5G IMPLEMENTATION IN NON-EU COUNTRIES OF THE EUROPE REGION

ITU Regional Initiative for Europe on Broadband Infrastructure, Broadcasting and Spectrum Management

Version 1.3

Living Document

ACKNOWLEDGMENTS

This paper was developed by the ITU Office for Europe within the framework of the ITU Regional Initiative for Europe on broadband infrastructure, broadcasting and spectrum management. It was elaborated by ITU Office for Europe team including Mr. Iago Bojczuk, Junior Policy Analyst, and Mr. Julian McNeill, Consultant, under the supervision and direction of Mr. Jaroslaw Ponder, Head of ITU Office for Europe.

The paper incorporates comments and amendments from all sectors of the ITU, including the Radiocommunication Bureau (BR), the Telecommunication Standardization Bureau (TSB) and the ICT Data and Analytics Division (IDA) as well as the Telecommunication Networks and Spectrum Management Division Division (TND) of the Telecommunication Development Bureau (BDT).

Moreover, important feedback has been provided to this report by:

- Electronic and Postal Communications Authority (AKEP), Albania;
- Ministry of Infrastructure and Energy, Albania;
- Communications Regulatory Agency (CRA), Bosnia and Herzegovina;
- Post and Telecom Administration (PTA), Iceland;
- Ministry of Communications of Israel;
- Office for Communications of Liechtenstein;
- Ministry of Economy and Infrastructure of Moldova;
- National Regulatory Agency for Electronic Communications and Information Technology (ANRCETI);
- Ministry of Economy, Montenegro;
- Agency for Electronic Communications and Postal Services (EKIP), Montenegro;
- Ministry of Information Society and Administration, North Macedonia;
- Agency for Electronic Communications of North Macedonia;
- Ministry of Trade, Tourism and Telecommunications, Serbia;
- Information and Communication Technologies Authority, Turkey;
- National Commission for the State Regulation of Communications and Informatization, Ukraine;
- Department for Digital, Culture, Media & Sport (DCMS), United Kingdom;
- Dicastero per la Comunicazione - Direzione Tecnologica, Vatican City.

The paper was prepared as a living document and background contribution to the ITU Regional Forum for Europe on 5G strategies, policies and implementation, held on 22 and 23 October 2020. Version 1.3 of this document is an advanced draft that builds upon the discussions held and comments received from participants of the ITU Regional Forum for Europe.

As the 5G implementation is a dynamic process this document is treated as a living document that can be amended at any point of time depending on the availability of additional information.

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1. Introduction

1.1 The recent landscape

The discussion over IMT-2020 (5G)[1] implementation has been widespread over the past three years, during which the first auctions and trials have been carried out and commercial services have been rolled out. This trend has gained pace vis a vis the COVID-19 pandemic. Administrations responses all over the world ensured continuity of operations while strengthening the digital transformation within countries testifying the importance of broadband services, both fixed and mobile, in our societies.

During lockdowns, the importance of mobile connectivity has become evident as a fundamental complement to fixed broadband which is still missing in almost 14% of households across the 46 countries of Europe region, according to ITU data.[2] In this context, it is critical to ensure that mobile communications are resilient and support citizens by facilitating access to the Internet.

1.2 Purpose of the paper

As the European Union moves ahead with harmonious IMT-2020 (5G) development, as demonstrated by the recent 5G Action Plan seeking to launch 5G services in all Member States by the end of 2020 as well as ensure uninterrupted 5G coverage in urban areas and along main transport paths by 2025, non-EU countries of Europe region proceeding independently risk being left behind or not being monitored appropriately.

ITU's goal is not only to ensure that existing gaps are reduced but also to ensure that the same existing gaps are not widening or that new ones are not created. In order to accelerate the countries' digital transformation and support the attainment of UN Sustainable Development Goals, ITU seeks to promote a favourable environment to investments in 5G technology and the infrastructure underpinning it.

To this end, as part of the ITU Regional Initiative 1 on "broadband infrastructure, broadcasting and spectrum management," the ITU Office for Europe has developed a series of 5G country profiles in non-EU countries offering a clearer picture on the status of 5G implementation in non-EU countries of Europe Region.

As each country has its own specificities, the 5G country profiles seek to draw attention to the main drivers of 5G from different angles but in a structured way. In particular, each country profile includes the following sections:

1. ICT Background and current status of broadband;
2. Broadband and mobile telecommunication sectors data;
3. Current progress on 5G: consultations and national strategies;
4. Spectrum assignment for 5G & market development;
5. Electromagnetic fields levels and the implementation dynamics;
6. 5G commercial launches: announcements, trail cities, and digital cross-border corridors.

Overall, this paper seeks to offer a better and comparable picture of 5G implementation across 18 non-EU countries of Europe Region, namely Albania, Bosnia and Herzegovina, Georgia, Iceland, Israel, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, San Marino, Serbia, Switzerland, Turkey, Ukraine, United Kingdom and Vatican from now referred to as the "Countries." The paper also seeks to aggregate data enabling identification of key trends characterizing the development of 5G across the Countries to provide all stakeholders operating in the region with the necessary information for effective decision making.

A first draft of this report had been published in the context of the ITU Regional Forum for Europe on 5G strategies, policies, and implementation held virtually on 22-23 October 2020.

2. Executive Summary

2.1 ICT background and current status of broadband

To sustain the transition to 2G into 3G, 4G and now 5G, governments have adopted a number of regulatory and policy measures setting clear goals for digital development which have driven the process over the past 20 years. Either through national broadband plans, "digital agendas," or other more specific activities, all governments and regulators have collaborated to provide clarity to the market, thus spurring investment in the development of electronic communications, of which 4G and 5G are only the latest steps, creating endless opportunities for businesses and empowering millions of citizens.

2.2 Broadband and mobile telecommunication sectors data

According to the latest ITU data from the ITU World Telecommunication/ICT Indicators Database,[3] the countries considered in this report have increased their collective internet penetration from 52.7%[4] in 2010 (63.2% in the wider ITU Europe Region[5]) to 82.5%[6] in 2019. 84.4% in the ITU Europe region[7]).

Since 2010, the number of Internet users in these 18 countries has grown by 78 million people. However, in 2019 more than 33 million people remain unconnected across these countries. This illustrates the potential for further developments in the coming years not only to improve connectivity but to connect the unconnected, especially in countries characterized by a young population.

Focusing on broadband, between 2015 and 2019 both fixed and mobile subscriptions per 100 inhabitants have been steadily growing at rates beyond 7% per year. In particular, mobile broadband subscriptions per 100 inhabitants have seen an increase from 56.2 in 2015[8] to 77.9 in 2019,[9] a 39% composite increase over the 4-year period. Similarly, the average for Europe Region as a whole, indicates an increase from 69.6 per 100 inhabitants in 2015[10] to 78.9 in 2019.[11] The shrinking gap suggests that mobile connectivity is a strong contributor to countries' internet penetration rates and to their transition towards digital economies overall.

Moreover, a 10-fold increase in mobile broadband traffic within countries since 2010, estimated at 6 exabytes in 2019,[12] and growing at a yearly average of 44.6% over the past two years, complete the positive picture for mobile broadband. This data exceeds growth rates of 41.6% for Europe region taken as a whole.

It must be noted that the growth in data traffic for Europe region as a whole is enabled by LTE coverage which now reaches 96.80% of the Europe region population, up from the 73.70% figure of 2015.[13] Similarly, the increase in 4G/LTE coverage for the 18 non-EU countries has increased from 41.62% of the population to 91.92%, therefore enabling additional 57 million people to enjoy fast speed mobile connectivity over the past 5 years.[14] This data evidently shows how a large gap has been consistently reduced in a limited time span.

Finally, as cost is a fundamental component of mobile broadband uptake, the average mobile-data basket cost[15] for the non-EU countries averaged 0.9% of GNI per capita in 2019 for a minimum monthly allowance of 1.5 Gb, while the European region's average was 0.8% for the same year.[16] Affordability is in fact a fundamental enabler of service uptake and a key component of the virtuous circle made of investment, market development and return on investment.

2.3 Current progress on IMT-2020 (5G): consultations and national strategies

As of October 2020, 12 countries which have undertaken specific 5G consultations, while 10 have adopted ad hoc 5G strategies or incorporated 5G provisions in broader broadband plans, and 7 have assigned frequencies for IMT-2020 (5G). The Table below illustrates the status in each country.

Table 1 - Snapshot of 5G dynamics in non-EU countries

	Albania	Bosnia and Herzegovina	North Macedonia	Montenegro	Serbia	Georgia	Moldova	Turkey	Ukraine	Israel	Iceland	Liechtenstein	Monaco	Norway	San Marino	Switzerland	United Kingdom	Vatican
Held 5G Consultations	✓		✓	✓	✓	✓	✓	✓			✓	✓		✓		✓	✓	
Adopted *ad hoc* 5G strategies or Incorporated 5G provisions in existing policy frameworks	✓		✓	✓	✓	✓		✓	✓		✓			✓			✓	
Allocated frequencies for 5G			✓ (2020)							✓	✓		✓	✓		✓	✓	

Source: ITU

These undertakings have been carried out in various ways and according to practices which are country specific. In all cases, these actions have been driven by governments and/or regulators, in some cases

with a strong involvement of the private sector. It is however to be underscored that civil society is generally excluded from the process of elaboration of these undertakings.

In some cases, it can be noticed that the consultative processes between administrations, operators and other stakeholders has led to the creation of hubs or working groups focused on advancing IMT-2020 (5G) implementation in the country. These often include the involvement of Academia and research centres and are a very good examples of the collaborative practices needed to achieve integrated and organic development of mobile ecosystems at the country level.

2.4 Spectrum assignment for IMT-2020 (5G) & market development

In all countries, spectrum for IMT has been identified following WRC-19 outcomes and CEPT decisions. International and regional organisations play a significant role in providing guidance on spectrum harmonization and continue acting as a reference points for the international community and private sector stakeholders setting the basis for standards and interoperability that are crucial at the international level.

With regards to the specific bands identified for IMT-2020 (5G) it is important to highlight that the 3.6GHz band is already being allocated to the land mobile service (or in some cases identified for IMT following the technology neutrality principle) across almost the totality of countries. This is undertaken either through licensing for commercial rollout or through temporary testing licenses providing operators with the chance to test new technology and develop their services.

In countries where spectrum auctions have not yet taken place, the IMT pioneer bands (the 26GHz band and the 700MHz band) are usually held back for various reasons. One of the challenges most commonly encountered with regards to the 700 MHz band is the process of freeing up the DD2 and re-purposing spectrum from broadcasting services to land mobile services (in some cases identified for IMT systems). This process is facing substantial delays across the region, and even within the European Union.

With regards to the 26 GHz band instead, one of the main challenges is the moderate interest in the near future by the industry. As no disruptive IMT-2020 (5G) application has emerged in context of smart cities or smart manufacturing, operators tend to refrain from betting on a frequency band which does not seem favourable for market development giving the current status of adoption of devices and applications.

Finally, it is important to notice that Covid-19 has held back planned spectrum auctions in many of the Countries, suggesting that 2021 will be a very concentrated year for allocation of spectrum in the region.

2.5 Electromagnetic fields levels and the implementation dynamics

When it comes to radio frequency electromagnetic fields (RF-EMF) exposure limits, the Countries mainly take two lines of approach with some transposing Guidelines from the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE) into law, whereas other prefer adopting a precautionary principle and opt for more restrictive limits in the order of 10-100 times than recommended by the relevant scientific bodies.

This often results in a double negative outcome of increasing cost of deployment (due to more antennas needed) and of increasing the number of antennas visible to the public and therefore increasing concerns of parts of the public. Considering the attention that RF-EMF has gained in relation to 5G, a trend which has been further exacerbated by the misinformation associated to the spread of COVID-19, this trend may cause delays 5G deployment in the near future.

Countries have responded in different ways, either by strengthening collaboration and communication with government departments in areas of public health and/or environment to better address the general public's concerns or by strengthening the monitoring and reporting power of regulators to gather, analyse and present measurement data.

Noting these facts, in coordination with all its three sectors, the ITU has been preparing a background paper on "Implementing 5G for Good: does EMF matter?." The paper provides policymakers with a point of reference on the status of scientific evidence and recommendations on the topic.

2.6 5G commercial launches: announcements, trial cities, and digital cross-border corridors

While in some Countries IMT-2020 (5G) non-standalone services are already available as they are in some EU countries, all Countries have seen their major operators announcing operations relating to 5G. Moreover, in all countries at least one operator has carried out trial tests in cities and in most of them there are multiple operators which have carried out such tests.

In this regard, it is possible to observe numerous partnerships arising between telecom operators and network equipment suppliers. In some notable cases, the collaboration goes as far as to include academia, research institutions or other vertical industries, creating actual 5G ecosystems supporting innovation in the field.

With regards to cross-border cooperation on 5G, no formal corridor has been established yet. However, within the context of the EaPeReg, for Eastern Partnership countries, and RCC[17], for the Western Balkans, multiple activities focusing on frequency coordination are in place and will contribute to harmonized development of 5G in the future.

Endnotes

1 IMT stands for International Mobile Telecommunications and "IMT-2020" is the nomenclature chosen to define the fifth-generation technology standard for broadband cellular networks, otherwise known as "5G". https://www.itu.int/net/pressoffice/press_releases/2015/27.aspx. For the purposes of this paper, "IMT-2020" will be referred to as "5G".

2 See: World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicator "xHH6_IDI" and "I99H").

3 See: World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en

4 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I99H").

5 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I99H"). Note: sample missing data for Iceland, Liechtenstein, Luxembourg, Moldova, Monaco, North Macedonia, Ukraine. Sample covering 79.71% of the population.

6 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I99H"). Note: missing value for San Marino and Vatican. Sample of 99.99% of total population.

7 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I99H"). Note: missing values for Andorra, Iceland, Israel, Ireland, Italy, Liechtenstein, Luxembourg, Moldova, Monaco, North Macedonia, San Marino, Vatican. Sample of 83.29% of total population

8 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I911mw"). Note: missing data for Albania, Liechtenstein, San Marino and Vatican.

9 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I911mw"). Note: missing data for Ukraine, United Kingdom and Vatican.

10 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I911mw"). Note: missing data for Albania, Andorra, Liechtenstein, San Marino, Vatican.

11 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61" and "I911mw"). Note: missing data for Andorra, Luxembourg, Netherlands, Norway, Ukraine, United Kingdom and Vatican.

12 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicator "I136mwi"). Note: data only for Albania, Georgia, Iceland, Moldova, Monaco, Montenegro, North Macedonia, Norway, Serbia, Switzerland, Turkey.

13 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61 "I271GAi"). Note: data for 2019 excludes Andorra, Latvia, Norway, United Kingdom and Vatican.

14 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (Indicators "i61 "I271GAi"). Note: data for 2019 excludes Andorra, Norway, United Kingdom and Vatican.

15 Note: The mobile-data basket uses the cheapest price with the largest operator for a data plan with a monthly allowance of at least 1.5 GB, irrespective of the device used, over a 3G or higher data transmission network.

16 See: ITU Measuring Digital Development: ICT Price Trends 2019: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf. Note: data missing for Liechtenstein, Monaco, San Marino and Vatican. It must be noted that this data has 1.5 Gb allowance as a minimum common denominator, with operators often offering higher data traffic packages

17 Regional Cooperation Council

3. 5G Country Profiles

3.1 Republic of Albania

3.1.1 ICT background and current status of broadband

The development of broadband in Albania has been a government priority for years, largely aligned with the integration perspective of the European Union. In 2003, the Albanian government underlined the need to introduce and develop the ICT sector to achieve higher economic growth through the National ICT Policy Strategy.[18] Several policies and programs have been in place ever since, and notable improvements have been achieved in terms of access, infrastructure, and affordability. Nowadays, the broadband market is one of the most vibrant markets in the telecommunications sector in Albania.[19] Despite the recent ICT developments in the country, rural connectivity remains a challenge, where costs can be high and penetration low.[20]

Albania saw significant developments as a result of its first National Broadband Plan (NBP) from 2013, which provides a set of directions and goals to be undertaken by the government, public agencies, and other regulatory agencies for the 2013-2020 period. The NBP for the 2013-2020 period was focused on: I) Improving and further developing broadband infrastructure throughout the country; II) Increasing Internet penetration; III) Providing Internet with high speed and reliability at local, regional and national level, including rural and remote areas; IV) Increasing competition and lowering the prices; V) Improving quality of service; VI) Expanding the number of electronic services (e-services) available to Albanian citizens and digitalization of all public services; and VII) Raising the awareness of the society, including people with special needs, regarding the benefits arising from the use of broadband services.

In June 2020, the Albanian government approved and adopted the National Plan for Sustainable Development of Digital Infrastructure, Broadband 2020-2026.[21] The new National Broadband Targets ("NBTs") of Albania constitute the following:[22]

- By the end of 2025, to have broadband penetration of 100% of households, businesses and public institutions with:
    - ✓ 50% having high-speed access of at least 1 Gbps (urban areas – Tirana);
    - ✓ 50% having access at the speed of at least 100 Mbps;

- By the end of 2025, to have 100% of households in rural and remote areas connected with broadband access of at least 100 Mbps;
- By the end of 2025, to have 100% of schools connected with high-speed broadband connectivity of 1 Gbps and access in every classroom;
- By the end of 2025, to have 100% of universities connected with high-speed broadband connectivity of 1 Gbps;
- By the end of 2025, to have 100% of health centres and hospitals connected with a high-speed 1 Gbps broadband connection;
- By the end of 2025, have one major city, the major transport corridors and strategic locations covered with 5G connectivity;
- By the end of 2023, bring free access to Wi-Fi connectivity in 50% of the biggest public spaces like parks, libraries and squares in all cities and villages.

The major supporting targets ("SNBTs") for the 2020-2025 constitute the following:[23]

- By the end of 2020, to have established a clear process with clear responsibilities regarding the application and issuing of construction permits;
- By the end of 2022, to have freed up the 700 MHz band from media broadcast operators and have reissued the 700 MHz band to MNOs;
- By the end of 2020, to have established Competent Broadband Offices (CBOs) and assigned responsibilities at municipality level;
- By end of 2021, to have established the national regulator as the sectoral CIRT;
- By the end of 2021, to have established a US Fund, including a public funding mechanism and clear rules for disbursement;
- By the end of 2021, to have adopted regulations for State Aid;
- By the end of 2020, to have updated Atlas to include all active infrastructure operators and alternative infrastructure providers (utilities);
- By the end of 2020, to have created an inventory of alternative infrastructure that can be used for broadband, including utilities and passive infrastructure owned by municipalities;

- By the end of 2022, to have established financing, funding and provision mechanisms for public Wi-Fi networks; and
- By end of 2022, to have addressed any given anticompetitive practices that undermine the development of broadband infrastructure.

In the context of Western Balkans Investment Framework (WBIF), a feasibility study and CBA for the regional broadband development in Albania was completed. The closure workshop was held on 28th of July 2020.[24] Moreover, the European Investment Bank is in the preparation phase of providing a 48 million EUR grant to Albania's Ministry of Infrastructure and Energy to develop Broadband. This projects aims to achieve the following results and benefits in the country: I) 500 health facilities with at least 30 MB fixed broadband connection; II) 3,000 educational facilities with at least 30 Mbps fixed broadband connection; III) 61 public institutions with at least 30 Mbps fixed broadband connection; and IV) Increase to 70% the share of households with broadband connection across the country.[25]

Additionally, the Electronic and Postal Communications Authority (AKEP) is continuously cooperating with local authorities to grant permits for operators to deploy broadband infrastructure, especially in underserved areas with fixed and mobile services as part of the AKEP Action Plan 2019.

Other broadband-related relevant policies include the Economic Reform Programme 2019-2021, Albania's 5G Strategy, Regional Strategies—Including SEE-2020 and MAP-REA WB6 and the Balkans Digital Highway—and Albania's National Cyber Security Strategy.[26]

3.1.2 Broadband and mobile telecommunication data

According to ITU data, 69.6% of individuals in Albania used the Internet in 2019.[27] In 2010, the data estimate for Albania was 45% and, in 2000, only 0.1%.[28] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 15.1.[29] Between 2013 and 2020, fixed-broadband penetration for both population and family has increased more than twofold, although it remains well below the EU average and neighbouring countries, albeit growing by 10%-15% annually.[30] Europe's average fixed-broadband basket cost was 1.5 percent of the GNI per capita in 2019, while Albania's corresponded to 1.6 per cent for unlimited Internet data cap.[31] Despite the significant increase, ITU data show that the proportion of households with Internet access at home was 32.9%.[32]

According to the Digital Agenda for 2015-2020, Albania's physical extension of fibre optic infrastructure reached 5,000km in 2015, and the network has been growing ever since.[33] Broadband is currently supplied

through myriad fixed and mobile technologies including DSL, FTTH/FTTB, FTTx in combination with NGA. Most DSL lines are combined with fiber optic and copper networks (FTTN /FTTB). Broadband is also supplied via coax cable (HFC) and electricity lines (BPL). Increased investments on fiber optics (FTTH and FTTB) are undergoing by fixed-network operators. Yet, broadband speeds, according to AKEP's reports and Feasibility Study's results, are low: the existing bandwidth in fixed and mobile networks is less than 30 Mbps.[34]

In 2019 the number of active mobile-cellular subscriptions per 100 inhabitants was 91.3.[35] Moreover, the, the number of active mobile-broadband subscriptions per 100 inhabitants was 62.1 in the same year.[36] There are 240 internet service providers authorized by AKEP in Albania and three mobile network operators that offer 3G and 4G services: Vodafone, Telekom Albania and ALBtelecom. Most of the 4G coverage is concentrated in urban areas, which is supported by the most recent findings of the WBIF19 Digital Diagnostics Report. In total there are 63% of Albanians that use mobile broadband. [37] The country's mobile-data basket cost corresponded to 1.1 per cent of the GNI per capita in 2019 for a monthly data allowance of 3.0 Gb,[38] while the European region's average was 0.8 per cent for the same year[39].

In terms of mobile technologies, broadband is supplied via 3G/HSPA/HSPA+ and 4G/LTE networks, as well as satellite technologies. In 2019, 99.2% of the population had 3G network coverage, while 4G covers about 95% of the population in Albania.[40] During the same year, the mobile-broadband Internet traffic within the country corresponded to 0.069 exabytes.[41]

3.1.3 Current progress on 5G: consultations and national strategies

4G services were launched in July-September 2015 using the 1800 MHz frequency band covering between 65% and 85% of the population.[42] 4G infrastructure is present in most cities but not in all rural areas, though AKEP issued 2 authorizations to two operators in the 800 MHz band (4G) in 2018 to improve coverage.

Stakeholders and telecom investors expect 5G to play a crucial role in Albania's national infrastructure. While the expansion of broadband has seen a steady growth over the past few years, 5G development in the country is in its initial phase. As the country is proceeding towards granting extensive 4G coverage, government has already considered 5G as a future step in broadband infrastructure development. In recent policy documents, 5G infrastructure development is mentioned in Objective 1 of the "Digital Agenda of Albania" in relation to appropriate spectrum policy development.

Furthermore, Albania's Ministry of Infrastructure and Energy and external experts held a 5G ecosystem Workshop in July 2019 as well as an Expert Report "5G Strategy for Albania", which generated a roadmap and 5 key recommendations for 5G development, yet to be finalized.[43] Put forward by AKEP and by the Ministry of Infrastructure and Energy (MIE), together with experts and market stakeholders, these recommendations are as follows:[44]

- ✓ Recommendation 1: Facilitate the timely availability of spectrum.
    - Make spectrum available in the 5G bands according to the ITU spectrum roadmap and consultation with operators plans;
    - Clearing 700MHz for broad 5G coverage;
    - Adopt national spectrum policy measures to encourage long-term heavy investments in 5G networks;
    - Address synchronisation issues with other networks, including those with neighbouring countries;
    - Effective spectrum pricing policies are vital to support better quality and more affordable 5G services;
    - Make available test frequencies.
- ✓ Recommendation 2: Simplification of processes to reduce the administrative complexity for build permits.
    - Reduce the application complexity to avoid additional overhead cost and minimize the application time;
    - Consider adding Small Cells, in the list of construction, installation and works, defined from the Development Regulation, as works that do not require build permits and are subject to a preliminary declaration (Article 41, Law 107/2014). The same approach may apply for rooftop sites as well;
    - Flexibility from AZHT on law interpretation, regarding the number of sites to include in one application;
    - Review of procedure for construction tax payment, by avoiding steps that delay the process and have additional cost from operators as no need for additional confirmation from the

municipality to AZHT, but just to upload the certification of the payment from the operator and the process to be closed.

✓ Recommendation 3: Facilitate Network rollout

- Facilitate access to lamp posts, street furniture and public buildings for small cell deployments;
- Bring into effect new building regulations which require all new buildings to have infrastructure capable of delivering superfast broadband;
- Facilitate additional deployment and access to fibre;
- Support and challenge local government in their plans to enable the delivery of digital infrastructure; both in terms of ensuring that these plans help Albania to meet its national objectives, and that local authorities develop consistent approaches to support the deployment of mobile infrastructure across the country;
- Recommend promulgation of guidelines on infrastructure sharing spanning both passive (site common space, towers/ducts) and active (antennas, BBUs etc.) infrastructure components;
- Consider a proportionate fees regime for site rental to ease the deployment of a larger number of antennas;

✓ Recommendation 4: Address any environmental consideration

- Promote network densification with small cells to ensure low radiation levels;
- Re-evaluate the accuracy of the limits, considering the new technological developments along with the potentially large number of intelligent antennas using MIMO and beamforming techniques;
- Pursue efforts regarding transparency by making the authorisations and measurement results publicly available.

✓ Recommendation 5: Promoting awareness on opportunities and benefits of 5G

- Organize 5G events where applications that address different user cases might be presented and experiences from other countries on 5G successful deployment can be shared;
- Initiate 5G Dialog forum to intensify the dialogue with the user industries;

- Need for structured skills development programs.

Moreover, to achieve the goals of 5G service provision in 2021 as set out in the 5G Strategy, the 3.5 GHz band should be auctioned as soon as possible during 2020 and be a key part of the National Broadband Plan.[45]

While the Government is in the process of finalizing a draft strategy on 5G, a spectrum policy paper was approved by Decision of Government no. 636 dated 29.07.2020 "For the approval of the multiannual spectral policy program and action plan."

In October 2020, during the Western Balkan Digital Summit, Western Balkans signed a Memorandum of Understanding on regional interoperability and trust services in the Western Balkans region and a Memorandum of Understanding on a roadmap for the 5G digital transformation of the six economies of the Western Balkans. The document expresses the intention of all economies in the region to provide a legislative and regulatory framework that will simplify administrative procedures, stimulate investment through competitive market competition and ensure the application of the latest technologies to continue the accelerated digital transformation. The whole process will be implemented in a way that is fully harmonised with European regulations, standards and best practices in this area.[46]

3.1.4 Spectrum assignment for 5G & market development

AKEP claims that the main barrier for 5G development in Albania is the "clash of frequencies" in the country. The 700 MHz band (694-790 MHz) is being used by TV broadcasters, making it challenging for the development of 5G networks,[47] in line with the requirements for Region 1 agreed at the World Radiocommunication Conference in 2019 (WRC-19). In this context, regulators expressed they are prepared to intensify the work toward migrating Albanian digital television frequencies to the 470MHz-694MHz band in order to release the 700MHz band (694-790 MHz) for use by mobile telecom networks.

The microwave links using the V-band—or the E-band—are a good and more cost-effective alternatives to optical fibres and well suited to supporting 5G (and broadband in general). Private sector stakeholders raised the issue that high frequency fees for microwave links in the V- and E-bands serve as a disincentive to invest, particularly so in the context of 5G[48] and would like to see a downward review of current fees for these bands per link to boost deployment.

Furthermore, the challenges for policymakers, regulators, industry, and operators remain the case, with spectrum allocation and regulatory policies likely to continue one of the critical issues in this process.[49]

As of now, there are no specific 5G regulations and strategies in place by the government. The tender of 800 MHz has been concluded with 2 assignments of 10 MHz (paired) to Vodafone Albania and Telecom Albania. In addition, there is still a part of 800 MHz band (10 MHz paired) available for mobile broadband.[50]

Currently, the stakeholders hope to proceed with testing of DVB-T2 digital terrestrial television (DTT) broadcasting, whose adoption will involve migrating DTT providers from the 700MHz frequency band to a lower range, freeing up the 700MHz band for subsequent 5G mobile spectrum licensing. Similar to other nations in the region, the 700 MHz band is currently in use by analogue and digital operators for audio-visual transmission.[51]

As mobile networks are more advanced in Albania than fixed networks in regard to penetration and speeds, the private sector stakeholders stress that the auction of the 3.5 GHz band needs to be accelerated and auctioned as soon as possible during 2020, in addition to becoming as a key part of the NBP.[52]

More commercial, as well as government-led developments on 5G, are expected to be rolled out in 2020 and years ahead.

3.1.5 Electromagnetic fields levels and the implementation dynamics

In the Republic of Albania, the competent bodies which cover the main issues of nonionizing radiation are the Commission for Radiation Protection (CRP) and the Office for Radiation Protection (ORP), in accordance of Law no. 10469, dated 13.10.2011 “On Protection from Non-ionizing Radiation.” These bodies are responsible for the drafting of regulations which determine the radiation limits, as well as the conduction of studies to prevent and maintain public health in our country.

In 2018 and 2019, AKEP conducted a frequency monitoring campaign in public institutions such as schools, kindergarten, and hospitals. Results, also published on AKEP’s website, were sent to Office for Radio Protection (ORP) which calculated the electromagnetic field levels. Measurements were also carried out near the transmitting antennas in cases when it was requested by the Office for Radiation Protection.[53]

AKEP conducts measurements of field transmission points, which are a concern, ensuring compliance with the guidelines published by the ORP and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The results of the measurements recorded so far indicate that the levels of radiation emitted by mobile antennas do not exceed the safety threshold, set by ORP and ICNIRP. ORP has assessed that no tested installation has exceeded the specified radiation safety limit.

In face of the social concerns surrounding EMF and 5G, AKEP, supporting the mission of the competent bodies CRP and ORP, will continue to perform measurements of the power of antenna transmission, in order to ascertain the field values and will monitor changes in power derived from the implementation of 5G technology.

Albania does not belong to the group of European countries high-level EMF limits being perceived as the barrier for swift 5G implementation.

3.1.6 5G commercial launches: announcements, trail Cities, and digital cross-border corridors

In October 2019, AKEP granted Vodafone Albania permission to kick off 5G technology testing in the country. As the largest and most stable telecommunication supplier in Albania, supplying GSM services in the country since 2001, Vodafone was given the authorization to use the frequencies 3600-3700 MHz of the 3600-3800 MHz band for measurement, research, and testing, all of which would need to be reported at the end of the two-month testing period to AKEP.[54] In this engagement, Vodafone Albania managed to to use these allocated frequencies to test new 5G technology, including Massive MIMO, maximum speeds with LTE carrier aggregation and 5G, and latency.

During a public event to celebrate the spectrum allocation for 5G research in the country, Vodafone Albania demonstrated the potential of 5G networks by introducing high-level politicians to a remote electric car in Tirana; thus, becoming the first operator to bring 5G experience to the country.[55] After the testing period in December 2019, however, Vodafone Albania did not continue with the testing trials.

In addition to Vodafone Albania, there have also been commercial announcements of Telekom Albania, now One Telecommunications,[56] and Ericsson in signing agreements to modernize the country's transmission network, which may have consequences for the 5G development, as well as for the ways in which it will be regulated or how stakeholders will compete or collaborate. The agreement between these two companies expects Ericsson to upgrade Telekom Albania's network capabilities to Gigabit LTE while also making the network 5G ready using the latest Eric Radio System equipment.[57]

Endnotes

18 See: https://danube-inco.net/object/document/11073/attach/0120_ict_strategy_Albania.pdf

19 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets.

20 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf

21 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

22 Both of Albania's national broadband plans were developed with the support of the ITU under the Regional Initiatives for Europe. See more: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets

23 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets, 2020.

24 See: https://eeas.europa.eu/delegations/albania/83464/regional-broadband-infrastructure-development-albania-closing-workshop_en

25 See: https://www.wbif.eu/project/PRJ-ALB-DII-001

26 Ibid., 24.

27 See: ITU World Telecommunication/ICT Indicators Database online: http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H")

28 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H")

29 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b")

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31 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

32 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "xHH6_IDI"

33 See: Albania Digital Agenda 2015-2020, https://issuu.com/miap4/docs/booklet_m-inovacionit_preview

34 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

35 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i911")

36 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i911mw")

37 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

38 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

39 The data-only mobile-broadband basket5 is based on a monthly data usage of a minimum of 1.5 GB. For plans that limit the monthly amount of data transferred by including data volume caps below 1.5 GB, the cost for the additional bytes is added to the basket. The minimum speed of a broadband connection is 256 kbit/s. The data-only mobile-broadband basket is based on the most common contract modality (prepaid or postpaid) in the economy in question, i.e. if more than 50 per cent of subscriptions are prepaid, then prepaid is selected. Otherwise, a postpaid plan is selected.

40 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i271G and i271GA"

41 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicators "i136mwi.")

42 See: Policy Paper Update: National Broadband Plan 2020-2025 for Albania, ITU.

43 See: ITU, 2020: Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets, 2020. Annex: "5G Strategy for Albania – Roadmap for the 5th generation of mobile communication in Albania."

44See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania: A review of the 2013 vision, objectives and targets, 2020.

45 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf. Please note the draft on 5G is still to be finalized. For more information contact the Ministry.

46 See: https://www.rcc.int/events/1400/rcc-supports-one-of-the-regions-most-prominent-events-western-balkans-digital-summit

47 See: https://cms.law/en/int/expert-guides/cms-expert-guide-to-5g/albania

48 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania, 34.

49 See: http://ijcsn.org/IJCSN-2017/6-3/The-Way-to-5G-Networks-and-Spectrum-Policies-to-Cope-with-High-Data-Communication-Consumption-The-Albanian-Case.pdf

50 For more information, please contact AKEP.

51 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania, ITU, 34.

52 See: ITU, 2020. Policy Paper Update: National Broadband Plan 2020-2025 for Albania, 35.

53 See: http://www.infrastruktura.gov.al/wp-content/uploads/2020/07/National-Plan-BBand-EN.pdf

54 See: https://akep.al/wp-content/uploads/2019/10/VKD-nr.-34-date-14.10.2019-Vodafone-Albania-Autorizim-Individual-3600-3700-MHz-per-prove.pdf

55 See: https://www.vodafone.al/per-median/publikime-zyrtare/vodafone-albania-sjell-eksperiencen-e-pare-5g-ne-shqiperi/

56 See: https://businessmag.al/telekom-albania-ndryshon-emrin-behet-one/

57 See: https://www.ericsson.com/en/news/3/2020/ericsson-to-modernize-telekom-albania-core-and-radio-networks

3.2 BOSNIA AND HERZEGOVINA

~~2.2.1~~3.2.1 ICT background and current status of broadband

In 2003, Bosnia and Herzegovina approved the first national law specifically targeting communication-related affairs, with a particular focus on electronic communications and ICTs. 2018 ITU Measuring Information Society as well as ITU's Digital Innovation Profile for Bosnia and Herzegovina show that hard infrastructure in the country is quickly evolving—there are fixed and mobile broadband connectivity in rural areas as well as in town and cities.[1] Moreover, competition in the telecommunication market as well as pro-growth regulatory measures have impacted the overall progress of services in the country.[2]

One of the country's milestones in ICT has been the adoption of the Policy of Electronic Communications Sector of Bosnia and Herzegovina 2017-2021,[3] which is aligned with the Digital Agenda of Europe.[4] This policy elaborates on the measures and the activities that will lead to their implementation, including the maintenance of market competitiveness that increase service quality and promote price reduction, as well as an expansion of broadband infrastructure in less developed and populated areas.[5] Additionally, it identifies support for the ICT sector and innovation as a central element in driving the country's economy forward on a range of fronts—enhancing competitiveness within Europe, increasing productivity and efficiency in business, and improving public and e-government services. This policy's action plan includes the following measures: [6]

- Construction of broadband networks that will enable high-speed transmission and provision of new services, thus ensuring reliable access to multimedia and interactive content;
- Stimulate the application of broadband wireless access networks in rural areas to reduce the digital divide among the population;
- Encouraging the development of digital content and services as well as translating conventional content into digital format;
- Harmonization of EC and media regulations that will be technology-neutral and easier convergence of information society and media services;
- Ensuring technical preconditions for the implementation of broadband Internet access to all users, especially schools and educational institutions;

- Improving cooperation with all scientific institutions in the country while and enabling their cooperation on important projects for the development of the information society as well as other projects of common interest; and
- Involvement and active participation of Bosnia and Herzegovina in international projects related to broadband access.

The country has introduced the 4G network in 2019 but lacks a national broadband strategy, which remains one of the most pressing issues for the development of broadband in the country in terms of market competitiveness and growth in the ICT sector.[7] Furthermore, an assessment by the European Commission argues that the policy for 2017-2021 is a prerequisite for the further development of the regulatory framework on radiofrequency.[8] Recommendations from the European Union highlighted that efforts should be made to further align this policy with the EU digital single market strategy as well as the Digital Agenda for the Western Balkans. Another point addressed is the need of improving the collection of statistical data on digital performance and digital competitiveness to critically assess Bosnia and Herzegovina in contrast to some of the existing compliances of the EU rules pertinent to electronic communications services.

~~2.2.2~~3.2.2 Broadband and mobile telecommunication data

Bosnia and Herzegovina's Agency for Statistics shows that in 2019 alone, 69.9% of individuals in the country used the Internet, up from 42.7% in 2010.[9] Despite the ICT divide still present, the data estimates show a significant increase in terms of Internet penetration over the years, particularly from 2013 onwards.

In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 22.6.[10] According to the Communication Regulatory Agency (RAK), Bosnia and Herzegovina currently has 67 Internet service providers.[11] In 2019, ITU data show that the proportion of households with Internet access at home was 72%,[12] a situation comparable with other countries in the Western Balkan region. In terms of affordability the price of the representative fixed-broadband basket was equivalent to 1.5 percent of monthly GNI per capita, compared with average cost of 1.5 percent in Europe. The price of unlimited Internet data cap is equivalent to 2.5 per cent of GNI per capita.[13] RAK data also show that dominant type of Internet access remains xDSL, which accounted for 56.8% percent of total broadband subscribers, followed by cable

access with 33.4%.[14] The regulator also stated that further liberalization of the market of telecommunications and the introduction of new technologies are expected in the upcoming years.

Concerning the mobile sector, Bosnia and Herzegovina had a penetration of 111.9 mobile-cellular subscriptions per 100 inhabitants in 2019,[15] while the number of active mobile-broadband subscriptions corresponded to 59.1.[16] The country's mobile-data basket cost corresponded to 1.5 per cent of the GNI per capita in the same year for a monthly allowance of 2.0 Gb, while the European region's average was 0.8 per cent.[17] In terms of coverage, 3G covered 96% of the population in 2019, while 4G/LTE's coverage covered 82% of Bosnia and Herzegovina's population.[18]

~~2.2.3~~3.2.3 Current progress on 5G: consultations and national strategies

The market development section of the Policy of Electronic Communications Sector of Bosnia and Herzegovina 2017-2021 states the implementation and development of new technologies that enable wireless broadband access to a large number of potential users throughout the country will be encouraged.[19] However, the government plans to provide the necessary frequency bands in order to enable wireless broadband access in urban, suburban and rural areas in the country, while respecting the principle of technology neutrality.

With 4G trials started in 2014, the decision on the conditions for the provision of 4G network services in the country was adopted in March 2019 by the Council of Ministers and the licenses were issued by RAK, thus enabling existing mobile operators BH Telecom d.d. Sarajevo, Telekom Srpske a.d. Banja Luka and JP Hrvatske telekomunikacije d.d. Mostar to market the service since April 2019.[20] Adopting the decision, the Counsel of Ministers' aim was to complete 4G coverage by licensing at a low price and demanding stricter requirements to reduce the length of the investment cycle and enable to start the 5G investment cycle earlier.[21] Coverage obligations, specifying territorial and main roads coverage, have been set for periods 1/3/5 years of operation. In the context of 4G development, there has not been particular reference to 5G yet. However, the decision prescribed allocation of 800 MHz, 900 MHz, 1800 MHz, 2100 MHz and 2600 MHZ spectrum on technology-neutral basis, thus giving the operators possibility even to deploy 5G technology in the available frequency ranges.

Recent public statements by RAK show a positive outlook toward the development of 5G in the country in the context of business opportunities and services for smart cities.[22]

~~2.2.4~~3.2.4 Spectrum assignment for 5G & market development

RAK highlights that the volume of investment in the 5G network requires multimillion funds and that the success of 4G implementation will directly shape the development of 5G. Given the late adoption of 4G and the potential delay for effective development of 5G infrastructure and regulation, very little information is public concerning the additional spectrum assignment for 5G.

In April 2019, Bosnia and Herzegovina's major telecom operators - BH Telecom d.d. Sarajevo, Telekom Srpske a.d. Banja Luka and JP Hrvatske telekomunikacije d.d. Mostar —announced they would start implementing 4G network in the cities of Sarajevo, Banja Luka and Mostar, after obtaining 15-year licensees from the Council of Ministers. Through that agreement the government recognized the importance of 4G for state budget and investments in network infrastructure of mobile operators will, including the introduction of new services, all in the best interest of end-users. The plan was that more than 40% of Bosnia and Herzegovina's territory would be covered by 4G networks in 2020 and 75% by 2024. The licenses also pointed that allocated frequencies for 4G would allow coverage of rural areas with lower population density, and operators will be able to plan the development of their networks more efficiently.[23]

Telecom operators were obliged to pay a fee of 17.5 million KM (10.06 million U.S. dollars) into the budget of the country's institutions between the early implementation period between 2019-2023.[24] In this way, 4G licensing paved the way for the transition conditions to 5G.[25]

BH Telecom claimed that the company adopted a master plan for the implementation of 5G back in 2017.[26] BH Telecom also made it explicit that its investments during 2019 on 4G and 5G have been higher than the three previous years. In particular, replacement of the broadband infrastructure during 2019 has opened door for testing and pre-commercial trials of 5G network. Similarly, HT Mostar claimed that the company already started fulfilling the procedures related to the introduction of 5G networks.

~~2.2.5~~3.2.5 Electromagnetic fields levels and the implementation dynamics

Bosnia and Herzegovina has no specific guidelines for the limit levels of electromagnetic fields for 5G yet, as only one operator started testing 5G networks, while others are focusing primarily on the continuity of 4G expansion in the country.

Despite that, RAK has adopted the Rule on Restricted Electromagnetic Radiation—which implies that all users of the radio spectrum, which include not only telecom operators, must harmonize the operation of

their systems in accordance with this rule. The Rule on Restricted Electromagnetic Radiation refers to level limits from valid international recommendations such as ITU K.83, ICNIRP (2020) and IEEE C.95-1.

In addition to that, the RAK is preparing a campaign to check the technical parameters of licensees in terms of protecting the general population from potential harmful effects. RAK's plan is also to provide transparent information to the public about the current electromagnetic exposure as the early phases of 4G and 5G in Bosnia and Herzegovina continue to take shape.[27]

~~2.2.6~~3.2.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

A few months after the 4G kick-off, in August 2019, Sarajevo-based BH Telecom—along with its partners Huawei, Ericsson, and Samsung—presented the 5G networks capabilities, including opportunities and applications of new technologies.

While 4G has not been fully provided throughout the country, BH Telecom has claimed that the investments in infrastructures enabled the research and development of 5G network, although RAK had previously informed that telecom operators would likely need to wait until 2024 to return the investment from 4G for the infrastructural development for 5G networks.[28]

In May 2019, national media coverage has reported that BH Telecom has successfully tested 5G technology, achieving downlink speeds of 1.4Gbps in Sarajevo.[29] BH Telecom announced the development in a press release, noting that the test had taken place in a multi-vendor environment, becoming the first operator in Bosnia and Herzegovina to test 5G technology. On that same occasion, BH Telecom made it public that the company hopes to use 5G technology to support the production and distribution of audio-visual content, in cooperation with TV companies in the country. No additional activities were carried out on the expansion or commercialization of the 5G network by the company ever since.

Without revealing a specific timeline for commercial rollout, BH Telecom informed that such a development would arrive when the demand was sustainable for the business model in place and upon appropriate regulatory measures. BH Telecom also did state its intention to utilize 5G to provide a fixed wireless access (FWA) service in rural areas. In face of the COVID-19 pandemic, BH Telecom also reiterated that 5G would help open up new business opportunities while also helping bridge the existing divide between rural and urban areas.[30]

In face of the wave of misinformation surrounding the 5G development, BH Telecom issued in August 2020 a press release informing the public that the operator does not have a 5G base unit installed on its base stations in Bosnia and Herzegovina, nor does it install equipment and base stations without notice.[31]

Endnotes

1 See: https://www.itu.int/en/ITU-D/Innovation/Documents/Publications/eBAT_Brochure%E2%80%93DIP%20BosniaH_431106_.pdf

2 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

3 See: http://www.sluzbenilist.ba/page/akt/WBr1TX3CmYY=

4 See: https://ec.europa.eu/neighbourhood-enlargement/sites/near/files/20190529-bosnia-and-herzegovina-analytical-report.pdf

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9 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i99H")

10 See: https://www.itu.int/net4/ITU-D/icteye/#/countries

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13 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf. Unlimited data caps are internet service providers' offers providing access to Internet without cutting service at the data cap.

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15 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911")

16 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i911mw")

17 See: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/prices2019/ITU_ICTpriceTrends_2019.pdf

18 See: ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271G and i271GA")

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3.3 REPUBLIC OF NORTH MACEDONIA

3.3.1 ICT background and current status of broadband

The Republic of North Macedonia is one of the fastest-growing ICT markets in the Western Balkan region with a robust telecom infrastructure. In 2018, ICT sector valued about 862 million EUR, contributing about 4% to the country's GDP.[1] North Macedonia experienced quick development of the electronic communications market as a result of the opening up of the telecommunications sector to competition,[2] attracting investments from foreign actors in telecommunications and IT due to the country's low corporate tax and free economic zones.[3]

Broadband is on the rise as the government continues to promote digital infrastructure developments. With a less developed fixed network, mobile plays an important role in the country with penetration rates being relatively high and likely continue increasing for mobile-cellular and for mobile-broadband services.[4] 3G licenses were first awarded in 2008 to MakTel and Vip (now named A1 Macedonia). At the end of 2013, LTE services were launched commercially. Currently, North Macedonia benefits from substantial 2G, 3G, and 4G infrastructure that covers more than 98% of the population.[5] The mobile market revenue in 2018 totalled 136 million EUR.[6]

Building upon the previous ICT-related policy frameworks of the National Strategy for the Development of Electronic Communications with Information Technologies and the National Strategy for Information Society Development and Action Plan, the government adopted in 2019 the National Operational Broadband Plan for 2019-2029 (NOBP). Among other things, this new plan relied on information from the national broadband mapping as well on the expected investments by telecom operators in the near future. Aligned with the strategic objectives of the Digital Agenda for Europe and the EU's Gigabit Society, the NOBP articulates a 5G roadmap with the following targets:[7]

- By the end of 2023, at least one larger city to be covered with 5G signal;
- By the end of 2025, the main corridors in accordance with the Treaty establishing the Transport Community on the basic and comprehensive road network in the country should be covered with an uninterrupted 5G signal;
- By the end of 2027, all towns in the country are covered with uninterrupted 5G signal;
- By the end of 2029, anyone can have the opportunity to access the internet through 5G with a minimum speed of internet access of at least 100 Mbps;

- By the end of 2029, at least 50% of the total number of household subscrption contracts across the country are for internet access of at least 100 Mbps;
- By the end of 2029, all households will have affordable opportunity to access a network that allows for a download speed of at least 100 Mbps, with a possibility for an upgrade to Gigabit speed; and
- By the end of 2029, all public institutions (schools, universities, research centres and other educational institutions, healthcare facilities, ministries, courts, local self-governments and other state authorities and bodies) have symmetrical internet access with a speed of at last 1Gbps.

There are four pillars in place to support the measures and activities in achieving the targets in the NOBP: I) Use of state aid; II) Additional measures for encouraging the use of access to ultrafast Internet; III) Improved legal framework and regulation; and IV) 5G introduction and development plan.

While broadband services continue to expand in the country, a 2018 domestic mapping of current commercial networks and operators' future plans indicate that 30% of households are located in "white zones." These white zones correspond to areas that lack capacities for access to super/ultra-fast Internet (with download speed higher than 100Mbps), and that there are no plans to invest in such networks in the foreseeable future.[8]

To tackle this issue, and in alignment with the NOBP, the Ministry of Information Society and Administration announced a collaboration with the World Bank to develop a National Transport Fibre Network. The government expects such network to access these "white zones," as well as fibre network within these specific areas, that would be available for operators to use so to provide services to the citizens. The only condition for this plan is that retail prices for super-fast internet access for households should not exceed 2% of the average monthly income in a respective planning region.[9]

3.3.2 Broadband and mobile telecommunication data

ITU data shows that 79.2% of individuals in the Republic of North Macedonia used the Internet in 2018.[10] In 2010, the ITU data estimate for the country was 51.9% and, in 2000, 2.5%. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 21.3.[11] ITU also estimates that the proportion with Internet access at home in North Macedonia was 79.3%. [12]Moreover, according to the latest Broadband

competence office Report[13] on the country's broadband development, the Republic of North Macedonia reports the following indicators::

- Fixed broadband coverage (% of households) is 97.87%;
- Fixed broadband take-up (% of households) is 72.95%;
- 4G coverage (% of households) is 99.38%;
- Preparedness for 5G (% of harmonized spectrum) is 22,2% (14.07.2020);
- Fast broadband (NGA) coverage (% of households subscribed to broadband with at least 100 Mbps download speed. Affected technologies include FTTH, FTTB, cable Docsis 3.0 and VDSL) is 78%;
- Fast broadband take-up (% of households) is 27,43%;
- Ultra-fast broadband (NGA) coverage (% of households) is 43,8%;
- Ultra-fast broadband take-up (% of households) is 1,74%.

Information detailed in the NOBP shows that coverage with fast broadband networks is roughly the same as the average in the European Union. However, the existing coverage with ultra-fast broadband networks (43.8%) is lower than the EU average (58%).[14] For enterprises (with 10 or more employees) in 2019, 85.8% of them had fixed broadband connection, an increase of 4.3 percentage points compared to the previous year.[15] Additionally, the wholesale broadband market in North Macedonia is highly concentrated with few providers, and the high wholesale broadband prices prevent investments, especially among the smaller or regional operators.[16] From the regional perspective, the fixed-broadband basket cost for North Macedonia corresponded to 3.8% of the GNI per capita in 2019 for a 50 Gb Internet data cap,[17]compared to an average of 1.5 percent of monthly GNI per capita for Europe region as a whole.

In regards to the mobile sector, the number of active mobile-cellular subscriptions is 98.65 per 100 inhabitants, while the mobile-broadband subscriptions per was equivalent to 69.9 in 2019.[18] Moreover, according to ITU data 3G population coverage in North Macedonia is 99.9% while 4G/LTE coverage is 99.5%.[19] In terms of prices, the country's mobile-data basket cost corresponded to 1.9% of the GNI per capita in 2019 for a monthly allowance of 1.5 Gb,[20] while the European region's average was 0.8 per cent for the same year. In 2019, alone, the mobile-broadband Internet traffic within North Macedonia was equivalent to 0.045 exabytes.[21]

3.3.3 Current progress on 5G: consultations and national strategies

As part of the NOBP, operators are expected to invest in two critical areas in the country to facilitate 5G development: [22]

- Infrastructure investments: Mainly to build a denser fibre optic network infrastructure, thus ensuring 5G connectivity of base stations by funding their installation. The next generation of 5G wireless networks will support applications requiring high speeds. One of the solutions, in this case, is to allow higher density of base stations by deploying small cells.
- Investments in service innovation: Mainly to stimulate the emergence of new 5G services. Such a focus on innovation includes the financing of pilot projects through which the potential 5G features will be demonstrated and tested, thus allowing the development of new services.

Moreover, according to NOBP, the new government should establish inter-ministerial working groups for mutual harmonization and amendment of the laws and bylaws related to construction and electronic communications, taking into account the proposals submitted by operators and the measures outlined in the national broadband plan. Representatives of ministries, regulatory bodies, operators, universities, chambers of commerce, equipment manufacturers, independent experts, civil society associations, private companies, and others, participated in the working group.[23]

As a result, a dedicated website page has been created to host relevant information on 5G development as well as proposals by stakeholders.[24] Moreover, according to NOBP, the government representatives should engage discussions with stakeholders to ensure:[25]

- Joint use of the existing physical infrastructure;
- Intensifying the coordination of construction works;
- Use of free optical fibre for aggregation linking to the development of 5G. Procedures that will enable quick and simple acquisition of approvals for construction of electronic communication networks, and in particular for deploying fibre optic infrastructure and base stations for the new 5G network;
- Deployment of 5G equipment on existing lighting poles, at bus stops, transmission line towers, etc; and

- Deployment of small-size and low output equipment for mobile networks should be in accordance with the regulations for the installation of urban equipment (without an approval/decision), and via very simple and quick procedure.[26]

The document articulates that the 5G implementation in North Macedonia should guarantee the building of a nation-wide ecosystem for wireless connectivity with a focus on quality of user experience not only within the context of increased speed, reliability, and reduced communication latency but also in the context of significantly expanding the number of offered services and improving the overall quality of life.

Accordingly, one of the central government's strategy in achieving these 5G-related targets focuses on maximizing the benefits of 5G implementation for financial return through governmental support. Such a strategy includes the development of a thriving economic market through support and advancement of new services in various vertical market segments that may be offered to end-users through a diverse niche of possible industries and services.

To accomplish that, according to the NOBP, government representatives should engage in discussions with vertical sectors, industry and the telecommunication operators[27] to the following end:

- Sign a Memorandum of Understanding for 5G development and digital transformation in all spheres of the society through the use of 5G technology;
- Possible financing of pilot projects through which the potential 5G features will be demonstrated and tested, thus allowing development of new services;
- Raising the level of the digital skills within the industry, as well as among the citizens.

3.3.4 Spectrum assignment for 5G & market development

The 2019 NOBP recognizes that one of the preconditions for the promotion of 5G networks is providing a sufficient and adequate radio frequency spectrum as early as possible to stimulate investments, innovation, and competition in the development of 5G services.

The Agency for Electronic Communications (AEK) expects to assign 5G spectrum in the second half of 2020, with plans to initially award 5G-suitable spectrum in the 700MHz and 3.6GHz bands.[28] To facilitate this process, AEK launched a public consultation in February 2020 so that interested parties could provide their input regarding terms and conditions of the spectrum auction, demand for spectrum, optimal way of allocating the airwaves, and deadline aligned with the operator's return on investments.[29]

From February 2020 700 MHz band is freed up from digital video broadcasting-terrestrial (DVB-T) and will enable nationwide and indoor 5G coverage.[30] Due to favourable propagation conditions, AEK states that the 700 MHz frequencies will provide the opportunity for network operators to develop comprehensive 5G coverage early, based on their existing network infrastructure.[31]

Furthermore, the AEK expects to award 2×10MHz of spectrum in the 700 MHz band per operator, while it plans to distribute 300 MHz in the 3.6GHz band (100 MHz per operator) nationally and 68.5MHz regionally.[32] Some of the conditions proposed by AEK for the allocation of these two bands deals with both territorial and population coverage. One condition determines that at least one North Macedonian city needs to have uninterrupted 5G coverage by the end of 2023, and all remaining cities by 2027, while the second condition expects that all citizens must be provided with 5G access with a minimum downlink of 100Mbps by 2029.[33]

Additionally, the AEK plans to reserve 2×10MHz in the 700MHz band and 100MHz in the 3.6GHz bands for a new network operator, with a lower one-time fee and coverage obligations. For the 24.25-26.5 GHz radio frequency band, if needed, AEK may conduct re-planning by 2023 and allocate it for land mobile services.

3.3.5 Electromagnetic field levels and the implementation dynamics

As, AEC issued temporary licences to both MNO for testing 5G on a period of 12 months in the frequency band 3.6 GHz band, AEC conducted measurements of non-ionizing radiation in order to see the contribution of the new 5G NR technology from the test network of Makedonski Telekom. During the measurements, two base stations were active, one from the building of Makedonski Telekom and the other from the building of TK Centar. The measuring point is in front of the AEC building, 160 meters from the first base station. Limit values for the EMF are taken from the recommendations of International Commission for Non-ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz) (1998), whose recommendations are implemented in the European legislation given in CEPT Recommendation ECC REC(02)04-Measuring non ionizing electromagnetic radiation (9 KHz-300 GHz). According to these recommendations, basic limit values and reference limit values are defined.

The whole Report from the measurement is published on 18/12/2019 on the official web page of AEC.[34] A final result of the measurement is that the contribution of 5G as a part of all the other technologies is

32% whereas, for example, LTE is at 49 % from the maximum allowed value. 5G's contribution in the total density of electromagnetic energy is 38 % instead of LTE which is 47 %. Another important remark of this Report is the fact that this measurements and calculation were done in the worst-case scenario when 5G sites were active 100 % and the whole beams were towards the measurement equipment.

3.3.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

As of August 2020, there is no commercial availability of 5G products, although commercial pre-release and tests have occurred.

In September 2018, Makedonski Telekom, which has the largest share of the broadband market in North Macedonia, informed that it performed the first 5G demo in the country, claiming the tests results of the tests reached the highest Internet speed registered. On that occasion, the operator also claimed that the provider had planned investments in the next two years in order to meet all prerequisites for the commercial launch of 5G.[35]

In May 2019, Makedonski Telekom and Faculty of Electrical Engineering and Information Technologies (FEEIT) of the "Ss. Cyril and Metodius" University, being also ITU Centre of Excellence, announced a partnership for testing 5G network. The press release informed that the 5G-related tests would occur in the FEEIT's "5G Evolution Laboratory" within the Wireless and Mobile Networks Lab at the institution based in Skopje, which is equipped with a 5G core network emulation and virtual wireless access. The provider announced that the partnership's plan included furthering the engagement with researchers in performing real scenario tests while conducting experiments.[36]

In July 2019, Agency for Electronic Communications issued two temporary frequency authorizations for testing 5G network. Frequency authorizations are issued to A1 Makedonija for frequency band 3.7-3.8 GHz (100 MHz) with validity date till 14.07.2020 and to Makedonski Telekom for frequency band 3.6-3.7 GHz (100 MHz) with validity date till 31.10.2020.

In November 2019, Makedonski Telekom has set up a trial 5G network in the centre of Skopje, with tests scheduled to be carried out during 2020 before a full commercial launch. The provider said that it was aiming to test the 5G performance in real-time, thus enabling new services for users. These services included the following: super-fast fixed-wireless internet, virtual reality (VR) 3600 live video, VR gaming in real time and ultra-HD multi-video streaming.[37]

Endnotes

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3.4 MONTENEGRO

3.4.1 ICT background and current status of broadband

The electronic communications, information, and communication technologies sectors in Montenegro are regulated by the 2013 Law on Electronic Communications. This law has been enacted to ensure that telecommunication services are provided to Montenegrin users at fair prices, with the adequate stimulation of market competition and reduction of monopolies when it comes to high-speed Internet access.[1] Stakeholders from both the public and private sectors are working together to implement strategic objectives in order to leverage the potential of digital technologies in the country.[2] Following independence and the accession process to the European Union and the telecommunication acquis, the telecommunication sector has grown increasingly independent and competitive, marked by significant financial investments by the country's telecom operators.[3] With many government-led initiatives—such as the Strategy for the Information Society Development (2016-2020) and Strategy of Innovative Activity (2016-2020)—Montenegro has improved the overall ICT sector and the state of broadband throughout the country.

The Strategy for the Information Society Development (2016-2020) encompass three major components: I) Infrastructure; II) Cybersecurity; and III) E-economy, which involves e-business, e-inclusion, e-government and research, and innovation and development in the field of ICT. Harmonized with the Digital Agenda for Europe by 2020, the strategic priorities for ICT and broadband development in Montenegro include the following:[4]

- Expansion of broadband access by reaching:
    - 100% of the population with basic broadband coverage by 2018;
    - 100% of the population with fast broadband coverage (30Mbit/s or more) by 2020;
    - 50% of households with ultra-fast broadband usage (100 Mbit/s or more) by 2020;
- Strengthening capacities of the National Computer Incident Response Teams (CIRT) for protection, prevention and combat against Internet incidents, elevating the number of team experts to 20 by 2020;
- Improvement of the structure of local CIRTs;
- The percentage of ICT graduates in the total number of the graduating class should amount to 10% by 2020;

- The number of European Computer Driving Licence (ECDL) certification issues should reach 15.000 by 2020;
- The share of ICT in GDP should reach 6%, which will be reflected in economic growth and job creation in other sectors of the economy;
- The share of e-commerce in total commerce should reach 1.5%;
- In the context of e-education, the computer-student proportion should be 1:10 by 2020;
- The percentage of teachers trained to work on computers should be 30% of the total teaching staff, whilst the percentage of the teachers skilled in the field of cyber security should be 20% of the total number of the teaching staff;
- The percentage of e-prescriptions and e-referrals issued should reach 60% out of all medical prescriptions issued. Online medical appointments should surpass the traditional appointments and reach 70% of the total number of appointments;
- The elimination of the digital divide between urban and rural areas;
- The elimination of the income-based digital divide, and the divide based on social and demographic characteristics;
- The percentage of citizens who use e-services should be 50%;
- The percentage of legal entities using e-services should be 30%;
- The percentage of scientific and research institutions in the field of ICT should reach 30%.

Montenegro has complied its regulatory and legislative framework in the field of ICTs with EU regulations. The government admits that the legal framework has been implemented thoroughly, thus providing operators with a more stable business environment, which benefits domestic customers as they now can access providers and telecom services at affordable prices.[5]

In 2019, the European Union awarded 600,000 EUR to Montenegro at the 20th meeting of the Management Board of the Western Balkans Investment Framework on June 25-26, 2019 to fund the "Broadband Infrastructure Development in Montenegro" (PRJ-MNE-DII-001), which is currently being implemented.[6]Based on the complete mapping process of the infrastructure, the goal of this project is to analyse the current situation and examine the potential of the market to eliminate the existing infrastructural gap. There are three expected results and benefits:[7]

- Increase broadband coverage and availability of new generation broadband networks to the currently uncovered (mostly rural) areas in Montenegro;
- Offer an adequate infrastructure for fast and secure internet to all households, businesses, educational and health institutions in order to support the digital transformation of society and economy;
- Increased the percentage of households passed with NGA (Next Generation Access) network from 70% to 95%.

3.4.2 Broadband and mobile telecommunication data

ITU data shows that 73.5% of individuals in Montenegro used the Internet in 2019.[8] In 2010, that percentage was 37.5%. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants corresponded to 28.5.[9] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 percent of the GNI per capita in 2018, while Montenegro's fixed-broadband basket cost corresponds to 1.8 per cent of the GNI per capita for unlimited Internet data cap at 2 Mbps[10] for 2019.[11] The country's mobile-data basket cost corresponded to 0.8 per cent of the GNI per capita in the same year for a monthly allowance of 1.5 Gb, which is the same as the European region's average for the same.[12]

The north region of Montenegro remains the least connected, having about 64.8% of the households with some kind of Internet use.[13] The same report also shows that while 80% of households in urban areas were connected in 2019 (representing 3.7% increase compared to 2018), the percentage for rural areas was 62.8%. In terms of household connectivity, data from the country's State Statistical Office show that 74.3% of the surveyed households had access to the Internet in 2019, which represents an increase of 2.1% in relation to the previous year.[14]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants corresponded to 183.3,[15] while the mobile-broadband subscriptions were equivalent to 80.5.[16] In 2019 alone, the percentage of households connected via mobile increased by 5.1% when compared to 2018.[17] Three mobile network operators (MNOs) secure spectrum in multi-band auction in Montenegro: Crnogorski Telekom (T-Mobile Montenegro), M:tel, and Telenor Montenegro. In terms of the quality of mobile networks, Montenegro's the Agency for Electronic Communications and Postal Services (EKIP) has recently made public that Crnogorski Telekom's mobile network offers the highest download speed in urban areas, at 47.5Mbps, followed by Telenor (43.5Mbps) and M:tel (22.5Mbps).[18] As of 2019, 4G/LTE networks cover 97.7% of the

population of Montenegro,[19] with an average download speed of 10 Mbps.[20] 3G coverage is available to 98% of Montenegro's population.[21] In 2019 alone, the mobile-broadband Internet traffic within the country was equivalent to 0.041 exabytes.[22]

3.4.3 Current progress on 5G: consultations and national strategies

As of 2020, there is no public information regarding national strategies for Montenegro's 5G development. However, EKIP is set to launch a 5G roadmap with national strategies and goals by the end of 2020, with an eye on holding spectrum auctions for assigning radio frequencies in the second half of 2021.

Alongside the national strategy for the implementation of 5G, EKIP plans to elaborate a new regulatory framework for spectrum, which is set to be completed by the end of 2020. This will be based upon consultation with stakeholders on 5G pilot projects (MNOs, public institutions at both state and local levels, as well as vertical industries, and universities). EKIP predicts an information document to come out in the first quarter of 2021, with an auction process to occur in the third quarter of the same year —five years after the previous one.[23]

3.4.4 Spectrum assignment for 5G & market development

In the past years, the country's major telecom operators have continued to modernize and upgrade their networks, reaching a total investment of 91.5 million EUR in 2018 and 78 million EUR in 2019 for the country's electronic communications sector.[24] In particular, the fibre sector in Montenegro, which is critical in terms of backhaul to supporting 5G development, has shown particularly strong growth since 2010 as the incumbent has invested in infrastructure upgrades, albeit mainly to serve apartment blocks in the main towns.[25]Between 2017 and 2018, for example, an increase of 36.04% has been observed in the number of users who accessed Internet via optical fibres (between 2018 and 2019 increase was 32.77%), followed by an increase in overall Internet data traffic.[26]

In terms of mobile network signal, Montenegro can be compared to the most developed countries in Europe. By the end of 2018, 97% of the populated areas were covered by 4G networks offered by two operators.[27] At the end of 2019, more than 97% of the populated areas were covered by 4G network offered by Crnogorski Telekom, about 97% covered by 4G network offered by Telenor, and about 94% covered by 4G network offered by M:tel. In the past years, quality and availability of mobile broadband

services of data transmission were much improved in urban and rural areas, mostly thanks to increased LTE coverage of all three mobile operators and introducing LTE-Advanced technology (2CA & 3CA) with LTE carrier aggregation from two or three bands on a large number of locations.[28] As a result, the wide availability of LTE has made mobile broadband a viable alternative to fixed-line broadband access in many of the country's rural areas.

The last spectrum auction in Montenegro took place in 2016. Currently, there are five bands in use by three MNOs: 800 MHz, 900 MHz, 1800 MHz, 2 GHz and 2.6 GHz. With 15-years licenses starting from mid-2022, the spectrum to be auctioned for 5G in Montenegro in 2021 are: I) Band 700 MHz: 2x30 MHz FDD + up to 20 MHz TDD; Band 3400-3800 MHz: 400 MHz; Band 26 GHz: 1000 MHz. EKIP articulates the following current configuration for RF spectrum for initial 5G implementation in Montenegro:[29]

Band 694-790 MHz:

- The 700 MHz band is free;
- Usage for 5G is possible only in northern region due to DTV signals from ALB, ITA and CRO;
- Regional harmonisation of the deadline for release of the band 700 MHz for MFCN is of crucial importance. Predicted deadline not before 30 June 2022;

Band 3400-3800 MHz:

- Part of the 3400-3600 MHz band is licenced to BWA until April 2022;
- The whole 3600-3800 MHz band is free and can now be used for 5G;

Band 24,25-27,5 GHz:

- Band 24,5-26,5 GHz is currently used for fixed satellite links (gradual migration in other bands, depending of market demand for spectrum for 5G);
- Band 26,5-27,5 GHz (1 GHz) is free and can now be used for 5G.

As a 5G-related strategy, EKIP and Albania's Audiovisual Media Authority (AMA) have signed a memorandum of understanding in 2019 to cooperate in the area of radio frequency spectrum management harmonisation.[30]The agreement focuses on the 700MHz band. Both EKIP and AMA expressed their readiness to intensify work to migrate Albanian digital television frequencies from the 470MHz-694MHz band to release the 700MHz band for use by mobile telecom networks.

In July 2020, EKIP has determined that the Crnogorski Telekom (CT) must cut the cost of calls from its fixed network to mobile and fixed networks by 10% and 5% respectively. EKIP has also examined the relative market dominance of the country's operators alongside their pricing models. Following this, it has ordered CT, Telenor and m:tel to lower their wholesale call termination fees by 11.8% for mobile networks and 15.5% for fixed networks.[31]

In September 2020, EKIP outlined plans to launch an auction for frequencies in the 5G mobile spectrum in the fourth quarter of 2021. The regulator submitted a draft financial plan to Montenegro's parliament on September 29th. The document states that EKIP plans to launch a single auction for the frequencies in the 694-790 MHz and 3400-3800 MHz bands, as well as 1 GHz of the 24.25-27.5 GHz band.[32]

3.4.5 Electromagnetic fields levels and the implementation dynamics

Allowed Electromagnetic Field Levels in Montenegro are set by the ministry responsible for environmental protection, which is the Ministry of Sustainable Development and Tourism. According to the "Rules on the limits of exposure to electromagnetic fields" adopted 2015,[33] in Montenegro limits recommended by relevant ICNIRP guidelines for general public exposure, and half of them for sensitive areas (schools, hospitals, kindergartens and buildings in which people live) are applicable.

3.4.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

As of 2020, there have been no announcements related to 5G commercial launches in Montenegro. Nevertheless, EKIP has anticipated that 5G mobile network will not be commercialized before 2022.[34]The regulator also informed the press that operators have expressed an interest in conducting 5G trials in 2020.[35] For the near future, EKIP claimed that the country's mobile operators are keen to carry out 5G pilot projects 2020, which will provide an opportunity to showcase the technology's benefits to the public and businesses.[36]

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3.5 REPUBLIC OF SERBIA

3.5.1 ICT background and current status of broadband

Serbia has made significant progress in the ICT sector over the past years, and recently achieved the status of the country with the highest average Internet speed in the Balkans.[1] Despite being a predominantly rural country, the ICT sector is growing with many business opportunities. For example, between 2008 and 2015, export revenues from IT services tripled while the revenues from computer services have increased by four times.[2] Some of the challenges in the ICT sector remain around the areas of broadband access across the country's regions, fixed-broadband networks in rural areas, and the coordination mechanisms for connecting the actions of different stakeholders remain some of the challenges in the ICT sector in the country.[3]

The Digital Agenda for Serbia consists of two documents: the "Strategy for the Development of the Information Society in the Republic of Serbia to 2020" and the "Strategy for the Development of Electronic Communication in the Republic of Serbia from 2010 to 2020." These documents cover various aspects of socioeconomic development in relation to ICT such as education, business, security, as well as e-government, e-health, and e-justice. As pertained to broadband, these two strategies include the following goals and targets that Serbia needs to reach by 2020: [4]

- Increase network availability to all users;
- Provide broadband access by FTTH/B/C to all users;
- Offer Broadband services with speed rate of at least 100 Mbps;
- Proceed with harmonization of the Radio frequency allocation plan with the international actors (EU Plan);
- Allocation of 120 MHz of digital dividend frequencies for mobile broadband access;
- Improvement of tariff policy by applying the cost model in pricing of services by operators with significant market share;
- Harmonization tariff of operators with significant market share with the application of the cost model, analysing and defining relevant retail and wholesale markets;
- Formation of the National Network based on IP technology, according to the principles of open networks and open services, which connects all available network state-owned infrastructure;

- Provision of access to the network with special purpose connections, i.e. functional systems, at the level of the passive optical network. The resources of such a network should approach on the principle of multiplex by wavelength;
- Ensuring the distribution of digital television programs using the National Network by expanding it with microwave links;
- Defining the framework for sustainable development and exploitation of broadband network and service.

These strategies state that these goals shall be based on the following principles: I) Technological neutrality of networks and services; II) Broadband access as a universal service; and III) Development of next-generation networks.[5]

As part of the accession process, a 2019 report by the European Commission provides three recommendations for Serbia, stating that its government should:[6]

- Harmonise its legislative framework in electronic communications with the 2009 EU regulatory framework;
- Ensure financial and operational independence, of the regulators for electronic communication and postal services (RATEL) and for electronic media (REM);
- Take measures to ensure implementation of competitive safeguards and facilitate market operator's access to telecommunication infrastructure (ducts, antennas, fibre optics and fixed telephony infrastructure).

Additionally, the "Next Generation Broadband Connectivity for Rural Schools in White Zones" project, planned within the context Western Balkans Investment Framework (WBIF), is in the preparation phase and will benefit from a 72 million EUR loan provided by the European Bank for Reconstruction and Development (EBRD).[7] This project will enable development infrastructure and interconnection of the two existing operators' networks and schools in rural (white) zones. Schools will obtain fibre connectivity (1 Gbps+), while neighbouring households (private investment part that will follow middle-mile CAPEX investment by the government) will obtain 30+Mbps connectivity.[8]

3.5.2 Broadband and mobile telecommunication data

ITU data shows that 77.4% of individuals in the Republic of Serbia used the Internet in 2019.[9] In 2010, the ITU data for the country was 40.9%.[10] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 18.5,[11] being the majority through xDSL (about 37.8%) or cable access (about 44.8%)[12]—although the number of users of xDSL users have been slowly decreasing over the years.[13] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 percent of the GNI per capita in 2019, while Serbia's corresponded to 2.9 per cent for unlimited Internet data cap.[14]

Serbia's xDSL subscriber structure has changed significantly over the years, with a significant increase of the number of users of VDSL technology that account for 42% of the total number of xDSL users, due to greater demand for packages with bigger throughput.[15] Wireless broadband access, however, has remained stable in the 2013-2018 period,[16] although the average data rates were improved by all operators in 2019.[17] While the north districts of Belgrade and South Bačka have the highest household penetration rates in terms of broadband subscription, the south districts Jablanica and Pčinja have the lowest.[18] ITU data from 2019 show that 80.1% of households in Serbia had Internet access at home.[19]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was of 96.4%,[20] which makes Serbia the country with the highest penetration rates for mobile services in the Balkans.[21] There are three mobile network operators (MNOs)—Telekom Srbija, Telenor and VIP Mobile—that currently have licenses for the use of radio frequency. In 2019, the number of active mobile-broadband subscription per 100 inhabitants was 71.3.[22] In terms of price, the country's mobile-data basket cost corresponded to 1.3 per cent of the GNI per capita in 2019 for a monthly allowance of 5.0 Gb, while the European region's average was 0.8 per cent for the same year.[23] With a relatively equally distributed market share, the total revenue of all MNOs has been constant over the last 3 years, but individual net realized profits are declining at the same time.[24]

For the first quarter of 2020, RATEL reports that the majority of mobile subscribers (around 47%) connected to the Internet benefited from connectivity speed of over 50 Mbps, while around 42% accessed the Internet in between 10 Mbit/s to less than 30 Mbit/s.[25] In comparison to the previous year, data transmission over mobile networks has shown growth, amounting to 101.3 million Gb in Q1 2019, meaning that a mobile broadband subscriber used on average 183 MB daily, or almost 5.6 Gb a month.[26] In total, mobile-broadband Internet traffic within Serbia in 2019 was equal to 0.3 exabytes.[27]

Furthermore, data from the Republic Agency for Electronic Communications and Postal Services (RATEL) published in the market overview for 2018, all three MNOs have a high 3G and 4G/LTE mobile network

coverage, covering respectively 99% and 97% of the population[28] and between 72% and 78% of the territory of the Republic of Serbia.[29]

3.5.3 Current progress on 5G: consultations and national strategies

In line with the strategic framework of the European Union, Serbia's "Strategy for Development of New Generation Networks Until 2023", adopted in 2018, defines measures to ensure infrastructure development of a Single Digital Market in the country.[30] The introduction and expansion of cloud computing, Internet of Things (IoT), as well as the development of mobile systems pertained to the 5G are central points of discussion in this national strategy.[31]

The document acknowledges the need of updating the regulatory framework necessary to support the development of 5G in Serbia. Oriented by the notion that 5G, among future generation networks, is linked to overall increase in gross domestic product and socioeconomic development, the document specifies targets and goals, focusing specifically on:[32]

- Developing of a backbone for broadband network by consolidating the infrastructure that is state-owned;
- Developing of broadband access networks by:
  - Providing conditions for easier construction of broadband infrastructure via the enactment of a broadband law. That will help telecom operators to reduce the cost of building such infrastructure by sharing existing infrastructure and facilitating acquisition of necessary permits;
  - Providing state aid to operators or other legal entities that agree to build their network in areas where there is a little economic viability for the construction of broadband infrastructure;
- Preparing for Spectrum auction for the development of new technologies and 5G in particular.

Other targets and goals that are relevant to 5G to a greater or lesser extent include:

- Strengthening broadband capacities for the needs of state/public institutions;
- Offering a larger set of IP addresses by switching to IPv6;
- Providing state aid incentives for operators that switch to IPv6;

- Promoting the introduction and use of IoT;
- Promoting the introduction and use of smart services in all sectors of the economy;
- Promoting cloud computing and expanding data centres in the country;
- Adopting interoperability standards that would ensure exchanging of large amounts of data between different entities with the aim of introducing smart services;
- Developing mechanisms for improving the safety of work on the Internet;
- Improving the conditions for educating the population in the field of ICT at all educational levels.

3.5.4 Spectrum assignment for 5G & market development

Serbia is the one of the few countries that has made both digital dividends free at the moment of its switchover to digital broadcasting. The 800MHz (DD 1) band was sold, and 700MHz (DD2) band was earmarked for use by 5G systems. [1]

The Government of the Republic of Serbia has adopted Allocation Plan of Radio Frequency Spectrum ("Official Gazette of RS", No. 89/20). Due to the decisions of the World Radio Conference 2019 (WRC19) this plan has allocated 700MHz (694-790MHz), 26GHz (24.25-27.5GHz) for IMT-2020 purposes. Thus, besides these two bands, the band 3400-3800MHz has already been allocated for the IMT. Having in mind necessity for testing of the new technologies, 3400-3500MHz band has been reserved for new projects with that goal for the period of next three years. The Allocation Plan has reserved 5+5MHz for smart cities applications in 1800MHz band.

Spectrum assignment plans for 2500MHz-2690MHz and 3400MHz-3800MHz bands are in the process of adoption of the Ministry of Trade, Tourism and Telecommunications. Moreover, the Ministry is preparing the Rulebook on minimum requirements for issuing individual licenses for the use of radio frequencies according to the tendering process, in radio-frequency band 3500-3800MHz. 5G network is expected to be rolled out in 2021.

The Government of the Republic of Serbia has adopted, in 2019, the Bases for Development of Initial Network for Testing of New Technologies Necessary for Inclusion to Digital Single Market. It represents realization of goals defined in the Strategy for Development of New Generation Networks and Services

until 2023. Hence, the initial network has been launched for the pre-commercial tests, by license for temporary 5G spectrum usage in 3.4-3.8GHz (100MHz; 3.45-3.55GHz) with LTE anchor in 2.6GHz (2x20MHz; 2.64-2.66GHz DL; 2.52-2.54GHz UL), issued by RATEL.

In accordance with the Strategy for the Development of Next Generation Networks by 2023, the Ministry, in cooperation with the Organisation for Security and Co-operation in Europe, has organized workshops intended for local government representatives on the territory of Serbia, which highlighted the importance of new technologies in broadband access and their impact on the development of industry[33]. Presentations were held at which representatives of the Ministry, RATEL and the academics presented data and challenges related to the setting up of base stations. The data on the limits of exposure levels of electromagnetic radiation produced by mobile systems and the measured results have been presented. Workshops produced positive response and organizers have been asked to expand number of cities covered by future workshops. Due to the COVID-19 pandemic, the Ministry and OSCE plan to organize virtual workshops from the beginning of the next year.

Having in mind the importance of future 5G network and challenges introduced by this technology, OSCE initiated development of a study that will cover major aspects of its introduction, regulation and exploitation. This study is aimed at, not only experts, but also to give insight to public about main 5G performances as well as obstacles that could slow down the realization of a new network[34].

OSCE provided funds for realization of the study: Fifth generation of mobile systems 5G – on electromagnetic radiation and its effect on humans and environment, how it is going to be regulated and monitored, how the 5G is functioning and why it is necessary for us. The study will be done by independent experts in the field of mobile communications and is planned for the end of 2020.

Besides that, RATEL has commissioned a feasibility study recommending that spectrum auction for minimum of 15 years should be scheduled for early 2021 on technology neutral basis, according to the Law on Electronic Communications, and with national allocation. It also recommended that the licence fulfilment requirements should be related to the quality of service provided and independent of technology used.

However, due to the regional and local impacts of the COVID-19 pandemic, Serbia's Ministry of Trade, Tourism and Telecommunications have informed the local press in July 2020 that the auction for the 5G spectrum will be postponed and it is likely that will be held in the first quarter of 2021.

3.5.5 Electromagnetic fields levels and the implementation dynamics

In the Republic of Serbia, the limits of exposure to electromagnetic fields for the general public are defined in the Rulebook on the limits of exposure to non-ionizing radiation ("Official Gazette of RS," No. 104/2009), and they are approximately two and a half times lower and more stringent than the ICNIRP recommendations on limits of exposure to electromagnetic fields in radio frequency bands 100 kHz-300 GHz.[35]

As part of the *EMF RATEL* project, which is a system for continuous monitoring of electromagnetic field levels, RATEL has been continuously monitoring changes in electromagnetic field levels, as well as exposure of the population to electromagnetic radiation.[36]In this moment, a total of 57 sensors performing continuous measurements are installed nationwide.[37] RATEL also informs that the results obtained through measurements so far have been far below the allowed electromagnetic field level values. No field levels deviating from the prescribed values and applicable standards were recorded at any time.

3.5.6 5G Commercial Launches: Announcements, Trail Cities, and Digital Cross-border Corridors

During the 2018 Digital Assembly in Sofa, Bulgaria, Greece and Serbia signed a Letter of Intent to work together on the Thessaloniki – Sofia – Belgrade 5G cross-border corridor for connected and automated mobility (e.g. driverless vehicles over hundreds of kilometres of motorways).[38] Represented by Serbia's Ministry of Trade, Tourism and Telecommunications, the letter of Intent propose action in data exchange, common approaches on regulations, and coordinated policy action.

This ratification builds on a number of previous agreements among European countries, and highlights that a pan-European network of 5G corridors is under development.[39] Within the context of the Serbia-Greece-Bulgaria agreement, there are three major guiding goals:[40]

- The corridor will provide a technologically neutral hub for industry, research centres, academia and any other stakeholders for testing and evaluating innovative mobility technologies;
- "Learning by experience approach" and exchange of information will be key points in the use of the corridor;
- Recognition and coordination in specific regulations on automated driving testing will be key aspects in the collaboration.

In June 2019, operator Telenor launched a test service of the first 5G station in Serbia utilizing a temporary license for spectrum in the frequency of 2600MHz and 3500MHz bands, previously assigned by RATEL for 5G tests.[41] Housed in the Science-Technology Park Belgrade, the Telenor's 5G network became available in September 2019 to students at the School of Electrical Engineering, University of Belgrade, who are the first partners of this project.[42]

Relying on the 5G test environment enabled by Telenor, other companies are developing 5G-related products and research. For instance, local start-ups (Novelic and DigitalWorx) performed presentations on development solutions related to smart manufacturing and IoT simulations.[43]

Additionally, a U.S.-based Drone Company Easy Aerial has now a development centre in the Science-Technology Park Belgrade named Startup Aerial d.o.o. Serbia. The start-up is performing research and tests on 5G-enabled drones for advancing reliable video-surveillance and integration with other security-based systems, which may have application for emergency services systems.[44]

Within the context of 5G as an enabler of the smart city projects and IoT ecosystem, the Serbian Government signed an agreement between the country and Huawei Technologies, encompassing the country's largest cities: Belgrade, Novi Sad and Nis (which will serve as the pilot-project).[45] This project entails the building of system of transmitters and the development of an information system which should enable an economic implementation of various services (sensors, lights and counters for collecting and analysing data - traffic signalization, parking spaces, water meter control, public lighting, etc.).[46] The special goal of this cooperation is the opening of the Huawei Innovation Centre for Digital Transformation.[47]

In December 2019, the Bechtel-ENKA Joint Venture has been selected by the government of Serbia to build the Morava motorway—Serbia's first 5G-ready digital motorway and flood defence system in the West Morava river valley due to complete by the end of 2023.[48] With construction set to start in 2020, the dual carriage way will cost 783 million EUR. The road will be 112-kilometre long and is set to create 10,000 jobs in central Serbia. Alongside with the road infrastructure, a telecommunication corridor will be built beneath the side of the motorway to allow for future 5G fibre and tower installations, which will allow broadband to impact the economic development zones along the route between Preljina and Pojate.[49] The road will also connect to the north-south motorway running between Hungary and North Macedonia, in addition to linking with trans-European corridors X and XI, which connect Austria with Greece and Italy with Romania.[50]

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3.6 GEORGIA

3.6.1 ICT background and current status of broadband

Since 2010, Georgia has strengthened its support to ICTs through a variety of public-private partnerships and digital-related initiatives and programs such as zone tax exemption, foreign investments and projects to improve the labour force. The 2014 document "Georgia 2020—Social Economic Development Strategy" outlines several target areas to enhance the digital ecosystem, including high-speed broadband Internet for future development, e-literacy and capacity building, innovation and high-tech, and e-government.[1] With a competitive sector largely driven by private investments, the telecommunication market remains among the fastest growing and in 2017 represented between 5-7% of the country's GDP.[2]

In 2014, the Georgian government announced its plans to provide high-speed Internet throughout the country through a program called "Broadband Internet to Every Citizen," which was executed by the NNLP 'OpenNet.' Established by the government in 2015 as the National Program for Broadband Development as a non-entrepreneurial and non-commercial legal entity, OpenNet has performed its activities in accordance with previous development-related resolutions which was approved by the Georgian government on July 28, 2016.[3]

More recently, Georgia's National Broadband Network Development Strategy for 2020-2025[4] mandates that schools, highways and public facilities must be provided with Internet access at a download speed of 1 GBps by 2025, in line with EU plans, and also aligned with plans for 5G development in the country.[5] The strategy aims not only at creating infrastructure, but also establishing Georgia as a digital and information hub in the region between Europe and Asia while also upgrading knowledge and skills, leading to employment growth.[6]

Within the framework of the OpenNet project and the Georgia's National Broadband Network Development Strategy for 2020-2025, the World Bank is supporting the development of broadband through the Log-in Georgia Project, a 32.7 EUR million support package[7] which has the goal to expand access to affordable broadband in rural settlements and to support the development of Georgia's digital economy.[8] The three major project outcomes include: i) increasing access to affordable broadband internet; (ii) promoting the use of broadband-enabled digital services; and (iii) project implementation support.[9] The project expects to connect up to 1,000 villages, including settlements in mountainous regions, to high-quality and affordable broadband service. Nearly 500,000 people, residing in locations

currently unserved by high-quality broadband services stand to benefit from deployment of the broadband infrastructure envisaged by the Log-in Georgia Project.[10]

In the context of rural areas and under the project Harmonized Digital Market (HDM) EU4Digital "Eastern Partnership Countries (EaP) Broadband Infrastructure Development Strategy," other development goals in Georgia focus on enhancing the relevant legal and regulatory framework for broadband development in line with the EU norms and overcoming the digital divide across the country's regions.[11]

The urban-rural divides are intertwined with the development of ICT in the country. Approximately 83% of urban households benefit from fixed broadband services, while in rural areas the figure drops to 5%.[12] Over the past years, growth in mobile broadband has been steady, supported by the auction of spectrum in the 800MHz and 2100MHz bands which has enabled the network operators to expand the reach and capabilities of LTE services, which now covers the vast majority of the population.[13] On a regional level, the construction of the Black Sea and the Caspian Sea submarine fibre-optic cable backbone is currently under discussion by the Ministry of Economy and Sustainable Development.[14]

3.6.2 Broadband and mobile telecommunication data

ITU data shows that 68.8% of individuals in the Democratic Republic of Georgia used the Internet in 2019.[15] In 2010, the ITU data for the country was 26.9% and, in 2000, 0.5%. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 23.6.[16] ITU data also shows that 79.3% of households in Georgia had Internet access at home in 2019.[17] Fixed-broadband networks (using fibre-optic or cable networks) are limited in their reach outside of urban areas.[18] The country's data published by the Georgian National Communications Commission (GNCC) from May 2020 show that that the Tbilisi and Adjara are the regions with the highest Internet penetration in the country, while the north-western region of Abkhazia has the lowest penetration rate.[19] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 percent of the GNI per capita in 2019 (and CIS 3.7 per cent), while Georgia's corresponded to 3.4 per cent of the GNI per capita in 2019 for an unlimited Internet data cap.[20]

Since 2014, fibre infrastructure has been steadily expanding in the country while xDSL has been reducing. In 2018, 75% of total subscriptions used FTTx technology, compared to only 31% in 2010 (when xDSL accounted for 59% of total subscriptions). Nowadays, fibre is by far the most used technology in Georgia and Wi-Fi the second most common, mostly in rural parts of Georgia, where FTTx connections are not available.[21]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was of 134.7.[22] At this moment, there are three 5 MNOs operating in Georgia—Geocell, Magticom, Beeline (Veon Georgia), and Silknet—that currently have licenses for the use of radiofrequency for commercial use. The number of active mobile-broadband subscriptions per 100 inhabitants was 79.9 in 2019.[23] During the same year, Georgia's mobile-data basket cost corresponded to 0.8% of the GNI per capita for a monthly allowance of 2.0 Gb,[24] which is the same as the European region's average of 0.8 per centre, while the CIS region average is 2.2. per cent. With extremely low prices compared to many other regional and European countries, 2G and 3G networks cover approximately 99.98% of Georgia's population,[25] while 4G/LTE covers 99.72%.[26] While all of the MNOs have been investing to expand the reach and capabilities of LTE infrastructures to areas outside of Tbilisi,[27] Magticom and Veon Georgia are the operators with most mobile Internet traffic in the country.[28]

Due to the significant investments made by Georgian MNOs to improve telecom infrastructure and achieve higher coverage, Internet traffic has grown from 1.5 million Gb in 2013 to 63.7 million Gb in 2018.[29] In 2019, Georgia had 0.09 exabytes of mobile-Internet traffic.[30]

Although the majority of mobile subscribers are individuals, data show that the number of corporate subscribers is growing.[31] A nationally representative survey found that of the out 97.5% of firms in Georgia that had access to the internet in 2016, about 40% had broadband, 31% used DSL connections and the remainder access internet through their mobile phones (typically using a GSM connection)—although only 9.5% engaged in e-commerce.[32]

3.6.3 Current progress on 5G: consultations and national strategies

Since 2016, Georgia has been actively involved in the work of the Spectrum Expert Working Group (SEWG) established within the EaPeReg network to advance implementation and harmonization of next generation networks. Regarding 5G progress in the country, GNCC acknowledges that the development of broadband services and 5G technology plays an important role in the further development of the country and has accordingly developed a strategy to introduce 5G, incorporating elements such as coverage obligations, network access, and the possibility of a joint ventures to build the network.[33]

This initial plan seeks to achieve the following: [34]

- By 2020, in case of adjustments by the operators, GNCC should have the opportunity to ensure the temporary use of the frequency spectrum allocated to 5G;

- By 2020, based on the strategy and action plan developed and approved, 5G-based services will be launched in test mode in at least one geographical area.

GNCC's preliminary strategy also include a list of industries that are likely to be impacted by 5G development in the country such as transportation, infrastructure management, media, energy, public safety, smart cities, and e-health.

In July 8, 2019, GNCC started a 5G consultation process with operators to obtain their views and plans on 5G. This document outlined a plan for frequency allocation for 5G and the regulation of related issues.[35] Two out of the three operators shared their position, all in favour of the development of 5G network to be a necessary factor in the country's telecommunication sectors—both in terms of technological progress of the country and the advancement of the digital economy.[36] Despite the plan, there is no clear roadmap for 5G frequency allocation.[37]

According to private sector stakeholders, LTE technology will be enough for the foreseeable future in meeting the existing needs of the country. Operators also named a few existing obstacles such as the costs associated with deploying a new generation of telecommunications infrastructure, that need to be overcome in order to facilitate the introduction of 5G network in a relatively short time. To solve this problem, operators considered the possibility of non-discriminatory access to passive infrastructure to be used for state-owned (and not only) telecommunications purposes. GNCC notes that a legislative initiative has already been prepared to share the infrastructure used for telecommunications purposes, based on EU Directive 2014/61 / EU.[38]

In December 2019, GNCC developed and published the "Strategy for Promoting the Development of 5G Network and Services."[39] The document contains information about the plans, vision and goals of the Commission, including: I) 5G Frequency Band Release, Coordination and Harmonization Plan; II) Expected sequence of transmission for temporary use of 5G frequency bands III) List of liabilities; IV) Plan for legislative changes that will affect 5G; V) On development in Georgia; and V) Examples of future use of 5G in Georgia.[40] This document has been created with the purpose of making the spectrum dedicated for mobile broadband services available for operators in the first half of 2020. This spectrum plan allows operators to develop and expand 5G networks and products for future commercial use.

In April 2020, GNCC published the "5G Frequency Resource Fee Consulting Document." The regulator received questions regarding this document from MagtiCom Ltd and Silknet JSC. As part of the consulting regime, an online meeting was held to discuss questions related to the calculation of fees.[41]

In December 2020, GNCC published the "5G Terms and Conditions Consultation Paper". The consultation builds upon the previous consultations and on the previously calculated reserve prices, to present a vision regarding the obligations and licensing conditions for 5G service frequencies in the forthcoming auction.[42]

3.6.4 Spectrum assignment for 5G & market development

In 2014, Georgia agreed to gradually ensure the harmonization of the existing legislation in the field of electronic communications with the existing regulatory norms within the EU. With the assistance of the European Bank for Reconstruction and Development (EBRD), GNCC analysed the non-compliance of Georgian legislation and regulatory norms with European directives. As a result, a two-stage package of legislative changes for radio communication was developed: The first stage involves the introduction of general liberal fundamental approaches while the second involves individual licensing. [43]

GNCC states that the main inconsistencies that hinder the rapid technological development of the country are:[44]

- Lack of conceptual approaches to the use of frequency resources based on general permission and individual licensing;
- Inflexible regime for determining the licensing period;
- Freedom of choice of frequency resource use form and proportional selection criteria;
- Absence of a formal written consultation procedure for the allocation and issuance of frequency resources;
- Lack of opportunity to use frequency resources in test mode in a limited geographical area for a specified period on a non-commercial basis.

Due to the high importance given to 5G in the country, GNCC plans to hold an auction in 2021 to allocate the necessary spectrum. GNCC states that when determining the basic requirements for the 700 MHz and 3400-3800 MHz frequency spectrum, it is recommended for providers to make a specific coverage plan, which will include a specific list of cities and major roads to be covered under the 5G license. Besides, the regulator notes that the license should impose certain obligations regarding the coverage of specific settlements, as well as in terms of investments and network development.

Current Georgian legislation recognizes individual licensing through auctions as a preferred principle of frequency resource use. GNCC documents show that this often creates barriers to market access with new technologies, affects resource costs, and prevents the spread of new, diverse technologies and services across the country.

The law states that spectrum is an inexhaustible resource, which is fundamentally the opposite of EU approaches. According to this rationale, the resource is limited only in those ranges where there is an excess demand for individual licenses. This is largely because the Georgian market is not well saturated with the consumption of high-speed mobile broadband services and a certain part of the frequency bands for broadband services is untapped.[45]

The regulator is working with different network operators to ensure network synchronization and eliminate potential risks such as error regarding data transmission in asynchronous network; the need for geographical division of neighbouring and the same channels; and a continuous mode of service delivery to subscribers using various wireless networks. Accordingly, GNCC states that that synchronized operation eliminates any BS-BS and MS-MS interference, allowing neighbouring networks to coexist without additional filters and shielding frequency bands. This mode of operation facilitates the expansion of the mobile network at the expense of reducing interference.[46] GNCC considers it appropriate to impose a network synchronization obligation as one of the conditions of the license to avoid undesired interference and to ensure the sustainability of the service.[47]

According to the "5G Terms and Conditions Consultation Paper" presenting the vision for the 2021 auction, a total of 400 MHz will be available under the auction for frequencies in the 700 MHz, 800 Mhz, 3,400 - 3,800 MHz frequency bands distributed as follows:

- 703–733 / 758–788 MHz (2 x 30 MHz - 700 MHz band)
- 816-826 / 852-862 MHz (2 x 10 MHz - 800 MHz band)
- 3400-3800 MHz (5 x 50 MHz, 1 x 40 MHz, 1 x 30 MHz, 3400-3800 MHz)

Within the scope of auction, the regulator plans to make available following lots of spectrum in 700MHz, 800MHz, 3400-3800MHz frequency bands:

- 4 lots of a category A bundles composed as follows:
    - 700 MHz: 2x5 MHz
    - 3.4 – 3.8 GHz: 50 MHz
- 7 lots of category B standalone lots as follows

- 700 MHz: 2x5 MHz (2 lots)
- 3600-3650 MHz: 50 MHz (1 lot)
- 3650-3690 MHz: 40 MHz (1 lot)
- 3770-3800 MHz: 30 MHz (1 lot)
- 816-821 / 852-857 MHz: 2x5 MHz (1 lot)
- 821-826 / 857-862 MHz: 2x5 MHz (1 lot)

The spectrum cap will be 2x10 MHz in both the 700 MHz and 800 Mhz bands and 100 MHz in the 3.4-3.8 GHz band. Moreover, the reserve price will be 363,000 GEL/1MHz in the 700 MHz band, 741,000 GEL/1MHz in the 800 MHz band and 52,000 GEL/1 MHz in the 3.4-3.8 GHz band.

With regards to the licensing period, according to the Law of Georgia on Electronic Communications, the licenses issued will be valid from 15 years from the date of issue and obligation to start the activities is 6 months after the date. Regarding coverage obligations, incremental obligations with time are foreseen with the first obligations expected to be applicable 2 years from obtaining the license. Finally, the document also sets technical terms for operation.

The consultation was open until 22 December 2020 and also specifically requested feedback on the following topics:

- Whether the access to national roaming and / or local roaming should be considered within the framework of the mentioned licenses and in what form;
- Whether additional obligations for the standalone lots should be determined;
- Whether there should be one bundled lot reserved for a new entrant;
- Whether coverage commitments for the newcomer and the existing MNOs should be different;
- Whether the so called MVNO access for 5G network should be regulated;
- Present your vision infrastructure sharing and joint venture possibilities (Unified 5G Network).

3.6.5 Electromagnetic fields levels and the implementation dynamics

In the past, GNCC has studied the effects of mobile phone electromagnetic radiation.[48] The research aimed to advise the public about the harmful effects and permissible norms of mobile phone electromagnetic radiation, as well as to inform the population about measures to protect against electromagnetic radiation: http://www.ena.ge/gncc-sar. However, no further information is available in English regarding the EMF limits in Georgia more broadly considered.

3.6.6 Commercial launches: announcements, trail cities, and digital cross-border corridors

In April 2020, GNCC informed the local press that it has already carried out large-scale work to install 5G internet infrastructure and soon will announce a tender for operators.[49]

The Georgian Association of Small and Medium Operators indicated to local press that Internet tariffs will decline after 5G is introduced in the country, maintained that the GNCC sets optimal prices for operators leading up to the frequency spectrum auction in the country.[50] As of August 2020, however, there has been no 5G-related testing or commercial launches in the country, although Beeline Georgia already indicated its interests in 5G networks.[51]

Endnotes

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3.7 REPUBLIC OF MOLDOVA

3.7.1 ICT background and current status of broadband

The Republic of Moldova has a dynamic and competitive telecommunication market which is characterized by high Internet access speeds, good mobile services accessibility and robust nation-wide infrastructure. There is a clear interest and drive on the part of both the government of Moldova and the regulator to provide a strong role for ICT-centric innovation as a support for the economy.[1] Fixed-line and mobile broadband sectors have seen years of solid growth, but between 2016 and 2019 the sector experienced a revenue decline.[2] The mobile market is currently responsible for generating a larger portion of the telecom revenue in the country. Additionally, Moldova legislation in the ICT sector is largely aligned to the European Union legal framework.[3]

The Moldovan government has implemented a variety of ICT-related strategies on a national level, such as the 2005 National Strategy for Building an Information Society ("Electronic Moldova" or E-Moldova), the 2011 Strategic Program for Technological Modernization of Governance (e-Transformation), the 2013 e-Agriculture Strategic Program,[4] among other strategies and action plans.[5] The creation of the IT Park in 2018 also promoted fiscal and economic incentives,[6] thus enhancing the competitiveness of the IT industry by confronting challenges such as the low regional/international competitiveness, risk of business relocation to other countries, and the migration of a skilled labour force.[7]

The National Strategy for Information Society Development "Digital Moldova 2020" launched in 2013 currently guides the policies directed toward sustainable growth of the ICT sector and is based on three pillars[8] followed by an action plan:[9] I) Infrastructure and access – improving connectivity and access to the various networks; II) Digital content and electronic services – promoting the generation of digital content and services; and III) Capacities and usage – enhancing literacy and digital skills to enable the innovation and stimulate the usage.

In terms of broadband development in the country, the strategy listed the following goals for 2020:[10]

- All localities of the country shall have at least one point of access to broadband with a minimum speed of 30MB/s while at least 60% of households shall be connected to broadband Internet;
- At least 75% of citizens shall be Internet users;
- 100% of public services which may be provided electronically shall be available online;

- 100% of archives, civil status records, cultural and scientific heritage shall be digitized and available;
- At least 80% of citizens shall be satisfied with the quality of provided services;
- Public services shall be provided under the ID card, including electronic or through electronic or mobile identification;
- At least 70% of the population shall use electronic services;
- At least 60% of the population shall use digital signature;
- At least 20% of the population shall shop online;
- 100% of the population shall have access to digital terrestrial television.

In 2018, the government of Moldova launched the "Strategy for the development of the information technology industry and the ecosystem for digital innovation for the years 2018-2023." Through this strategy, more focused on IT and entrepreneurship, the government aims to facilitate the emergence of dynamic ecosystems through close collaboration with entrepreneurs, investors, corporations and other stakeholders, as well as multiplying IT solutions horizontally.[11] As of 2020, there are 2,145 companies with over 27,000 employees working in the IT sector, which generates about 7% of the country's GDP.[12]

In response to the COVID-19 pandemic, the Ministry of Economy and Infrastructure, the Ministry of Education, Culture and Research, the National Association of Information Technology and Communications Companies and the Tekwill ICT Training and Innovation Centre signed a Memorandum of Understanding on the 'Development of digital skills, IT and STEM throughout life' in July 2020. This document provides information on the use of digital technologies at all school levels. It also specifies the teachers' role in preparing students for digital transformation, thus ensuring the quality and relevance of ICT skills for professional activity in a digital economy.[13] Within the COVID-19 context, a roadmap with 37 actions for boosting the process of the digitization of the Moldovan economy and the expansion of e-commerce was also prepared by the government.[14]

3.7.2 Broadband and telecommunication data

ITU data shows that 72.1% of individuals in the Republic of Moldova used Internet in 2017.[15] In 2010, the ITU data for the country was 32.3% and, in 2000, 1.3%. A report by the National Regulatory Agency for Electronic Communications and Information Technology in Moldova (ANRCETI) shows that the country

also had one of the lowest fixed broadband costs globally in 2015.[16] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 16.6[17] with 94 active Internet service providers.[18] However, more recent data from ANRCETI shows that fixed broadband household subscriptions in Moldova amount to 25 every 100 inhabitants. As ANRCETI estimates an average of 3 persons per household ù, then the regulator estimates 75% of the population enjoys fixed access at home 2019.[19]

In 2019, half the subscriptions to fixed Internet access services benefited from speeds between 30 and 100 Mbps, while 13.8% enjoy speeds over 100 Mbps.[20] According to ANRCETI, FTTx connections increased by 14.7%, reaching 452,300, while coaxial cable connections increased by 20.6% to reach 53,500. FTTx technology now represents 66.6% of the total number of subscribers,[21] with a significant high rate in Chișinău and other major cities, while xDSL technology is most common in smaller towns and rural areas.[22] Moreover, the number of subscribers using xDSL connections was down by 10.5% to about 163,000.[23]

According to ANRCETI data, in 2019, the number of active mobile-broadband subscriptions per 100 inhabitants was of 88.8, an increase from the same figure in 2018 standing at 79.4.[24] At the moment of writing, there are 3 MNOs operating in Moldova—Orange Moldova, Moldcell, and Moldtelecom—that currently have licenses for the use of radiofrequency for commercial use. The mobile market sector now accounts for the majority of total telecoms revenue in the country.[25] In terms of network coverage, 3G covers 99% of Moldova's territory[26] and 4G networks provide the coverage of 95% of the territory,[27] serving 98% of the population according to ITU data.[28] The traffic generated by mobile broadband users via smartphones increased by 47.2% up to about 52.4 million GB out of the total of 104,7 million GB consumed during the reference period in the country, which increased by 24%.

Despite the overall decline in telecom revenues between the 2016-2019 period, ANRCETI data show that there has been a significant increase in sales from 2018 onwards, with Orange Moldova registering the largest growth in revenue (63.4%) at the end of 2019.[29] In 2019, the total number of users accessing mobile broadband based on 4G technology registered a significant increase when compared to 2018.[30] In the same year, the market for fixed broadband Internet access services in Moldova registered a significant increase, with the volume of sales rising by 6.1% year-on-year to reach 1.16 billion lei (59.1 million EUR).[31] In 2019 alone, the total amount of mobile-broadband Internet traffic within the country corresponded 0.1 exabytes.[32]

3.7.3 Current progress on 5G: consultations and national strategies

Moldova's Ministry of Economy and Infrastructure is finalising the draft programme on 5G, which was submitted for public consultation and is to be approved by the government by the end of 2020. Some of the preconditions for the establishment of 5G allocation and consequent implementation in Moldova set out by the Ministry of Economy are:[33]

- Creating the legal framework for sustainable development of terrestrial mobile electronic broadband communications and other types of communications for the years 2021-2025 by continuing the Radio Spectrum Management Program for the years 2013-2020;
- The need to harness the available radio spectrum resources;
- The need to continue the application of best practice with reference to the implementation of the EU's Multiannual Policy Program in the field of radio spectrum (Radio Spectrum Policy Program-RSPP, Decision 243/2012 / EU of 14.03.2012);
- Ensuring the possibility of implementing 5G mobile broadband communications services, which offer citizens and industries the competitive advantages necessary for development in a favourable environment.

In the National Development Strategy "Moldova 2030," approved on June 10, 2020 [34] by the Government, it is established that a considerable increase in access speeds is expected due to the development of the implementation of new access technologies and revamp of networks. The document also establishes the need to promote 5G accessibility at over 100 Mbps for any household in the country by 2030.[35]

In June 2020, the government held a public consultation session with operators as well as the National Agency for Public Health, the National Radio Frequency Management Service and the national regulator to discuss the new Radio Spectrum Management Programme, the plans of mobile communications operators regarding next-generation 5G technologies, and the state of play regarding the protection of public health.[36] MNOs informed that their investment plans did not foresee the implementation of 5G technology before 2023.[37] During the consultation, it was also agreed to create a working group with all stakeholders to develop the regulatory framework for the implementation of 5G technology in Moldova.

3.7.4 Spectrum assignment for 5G and market development

Moldova's Ministry of Economy and Infrastructure, in partnership with experts from ITU and Korean Information Society Development Institute, is developing a spectrum management program for 2021-

2025. This new document will continue the Ministry's spectrum management program for the 2013-2020 period, which had previously freed radio frequency bands 800 MHz, 900 MHz, 1800 MHz; 2100 MHz; 2600 MHz and 3400-3800MHz. [38]

The 3400-3800 MHz frequency band is free while the 700 MHz band is assigned for terrestrial television services in an analogue format as its allocation will be possible once the transition to digital television is completed.[39] Therefore, the new rules are set to continue the harmonization processes established in the previous program and aligned with the EU. The main tasks and objectives of the new policy program include:

- Concluding the activities for releasing of the spectrum in the 700 MHz band;
- Creating the legal framework for organization of an objective, transparent, non-discriminatory and proportionate auction process for the targeted spectrum resources;
- Developing long-term spectrum policy and ensuring medium and long-term predictability of radio spectrum resources usage;
- Maximizing the efficiency of the use of limited radio spectrum resources and stimulating the competition on the mobile electronic communications market.

Based on the technical requirements and channel arrangements are based on CEPT Decisions and Recommendation, there are two main stages for the development of the new program: I) consolidation of the current networks (2021-2022 years, some spectrum re-farming and consolidation activities on the current bands and technologies); and II) 2022-2025 years, creation of conditions and enabling the environment for implementation of 5G networks.[40]

The targeted bands for the new 2021-2025 spectrum management program include 700 MHz, 3600 MHz, 26 GHz, and also 1500 MHz (L band) and 2300MHz. The program also targets available spectrum resources from the 450MHz, E900MHz, 2100MHz and 2600MHz bands. With the ongoing strategies on the spectrum use that will pave the way for 5G implementation in Moldova, the government plans to:[41]

- Ensure stakeholders with sufficient spectrum resources that will make possible the implementation of 5G networks, and consequently the new applications and business cases that 5G can deliver;
- Implement new broadband technologies and services and increasing the capacities of existing networks;

- Attract new investments in the information and communications technology sector of the national economy;
- Increase the turnover of companies in this sector;
- Increase of the incomes to the state budget generated by the capitalization of the radio spectrum resources and by the economic activities in the market of the mobile electronic communications services;
- Promote the development of other sectors of the national economy as a result of modernization and continuous development of the radio communications infrastructure and the diversification of the offer of mobile electronic broadband communications services;
- Increase the accessibility of broadband mobile electronic communications services to the population as a result of establishing a fair and efficient competitive environment on the mobile electronic communications services market;
- Improve the quality of services provided; reducing the digital divide between rural and urban areas;
- Create new jobs and increasing the average wage in the ICT sector.

3.7.5 Electromagnetic fields levels and the implementation dynamics

There is no public information on EMF limits in Moldova. The country is in talks to participate in the World Health Organization EMF project.[42]

3.7.6 Commercial launches: announcements, trail cities, and digital cross-border corridors

Since 2018, the Orange Group implemented Nokia Voice over LTE technology in Moldova to significantly enhance the quality of its mobile voice services. Orange uses Nokia's Cloud-based IP Multimedia 2 Subsystem (IMS), which includes Telecom Application Server (TAS), a native cloud application, to deliver full-featured 4G network calls. Through this implementation, Orange is also delivering virtualization of its core network, a key milestone for the launch of 5G.[43]

In a January 2019 meeting with high-level government representatives, the Chinese company ZTE expressed business plans to allow the implementation of 5G technology in Moldova.[44]

In March 2019, Orange Moldova became the first operator to test 5G technology in the country. On that occasion, Orange Moldova shared with the Moldavian public that their 5G strategy is based on improving high-speed mobile bandwidth; establishing high-speed access to the fixed network; and promoting applications to support the local business digital transformation.[45] Several months before the first test, Orange Moldova expressed their interests in 5G implementation as well as mobile financial services to the Moldovan government.[46]

In April 2019, Moldtelecom displayed their preliminary work on 5G research and development to the public on a mobile truck lab at the Museum of Outdoor Technology of the Technical University of Moldova. Operator's technical experts discussed topics in wireless networks, backhaul, IT, and basic network services to hundreds of visitors.[47] There were also interactive presentations on large-scale infrastructures, ecosystems, as well as 5G-related equipment such as robots, vehicles, and smart TVs.[48]

In October 2019, ANRCETI hosted the 9th EaPeReg Network (Eastern Partnership Electronic Communications Regulators Network) meeting of the Radio Frequency Spectrum Expert Working Group (SEWG), which is fostering 5G frequency harmonization across EaP countries.[49]

As of September 2020, there have been no commercial 5G launches as the national MNOs did not requested the national regulator authorizations in order to commercially operate 5G networks and the necessary equipment.

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3.8 TURKEY

3.8.1 ICT background and current status of broadband

Turkey's telecommunication sector has gone through tremendous changes during the last decade, driven by advancements in technology and increasing customer demand.[1] The ICT sector is considered a priority sector by the Turkish government and various initiatives have been taken to promote investments in the area.[2] Government contributions to the country's ICT ecosystem include programs and strategies such as the Turkish National Information Infrastructure Plan – TUENA (1999), e-Turkey Initiative Action Plan (2000), e-Transformation Turkey Project Short-term Action Plan (2003-2004, 2005) Information Society Strategy and Action Plan (2006-2010), the second Information Society Strategy and Action Plan (2015-2018),[3] and others. Turkey's Strategic Vision of 2023 sets out important goals for the country, giving special importance to ICTs as an accelerator for the achievement of the UN's 2030 Agenda for Sustainable Development and the SDGs. The country's goals include I) Expanding the economy to rank among the global top ten; II) Transformation to knowledge-based society; III) Building an intercontinental hub for ICTs; and IV) Providing an ICT-based economic growth, enhancing high-speed broadband access for all.

The country's telecom network has been undergoing a fast modernization process, with a considerable expansion of its geographical coverage and provision of various telecom services. On the one hand, communication infrastructure between cities is largely possible due to an advanced networked of intercity backbone that relies both on fibre-optic cable and digital microwave radio relay. On the other hand, domestic satellites currently cover most of the country's rural areas, and more satellite-projects are underway with expected launches for the upcoming years.[4]

In terms of broadband development, Turkey's National Broadband Strategy and Action Plan for 2017 to 2020, which emerged within the framework of the 2015-2018 Information Society Strategy, outlines the following basic principles:

- Improvement of the broadband infrastructure across the country,
- Expanding fiber access across the country,
- Increasing capacity and speed of broadband connectivity,
- Ensuring the sectorial development based on competition and in compliance with the market requirements,
- Developing the demand on the broadband internet services.

In terms of private sector expansion, the country's privatization program has reduced state involvement and attracted a significant number of international companies to make investments in Turkey's digital market.[5] As of now, xDSL and mobile broadband technologies are the most common Internet technologies in Turkey. Although cable and fibre penetration is low in Turkey, both connectivity technologies are steadily growing.

Turkey has also experienced a steady growth in e-commerce. Data from the Turkish Statistical Institute show that in 2018 the rate of e-sales of enterprises increased by 1.4 points compared to 2017 and became 11.2%. E-sales concern the receipt of orders by methods specifically designed for the purpose of receiving orders, either via electronic data interchange (EDI) or through websites or apps (web sales). This percentage was 24.4% in enterprises with 250 or more employees, while 12.9% in enterprises with 50-249 employees, 10.5% in enterprises with 10-49 employees.[6]

3.8.2 Broadband and mobile telecommunication data

BTK data for the first quarter of 2020 shows that 79.0% of individuals in Turkey used the Internet, an increase compared to 2019 official ITU data[7] standing at 74. In 2010, according to the ITU data, the proportion of Internet users stood at 39.8% and 3.8% in 2000.[8] In 2018, the number of fixed-broadband subscriptions per 100 inhabitants was 17.06.[9] BTK data shows that 90.7% of households in Turkey had Internet access at home in 2020;[10] the ITU figure for 2019 was 88.3%.[11] While 50.8% of households used fixed broadband connection (ADSL, cable, optic fibre, etc.) as reported by Turkstat, data shows that 98.6% of households accessing the internet made use of mobile broadband.[12] Over the years, fixed-broadband usage has increased considerably, totalling about 3.3 million subscriptions relying on fibre technology (FTTH/FTTB) by the first quarter of 2020. In 2019, 93.3% of enterprises used a fixed-broadband connection to access the Internet.[13]

Recent data by the Information and Communication Technologies Authority (Bilgi Teknolojileri ve İletişim Kurumu – BTK), Turk Telekom has the widest fibre infrastructure in the country with a 308,000-kilometre network, while other operators' fibre length was 89,000 kilometres in 2020.[14] Compared to the OECD average of 31.4% fixed broadband population penetration rate, Turkey has important growth potential with its 17.5% penetration rate estimate for 2020,[15], while ITU data for 2019 shows 17.1 subscriptions per 100 inhabitants.[16]

With regards to mobile, there are 3 mobile network operators (MNOs) operating in Turkey with the following subscriber market share: Turk Telekom (28.4%), Turkcell (40.6%), and Vodafone Turkey (31%).[17] According to the latest BTK data, in the first quarter of 2020, the number of active mobile-cellular subscriptions per 100 inhabitants was of 98.4,[18] while the official ITU data for the same indicator from 2019 reports 96.8%.[19] Moreover, according to ITU statistics, mobile broadband subscriptions per 100 inhabitants amount at 74.8.[20] 4G LTE networks are well developed and cover about 98% of the population in the country;[21] the official figure for 2019 stood at 96.7%.[22] In 2019, the mobile-broadband Internet traffic within the country corresponds to 4.1 exabytes.[23] As of 2020, BTK data show that the average monthly mobile data usage per active LTE subscriber in Turkey was 9,1 GB.

3.8.3 Current progress on 5G: consultations and national strategies

In April 2016, BTK established the "Turkish 5G Forum," also known as the 5GTR Forum—a baseline program that brings together Turkey's prominent academics, research and development firms, vendors and operators to discuss 5G development in the country.[24] There are four working groups under the 5GTR Forum. Working groups for Core Network, Physical Network, Service and Applications and Standardization under the 5GTR Forum organization structure, that are established to provide 5GTR Forum activities to be efficient in a short period of time.

5GTR Forum organises different meetings, workshops and cooperation agreements with relevant platforms. In this context, "The Automotive Sector on the Road to 5G Workshop" was organized on 11 May 2017. This workshop, dedicated to one of the sectors that will use 5G technology mostly, aimed to see the trends, studies, plans and challenges related to 5G automotive vision and to establish a common working platform between the electronic communication sector and the automotive sector.

Also "Turkey-Japan Terahertz Communications Technology Workshop" was held on 13 October 2017. The workshop hosted by the BTK was organized in cooperation with the Japanese National Institute of Information and Communication Technology (NICT) and Medipol University with participation of many university and sector representatives. In addition, in the 4th Global 5G Event held in Seoul within the frame of international collaborations, two separate Memorandum of Understandings were signed on 23 November 2017 between the 5GTR Forum and the 5G Forum Korea and between the 5GTR Forum and Japan 5GMF in order to develop the external relations of the 5GTR Forum with the equivalent institutions.

In June 2018, the signing ceremony of "End to End Domestic and National 5G Communication Network Project" was held in Ankara by the Ministry of Industry and Technology, the Ministry of Transport and Infrastructure and BTK. This project, which is supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK) has been carried out by 14 companies under the Cluster of Communication Technologies (*HTK*) and 3 mobile operators. As a result of the project, critical infrastructure components for 5G will be produced locally and nationally such as 5G core network, 5G base station, 5G network and business management software.[25]

Since 2016, 5GTR Forum members had various meetings and prepared the "5G and Beyond White Book" in 2018,[26] in addition to providing support of Turkish companies within the framework of the EU HORIZON 2020 programs. Turkey's 2018 5G white paper discusses the possible and necessary work to be done regarding the network and physical layers, and the services and applications that will run over these layers that form the core 5G network in Turkey.[27] The "5G and Beyond White Book" provides a perspective on the current situation in 5G technologies and studies in other nations, showing predictions of 5G architecture and the potential technology building blocks for 5G requirements. In addition, "5G and Vertical Sectors Report" has been published by BTK on the use of 5G and its effects on vertical sectors.

As part of the Turkish government's plan to deploy an advanced telecom infrastructure serving millions of citizens, Turkish operators are moving ahead with more robust software and hardware development. The strategy also predicts that the 5G-related research and development will prioritize domestic production, which will likely increase supply and demand together, and that operators will require incentives and obligations.[28]

An example of this is the "End-to-End Domestic and National 5G Network Project," which was recently initiated by the Communication Technologies Cluster (HTK) with the support of BTK, OSTİM and TÜBİTAK. The project's goal focus on the development of critical network hardware and software that are specific for 5G technology in order to improve Turkey's domestic and national 5G infrastructure. In July 2020, the project's executive board had a digital meeting with high-level government servants and more than 100 participants from public institutions and private sector representatives.

Furthermore, as part of Turkey's 2023 Goals, several 5G smart city-related projects are being implemented across various cities. These smart city projects aim to generate cost savings and provide the infrastructure necessary to fuel future tech developments.[29]

3.8.4 Spectrum assignment for 5G & and market development

The GSM frequencies in the Turkish mobile market range from 800MHz to 2600 MHz, with Turkcell possessing overall the widest amount of spectrum.[30] In August 2015, BTK held an auction for 4G, which represented an important milestone for Turkey's transition to 5G.[31] Excluding value-added tax, the total auction fee for 365.4 MHz of spectrum across 18 packages in 5 separate frequency bands (800, 900, 1800, 2100 and 2600MHz bands) amounted to the equivalent of 3,356 million EUR. Following the auction, the portion of frequencies allocated to mobile operators increased from a total of 184MHz to 549MHz.[32]

With regards to 5G, testing licenses have been provided to operators for the 3.5, 3.7 and 26 GHz bands.[33] However, there is no prediction for 5G spectrum auctions in Turkey in the foreseeable future.[34] The regulator has announced that upon the renewal of the infrastructure by the current operators from the 2015 auction, and will automatically be used without the need for licensing a new service provider.[35]

According to BTK, in the context of operators' need of wider spectrum blocks required by 5G, the public announcement of spectrum identified for mobile broadband services with release dates enables operators to make their plans effectively. This information enables operators to save cost of installation of more base stations due to the lack of spectrum and the increase in data usages.

In this regard, BTK has prepared a draft mobile broadband spectrum strategy[36] to identify the roadmap which is necessary to achieve our country targets related to mobile broadband services (such as increasing minimum downlink rates per user to EU level, decreasing the customers' fees for accessing these services, release of new technologies). Taking into account the assigned mobile spectrum and the level of mobile service usage, the report consisting of all spectrum identified for IMT services with assignment dates and the determination of necessary spectrum for sustainable growth of mobile services has been presented to the stakeholders.

In this draft strategy document, spectrum blocks are classified under three periods for the dates of assignments: Short, mid and long term. According to the draft report, Turkey plans to assign mainly 694-790 MHz, the remaining spectrum in 2500-2690 MHz, 3400-3800 MHz and 24.25-27.5 GHz frequency bands in the short term for IMT. Also within the 700 MHz frequency band 698-703 MHz and 733-736 MHz bands (2x8 MHz) are foreseen for BB PPDR services.

Regarding 5G additional spectrum planning, legal framework for granting of right of use of spectrum is drawn by Electronic Communication Law Numbered 5809, which assigns the Ministry of Transport and Infrastructure as strategy and policy decision maker and BTK to develop strategy proposals. Within this

framework, BTK will also develop a strategy proposal for the granting of rights of use of 5G frequencies and present to the Ministry of Transport and Infrastructure for final revisions. After the approval by the Ministry of Transport and Infrastructure, BTK will take necessary actions to apply all steps defined.

3.8.5 Electromagnetic fields levels and the implementation dynamics

In 1999, the Turkish government held a symposium on "Electromagnetic Pollution," and since then the country has been involved with EMF, providing studies on the biological effects of electromagnetic and possible ways of providing guidance. While many different radiation frequencies are under consideration, most of the research activities have focused on 50 MHz TV broadcasting frequencies, 900MHz, 1800MHz, 2100MHz and 2450MHz. Effects of electromagnetic radiation are frequently shared with the public by Universities, Chamber of Electrical and Electronics Engineers, Chamber of Medical Physicists, Technology Informing Platform. Some groups also plan to deal with electromagnetic radiation accompanied by ultraviolet and infrared light incidence.[37]

BTK has a special division on EMF and follows the most recent guidelines released by the International Committee on Non-ionizing Radiation Protection (ICNRP). The Ministry of Transport and Infrastructure, in particular, have published regulations based on ICNIRP's Standards and regulations. In 2011, they had prepared "Limiting, controlling and directing Electromagnetic field intensity caused by the electronic communication devices by taking the international limits" regulations,[38] which mandate four times stricter limits than those indicated by ICNIRP.[39] Then, with several revisions of this regulation, as of April 2018 the name was changed to "Electronic Communication Devices Safety Certificate Regulation". In the context of principle of precaution, the limit values allowed to cellular systems for the environment was set to 70% of the limit values set by ICNIRP, which keeps the general practice of applying stricter limits than those indicated by ICNIRP.

Furthermore, the government Ministry of Health is paying attention to raise public awareness of the health effects of electromagnetic field. Non-Governmental Organizations (NGOs) like Temkoder, Turkish Electrical and electronics Chamber, as well as the Chambers of Physicians are sensitive on the issue of health effects on electromagnetic fields. Workgroups have been formed in the body of these NGOs. These groups have organized public awareness meetings to inform the society about the effects of electromagnetic fields on health. The Turkish Electrical and Electronics Engineering Society is organizing meetings on recent issues on electrical, electronics and computer engineering issues including effects of electromagnetic fields.[40]

3.8.6 Commercial launches: announcements, trail cities, and digital cross-border corridors

Turkey is making great strides with its 5G evolution and operators have conducted significant 5G trials and engaged with commercial negotiations. 5G is considered as an investment worth approximately TL 253 million (approx. 40 million EUR)[41] in Turkey, and private stakeholders such as Türk Telekom, Turkcell, and Vodafone Turkey are the major investors in the networks.

In 2016, Turk Telekom signed a Memorandum of Understanding with Nokia to accelerate the development of 5G radio access network technology and the applications driving the Internet of Things (IoT) and other sectors as diverse as healthcare, smart cities, etc.[42] During the same year, Vodafone Turkey reported that it tested 10Gbps 'E-band' point-to-point radio link technology in densely populated urban areas, saying the tests paved the way for 5G commercial launches using the 71GhZ-86Ghz ranges.[43] Since 2016, Turkcell has also established partnerships with Ericsson, Samsung, and Huawei,[44] becoming the telecom operator with most 5G-related expansion as of September 2020.

In 2017, Turkcell rolled out a Narrow Band-Internet of Things (NB-IoT) network across Turkey. The operator informed that the technology could be used by industries such as energy and logistics as well as healthcare and education, allowing machines to communicate with each other via Turkcell's LTE-A infrastructure, extending possible smart city applications.[45]

In February 2018, Turkcell and Samsung signed a Memorandum of Understanding that resulted in Turkey's first 'live 5G trial' offering a live trial the technology in Istanbul in November 2018. The 5G experience zones featured ultra-high-definition live streaming, cloud gaming, 360-degree camera and virtual reality streaming by using Samsung's 5G Fixed Wireless Access (FWA) solutions, combined with the operator's network infrastructure.[46]

In March 2018, during the Mobile World Congress, the Turkish government signed a protocol to test the latest communication technologies with the Open Networking Foundation,[47] a non-profit operator-led consortium funded by Deutsche Telekom, Facebook, Google, Microsoft, Verizon, and Yahoo. The consortium in collaboration with the ministry is working on Turkey's network infrastructure and carrier business models to help the country resolve its network coverage.[48] In July 2018 a Memorandum of Understanding for the installation of test network infrastructures were signed between the stakeholders of the 5G Valley Open Test Bed at the campuses of Middle East Technical University, Bilkent University, Hacettepe University and BTK.[49] The area between these three universities and BTK headquarters is a

developing region with a dynamic population and various vertical sector components such as hospitals and shopping malls. In November 2018, BTK launched the country's first "5G Open Test Site" at the BKT Market Surveillance Laboratory located in Ankara's Hacettepe University.[50] Academics, researchers and start-ups can utilise the 5G Valley Open testbed for R&D tests for 5G and beyond technologies.[51] Tests were carried out on various issues such as 5.9 GHz C-V2X Channel Measurement, Energy Harvesting, 28 GHz Intravehicular Channel Measurement, Power Amplifier Modelling Efficiency and Linearization, V2X, MIMO and spectral efficiency in the 5G Valley.

BTK also established "5G and Beyond Joint Graduate Program" between universities and disciplines to contribute to the cultivation of qualified human resources that Turkey will need in 5G and Beyond in short, medium and long term. The program aims to produce sustainable competence on advanced communication technologies and to produce outputs in a wide variety of forms such as patents, projects, articles, spin-off companies and thesis studies. Currently 38 students are employed in the operators and continue their academic studies at the same time.

In January 2019, Turkcell has achieved Turkey's first end-to-end, 3GPP-compliant, multivendor 5G data call on 2.5 GHz band in a partnership with Ericsson. The call used Ericsson Radio System solutions and Ericsson Cloud Core and test devices from ecosystem partners over Turkcell's 5G test network. The tests in Istanbul used the 5G systems over Turkcell's existing Gigabit LTE (4.5G) network.[52]

In February 2019, BTK approved applications by the country's three mobile network operators Turkcell, Vodafone and Turk Telekom (TT Mobil, formerly Avea) to conduct 5G trials in different frequency bands in the largest three cities of Istanbul, Izmir, and Ankara.[53] In August 2019, the local press reported that Turkcell broke world 5G speed record, reaching 2.283 Gbps speed on a 5G-enabled smartphone with allocated 3.5GHz frequency using 1,000MHz bandwidth.[54]

In February 2020, Turkcell showcased Turkey's first 5G live TV broadcast in high quality and capacity combined with and low latency while covering a soccer match at the Trabzonspor stadium. The broadcasting also relied on a local software, which was used along with Turkcell's 5G test network.[55]

Co-financed by the European Commission within the framework of the Horizon 2020 programme, 5G-MOBIX is developing and testing automated vehicle functionalities using 5G core technological innovations along multiple cross-border corridors and urban trial sites.[56] The project envisions a Greek-Turkish cross-border trial corridor as one of the eight trial sites with a strategic geopolitical environment.[57]

With the participation of the two largest MNOs in Greece and Turkey and the guaranteed cell-edge conditions to be created at the border, 5G-MOBIX will also offer a unique opportunity to address 5G cross-border deployment issues while driving across a hard border where trucks have to stop and are subject to human control. It will also provide important insights into the limits of coverage and performance that can be expected by 5G technology and the level of support provided for CCAM (Connected and Cooperative Automated Mobility) use cases.[58]

In March 2020, the Ministry of Transport and Infrastructure announced that they are preparing to launch 5G services in the Istanbul airport through its 5G indoor network.[59]

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3.9 UKRAINE

3.9.1 ICT background and current status of broadband

Ukraine has set the ICT sector as a policy priority and implemented several ICT programs on education and public health.[1] With 4G being implemented in 2018, the government is rapidly improving the network coverage while promoting e-services in the public and private sectors,[2] and recently signed a memorandum with operators to provide 4G coverage for 90% of Ukraine's territory by 2022.[3] Some of the main challenges in the ICT sector include updating the legislative framework for electronic communications and the development of an accurate up-to-date interactive map of broadband coverage of its territory.[4]

In January 2018, the Government and State Agency for e-Governance of Ukraine published the new "Digital Agenda for Ukraine 2020,"[5] which aims to guide the country's digital development. The agenda has seven main pillars: I) Telecommunications and ICT Infrastructure; II) Digital Skills; III) e-Market; IV) Digital Governance; V) Innovation and R&D; VI) Trust and Cybersecurity; VII) Benefits from ICT for Society and Economy.[6]

To enact the implementation of the "Digital Agenda of Ukraine 2020" and to remove barriers toward sustainable digital transformation in the country, the Ordinance of the Cabinet of Ministers of Ukraine No. 67-p approved in 2018 the "Conception for Developing Digital Economy and Society in Ukraine for 2018 to 2020" and adopted the "Action Plan Implementing the Conception."[7]

The implementation of the concept measures should pursue the following objectives:[8]

- Stimulating the country's economy and attracting investment;
- Creating the basis for the transformation of domestic industries toward increased competition and efficiency via digitalization;
- Solving the domestic problem of the digital divide, thus bringing digital technologies closer to citizens and providing them with access to broadband Internet—especially in villages and small towns;
- Creating new opportunities for the realization of human capital, the development of innovative, creative and digital industries and businesses;
- Developing more exports of digital products and services—IT outsourcing.

The document also establishes the priority sectors and suggestions for the digital development in Ukraine with a particular focus on bridging the digital divide through the development of digital infrastructures; developing digital competencies; implementing the concept of digital workplaces; digitizing the country's economic systems implementing digital transformation projects; supporting public security; education; health care; tourism; e-democracy; ecology and environmental protection; and life of cities; e-payments; and harmonization with European and world initiatives as well as governance.

The accelerated scenario of digital development envisages the following actions to facilitate the implementation of the above-mentioned objectives and priorities:[9]

- The removal of legislative, institutional, fiscal and other barriers to the development of the digital economy;
- The introduction of incentives and motivations to encourage business and industry in general to digitize;
- The creation of demand and formation of needs among citizens for digitalization through an introduction by the state of large-scale projects concerning digital transformations—based on modern models of public-private partnership;
- The creation and development of digital infrastructures as a basis for using the advantages of the digital world in everyday life and a platform for achieving economic efficiency in general;
- The development and deepening of digital competencies of citizens to ensure their readiness to use digital opportunities, as well as to overcome the associated risks;
- The development of digital entrepreneurship coupled with the creation of appropriate (including analogue) infrastructures to support and develop innovation, as well as the introduction of funding mechanisms, incentives, and support.

In coordination with the ministries and aligned with international practices, the Action Plan identifies the required indicators and methods for assessing the digital development. Ukraine's implementation plan has also been supported by private stakeholders. Increasingly, the government is offering incentives and motivations for the private sector to foster business and empower citizens to consume and use information, communication, and digital technologies. [10]

With specific reference to broadband development in Ukraine, and in context of the plan's focus toward a national hard digital infrastructure, the "Conception for Developing Digital Economy and Society in

Ukraine for 2018 to 2020" calls for a national broadband plan that has appropriate indicators of I) Internet access coverage in the country; II) specifications on the technical requirements for the broadband Internet access services; and III) models for using the existing physical infrastructures (highways and railways, gas pipelines, power lines) for the development of telecommunications networks.

In this regard, the document argues that particular attention should be paid to broadband Internet access in rural areas.[11] In April 2020, Iskratel, PJSC Ukrtelecom and SID Bank signed an agreement to build a fibre-optic Internet network (GPON) to connect the rural areas of Ukraine under a two-year network construction project. This has had a total investment of almost 200 million Hryvnia (about 6.1 million EUR)[12]. The project will include the manufacture of more than 2,000km of fibre optic cables and the installation of modern certified telecommunication equipment.[13] Other initiatives concerning rural areas and Internet connectivity are currently undergoing under the auspices of the Ministry of Education and Science, Ministry of Digital Transformation, Ministry of Finance,[14] as well as the Ministry of Culture and information policy, which recently collaborated with the World Bank on the fixed-broadband market and connectivity maps.[15]

3.9.2 Broadband and mobile telecommunication data

ITU data shows that 62.55% of individuals used Internet in 2018,[16] with the majority being in urban areas. In 2010, the ITU data for the country was 23.3% in 2010, in 2000, 0.7%.[17] In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 16.2[18] and DSL remains the most used technology platform while fibre continues to grow due to the efforts by operators build networks based on Fibre-to-the-Premises (FTTP).[19] While most cities have access to fibre-optic networks operated by several private stakeholders, the urban-rural gap in terms of Internet coverage is significant in Ukraine, given that the country has more than 17,000 settlements not covered by this technology.[20] The government recently announced that about 65% of Ukrainian villages are not covered by high-quality broadband, which corresponds to about 5.75 million citizens,[21] and according to ITU data, in 2018 61.9% of households had Internet access at home.[22] For rural areas that not covered by optical fibres, the cost of connection exceeds the average market cost by about 150%. From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of the GNI per capita (and the CIS region was 3.7 per cent) in 2019, while Ukraine's corresponded to 1.8 per cent for an unlimited Internet data cap.[23] Continued growth in community wireless platforms based on Wi-Fi and WiMAX technologies is expected to attract investments and shape the average price for Internet connectivity.[24]

In 2019, the proportion of mobile cellular subscriptions per 100 inhabitants stood at 130.6.[25] In 2018, the number of active mobile-broadband subscription per 100 inhabitants corresponded to 47.7.[26] There are three major mobile network operators (MNOs) that dominate the market in Ukraine: Vodafone Ukraine (formerly MTS), Kyivstar (VEON), and lifecell (Turkcell). The country's mobile-data basket cost corresponded to 1.2 per cent of the GNI per capita in 2019 for a monthly allowance of almost 2 Gb. The average 1.5 GB mobile-data basket price in the European region was 0.8 per cent (and the CIS region was 2.2) for the same year.[27] Over the past years, significant investment has been made in extending 3G infrastructure, while operators have more recently concentrated on LTE. Kyivstar, Ukraine's largest operator, announced that the 3G coverage corresponded to nearly 80% in 2018, although a large portion of the territory still lacks 4G/LTE coverage.[28] With the recent expansion of LTE in Ukraine, it is expected that the majority of the country's territory will be covered in the next years.[29]

Additionally, data from ITU show that in 78.1% of the population in Ukraine had 4G/LTE coverage in 2019, while 3G population coverage corresponded to 89.1%.[30] In August 2020, the government announced that 4G is now available in nearly half of the underground stations of the Kyiv metro, a result of a partnership between the country's MNOs with Huawei.[31]

3.9.3 Current progress on 5G: consultations and national strategies

In May 2019, on the World Radio Day, Ukrainian President signed a decree to roll out 5G network in the country,[32] which is a similar government approach to what was done in the past for the launching of 3G and 4G.[33] While the decree defines a timetable stating that 5G will be launched in 2020, it has no details regarding conversion or freeing up of new frequencies for the new networks.

The decree has been sent to the regulator, the National Commission for the State Regulation of Communications and Informatization (NCCIR), by the State Service for Special Communication & Information Protection of Ukraine on 25 October, 2019.[34] Under this decree, the government and NCCIR, must structure and adopt a step-by-step plan for 5G implementation, sending relevant information to the Cabinet of Ministers for confirmation before setting up a frequency auction allocation for the operators.[35]

In March 2020, Ukraine held in Kyiv the third of a series of consultations to discuss cybersecurity policy, national cyber capacity building, international cybersecurity policy issues and security issues for future 5G networks.[36]

3.9.4 Spectrum assignment for 5G & market development

Ukraine has been successful in harmonizing the 1800MHz, 2100MHz and 2600MHz bands by introducing technology-neutral principles for operators in the Ukrainian market.[37] In January 2018, the Ukrainian regulator provided operators with additional spectrum in the 2600MHz band, and with spectrum in the 1800MHz band in the following July, issuing 15-year licenses.[38] In November 2019, NCCIR issued decision No. 529 confirming it will allocate country-wide 5G-suitable wireless spectrum in the 3400MHz-3600MHz range on a competitive or tender basis in accordance with the 2000 "Law on Radio Frequency Resource of Ukraine"[39] and other regulations.[40]

Given that 4G auctions were conducted in 2018, some private stakeholders recently expressed their unwillingness to invest in new technologies for the moment. Even though some 5G-related commercial progress has occurred,[41] part of the telecommunication sector in Ukraine is currently focused on the development of 4G and the expansion of Internet services in rural areas,[42]

In January 2020, Kyivstar, lifecell and Vodafone Ukraine have submitted a joint statement on redistribution of the 900MHz band and separate applications for license renewal to the NCCIR.[43] Previously, the 900MHz band was fragmented and a large proportion of it was concentrated with one of the telecommunications operators, preventing the provision of next-generation 4G services across Ukraine.[44] Currently, these MNOs are deploying 900MHz LTE services to expand their existing LTE-1800/2600 networks in rural areas, after their LTE-900 licences became valid at the start of July 2020.[45] As a result, in March 2020, NCCIR provided a technology-neutral license to Kyivstar, lifecell and Vodafone Ukraine, allowing them to begin offering 4G LTE-900 services starting on July 1st, 2020.[46] Under the terms of the licenses, the operators must extend LTE-900 services to all areas of the country with a population of over 2000 people across the next two years.[47]

As of August 2020, no announcement has been made regarding the tendering process for the 5G spectrum assignment in Ukraine. Government representatives also stated that it is necessary to provide a regulatory apparatus for technological neutrality for mobile communications, and that release of the first (790-862MHz) and second (694-790MHz) digital dividends is one of its priorities for 2020.[48]

3.9.5 Electromagnetic fields levels and the implementation dynamics

To foster the development of current 4G networks and advance the potential of 5G-enabled services and applications, the Cabinet of Ministers of Ukraine instructed the Ministry of Health to increase the

maximum permissible level of EMR for high (30-300 MHz), ultra-high (300-3000 MHz) and very high (30-300 GHz) frequency bands by 10 times—from 10 μW / cm^2 to 100 μW / cm^2, which remains 40 W/m2 (4000 μW /cm2). In 2017, a similar change occurred[49] to the original legislation on EMF from 1996,[50] which already increased the permissible level from 2.5 to 10 μW/cm.[51]

In response to public pressure on alleged health hazards from 5G introduction in Ukraine,[52] an order from the President of Ukraine from July 2020 requested NCCIR to propose a number of measures to resolve the issue and provide the public with the appropriate information on the impact of mobile technologies and networks. In August 2020, the NCCIR announced its action plan[53] to meet the President's demands. Some of the measures include the provision of protocols for measuring electromagnetic fields by operators; public consultations with suppliers of radio equipment; creation of a new section of impact mobile technologies (4G, 5G) on human health on the NCCIR website; among others.[54]

Furthermore, NCCIR intends to involve the Ministry of Digital Transformation, the Ministry of Health, the Administration of the State Service for Special Communications and Information Protection of Ukraine and other bodies to take action on a number of EMF-related challenges and issues such as:[55]

- The need to adopt national standards that are necessary to assess the impact of the electromagnetic field from cellular base stations on humans;
- The introduction of a warning sign about the presence of a source of non-ionizing radiation of the appropriate level of its danger to humans;
- The need for additional medical research on the effects on humans of non-ionizing radiation from 5G stations in the millimetre wave range or scientific recognition of such research conducted outside Ukraine, including their implementation in the legislation of Ukraine;
- The need to develop and approve the procedure for the relevant bodies in the system of the Ministry of Health of Ukraine to measure compliance with the levels of EMF at the request of citizens;
- Carrying out of regular measurements within the Ministry of Health's system to monitor EMF levels during deployment of 5G networks;
- Placing social advertising or information on the impact of mobile radio technologies on human health within the context of 5G.

Private stakeholders in Ukraine are also engaging with questions pertinent to EMF. In August 2020, representatives from Huawei Ukraine[56] and ZTE[57] have presented solutions on electromagnetic fields from 5G base stations and 5G Massive-MIMO EMF[58] to NCCIR.

3.9.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

In May 2019, Vodafone Ukraine announced it was ready to launch 5G tests.[59] During the same month, operator lifecell—part of the Turkcell Group—has tested 5G mobile technology in the 28GHz frequency range in the city of Kyiv in partnership with Ericsson.[60] Through massive multiple-input multiple-output (MIMO), a peak download speed of 25.6Gbps was reached in the ultra-high frequency range of 28Ghz.[61]

As part of the 2019 Swedish-Ukrainian Business Forum, lifecell also showcased a demonstration of 5G network and applications, including remote robotics for surgery, immersive real-time conferencing and virtual reality (VR) multiplayer interactive games. Private stakeholders organizing the event outlined six main regulatory and economic factors that would make 5G roll out a success in Ukraine: I) Transparency on the state's plans for 5G development; II) Comprehensive frequency spectrum allocation and licensing strategy; III) Consumer and market readiness that includes accessible devices; IV) Economic demand and developed infrastructure; V) Having mobile networks, hardware, and software ready to be operated; and VI) Develop partnerships and ecosystem (devices and app developers, for example) necessary to take the offers to prospective customers.[62]

In April 2019, Ukraine's Ministry of Infrastructure launched a pilot project regarding the Internet of Things (IoT) on the roads in partnership with Vodafone, Nokia Solutions, and Networks Ukraine to create a virtual network to tackle issues related to road safety and traffic flow analysis. The project is divided into three phases: testing, scaling and full implementation.[63] The long-term goal is to launch a full-scale project which will provide coverage of all highways of international importance with modern technologies.[64]

Between December 2019 and May 2020, Ericsson and operator lifecell conducted 5G tests using 3.5GHz band in seven of the operator's points of sales in six Ukrainian cities: Kyiv, Dnipro, Kharkiv, Lviv, Odesa, and Cherksay.[65]

In February 2020, the Ministry of Digital Transformation of Ukraine and Swedish company Ericsson signed a Memorandum of Cooperation in the development of fixed and mobile 4G LTE-A and 5G networks.[66] The Ministry noted that a joint working group is being organized to work on technical expertise in mobile and

fixed internet development.[67] The working group will also provide advisory and information support to the Ministry on the evolution of mobile communications, frequency strategy and licensing policies.[68] The Ministry also started a cooperation with Vodafone and Nokia to launch a pilot project regarding the implementation of the IoT on roads through 5G connectivity.[69]

In April 2020, Vodafone Ukraine completed testing of AirScale equipment from Nokia on its LTE network in Kyiv. The 5G-ready equipment was tested on the 1800MHz and 2600MHz bands, achieving connectivity speed as fast as 525 Mbps.[70]

In July 2020, Vodafone Ukraine and Kyivstar signed a Memorandum of Intent (MOI) on network sharing for the exchange of the 900MHz spectrum in 8 Ukrainian regions.[71] The agreement covers both passive and active infrastructure on operators' mobile networks and should result in the acceleration of LTE technology coverage of Ukraine, reaching the country's rural areas and highways.[72] The operators plan to start the practical implementation of the memorandum in November-December 2020 after approval of the project by government agencies.

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3.10 STATE OF ISRAEL

3.10.1 ICT background and current status of broadband

Israel has one of the highest gross domestic expenditure on high-technology research and development, often referred to as a "start-up" nation characterized by its a vibrant ICT sector.[1] Through many policies and initiatives since the 1990s, the Israeli government laid the foundations for private industry to support innovation and made heavy investments in building a strong human capital.[2] Israel also has a robust telecom market with a significant number of operators,[3] providing high household broadband penetration and covering almost the entire territory with 3G and 4G networks.[4] By 2017, Israel's ICT sector represented about 7.2% of its GDP and 20% of its exports of goods and services.[5] Despite the steady growth in the ICT sector, the fall of profits and revenue by the country's largest operators over the past years remains one of the most pressing challenges as the private sector prepares to invest in new telecommunication infrastructure.[6]The ICT development in Israel is oriented by the National Digital Program (2017-2022), which outlines the following three primary goals and areas of focus:[7]

Reducing Socio-economic Gaps

- Bring the geographic and social periphery closer by improving digital literacy among weakened populations; providing access to quality public goods and services by digital means; creating jobs and developing business in the geographic and social periphery;
- Reduce the cost of living by advancing the digitization processes in the housing and real state areas; developing the financial area in the digital age; promoting the transition to digital products that produce economic savings; foster informed consumption by digital means;
- Promote legal literacy by increasing access to information about rights through digital means; streamlining rights realization processes through digital means.

Accelerating Economic Growth

- Promote digital industries and businesses by developing digital-based industries; turning business into digital business; increasing digital presence and encouraging the use of e-commerce platforms;
- Develop the employment market in the digital age by adapting digital skills in the education system, academia, and the labour force to the modern employment market; increasing the use of

online occupational training; expanding employment options in the digital age by removing distance barriers; qualifying professional workers in digital and ICT fields;

- Support infrastructure development by developing physical infrastructures; promoting an enabling a digital activity ecosystem.

Creating a smart and friendly government

- Accessibility of state and local government by improving government services to citizens and reducing the bureaucracy; digitization of local government; advancing "Smart Cities"; promoting Open government; increasing ease of doing business;
- Promote innovative and effective government by increasing digitization in internal government work; promoting information-based policy and cross-governmental sharing; developing the digital competencies of human capital in government; expanding innovation and entrepreneurship in government;
- Improve public goods by focusing on the improvement of education, health, social welfare and other additional goods by digital means.

As the Israeli government seeks to bridge the digital divide between urban and rural areas, the Ministry of Communication notes that a wide geographical competition approach is the best way to improve the network coverage by the domestic operators, including the quality of the service offered, price performance, overall penetration, as well as further commercial competition with other private stakeholders.[8]

While other nations in the European region are operating fibre optic networks, Israel relies on infrastructure rolled out before 2010, which presents consequences for the capacity of data trafficking as more users engage with ICTs and as users require increasingly high data rates. In face of the COVID-19 pandemic, telecom operators in the country are hard-pressed to invest significant resources in infrastructure upgrades. Accordingly, the government has raised concerns over the need for upgrading the domestic telecom infrastructure due to the broadband needs of the Israeli population. The Ministry of Communications is currently working to approve operators to make fibre available across Israel's territory, especially in remote areas.[9]

3.10.2 Broadband and mobile telecommunication data

ITU data shows that 86.79% of individuals in Israel used the Internet in 2019.[10] In 2010, the ITU data for the country was 67.5% and 20,9% in 2000. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 29.1[11] with an averaged fixed-network access speed of 99.7 Mbps.[12]

According to ITU data for 2019, the estimate proportion of households with Internet access at home stands at 75.9%.[13] In terms of technology, DSL represents the largest market share of broadband subscriptions, while the fibre-network deployment is being deployed under the auspices of Israel Broadband Company (IBC).[14] As of June 2019, the percentage of subscribers in Israel for fibre optics to the premises/home/building (FTTP/FTTH/FTTB) comprised 2% of all broadband network connections.[15] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of the GNI per capita in 2019, while Israel's corresponded to 0.8 per cent for an unlimited Internet data cap.[16]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was of 126.8,[17] while the number of mobile-broadband subscriptions per 100 inhabitants were 115.[18] There are five mobile network operators after a merger between (MNOs)—Cellcom, Partner, Pelephone, Partner HOT Mobile, Marathon 018—that currently have licenses for the use of radiofrequency.[19] Given the highly competitive nature of the Israeli mobile market with 6 MNOs, the average revenue per user has dropped in 2018 for all major operators.[20] Falling revenues are largely attributed to increasing tariff competition between firms, and consumers switching providers at almost unprecedented levels.[21] Despite the situation, the country's mobile-data basket cost corresponded to 0.3 per cent of the GNI per capita in 2019 for a monthly allowance of 30 Gb, while the European region's average was 0.8 per cent for the same year.[22] This makes the 3G and 4G services one of the cheapest in relation to the European region and with coverage of nearly the entire territory[23] and 94% of the population covered by 4G/LTE services and 99% covered by 3G.[24] In 2020, the number of MNOs in Israel declined to 5 after a merger between Cellcom and Golan Telecom approved by the Israeli regulators.

3.10.3 Current progress on 5G: consultations and national strategies

The government of Israel started consultations on 5G as early as 2018, focusing initially on the expansion of the deployment of cellular communications infrastructure in order to commence a robust deployment of 5G.[25]

In July 2019, the government launched a tender for the development of 5G networks with expected launch and development to occur between the 2020-2023 period.[26] The 5G tender was conducted in three main stages and considered the following frequencies: 700MHz, 2,600Mhz, and 3,500-3,800 MHz.[27] The 2,600 MHz frequency range is meant to initially provide services for 4G and ultimately 5G once the transfer is complete, while the 3,500 MHz range is assigned entirely for 5G use-cases.[28] Accordingly, the 5G tender outlined the following frequency inventory for each frequency band:[29]

- 700MHz – Bandwidth of 30x2 MHz in the Frequency Division Duplexing (FDD) method;
- 2,600MHz – Bandwidth of 60x2 MHz in the Frequency Division Duplexing (FDD) method; and
- 3,500-3,800MHz – Bandwidth of 300 MHz in the Time Division Duplex (TDD) method.

As the Ministry of Communication articulated in the 2019 5G tender in Israel, the expected outcomes encompassed the following:[30]

- The frequencies offered in the tender will enable a response to the growing demand for broadband communications by expanding capacity;
- For the first time, the frequencies tender will be accompanied by an incentive system that includes grants and a reduction of 500 million NIS (125 million EUR)[31] in fees;
- Tender payments will be deferred to September 2022 in order to enable the operators to direct their financial resources to invest in upgrading the networks;
- In the tender, the owners of existing networks will be able to compete by submitting joint proposals in a manner that will lead to effective allocation of frequencies for the benefit of the public;
- Besides, the tender will include an open segment of 100MHz for new players that will generate technological competition in the infrastructure and services of the 5th generation networks.

Operators will be expected to pay a total of 80 million NIS (20 million EUR)[32] per year for the use of the new frequencies—in addition to the 320 million NIS (79.8 million EUR) they currently fork out for 4G and 3G services. Winners can receive a 28% reduction for the first four years, subject to government approval. They will be required to complete the deployment within five years and begin providing 5G services within 18 months of the start of the deployment. The total cost of the deployment is estimated at 2 billion NIS (448.6 million EUR).

In August 2020, The Ministry of Communications has initiated a series of conferences titled "Connected Authorities – Connect Israel" with the goal of assisting the local and district authorities in connecting to advanced communications infrastructure. The Ministry informed that additional conferences will be held for the heads of local councils and mayors in a similar format to facilitate a more effective dialogue and consultations regarding the Ministry's areas of operation in regard to 5G and other technologies.[33]

In a partnership with the Ministry of Economy's Innovation Authority, the Ministry of Communications is launching a new program that will allow Israeli start-ups and industry to submit applications for research and development programs at various sites (such as campuses, public spaces, hospitals, etc.), using 5G technologies in two formats: I) Materializing such on the frequencies allocated to the communications companies; and II) Materialization on designated experimental frequencies to be allocated by the Ministry of Communications for the purpose of the trials.[34]

In September 2020, India, Israel, and the United States have begun a collaboration for the development of 5G with the goal of establishing a transparent, open, reliable and secure 5G communication network.[35]

Upon the launch of the 5G tender, the Ministry of Communication also expressed strong interest in promoting the use of 5G for a potential smart city program for Israel, although not many details have been publicly announced as of September 2020.[36]

3.10.4 Spectrum assignment for 5G & market development

In August 2020, the Ministry of Communications has concluded the multi-spectrum auction to enable operators to roll out 5G, and the winning bidders were Pelephone, Cellcom Golan Marathon, and Partner HOT mobile. All three secured identical spectrum allocations, specifically a 10MHz block in the 700MHz band, a 20MHz block in the 2600MHz band and 100MHz in the 3.5GHz (3500MHz-3800MHz) band.[37] The 700MHz band allocations will be valid for 15 years, while both the 2600MHz and 3.5GHz allocations are valid for ten years, with all concessions being renewable at the end of those periods.

Cellcom, Israel's largest mobile phone operator which is in the process of acquiring rival Golan Telecom, stated it will pay 115 million NIS (28.7 million EUR)[38] in license fees. Partner Communications, the second-largest mobile operator, stated it will pay, together with HOT mobile, 62.3 million NIS (15.5 million EUR) for its frequencies. Partner operates a joint radio network with HOT, a subsidiary of telecoms and cable group Altice Europe.[39] Bezeq's subsidiary Pelephone will pay over 88 million NIS (21.9 million EUR)[40] for

its spectrum allocations. The aforementioned operators will not be required to make payment for their new spectrum until September 2022.[41]

Based on the Ministry's estimation, the conclusion of the frequency tender and the commencement of the deployment of the 5G infrastructure by the license holders will occur during the second half of 2020.[42]

In terms of market development, local press reported that there are currently about 25 Israeli companies working on 5G-related technologies, ranging from transnational firms as large as Intel to small early-stage start-ups such as TetaVi Ltd. and Binah AI Ltd. From health care to autonomous traffic management and from entertainment to drones, Israeli firms are gearing up for 5G by researching product potential and integrating with other verticals.[43]

3.10.5 Electromagnetic fields levels and the implementation dynamics

The 2006 Non-Ionizing Radiation (NIR) Law includes requirements related to the installation and operation of energy-emitting sources, as well as requirements for monitoring NIR sources and publicizing the results. The Law stipulates that in order to install a source of radiation, to operate a source of radiation, or to provide radiation measurement services, it is necessary to receive prior authorization from the Ministry of Environmental Protection**.** Permits are granted for a limited period and must comply with certain conditions. In the context of 5G, the Ministry of Environmental Protection determines the maximum power output of broadcast centres so that radiation exposure levels are at least 10 times less than the radiation exposure thresholds defined by the World Health Organization (WHO) as being harmless to the general population**.**[44]

The validity of the permit, depending on the different types of radiation sources, is stipulated in the regulations:[45]

- **Installation permit:** In order to obtain a permit to install a radiation-emitting source, certain conditions detailed in the Law must be complied with. Among them: evaluation of maximal levels of exposure anticipated from the sources of radiation, based on the technical specifications, operation of the radiation sources for a limited period and performance of trial measurements, over a period defined by the Law;
- **Operations permit:** This is the second stage: subject to the validity of the measurements performed during the period allocated by the above Installation Permit, a permit must be

obtained to operate the radiation sources for a defined number of years. This permit is subject to the conditions stipulated by the Law;

- **Radiation Services permit:** not everyone is entitled to measure radiation. In order to perform this activity, one must obtain a radiation measurement services permit according to the Law. This permit, too, must comply with certain conditions, such as professional training and possession of the appropriate equipment and means to provide the service.

In coordination with the Ministry of Science and Technology, the Ministry of Environmental protection established the Israeli National Information Center for Non-Ionizing Radiation (TNUDA) in 2013. The Center is guided by the precautionary principle and therefore promotes educated use of technologies involving nonionizing radiation while maintaining a balance between the rapid technological advances and protection of public health.

Since September 2014 the TNUDA website serves as the main information channel for various target audiences in Israel (the general public, governmental offices, scientists & industry). In light of the growing interest abroad and the wish to enable wider access to the information distributed by the centre, the English version of the website was launched in 2016.[46] To date, more than 200 articles have been published, covering a large spectrum of topics such as health, physics, legislation & policy. In addition, other items such as FAQ, selected publications & glossary are available to the readers.[47]

Within the context of 5G development in Israel, the Ministry of Communications has analysed the recommendations on the relationship between the network and EMF levels and announced that it will act, if necessary, to ensure the rollout of 5G networks in the country while maintaining standards of public health. In parallel to publishing the tender and the subsequent technological development, the Ministry of Health recommended further monitoring by the Ministry of Environmental Protection, which is expected to assess exposure levels, including an examination of the various sources of the exposure of multiple sources of radiation (cellular sites of different sizes) at different stages throughout the 5G development. The Ministry of Environmental Protection also recommends the following for the development of 5G:[48]

- Encouraging the sharing of cellular networks;
- Encouraging broader deployment within buildings which reduces exposure to radiation;

- Deployment of additional broadcasting centres in areas where there is insufficient deployment;
- To act in such a manner that most of the data volume is transmitted through wired networks that do not radiate.

The Ministry is especially expected to take into account exposure levels at "hot spots" — and with the combination of output data and antenna orientation (aggregating the application of beam deflection technology) while adhering to the principle of preventative precaution. The recommendation also included the establishment of an inter-ministerial committee to review the exist standards in 5G implementation and promote new actions or revisions if necessary.[49]

3.10.6 5G commercial launches: announcements, trail Cities, and digital cross-border corridors

In July 2020, Partner announced the establishment of its 5G network, known as the "Partner 5G project," which positions the operator as the first private stakeholder to launch 5G in Israel. The operator announced that it is conducting 5G-related capabilities tests and managed to reach more than 1GB of transmission speed. Partner also stated that it is currently upgrading the core of its existing cellular network with the goal to pave the way for new technological capabilities, thus expanding the existing capacities of advanced voice calling services such as VoLTE (Voice Calls on Generation 4), Wi-Fi Calling and others.[50]

In August 2020, the operator Pelephone Communications Ltd. announced the launch of its 5G network named "Pelephone Plus," which is set to start operations upon the finalization of frequencies allocation by the Israeli regulator. Pelephone acquired a network of 250 5G sites from Ericsson, which has earned it an 80 million NIS (19.9 million EUR)[51] grant from the Ministry of Communications.[52]

In September 2020 3 MNOs Pelephone, Partner and Hot Mobile launched their 5G networks and start to provide commercial services, after the Ministry grant them the licences and the spectrum allocation was finalized.[53]

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3.11 ICELAND

3.11.1 ICT background and current status of broadband

Iceland is one of the world's most advanced and mature markets when it comes to the infrastructure, diffusion, and use of ICTs. The government first recognized the potential of ICTs as early as 1996 in the "Icelandic Government's Vision of the Information Society" document[1]. Moreover, the development of ICT-related policies such as the 2008-2012 "Iceland the e-Nation" (2008-2012)[2], the "Telecom Policy Statement" (2011-2014)[3], and the "Electronic Communications Plan" (2011-2022)[4] played an important role in paving the way for a country with a solid and advanced fibre-optic network infrastructure as well as a strong focus on e-governance.[5] Largely thanks to its low corporate tax incentives, its highly skilled IT labour force[6] and its geographical position, Iceland has also become a connecting global hub for the operation of large international Data Centres[7] and an important location for international submarine cable systems.[8]

With a small domestic telecom sector, Iceland is known for having a competitive and highly progressive market when it comes to ICTs. Iceland has also considerably harmonized[9] its electronic communications environment to the laws and regulatory framework of the European Union.[10] However, there are still areas that are not covered by private operators and that lack broadband services, which gained rapid popularity in Iceland the early 2000s due to the early use of IPTV technologies. More recently, Iceland has also encountered a decrease in investment in the telecommunication sector, which fell 5.5% in 2019 in comparison to the previous year.[11]

The Electronic Communications Plan (2011-2022)[12] contains ambitious objectives on quality, access, distribution and security of electronic communications services. The main objectives concerning the access to electronic communications services are:

- 90% of homes and places of work will have the option of a 30 Mbps fixed connection by 2014 and 100% by 2022;
- 70% of homes and places of work will have the option of a 100 Mbps fixed connection by 2014 and 99% by 2022;
- 98% of homes and places of work will have the option of high-speed mobile networks by 2014 and 99.9% by 2022;

- 80% of the country and the coastal waters will have the option of a high-speed mobile network in 2018.

Moreover, the government's approach has been to focus on strengthening the country's fibre-optic backbone network and also supporting fibre-optic cable-laying in rural areas—where distances are such that other technology cannot provide 100 Mb/s on a fixed network. The document also detailed a strong focus on mobile broadband services (4G/LTE), support to private stakeholders, networking sharing, the preservation and maintenance of the ever-growing maintenance of infrastructures, and a strong collaboration between telecom operators and municipalities as well as the federal government and other stakeholders.[13]

To achieve the above-mentioned targets, the government also approved a "Four-year electronic communications plan for the years 2011–2014"[14] which sets objectives for:

- Accessible and easy communication;
- Cost-effective and efficient communication;
- Secure communications;
- Environmentally friendly telecommunications.

Since 2016, government-led efforts have been in place to lay fibre-optical cables in Iceland's rural areas. For example, Iceland's Rural Fibre Project (Icel. *Ísland ljóstengt*)[15] is a short-term Government initiative to bring ≥100 Mb/s wired internet to 99.9% of households and businesses nationwide by year-end 2020, thereby accelerating the achievement of the objectives the Electronic Communications Plan (2011-2022) released in 2010. This project is overseen by the government-led Telecommunications Fund and originally included roughly 5,500 household and business[16], and has a strong emphasis on cost efficiency, synergies with other infrastructural projects, and cooperation with operators as much as possible.[17]

3.11.2 Broadband and mobile telecommunication data

ITU data shows that 99% of individuals used the Internet in 2018.[18] In 2010, the ITU data for the country was 93.4% and in 2000 44.5%. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 40.8.[19] xDSL subscriptions peaked in 2008 at 98% of connections and has been in constant decrease since 2013 as connections are being replaced by fibre, which corresponded to 62.8% of all Internet subscriptions in Iceland in 2019.[20] Due to the high penetration of FTTH access throughout the country,

Internet average speeds in Iceland are faster when compared to most countries in Europe, with only 0.3% of connections registering a speed average below 10 Mbps.[21] As of 2019, about 75% of premises have Fibre-to-the-Home (FTTH)[22] access with all of the City of Reykjavik and towns areas connected through Gagnaveita Reykjavíkur's (GR) full fibre-network.[23] 54.8% of Internet subscribers benefited from more than 500 Mbps in 2019, while only 4.4% had average speed lower than 30 Mbps. Fibre-to-the-Premisses (FTTP) access has also been steadily growing, offering services to business, government, and other organizations.[24] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of the GNI per capita in 2019, while Iceland's corresponded to 1.6 per cent for a 50 GB cap per month in 2017.[25]

In 2019, the number of active mobile cellular subscriptions per 100 inhabitants was of 122.[26] Moreover, the, the number of active mobile-broadband subscriptions per 100 inhabitants was 128.6 in the same year.[27] There are four major mobile network operators (MNOs) that dominate the market in Iceland: Síminn (formerly Landssíminn), Nova, and Vodafone (Formerly Og Vodafone, Íslandssími). The country's mobile-data basket cost corresponded to 0.5 per cent of the GNI per capita in 2017 for a monthly allowance of 5.0 Gb, while the European region's average was 0.8 per cent in 2019.[28] Over the past years, significant investment has been made in extending 4G infrastructure, and the major operators now provide 4G services to 98.9% of the population in the country,[29] above Europe region average of 97.6%, though 2G and 3G are still being used by a small percentage of the population.[30] Domestic mobile data traffic for 2019 stands at 0.05 exabytes per year, more than a 20% increase on a yearly basis.[31]

3.11.3 Current progress on 5G: consultations and national strategies

In May 2018, Iceland signed a declaration of intent for a cooperation on 5G with other Nordic countries within the framework of the Nordic Council of Ministers.[32] In addition to accelerating the development of 5G, this declaration outlines the collective vision for the Nordic region becoming the first interconnected 5G region in the world and identifies areas in which Nordic cooperation needs to be strengthened. The document also acknowledges the deployment of 5G will require substantial investments as well an appropriate regulatory framework both in national contexts as well as in forging a common Nordic 5G space.[33] This agreement is also aligned with other Nordic areas of cooperation dealing with the adoption of IoT and other emerging technologies such as the Nordic Smart City Network,[34] which helps governments create best practices for smart city projects and urban development.[35]

To achieve this goal, in June 2018 Iceland agreed to cooperate closely with other Nordic countries to set up a common action plan for early adoption of 5G technology across the Nordic region. The action plan will:[36,37]

- Encourage the development of new testing facilities, including testbeds;
- Ensure the technical coordination of 5G frequency bands within the region;
- Remove obstacles to the expansion of 5G network, in particular, the deployment of base stations and antennas; and
- Encourage and monitor the development of 5G, specifically for certain sectors such as transport, mission-critical communications, and advanced automation in the manufacturing industry, and the energy sector.

Developments will be monitored and followed up by the Nordic Council of Ministers, facilitating implementation in cooperation with the Nordic governments, national telecommunication and digital regulatory bodies, and stakeholders from the ICT and telecom industries.[38]

The 5G Action Plan 2018-2020[39] was released in late October 2018 establishing 23 deliverables grouped under the following policy goals:

- Encourage the development of new testing facilities, including test beds;
- Ensure the technical coordination of 5G frequency bands within the region;
- Remove obstacles to expansion of the 5G network, in particular deployment of base stations and antennas;
- Encourage and monitor the development of 5G, specifically for certain sectors including transport, critical communications, manufacturing, energy and the environment, health and welfare, stakeholder dialogue on 5G application.

Nordic telecoms companies in support of the region include Ericsson, Nokia, Iceland Telecom, TDC Group, Telenor Group, Tele2 Group, Telia Company and Vodafone Iceland. Representatives of these operators issued a statement welcoming the new deal between the countries and expressed their visions for appropriate spectrum assignment rules and the removal of the obstacles around the deployment of 5G infrastructure.[40]

Aside from the recent 5G spectrum allocation, cooperation with other Nordic countries, and work on 5G-related EMF concerns, Iceland does not have a national strategy document on 5G as of October 2020.[41]

3.11.4 Spectrum assignment for 5G & market development

The current generations of mobile network transmitters in Iceland (GSM, 3G and 4G) use frequencies between 700 MHz - 2.6 GHz.[42] In April 2020, Iceland's Post and Telecom Administration (PTA) allocated 5G frequency licenses in the 3.6 GHz frequency band to Síminn,[43]Nova,[44] and Syn (Vodafone Iceland), [45] which are MNOs that are already operating 4G networks. The spectrum in the 3.6 GHz band is allocated as follows:[46]

- Siminn: block B3600 (3500MHz-3600MHz);
- Nova: block C3600 (3600MHz-3700MHz);
- Vodafone Iceland (Syn): block D3600 (3700MHz-3800MHz).

In the frequency authorization for these MNOs, it is stated that thee 3.6 GHz frequency band shall be used for high-speed mobile network through technology neutrality. The service shall be in accordance with the standards and definitions set out in the data from ETSI, 3GPP and current conditions from CEPT (e.g. ECC Decision (11) 06).[47] Due to the uncertainties concerning the various ways in which 5G can develop in the country and worldwide and its impact on communication law, the licenses are valid only through the end of 2021. Future amendments in terms around the legislation as well as spectrum assignment may occur.

Through the license, PTA informs that frequencies at 3.6 GHz, as well as other and other higher frequency (e.g. 24.25 - 27.5 GHz bands), are yet to be allocated and likely to be the mainstay for 5G in Iceland. With that, the regulator expects that 5G will be implemented in different stages, with the first being intended to support normal technological upgrades and the capacity of existing high-speed mobile networks in the companies' operations. Allocation of higher 5G frequencies will also include the development of IoT and other secure high-speed mobile network services, as well as cloud services, data centres and other technologies such as artificial intelligence.

Radio frequencies are expected to be used efficiently and the PTA has defined certain requirements for network development for each MNO, with the intention of improving service dissemination. Each license receives a general and a special requirement detailing a percentage of the population to be covered (25%

each) alongside a list of 30 mobile sites across the country where 5G network shall be built with the average speed goal of 200 Mbps to be reached by December 31, 2021. In particular, Síminn is required to provide 5G services with a minimum downlink of 200Mbps to 90% of the population in Blonduos, Thorlakshofn and Egilsstadir; Nova has the same requirement for Hellu, Sandgerdi and Vestmannaeyjum; and Vodafone Iceland has it for Hvolsvelli, Siglufirdi and Grindavik.[48]

The renewal of the frequency authorizations for the MNOs will depend on whether they have used the frequencies effectively in accordance with the relevant PTA criteria. With the renewal of the 5G frequency licenses, it can be expected that the data transfer speed will be increased, and more urban areas will be added to the group of those who will have access to 5G services in the future.[49]

3.11.5 Electromagnetic fields levels and the implementation dynamics

In 2002, a new government act on radiation protected added non-ionizing radiation to the tasks of the Icelandic Radiation Safety Authority (IRSA).[50] For work-related situations, protection measures dealing with the effects of non-ionizing radiation are subject to an Act on Working Environment, and Health and Safety in the Workplace and fall under the auspices of the Administration of Occupation Safety and Health in Iceland (AOSH). Both of the above-mentioned authorities refer to the ICNIRP Guidelines and no national deviation from these are expected.

IRSA And PTA established a collaborative project in parallel with the introduction of 5G. The project involves monitoring the development of 5G technology in Iceland as well as various measurements. IRSA is closely monitoring the development of 5G issues around the world, including the active participation in co-operation between the Nordic Radiation Protection Institutions and international cooperation with the World Health Organization (WHO). In order to keep the Icelandic public informed of the recent developments, IRSA monitors information from reliable sources such as WHO, ICNIRP, IARC, and SCENIHR on health risks due to EMF and publishes it on its website. More specifically, several recent informative notes on 5G and EMF have been published supporting the ICNIRP guidelines (both the 1988 and most recent versions),[51] highlighting the limit value for the intensity of the electromagnetic field in the frequency range 100 kHz - 300 GHz limits.

In the spectrum allocation approved by PTA in April 2020, Article 9 stipulates the conditions to radiation and environment for MNOs using the 3.6 GHz band. The document establishes that the MNO shall ensure that the electromagnetic radiation from their equipment is within the limits specified in the ICNIRP

guidelines for EMF or in accordance with criteria that are in Icelandic rules and laws. Moreover, the MNO shall ensure that the installation and use of the MNO's equipment shall be in accordance with the recommendation from the International Telecommunication Union (ITU-K.52).[52]

If it is found that electromagnetic radiation from electronic communications installations exceeds the specified limit values are in ICNRIP recommendations, rules or relevant Icelandic standards, the frequency holder shall make amendments without delay or otherwise discontinue use of the relevant electronic communications infrastructure. If the combined electromagnetic radiation from electronic communications installations located close to each other passes limit, without any individual equipment exceeding the limit, the frequency holder shall replace the equipment while ensuring that the public does not have access to the area or stop using it.[53]

3.11.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

In February 2019, after receiving authorization from the Post and Telecom Administration, Nova announced it started 5G tests by launching the first 5G transmitter in Iceland, which was manufactured by Huawei. Through a Memorandum of Understanding signed in the same month, the two parties also announced their intention of extending the cooperation on 5G technology to realize the best telecommunications network in Iceland in terms of radio coverage, stability and bandwidth to ensure the reliable service quality and the enhanced experience.[54]

Within the framework of the Memorandum, Huawei installed 5G base stations and routers at Nova's facilities and will be supplying 200 sites of 5G Massive MIMO technology. The agreement states that Huawei will be responsible for planning, design, rollout, and optimization to ensure the overall network quality and user experience. It will supply approximately 2000 units of 5G CPE (Customer-Premises Equipment). [55] Nova was also the first operator to deploy 3G in 2006, 4G in 2013, and 4.5G in 2017.[56] In 2018 and 2019, Nova invested around a billion krónur (6.2 million EUR)[57] per year in the development of its network.[58] On May 5, Nova commercially launched the first 5G network in Iceland and are to date providing 5G service in Reykjavik, Hella, Sandgerdi and Vestmannaeyjar.

In May 2019, Siminn (Iceland Telecom), which has the largest market share of data subscriptions in Iceland, and Ericsson have signed an agreement for the modernisation of the operator's radio access and core networks by deploying Ericsson Cloud Packet Core portfolio upgrades to support the transition from

4G to 5G in Iceland. Enabled by Ericsson 5G New Radio and Ericsson Spectrum Sharing, the two companies plan to conduct 5G trials.

Furthermore, the agreement also aims to accelerate the growth of the Internet of Things ecosystem (IoT) across Iceland's commercial sectors through Narrowband IoT (NB-IoT) and Category M1 (Cat-M1).[59] Accordingly, the Siminn-Ericsson agreement includes geo-redundant Ericsson Network Functions Virtualisation Infrastructure operated on Ericsson's Blade Server Platform with Ericsson Virtual User Data Consolidation, and Ericsson Fast VoLTE. Ericsson Fast VoLTE enables HD voice services with simultaneous LTE-speed surfing, which is likely to pave the way for more advanced communication services.[60]

In September 2020, Vodafone Iceland activated its first 5G transmitter with the intention of building a 5G network in the capital area over the next 2 years.[61]

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3.12 PRINCIPALITY OF LIECHTENSTEIN

3.12.1 ICT background and current status of broadband

The Principality of Liechtenstein has a well-developed telecommunication infrastructure with high penetration rates above the regional average both for fixed and mobile services. Focusing on the investments of state-owned companies, Liechtenstein has been expanding its fibre-optic network since the mid-1990s. According to the Office for Communications, by the end of 2022 all premises will be connected by fibre optic and the legacy infrastructure, i.e. copper and coax, will be switched off. The various policy and regulatory initiatives undertaken by the Government and the regulator over the past years have fostered competition and supported infrastructure investment, which influenced the country's early development and high growth rates recorded in the mobile-broadband market.[1] As of September 2020, no official strategy has been laid down by the Government for 5G roll out in Liechtenstein, although frequencies are being allocated to operators.

As a member of the European Economic Area (EEA), the EU telecommunication *acquis* is applied in Liechtenstein. The latest revision to the Communications Act was in 2020 and the country is undergoing its revisions to transpose the latest EU telecommunication directives (the "Code") in the area of electronic communications. With the aim of promoting investment in a small market while fostering competition, two key policies have been implemented: the obligation to share mobile towers imposed to all mobile network operators (MNOs) and the vertical separation of the fixed-line incumbent.[2] The latter was a decision of the Government of Liechtenstein that came into effect in 2007, thus separating the network infrastructure operations and the retail businesses of the fixed incumbent.[3] Liechtenstein's telecommunication market benefits from a competitive environment in the fixed and mobile segments based on the non-discriminatory access for all telecommunication service providers to the network infrastructure. More recently, many of the Government's digital strategies have focused on legislation, governance, infrastructure, and business,[4] thereby playing a crucial role in expanding broadband access and connectivity speed throughout the country.[5]

As part of the Government Program for 2017-2021, the Digital Agenda is a central field of action for the new legislature concerning ICTs in the country. The main objective of Digital Agenda for Liechtenstein is to optimize the process efficiency of the National Administration with a focus on electronic means of communication, thus strengthening the digital service and the expansion of digital infrastructures—which also includes the development of 5G networks.[6]

The Digital Agenda is oriented by the following overarching principles:[7]

- That the country shall actively use the opportunities of digitization actively and address the associated challenges;
- That the country shall seek opportunities and deal with challenges of digital in cooperation in regard to the society, economy, science, education and administration;
- That the country shall work toward achieving the population's trust in digital services in a way that is driven by reliable information, transparency, security and a strong and clear legal foundation;
- That the companies based in Liechtenstein companies shall offer digitization the chance of penetrating into existing markets further establishing new segments as well as new niches areas for growth. In so doing, they will help foster existing skills and create new ones able to generate added value;
- That Liechtenstein shall seize the opportunity for better, cheaper and innovative products, as well as technologies, service performances and business models;
- That the country shall boost its investment attractiveness as a location that is enhanced by digitization. As such, the country shall create novel kinds of workspaces and job-related opportunities domestically;
- That the country shall promote access to knowledge for all relevant sectors in a simplified way for the population.

The areas for which these principles are designed for, as well as the goals and measures articulated in the Digital Agenda, are structured in the following topics of relevance: State and Administration; Education; Economy; Blockchain and Fintech; Infrastructure; Transportation; Health; Family affairs; and Culture. The strategy also informs that its main goal shall influence the ICT development beyond the legislation, and its core concepts shall be seen as an overarching and cross-institutional that is resourceful for all kinds of stakeholders in the country.

In addition to this Government-led agenda, the Digital Roadmap for Liechtenstein[8] was launched at the end of 2017 in coordination between the Government and other stakeholders in order to support the business development of the country, which included over 50 companies and organizations and networks with relevance in business, science, and politics. Complementarily to the Digital Agenda

(2017-2021), the Digital Roadmap for Liechtenstein focuses primarily on eight areas of focus, especially from the point of view of the economy, so that Liechtenstein can reach a high status of digitalization by 2025[9]:

- Education: the focus is placed on educating and sensitizing the population, encouraging businesses to train workers as well as fostering cooperation between educational institutions and business;
- Workforce: shortage of skilled workers is a central topic of the digital roadmap. Flexible residence permits and a smart job platform for foreign specialists are among the measures to attract foreign talent;
- Digital infrastructure: this includes expanding the fiber optic network and the introduction of the new generation of mobile communications 5G in high quality and as inexpensive as possible. The economy should expand its range of broadband and smart services accordingly;
- Cybersecurity: sensibilization about security risks on the Internet is an important part of the roadmap and this should be incorporated in the national strategy;
- Research and innovation: continuing the work of platforms for research and innovations to support knowledge and technology transfer is of primary importance. This includes the "Innovation Day", the annual Congress Digital Summit Liechtenstein for decision makers from home and abroad as well as the regular workshop events at companies. The initialization of a DigiLab focused on SMEs is also planned as well as programs for start-up funding fund and the expansion of endowed professorships at educational institutions;
- Healthcare: e-Health offers new and modern solutions for insured persons as well as service providers. An electronic health service provision can create significantly more security and efficiency in data handling, unnecessarily reduce duplication and increase the quality of care;
- Mobility and energy: according to the strategy paper, all actors should be given high priority in the areas of mobility and energy to develop innovative mobility concepts;
- e-Government: E-government is the focus of politics, administration and the legal framework. The population and companies should be able to use the services of the state administration in a digital way.

Moreover, extra attention is paid to emerging technologies such as artificial intelligence (AI), robotics, Internet of Things (IoT), big data, cloud computing, and so forth. The digital roadmap is now to be implemented step-by-step in dialogue with politicians and the population and continuously developed.[10] In other words, Liechtenstein now has a strategy paper from the perspective of the economy and from the perspective of the state.[11]

3.12.2 Broadband and mobile telecommunication data

ITU data shows that 98.1% of individuals used the Internet in 2017 in Liechtenstein.[12] In 2010, the ITU data for the country was 80% and, in 2000, 36.5%. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 45.4.[13] Since 2014, xDSL has been reducing while coaxial cable internet access has been increasing steadily, and especially after 2017 with a rapid increase in glass fibre access for private customers.[14] By the end of 2019, fibre-optics network represented a quarter of all internet connections in Liechtenstein (about 4,000 subscriptions).[15] As part of a 48.3 million EUR expansion plan, the regulator's vision is that operators will provide fibre-optic connectivity to the entire country by 2023,[16] which is part of the country's vision in deploying and ensuring a further data traffic capacity development toward a "gigabit society."[17] While the 2019 ITU Measuring Digital Development ICT Price Trends report does not provide basket cost for the fixed-broadband indicators because the GNI per capita data on Liechtenstein are not available, an unlimited monthly data cap of data traffic costs about 42.82[18] USD (36.25 million EUR)[19] in 2020, a decrease from 61.36 USD (51.94 million EUR) in 2019.[20]

In 2019, the number of mobile-cellular subscriptions per 100 inhabitants was of 127.1,[21] while the active mobile broadband subscriptions per 100 inhabitants were 132.4.[22] There are three major MNOs that dominate the market in Liechtenstein: Telecom Liechtenstein (FL1), Swisscom (Switzerland), and Salt (Liechtenstein) (formerly Orange Liechtenstein). Since the introduction of roam-like-at-home tariffs in the European Economic Area (EEA) from mid-2017, mobile subscriptions with Liechtenstein +423 numbers increased again significantly in 2019 and reached a share of 31% at the end of the reporting year. The total number rose by 2% to 48,000 subscriptions.[23] Despite that, a significant number of mobile subscriptions are from Swiss mobile phone providers with the number +417, which means that these mobile phone subscriptions are subject to Swiss legislation.[24] Although the basket cost for mobile data remain unavailable due to the lack of data on GNI per capita in Liechtenstein, a monthly package of 20 GB Internet data traffic cap was reported to cost about 24.54 USD (20.77 EUR)[25] in 2019.[26] Overall, according to ITU

elaborations, 98% of the population enjoys 4G/LTE services while 99% of the population is covered by 3G.[27]

3.12.3 Current progress on 5G: consultations and national strategies

The government regards the introduction of 5G as an important building block for the country's digital future, and as the logical continuation of previous strategies and Government-led plans in the field of electronic communication. Therefore, no dedicated national strategy on 5G is necessary. The Government states that it is largely through a modern and optical communication infrastructure the country will be able to make its territory a highly attractive location for telecom investments and consequently improvement of the economy in the future.[28]

The initial strategy for Liechtenstein was to award 5G frequencies to operators at the end of 2019. However, the Ministry of Economy informed that the Office for Communications decided to wait for the frequency allocation to take place in neighbouring countries. In parallel to the proceedings in Austria, the Office prepared the allocation of 5G frequencies in Liechtenstein,[29] taking into consideration the possibility of coordinating the available frequencies closely with Switzerland and Austria[30] and ensuring an optimal frequency allocation and efficient frequency use in the country.[31]

The MNOs in Liechtenstein can rely on a comprehensive fibre-optic network for connecting all the radio cells required for 5G.[32] Additionally, the Office for Communications also states that it is currently not possible to estimate how many new antenna locations in total will be required, although it can be assumed that in a first phase of the 5G roll out in Liechtenstein, the existing transmitter network which consist of 23 so-called "macro locations" will be taken as a basis for building the network.[33]

Based on the current telecommunication rules in the country, the technical design of the networks falls into the responsibility of MNOs, which depends on the frequency band and the respective geographic coverage area. Depending on the technical expansion concept, MNOs in Liechtenstein must handle increased bandwidths, which will require antenna with higher transmission capacities. Different network concepts are also considering the use of microcell in metropolitan areas of the country.

3.12.4 Spectrum assignment for 5G & market development

In 2020, Liechtenstein started the process of assigning the 5G frequencies in the ranges of 700 MHz, 1400 MHz and 3.5 GHz bands. The regulator has already informed, that it will not use an auction, but an administrative procedure,[34] under which the MNOs propose the optimal distribution of the available frequencies.

According to the Liechtenstein frequency allocation plan, the following additional frequency ranges will be available for the provision of public, nationwide mobile communications services for technology-neutral use to be taken by the major MNOs in the country:[35]

- 703-733 MHz / 758-788 MHz (2 x 30 MHz) bands;
- 738-753 MHz (15 MHz) band;
- 1427-1517 MHz (90 MHz) band;
- 3410-3800 MHz (390 MHz) band.

The Office for Communications assumes that the award procedure can be completed in 2021. The Office for Communications will report on the result after the award procedure has been completed.

3.12.5 Electromagnetic fields levels and the implementation dynamics

To ensure protection of the population from electromagnetic radiation, the Government issued the Environmental Protection Act (USG) in 2008[36] and the Ordinance on Protection from Non-Ionizing Radiation (NISV) in 2008.[37] This act and ordinance limits the non-ionizing radiation emanating from fixed systems (e.g. high-voltage lines, mobile radio or radio transmitters).

In December 2009 the population of Liechtenstein voted in a referendum to maintain the same limit values as pronounced in Switzerland. These are currently the lowest permissible exposure limits in Europe. The Swiss threshold level is set at 4-6 volts per meter (V/m) for the electric field strength.[38] In other words, the limits for the electromagnetic fields (EMF) values in Liechtenstein are today 10 times stricter than those proposed limits by the World Health Organization (WHO).[39] In February 2019, MPs raised the question on whether a relaxation of radiation protection is also expected to facilitate 5G deployment and uptake as 23 antenna masts are currently in place and current limits would require installation of additional masts.[40]

Nevertheless, it is still unclear whether the legal regulations regarding the non-ionizing radiation will have to be adapted for the introduction of 5G. Based on the amendment on the Environmental Protection Act from June 30th 2020,[41] the responsible Office for the Environment stated, that Liechtenstein is actively monitoring developments related to 5G and EMF in Switzerland, and explained further, that it will respond to any adaptation of the legal framework to examine whether there would be any need for action for Liechtenstein.[42]

3.12.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

In 2018 FL1 and Swisscom made announcements of their intention of expanding their networks to encompass 5G services but without providing a timeline or specific targeted goals to the public.[43]

In August 2019 A1 Telekom Austria Group has announced the sale of its 24.9% stake in Telecom Liechtenstein (FL1) to the state of Liechtenstein. The transaction increases the state's shareholding in the telecom operator from 75.1% to 100%. The companies agreed to a strategic partnership in 2014 that lasted for five years and A1 exercised its termination option last year. Further cooperation, especially on a technical-operational level but without capital interlocking, was agreed between FL1 and the A1 Telekom Austria Group, which may have implications for 5G development in Liechtenstein.[44]

However, despite the changes in the telecom structures and other 5G developments by Swisscom in Switzerland, there have been no major 5G-related commercial announcements in Liechtenstein as of October 2020.

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3.13 PRINCIPALITY OF MONACO

3.13.1 ICT background and current status of broadband

Monaco has a strong ICT sector characterized by the majority of its population being connected to the Internet. The government continues to prioritize the roll-out of fixed and wireless Next Generation Access (NGA) networks and the deployment of Monaco Telecom's own mobile network to support ICT development in the country.[1]

Unlike most countries in the European region, there is no independent telecommunication regulator in Monaco, but the Department of Platforms and Digital Resources which is part of the Government's General Secretariat, is charged with regulating the telecommunication market in the country.

Monaco does not have a national broadband strategy, but in April 2019 the government implemented the "Extended Monaco: Smart Principality" programme as the Monegasque model to the digital world. Led by a cross-disciplinary authority, the Digital Transition Office, the program's overarching vision combines the positive affordance of digital technology and link them to matters of public policy and sustainable economic development until 2022. In other words, the program sets out to take advantage of the enormous potential offered by digital technology and ensure that it directly benefits the Monegasque population.[2]

It is the government's view that by liberating Monaco from its territorial constraints, digital technology is an opportunity to embark on a new development cycle and to play a more prominent role alongside other global cities.[3] The areas of interest covered by "Extended Monaco" include smart city, e-health, e-education, infrastructures, fintech, and initiatives related e-government.[4] The "Extended Monaco" programme is based on three main pillars: I) enhancing quality of life; II) inaugurating a new cycle of economic prosperity; and III) boosting the value of the civil service.

In terms of digital-driven economic growth, the programme focuses on the following strategies and actions:[5]

I) Give companies in the Principality a framework that is conducive to capturing all the potential of digital technology:

- By equipping itself with large digital infrastructures such as 5G and fibre throughout its entire territory;
- By guaranteeing security and sovereignty;

- By adapting Monaco's legislative framework to facilitate the development of digital technology;
- By adapting legislations. Three laws, in particular, were enacted in 2019, enshrining the blockchain, digital identity and digitization concepts;
- By adopting a Strategic State approach, with for example the Monaco Government initiating and driving digital technology-based economic growth initiatives or attracting digital and industrial partners;

II) Boost and perpetuate the Principality's current economic model:

- By contributing to the Principality's event strategy, for example by increasing the impact of key events such as the Grand Prix or the Yacht Show;
- By encouraging companies that enjoy a monopoly (SBM, SMEG, Monaco Telecom, CAM, etc.) to develop new services via digital technology;

III) Creating new, highly targeted growth drivers for the digital sector in the Principality:

- By focusing on the technologies of the future in tandem with leading sectors in Monaco (Real Estate, Wealth Management, Luxury, Yachting, Sport, Business Tourism) via the creation of financing structures or the setting up of dedicated startups through Monaco Tech, Monaco's business incubator;
- By Attracting innovative and ethical companies through new funding methods such as Initial Coin Offerings.

Additionally, in the context of the COVID-19 global pandemic, the Ministry of State recently announced that the government is working on a digital resilience strategy. To succeed in such a strategy, the Principality will need to build new infrastructure, create and provide access to a local and international digital ecosystem and develop services that ensure continuity for public policies. This action plan will have three main strands: I) Developing digital infrastructure, including telecoms networks and the cloud; II) Optimising digital technology for use by private users and businesses (smartphone equipment rate, availability of electronic signatures and stamps, e-commerce platforms, etc.); and III) Improve the State's digital maturity (education, health, government, cybersecurity, etc.).[6]

3.13.2 Broadband and mobile telecommunication data

ITU data shows that 97.1% of individuals used the Internet in 2017 in Monaco[7] and in 2019 77.8% of main residencies in the country had some form of Internet access.[8] In 2010, the ITU data for the country was 75% in 2010 and, in 2000, 36.5%. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 52.6.[9]

Through an agreement with the Principality of Monaco, Monaco Telecom (a member of Eurecom in France) holds the monopoly of landline telephone services, fixed-Internet access, and TV services. In the past, the telephone network used to be fully owned by the state, which currently owns 45% of it.[10] Additionally, Monaco Telecom is aiming to equip 100% of eligible buildings with fibre-optic cables by the year 2023.[11] In March 2019, local press reported that Monaco Telecom executed a 6-month long optical fibre-networks rollout in the Fleur district of Monaco. The three-part project has been handled by Monaco Telecom, the Monegasque Water Company and the Urban Planning Department for Sanitation. By 2025, the government aims to provide full FTTH coverage.[12]In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was 86.7.[13] Although the penetration of mobile phones has been high since the early 2000s, steady growth has been observed particularly after 2008.[14] Moreover, the number of active mobile-broadband corresponded to 86.4 subscriptions per 100 inhabitants in 2019.[15] Monaco Telecom is the one national Mobile Network Operator (MNO) that dominates the mobile sector, although French MNOs such as Orange, Bouygues Telecom, SFR, and FREE are also widely available in the country. In 2019, the mobile-broadband Internet traffic within Monaco corresponded to 0.001 exabyte according to ITU.[16]

Over the past year, Monaco Telecom has heavily invested in revamping its networks, pioneering the deployment of country-wide infrastructures and services such as mobile coverage in LTE+ technology as fast as 1 Gbps, fixed Internet data speed of 1 Gbps, and high-security data transfer across the operator's networks.[17] Nowadays, 3G and 4G/LTE are widely available in the country with 100% coverage.[18] Although the basket cost for mobile data remains unavailable due to the lack of data on GNI per capita in Monaco, a monthly package of 20 GB Internet data allowance cost 47.23 USD (39.86 EUR[19]) in 2019.[20] Given Monaco Telecom's small area of operation and the intense level of competition, it is facing from French operators, the operator is allowed to have around 30 per cent higher prices than French operators according to government regulations.[21]

3.13.3 Current progress on 5G: consultations and national strategies

In 2019, Monaco became the first state in Europe to have a full, operational, and commercial 5G network coverage in its national territory,[22] over an area of an approximately 2-kilometre square with 27 antennas deployed as of October 2020.[23]

While the country does not have a 5G strategy, 5G connectivity is the first pillar of the "Extended Monaco," alongside cloud services and fibre-optic development. Launched in April 2019, "Extended Monaco" holds the deployment of infrastructure and public policy initiatives across all relevant sectors such as health, education, smart city, and others, as priorities until at least 2022.[24]

Through this program the government recognizes the need of building a cross-cutting architectural infrastructure foundation that will support the digital transformation in the country, focusing on the quick development of an ecosystem that meets leading international standards and foster integration with other relevant vertical markets that ultimately will bring further economic development in Monaco.

In February 2020, the government published a user guide to 5G, answering the most frequently asked questions on the 5G roll-out and providing information on how these networks are set to benefit the population as well as both private and public stakeholders.[25]

3.13.4 Spectrum assignment for 5G & market development

As of October 2020, no public information or document on spectrum assignment for 5G is available in Monaco. However, it has been reported that 5G is being deployed on frequencies similar to those used for 4G and Wi-Fi.[26]

3.13.5 Electromagnetic fields levels and the implementation dynamics

In Monaco, the Smart Nation Department, which is operated under the General Secretariat of the Ministry of State, is responsible for ensuring that emissions from the Principality's radio networks comply with the regulatory thresholds. It takes regular measurements across the Principality, focusing particularly on schools, healthcare institutions, and retirement homes.[27]

Considering the law number 928 of December 8, 1972, the ordinance number 3.020 of 26 November 2010, pertaining to the limits of the public's exposure to EMF, sets a global limit of 6 V/m (volts per metre) on average for all radio frequencies, and a second, lower limit of 4 V/m for mobile phone publics networks (2G, 3G, 4G and 5G).[28] These are more restrictive EMF limits than the international standard published by

the ICNIRP (International Commission on Non-Ionizing Radiation Protection) and European Union Recommendation (28 to 87 V/m).[29]

Within the 100 kHz and 6 GHz frequency bands, this limit value is 4.5 times below the lowest limit recommended by the World Health Organization (WHO), which is 28 V/m. Furthermore, an additional restriction of 4 V/m[30] was introduced for emissions from mobile phone base stations (set at 6 V/m for places inside buildings).[31]

The measurements carried out by Directorate for the Development of Digital Uses (DDUN) are available to the public in the form of an interactive map,[32] thus providing information on all the radio transmission sites constituting the public communications networks in the Principality, encompassing both broadcasting and mobile telephony.[33] This interactive site uses the latest measurements of electromagnetic fields carried out by the DDUN). which are regularly updated and that highlight compliance with the exposure limits of the Principality.[34]

3.13.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

In September 2018, Monaco Telecom tested 5G services in conjunction with Huawei as part of an equipment supply deal, extending previous collaboration agreements between the two private stakeholders. In this context, the operator showcased a 5G-connected UAV (unmanned aerial vehicle) broadcasted live high-resolution 360-degree panoramic images through a virtual reality headset.[35] Monaco Telecom also announced that the first 5G antennas have been installed in the Port Hercule area and that extended network coverage was underway.[36]

In February 2019, Monaco Telecom and Huawei signed a Memorandum of Understanding (MoU) to accelerate the deployment of smart city-related projects in the Principality within the context of Monaco's "5G Smart Nation" project.[37] The strategic agreement sets out the collaboration of the project in the fields of Internet of Things (IoT), big data, and cloud services.[38] The MoU also inform that Monaco Telecom will be able to rely on Huawei's 5G and NB-IoT networks already deployed in Monaco as well as on the test cloud platform based in Dusseldorf, Germany.[39] Relying on Huawei's networks, Monaco Telecom switched 5G in July 2019.[40]

In September 2019, the Belgium operators BICS announced it established the live 5G data roaming service between Monaco Telecom and an Italian telecommunications company using BICS's 5G global IPX network.[41]

In addition to the 5G trials and pre-commercial announcements by the country's only MNO, local press has reported in October 2020 that companies such as Vizua 3D entertainment, an augmented reality start-up based in the MonacoTech Incubator, as well as public entities such as Monaco's firefighters working on reconnaissance drones with high-definition cameras, have plans to deploy 5G services shortly.[42]

Other projects related to Smart Cities by local start-ups were also reported within the context of self-driving eco-bus and remote-control installations for better energy efficiency.[43]

Endnotes

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3.14 NORWAY

3.14.1 ICT background and current status of broadband

Norway possesses one of the most advanced telecommunication markets in Europe. The country has penetration rates for fixed and mobile services well above the regional average, in addition to having a mature digital media sector. As a member of the European Economic Area (EEA), Norway has adhered to EU electronic communication directives, which has paved the way for further economic expansion of ICT in the country by private stakeholders. Since the *e*Norway action plan in 2000, ICT has been an integral part of Government policies in the transition toward an information society, setting the basis for subsequent ICT-related government programs.[1]

In 2016, the Norwegian Ministry of Local Government and Modernisation published the "Digital Agenda for Norway" [2] in the format of a white paper, although initiatives on broadband have occurred in Norway since 2005.[3] In the 2016 "Digital Agenda," the government announced its intention to enable Norway to exploit the opportunities of ICTs.[4] Additionally, the white paper is driven by two key objectives: to ensure a user-centric and efficient public administration, and to achieve value creation and inclusion. The five key priorities articulated in the agenda include the following: I) A user-centric focus; II) ICT should constitute a significant input factor for innovation and productivity; III) Strengthened digital competence and inclusion; IV) effective digitisation of the public sector; and V) A sound data protection and information security.[5]

In other words, the "Digital Agenda for Norway" describes how better access to digital literacy in the public and private sectors, regulation better adapted to a digital society, and a public sector as a demanding customer will serve as policy instruments to achieve Norway's goals for the information society.

Particularly regarding mobile and broadband for growth and inclusion, the Norwegian Government has set the following goals for future electronic communication policy:[6]

- 90 per cent of all households shall have access to at least 100 Mbit/s by 2020, based on a commercial rollout in the market;
- The long-term goal is that all households shall have access to high-speed broadband;
- Mobile coverage where people live, work and travel;

- Good electronic communication networks shall be a competitive advantage for business and industry nationwide;
- The electronic communication authority shall map demand for and access to infrastructure that can be used by data centres;
- It shall be easy to deploy broadband networks;
- The regulations for laying broadband cables along municipal and county roads shall be as uniform as possible; and
- Electronic communication service providers shall have fast access to available frequency resources to meet their needs.

Norway's ICT policy also reinforces the importance of a robust broadband infrastructure and widespread digital literacy among the population. The three main priority areas of that policy are to:[7]

- Ensure an information society for all, including by facilitating the supply and distribution of high-speed broadband, increasing digital literacy in the population, and ensuring a universal design of ICTs.
- Contribute to innovation and value creation in business, by facilitating the development and use of services based on digital content, promoting a digital culture industry, make public data available for further use, and promoting smart, energy-efficient ICT solutions in transport, energy and construction. The digitisation of business processes and the development of innovative solutions for the healthcare sector add also significant value.
- Digitise public services, by coordinating ICT projects that have an impact across the public sector, promoting the development of self-service solutions, adapting regulations to promote digital solutions, and ensuring that common ICT solutions are established and made available to the rest of management.

While Norway has strong and affordable 4G coverage and its 3G networks are set to be phased out by 2025, significant investments and developments have occurred in the fibre sector as there are more emerging key players in the country. As of October 2020, at least nine new subsea fibre projects are under progress and are expected to be finalized by 2022,[8] reaching more than 13,000 km of extension.[9] This fits into the more than 316.7 million EUR expected to be invested in new submarine cable systems in the Nordic region by 2023. As a result, this will likely provide the country with a wider set of economic

possibilities for different routes going in and out of the country,[10] and thus reduce Norway's reliance on existing networks coming out of other Nordic countries.[11]

In face of the COVID-19 pandemic, many Norwegian municipalities have successfully adapted to digital teaching, but as it is in the case of other countries in the region, not all municipalities have had equal access to infrastructure, equipment and resource. To mitigate the upcoming phases of the pandemic, the Norwegian government submitted its proposal for a revised national budget for 2020 on 12 May. This includes a proposal to increase the budget for digital teaching by 12.95 million EUR.[12]

3.14.2 Broadband and mobile telecommunication data

ITU data shows that 98% of individuals used the Internet in 2019,[13] with practically all citizens connected to broadband.[14] In 2010, ITU data for the country was 93.4% and in 2000 52%.[15] According to ITU data, the estimated proportion of households with Internet access at home in 2019 is 98%.[16]

In 2018, the number of fixed-broadband subscriptions per 100 inhabitants was 41.3.[17] In 2015, the country's Internet services relied on nation-wide DSL coverage and more than 100 local fibre providers. However, since 2016, Digital Subscriber Line (DSL) technology has been steadily decreasing while fibre coverage is growing. The operator indicated that it aims to convert all customers on its copper network to fibre by 2023.[18] Due to the demand and the Norwegian Communications Authority (Nkom)'s goal to expand broadband infrastructure in Norway, fibre has become a common technology for Internet access and is available in almost every city in Norway,[19] offering a variety of services including the access to the delivery of pay-TV.[20]

In 2018, Norwegian residential fibre connections exceeded 1 million for the first time.[21] In October 2020, Nkom published its annual broadband survey, reporting that 74% of households had access to fibre broadband as of June 2020. Nkom highlighted the development of fibre-based technology in less populated areas in Norway, particularly noting that 55% of residential households in rural regions now have access to fibre-enabled broadband, up from 45% reported at mid-2019. Largely due to the revamped fibre-network coverage, the regulator also reported that 98% of Norway's households had access to at least 30 Mbps, and that the number of above 100Mbps connectivity is steadily growing.[22] Moreover, the regulator recently selected Telia Carrier to build a secure diverse fibre route facilitating an increased geographic distribution of traffic between Norway and continental Europe and is set to be ready for service by the end of 2021.[23] From the regional perspective, Europe's average fixed-broadband basket

cost was 1.5 per cent of the GNI per capita in 2019, while Norway's corresponded to 0.7 per cent for an unlimited data cap in 2019, ranking among the top ten countries in Europe.[24]

According to ITU data, in 2018, the number of active mobile-cellular subscriptions per 100 inhabitants was of 107.2,[25] while mobile-broadband subscriptions per 100 inhabitants for the same year corresponded to 99.2.[26] There are three major mobile network operators (MNOs) that dominate the market in Norway: Telenor, Telia (formerly NetCom before being rebranded in 2016), and ice Norway. Over the past years, significant investment has been made in extending 4G infrastructure by private stakeholders.[27] In terms of 4G coverage, Telenor and Telia provide outstanding network coverage throughout the country, which makes Norway one of the countries with highest percentage of 3G and LTE/4G coverage, with both networks covering 99.9% of the population.[28] In 2018, the mobile-broadband Internet traffic within Norway corresponded to 0.298 exabytes.[29]

Furthermore, Norwegian operators have been particularly efficient about encouraging adoption of VoLTE, enabling subsequent re-farming of the 3G spectrum to 4G. For example, Telenor announced that it has plans to entirely shut down the 3G network by the end of 2020[30] to provide better service on its 4G network.[31] The country's mobile-data basket cost corresponded to 0.4 per cent of the GNI per capita in 2019 for a monthly allowance of 5 Gb, while the European region's average was 0.8 per cent during the same year.[32]

3.14.3 Current progress on 5G: consultations and national strategies

Nkom began plans to clear the 700 MHz 5G frequencies in 2017 making Norway one of the first countries headed towards 5G development.[33] As listed in the state budget, this move had an approximate cost of approximately 13.9 million EUR to Norway,[34] which paved the way for the first 5G commercial activities in the country in March 2017.[35]

Around the same time, the early stages of the Nordic 5G Action plan also occurred upon the Nordic-Baltic states discussing how their governments could better support and facilitate rapid development of 5G in the region. In such an early agreement, Norway and co-signers decided to:[36]

- Make more spectrum available in a speedy manner, necessary for testing, research and the commercial roll-out of 5G networks;
- Cooperate with industry in pilots on 5G services through public-private partnerships, e.g. through Universities or public enterprises;

- Support innovation and development of products and services making use of 5G networks;
- Encourage participation from Universities and public research programs in the development of new use of 5G services; and
- Promote early deployment in major urban areas and along major transport paths.

Although the country does not have a national strategy particularly targeting 5G, Norway articulates some of its objectives on 5G network development through the "National Strategy for Artificial Intelligence," which was prepared by the Ministry of Local Government and Modernisation in February 2019 for both the private and public sector.[37]

In the AI strategy, 5G is regarded as a vital enabling infrastructural technology for AI and a priority investment area by the Norwegian government.[38] The development of the Internet of Things (IoT) as well as 5G-enabled products in the Norwegian mobile market are considered as essential elements for the development of AI. In other words, the strategy highlights that 5G infrastructure is set to play a crucial role in implementing a full-scale realisation of IoT and other AI-enabled services across a variety of sectors such as transport, healthcare, and smart cities. While the 5G deployment is largely in the hands of private sector operators such as Telia—which plans to develop 5G network by the end of 2023[39]—the Norwegian government indicates that it plans to facilitate the rapid rollout of 5G in the country.

Additionally, the Nordic Council cooperation in the field of 5G—comprised by Denmark, Finland, Iceland, Norway and Sweden as well as the Faroe Islands, Greenland and Aland[40]—is another component of Norway's 5G strategy. In 2018, the Nordic ministers signed a Letter of Intent (LoI) for the Nordic region to be first and most integrated 5G-region in the world.[41] The LoI acknowledges the deployment of 5G will require substantial investments and an appropriate regulatory framework both in national contexts toward a common Nordic 5G space.[42] This agreement is also aligned with other Nordic cooperation dealing with the adoption of IoT and other emerging technologies such as the Nordic Smart City Network,[43] which helps governments create best practices for smart city projects and urban development.[44]

To achieve this goal, Norway agreed to cooperate closely with other Nordic countries to set up a common action plan for early adoption of 5G technology across the Nordic region. The action plan will:[45]

- Encourage the development of new testing facilities, including testbeds;
- Ensure the technical coordination of 5G frequency bands within the region;

- Remove obstacles to the expansion of 5G network, in particular, the deployment of base stations and antennas; and
- Encourage and monitor the development of 5G, specifically for certain sectors such as transport, mission-critical communications, and advanced automation in the manufacturing industry, and the energy sector.

Norway is also instrumental in the EU project 5G VINNI, where Telenor, Ericsson Norway and Huawei Norway and others are pushing 5G technology development.[46]

3.14.4 Spectrum assignment for 5G & market development

In April 2019, Nkom indicated the following frequency bands as relevant for allocation to mobile communications and 5G in the coming years: 738-758 MHz (700 MHz SDL); 1427 1518 MHz (1500 MHz SDL); 2300-2400 MHz (2.3 GHz); 2500-2690 MHz (2.6 GHz); 3400-3800 MHz (3.6 GHz); and 24250-27500 MHz (26 GHz).[47]

Between June and August 2019, Nkom completed a consultation[48] on frequency resources for mobile communications and 5G.[49] The first 5G auction in Norway took place on June 2019, with the allocation of 700 MHz Band. Telia, Telenor and Ice won spectrum in this auction. Then in May 2020, the 28 GHz (n257) and the 38 GHz (n260) were auctioned to these operators. Auction for the 2.6 – 3.6 GHz band is set to occur sometime in 2021.[50]

The process ended with the following assignments:[51]

- Telenor was assigned 2×10 MHz of spectrum in the 700 MHz band subject to the coverage obligation on main highways, for a total auction price of 16.6 million EUR;
- Telia was assigned 2×10 MHz of spectrum in the 700 MHz band subject to the coverage obligation on designated railway sections, for a total auction price of 20.2 million EUR; and
- ice was assigned 2×10 MHz of spectrum in the 700 MHz band and 2×15 MHz in the 2.1 GHz band, for a total auction price of 31.2 million EUR.

In September 2019, Nkom has established a frequency compass, which is a roadmap for frequency bands for mobile communications and 5G. The regulator states that its plans for allocations and harmonization with international guidelines. Norway is part of the frequency harmonization within the EU, through the

EEA agreement, for which the country engages as an observer in certain cooperation groups such as the Radio Spectrum Committee and Radio Spectrum Policy Group.

Nkom has suggested there are grounds for allocating 300MHz in the 3.6GHz band under national permits, with 100MHz to be issued under regional/local licences, although an alternative distribution method being examined is that all 3.6GHz spectrum would be offered on a nationwide basis, with 2.3GHz frequencies to be issued on a regional/local basis.[52] Based on this consultation inputs, the regulator started assessing the consultation and inputs and continue the preparations further ahead allocation.[53]

With negotiations on standardization and technical prerequisites beginning 2020, observations on these frequency ranges have been conducted by the Nkom:[54]

- 700 MHz: Available to mobile operators today and is considered. Frequencies with long-range, but lower data capacity. 700 MHz SDL is the former broadcast band that is now harmonized for mobile communications;
- 3.6 - 3.8 GHz: Most important pioneer band for 5G in Europe. In Norway, these frequencies will be auctioned off in 2021, but the mobile operators have test permits today, and test areas are being built where these will be used. The frequencies have a shorter range and high data capacity and are currently used for fixed-mobile broadband and 5G testing;
- 26 GHz: Used today for radio link and testing of 5G. The use will probably be to create smaller, delimited areas with good coverage in Norway. Short-range and very high data capacity.

Existing licenses in the 2.3 GHz, 2.6 GHz and 3.6 GHz bands expire on 31 December 2022. In the 700 MHz SDL, 1500 MHz SDL and 26 GHz bands, the current licenses and use are extended to a possible allocation has been decided.[55]

Finally, the regulator is deliberating setting a spectrum cap for frequencies across all three bands, with consideration also being given to whether a 100MHz cap should apply in the 3.6GHz band specifically. In addition to this, the regulator also plans to set a starting price of approximately 2.2 million EUR per block and a frequency limit of 80MHz.[56]

3.14.5 Electromagnetic fields levels and the implementation dynamics

Norway follows the EMF recommendation limits proposed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).[57] Since 2013, Nkom has performed outdoor measurements of EMF

in Norway and today continues to monitor EMF-related subjects concerning the recent advances in telecommunications. In 2016, the government implemented the Norwegian Occupational Safety Regulation, which was enacted within the framework of the Directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from EMF.[58]

Nkom regularly monitors the EMF exposure in Norway and maps out the exposure from various transmitters to guarantee that they are not exceeding the limit values.[59] To facilitate the access to EMF information in the country, a radiation calculator is also available on the operator's website, which citizens can calculate the exposure level at a given geographic point within the country's territory.[60] More recently, Nkom also published a brochure from antenna systems for staff working on the installation of communication equipment who may be exposed to radiation.[61]

As of October 2020, Nkom and the Directorate for Radiation Protection and Nuclear Safety (Direktoratet for strålevern og atomsikkerhet – DSA)[62] have produced several information brochures on radiation,[63] with the latest coming out in May 2020.[64] Moreover, Nkom dedicated an entire page on its website detailing information on EMF regulations within the 9 kHz–400 GHz frequency range to educate the general public on ongoing debates and the regulator's decisions to be abided by private operators.[65]

Concerning the potential health hazards concerning the use of the highest 5G frequency (26 GHz), the DSA states that on its website that similar frequencies have for decades been used for radars and radio links as well as in countries such as the United States.[66]

Nkom has also conducted surveys in private homes and several schools, kindergartens and other public buildings in the largest cities (Oslo, Kristiansand, Bergen and Trondheim) to gather more information on EMF in the country.[67] Other engagements on EMF-related issues have been headed by the Norwegian Institute of Public Health, commissioned by Ministry of Healthy as well as the Care Services and the Ministry of Transport and Communication, to educate the Norwegian public on the effects of wireless networks on health.[68]

3.14.6 5G Commercial launches: announcements, trail cities, and digital cross-border corridors

In May 2017, Telenor Group and Huawei jointly announced the first 5G-based E-band multi-user Multiple Input Multiple Output (MIMO) demonstration in Norway, reaching a maximum speed of 70Gbps.[69] In November 2018, Telenor founded the first Norwegian 5G testbed in Kongsberg,[70] which later received industrial support and now has grown to become a viable 5G innovation hub.[71] Telenor has also been

coordinating the 2018 pan-European 5G-VINNI project, an EU-funded initiative within the Horizon 2020 which has a budget of 20 million EUR.[72]

In February 2019, local press reported that the 5G tests using the non-standalone 5G variant began at the movie theatre Odeon Oslo, which is located within the Telia Norway's coverage area of the pilot networks. This cinema is the newest and biggest in the city of Oslo, with 14 halls all equipped with the newest sound and image technology. The location is testing 5G for delivery of digital movie files, as well as providing internet access to their guest Wi-Fi zones in the building. This makes Odeon Oslo the world's first 5G-based movie theatre.[73]

In February 2019, ice Norway announced that it was building a 5G-ready network in urban areas across Norway based on Nokia AirScale Radio Access technology, with approximately 1000 5G-ready base stations already deployed. The deployment is part of a multi-year agreement between ice Norway and Nokia which includes network planning, site acquisition, civil works, deployment and care.[74]

In March 2019, Telenor announced its plans of investing on Trondheim as the first major city in the country to receive 5G, which represents the operator's biggest 5G project. The existing partnerships between the municipality, the Norwegian University of Science and Technology and the business community on smart city, 5G presented as a promising network for the residents and a strategic investment focus for the operator.[75]

In September 2019, Telenor launched Scandinavia's largest and 5G pilot in the municipality of Elverum in addition to other pilots in nine further locations in Norway.[76] Through this project Telenor became the first operator in Norway to integrate 5G into its mobile network, enabling more than 50 pilot customers in the municipality to be connected to the 5G network. Telenor also announced that Ericsson would be contributing to both 5G network equipment[77] and deployment.[78]

In October 2019, Telenor Group and Cisco signed an agreement whereby Cisco declared it would upgrade Telenor Norway's existing mobile core network to deliver 5G in Norway. Since 2010, Cisco has provided core technology to Telenor Norway's 3G and 4G networks. In 2018, the companies upgraded Telenor Norway's core network to provide Scandinavia's first nationwide network for the Internet of Things (IoT).[79]

Following the same strategy for the 4G deployment in the past, in October 2019 Telenor launched 5G pilots in Longyearbyen, the economic and administrative capital of the Archipelago of Svalbard, becoming the world's northernmost 5G pilot. The operator chose the region because Svalbard is a testbed for new

technologies. It also illustrates the potentialities and challenges presented by 5G-enabled smart city projects as an example for mainland Norway. The operator also reported on the development of 5G-powered drones on the Svalbard region for monitoring global warming effects[80] as well as the use of emergency networks and 360-degree cameras.[81]

In December 2019, after more than a decade of collaboration on 4G, Telenor ceased its collaboration with Huawei and chose Ericsson as the key technology provider for 5G. In the context of the new firmed partnership, the operator announced that it carried out extensive security evaluation and consisted of factors such as technical quality, innovation, and modernization of the network. According to Telenor, the use of Huawei network components in Norway will be phased out over a 4-5-year modernization period.[82] Despite that, the press also reported that Huawei would still maintain collaboration with Telenor both to maintain the 4G network and also upgrade to 5G coverage in selected areas of Norway.[83] The Norwegian Government has not yet decided whether the security legislation disqualifies Huawei from being a provider to the country's 5G-network.[84]

Furthermore, in December 2019, the press reported that Ericsson, Telia and Norwegian University of Science and Technology (NTNU) partnered in the 5G testing of an autonomous ferry, named milliAmpère. Ericsson 5G technology enabled Telia to securely support the large amount of data needed to support the driverless transport ferry. milliAmpère was equipped with sensors that recorded its surroundings and controlled the steering system onboard via 5G.[85]

In January 2020, Nokia Nuage Networks and Telia launched SD-WAN, the next-generation datacom services for the enterprise market. With SD-WAN, the control and operation of the network are simplified as it is separated from underlying infrastructure and hardware and depends solely on the cloud. The companies announced that the new datacom services will utilize their 5G network. [86]

In March 2020, Telenor launched its commercial 5G network in nine different cities and villages across Norway, making it the first mobile operator in the country to offer 5G connection. According to the operator, it was intended that the official opening of Norway's first commercial 5G network would take place in the country's tech capital of Trondheim. However, due to the current situation with COVID-19, Telenor has decided to cancel the event and instead host the opening as a virtual video conference. [87] The enhanced mobile broadband services are being delivered on the 3.6 GHz band.[88] Telenor plans to launch 5G services in the capital town Oslo and Bergen, Stavanger, and Sandnes by the end of 2020.[89]

In May 2020, Telia Norway launched its commercial 5G network while relying on Ericsson's NR radio access network (RAN).[90] Both companies started working on 5G-related development in 2019. The network

launch celebrated the coverage of Lillestrøm and parts of Groruddalen in the greater Oslo region as the first areas to benefit from enhanced mobile broadband services.[91] Per the agreement, the collaboration also involves the deployment of Ericsson's Spectrum Sharing (ESS) software,[92] which enables Telia Norway to share its spectrum between 4G and 5G network.[93] The operator announced that it aims to provide coverage to at least half of the Norwegian population by 2021 and offer a nationwide 5G coverage in 2023.[94]

In September 2020, ice Norway launched a main 5G pilot encompassing 7 main sites in the northern region of Tromsø. The operator received a 3.7-3.8 GHz band test license from the regulator, and it already has a large amount of 5G-ready Nokia base stations. In addition to lab tests reaching up to 1 Gbps. Press reports have indicated that the operator will invite just a few dozen customers to try out the network during the remainder of 2020.[95] The operator said it does not know exactly how long the trial will last but it is likely to run for several months. Customers wishing to participate must have 5G devices that support 3,600 MHz and ice Norway will probably offer the pilot for routers as well as smartphones.[96] The operator also said that initial public 5G offering in urban and rural areas expected during early 2021, using 700/2100MHz.[97]

Telenor anticipated that during 2021 they will upgrade close to 2,000 5G base stations, while a total of 8,500 base stations are set to be upgraded within the next four to five years.[98]

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3.15 REPUBLIC OF SAN MARINO

3.15.1 ICT background and current status of broadband

San Marino has made significant investments in strategic ICT infrastructure in the past several years. The cabling of the country's full territory in fibre-optic networks is well underway by the major telecom providers. In the context of 5G, San Marino gained relevant global attention when it became the 5G test pioneer location in Europe in 2018. The government is currently working with private stakeholders on the construction of a nation-wide public infrastructure for the provision of the next-generation mobile services for commercial users.[1]

In 2018, the Institute for Innovation of the Republic of San Marino, a private law company that is exclusively State-owned,[2] launched a series of projects and initiatives titled "Digital Agenda" orienting the country's digital development plan. According to Delegate Decree n.23 of 7th March 2018, San Marino Innovation should:

- Study, develop and deploy innovation strategies for the public administration;
- Gather, foster and evaluate projects and ideas supporting the development of the Sammarinese Digital Agenda;
- Propose to State Congress the approval of the plan for digital development and file annually a report on the general status of digital development and implementation of the Sammarinese Digital Agenda.

The Sammarinese "Digital Agenda" is coordinated with the Digital Agenda for Europe[3] and is oriented to fostering priority cooperation between business systems, innovators, public administration, research and San Marino services, through the involvement of all the actors involved.[4]

While the country does not have a broadband strategy, the Sammarinese "Digital Agenda" presents a series of actions and initiatives focused on structural interventions that are capable of fostering technological innovation while pursuing the objectives of sustainable socio-economic growth in the country.

Additionally, the country is at the forefront of Distributed Ledger Technology and has also recently adopted several decrees to facilitate ICT development in the areas of new technologies such as blockchain[5] and others.[6]

3.15.2 Broadband and mobile telecommunication data

ITU data shows that 60.2% of individuals used the Internet in 2017 in San Marino, with significant growth in the 2011-2017 period.[7] In 2009, ITU data for the country was 54.2% and 48.8% in 2000[8]. In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 32.7.[9] While the 2019 ITU Measuring Digital Development ICT Price Trends report does not provide basket cost for the fixed-broadband indicators because the GNI per capita data on San Marino are not available, an unlimited monthly data cap of data traffic costs about 19.65 USD (16.57 EUR[10]) in 2019.[11]

In 2019, the number of active mobile-cellular subscription was 114.4 per 100 inhabitants,[12] while the number of broadband subscriptions per 100 inhabitants stood at 131.4 in the same year.[13] While the penetration of mobile phones has been high since the early 2000s, steady growth has been observed after 2008.[14] Despite the small size of its territory, there are three major Mobile Network Operators (MNOs) in San Marino: San Marino Telecom (SMT), Telefonia Mobile Sammarinese (TMS), and Telecom Italia (TIM) San Marino. Additionally, Italy's major operators such as Illiad, TIM, Vodafone, and Wind Tre are also available in San Marino's territory.[15] Nowadays, 3G and LTE/4G are widely available in the country with 99% of population coverage according to ITU data.[16]

3.15.3 Current progress on 5G: consultations and national strategies

As early as 2017, the government of San Marino has been engaging with public-private cooperation agreements to replace 4G to 5G networks in the country, with the goal of becoming Europe's first nation to have a 5G full coverage ahead of others in the region.[17] Despite these early 5G-related initiatives, the country does not have a national strategy on 5G. Since the country's territory only consists of 61 square km and has more relaxed laws on airwaves, some operators claim that it is a far more suitable testing ground for 5G than surrounding Italy.[18]

However, local press reported that the government's strategies on 5G are likely to focus on banking and tourism, two very active sectors in San Marino and with a significant economic return in the long run. Other areas of possible focus include industry 4.0, public security, and smart city.[19]

3.15.4 Spectrum assignment for 5G & market development

There is no public information available from the San Mariann regulator concerning 5G spectrum assignment plans in the country. However, the key spectrum to be auctioned is in the 3.5 GHz and 26 GHz bands.[20]

Local press has reported that TIM, for example, will run on a 3.5 GHz spectrum while it tests 26 GHz transmission in Turin, Italy, with the hopes of rolling out these frequencies in San Marino.[21]

3.15.5 Electromagnetic fieds levels and the implementation dynamics

As of October 2020, no public information on EMF limits is available in San Marino.

3.15.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

In July 2017, Telecom Italia (TIM) announced that the Republic of San Marino was in the operator's targets to become Europe's first country with an operating mobile network. On that occasion, both TIM and the Government of the Republic of San Marino signed a Memorandum of Understanding (MoU), describing TIM's engagement in updating the mobile sites of its network in the country with 4.5G.

The MoU articulated the introduction of some of the features of 5G, such as evolved mast towers (MIMO4x4), Carrier Aggregation, superior modulation, and Cloud architecture, as well as introducing "small cells", small, low power masts with low environmental impact in the principal streets and piazzas of the historical centre of the Republic of San Marino, a UNESCO world heritage site.[22]

Furthermore, the technology plan in the MoU included doubling the number of existing mobile sites and installing several dozen "small cells", linked by optic fibre and distributed throughout the whole of the territory of San Marino. Some of the expected services originating from the 2017 MoU established that TIM was set to supply to the San Marino government the new-generation services linked to the Smart City. It also encompassed remote surveillance solutions in extensive areas of the territory, virtual reality to support tourism and, through the introduction of 5G technologies in the production processes used in its manufacturing industry, novel services to develop Industry 4.0 in the San Marino area.[23]

Given San Marino's small territorial dimensions, the early stages of 5G rollout in the country included the deployment of performance tests of network equipment and applications to help refine the definition of 5G standardization[24] and fix any issues before the rollout in neighbouring Italy, one of TIM's most active markets, and in wider Europe.[25] It is within this context that TIM and LG also signed a collaboration

agreement focused on the development of 5G in Italy. This partnership aims to enhance the innovation capacity of these private stakeholders in the development of 5G in the region.[26]

In May 2018, TIM conducted a live demonstration of 5G in the 26 GHz band in the country[27] ahead of full commercial launch.[28] The test allowed users to stream live video using a device featuring a Qualcomm Snapdragon X50 5G modem.[29]

In September 2018, the operator announced that it has turned on the first full 3GPP Rel15 standard 5G site in the region of Faetano using the 3.5 GHz frequency band in collaboration with Nokia.[30] As part of the TIM-Nokia agreement, the private stakeholders managed to cover nearly the entire territory, in addition to deploying 8 macro sites operating 3.5 GHz and 26 GHz antennas in the count, with all locations being equipped with massive multiple-input multiple-output (Massive-MIMO) technology as well as beamforming.[31]

In October 2018, the operator activated a 5G antenna in Serravalle Stadio, which also used 3GPP Rel15 standard on the 3.5 GHz frequency band. This corresponded to the site that services the whole Rally Village area and will support the various applications developed by TIM and Nokia during the competition, showcasing 360° high-definition cameras, virtual reality headsets, the potentialities power of "TIM Streaming" broadcasting platform and the 5G-enabled opportunities in "virtual tourism."[32]

In December 2018, TIM signed an agreement with Nokia to foster 5G development in San Marino.[33] As a result, TIM confirmed in late 2018 that it had switched on 5G in San Marino[34] through Nokia's New Radio (NR) interface, becoming the first country in the world to activate a 5G for commercial tests.[35]

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3.16 SWITZERLAND

3.16.1 ICT background and current status of broadband

Switzerland is a leading country in ICT development and benefits from one of the most sophisticated ICT sectors in the world. The country possesses high-quality mobile phone services as well as significant broadband penetration, with average speeds well above the European average. In terms of fixed-broadband, the country has a universal Digital Subscriber Line (DSL) infrastructure and an expansive optical fibre broadband network characterized by cross-platform competition.[1] Operators in Switzerland are among the biggest investor in telecommunication networks in Europe, and telecom services are affordable for Swiss customers.[2] More recently, fibre has increased rapidly in the country and now at least one-third of Swiss households are directly connected by a fibre-optic connection (FTTH).[3] From the perspective of mobile, despite market liberalization occurred in 1998 with the entry of numerous alternative operators, Switzerland has on one of the least competitive markets in Europe.[4]

The first national strategy for the digitalization of Switzerland was published in 1998 and revised several times. While Switzerland has aligned some of its policies with those of the European Union, its telecommunication polices are yet to be harmonized. In 2016, the country adopted the "Digital Switzerland" strategy, which contained four key objectives: innovation; growth and prosperity in the digital world; equal opportunities and the participation of all; transparency and security; and contribution to sustainable development.[5] Many other ICT policies have been implemented ever since, with a particular focus on e-government, e-health, and digital transformation.[6]

In September 2020, the Swiss Federal Council adopted the "Digital Switzerland" Strategy for the 2020-2022 period.[7] As a joint task of authorities at all levels of the state, the economy, science, civil society and politics, the strategy provides the guidelines for government action and indicates where and how authorities, academia, the private sector, civil society and politics must work together in order to shape the transformation process for the benefit of everyone in Switzerland.[8]

The strategy is structured in a way that aims to centre Swiss people at the forefront while facilitating structural change. Furthermore, the strategy focuses on five key objectives: I) Enabling equal participation for all and strengthening solidarity; II) Guaranteeing security, trust and transparency; III) Continuing to strengthen people's digital empowerment and self-determination; IV) Ensuring value creation, growth and prosperity; and V) Reducing the environmental footprint and energy consumption.[9]

Based on the key objectives, the "Digital Switzerland" strategy focuses on the following fields of actions and respective vision/goals as well as measures and key documents related to them:[10]

- Education, research, and innovation;
- Infrastructure;
- Security;
- Environmental protection, natural resources and energy;
- Political participation and e-government;
- The economy;
- Data, digital content and Artificial Intelligence;
- Social Affairs, Healthcare and culture; and
- International Commitment.

The strategy also contains information on how each broader fields of action contribute to the United Nation's Sustainable Development Goals. Under each wider fields of actions described in the strategy, there are a series of goals and a list of key documents related to each goal, as well as a few indicators to measure their progress.

Accompanying the strategy and its goals, there is an action plan whereby for each project, there is a short description, a status of the measure, and the responsible stakeholder so that stakeholders can monitor the accomplishment of the broader objectives laid out on the document. [11] The "Digital Switzerland" office within the OFCOM decides on the inclusion of measures undertaken by participants outside the federal administration in the action plan by arrangement with the respective competent specialist agencies of the federal administration.[12]

Concerning broadband in underserved areas, private stakeholders are heavily investing on the deployment of telecommunication infrastructure[13] and, more recently, they have also engaged on joint venture strategies to maximize FTTH services as well as Wi-Fi technology[14] throughout Switzerland.[15]

3.16.2 Broadband and mobile telecommunication data

ITU data shows that 93.2% of individuals used to the Internet in 2019 in Switzerland.[16] In 2010, the ITU data for the country was 83.9% and, in 2000, 47.1%. According to ITU data, the estimated proportion of households with Internet access at home in 2019 is 91.5%.[17]

In 2019, the number of fixed-broadband subscriptions per 100 inhabitants was 45.2.[18] DSL/FTTx providers are still way ahead of optical fibre network operators when it comes to Internet access, though DSL has been decreasing each year. At the end of 2019, just over 71% of users were connected via a telecom's operator (2,838,000 connections), while 29% were connected via a cable operator (1,157,000 connections). When it comes to the customers who are supplied via an FTTH/B connection as well as via hybrid fibre and copper technologies (FTTC and FTTS), the alternative telecom providers play a critical role in Switzerland and, when combined, they had a market share of about 20.2% of the broadband connections in the country in 2019.[19] Most of the broadband internet users in Switzerland enjoy a downlink transfer rate between 30 and 100 Mbps[20] with a registered record of averaging 61 Mbps in 2019, compared with 44 Mbps in 2018.[21]

Moreover, as a result of DSL and CATV subscribers migrating to fibre-optic technology (FTTH + FTTB), significant growth in the fibre sector has been noted particularly since 2010.[22] By the end of 2019, about 21% of all broadband subscribers in Switzerland (about 850,000 users) were using a fibre-optic connection.[23] In 2017, about 15% were subscribers of fibre-optic connection in Switzerland.[24] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of the GNI per capita in 2019, while Switzerland's corresponded to 1.0 per cent for an unlimited data package per month in 2019.[25]

In 2019, the number of active mobile-cellular subscriptions per 100 inhabitants was of 127.2,[26] while active mobile-broadband subscription per 100 inhabitants was of 99.[27] In addition to a small number of mobile virtual network operators (MVNO), there are three major mobile network operators (MNOs) that dominate the market in Switzerland: Swisscom, Sunrise, and Salt (formerly Orange). Between 2010 and 2017, the number of mobile users who signed up for Internet data plans rose from 3.4 million to 8.4 million.[28] In 2019, there were 5.3 million online shoppers, a significant increase in the number of users engaging with e-commerce.[29] The country's mobile-data basket cost corresponded to 0.7 per cent of the GNI per capita in 2019 for a monthly allowance of 30 Gb, while the European region's average was 0.8 per cent in 2019.[30] 3G as well as LTE/4G and 4G+ covers practically the entire population of Switzerland,[31] with official ITU data standing at 99% for 4G/LTE and 100% for 3G in 2019.[32] ITU data for the same year also show that the mobile-broadband Internet traffic within Switzerland corresponded to 0.85 exabytes.[33]

3.16.3 Current progress on 5G: consultations and national strategies

The Swiss government anticipates that 5G is set to significantly impact the delivery of services such related to the following: broadband mobile radio network; mobility, transport and logistics; Public security; Production; Energy; and Health.

The country started discussing 5G frequency allocation as early as 2017, with the Federal Council reserving the frequency bands (700MHz and 3.5GHz) for mobile communications. This strategy involved conducting changes to the National Frequency Allocation Plan (NFAP),[34] which was approved by the Federal Council in November 2017. Moreover, the Federal Council agreed to lower the license fees for mobile spectrum in the 3GHz range from January 2018 onwards. The move aimed to take into account the less favourable propagation characteristics of the higher frequency bands, and thus facilitate the development of 5G in Switzerland.[35]

In February 2018, the Swiss parliament's Commission for Transport and Telecommunications (Kommissionen Fur Verkehr Fernmeldewesen, KVF) has called for a revision of the nation's regulations regarding non-ionising radiation, claiming that the existing rules hinder necessary mobile network expansion works, particularly with regards to 5G.[36]

Between January and February 2019, on behalf of Federal Communications Commission (ComCom), the Federal Office of Communications (OFCOM) conducted a frequency auction for 5G, auctioning off an extensive bundle of mobile frequencies and thus creating the conditions for 5G development in Switzerland.[37] By incorporating bidding restrictions and consolations with private stakeholders, the frequency licenses for 5G were acquired by the country's three MNOs for the following auction prices: Salt (88 million EUR)[38], Sunrise (83.1 million EUR), and Swisscom (182 million EUR).

In January 2020, OFCOM posted a 5G fact sheet with an introductory overview of Switzerland's stands on 5G development. No comprehensive authorisation by a central authority is necessary for the introduction of 5G in Switzerland. However, like all other radio technologies operating in the country, 5G deployment must meet the conditions concerning regulations for mobile radio antennas, the appropriate frequency use band, and the conditions laid down in the licenses.[39]

OFCOM also maintains an interactive website containing information on the geographic distribution of 5G antenna locations so the public can follow the development of 5G in the country, which is based on the

data provided by operators. Information on 4G, 3G, 2G, radio, TV broadcasters, as well as microwave links, are available.[40]

As of October 2020, Switzerland has no national strategy for 5G development but continues to be among the European pioneers on the new-network deployment.

3.16.4 Spectrum assignment for 5G & market development

In Switzerland, the mobile telephony frequencies are licensed in a technology-neutral manner, which gives operators the freedom to choose the technology that provides mobile telecommunications services[41]. The 800 MHz, 900 MHz, 1800 MHz, 2100 MHz and 2600 MHz bands were auctioned off for in 2012, while the 2019 auction encompassed a wide range of additional mobile radio frequencies (700 MHz, 1400 MHz and 3500 MHz), more relevant to 5G, and generated about 353.9 million EUR from the private operators.[42] Using the frequency bands below 6 GHz, as are currently licensed in Switzerland, a maximum data rate of 3 Gbit/s is expected.[43]

The auction's result for 2019 spectrum is reflected below according to each MNO:[44]

- Swisscom: 2×15MHz (three 2×5MHz blocks) in the 700MHz band and 120MHz of unpaired spectrum in the 3500MHz range, as well as 50MHz of supplementary downlink (SDL) frequencies in the 1400MHz band;
- Salt: 2×10MHz in the 700MHz band, 80MHz in the 3500MHz band and 10MHz of SDL 1400MHz frequencies; and
- Sunrise: Sunrise was awarded 2×5MHz of paired spectrum and 1×10MHz of SDL airwaves in the 700MHz range, as well as 100MHz of 3500MHz frequencies and 15MHz of SDL spectrum in the 1400MHz band.

Five frequency blocks of 5 MHz in the 2600 MHz band and the 700 MHz and 1400 MHz ranges were not sold. The frequencies that have not been awarded will remain with the Confederation and put out for tender again at a later date. According to the auction, the frequencies were assigned for 15 years, whereby giving the operators long-term planning security to develop their networks. Licences are granted with coverage obligations. By 2024, licenses have to cover 50% of the Swiss population with 700 MHz spectrum and 25% with other frequencies.[45]

3.16.5 Electromagnetic fields levels and the implementation dynamics

Switzerland applies precautionary principles regarding EMF admitted from mobile communications installations. The relevant sources of EMF regulation in the country steam from the "Ordinance relating Protection from Non-Ionising Radiation" (NISV; RS 81.710)[46], which is technological-neutral and applies regardless of 3G, 4G, or 5G. In the ordinance, the Federal Council set two types of limit values for mobile phone radiation, the emission limit values[47] and the installation limit values, which include in particular apartments, schools, kindergartens, hospitals, permanent workplaces and children's playgrounds.

The document was prepared in 1999 and enacted in February 2000[48] by the Federal Office for the Environment (FOEN) of Switzerland.[49] The document was later adapted in 2008 and 2013, when a component of technology neutrality was applied. NISV mandates the exposure limits for EMF emission as recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the World Health Organisation (WHO) and the European Union. This includes:

- Emission Limit Values (ELV): In the area of mobile radio frequencies, the limit is between 41 and 61 volts per meter (V / m); and
- Installation limit values (LFV): These so-called "plant limit values" are around 10 times lower than the emission limit values for mobile phone radiation (4 to 6 V / m). They do not have to be adhered to everywhere, only in the places with sensitive use.

In November 2019, Switzerland's Department for the Environment, Transport, Energy, and Communication (DETEC) published a report titled "Mobile Communications and Radiation,"[50] which is a result for a previous working group on the topic from the previous year.[51] This working group was made up of representatives from research and technology, the medical profession, the telecommunications industry, interest groups and municipal, cantonal and federal authorities. Overall, this report provides information on the existing mobile phone networks and the necessary expansion steps to support the data transfer demand in the country. It also summarizes the knowledge on the current and forecasts future radiation exposure to the population, as well as the current understanding and gaps in the subject. In five steps, the report presents the measures with which the necessary expansion steps could be made possible, what costs would arise, what additional infrastructure would be required and how the limit values for cell phone antennas would have to be adjusted.[52]

Based on this report, the Federal Council decided on further actions concerning EMF and 5G, which focused on the following:[53]

- Implementation aid for adaptative antennas: The federal government is in the process of developing an implementation guide for dealing with the new adaptive antennas. This means that all mobile phone antennas must comply with the provisions of the Ordinance on Protection against Non-Ionizing Radiation. Adaptive antennas, which are a fundamental component of 5G, can focus the radiated power specifically on individual users. This means that a higher power is emitted in the direction of the user, but the radiation is much lower in all other directions. The exposure with adaptive antennas is therefore usage dependent.
- Implementation of the accompanying measures: The accompanying measures according to the report of the "Mobile Communications and Radiation" working group from November 2019 will be implemented with the involvement of relevant departments, interested stakeholders and the cantons within the scope of the existing resources while maintaining the existing responsibilities.
- Sustainable cellular network: With the report on the postulate Häberli-Koller 19.4043 "Sustainable mobile radio network", a better basis for decision-making for future mobile radio technologies is to be created to counteract a renewed polarization of opinions.

In addition to the FOEN and the work done by the Federal Office of Public Health (FOPH), the cantonal environmental protection offices are responsible for the compliance with the limits for non-ionising radiation laid down in the ordinance. They examine operators' calculations on the radiation intensity of every antenna. The consents for the construction of new antennas or the modification of existing antennas are available in the FOEN explanations.[54] Additionally, a series of fact sheets for various appliances producing non-ionizing radiation (NIR) is available on the FOPH's website.[55]

While the EMF limits are much more strictly limited in Switzerland than in most European countries, recent attempts to change the legislation have occurred[56], as anticipated in section 3. For instance, a parliamentarian motion[57] pushing potential relaxation for the limit values for EMF exposure in the country was rejected by the Swiss Parliament amid safety concerns.[58] The basis for that is largely due to the precautionary principle of the Environmental Protection Act[59], which states that emissions are to be limited to the extent that this is technically and operationally possible and economically viable.[60]

In addition to the 2019 civic pressure from opponents of 5G in Switzerland,[61] in February 2020, local press reported that Swiss regions have responded to locals urging for "5G-free zones" and suggested that they temporarily suspended the use of new mobile sites constructed for 5G and requested the regulator to

provide more scientific and technical information proving that 5G presents no health hazard.[62] However, other news media reports later reported that the FOEN only submitted an information letter to the cantons, some of which imposed moratoria on 5G planning permission.[63]

3.16.6 5G Commercial launches: announcements, trail cities, and digital cross-border corridors

One of the earliest commercial announcements related to 5G took place in June 2016, when Swisscom announced a partnership with Ericsson to launch the "5G for Switzerland" programme in collaboration with the Ecole Polytechnique Federale de Lausanne (EPFL). **"5G for Switzerland"** is part of the Ericsson "5G for Europe" program, announced in 2015.[64] Under the collaboration in Switzerland, Swisscom, Ericsson and the EPFL announced they planned to address challenges such as smart transportation, autonomous driving, automated traffic control systems, smart grid and Internet of Things (IoT).[65]

In May 2017, Swisscom introduced Network Function Virtualisation (NFV) and launched 5G tests at its shops in Switzerland, allowing customers to experience an Internet speed of 800 Mbps.[66] In June 2017, Swisscom and Ericsson demonstrated applications based on 5G network slicing and NB-IoT.[67] In July 2017, the operator carried out field tests in Zurich of an Ericsson-built 5G system. The test used a single base station and two-terminal devices and achieved peak download speeds of 10Gbps.[68] On that occasion, the operator expressed interests in developing IoT-related services in Switzerland.

Within the Ericsson-Swisscom partnership, the operator announced in November 2017 that it was upgrading Swisscom's LTE networks to revamp data traffic speeds. They also announced that had plans to rely on Ericsson's full Transformation includes the deployment of Ericsson's full-stack telecom cloud solution with network slicing technologies, and 5G portfolio offering with Massive Multiple-input and multiple-output (MIMO).[69] Moreover, Swisscom's industrial partner, Ypsomed, has used 5G applications in the Industry 4.0 sector.[70] In a pilot project, Ypsomed created a 5G test network and digitised the entire process chain, from the delivery of raw materials and product manufacture and through to provisioning and supply.[71]

In January 2018, Salt and Nokia demonstrated 5G 3.5GHz network performance in Salt's headquarters in the municipality of Renens under a temporary license from OFCOM. The demonstration involved a 5G antenna with 8×8 MIMO technology supporting end-to-end applications, which included: 4.5Gbps mobile

data downloads; virtual reality applications showcasing ultra-fast network latency (in the range of 1 millisecond) under 'real conditions'; and 360-degree live video transmitted from secondary locations, further highlighting the ultra-fast latency and capacity of the 5G network configuration.[72]

In June 2018, Sunrise commissioned its first 5G cell tower in Switzerland and took the opportunity to announce that its plans to launch "5G for People" (or the so-called "fibre-optics over the air") for 2019. In addition to boosting mobile data services, Sunrise intends to use 5G to offer residential broadband with data transfer rates of up 1Gbps in areas where customers do not have access to fibre networks. In other words, the operator suggests that 5G could be used as a replacement for ADSL/VDSL connections, especially outside high-population areas, as these locations are typically lower-priority for fibre deployments and have greater potential to upgrade existing mobile networks without exceeding the current radiation limits.

In July 2018, Swisscom began the 5G trials in Guttanennen, a remote mountain village of 200 km² in the Bernese Oberland with about 300 inhabitants, to test how the platform could improve connectivity in remote areas.[73] Based on this trial, the operator suggested that 5G technology could be used in combination with the fixed-network infrastructure, improving the availability of ultra-fast broadband as a result.[74]

One of Switzerland's biggest milestones in 5G was announced in September 2018, when Ericsson and Swisscom claimed that they accomplished Europe's first end-to-end, multivendor Non-Standalone (NSA) data call on 3.5 GHz band in the Swiss city of Burgdorf. Data transmissions were carried out using Intel's Mobile Trial Platform (MTP) device and Swisscom's 5G-subscribed SIM card.[75] A few weeks later the Swiss operator informed that it had expended the number of 5G test locations to other areas of the country. Furthermore, it announced that it connected to its test system, for the first time, a smartphone prototype equipped with a Qualcomm 5G mid-band modem[76] and a Wistron NeWeb Corporation (WNC) hotspot.[77]

Within the framework of its plan of "5G for People," Sunrise deployed the first end-to-end 5G network in November 2018, when it activated its 5G network at the LAAX ski resort on Crap Sogn Gion, becoming the world's first standardized 5G network at a ski resort.[78] On this occasion, the operator informed that its system was capable of providing download speeds of up to 300Mbps and utilises 8×8 MIMO technology and 3.5GHz spectrum.

In January 2019, Salt has signed a Letter of Intent (LoI) with Nokia to upgrade the operator's radio and mobile core network, thus improving its existing 3G and 4G platforms for more efficient launch of 5G services.[79] In February 2019, Sunrise has announced plans for a limited 5G trial for around 100 selected residential and business customers using its "Sunrise Internet Box 5G."[80] The operator's initial expectation was to launch commercial 5G in the first half of 2020, though that has been delayed.

In April 2019, the operator confirmed that its new 5G network was turned on, with initial network coverage of 150 towns, villages, and cities. In August 2019, Sunrise expanded its network coverage in 262 cities, towns, and villages across the country, though it was not until September 2019 that the operator opens its services to the general public.[81] In November 2019, Sunrise announced that its 5G network was then live on 309 town, which was almost double the coverage provided by the other competitive provider. The company stated that its 5G services were able to provide a top speed of up to 2 Gbps to at least 80% of the population. With Huawei's "LampSites" solution, Sunrise is ensuring powerful 5G coverage inside buildings.[82] Instead of relying on the millimetre wave (mmWave) frequencies being used to support 5G in other markets, Sunrise confirmed that its 5G networks utilise spectrum in the 700MHz and 2.4GHz-2.5GHz bands.[83]

In April 2019, Swisscom activated its 5G network in 102 locations in the first 54 towns—including Basel, Bern, Chur, Davos, Geneva, Lausanne and Zurich. Alongside the upgrade for mobile users, and amid the charged debates over EMF limits and health around the same time, Swisscom announced its plans to use the 5G network to provide broadband connections for customers outside of its fibre footprint.[84] Swisscom also announced plans to use dynamic spectrum sharing (DSS) to offer 5G coverage to the rest of the population.[85]

In October 2019, Sunrise partnered with Huawei to boost the maximum download speeds of 3.67Gbps in a Zurich-based 5G trial. The trial utilised a 100MHz block of C-band (3.3GHz-4.2GHz) spectrum, alongside commercial network equipment fully conforming to 3GPP standards.[86]

In August 2020, after a months-long pause on commercial 5G announcements in Switzerland amid the COVID-19 pandemic, Sunrise deployed a Nokia's cloud-native converged charging software to drive 5G monetization. According to Ericsson, such a solution enables the operator to more rapidly package, price and promote a wide range of consumer and business services. As such, Nokia notes that Sunrise will be able to quickly create differentiated offers for even the most complex IoT use cases and services enabled by 5G network slicing.[87]

Although Switzerland has a dynamic commercial sector for 5G tests and deployment, 4G plays a significant role as the early 5G still rely on 4G connections to operate because they use 5G non-standalone access.[88]

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3.17 UNITED KINGDOM

3.17.1 ICT background and current status of broadband

The United Kingdom is one of the world's largest ICTs markets, with a highly advanced telecommunication sector, characterized by its early liberalization and strong commercial competition. With affordable prices, the country has high penetration rates for fixed and mobile services. For fixed broadband, the penetration is also very high, and well above the European average. In the European region and beyond, the UK continues to be a champion of privatization in the telecommunication sector and elsewhere, and its example greatly impacted the shaping of the EU policies on telecommunications. While national policies continue to prioritize the roll-out of high-speed broadband throughout the UK and the upgrades of networks, there are still rural areas that lack broadband.

Building on a longstanding strategic approach to digital development, in March 2017, the UK government launched its UK Digital Strategy. The Strategy builds on the Culture White Paper[1] as well as the Industrial Strategy green paper,[2] and articulates its framework for the digital economy with particular regard to growth, technology, and innovation. The UK Digital Strategy sets out the Government's goals for digital infrastructure, creating an advanced skills base, encouraging the use of digital tools and improving access to digital services while addressing opportunities for businesses, research and development. Accordingly, the UK Digital Strategy's main seven strands are:

- Connectivity – building a world-class digital infrastructure for the UK;[3]
- Digital Skills and Inclusion – giving everyone access to the digital skills they need;[4]
- The Digital Sectors – making the UK the best place to start and grow a digital business;[5]
- The wider economy – helping every British business become a digital business;[6]
- A safe and secure cyberspace – making the UK the safest place in the world to live and work online;[7]
- Digital government – maintaining the UK government as a world leader in serving its citizens online;[8]
- Data – unlocking the power of data in the UK economy and improving public confidence in its use.[9]

Based on the legislation as well as rules imposed by the regulator, every home and business in the UK has the legal right to request a decent, affordable broadband connection.[10] Moreover, some of the UK government's targets set in the strategy are consistent with the European Commission's Digital Agenda for Europe (DAE).

Furthermore, it is worth mentioning that the UK Government has achieved its aim of providing 95% coverage with 24 Mbps by the end of 2017[11]. The Government has set a target to achieve nationwide gigabit connectivity as soon as possible, with an ambition to achieve this by 2025.[12]

In addition to the fixed-services expansion, the UK government launched the Shared Rural Network (SRN) in March 2020. This project is a public-private investment partnership to transform mobile broadband coverage in rural areas without duplicating infrastructure. Led by UK's four MNOs—EE, Telefónica UK (O2), Three and Vodafone— through a jointly owned company called Digital Mobile Spectrum, SRN determines the following:[13]

- Each MNO shall reach 88 per cent coverage of the UK by 2024;
- Each MNO shall reach 90 per cent coverage of the UK by 2026;
- Each MNO shall reach nation-specific coverage targets in England, Northern Ireland, Scotland, and Wales by 2026; and
- Collectively, the MNOs shall provide additional coverage to 280,000 premises and 16,000km of roads by 2026.

To accomplish these targets, Ofcom has developed legally enforceable coverage obligations that are attached to the mobile network operators' radio spectrum licences. Together this means all four mobile network operators will deliver 95% combined 4G coverage across the whole of the UK landmass[14] by the end of 2025.[15]

Other broadband-related government-led policies that are worth mentioning in the UK context include the Welsh Government's Superfast Cymru: a project to deliver superfast broadband access of at least 30 Mbps to nearly 700,000 premises;[16] the Scottish Government's commitment to extending superfast broadband access to 100% of premises across Scotland by 2021;[17] the UK's ICT and digital services strategy for the 2020-2025 period, which deals with the government's engagement with private stakeholders to achieve the United Nation's Sustainable Development Goals and meet the government's net-zero commitments;[18] the Digital Northern Ireland 2020 (DNI);[19] and others.

Amid the socioeconomic challenges that resulted from the COVID-19 pandemic, the local press has reported that the UK government is currently working on a new digital strategy[20] with a focus on I) Securing an adequacy agreement with the European Union; II) creating a highly-skilled digital workforce; III) building a world-class next-generation infrastructure; and IV) ensuring a regulatory regime that is pro-competition and pro-innovation.[21]

3.17.2 Broadband and mobile telecommunication data

ITU data shows that 92.5% of individuals had access to the Internet in 2019 in the United Kingdom.[22] In 2010, the ITU data for the country was 85% and, in 2000, 26.8%. In 2018, the number of fixed-broadband subscriptions per 100 inhabitants was 39.6.[23] Data from the UK's Office for National Statistic show that fixed-broadband has continued to be the most popular type of household Internet connection since first measured in 2015, with 98% of households with internet access having this type of connection in 2019.[24] While Asymmetric Digital Subscriber (ADSL) 1 and ADSL2+ are available throughout the country, cable and fibre-to-the-cabinet (FTTC) as well as fibre-to-the-premises (FTTP) are becoming increasingly available and offered by several Internet Service Providers (ISP), with FTTP now representing the most common fibre connection in the UK.[25] Throughout the country, London and the South East were the UK regions with the highest internet use in 2019, while Northern Ireland remained the lowest.[26] Despite that, Northern Ireland has the highest full-fibre coverage of any UK nation, with nearly a third of homes able to receive it. Wales was also above the UK average, with 12% coverage.[27] In terms of fibre connections throughout its territory, only around 10% of UK homes received full-fibre broadband, offering download speeds of up to 1 Gbps as of September 2019.[28]

In its 2019 report, the Office of Communications (Ofcom), the regulatory authority in the UK, reported that data use on fixed lines increased to an average of 315GB per connection per month, from 240GB in 2018.

In its 2020 Summer update, Ofcom reported that 14% homes in the UK had full-fibre broadband connectivity, offering download speeds of up to 1 Gbps, showing an increase in fibre connectivity of at least 2.2 million additional homes in comparison to the previous year.[29] Additionally, 57% of UK homes were able to get ultrafast broadband (300 Mbps).

Whilst household internet access has risen over the last decade, it has been levelling off in recent years.[30] From the regional perspective, Europe's average fixed-broadband basket cost was 1.5 per cent of the GNI

per capita in 2019, while the United Kingdom's corresponded to 1.3 per cent for an unlimited data package per month in 2019.[31]

In 2018, the number of mobile-cellular subscriptions per 100 inhabitants was of 118.37.[32] Moreover, the number of active-mobile broadband subscriptions per 100 inhabitants was 98.54 in the same year.[33] In addition to a few mobile virtual network operators (MVNO), there are four major mobile network operators (MNOs) that dominate the market in the United Kingdom: Vodafone, 3 UK (H3G), Telefónica O2, and EE (acquired by BT).[34] Both 3G and 4G mobile networks were available to 99.7% of the population in 2018.[35] In terms of geographic coverage, data from the regulator reveals that 67% of the UK's land area is covered by 4G by the four major MNOs in the country, while 91% of the country can get reliable 4G from at least one operator.[36] However, challenges concerning mobile broadband coverage in rural areas remain a relevant issue as only 63% of rural areas received coverage from all four major operators, while 5% of the UK's landmass gets no mobile voice and text reception at all.[37] The country's mobile-data basket cost corresponded to 0.6 per cent of the GNI per capita in 2019 for a monthly allowance of 5 Gb, while the European region's average was 0.8 per cent in 2019.[38]

2.17.3 Current progress on 5G: consultations and national strategies

In October 2015, the Chancellor of the Exchequer announced the creation of a National Infrastructure Commission (NIC), to be commissioned to provide a clear picture of the future infrastructure that the UK needs to prioritize.[39] As early as 2016, NIC published a final report on 5G with a set of recommendations on metrics for the networked development. The report also included a call for Ofcom and the government to review the then-existing regulatory regime regarding spectrum and obligations to ensure that it supports the sharing of telecoms infrastructure for the 5G roll-out. NIC has called for local authorities and Local Enterprise Partnerships (LEPs) to work with network providers to develop approaches that enable the deployment of the tens of thousands of small cells in urban centres.[40]

Also, in 2016, the UK government announced its National Productivity Investment Fund (NPIF) worth in total of 25.3 billion EUR, of which 815.6 million EUR funded by the government were allocated to 5G trials and full-fibre deployment across the UK by 2020-2021.

In January 2017, a report from the Future Communications Challenge Group (FCCG) has identified three policy areas that could enhance the 5G deployment phase in the UK: I) Facilitating operators' ability to

deploy network equipment; II) Ensuring the industry has sufficient spectrum; and Ensuring application of net neutrality rules is compatible with 5G use cases.[41]

In March 2017, the Department for Digital Culture, Media and Sport (DCMS) has released a policy paper entitled "Next-Generation Mobile Technologies: A 5G strategy for the UK."[42] This strategy sets out the government's ambition that the UK should be a global leader in 5G so that we can take early advantage of its potential and help to create a world-leading digital economy that works for everyone. The strategy outlines the key themes and a set of specific measures to determine the UK's progress towards 5G, which are:[43]

- Building the economic case;
- Fit for purpose regulations;
- Local areas – governance and capability;
- Coverage and capacity – convergence and the road to 5G;
- Ensuring a safe and secure deployment of 5G;
- Spectrum; and
- Technology and standards.

In terms of investment, the strategy details the government's plan to initially invest aroundUSD19.5 million) on a 'cutting edge' facility equipped with appropriate technology to run the trials in partnership with industry working at the forefront of 5G.[44] The strategy outlines DCMS' collaboration with Ofcom in identifying and tackling unnecessary barriers to infrastructure sharing and will explore the potential for a clearer and more robust framework to allow companies to share infrastructure while preserving investment incentives.

After building upon a series of documents regarding 5G in the country, the UK government has announced, in July 2018, its main target on providing the majority of the population with 5G signal by 2027. The Government's strategy for future digital infrastructure—full-fibre and 5G—is set out in DCMS's Future Telecoms Infrastructure Review (FTIR). FTIR focuses on supporting a "market expansion model" for 5G in the UK.[45] The FTIR identified four priority areas that Government policy for 5G will focus on to support the market expansion model:[24]

- Make it easier and cheaper to deploy mobile infrastructure and support market expansion, including the implementation of the wide-ranging Electronic Communications Code (ECC) on-site access and consideration of further planning reforms;
- Support the growth of infrastructure models that promote competition and investment in network densification and extension;
- Fund beneficial use cases through the Government's 220.5 million EUR 5G Testbeds and Trials Programme that helps de-risk business models for 5G; and
- Promote new, innovative 5G services from existing and new players, through the release of additional spectrum. We should consider whether more flexible, shared spectrum models can maintain network competition between MNOs while also increasing access to spectrum to support new investment models, spurring innovation in the industrial IoT, wireless automation and robotics, and improving rural coverage.

In November 2018, Ofcom launched a report entitled "Enabling 5G in the UK," providing further information on the regulator's work to guarantee the early 5G roll out in the country within the framework of the 2017 strategy and previous public consultations. The report provides an overview of the actions taken by Ofcom to enable the 5G development in the UK:[46]

- making spectrum available for 5G and other wireless services;
- working with Government and policymakers to ensure access to sites is not a barrier to 5G;
- ensuring access to appropriate connectivity between 5G base stations and the core network (backhaul);
- ensuring net neutrality regulation is not a barrier to deployment; and
- acting as a facilitator, working with Government, different industry sectors and other countries to further understand potential applications of 5G.

In November 2018, the UK Government published the "National Infrastructure and Construction Pipeline" report, which givens an overview of public and private investments that are underway or expected to be put toward 5G and full-fibre (FTTP) between 2018/19 and 2020/21 (financial years). The document specifies that 7.5 billion EUR should be devoted to full-fibre and 5G upgrades by 2021.[47]

Following previous 5G-related investments by the government, the UK's Department for Digital, Culture, Media & Sports (DCMS) announced a 64 million GPB (70 million EUR)[48] funding package for 5G trials in

February 2020. DCMS also announced that the funding package shall benefit residents of rural areas.[49] The package can be broken down into:[50]

- 33.1 million EUR for the Rural Connected Communities (RCC) competition for seven 5G research and development projects across the UK. This includes five in England, one in Wales and one in Scotland with plans to expand into Northern Ireland. Test sites will be set up in Yorkshire, Gwent, Monmouthshire, Orkney, Wiltshire, Nottinghamshire, Dorset, Shropshire and Worcestershire;
- More than 5.5 million EUR of funding will be awarded to two industrial projects, led by Ford Motor Company and Zeetta Networks, to test the benefits of using 5G to boost productivity in the manufacturing sector;
- A new 33.1 million EUR to open competition—"5G Create"—has been launched to develop new uses for 5G in a variety of industries, including our creative sectors such as film, TV and video games. From enabling remote production to supporting the expansion of the increasingly popular world of esports, 5G has the potential to revolutionise the UK's booming creative industries. Six projects have already been selected across the UK with more to be announced soon.

Additionally, many other public consultations covering issues of the spectrum allocation, rules on the auction for the 700MHz and 26 GHz bands, as well as rural mobile coverage and EMF have been launched by the regulator between 2019 and 2020,[51] all of which have been considered by the account for the auctions and 5G rollout rules in the UK. [52]

2.17.4 Spectrum assignment for 5G & market development

In September 2017, Ofcom publish a report outlining its preparations for the release of spectrum suitable for future mobile services.[53] The regulator also mentioned that it supports the Radio Spectrum Policy Group's (RSPG's) identification of 26GHz as a 'pioneer band' for 5G in Europe.[54]

In April 2018, Ofcom concluded the first auction of 5G spectrum by selling 150 MHz of 3.4GHz spectrum previously used by the Ministry of Defence, with all four MNOs securing spectrum for 10 years.[55] The auction had two bidding stages—principal and assignment stages—using a format known as simultaneous multiple round ascending (SMRA), generating the following licensing results:[56]

- Airspan Spectrum Holdings Limited has not won spectrum in either band;
- EE Limited has won 40 MHz of 3.4 GHz spectrum at a cost of 335.2 million EUR;

- Hutchison 3G UK Limited has won 20 MHz of 3.4 GHz spectrum at a cost of 167.6 million EUR;
- Telefónica UK / O2 has won all 40 MHz of 2.3 GHz spectrum available, at a cost of 228.1 million EUR; and 40 MHz of 3.4 GHz spectrum at a cost of 352.1 million EUR; and
- Vodafone UK has won 50 MHz of 3.4 GHz spectrum at a cost of 419 million EUR.

As reflected above, Ofcom also auctioned off 40MHz of 2.3GHz spectrum for immediate use to provide additional capacity for 4G networks, which can also be used for 5G in the future. When compared to the 4G spectrum auction that took place in 2013, the 2018 auction generated a financial amount that is equivalent to roughly three-quarters of the spectrum previously auctioned.[57]

On 9 March 2020, the UK Government announced that it had agreed a deal with the four mobile operators to deliver the Shared Rural Network, which will see operators collectively increase mobile phone coverage throughout the UK to 95% by the end of 2025, underpinned by legally binding coverage commitments. Compliance with these obligations will be assessed by Ofcom in 2024, by when each operator has committed to have reached 88% geographic coverage of the UK, and 2026 when each operator has committed to have reached at least 90% geographic coverage of the UK. Each operator has also agreed to meet coverage thresholds in each UK nation, again to be assessed in 2024 and 2026, alongside collectively providing new roads and premises coverage. Progress towards these outcomes will be published in the regular Ofcom Connected Nations reports.

In July 2018, Ofcom opened up a consultation on 57-71 GHz frequencies. On this occasion, the regulator decided to change the authorization approach for fixed wireless systems in the 64-66 GHz band to license-exempt and to implement common technical conditions across the 57-71 GHz band for short-range wideband data transmission systems and fixed wireless systems.[58] Furthermore, Ofcom has been working to free up the 168MHz of the spectrum between 7.9GHz and 8.4GHz, and 2.25GHz of the spectrum between 24.25GHz and 26.5GHz.[59] It plans to make the 1492-1517MHz band available for future wireless broadband services by December 2022. Moreover, Ofcom is also considering the 37-43.5 and 66-71GHz bands, and potentially also the 32GHz (31.8 – 33.4GHz) band.[60]

In June 2019, Ofcom issued a public consultation on defragmentation of 3.4-3.8 GHz frequencies. As a result, the regulator plans to introduce spectrum sharing and open up spectrum (3800-4200/1800/2300 MHz) to private network operators and vertical industry players on a first-come-first-serve basis. Spectrum sharing will also be introduced in the 26 GHz frequencies, but only for indoor services. In July

2019, Ofcom published a document "Draft UK Interface Requirement (IR) 2105," defining the technical conditions for "Shared Access Indoor 26 GHz".[61]

In November 2019, Ofcom has issued a consultation on draft statutory instruments that would support its local spectrum access and spectrum sharing policies.

In March 2020, Ofcom announced the rules that will apply for its forthcoming auction of 5G-suitable spectrum. According to the regulator's rules, the spectrum would be made available for bids in the following lots:[62]

- Six lots of 2x5 MHz (60 MHz in total) in the 700 MHz band with a reserve price of 110.8 million EUR per lot;
- Four lots of 5 MHz (20 MHz in total) of 700 MHz downlink-only spectrum, with a reserve price of 1.1 million EUR per lot; and
- 24 lots of 5 MHz (120 MHz in total) of 3.6-3.8 GHz spectrum, with a reserve price of 22.2 million EUR per lot.

Regarding the obligations, Ofcom confirmed it does not plan to any longer include coverage obligations, and that the two spectrum lots that carried a proposed maximum will no longer apply.[63] The regulator has also Ofcom has imposed a 37% cap on overall spectrum holdings. As a result, EE will be allowed to obtain a maximum of 120 MHz, while Three and Vodafone will be able to secure up to 185 MHz and 190 MHz respectively. Due to its current spectrum holdings, O2 will not be restricted by the cap.[64]

Private stakeholders have also requested Ofcom to move to a more flexible approach to licensing for 5G spectrum to allow spectrum that is not being used by the major MNOs to be used by other parties, for example in rural areas.[65]

In August 2020, as a result of the COVID-19 pandemic, Ofcom postponed its plans to auction the 700MHz and 3.6GHz-3.8GHz bands to January 2021.[66]

2.17.5 Electromagnetic fields levels and the implementation dynamics

The UK Government mandates that that EMF emissions should comply with the ICNIRP Guidelines. More specifically, the UK's policy on EMF limits is set out in the Written Ministerial Statement of 2009, though it stems from the advice given by the National Radiological Protection Board (NRPB) in 2004.[67] This policy details the national compliance with the 1998 ICNIRP exposure guidelines[68] in the terms of the 1999 EU

Recommendation, and a precautionary policy called "optimal phasing."[69] All the practical details needed to apply the policy of compliance with exposure limits as well as the optical phasing are contained in a Code of Practice.[70] It is the Public Health England (PHE), an executive agency to the Department of Health and Social Care, that is at the forefront of public health matters associated with radiofrequency electromagnetic fields in the UK.[71]All manufacturers, installers and operators of radio equipment should therefore already consider the recommendations by PHE and Ofcom when manufacturing, installing or operating equipment.[72]

While the UK's Mobile Telecommunications and Health Research Programme (MTHR) ended in 2012, the UK government has been funding research on the effects on the health of a range of EMF and mobile technologies mainly through the Department of Health and Social Care's National Institute for Health Research (NIHR) and Public Health England (PHE). Recent projects have considered airwave health monitoring, the study of mobile phone use on health,[73] study on mobile phones and adolescents and cognition at Imperial College London,[74] as well as other initiatives by PHE's research initiatives, including its Advisory Group on Non-Ionising Radiation (AGNIR), which came to an end in 2017.[75]

Although Ofcom is not responsible for setting the EMF safety levels in the UK, it has been testing the EMF levels near to mobile phone base stations for many years. Ofcom's published measurements have consistently shown that EMF levels are well within the internationally agreed levels published in the ICNIRP Guidelines.[76] In February 2020, Ofcom published a consultation which proposes to include a specific condition in Wireless Telegraphy Act licences requiring licensees (including mobile operators and other radio users) to comply with the ICNIRP Guidelines.[77]

Concerning 5G development, the PHE has been providing the public with information on reviews, guideless and policies while acknowledging that fewer studies have been conducted at the mm-wave frequencies that are planned for use by 5G than at lower frequencies. In recent measurements near 5G-enabled base stations, Ofcom has recorded measurements well within the levels for general public exposure from the ICNIRP Guidelines. In fact, the highest level measured was approximately 1.5% of the levels identified in the ICNIRP Guidelines.[78]

In April 2020, within the context of growing civic pressure concerning conspiracy theories around 5G to the global COVID-19 pandemic, Ofcom released a brochure claiming that there is no scientific basis or credible evidence regarding a causal relationship between the two.[79] Currently, PHE information about EMF exposures is available on the unified UK Government website.[80] The material about base stations has

been updated to mention recent technology developments, such as 5G, and the latest national and international health evidence reviews. PHE continues to deliver expert review reports on non-ionising radiation topics as and when sufficient new evidence has accumulated. [81]

On 24 September 2020, PHE updated it's guidance on mobile phone base stations, and how exposures are measured. This information can be found on gov.uk. Following a consultation earlier in the year, Ofcom announced on 5 October 2020 that it intends to include a specific condition in the licences of mobile phone companies, TV and radio broadcasters requiring licensees to comply with the limits on EMF exposure proposed by ICNIRP (the International Commission on Non-Ionising Radiation Protection[82]).

Finally, Ofcom is making available a trial version of an EMF calculator[83] that will allow many licensees and other spectrum users to demonstrate their compliance in a straightforward way. Ofcom also recently opened a further consultation on EMF by private stakeholders.[84]

2.17.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

Since 2015, private stakeholders have been engaging with Ofcom on matters related to the commercialization of 5G, providing comments on high-frequency bands and other regulatory measures.[85] Additionally. during the same year, the University of Surrey announced that its 5G Innovation Centre (5GIC) has achieved data speeds of 1 Tbps over a distance of 100 meters in lab tests using university-built equipment.[86] Other tests and partnership between operators and equipment providers also occurred during the same year. For instance, EE, in partnership with Alcatel-Lucent, achieved download speeds of more than 5Gbps using "XG.FAST" in 35 metres cable and 1.8 Gbps over 100 metres over copper lines.[87]

In August 2016, EE announced a research collaboration agreement on 5G with Nokia. The agreement details the companies' plans to work together on potential customer use cases for 5G technologies, the creation of 5G Proof of Concept (PoC) trials and the development of the emerging technology standards and equipment. Local press reported that Nokia and BT conducted trials at the operator's lab in Suffolk using Nokia's AirScale radio access.[88]

In February 2017, telecom infrastructure company Arqiva announced plans for 5G trials in the UK in partnership with Samsung. The 5G trials included testing 5G fixed-wireless access (FWA) technology in highly urbanized areas such as downtown London. The trials utilized Samsung's 5G network solution and Customer Premises Equipment (CPE) and using Arqiva's 28GHz millimetre wave (mmWave) spectrum.[89]

After four months, the companies announced that they established a stable two-way mmWave link with downlink speeds of around 1Gbps through CPE.[90]

In February 2017, Vodafone, Ericsson and Qualcomm Technologies announced a new collaboration focused on 5G New Radio (NR) trial based on the 5G NR specifications. The trial utilized advanced 3GPP 5G NR technologies including Massive Multiple-Input Multiple-Output (MIMO) antenna technology, adaptive self-contained TDD, beamforming techniques, scalable OFDM-based waveforms to support wider bandwidths, advanced coding and modulation schemes, and a new flexible framework design.[91]

In March 2018, O2 UK announced the construction of 5G tests beds at the O2 arena in North Greenwich, the first venue to launch a live 4G trial in London in 2011. The operator informed the public that its 5G testbed will rely on a Multi-access Edge Computing (MEC) solution and will be configured for the virtualisation of core 5G network technologies.[92]

In April 2018, Vodafone, after securing a 50MHz block of spectrum in the 3.4GHz band in April, announced that it became the first UK's MNO to complete a test of 5G spectrum across an existing live network (LTE/4G). The operator claimed it used 3.4GHz frequencies on its network between Manchester and its headquarters in Newbury, Berkshire. To carry out the 5G spectrum test, the g used a site at its Manchester contact centre which houses around 1,000 customer service employees, and its offices in Newbury, with the test utilising Massive MIMO technology combined with 3.4GHz spectrum running over the operator's core 4G network.[93] In June 2018, Vodafone announced that the 7 initial "5G Tral Cities"—Birmingham, Bristol, Cardiff, Glasgow, Liverpool, London and Manchester.[94] In October 2018, Vodafone UK announced, for the first time, that it was able to stream live 5G mobile data a site in Salford, Manchester.[95]

In September 2018, DCMS announced West Midlands as the first's large-scale 5G testbed in the UK.

In October 2018, in preparation for a full commercial 5G launch, EE has switched on the UK's first 5G trial network in London's Canary Wharf.[96] In November 2018, EE announced new 5G trial sites across East London: Provost Street, City Road, Central Street, Old Street, Cheapside, St Paul's, Finsbury Circus Garden, Clerkenwell Street and Bartholomew Square.[97] The operator launched its commercial 5G network in May 2019. Moreover, EE claims to have extended the reach of its next-generation mobile broadband connectivity to a total of 112 towns and cities across the country by October 2020. Meanwhile, the EE claims that in the last twelve months it has more than doubled the amount of 5G sites in what it refers to as 'key cities', such as Belfast, Birmingham, Cardiff and Edinburgh.[98]

In November 2018, Three UK announced investments of more than 2.2 billion EUR[99] on network infrastructure as preparation for the launch of 5G.[100] To upgrade its network, the operator announced that it acquired the country's 'leading 5G spectrum portfolio'; signed an agreement for the rollout of new cell site technology to prepare major urban areas for the rollout of 5G devices; built a super high-capacity dark fibre network, which connects 20 new data centres; deployed a 5G-ready, fully integrated cloud-native core network in the new data centres, which at launch will have an initial capacity of 1.2TBps; and rolled out carrier aggregation (CA) technology at 2,500 sites in the 'busiest' areas.[101] Beyond London, the company announced 16 additional cities, including UK's three other capitals: Cardiff, Edinburgh, and Belfast.[102]

In February 2019, Vodafone UK has announced the switch-on of a 5G hotspot at Manchester Airport using massive MIMO technology. Given that 5G handsets are not yet available for consumers, the operators used its Gigacube device—a portable router that is 5G-enabled. As such, the trial has seen consumers connect to 5G via the Gigacube and use a free 'Entertainment Pass' for streaming video service NOW TV to download and stream content.[103] In other 5G tests occurring at the same time, local press reported that Vodafone was using 5G smartphones form factor connected to Qualcomm Snapdragon X50 5G modems and antenna modules with integrated RF (radio frequency) transceiver, RF front-end and antenna elements.[104]

In June 2019, O2 UK announced it initiated 5G tests at the Millbrook Testing Ground for self-driving cars in Bedfordshire using the 2.3GHz and 3.4GHz spectrum.[105] According to O2, the on-site network at Millbrook consists of 59 cell sites and 89 small cells and is operated by British wireless solution provider Dense Air. Under a twelve-month agreement with the AutoAir project, O2 will integrate the sites and small cells into its public infrastructure.[106]

In July 2019, Vodafone UK switched on its 5G network for both residential and business customers for about the same price, with initial coverage of seven cities--Birmingham, Bristol, Cardiff, Glasgow, Manchester, Liverpool and London. The operator also announced that choices for 5G smartphones during the summer of 2019. Moreover, it also announced the launch of a 5G router for use in the home and office to give customers without a fixed-line connection high-speed broadband access.[107] A few weeks later, the operator expanded 5G to Birkenhead, Bolton, Gatwick, Lancaster, Newbury, Plymouth, Stoke-on-Trent and Wolverhampton.[108]

In August 2019, Three UK announced the launch of "5G home broadband service" in London. In the second half of 2019, the operator reveals its 5G commercial launch across 25 towns and cities. It also announced

the introduction of the world's first 5G-ready, fully integrated cloud core network in a partnership with Nokia. Three UK says it has already successfully tested its new core network with 3,500 of its employees and has started to migrate 4G customer traffic on to the new core.[109]

In October 2019, O2 UK announced the launch of its 5G network with a range of new tariffs, including an unlimited data option, at the same price of its 4G equivalents. The commercial launch is based on the partnership with Ericsson and Nokia, following a competitive tender. O2 UK also noted that it expects the new 5G network to supplement its existing 4G connectivity, which remains 'the backbone of the network'.[110]

In January 2020, Vodafone UK announced that it became the first operator in the country to successfully introduce 5G multi-operator radio access network (MORAN) technology.[111]The operator noted that the new platform enables providers to share the same mobile base station, helping to reduce energy usage and the number of masts needed. Moreover, Vodafone UK has confirmed that it started offering 5G roaming in five locations in the Republic of Ireland-- Cork, Dublin, Limerick, Galway and Waterford. Previously, it had made 5G roaming available in Germany, Italy and Spain.[112]

In February 2020, Three UK outlined details for its mobile 5G launch plans. The operator contended that it was the only operator able to meet the International Telecommunication Union (ITU) 2020 standard for full 5G services, by having at least 100MHz of the 5G-suitable spectrum. Three UK also confirmed that all new and existing customers will have access to 5G with no speed caps and at no extra cost on all post-paid, pre-paid and SIM-only tariffs.[113]

in April 2020, BT has signed an agreement with Ericsson for the deployment of its dual-mode 5G Core (Evolved Packet Core and 5G Core), a fully container-based, cloud-native Mobile Packet Core for 4G, 5G Non-standalone and 5G Standalone services as a single fully integrated core. Ericsson highlighted that its 5G Core should help BT create and deliver new services such as enhanced mobile broadband, network slicing, mobile edge computing, mission-critical vertical industry support and advanced enterprise services.[114]

In June 2020, O2 UK also selected Ericsson as the equipment provider for 5G radio access network (RAN) to other regions of the UK as part of its network modernization programme.[115]

In June 2020, EE's 5G service was reported to be live in 80 towns and cities across the country. The company is using a Non-standalone 5G New Radio deployment focused on using the combined power of 4G and 5G technologies. In a second phase from 2022, it will introduce the full 5G core network, enhanced

device chipset capabilities, and increased availability of 5G-ready spectrum. A third phase, beginning in 2023, will introduce Ultra-Reliable Low Latency Communications (URLLC), network slicing and multi-gigabit-per-second speeds.[116]

In July 2020, Vodafone UK announced that it launched a new 5G standalone (SA) network at Coventry University, in partnership Ericsson, MediaTek, OPPO and Qualcomm. The operator contended that the new network =will be used to show the true benefits of 5G, including ultra-low latency, guaranteed speed performance, and the IoT.[117]

In September 2020, Three UK has signed a deal with British pure fibre provider CityFibre, extending their multi-million EUR 5G backhaul contract signed earlier in 2020. Under the amended contract, the fibre network provider will connect a further 1,300 mobile masts in 59 towns and cities across the UK.[118]

In September 2020, BT announced that Nokia has been selected as a 5G RAN vendor for its commercial operations in the UK. Nokia will supply its AirScale Single RAN (S-RAN) portfolio for both indoor and outdoor coverage, including 5G RAN, AirScale base stations and Nokia AirScale radio access products.[119] Furthermore, under the terms of the deal, Nokia will also optimise BT's 2G and 4G networks and work alongside the carrier on the development of the OpenRAN ecosystem. it will also utilise Nokia Software's ng-SDM and NetAct network management platform, supporting the network evolution to 5G.[120]

Still in September 2020, under this agreement, BT's Nokia-powered network, which is said to currently cover Greater London, the Midlands and rural locations, will reportedly be extended to cover multiple other towns and cities across the United Kingdom, with those locations named as: Aberdeen, Bournemouth, Brighton, Cambridge, Carlisle, Cheltenham-Gloucester, Chesterfield, Dundee, Exeter, Grimsby, Hull, Ipswich, Lincoln, Newbury, Northampton, Norwich, Peterborough, Plymouth, Southampton, Stoke-on-Trent, Swindon, Torbay and York.[121]

1 See: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510798/DCMS_The_Culture_White_Paper__3_.pdf

2 See: https://beisgovuk.citizenspace.com/strategy/industrial-strategy/supporting_documents/buildingourindustrialstrategygreenpaper.pdf

3 See: https://www.gov.uk/government/publications/uk-digital-strategy/1-connectivity-building-world-class-digital-infrastructure-for-the-uk

4 See: https://www.gov.uk/government/publications/uk-digital-strategy/2-digital-skills-and-inclusion-giving-everyone-access-to-the-digital-skills-they-need

5 See: https://www.gov.uk/government/publications/uk-digital-strategy/3-the-digital-sectors-making-the-uk-the-best-place-to-start-and-grow-a-digital-business

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3.18 VATICAN CITY STATE

3.18.1 ICT background and current status of broadband

The State of Vatican City is the smallest state in the world in terms of population as well as territorial extension, extending over an area of fewer than 50 hectares enclaved in the heart of Rome in Italy.[1] The Vatican's interior telecommunication system is composed of two strongly integrated sub-systems: fixed infrastructure and mobile infrastructure. It is important to note that the mobile communication system has been designed to be capable of using satellite connections so that it is possible to ensure the telecommunication services wherever needed, following the Pastoral travels of the Pope.[2]

With a small number of residents, the Vatican City's telephone system operates through an automatic digital exchange. In terms of ICTs, the Vatican is known for controlling its own Internet top-level domain (TLD), which is registered as (.va), and broadband service is widely available in the State.[3] Vatican City has also been given a radio ITU prefix, HV, and this is sometimes used by amateur radio operators, moreover maritime and aeronautical international callsigns have also been assigned."

In face of the new digital transformation, the State of Vatican City has increasingly relied on new ICT-enabled services for a wider reach of messages from the Pope and other institutions in the state to the rest of the world. In November 2018, a Vatican's digital expert urged priests around the world to get online and take advantage of the affordances enabled by broadband.[4]

Furthermore, is also important to underline that the Vatican 5G strategy is evolving and is subject to changes.

3.18.2 Broadband and mobile telecommunication data

In terms of telephone services, the Governorate's Department of Telecommunication has been responsible for the Vatican Telephone Service since 2012, although it was first officially launched in 1930, and offered services to approximately 360 end users. Since 1960, the capacity has increased tremendously.[5]

In the 1990s, the Vatican expanded its internal telecom infrastructure, providing the city with a highly advanced state-of-the-art network. Currently (2020), the about 5000 phone terminals in Vatican City State are connected through an IMS exchange. Fiber optics links provide phone and data connectivity to Italian communications operators and international data carriers, as well as to the extra-territorial zones.

3.18.3 Current progress on 5G: consultations and national strategies

As of October 2020, no public information concerning the 5G consultation and strategies from the Vatican State is available.

3.18.4 Spectrum assignment for 5G & market development

As of October 2020, no public information concerning the 5G spectrum assignment in the Vatican State is available. However, the Vatican City State coordinates its spectrum use with its neighbouring country according to the ITU provisions.

In the near future, a 5G broadband application scenario could be to develop and improve broadcasting applications.

3.18.5 Electromagnetic fields levels and the implementation dynamics

Since 1992, through the resolution of the Special Delegate of the Pontifical Commission for the Vatican City State (prot. Gen. 225620 of 16/12/1992), the Vatican has adopted precautionary values provided by the ICNIRP (International Commission on Not-Ionizing Radiation Protection) for the EMF exposure limits for the 0 Hz- 300 GHz frequency range.[6] Italy adopted the Ministerial Decree 381/98 (which entered into force in January 1999) a limit of 20V/m regardless to frequency, however, in the case of the presence for continuous stays of not less than 4 hours, the Decree reduces these limits to 6 V / m for all electromagnetic waves.[7]

In face of the challenges provided by alleged EMF exposure violations of Italy's Ministerial Decree 381/98 on the occasion of the alleged violation of the Vatican Radio antennas in the city of Rome[8], the State of Vatican City agreed to have part of its programs broadcast by other stations in Italy or abroad (from within the Principality of Monaco), and the Italian government agreed to pay for the costs of the transfer.[9] Ever since, the national Italian EMF limits currently in force were set by Decree of the Prime Minister in August 2003, replacing a previous decree of 1992,[10] and present more restrictive quantitative limits than the standards provided by ICNIRP.[11]

3.18.6 5G commercial launches: announcements, trail cities, and digital cross-border corridors

As of October 2020, no 5G commercial launch has occurred in the Vatican City. Despite that, developments are swiftly ongoing in the surrounding areas of the enclave, primarily conducted by operators such as TIM (which activated its 5G network in parts of Rome and Turin in June 2019) and Vodafone (which switched on its network around the same time in Rome and Turin as well as Bologna, Naples and the metropolitan areas of Milan). In early in 2019, both TIM and Vodafone signed an agreement on the cost-share of rolling out new 5G infrastructure throughout Italy.[12]

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4. Conclusions

Overall, it must be appreciated that 4G technology now covers more than 91% of non-EU countries in Europe Region. Compared to only five years ago, this is a significant improvement which impacts the lives of millions and testifies that Europe region is reducing existing gaps within its boundaries.

Considering that the European Union is accelerating on 5G development, more needs to be done to reduce the investment cycle in 4G so to speed up 5G deployment, especially in some non-EU countries. Moreover, there remain a number of issues including freeing the 700MHz band (DD2) for mobile communications as well as creating an enabling environment for commercialization of services relying on the 26GHz band.

On top of these challenges, the proceedings of the ITU Regional Forum for Europe on 5G strategies policies and implementation have highlighted two further items. The first is that of Radiofrequency Electromagnetic fields (RF-EMF) which in some countries is cause of concern of the general public and underpins spread of misinformation that risks hindering the deployment of 5G. The second point which was widely agreed upon was the need to avoid creating new gaps within Europe region between EU countries and non-EU countries whereby the former take substantial and harmonized steps forward on 5G and the latter proceed independently. It was highlighted that 5G presents common hurdles that should be overcome through international collaboration.

Beyond these challenges, new ones will be raised as 5G networks are rolled out in the coming years. ITU's regional initiative 1 for Europe on "broadband infrastructure, broadcasting and spectrum management" creates the basis for supporting countries in their needs and priorities on 5G development through technical assistance or by fostering capacity building and exchange of information.