spectrum sharing.

The next few paragraphs are related to the potential spectrum allocation to industry verticals that in some countries have been seen as part of the spectrum release plan, but needs to be assessed very carefully as it can jeopardize the public 5G services and might waste the spectrum.

Harmonizing the use of spectrum bands across geographies is essential to achieving mass-market conditions which in turn enables cost-efficient and competitive industrial devices. Many countries have already begun to assign spectrum for 5G wide-area cellular networks, and quick regulatory actions and decisions have proven to be highly positive for all ecosystem parties, benefiting service providers and device makers with the ability to make technology investments as well as consumers with the possibility for earlier enjoyment of new generations of technology. Some countries have also begun to consider licensed spectrum as part of industrial digitalization and industrial applications. Germany, for example, allocated local licensed spectrum in 3700–3800 MHz band range to industries for their applications already in 2019, while Japan similarly announced the allocation of the 28 GHz band. Other countries, like France and Italy, are looking primarily at allocating spectrum to CSPs, who then need to ensure the availability of spectrum for industries. The approaches taken differ widely between regulators, and the allocated bands are in many cases shared with incumbents. Regarding the locally licensed spectrum considered by administrations, these diverse allocations pose challenges to building a device ecosystem for industrial applications. Device chipsets need to be supported not only by an ecosystem of traditional mobile broadband (MBB) devices but also by an ecosystem that includes industrial devices of varying complexity on different spectrum bands. These ecosystems, however, are still under formation.

Regulators and policy makers have a different set of challenges. In countries that have decided (or are planning to decide) on locally licensed industry spectrum, regulators and policymakers must find an easyto- understand and cost-efficient model for its regulation. If implementing locally licensed spectrum for industry purposes, they must ensure that its utilization is efficient. Additionally, it is important to note that the way in which licensed spectrum is managed within countries also impacts the appeal of the 3GPP path. When licensed spectrum is offered locally with the objective of satisfying the needs of industries, a few basic requirements should be fulfilled as to how this is offered.

These requirements include that:

- Access to spectrum must be predictable over a long period of time to support uninterrupted operation and major investments in production processes and industrial facilities having a lifecycle of typically 15–20 years.
- Schemes awarding excessive first-mover advantages should be avoided so that industries or other players do not block spectrum through spectrum hoarding.
- Local spectrum not yet licensed to industries should be kept available to increase spectrum utilization efficiency for spectrum license holders (such as CSPs), though with a sufficient safety margin to ensure that existing local networks are not subject to interference.

It should be noted that radio network providers and device makers can potentially face challenges with developing solutions for unique frequency bands unless the availability of devices and an ecosystem are factored into the decision of dedicating frequencies for locally licensed spectrum.

Allocating licensed spectrum for wide-area services to a limited number of CSPs has proven successful and cost-efficient through the well-functioning market and competitive services it has generated for consumers, with 3GPP network coverage serving roughly 95 percent of the world’s population. Widearea spectrum for industries would lead to the underutilization and fragmentation of spectrum and thus the loss of its efficiency. As for locally licensed spectrum, the situation is different, as deployments are typically made on private property and frequently indoors, where the availability of competing indoor offerings is not naturally secured.

If countries decide to dedicate locally licensed spectrum, an idea defined as the “real estate principle” should be the preferred principle to apply when doing so. In short, this refers to linking a priority right to acquire a local license to the real estate ownership (or tenant, depending on national prerequisites). This simple principle meets the three requirements mentioned earlier of having predictable spectrum access, avoiding rewarding first movers, and ensuring availability of unused local spectrum. The real estate principle offers predictable access to spectrum over time as well as a sustained possibility for late entrants to acquire local spectrum and still leaves unused spectrum available for short- or medium-term use by third parties.

Some additional examples of the benefits associated with the real estate ownership principle include that the legal principles surrounding real estate are established, well defined and understood, and digitized in most if not all countries. The logical connection needed in order to be able to dispose of spectrum on owned property is also easily understood and fits the need for local high-performance systems. Leasing of locally licensed spectrum should be allowed to ensure access to spectrum in all scenarios.

In a real estate ownership model, it should be possible for a CSP to offer services to the industry on the estate using the reserved spectrum. Most industries will want the operation to be handled by a third party, and, since some of the appealing services offered by CSPs (such as, for example, roaming, wide-area mobility, voice/IMS, and so on) are services optimized in their service offerings, it is particularly natural for the real estate owner to allow a CSP to operate the given service in places where there will typically be three or so networks serving the public and one logical IoT network operating (such as in an airport or hospital). A CSP can here easily handle the local IoT network as a combined network, and the CSP should then also be allowed to use the dedicated local spectrum for public services (following the real estate owner’s consent as well as the condition that all traditional requirements for public service be fulfilled).

Another major advantage is that the administration of real estate-based licenses can be very simple following this principle, as the real estate owner must simply accept the responsibility to fulfill conditions for use and (presumably) pay an initial plus an annual fee for the local license part of the spectrum, avoiding a complicated and time-consuming auctioning procedure in the process. The industries can then start planning and deploying equipment as soon as the sub-band is identified, and the regulatory decision made. For this model to succeed, spectrum management systems will be needed to automatically manage large amounts of local licenses as well as regulatory conditions. One such system with these and other capabilities is the evolved licensed shared access (eLSA) approach (based on the already standardized LSA system) being standardized in ETSI RRS[43].

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[43] https://www.etsi.org/deliver/etsi_ts/103600_103699/10365202/01.01.01_60/ts_10365202v010101p.pdf

Spectrum not yet claimed by the real estate owner can also be offered to CSPs and third parties for a limited time (for example, for sports events or concerts where temporarily increased coverage or capacity is needed), but only as long as sufficient safety margins are kept to fully guarantee existing local licenses are not interfered with.

To conclude on this subject, CSPs are well-positioned partners for industries, with several unique strengths to win industry business independently of the spectrum principles employed. In order to be successful, it is essential that offerings are tailored to the needs of the relevant industries, including long-term offerings, high quality, and operational independence.

For those countries who choose the path of locally licensed spectrum for industry purposes, we offer a suggestion as to how this should be done in a simple and structured way. Ericsson refers to this as the "real estate owner principle," in which the estate owner should have a prioritized right to spectrum for industrial purposes on the owner's grounds while also having the right to leverage the offering of public services provided by CSPs on the locally licensed spectrum.

Frage 3.8.:

Welches der beschriebenen Bewilligungsmodelle kommt aus Ihrer Sicht für die einzelnen Bänder bzw. Sub-Bänder (Teilbereiche der Frequenzbänder) in Frage? Wie beurteilen Sie die Position der Regulierungsbehörde? Bitte begründen Sie die Antwort. Bitte beschreiben Sie die wichtigsten Anforderungen und skizzieren Sie die wesentlichsten Elemente. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: While competitive auctions remain much more efficient than their assignment processes, ensuring plentiful supply and optimal auction approach to how the government launches their spectrum auction is critical.

Over the past 25 years, spectrum auctions have become a standard means of assigning high value spectrum. They have offered a competitive means of allocating spectrum efficiently among service providers, at a time of large increase in spectrum scarcity. It does not seem likely that the allocation system they replaced – 'beauty contests' – could have achieved this goal.

Auctions allow the government, not the service providers, to capture the rents associated with that increased spectrum scarcity, and use them for various public policy objectives, including policy objectives pertaining to the mobile sector itself. Spectrum auctions have also had grafted on them, in the form of spectrum caps and coverage obligations, by means of which greater downstream competition and wider deployment of networks can be gained at the cost of some of the government revenues achieved. Obligations are an increasingly important trade off to consider in wake of the potential positive external benefits that could be associated with the expansive version of 5G.

This would be a more constructive approach than a poorly constructed 'command and control' approach. It retains the competitive advantages of spectrum auctions, which have brought considerable benefits to the countries which have employed them. At the same time, auctions can be adapted to the new circumstances, and the balance between government revenue and increasing deployment can be flexed. This is likely to be a better course of action.

To promote the reach, availability and quality of connectivity some auction best practise approaches have emerged:

- Align spectrum pricing with policy goals, for example, by including coverage obligations in the pricing objective
- Package spectrum into small lots to enable rational and competitive bidding
- Avoid sealed bids, reduce complexity and ensure transparency
- Avoid set asides and artificial scarcity and maximise the spectrum available per band. C-band assignments in many countries keep aside spectrum that is being held by incumbent users that ultimately must be moved out of the band
- Maximise license duration to increase the asset life and investment horizon and set out renewal criteria to reduce uncertainty around investment
  Ensure predictability and allow for budget planning by providing a clear road map of spectrum assignment over the medium to long term
- Allow secondary trading of licences along with the ability to sub-lease amounts of spectrum to third parties

There is a trade-off between maximising spectrum revenues and service provider's ability to deploy networks[44] and are choosing to trade up to expansive connectivity, this is suggested to be kept as part of the spectrum plan too.

Frage 3.9.:

Im Falle, dass Sie die Vergabe regionaler Nutzungsrechte für einzelne Bänder vorschlagen, nennen Sie bitte die je Band von Ihnen präferierten Modelle einer regionalen Gliederung (Bundesländer, Bezirke, Gemeinden, etc.). Bitte begründen Sie die Antwort. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: The approach governments take will have considerable influence on whether 5G is deployed extensively and its full potential is realized. Key recommendations to governments in this regard are the following:

- Governments should prioritize pervasive, high quality network deployment over the goal of maximizing spectrum fees.

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[44] https://www.gsma.com/spectrum/wp-content/uploads/2016/11/spec_best_practice_ENG.pdf

- Longer and clearer license terms can incentivize higher levels of investment and innovation.
- Maximizing the availability of spectrum in a timely and planned manner is critical for economic growth.
- The value of spectrum is best realized throughs its economic and social use.

Ericsson considers national licenses to be the most efficient and effective approach of managing spectrum identified for 5G. If a regulator decides to offer parts of available spectrum regionally or locally then linking the right of using such spectrum to the real-estate ownership (or tenant, depending on national prerequisites) is an effective approach as doing so resolves many of the issues associated by regional or local licensing.

Frage 3.10.:

Welches andere nicht beschriebene Bewilligungsmodell kommt aus Ihrer Sicht für die einzelnen Bänder noch in Frage? Bitte begründen Sie die Antwort. Bitte beschreiben Sie die wichtigsten Anforderungen und skizzieren Sie die wesentlichsten Elemente der vorgeschlagenen Bewilligungsmodelle. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: The final aspect to consider is the auction evolution and commercial terms for spectrum access[45].

The vast majority of high value spectrum auctions are contested by firms proposing to offer similar services with the spectrum on offer. However, similar approaches apply when competition is between firms providing different services, for example broadcasting and mobile communications, or fixed and mobile broadband services.

The basic mode of operation of a spectrum auction can be described as follows. An individual firm bidding independently for a spectrum licence can be conceived as forming a conjecture as to how the downstream market will develop over the licence period in terms of growth of demand, industry structure, level of competition and other factors. On that footing it estimates the revenues it might earn and its costs of supply (including a cost of capital but excluding spectrum costs). The difference between the two is the maximum it would bid for the spectrum – although it would hope to pay much less. On this basis, firms which expect to be more efficient bid higher and have a greater prospect of success in the auction.

Over the past twenty-five years, giant strides have been made in the range of auctions formats available. This is the result of huge and successful advances in the field of mechanism design. There is evidence that firms are willing to bid higher in auctions with more sophisticated designs which insulate them from some auction risks.

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[45] https://www.gsma.com/spectrum/resources/effective-spectrum-pricing/

As with the case of other natural resource rights owned by the state, such as oil and gas extraction rights, auctioning the rights to spectrum allows the state to extract the scarcity value or rents of the asset without having to operate the business itself. Absent government abuse of its monopoly power on the supply side of this process (see below), this is a non-distortive way of gaining revenue which can then be used to pursue government objectives. In deciding how to spend it the government must make a trade-off between its broader social objectives such as education, health and defence, and more focussed sectoral objectives such as extending connectivity.

Experience shows that auction processes can be adapted to further such wider social and economic objectives in the mobile sector as equitable geographical coverage and the maintenance of competition in mobile service markets. Thus, some licences can be associated with an obligation to extend network coverage into so-called 'non-commercial' areas. In addition, to maintain a competitive downstream market in mobile communications, a cap can be placed on the amount to spectrum acquired by individual large firms. Both types of condition have been widely applied, without apparent detriment to the ability of the auctions to close satisfactorily[46]. In each case, the government is sacrificing some revenue from the auction for wider coverage or more competition.

Auctions can go wrong for a variety of reasons. One arises when the seller of the spectrum – i.e. the government or other relevant authority – exploits its own market power to increase auction revenues. Most simply, this can be done by hoarding spectrum which is available for release. An equally crude method is to sell all the available spectrum in one lot: the highest bidder is thus gifted market power in the downstream market, which – when valued by the method described above – generates a larger prize for that bidder. More subtly, a tranche of spectrum for release can be packaged such that only two firms can acquire significant quantities.7 Such 'duopolists' should be capable of maintaining prices above the competitive level, but to a somewhat lesser degree than a single firm. Each of these outcomes have adverse effects on coverage, quality and price. This lowers take up of the service, restricts connectivity, and stunts economic growth and the higher government tax receipts which go with it.

If this happens, there is an association between higher spectrum prices and higher service prices, but the former are not causing the latter. The causation is the other way round: it is the expectation of the high profits caused by manipulation of the spectrum market which generates the higher bids. Some empirical evidence on this question is discussed below.

Another possible problem with auctions is that they may generate overbidding, consequent on a systematic tendency for at least some service providers to harbour optimistic projections of the future and thus bid more than the spectrum is worth. When this occurs, the over-bidder might seek to retrieve the situation by raising service prices. But this would require similar action by all suppliers in the market, which is not likely to be forthcoming. Also, bidders for mobile spectrum are typically large international service providers with access to appropriate

46 https://www.sciencedirect.com/science/article/abs/pii/S0308596116302828

advice and familiarity with the risk of the so-called winner's curse, although the curse may have prevailed in the recent German auction where the reaction of winners was sour.

Auction design today will have a material impact on the version of 5G that is realised[47]. For a limited version, in which 5G is a quicker and more efficient version of 4G, spectrum policy and license terms continue largely unchanged. But for an expansive version, where fast and low latency communications capacity is available everywhere and "digitizes" industry verticals not yet much penetrated by intelligent connectivity, spectrum policy needs to change course.

Historically, obligations on network deployment contained in auctioned licences have typically been measured as a percentage of the population covered. They have often applied to spectrum assigned for a new generation of technology where the initial condition is one of zero coverage. Subsequently, it has become apparent that, for a variety of circumstances – based on a combination of topography, demographics and other factors - some locations are either not covered at all ('not-spots') or left uncovered by one or more service providers. Regulators have taken a number of ex post measures to fill in these gaps. An example relating to France is discussed below.

The combination of 5G and the imminent more widespread digital transformation within general social and economic arrangements creates an opportunity for a step change in the uses to which connectivity can be put, in a fashion which has the capacity to transform many sectors[48] – i.e. have major positive external effects – if the connectivity is widely available. In order to profit from a more expansive version of 5G connectivity, which delivers the potential efficiencies and externalities associated with the wider application of the industrial internet, e-government and Smart Cities (to name but a few applications), obligations are becoming more granular.

Coverage goals may still include a population percentage but are being extended to geographic targets including roads, railways and inside buildings. Regulators are also considering obligations that include consistent levels of quality and experience, currently measured by minimum speeds but that may extend to throughput and latency[49]. There is thus a case for governments to stipulate more granular obligations in licenses subject to auction. In doing so, they would accept less revenue upfront, but they would attain a better and more equitable market outcome within a given timeframe[50].

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[47] https://www.cerre.eu/sites/cerre/files/170330_CERRE_5GReport_Final.pdf
[48] https://cerre.eu/publications/towards-successful-deployment-5g-europe-what-are-necessary-policy-and-regulatory/
[49] https://cp.gsma.com/wp-content/uploads/2020/09/GSMA-Expanding-Mobile-Coverage-Partnerships-for-a-Connected-Future.pdf
[50] https://5gobservatory.eu/wp-content/uploads/2021/07/90013-5G-Observatory-Quarterly-report-12_v1.0.pdf

4 Chapter 4

Frage 4.1.:

Wie beurteilen Sie die Werteinterdependenzen zwischen den einzelnen Frequenzbändern? Welche Frequenzen sind (enge) Substitute, für welche Frequenzen bzw. Bänder bestehen komplementäre Beziehungen? Begründen Sie bitte ihre Antwort. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: The 700 and 800 MHz bands have similar coverage characteristics though the 800 MHz band has a much more developed ecosystem of devices. The 1800, 2100 and 2600 MHz bands have similar capacity characteristics and similar maturity in terms of ecosystem. The 3400-3800 MHz is a very significant band for 5G, since indoor coverage can be achieved based on an 1800 MHz macro site grid.

In general, the 700/800/900 MHz band forms one group of bands very suitable for network coverage and deep in-door penetrations. The 1800/2100/2600 are also well established bands, suitable for incremental network capacity. The 1400 MHz band is a future capacity band. The capacity bands are also excellent for carrier aggregation to increase network speed. The 3.5 and 3.7 GHz bands are very suitable for the introduction of 5G since they can be used for reaching in-door using the existing macro base station site grid.

Service providers need a well balanced mix and a timely availability of both coverage and capacity bands to be able to offer superior user experience for everyone in Austria (and in any country in Europe). It is expected that CSPs will need at least 80-100 MHz spectrum each in the 3.4-3.8 GHz band in order to introduce 5G in a meaningful way[51].

In addition, low and mid frequency bands <3GHz, currently occupied by narrowband technologies, will eventually become a target for spectrum migration towards broadband technologies. For example, it is envisioned that 900 MHz and 1800 MHz will be used more and more for LTE Advanced Pro technologies first and for 5G NR beyond 2025.

In addition, SDL (supplementary downlink) is a very efficient spectrum mechanism offering service providers the capability to augment the existing spectrum properties in a very efficient way improving the mobile broadband services in Austria.

L-Band, can complement bandwidth-limited low frequency bands, such as 700 and 800 MHz to improve the user average and peak throughput for both rural and urban areas without compromising service coverage. This is achieved by using the Carrier Aggregation function combining the two different spectrum bands resulting in a wider spectrum band equal to the sum of the primary combined carriers.

[51] https://www.gsma.com/spectrum/future-spectrum/

In addition, according to ECC Report[52], L-band deployment can operate on a high EIRP limit ranging up to 68 dBm/5 MHz, while higher levels may also be considered in specific circumstances such as when aggregated with FDD coverage bands in lower frequencies, to ensure the SDL capacity all over the base station cell. This makes the L-band even more attractive as it is possible to match lower frequencies coverage area.

Figure 21. Illustration on spectrum aggregation.

Frage 4.2.:

Welcher Spectrum Release Plan soll gewählt werden? Benennen Sie eine oder mehrere der genannten Optionen (gereiht nach Präferenzen) oder skizzieren Sie bitte die Eckpunkte eines Spectrum Release Plans. Wie beurteilen Sie die vorläufige Position der Regulierungsbehörde? Begründen Sie bitte die Antwort. Bitte berücksichtigen Sie bei ihrer Antwort die in Kapitel 1 genannten Ziele.

[Ericsson Response]: The detailed response is provided in answer to question 3.7.

Figure below gives a general indication of spectrum availability across all RAN generations over time. The spectrum available to 5G will vary from market to market, according to whether it is already in use and the timing of auctions and licensing processes.

[52] https://docdb.cept.org/download/1448

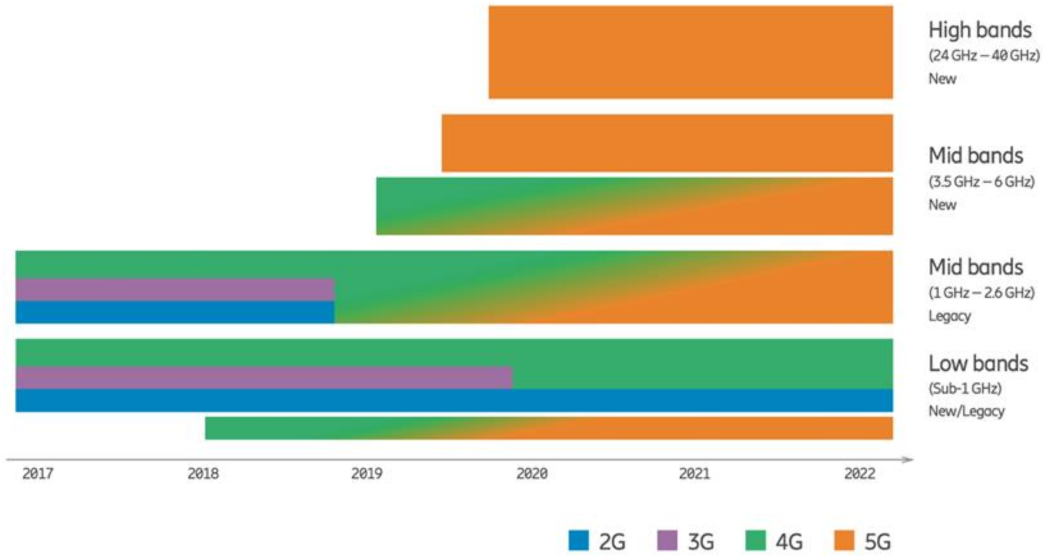
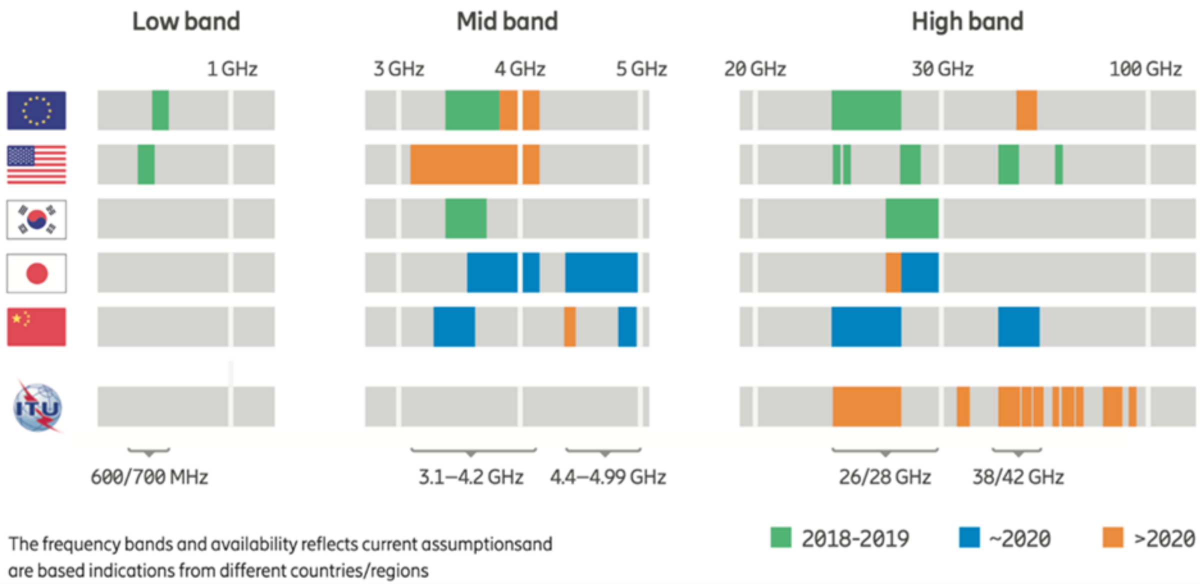


Figure 22. Spectrum availability across different RAN technologies.

As can be seen in another figure below, different bands are being made available for 5G NR in different parts of the world. The World Radiocommunication Conference (WRC) did not vote for any particular 'unifying' spectrum, but there is broad convergence on mid-bands, especially 3.5 GHz. Early roll-outs of 5G in Europe and Asia[53] have shown the use of these mid-bands, while in the USA service providers will mainly start with high bands for 5G, and re-farm some 4G low bands.



[53] https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/631060/IPOL_IDA(2019)631060_EN.pdf

Figure 23. Bands adoption strategies by different countries.

Each spectrum band has different physical properties, meaning there are trade-offs between capacity, coverage and latency, as well as reliability and spectral efficiency, as illustrated in picture below[54]. If the network is optimized for one metric, there may be degradation of another metric. These trade-offs need to be taken into consideration when planning 5G deployments, especially with regard to the service provider's service focus, whether this is enhanced mobile broadband, massive IoT, critical IoT or Fixed Wireless Access, for example.

Low-band spectrum has historically been used for 2G, 3G and 4G networks for voice and mobile broadband services, as well as broadcast TV. The available bandwidth is typically between 10 MHz and 30 MHz. This makes this spectrum most suitable for wide-area and outside- in coverage from macro base stations. For a typical 5G mobile broadband use case, capacity and latency are similar to 4G on the same band.

Legacy mid-band spectrum is currently used for 2G, 3G and 4G services. New mid- band spectrum has typically been allocated in 3.5 GHz spectrum bands. In these bands, especially in the new higher spectrum, we are likely to see larger bandwidths (50–100 MHz). This will enable high-capacity, lower- latency networks which can be used for new 5G use cases, with better wide-area and indoor coverage than higher-band spectrum[55].

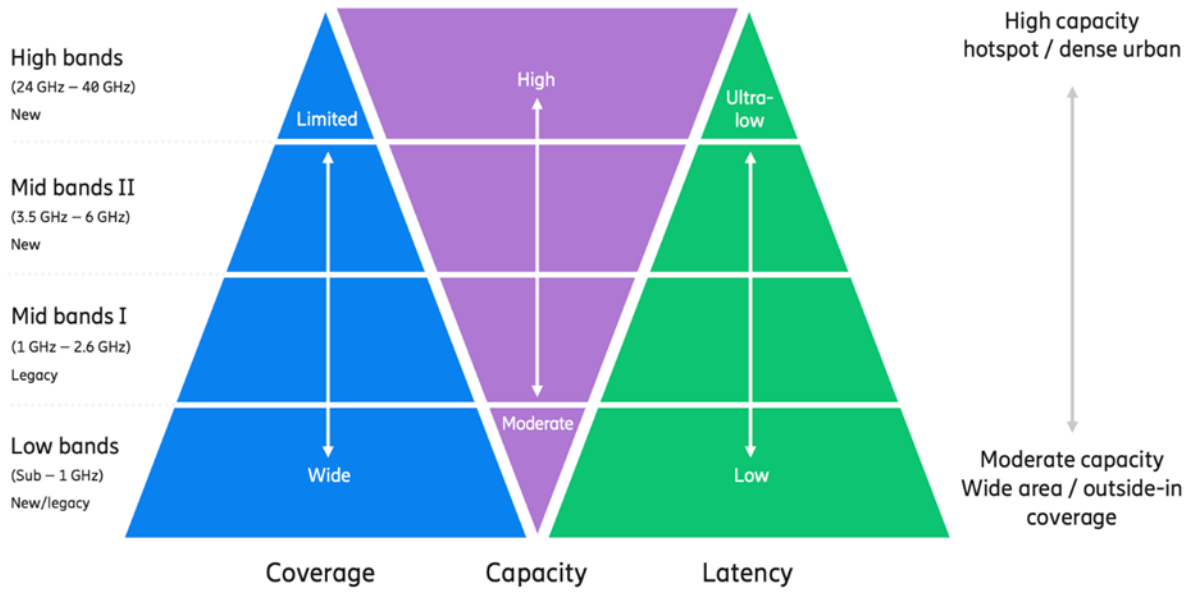


Figure 24. Combination of the different bands for the 5G roll-out purposes.

Ericsson as the provider of technology is committed to support or look into the support of various bands, however below is just one indication of the spectrum release strategy that might be considered as one of the ways forward.

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54 https://www.gsma.com/spectrum/wp-content/uploads/2021/04/5G-Spectrum-Positions.pdf
55 https://www.analysisgroup.com/globalassets/uploadedfiles/content/news_and_events/news/sosa-rafert-economic-impacts-of-reallocating-mid-band-spectrum-to-5g-1.pdf

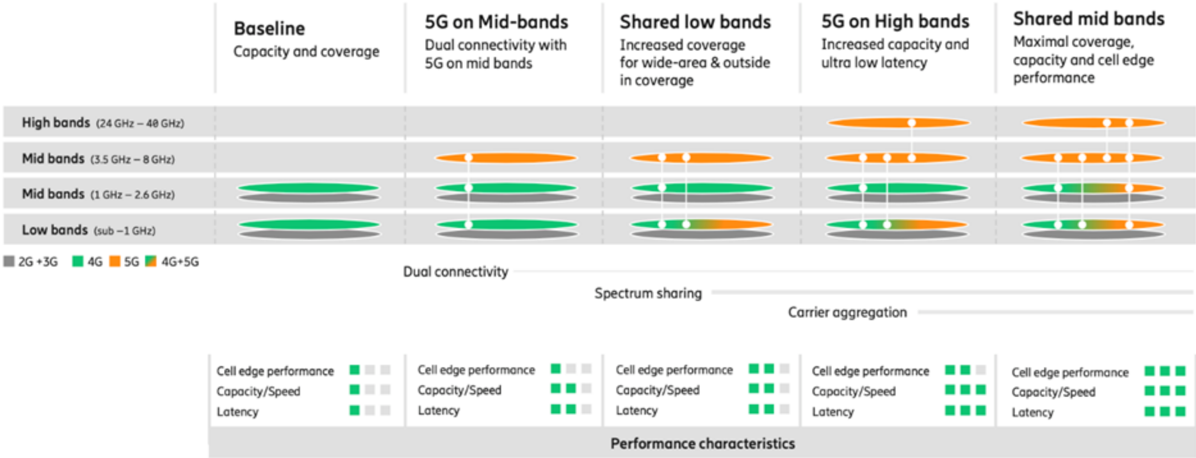

Figure 25. Performance characteristics across different bands.

As mentioned earlier, high-band spectrum provides the quantum leap in performance promised by 5G[56]. These new spectrum bands are typically in the 24–40 GHz range, with bandwidths in 100 MHz (or higher) blocks. Such large bandwidth enables ultra-high capacity networks (5–10 times higher than today), with latency as low as 1 ms. However, these higher frequencies come with a coverage limitation compared with lower bands.

Generally, we see that initial 5G deployments is mostly NSA in mid bands, as this approach is already standardized and enables service providers to reuse their existing 4G Evolved Packet Core (EPC) networks, with a software upgrade for NSA support. SA 5G is arriving first in low/mid bands, which provide a much larger coverage area and better indoor penetration than high bands – which is better from both a marketing and business case perspective, enabling the e2e 5G System values including 5G Core.

Existing spectrum used for 4G to be migrated smoothly to 5G over time, minimizing the impact on 4G as 5G is introduced in the same band. Functions that enable smooth spectrum migration and combinations (of both bands and technologies) are crucial for the planned evolution of the network.

There will likely be several combinations of bands and technologies (4G and 5G dual connectivity) for NSA 5G over the coming years[57], as traffic increases and markets mature. This will enable devices to be connected to both 4G and 5G at the same time (as shown in figure above).

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[56] https://ieeexplore.ieee.org/document/8386686
[57] https://on5g.es/en/enhance-5g-networks-with-channel-aggregation-dual-connectivity-and-massive-mimo/