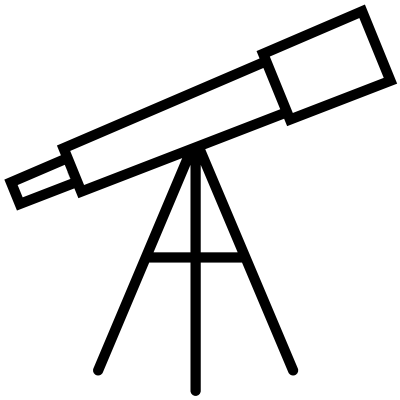
5G Observatory

Biannual Report

October 2023

Study on "European 5G Observatory phase III" (CNECT/2021/OP/0008).



EUROPEAN COMMISSION

Directorate-General for Communications Networks, Content and Technology

NOTE

This is the 19th edition of an independent, biannual summary of developments in the deployment of 5G in the EU, assessing progress towards EU policy goals. Quarterly publications of the European 5G Observatory have been issued since September 2018, under a contract with the European Union and the opinions expressed are those of the contractor and do not represent the official position of the European Commission. Since 2021, the 5G Observatory is run by a consortium of three companies (the contractors) VVA, PolicyTracker and LS telcom. Since March 2023 the Reports became biannual.

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1 Latest developments

As far as national spectrum assignments are concerned, there have been three major national 5G spectrum auctions in the EU in the past six months. Estonia completed its auction of the 26 GHz band in May. Sweden completed its award of the 900 MHz, 2.1 GHz and 2.6 GHz bands in September. In mid-October, Poland completed its auction of the 3.6 GHz band, awarding a total of 400 MHz to four operators. There is also continued interest in local spectrum assignments, with both Poland and Slovenia opening up spectrum bands for private network use.

Despite the latest spectrum auctions, several EU countries have not yet met their legal requirements regarding the assignment of the EU 5G Pioneer bands by the end of 2020. One country has yet to assign any spectrum in the core 3.6 GHz band, while four have not assigned any 700 MHz band spectrum.

In terms of recent public policy developments, the European Commission has published its first report on the State of the Digital Decade.[1] It concludes that, at the outset of the Digital Decade, the EU is still far from achieving the Digital Decade connectivity targets. While 5G population coverage stands at 81%,[2] the deployment of 5G stand-alone networks is lagging behind. The report also claims that 5G is still falling short in quality with regard to end-users' expectations and industry needs, as well as in addressing the divide between rural and urban areas. Overall, it also notes the EU is lagging behind in terms of coverage compared to the US, where 96% of the population is covered by 5G.[3]

The Digital Decade report also highlights that the population coverage of 5G service based on the 3.6 GHz band, which gives an important indication of high-quality 5G coverage, is still low at 41% (not a formal KPI). In this context, the Commission services have been working to improve the measuring of 5G progress with additional Key Performance Indicators (KPIs) that are under discussion with Member States. Further improvements will be made in the future as KPIs are expected to evolve.

The European Commission has selected a second group of 5G corridor investment projects funded under the Connected Europe Facility (to be announced in November 2023) and has launched a new call for corridors endowed with EU funding of €100 million.

In June 2023, the European Commission also adopted a Communication on cybersecurity of 5G networks to complement the latest progress report by Member States.[4] In its Communication, the Commission underlines the risks posed by certain suppliers of mobile network communication equipment to the security of the Union, and that it will apply the Toolbox criteria to assess the needs and vulnerabilities of its own corporate communications systems and those of the other European institutions, bodies and agencies, as well as the implementation of Union funding programmes in the light of the Union's overall policy objectives.

Major recent commercial developments include a steady increase in 5G population coverage, with various operators in Spain, Germany and Lithuania announcing new coverage milestones. Additionally, there is also an increased interest in launching 5G in a standalone configuration (5G SA).

[1] https://digital-strategy.ec.europa.eu/en/library/2023-report-state-digital-decade

[2] The current KPI for the 5G target does not take into account the quality of service provided under peak-time conditions. A key challenge is to ensure that the deployed networks respond to future needs, notably supporting key industry sectors and critical applications that will benefit consumers and businesses in all sectors. To measure Member States readiness to overcome this challenge, further examination is required to strengthen and broaden the 5G measurement framework. See C(2023) 7500 'Communication from the Commission establishing the Union-level projected trajectories for the digital targets'.

[3] ETNO, State of Digital Communications 2023. "5G coverage is approaching 96% in the USA, 95% in South Korea, 90% in Japan and 86% in China".

[4] Communication from the Commission: Implementation of the 5G cybersecurity Toolbox: https://digital-strategy.ec.europa.eu/en/library/communication-commission-implementation-5g-cybersecurity-toolbox

1.1 5G Spectrum awards

1.1.1 National spectrum awards

Over the past six months, three major national spectrum auctions have been concluded in Estonia, Sweden and Poland.

In May 2023, Estonia completed its award of the 26 GHz band, awarding a total of 2.4 GHz in the 24.7-27.1 GHz frequency band. The country's three major operators, Elisa, Tele2 and Telia, all secured spectrum in the band, and the auction raised a total of €4.8 million. Following this award, Estonia has now completed auctioning all three 5G pioneer bands, including the 700 MHz and 3.6 GHz bands.

In September 2023, Sweden completed[5] its award of the 900 MHz, 2.1 GHz and 2.6 GHz bands. Telia Sweden, Hi3G Access (Tre Sverige) and Net4Mobility (a joint venture between Telenor and Tele2) all won spectrum licences in these bands. Although the 900 MHz, 2.1 GHz and 2.6 GHz bands are not 5G pioneer bands, they are vital mobile spectrum bands that are expected to be utilised to improve 5G networks in the country.

Finally, in October 2023, Poland completed its auction of the 3.6 GHz band. The Polish telecoms regulator announced[6] that Polkomtel, P4, Orange and T-Mobile all won licences for 100 MHz of spectrum in this valuable 5G pioneer band. The auction raised a total of €432 million.

Europe is still lagging behind with regards to its objective of assignment of 100% of the two main 5G pioneer bands (700 MHz and 3.6 GHz) by the end 2020. This means that 5G deployment in several EU Member States is potentially limited in terms of performance and service quality. In addition, the fragmentation of approaches between countries regarding spectrum for campus/private networks has a negative impact on economies of scale in the particularly strategic area of new industrial use cases.

1.1.2 Local 5G spectrum awards

Interest in local spectrum licences, which are sometimes known as campus licences, has increased in recent months. These licences are awarded on a localised basis and are typically used for 5G private networks by various industries.

In September, Polish regulator UKE opened up the 3.8-4.2 GHz band for private network use. It announced[7] that local government bodies can apply for 100 MHz in the 3.8–3.9 GHz, while other users, including businesses, can apply for 3.9–4.2 GHz frequencies for vertical use. Entities can apply for blocks in multiples of 10 MHz, up to 100 MHz in total.

Meanwhile, in Slovenia, regulator AKOS announced it is working towards preparing an auction of spectrum for 5G private networks. Under the plan, the regulator will assign three blocks of 30 MHz in the 2.3 GHz band and 20 blocks of 10 MHz in the 3.6 GHz band.[8]

[5] https://5gobservatory.eu/sweden-completes-spectrum-auction/

[6] https://www.uke.gov.pl/blog/aukcja-5g-rozstrzygnieta-operatorzy-rozbuduja-swoje-sieci,94.html

[7] https://5gobservatory.eu/poland-opens-3-8-4-2-ghz-to-private-networks/

[8] https://www.policytracker.com/poland-slovenia-launch-spectrum-allocation-process-for-private-5g-networks/

1.2 Public developments

1.2.1 EU Policy developments

On an EU-wide policy level, the European Commission has been working to improve the monitoring of 5G deployment progress in Member States. On 30 June 2023, as part of the Path to the Digital Decade, the Commission adopted new Key Performance Indicators (KPIs) to assess the steps taken towards achieving 2030 Digital Decade targets.

The 5G KPI issued by the Commission for the first year of reporting tracks the percentage of households that receive a 5G signal, independent of the operator or service quality. Alongside these KPIs, it also issued guidance on how Member States should structure their national roadmaps to reach targets. In response to this, Member States will adopt national roadmaps. The national roadmaps were to be submitted to the Commission for the first time by 10 October.

While this approach is seen as satisfactory for tracking initial 5G deployments, the Digital Decade Committee deemed that further work on KPIs for 5G should be conducted to improve this indicator in the future. To improve these metrics, the KPI Expert Subcommittee is currently working to explore options for a possible future revision of 5G KPIs.

The Commission is considering introducing a complementary 5G KPI from 2024 in the Digital Decade reporting that provides a suitable proxy for the percentage of households that are covered by a network that is capable of offering a high-quality 5G service, e.g. high data rates and low latency. In addition to new metrics, the Commission acknowledges that further work will eventually be needed on estimating the actual 5G service quality and coverage from an end-user perspective.

As far as 5G cybersecurity is concerned, the European Commission has adopted a Communication on the implementation of the toolbox by Member States and in the EU's own corporate communications networks and funding activities. The Commission argues that "decisions adopted by Member States to restrict or exclude Huawei and ZTE are justified and compliant with the 5G Toolbox" and calls for Member States to "achieve the implementation of the Toolbox without delay".[9]

The NIS Cooperation Group[10] consisting of Member States' representatives has also published its second report on the implementation of the EU Toolbox. It concluded that 24 Member States have adopted or are preparing legislative measures giving national authorities the power to enhance security requirements for 5G networks based on the EU Toolbox. But so far only ten Member States have imposed these restrictions.[11] (See A1.10 5G Cybersecurity Toolbox Implementation)

1.2.2 Public 5G funding initiatives

The 5G Observatory has also reported ongoing interest in the public funding of 5G projects on an individual Member State Level. In May 2023, Lithuania's Ministry of Transport and Communications announced[12] it would allocate €24.5 million in funding for 5G projects. The Ministry says these funds will support projects that promote the development of digital technology solutions that require 5G

9 https://ec.europa.eu/commission/presscorner/detail/%20en/ip_23_3309

10 https://digital-strategy.ec.europa.eu/en/policies/nis-cooperation-group

11 Second report on Member States' Progress in implementing the EU Toolbox on 5G Cybersecurity, Une 2023 p22 https://ec.europa.eu/newsroom/dae/redirection/document/96519

12 https://5gobservatory.eu/lithuania-to-allocate-e24-5-million-in-funding-for-5g-projects/

connectivity, such as autonomous transportation, unmanned aerial vehicles (UAVs), Internet of Things (IoT), virtual reality (VR) and automation.

In June 2023, Spain's Ministry of Economic Affairs and Digital Transformation announced[13] that it would make available €500 million in funding for rural 5G development in the country. The project is designed to provide citizens with equal connectivity regardless of where they live and targets towns with fewer than 10,000 inhabitants.

Despite these recent funding initiatives, in its September 2023 report on the state of the Digital Decade, the European Commission says it has identified an investment gap in terms of communications infrastructure between the EU and its key trading partners.[14] The report notes that in the US, public investment has recently reached $90 million in the context of the Infrastructure Investment and Jobs Act and American Rescue Plan. Comparatively, it claims that in the EU, the amount of investment towards 2030 connectivity targets stands at just €23 billion in grants in the 2021-2027 period, including around €16 billion under the EU Resilience & Recovery Fund.[15] The report also states that in terms of total fixed capital investment in fibre and 5G measured per capita, only €104 million was invested in the EU, compared to €260 in Japan, €150 in the US and €110 in China.[16]

Following the launch of a first set of 15 projects in 2023 on 5G coverage along transport corridors funded under the Connected Europe Facility (CEF), the European Commission has recently selected a second group of projects which will be publicly announced at the end of November.

A third call for 5G corridors along transport paths is now open until 17 January 2024. The EU funding available for this new call to co-finance corridors projects amounts to € 100 million (the overall CEF Digital budget earmarked for 5G coverage along transport corridors over the period 2021-2027 is €800 million).

1.3 Commercial developments

1.3.1 5G coverage developments

Mobile operators across the EU have been rapidly expanding the reach of their 5G networks. Over the past six months, various operators have announced new coverage milestones.[17]

In Romania, Orange says it expanded its 5G service to 37 cities across the country.[18] In Germany, meanwhile, Vodafone[19] and rival Telefonica[20] both announced that their 5G network now reaches 90% of the population.

[13] https://5gobservatory.eu/spain-allocates-e500-million-for-5g-deployment/

[14] https://digital-strategy.ec.europa.eu/en/library/2023-report-state-digital-decade

[15] Source: SWD (2023)570 'Implementation of the Digital Decade objectives and the Declaration on digital Rights and Principles', Annex 5 Delivering the Digital Decade with EU investments. Beyond RRF funding, the estimate of over €23 billion in grants includes more than €4 billion cohesion policy funding, around €1 billion Horizon2020/Horizon Europe and around €1 billion CEF funding. Additional funding has been granted in the form of financial instruments (namely, trough Invest EU and the Connecting Europe Broadband Fund)

[16] ETNO, State of Digital Communications 2023, p.31.

[17] These are only recent announcements made in the last 6 months. To view a more comprehensive list of 5G coverage across the EU, refer to the section on 5G coverage in the Annex 1.2 of this report.

[18] https://5gobservatory.eu/orange-romania-expands-5g-to-37-cities/

[19] https://5gobservatory.eu/vodafone-germany-says-5g-network-now-reaches-90-of-the-population/

[20] https://5gobservatory.eu/telefonica-germany-reaches-90-5g-coverage/

Furthermore, in Lithuania, operator Bite announced in mid-August that its recently launched 5G network now covers over 1.2 million people.[21] In Slovakia, O2 reported in June 2023 that its 5G network is serving over 52% of the country's population.[22]

Finally, Swedish operator group Telia said in July that its 5G network coverage across its footprint of five EU countries now stands at 84% of the total population. The group expanded 5G coverage in Sweden, Finland, Denmark, Lithuania and Estonia.[23]

While 5G coverage is growing consistently across the European Union, coverage that relies on using the 3.6 GHz core 5G band remains limited in many countries. The 5G Observatory has observed only a minor growth of just 0.3% in the percentage of 5G base stations using the 3.6 GHz band since the last bi-annual report published in April 2023.

A lack of 5G deployment in mid-band frequencies has also previously been identified by vendor Ericsson. It estimates that as of end-2022, just 15% of European 5G coverage uses mid-band spectrum, including the 3.6 GHz band[24]. Ericsson says Europe is lagging other regions when it comes to mid-band deployment, which it considers important for enabling "step-change" 5G. There are however regional differences when it comes to 3.6 GHz deployment progress. German mobile operator Deutsche Telekom for instance has been aggressively rolling out 3.6 GHz band base stations and has built over 8,200 base stations in the band by March 2023.

1.3.2 5G standalone progress

There has also been an accelerated effort to launch new upgraded 5G networks in a standalone configuration (known as 5G SA). This brings several benefits, including increased performance, improved end-user battery life and the enablement of new features such as 5G network slicing that are only possible on 5G SA.

In terms of 5G SA rollouts, significant progress has been observed in Spain and Germany. In June 2023, Spanish operator Orange announced it was launching 5G SA services in 30 towns across the country, extending the reach of its network beyond major cities where it had already previously launched 5G SA services.[25] Competing Spanish MNO Movistar has also deployed[26] a standalone network dubbed 5G+. In Germany, Vodafone claimed[27] in August 2023 that its 5G SA network already covers 45% of the country's population.

In several Member States where operators have yet to launch commercial 5G SA, the Observatory has charted progress on early-stage trials. For instance, in the Netherlands, KPN has tested 5G SA technology on its network together with Ericsson[28]. It plans to introduce 5G SA gradually starting from 2024.

Overall, there is significant interest in 5G SA in the EU. The Global mobile Suppliers Association's July 2023 report on global 5G Standalone progress indicates most EU Member States have operators which are currently investing in public 5G SA networks.[29]

[21] https://5gobservatory.eu/bite-says-5g-network-now-covers-1-2-million-lithuanians/
[22] https://5gobservatory.eu/o2-5g-network-expansion-continues-in-slovakia/
[23] https://5gobservatory.eu/telia-increases-5g-coverage-to-84-across-six-european-markets/
[24] https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/network-coverage
[25] https://5gobservatory.eu/orange-spain-to-launch-5g-standalone-in-30-towns/
[26] https://5gobservatory.eu/movistar-launches-5g-network-in-spain-on-ericsson-5g-core-ran-networks/
[27] https://5gobservatory.eu/vodafone-germany-says-5g-network-now-reaches-90-of-the-population/
[28] https://5gobservatory.eu/kpn-tests-5g-standalone-technology/
[29] https://gsacom.com/paper/5g-standalone-july-2023-member-report/

While many operators have now launched 5G SA configurations, measuring the overall progress of 5G SA across the EU presents a challenge for the 5G Observatory due to a reliance on public announcements and a lack of centralised data on the subject. This issue is explored in more detail in a new editorial featured in the "5G Perspectives" section of this report, which also explores the value of collecting data on 5G SA progress and how this contributes to Digital Decade targets.

1.4 Major international developments

The 5G Observatory also keeps track of major international 5G developments. In recent months, the consortium team has observed rapid 5G growth in India, which first completed its 5G spectrum auction in late 2022, and MNOs are now rolling out 5G across the country. In August 2023, India's Department of Telecommunications (DoT) announced that there are 308,466 5G base stations in India.[30]

Other international trends include an increased interest in standalone 5G, and in particular, to offer network slicing services, which is enabled by 5G SA configurations. In August, US-based operator T-Mobile launched[31] a network-slicing beta solution, which will enable developers to test video calling features that utilise standalone 5G features. In India, national mobile operator Jio announced it would use network slicing to enable its 5G fixed wireless access (FWA) offering.[32]

The Observatory has also highlighted continued interest in satellite-enabled 5G networks. A report by ABI research published in July claimed that the non-terrestrial network (NTN) connectivity 5G ecosystem has the potential to reach a market value of $18 billion by 2031.[33]

Finally, the number of 5G fixed wireless access products available worldwide is also increasing. In a report released in June 2023, the Global Suppliers Association (GSA) claims that 455 operators have now launched FWA services.[34] However, it should be noted that while the share of 5G-based FWA is growing, the majority of these FWA services still rely on 4G.

[30] https://5gobservatory.eu/india-says-operators-have-deployed-300000-5g-base-stations/

[31] https://5gobservatory.eu/t-mobile-launches-network-slicing-beta/

[32] https://5gobservatory.eu/jio-to-use-network-slicing-for-its-fwa-service/

[33] https://5gobservatory.eu/report-satellite-enabled-5g-mobile-networks-could-reach-market-value-of-18-billion/

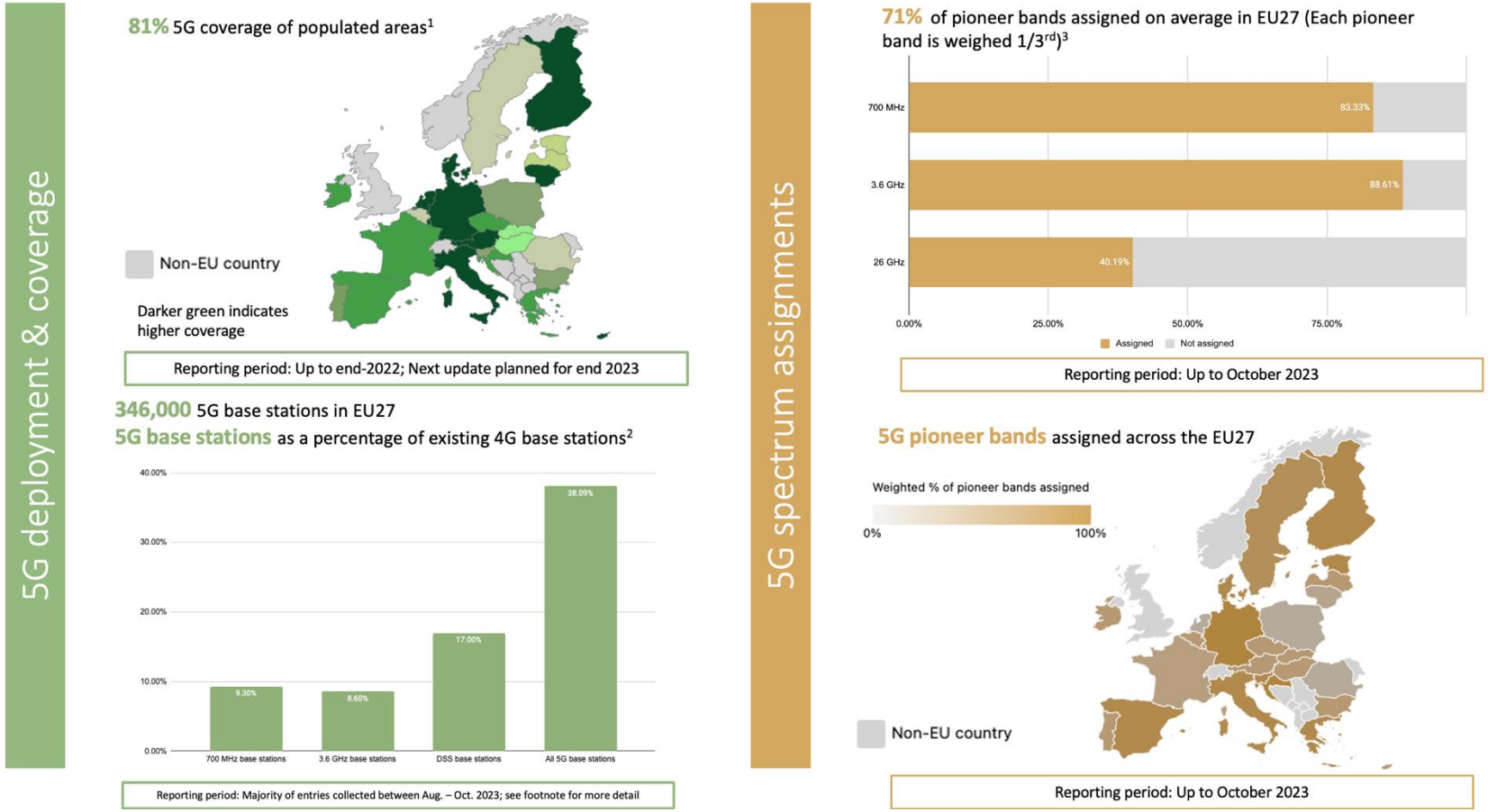
[34] https://5gobservatory.eu/report-455-operators-have-launched-fixed-wireless-access-services/

2 5G scoreboard

2.1 EU27 progress so far

The 5G scoreboard summarises the status of 5G commercial launches, spectrum assignments and 5G corridors in EU-27. To date:

- All EU countries now have commercial 5G service available at least in a part of the country (please see the section on Latest Commercial Developments).
- A total of close to 346,000 5G base stations are now active in the EU.
- The most common type of 5G base station makes use of 4G bands in a Dynamic Spectrum Sharing (DSS) configuration.
- Approximately 81% of the EU's population is covered by at least one basic 5G network (situation at the end of 2022, and hence unchanged since the reporting of April, (the next reporting milestone is planned for end 2023).



(Source: Data on population coverage, base stations and spectrum assignments is from the DESI index. This data is supplemented with data independently collected by the Observatory)

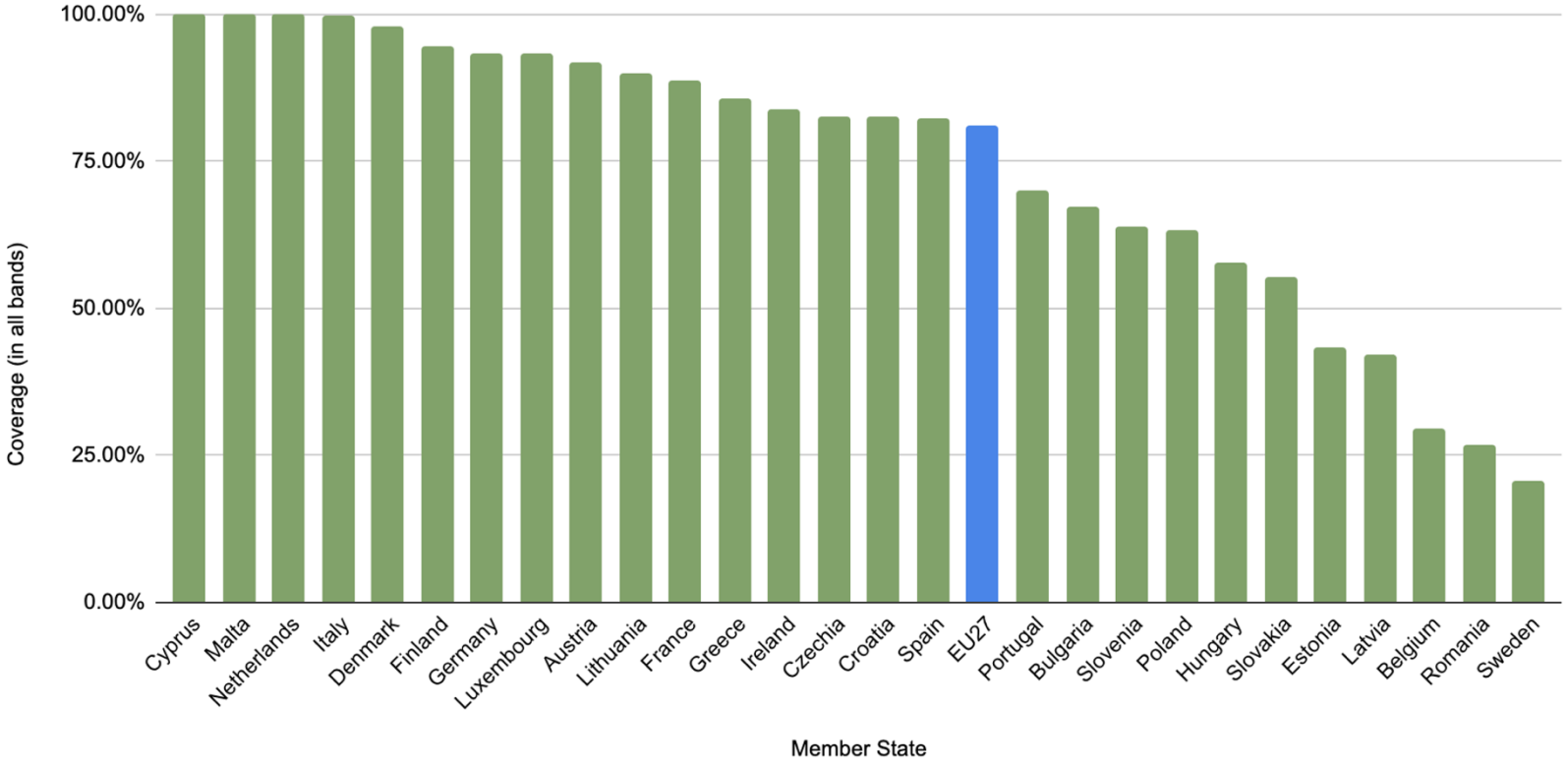
1 - Overall coverage is a general indicator that does not presume any particular quality of service measures. All 5G coverage is included, including that using DSS. Location covered by at least one operator.

2 - The data for Bulgaria, Czechia, Denmark, Greece, Germany, Hungary, Italy, Lithuania, Latvia, Poland, Romania, Slovenia and Sweden was collected between September - October 2023. The data for Austria, Belgium, Cyprus, Estonia, Netherlands, Croatia, Ireland, Malta, Slovakia and Spain was based on the latest available data from the January - March 2023. The data for Luxembourg was collected from the end of December 2022. The data for Finland, France and Portugal was collected from the end of August 2022. For some EU countries, only the total number of 5G base stations is known. This means the true total number of base stations in the EU in 700 MHz, 3.6 GHz or DSS bands may be higher.

3 – Countries need to assign 60 MHz in 700 MHz; 400 MHz in 3.6 GHz and at least 1000 MHz in 26 GHz to receive a 100% score.

EU 5G progress

5G coverage of populated areas (All frequency bands combined)[4]

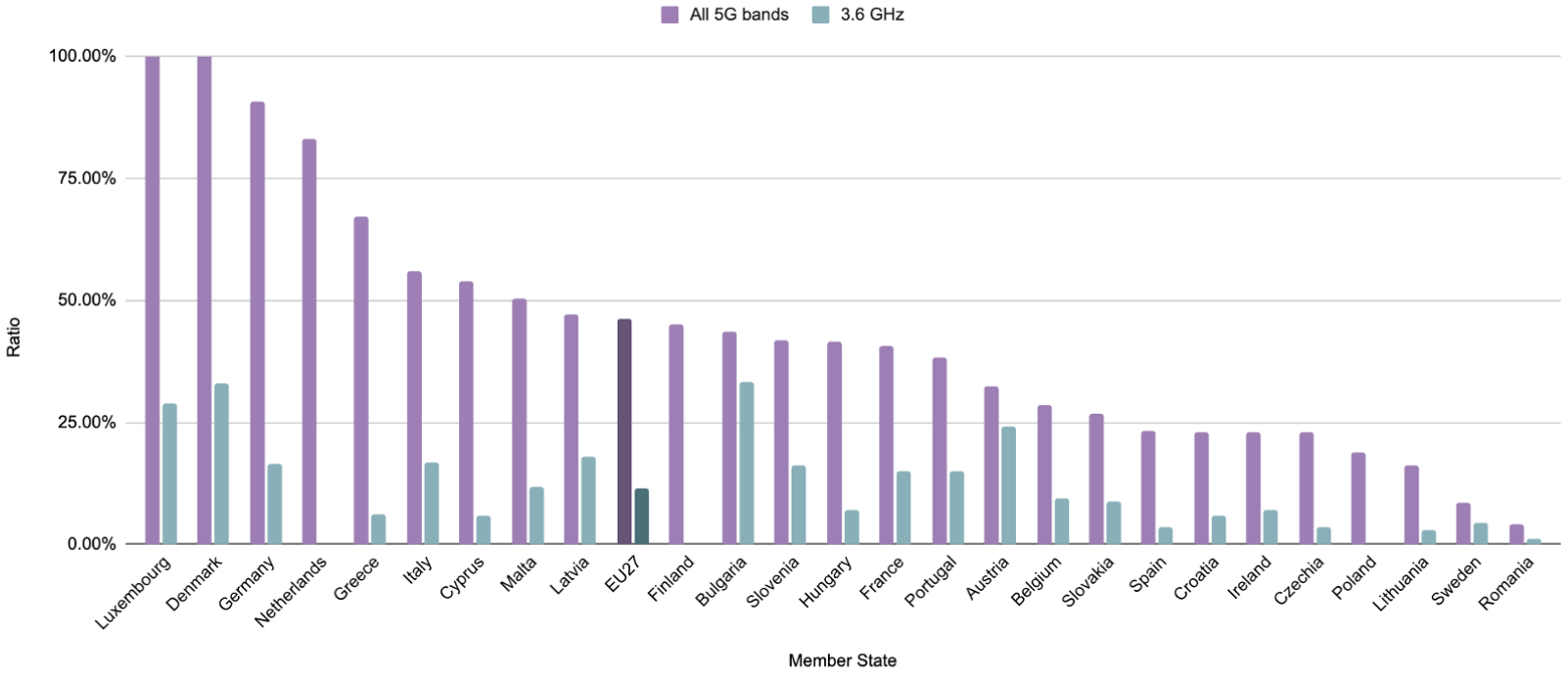


Reporting period: Up to end-2022; Next update planned for end 2023

4 – Percentage of households covered by at least one 5G network.

EU 5G progress

5G base stations as a percentage of existing 4G base stations in Member States[5]



Reporting period: Majority of entries collected between Aug. – Oct. 2023; see footnote for more detail

5 – Estonia excluded due to lack of data; The data for Bulgaria, Czechia, Denmark, Greece, Germany, Hungary, Italy, Lithuania, Latvia, Poland, Romania, Slovenia and Sweden was collected between September - October 2023. The data for Austria, Belgium, Cyprus, Netherlands, Croatia, Ireland, Malta, Slovakia and Spain was based on the latest available data from the January - March 2023. The data for Luxembourg was collected from the end of December 2022. The data for Finland, France and Portugal was collected from the end of August 2022.

5G Corridors

5G Corridor Projects: CEF Digital Call 1 2022

7 5G cross border works

8 5G cross border studies

WORKS

1. **5G SEAGUL**
   Sofia (BG) to Velestino (EL)
   ~ 475 km
2. **EVOCAM5G**
   Evora (PT) to Merida (ES)
   ~ 155 km
3. **IBERIANL5G**
   Vigo (ES) to Aveiro (PT)
   to Salamanca (ES)
   ~ 600 km
4. **MEDCOR5G**
   Barcelona (ES) to Montpellier (FR)
   ~ 550 km
5. **NATCOR5G**
   Bilbao (ES) to Bordeaux (FR)
   ~ 515 km
6. **5G DeLux**
   Frisange (LU) to Güdingen (DE)
   ~ 100 km
7. **5G NETC**
   Malmö (SE) to Helsinki (FI)
   to Riga (LV)
   ~ 2000 km

STUDIES

8. **5G Brno – Bratislava**
   Brno (CZ) to Bratislava (SK)
   ~ 140 km
9. **5G MELUSINA**
   Luxembourg (LU) to Metz (FR)
   ~ 70 km
10. **5G on Track**
    Mulhouse (FR) to Karlsruhe (DE)
    ~ 200 km
11. **5GCarolina**
    Prague (CZ) to Munich (DE)
    ~ 70 km
12. **5G Gail**
    Udine (IT) to Salzburg (AT)
    ~ 200 km
13. **5G Estuary**
    Antwerp (BE) to Vlissingen (NL)
    ~ 260 km
14. **Latest 5GS**
    Tallin (EE) to Vilnius (LT)
    ~ 670 km
15. **EUMOB**
    Bordeaux (FR) to Bilbao (ES)
    Perpignan (FR) to Barcelona (ES)
    ~ 500 km

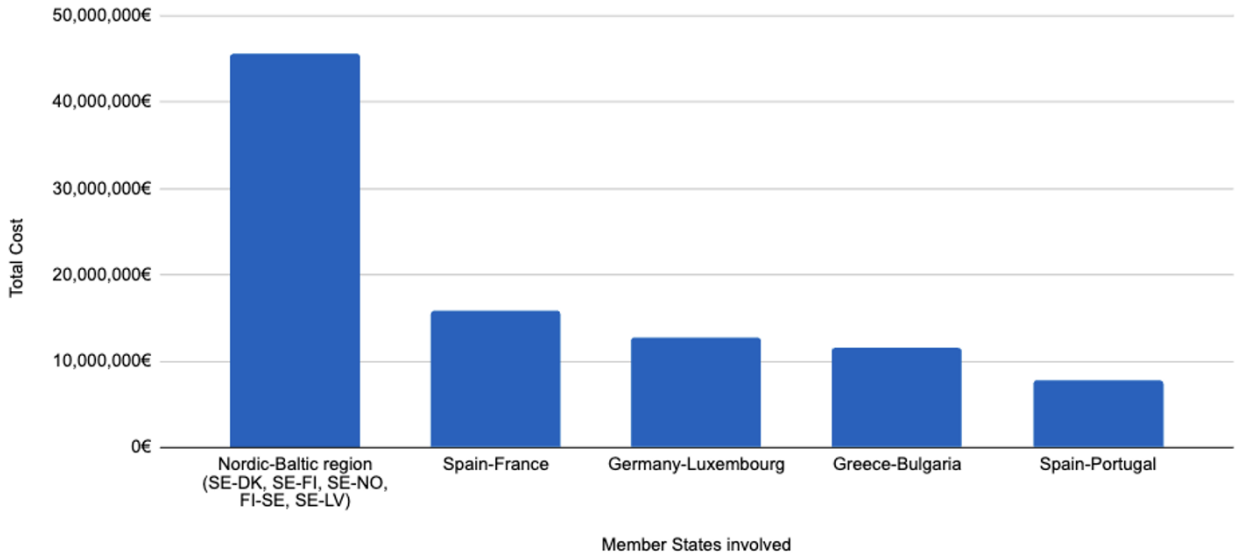
Road and rail network based on the list of 5G corridors and cross-border backbone connections identified in Part V of the Annex of CEF Regulation (EU) 2021/1153.

The GUIDE project is a Coordination Support Action funded by the European Union. Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor the granting authority can be held responsible for them.

Co-funded by the European Union

5G Corridors

Committed investment in 5G cross-border deployment



2.2 International developments

The international version of the scoreboard details the current status for 5G commercial launches and spectrum plans worldwide, including metrics such as "5G base stations per 100,000 inhabitants" which represents the extent of deployment of 5G is in each country. The following developments can be highlighted:[35]

- South Korea has the highest number of 5G base stations per 100,000 inhabitants: around five times more than the EU and nearly 14 times more than the US. Meanwhile, China has the second most 5G base stations per 100,000 inhabitants.
- The United States has awarded the largest amount of high-band spectrum in the mmWave range (28 GHz), with a total of 4950 MHz assigned to operators. South Korea meanwhile has assigned 2400 MHz of mmWave spectrum to operators. The average spectrum assignment in the EU27 is 365 MHz out of 3250 MHz of harmonised spectrum in the 26 GHz frequency band.
- The largest amount of 5G spectrum already awarded in Europe is located in the mid-band (3.6 GHz), followed by the low band of 700 MHz.

[35] Please notice that there may be discrepancies between the reported figures, as the method for calculating the number of base stations is not standardised between regions

5G rollout

Comparison of 5G rollout in international markets[6]

	China	South Korea	Japan	USA	EU
Approximate number of 5G base stations	2,937,000	217,000	146,000	100,000	346,000
Total country population	1,425,700,000	51,800,000	123,300,000	334,000,000	448,400,000
5G base stations per 100,000 inhabitants	206	419	118	30	77
Indicative 5G subscribers	689,200,000	28,000,000	14,190,000	79,000,000	143,000,000
Indicative 5G subscribers per 100,000 inhabitants	48,341	54,054	11,509	23,653	31,891

Reporting period: 5G base station data collected between July 2022 – July 2023; Population data collected July 2023; 5G subscriber data collected between July 2022- July 2023

(Source: Data on subscriber numbers and base stations was collected from various sources including regulator announcements.)

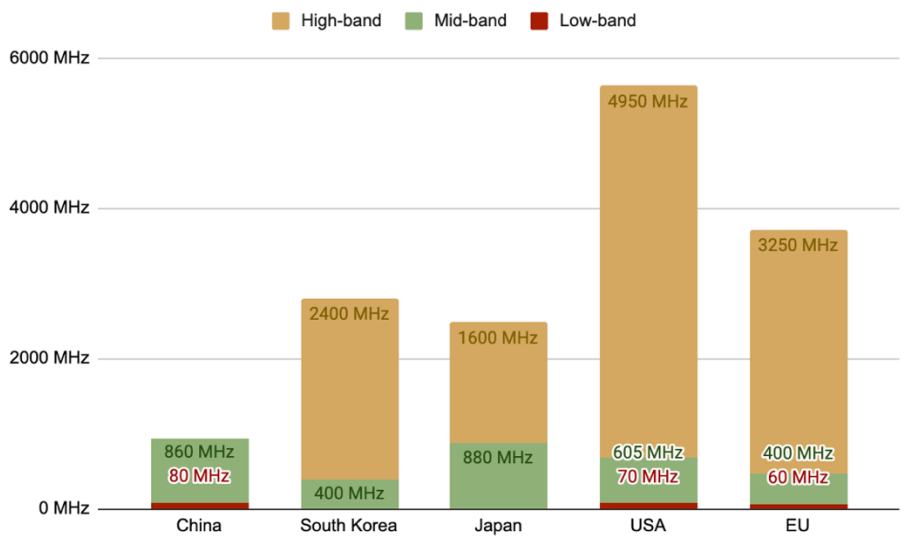
6 - There may be discrepancies between the reported figures, as the method for calculating the number of base stations is not standardised between regions

5G spectrum

Main bands authorised for 5G in international markets[7]

Country	Low-band (<1 GHz)	Mid-band (1 - 6 GHz)	High-band (>6 GHz)
China	700 MHz	2.6 GHz 3.6 GHz 4.9 GHz	-
South Korea	-	3.6 GHz	28 GHz
Japan	-	3.6 GHz 3.7 GHz 4 GHz 4.5 GHz	28 GHz
USA	600 MHz	2.5 GHz 3.45 - 3.55GHz 3.5 - 3.7 GHz 3.7 - 3.98 GHz	24 GHz 28 GHz 39 GHz 47 GHz
EU	700 MHz	3.6 GHz	26 GHz

Authorised 5G spectrum in international markets[7]



Reporting period: Up to Sept. 2023

(Source: Data on international spectrum assignments is sourced from the Policy Tracker database, the DESI index as well as FCC data.)

7 - US data shows all spectrum made available to mobile operators by the FCC. Not all of this spectrum will have been sold to operators so the final amount of spectrum assigned to operators may be slightly lower. For a more detailed explanation of the methodology used see section on *5G Spectrum comparison between EU and other world regions*. For the EU, the data represents spectrum that is harmonised across the EU27. Some individual countries may have more spectrum assigned for 5G, while some may have less or none. For a full breakdown see section A1.4.

3 Progress against monitored targets and strategic implications

The table below presents major strategic implications referring to the overall performance of EU27 against relevant 5G-related targets. These targets to be monitored throughout the publications have been sourced from EU Policy programmes, including the 5G Action Plan,[36] the Digital Decade Policy Programme (DDPP),[37] as well as the EU 5G Cybersecurity Toolbox.[38] This monitoring exercise will be the basis of a full strategic progress assessment, including relevant roadmaps, to be included in the final report:

[36] https://digital-strategy.ec.europa.eu/en/library/communication-5g-europe-action-plan-and-accompanying-staff-working-document

[37] https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade; Decision (EU) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030, OJ L 323, 19.12.2022.

[38] https://digital-strategy.ec.europa.eu/en/library/eu-toolbox-5g-security

Table 1: Progress against monitored targets and strategic implications

Targets: 5G AP; Digital Decade; Cybersecurity Toolbox	Performance/status	Bottlenecks identified	Solution/recommendation
All populated areas covered by next-generation wireless high-speed networks with performance at least equivalent to that of 5G.	According to the latest DESI indicators, the estimate overall 5G coverage in the EU is 81%.[39] Following the baseline trajectory, it is expected that 5G coverage in the EU will reach 97% by the end of 2023.	At Member State level, there is a lack of consistency in the reporting of 5G coverage based on the research of the study team on each MS. For example, reporting on 5G coverage in some MS is centralised from a national regulatory authority, while in some others, the reporting comes from private operators.	As the Digital Decade policy programme has come into force as of January 2023[40], the reporting is expected to become more uniform. The policy programme includes a common EU monitoring mechanism to track the progress towards 2030 targets based on key performance indicators reported by the Commission in the DESI annually[41]. Nonetheless, it should be noted that the current definition of the 5G targets of the Digital Decade only entails a coverage of all populated areas by a next-generation wireless high-speed network with the performance equivalent of at least 5G by 2030, while not specifying further the quality or the extent of performance experienced by end users (both regular consumers or professional users). Hence, this may lead to an inadequate reporting and a quasi-complete achievement by the end of 2024 based on the current projection. Consequently, a more layered KPI definition should be developed to reflect the different levels of the quality of services to be expected for future use cases, instead of a single blanket population coverage indicator.
Digital technologies, including 5G at the core of new products, new manufacturing processes and new business models	The rollout of private local 5G networks is growing across the EU, with more than 20 new deployments identified by the Observatory team since the last 5G Observatory report. Some countries such as Belgium, France, Germany and Spain have seen significant progress in the last period, while countries such as Portugal are taking their first steps in private 5G network deployment. 5G verticals seem to be particularly developed in ports, such as in Belgium, Estonia, Germany and Spain. Meanwhile, 5G	The lack of consensus on spectrum policies for private local networks can be a potential bottleneck. 5G verticals can either use spectrum already assigned to mobile operators or rely on dedicated spectrum licences issued by governments. A total of 10 Member States, including France and Germany, have offered a local licensing model, while this is not the case in the other MS.	Recommendations on the optimal licensing regime for local 5G authorisation regimes could help harmonise deployment and cross-border 5G projects. Regarding spectrum consistency, the European Commission published a mandate to the CEPT to develop technical conditions regarding the shared use of the 3.8-4.2 GHz band for wireless broadband systems providing local-area network connectivity in December 2021[42]. The study is scheduled to take place until March 2024, and this mandate may help resolve the lack of spectrum consistency as the 3.8-4.2 GHz band is emerging as a potential solution for this problem.

[39] DESI 2023
[40] https://eufordigital.eu/new-step-towards-the-digital-decade-2030-policy-programme-comes-into-force
[41] Source: https://eur-lex.europa.eu/eli/dec/2022/2481/oj; For more information regarding 5G targets in the digital decade see: https://digital-strategy.ec.europa.eu/en/policies/5g-digital-decade
[42] https://digital-strategy.ec.europa.eu/en/library/radio-spectrum-cept-mandates

Targets: 5G AP; Digital Decade; Cybersecurity Toolbox	Performance/status	Bottlenecks identified	Solution/recommendation
	verticals are still at an earlier phase in other industries (e.g. healthcare, transport), and most vertical industry trials are occurring within private networks.	Moreover, the exact portions of the spectrum used for these licences vary across Europe, which can occur pertaining to standardisation efforts. For example, Germany offers the upper part of the 3.6 GHz band (3.7-3.8 GHz), while France is awarding licences in the 3.8-4.0 GHz.	
Authorising 5G spectrum bands	On average, 71% of pioneer bands have now been assigned in the EU27. The 3.6 GHz band remains the most widely assigned one, with 26 out of 27 Member States having assigned at least 50% of the targeted spectrum in this band. The 700 MHz band is still the second most popular band, which has been assigned by 24 out of 27 MS. The least popular band is the 26 GHz band, which has only been assigned in 11 MS following Estonia's successful 26 GHz band auction in May.	There is a lack of demand for the 26 GHz band in Europe. Further development of the harmonised approach to spectrum sharing for local networks.	Specifically for the 26 GHz band, there have been differences in the way the band has been made available, suggesting there is no *"universal formula"*. Most approaches, such as Germany's local licenses or Finland's licenses, take into account the use of the band for industrial applications and 5G verticals.[43] The identification of additional band/capacity for 5G should be initiated in a timely fashion to anticipate the expected growing business demand. The current planned review of the RSPP programme by the European Commission[44] may provide more guidance for spectrum assignment procedures. Regarding local 5G networks, the European Commission has mandated CEPT to assess technical conditions for the 3.8-4.2 GHz band. While CEPT's studies are still ongoing, this mandate may help resolve the existing lack of spectrum consistency.[45]
Promoting pan-European multi-stakeholder trials[46]/ Developing Pan-European deployment of 5G corridors	Twelve "digital cross-border corridors" have been established to accommodate live tests of 5G for Cooperative Connected and Automated Mobility (CCAM). In addition, at least eight Member States refer to the European deployment of 5G corridors along	A total of 19 Member States are involved in the existing 12 cross-border corridor trials, and 18 are involved in corridor deployment work projects and studies funded under CEF Digital calls.	Upcoming projects (including under the support of the CEF Digital framework) and commitments of Member States in their recovery and resilience plans are expected to bridge existing gaps. Following the first series of the CEF digital calls in 2022, 15 corridor deployment projects, consisting of seven work projects and eight studies, were kick-started

[43] From a technical perspective this is very much a band used to serve congestion in high-capacity density networks as well which implies the need for a balanced approach.

[44] https://commission.europa.eu/system/files/2022-10/com_2022_548_1_annexe_en.pdf

[45] https://digital-strategy.ec.europa.eu/en/library/radio-spectrum-cept-mandates

[46] The original 5G AP target Source: https://digital-strategy.ec.europa.eu/en/policies/5g-action-plan can be linked to the Digital Decade reference to Multi-Country Projects (MCPs): large-scale projects facilitating the achievement of the targets for digital transformation of the Union and industrial recovery.

Targets: 5G AP; Digital Decade; Cybersecurity Toolbox	Performance/status	Bottlenecks identified	Solution/recommendation
	TEN-T networks in the interest of Single Market and cohesion in their recovery plans.[47]		at the beginning of 2023. Following a second call that was closed in March 2023, evaluations are ongoing to assess submissions and additional projects are expected to launch.
5G toolbox implementation	The NIS Cooperation Group published its second report on MS's progress in implementing the 5G cybersecurity toolbox in June 2023[48]. The extent of the progress varies for each strategic measure. SM01, which concerns strengthening the role of national authorities, have been adopted by 23 MS. Meanwhile, SM06 on strengthening resilience at the national level, has only been adopted by three MS.	Although a significant increase in the number of MS implementing the strategic measures is denoted for SM02, SM04 and SM05, there are still differences in the state of implementation of each measure. Some measures, including SM05 on ensuring the diversity of suppliers for individual MNOs through appropriate multivendor strategies and SM06, are difficult to implement due to the interdependency on transnational operators and the small size of the market/country.	NIS Cooperation Group's update report includes specific recommendations for each strategic measure, highlighting areas of improvement to be addressed for the next phases of the Toolbox implementation and monitoring (both at EU and MS level). A specific NIS report[49] on open RAN architecture was published in May 2022 and is the subject of implementation discussions with Member States.

[47] CZ, ES, IT, LV, EL, LT plans. Source: Commission Staff Working Document
[48] Second report on Member States' progress in implementing the EU Toolbox on 5G Cybersecurity | Shaping Europe's digital future (europa.eu)
[49] Cybersecurity of Open Radio Access Networks | Shaping Europe's digital future (europa.eu)

The table below represents the most recent data[50] on the number of base stations per Member State and band type. Empty cells in the table mean it was not possible to gather the data per band type but only as a total number of base stations. "n/a" means that no recently updated numbers are available. In addition, Annex II features the general number of 5G base stations per country, while this section only reports recent updates on the numbers.

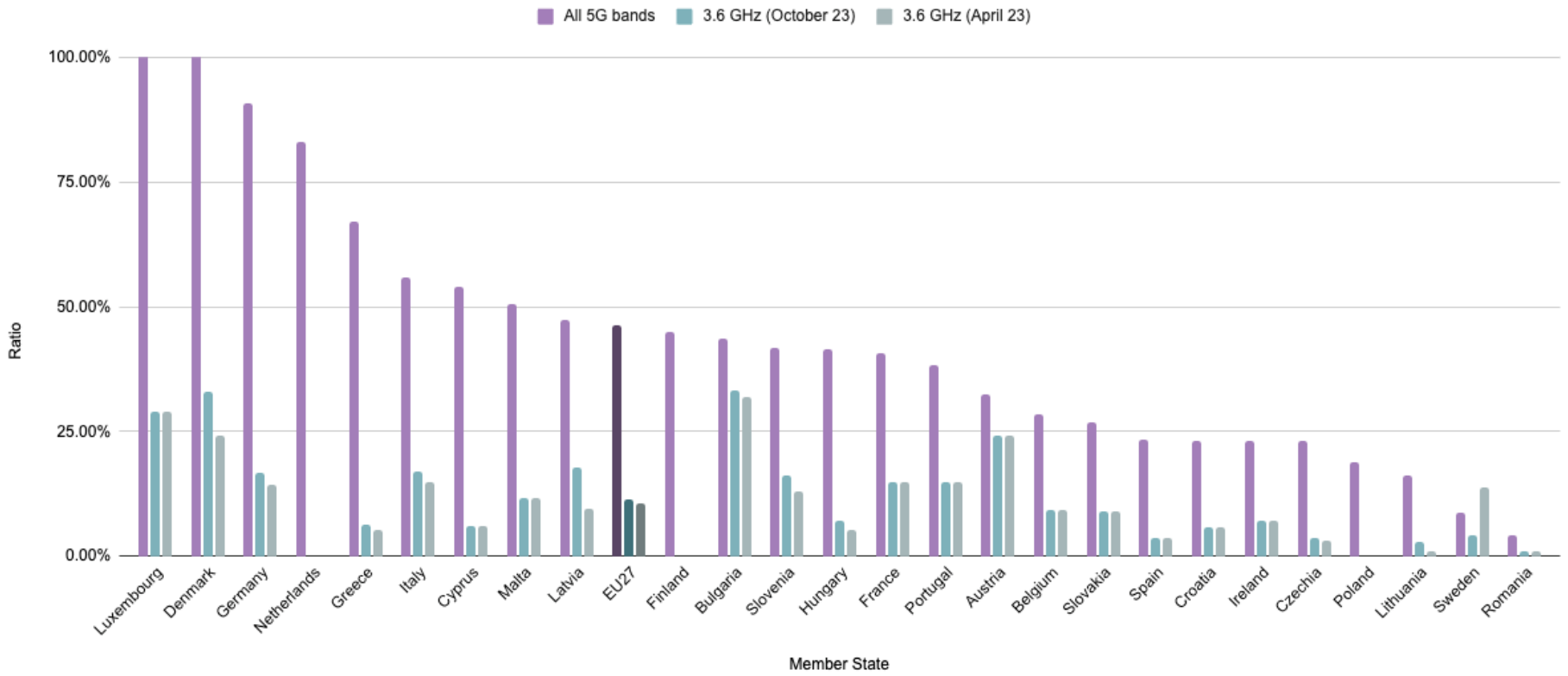
Table 2: Number of base stations per Member State and band type

Indicator	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LV	LU	MT	NL	PL	PT	RO	SE	SI	SK
Number of operating 5G base stations	4,287	2,266.5	3,697	979	10,821	90,671	8,558	n/a	6,634	18,844	9,000	39,502	3,533	4,711	3,098	60,601	2,717	983	887	440	12,858	25,949	4,634	2,048	5,077	1,562	2,470
700 MHz band	917	688	0	570	2,900	22,328	3,267	n/a	1,103	13,790		14,826	1,963	2,476	107	11,198	1,875	573	0	0	n/a	15	2,622	0	2,157	618	62
3.4-3.8 GHz band	4,015	834.5	2,808	108	1,669	16,606	3,311	n/a	792	4,619		14,457	907	806	1,088	18,392	492	663	164	102	0	37	1,811	495	2,516	610	823
in 4G spectrum bands (using dynamic spectrum sharing, DSS)	462	1,024	884	63	6,252	51,737	0	n/a	6,549	11,788		10,219	663	1,429	1,903	30,725	350	250	723	338	n/a	25,894	201	1,553		48	1,585
in dedicated non-pioneer bands (other than the above)			5		0	0	5,249		0					0		286	0	267				3		0	404	286	

Notes: the calculated total of the 5G base stations may differ from the summing of the indicators for each considered band. That is because both 700 MHz and 3.5 GHz can be used in one 5G base station. Consequently, summing these indicators, including the use of DSS, might give inaccurate results.

[50] The data for Bulgaria, Czechia, Denmark, Greece, Germany, Hungary, Italy, Lithuania, Latvia, Poland, Romania, Slovenia and Sweden was collected between September - October 2023. The data for Austria, Belgium, Cyprus, Estonia, Netherlands, Croatia, Ireland, Malta, Slovakia and Spain was based on the latest available data from January - March 2023. The data for Luxembourg was collected from the end of December 2022. The data for Finland, France and Portugal was collected from the end of August 2022. The figures are indicative and do not engage the responsibility of the 5G Observatory or any other parties. The data on the number of operating 5G base stations in dedicated non-pioneer bands is only collected from September 2023 onwards and only involves Bulgaria, Czechia, Germany, Denmark, Greece, Hungary, Italy, Lithuania, Latvia, Poland, Romania, Sweden and Slovenia. The cells are left blank for other MS where the data has not yet been collected.

Figure 1: Percentage of 5G base stations compared to existing 4G base stations (including 3.6 GHz change since last report in April)[51]



[51] Estonia excluded due to lack of data; The data for Bulgaria, Czechia, Denmark, Greece, Germany, Hungary, Italy, Lithuania, Latvia, Poland, Romania, Slovenia and Sweden was collected between September - October 2023. The data for Austria, Belgium, Cyprus, Netherlands, Croatia, Ireland, Malta, Slovakia and Spain was based on the latest available data from January - March 2023. The data for Luxembourg was collected from the end of December 2022. The data for Finland, France and Portugal was collected from the end of August 2022.

4 The relevance and feasibility of monitoring the deployment of Stand Alone 5G in the EU Member States

4.1 What is Stand Alone 5G?

5G Stand Alone (SA) is the next iteration of 5G network deployment; this upgrade follows mobile operators' initial deployments of 5G using the Non-Stand Alone (NSA) approach, which relies on connecting the radios to the core of a 4G network. This means that in these initial NSA deployments, although utilising the 5G frequencies and Radio Access Network elements, the traffic is carried in the 4G network 'Evolved Packet Core' and thus not fully optimised to 5G.

5G SA utilises a completely independent network core from that of NSA networks. It enables the 5G features and capabilities to their fullest extent. Essentially, it uses the radios coupled with cloud-native, service-based core network functions.

The technical benefits of deploying 5G SA include:

- Improved network reliability and security (i.e. better encryption and security software),
- More responsive networks, reducing traffic overheads
- Less battery drain in handsets
- Improved 5G coverage, including stronger indoor signals
- Lower latency achieving the peak latency targets of sub 10ms

Most 5G handsets in the market to date support 5G SA, meaning that almost all users will experience these benefits.[52]

5G SA also means that the proposed use cases 5G is intended to support, such as remotely controlled vehicles, remote assisted surgery and virtual reality, can be fully realised, provided that the 5G access network (i.e. base stations and backhaul) does also provide full performance. In addition, network slicing enables a proportion of network resources to be used (and dimensioned to cater) for different use cases, such as mobile broadband and IoT applications over different slices operated over the same common architecture.

Network slicing as a 5G feature becomes a lot easier to deploy within a 5G SA environment due to certain features being fully enabled across the network architecture. In turn, network slicing can help to address the needs of some verticals or specific applications that are seeking access to 5G services. One example of such an approach is the pilot by Vodafone and Ericsson that launched a trial network slice for cloud gaming[53] in August 2023.

The upgrade to 5G SA requires investment and plans on mobile operators' roadmaps, so that the switch-on can deliver immediate benefits as well as a proper return on investment. Therefore, this approach will be largely driven by the demand of users and growth in the uptake of technology. It was not expected that 5G SA would be available on "day one" of 5G network deployments. It is the inclusion of 5G NSA in 3GPP standards[54] that enabled operators to start deploying 5G networks using the spectrum bands they had acquired at auctions and thus achieve a return on investment. However, the upgrade to SA will take time and require careful implementation planning. As a result, it is unlikely to be widely available across

[52] According to a survey conducted by the Global Certification Forum (GCF) in 2022 see https://telecoms.com/516316/nearly-90-percent-of-new-5g-devices-support-standalone/

[53] https://www.vodafone.co.uk/newscentre/press-release/vodafone-and-ericsson-successfully-trial-cloud-gaming-on-5g-standalone-network-slice/

[54] https://www.3gpp.org/technologies/5g-system-overview

networks straightaway. Operators are expected to upgrade their networks first in city locations that will demonstrate immediate benefits, such as Orange's approach in Spain[55].

As explained earlier, once a mobile operator has upgraded its core to 5G SA, it unlocks the opportunity to provide improved services to verticals (e.g. port logistics, manufacturing sector, transport sector) and offer connectivity performance levels adapted differently to use cases (e.g. remotely controlled vehicles).

As reported by the previous 5G Observatory,[56] one major current trend is the fact that private 5G networks (also known as non-public networks) are growing steadily, offering an alternative approach to business solutions offered by MNOs. An enterprise does not require a 5G SA core per se within its premises as the radio technology can be integrated into existing IT infrastructure in a similar way to other wireless technologies such as Wi-Fi. However, if the private 5G network is intended to support the multiple features and functions of 5G, it would benefit from the full SA architecture. Examples of vendors that support private 5G networks for verticals and enterprises include Athonet, Nokia and FreedomFi.

5G SA can also be used to help mobile operators deploy private networks to serve verticals, an approach pioneered by Deutsche Telekom,[57] which has developed a private 5G network solution for its enterprise customers. The operators typically use their public mobile network infrastructure as the underlying infrastructure for building such private network offers. In some cases, however, it may be difficult for the operator to serve specific enterprise locations using its existing infrastructure. For example, providing coverage to machinery/equipment or people inside large metal-based structures of buildings, or at large-scale port facilities or in very remote locations that may be at the edge or outside the public operators' coverage area. In these circumstances, the operator would need to deploy additional infrastructure at these locations (including inside buildings) to extend its public infrastructure and support the private network deployment.

4.2 Progress of 5G SA deployment

The Global mobile Suppliers Association's July 2023 report on global 5G Standalone progress[58] indicates that globally, 115 operators in 52 countries and territories have been investing in 5G SA networks either in the form of trials, deployments or planned deployments. At least 36 operators in 25 countries and territories have launched or deployed public 5G SA networks. The GSA July figures show that **most EU Member States** have operators which are currently investing in public 5G SA networks.

This is the most comprehensive market survey available, but 5G SA deployment in Europe may be more advanced than shown in this report. This illustrates the challenges in tracking the 5G SA deployments and painting a full picture of the actual level of deployment in each of the EU Member States. For example, the GSA's July report places Austrian operator Drei at a planning stage for a public 5G SA network. Meanwhile, the operator says on its own website it was the first Austrian operator to launch 5G SA in the mass market in September 2022.[59] In an interview with the local newspaper Der Standard, Drei CEO said their 5G SA network coverage reached around 50% of Austrian households.[60]

The availability of 5G SA capable devices shows the preparedness of the vendors for the deployment and commercial use of 5G SA. The GSA July 2023 report notes devices often need software upgrades to be 5G SA capable.[61] The association has been tracking the availability of 5G SA capable devices, which,

[55] https://5gobservatory.eu/orange-spain-to-launch-5g-standalone-in-30-towns/

[56] https://5gobservatory.eu/report-18-april-2023/

[57] https://www.telekom.com/en/media/media-information/archive/telekom-and-microsoft-launch-campus-network-offering-1048758

[58] Global mobile Suppliers Association. 5G-Standalone July 2023 Member report. 31.7.2023, accessed 27.9.2023. https://gsacom.com/paper/5g-standalone-july-2023-member-report/

[59] Drei. Österreich-Start für 5G Standalone. 29.9.2022. https://www.drei.at/de/ueber-uns/presse/presseaussendungen/detail_1285190.html

[60] Mey, S. Drei-CEO Schrefl: "Sehe aktuell keinen Grund, warum die Preise wieder sinken sollten". *Der Standard,* 16.8.2023. https://www.derstandard.at/story/3000000182361/drei-chef-sehe-aktuell-keinen-grund-warum-die-preise-wieder-sinken-sollten. The GSA's database has since been updated to include Drei's commercial deployment.

[61] Global mobile Suppliers Association. 5G-Standalone July 2023 Member report. 31.7.2023, accessed 27.9.2023. https://gsacom.com/paper/5g-standalone-july-2023-member-report/

as of June 2023, account for 85.5% of all announced 5G devices globally. The GSA report does not break down the availability of these devices per country or region. More generally, the GSA figures show that the percentage of 5G SA capable devices among all 5G devices has been growing since 2019. The association is currently aware of over 1750 devices, an increase of 155% from the end of 2021.

One should take into account that there are key factors that may delay an operator's introduction of 5G SA network deployments. In particular, delays may result from the lack of required investments and the lack of commercially viable use cases. Operators may also experience competing priorities for investment (e.g. open RAN, fibre). The "fair share" debate over the contribution of big tech companies towards network infrastructure may also play a role in the future speed of development of 5G SA networks. [62]

4.2.1 Notable recent trials and deployments in the EU Member States

Orange Spain was reportedly the first Spanish operator to deploy commercial 5G SA technology in the country.[63] The operator said it would bring 5G SA networks to 30 cities by the end of the first half of 2023. Orange is also engaged in deployments of 5G SA in the other European countries the company operates in, including a hybrid private network trial at the company's own premises in Arcueil, France.[64]

Dutch mobile operator KPN and technology partner Ericsson used a test licence in the 3.6 GHz spectrum in combination with 5G SA to demonstrate a cloud gaming application.[65] The test achieved a download speed of nearly 1Gpbs and a latency of 14 milliseconds. KPN has said it will gradually introduce 5G standalone in 2024, but a delay is likely due to the 3.6 GHz auction being postponed until 2024.[66]

4.2.2 Notable recent trials and deployments in non-EU countries

In the UK, Vodafone launched the first 5G SA network for consumers in June 2023.[67] At launch, the 5G SA was available in major UK cities, including London, Manchester, Glasgow and Cardiff. Commercially known as Vodafone 5G Ultra, the operator promises better connectivity in busy areas, faster speeds and longer battery life. Vodafone and broadcaster ITN used 5G slicing during the live coverage of the coronation of Charles III.

BT Group and vendor Nokia claimed to demonstrate Europe's first simultaneous aggregation of two carrier components in a 5G SA trial.[68] Combining several transmission bands into one connection increases throughput and capacity. In another European first, BT and Ericsson trialled wideband transmission of 5G in a wideband FDD.[69]

Reliance Jio in India is reportedly on track to deploy its 5G SA network in all towns and cities by December 2023, which would make it the world's largest 5G SA network operator.[70]

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[62] STL partners. Telco Cloud Deployment Tracker: Is 5G SA getting real? 9.8.2023. https://stlpartners.com/wp-content/documents/Extracts/EXTRACT%20-%20Telco%20Cloud%20Deployment%20Tracker%20-%20Is%205G%20getting%20real%20-%20August%202023.pdf

[63] Orange Spain. Orange's 5G+ network, the only one in Spain, will reach thirty locations in the first half of 2023. 6.6.2023, accessed 27.9.2023. https://blog.orange.es/red/5g-de-orange-alcanzara-treinta-localidades-primer-semestre-de-2023/

[64] Krásová, T. Orange Business uses 5G SA for French hybrid private network. LightReading, 16.7.2023. https://www.lightreading.com/broadband/orange-business-uses-5g-sa-for-french-hybrid-private-network

[65] 5G Observatory. KPN tests 5G Standalone technology. 1.7.2023. https://5gobservatory.eu/kpn-tests-5g-standalone-technology/

[66] Wijkman-van Aalst, T. 5G-veiling wéér uitgesteld: 'Toppositie Nederlands mobiele netwerk op het spel'. NU, 21.9.2023. https://www.nu.nl/tech/6281713/5g-veiling-weer-uitgesteld-toppositie-nederlands-mobiele-netwerk-op-het-spel.html

[67] Vodafone. Vodafone launches 5G Ultra, the UK's first 5G Standalone mobile network for consumers. 23.6.2023. https://www.vodafone.co.uk/newscentre/press-release/launch-5g-ultra-uk-first-5g-standalone-network-for-consumers/

[68] BT Group. BT Group and Nokia demonstrate new network capabilities to meet future consumer demand. 24.8.2023. https://newsroom.bt.com/bt-group-and-nokia-demonstrate-new-network-capabilities-to-meet-future-consumer-demand/

[69] BT Group. BT and Ericsson wideband FDD trial promises enhanced 5G Standalone performance in European first. 10.8.2023. https://newsroom.bt.com/bt-and-ericsson-wideband-fdd-trial-promises-enhanced-5g-standalone-performance-in-european-first/

[70] Tomás, J. P. Jio already deployed 50,000 5G base stations in India: report. RCR Wireless. 23.3.2023. https://www.rcrwireless.com/20230323/5g/jio-already-deployed-50000-5g-base-stations-india-report

Operator Etisalat was the first to launch a commercial 5G SA network in the Middle East and North Africa (MENA) region in early 2023.[71] The network in the United Arab Emirates design allows for edge computing and network slicing. Elsewhere in Africa, the continent's largest mobile network operator MTN conducted a proof of concept 5G SA Core using Microsoft Azure cloud computing platform in South Africa.[72]

4.3 Economic impacts and policy relevance of 5G SA deployment

5G SA raises questions about potential economic benefits and impacts, its alignment with EU policy goals, including cybersecurity, SME support, and bridging the digital divide. Although some 5G SA features may have a more modest economic impact, they often align with key EU policy objectives. However, features like enhanced coverage and network slicing hold the potential to deliver substantial economic benefits while also driving progress toward broader policy goals. In this section, we discuss the contribution of potential benefits of 5G and how these may contribute to EU policy goals.

Improved network reliability, while generally beneficial, might not yield a significant direct economic impact since current networks already maintain a satisfactory level of reliability. However, from a policy perspective, reinforcing network reliability aligns with the EU's goal of ensuring robust and dependable digital infrastructure.[73]

The **efficient and flexible bandwidth allocation** will allow operators to allocate their resources more effectively (e.g. reducing the redundant allocation, guaranteed minimum bandwidth for those applications that require it) and improve the overall network performance. MNOs will be able to manage distributed locations as a single unified network and meet demand flexibly without adding more assets (people, hardware) or cost.[74] As a result, it will also lead to a better user experience. This fits well with the EU policy objectives to use spectrum effectively and efficiently.[75]

Less battery drain is advantageous for users, as it reduces the frequency of battery replacements. It also minimises electronic waste, aligning with environmental goals. This approach promotes resource efficiency and supports the EU's environmental objectives, which aim to create a greener and more sustainable economy.[76]

Enhanced 5G coverage carries substantial economic significance, particularly for underserved regions where it can stimulate economic activity and bridge the digital divide.[77] This feature strongly aligns with EU policy goals of fostering digital inclusion, enhancing access to digital technology, particularly for small and medium-sized enterprises (SMEs), and reducing regional disparities.[78]

Improved indoor signals enhance user experience and support the proliferation of IoT applications within indoor environments.[79] This not only benefits users but also supports the broader policy

[71] 5G Observatory. Etisalat launches MENA region's first standalone 5G network. 5.4.2023. https://5gobservatory.eu/etisalat-launches-mena-regions-first-standalone-5g-network/

[72] MTN Group. MTN deploys one of the first 5G Standalone Core in Microsoft Azure. 20.3.2023. https://www.mtn.com/mtn-deploys-one-of-the-first-5g-standalone-core-in-microsoft-azure/

[73] European Commission, 2030 Digital Compass: the European way for the Digital Decade, COM(2021) 118, 09.03.2021: https://commission.europa.eu/system/files/2023-01/cellar_12e835e2-81af-11eb-9ac9-01aa75ed71a1.0001.02_DOC_1.pdf .

[74] https://www2.deloitte.com/xe/en/insights/industry/technology/technology-media-and-telecom-predictions/2023/technology-media-and-telecom-predictions-standalone-5g.html

[75] Article 3 of the Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code, OJ L 321, 17.12.2018; Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multiannual radio spectrum policy programme, OJ L 81, 21.03.2012.

[76] Environment and green economy – EU action | European Union (europa.eu)

[77] The Socio-Economic Benefits of Mid-Band 5G Services: https://www.gsma.com/spectrum/wp-content/uploads/2022/02/mid-band-5G-spectrum-benefits.pdf

[78] European Commission, 2030 Digital Compass: the European way for the Digital Decade, COM(2021) 118, 09.03.2021: https://commission.europa.eu/system/files/2023-01/cellar_12e835e2-81af-11eb-9ac9-01aa75ed71a1.0001.02_DOC_1.pdf

[79] 5G and the innovation edge https://www.ericsson.com/en/blog/2023/8/how-5g-enables-business-innovation

objectives of encouraging digital innovation and sustainability. Improved indoor reception also aligns with the Digital Decade goal of bringing 5G to all populated areas.

Heightened security through better encryption and security software holds both economic and policy relevance. From an economic standpoint, it may protect against potential losses due to cyberattacks, while from a policy perspective, it aligns strongly with EU cybersecurity and resilience objectives.[80]

Network slicing stands out as a feature with the highest potential for both economic and policy impact. Its ability to significantly enhance industrial efficiency is achieved through MNOs offering tailored network configurations that prioritise critical applications and ensure low latency, thereby optimising production processes and reducing operational costs. This efficiency improvement aligns with innovation and sustainability goals, fostering technological advancements and reducing resource consumption, which are key objectives in EU policies.[81]

4.4 How feasible is it to measure 5G SA deployment progress?

The 3GPP specification for 5G SA was released in 2018,[82] which has prompted the adoption of this new technology. A 5G SA network requires purpose-built 5G architecture, including software-based 5G Core, whereas 5G non-standalone networks can use the existing LTE infrastructure while boosting capacity.

Therefore, the launch of a 5G standalone network is a considerable investment which should improve the network and the consumer experience. Industry players are, therefore, likely to exploit the PR potential via public announcements, which can be tracked to an extent.

Depending on the operator or vendor, there is a varied level of information available on the reach of the coverage, usage and technical specifications of their 5G SA networks. There is no standardised format for these public announcements, which leads to some operators offering only limited information. For example, the recent Orange Spain announcement focused on towns covered and gave a high-level overview of the benefits that a 5G SA network would bring.[83] Meanwhile, some operators or vendors might include a great level of detail on their initiatives, as was the case in Nokia and A1 Austria's trial in 2022.[84]

The limitation of measuring 5G SA coverage through this method is the reliance on operators to share this information publicly. The nature of public communications to investors or members of the press is that they highlight significant milestones or present a company's future deployment targets. It is less likely that a company would make public domain announcements on failing to reach their targets or report on their progress consistently. For example, an MNO may trumpet the launch of 5G SA in major cities but fail to announce when this has been rolled out to smaller towns and rural areas, a development which is of considerable interest to those seeking to monitor 5G coverage.

The scope of tracking the overall level of 5G SA deployment in the EU is therefore limited and biased in favour of companies that share their deployment figures publicly.

[80] European Commission, 2030 Digital Compass: the European way for the Digital Decade, COM(2021) 118, 09.03.2021: https://commission.europa.eu/system/files/2023-01/cellar_12e835e2-81af-11eb-9ac9-01aa75ed71a1.0001.02_DOC_1.pdf.

[81] Digital targets for 2030 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

[82] Tombaz, S. Non-standalone and Standalone: two standards-based paths to 5G. *Ericsson.* 24.4.2023. https://www.ericsson.com/en/blog/2023/4/standalone-and-non-standalone-5g-nr-two-5g-tracks

[83] Orange. La red 5G+ de Orange, única en España, alcanzará a una treintena de localidades en el primer semestre de 2023. 6.6.2023 https://blog.orange.es/red/5g-de-orange-alcanzara-treinta-localidades-primer-semestre-de-2023/

[84] Nokia. Nokia and A1 Telekom Austria reach 2 Gbps data rates with 5G 3 Component Carrier Aggregation technology, 19.12.2022. https://www.nokia.com/about-us/news/releases/2022/12/19/nokia-and-a1-telekom-austria-reach-2-gbps-data-rates-with-5g-3-component-carrier-aggregation-technology/

4.5 Conclusions

While it seems feasible to measure 5G SA, subject to the qualifications discussed above, the key question is how helpful this is in measuring progress towards EU policy goals.

The main Digital Decade target relating to 5G is the coverage of all populated areas by 2030, and while the use of SA will be helpful, it is not essential to achieving this basic goal. 5G coverage is expanded mainly by the deployment of base stations, although SA can have a marginal benefit in allowing these infrastructures to reach further out in remote areas.

5G SA can also make contributions to other EU policy goals of fostering digital inclusion, environmental goals, and enhancing cybersecurity and network resilience. However, as discussed above, these contributions are relatively minor. For example, universal 4G or 5G mobile coverage would be a much bigger win for digital inclusion than the marginal - but welcome - benefits associated with 5G SA.

The biggest impact of 5G SA is in the ability of mobile operators to offer network slices designed for particular purposes, such as vertical sector-specific applications. It is also helpful for SMEs access to connectivity as well as for achieving productivity gains in the wider society, but network slicing is primarily of benefit to mobile operators and not the only way to provide services to verticals. Regulatory policy in the EU[85] has also recognised the benefits of setting up local networks by verticals themselves or systems integrators. So, keeping track of MNOs' 5G SA deployments gives an indication of MNOs' preparedness for offering the most advanced services to verticals. However, this is not the complete picture, as verticals may use local private networks rather than a slice of the MNO's public network, and MNOs can offer services to verticals without network slicing.

Monitoring the deployment of 5G SA would give an indication of mobile operators' progress in deploying a **more advanced form of 5G where SA is a necessary pre-requisite**, but this is helpful rather than essential in achieving the policy goals which the 5G Observatory monitors. Measuring the deployment of 5G SA would therefore be useful as part of a suite of KPIs measuring progress towards EU policy goals, including 5G coverage, the provision of local licensing for 5G services and 5G Quality of Service (QoS).

[85] One example is the Commission mandate to CEPT to research technical conditions for local networks in 3.8-4.2 GHz. See https://ec.europa.eu/newsroom/dae/redirection/document/82230

5 5G Outlook on deployment forecasting for the intermediate 2025 perspective

This chapter features a summary of existing projections for the forecasting towards 2025 5G-related targets and, in some cases, even later.

5.1 Ericsson, Mobility Report,[86] 2023. Scope: Global

Methodological framework/approach

The forecast on mobile subscription and network traffic is based on historical data from several sources, which are then corroborated with internal data from Ericsson. Since the forecast is scoped for a five-year interval, future developments are approximated via technological advances, market maturity, and user and macroeconomic trends.

Outcome summary

In the June 2023 update, 4G technology is reported to be still dominant in Western Europe[87], with the subscription penetration reaching 79% at the end of 2022. 5G subscriptions experienced strong growth, moving from 32 million in 2021 to 69 million at the end of 2022. 5G subscriptions are expected to reach 143 million by the end of 2023 (a reduction of 7 million by comparison to last year's forecast), with a subscription penetration projected to reach 88% by 2028. Differently, in Central and Eastern Europe,[88] the uptake is slower due to both the reluctance of consumers to upgrade to more expensive subscriptions and slower spectrum allocation processes. 4G subscriptions accounted for 73% of the market at the end of 2022, but the growth has flattened and should be close to zero until 2025. Nevertheless, from 2025 onwards, only 5G subscriptions are projected to be growing.

5.2 GSMA, "The Mobile Economy",[89] 2023. Scope: Global

Methodological framework/approach

Representing the interests of mobile operators worldwide, the GSMA is considered an industry reference point for global mobile operator data, analysis, and forecasts, publishing annual industry reports and research. GSMA's annual state of mobile economy reports (global and regional versions) provide market intelligence (technology, socio-economic and financial datasets) through their in-house research team (i.e. proprietary models/forecasting methodology and datasets).

Outcome summary

According to the latest Mobile Economy report[90], in 2022, 5G technology comprised 11% of the market in Europe, representing an increase from the 4% figure in 2021, whereas 4G still accounts for 75% of the market. By 2030, 5G uptake is projected to grow to 87%, with a reduced 4G market share of 13%. Furthermore, overall mobile subscriber penetration is expected to only marginally increase from 90% in 2022 to 92% by 2030, accompanied by a moderate rise in smartphone adoption from 81% in 2022 to 91% by 2030.

[86] Ericsson Mobility Report June 2023

[87] Ericsson Mobility Report June 2023. According to the Ericsson Mobility Visualizer, Western Europe comprises of Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Luxembourg, Malta, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

[88] Ericsson Mobility Report June 2023. According to the Ericsson Mobility Visualizer, Central and Eastern Europe comprises of Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Bosnia and Herzegovina, Croatia, Czechia, Estonia, Georgia, Hungary, Kosovo, Kyrgyzstan, Latvia, Lithuania, Moldova, Montenegro, North Macedonia, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

[89] GSMA, The Mobile Economy, 2023

[90] GSMA, The Mobile Economy, 2023.

Annex I: Latest developments per country

This Annex I provides an update of the latest developments per country to reflect the situation on 30 September 2023.

A1.1 Latest commercial developments

Since January 2022, commercial 5G is now available in all 27 Member States.[91] The full overview of commercial launches per operator offering 5G services across EU-27, detailing their frequency usage and, where applicable, highlighting the use of DSS technology, network configuration i.e. 5G NSA vs. SA implementations and announced coverage targets is available on the European 5G Observatory website. This information is updated regularly. Below is a summary of the main changes compared to the previous edition of the report:

- Belgium:
  - Orange Belgium was selected by the Belgian government in March 2023 to carry out 11 5G pilot projects using standalone architectures across 2023 and 2024, which was supplemented by a five-year agreement to supply mobile connectivity and standalone and IoT services to the Flemish government in September 2023.
- Bulgaria:
  - A1 Bulgaria announced in February 2023 the construction of the Bulgarian part of the 5G corridor with Greece, spanning between Sofia and Athens. The 5G SEAGUL project is carried out together with WINGS ICT Solutions and COSMOTE (of Greece) and will combine both non-standalone and standalone 5G networks.
- Denmark:
  - Ericsson, together with TDC NET (the Danish digital infrastructure provider), launched the country's first standalone 5G network in September 2023, which is enabled by Ericsson's dual-mode 5G Core. The launch is expected to enhance speed and help achieve the Net Zero emissions target.
- Estonia:
  - Tele2 Estonia opened the country's first mmWave 5G base station close to Tallinn, which operates in the 26GHz range. The base station would enable data speed of up to 5 Gbps, although no commercial handsets support the range as of yet.
- Finland:
  - Syv, the joint venture of Telia and DNA, extended its low-latency, high-speed private 5G network across Northern and Eastern Finland throughout August and September 2023. The deployments not only enhanced 5G connectivity but also augmented existing 4G networks.
- France:
  - Orange Business announced its plan in July 2023 for a hybrid private mobile network utilising 5G standalone technology and network slicing, edge computing and local break-out functionalities. This plan would allow users to benefit from the advantages of private networks while maintaining the benefits of already existing network infrastructures.

[91] The first commercial 5G service has been launched in Lithuania in January 2022 at the time of this report publication, completing EU27 deployment in 2022, Source: Telia.

- Hungary:
    - Magyar Telekom announced its plan in May 2023 to extend its outdoor 5G service to cover 60% of the population between June and August 2023 and is expected to reach almost 99% of the population by 2026. The plan is enhanced by the Joint Declaration on the collaboration between Magyar Telekom and the Hungarian government on digital transformation in line with the National Digitalisation Strategy.
- Italy:
    - Wind Tre announced in September 2023 that its 5G TDD (Time Division Duplex) network now covers more than 70% of the population. Moreover, Wind Tre's advanced 5G Fixed Wireless Access (FWA) service has been extended to four more regions across Italy.
- Latvia:
    - Latvian Mobile Telecommunications (LMT) announced in July 2023 that its 5G service now covers almost 70% of the population and around 45% of the country's territory after significant investment in 5G network and infrastructure from the beginning of the year.
- Lithuania:
    - Telia, in cooperation with Ericsson, announced in July 2023 that its 5G service now covers 99% of the country's territory. The announcement came after the modernisation work that was undertaken between 2021 and 2023.
- Poland:
    - Plus announced in March 2023 that its 5G service is now available to over 20 million people across almost 1.000 municipalities across the country. The network consists of close to 3.500 base stations. More recently, Plus increased the maximum download speed to 1 Gbps, which is available via 356 base stations in 98 municipalities.
- Romania:
    - Telekom Romania Mobile launched its inaugural 5G service in April 2023, which is now available in 11 cities as of June.
    - In August 2023, Orange Romania announced the expansion of its 5G service to reach 37 cities, of which eight of the cities benefit from 100% 5G coverage.
- Slovakia:
    - Orange Slovakia confirmed in August 2023 that they have passed the end of 2023 target of 50% population coverage with its 5G mobile network that was first announced back in January 2023. The firm currently reaches 51,4% of the population in 254 cities and towns.
    - In June 2023, Slovak Telecom, in partnership with SOVA Digital and Siemens, launched the country's first private 5G standalone network at the Technical University in Košice.
- Spain:
    - After the launch of its 5G Standalone (SA) network in February 2023 under the name 5G+, Orange España extended its service to reach 30 cities and cover 30% of the population as of June.
    - In July 2023, Movistar, part of the Telefónica group, announced the launch of its 5G SA network covering 11 cities. Prior to the launch, Movistar's 5G coverage already reached more than 85% of the population in more than 2.000 municipalities.

- Sweden:
  - In July 2023, Telia announced that 73% of the country's population is now covered by its 5G network, growing from 63% in March. Telia is currently working together with Ericsson under the NorthStar programme launched earlier in the year to provide 5G access to leading industrial companies in Sweden.

A1.2 Population coverage

As already introduced in previous editions of this report, according to data collected by the Commission in 2020, the baseline for 5G coverage in the EU was 14% of populated areas at the time when the Digital Decade announcement was first made in March 2020 (with the breakdown per member state).

Following a change of methodology compared to previous reports, currently, all reports use data collected by the Commission for the DESI when available, ensuring consistency going forward. When possible, the data are also integrated with information based on operators' announcements.

The estimated coverage figure for EU27 (**81%**) in the table below is based on the sum of the total number of people covered in each country (computed based on the percentage of population covered) divided by the total EU27 population.[92]

Table 3: Population coverage

Country	Population coverage (September 2023 figures)	People covered (September 2023 figures)	Note (September 2023 figures)
Austria	91.7%	8.349.532	EC
Belgium	29.6%	3.482.549	EC
Bulgaria	67.2%	4.334.247	EC
Croatia	82.5%	3.176.469	EC
Cyprus	100.0%	920.701	EC
Czechia	82.6%	8.943.329	EC
Denmark	97.8%	5.804.607	EC
Estonia	43.3%	591.482	EC
Finland	94.7%	5.266.796	EC
France	88.8%	60.469.011	EC
Germany	93.2%	78.611.041	EC
Greece	85.7%	8.905.158	EC
Hungary	57.9%	5.556.670	EC
Ireland	83.9%	4.359.266	EC
Italy	99.7%	58.685.755	EC
Latvia	42.0%	790.897	EC
Lithuania	90.1%	2.573.151	EC
Luxembourg	93.2%	615.940	EC
Malta	100.0%	542.051	EC
Netherlands	100.0%	17.809.288	EC

92 Population statistics for 2023 accessed via Eurostat. This figure can be contextualised based on the latest population coverage figure estimated by ETNO, although not directly comparable, the latter one also covering non-EU countries, e.g., UK, Switzerland, Norway, Iceland and Western Balkans (73% by the end of 2022). Source: ETNO State of Digital Communications 2023

Country	Population coverage (September 2023 figures)	People covered (September 2023 figures)	Note (September 2023 figures)
Poland	63.4%	23.313.943	EC
Portugal	75.0%	7.850.525	Operator announcement[93]
Romania	26.8%	5.096.919	EC
Slovakia	55.3%	3.004.518	EC
Slovenia	63.9%	1.353.040	EC
Spain	82.3%	39.551.329	EC
Sweden	20.5%	2.152.912	EC
EU 27	81%	362.111.124	

A1.3 5G deployment comparison between EU and other world regions

Although the 5G Observatory primarily tracks developments in EU countries, it also follows significant international developments in the 5G sector. It is important to note that most of the figures collected on the number of 5G base stations are provided by governments, but in some cases, such as the US and Japan, they are based on market research estimates. It is possible that some market-based estimates are not entirely up-to-date or accurate. However, they allow for an indicative overview of the state of 5G deployment internationally.

Globally, South Korea is the clear leader in 5G deployment. According to the country's Communication Agency, it now has 217,000 5G base stations.[94] If the country's population is taken into account, this equals 419 5G base stations per 100,000 inhabitants. Following South Korea's lead is China, which has now deployed 2,937,000 base stations. Despite China's significant population size, this works out to 206 5G base stations per 100,000 inhabitants. The EU ranks ahead of the US, with approx. 346,000 base stations. This works out to 77 5G base stations per 100,000 inhabitants.

In terms of the assigned 5G spectrum, the 3.6 GHz band has proved to be the most used 5G band globally. All four regions in this comparison have assigned this valuable mid-band spectrum. The 28 GHz band is also well adopted, and it has been assigned in South Korea, Japan, and the US. In the EU, the situation is more complex as each country assigns their own spectrum. However, most countries have assigned at least the 3.6 GHz band for 5G deployment, while only 11 EU MS have assigned the 26 GHz band, for which the demand has been lowest so far. See the spectrum assignment chart in Section 2.1.

A1.4 5G spectrum comparison between EU and other world regions

In this section, we compare 5G spectrum use by first introducing the "pioneer bands" identified at EU level for the initial launch of 5G service, providing an overview of current spectrum assignment trends in the EU and contextualising these by introducing international developments.

[93] Based on NOS operator communication.
[94] Source: Korea Communications Agency https://www.etnews.com/20220719000167

Since the last 5G Observatory Report published in April 2023, there have been several spectrum auctions across the Union. On average, 71% of pioneer bands have now been assigned in European Union Member States.

In May 2023, Estonia completed its spectrum auction in the 26 GHz band, raising more than €4.8 million. All three major operators won licenses, including Elisa, Tele2 and Telia. In September 2023, Sweden completed[95] its award of the 900 MHz, 2.1 GHz and 2.6 GHz bands. Telia Sweden, Hi3G Access (Tre Sverige) and Net4Mobility (a joint venture between Telenor and Tele2) all won spectrum licences in these bands. In addition, Hungary completed its award of the 32 GHz band, which is intended to clear the 26 GHz band for a future 5G spectrum auction. Finally, in mid-October, Poland completed its auction of the 3.6 GHz band, awarding a total of 400 MHz to four operators.

Overview of pioneer bands

In 2016, with the release of the 5G Action Plan, the EU Commission proposed establishing a list of pioneer spectrum bands for the initial launch of 5G services. It proposed bands in three categories: below 1 GHz, between 1 GHz and 6 GHz and above 6 GHz.

The 5G pioneer bands identified at the EU level (Article 54 of the European Electronic Communications Code (EECC)) are as follows:

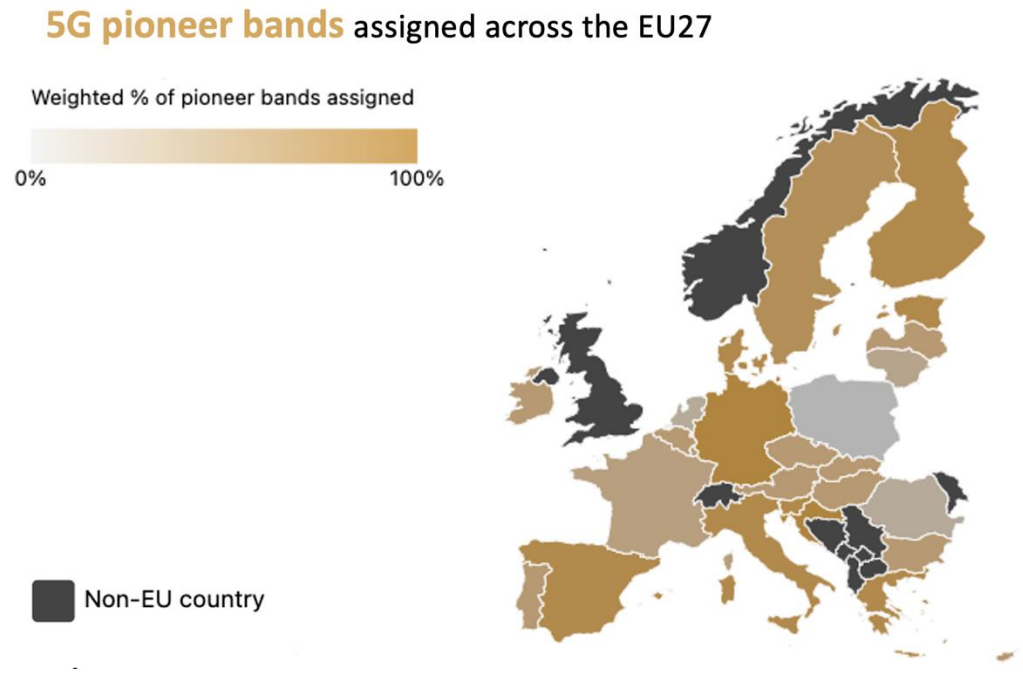
- 700 MHz (703-733 MHz and 758-788 MHz)
- 3.6 GHz (3400-3800 MHz)
- 26 GHz (at least 1000 MHz within 24250-27500 MHz)

In the years following the release of the 5G Action Plan and the adoption of the EECC, the Commission successfully harmonised the frequencies in these bands. The 26 GHz band was the final frequency band to be harmonised. This occurred in May 2019 with a Commission Implementing Decision (EU) 2019/784.96 Although the technical conditions for these three bands have been harmonised at the EU level, not all Member States have assigned the pioneer bands, despite the deadlines set out in the EECC stating that they should assign 700 MHz, 3.6 GHz, and 26 GHz by the 31 December 2020, provided that there is market demand for the latter and there are no significant constrains to clearing the bands.

[95] https://5gobservatory.eu/sweden-completes-spectrum-auction/

[96] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019D0784

EU27 trends



Source: Spectrum assignment data is based on the results of a European Commission survey of all 27 EU countries.

Pioneer bands assigned

The table below outlines how much spectrum each Member State has assigned in the pioneer bands. According to the 700 MHz Decision[97] and related Commission Implementing Decision[98] and the EECC, a country must assign 60 MHz in the 700 MHz band; 400 MHz in the 3.6 GHz band and at least 1000 MHz in the 26 GHz band to achieve 100%. The percentages displayed present how much spectrum has been assigned to operators compared to these numbers.

Amongst Member States, the 3.6 GHz band has been most widely assigned. 26 out of 27 Member States have assigned at least 50% of the targeted spectrum in this band (meaning at least 200 MHz out of 400 MHz). The second most assigned band is the 700 MHz band, where 24 out of 27 Member States have assigned at least 50% of the targeted spectrum (meaning at least 30 MHz out of 60 MHz). The least assigned band is the 26 GHz band. The 26 GHz band has only been majority-assigned in 11 Member States, meaning only 11 Member States have assigned at least 50% (500 MHz) of the targeted 1000 MHz.

[97] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32017D0899

[98] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.118.01.0004.01.ENG

Table 4: Pioneer bands assigned in the EU

Country	% of band assigned		
	700 MHz	3.6 GHz	26 GHz
Total harmonised spectrum (100%)	60 MHz	400 MHz	1000 MHz
Austria	100.00%	97.50%	0.00%
Belgium	100.00%	97.50%	0.00%
Bulgaria	0.00%	90.00%	100.00%
Croatia	100.00%	100.00%	100.00%
Cyprus	100.00%	100.00%	0.00%
Czechia	100.00%	100.00%	0.00%
Denmark	100.00%	97.50%	100.00%
Estonia	100.00%	97.50%	100.00%
Finland	100.00%	97.50%	100.00%
France	100.00%	77.50%	0.00%
Germany	100.00%	100.00%	100.00%
Greece	100.00%	97.50%	100.00%
Hungary	83.33%	97.50%	0.00%
Ireland	100.00%	87.50%	0.00%
Italy	100.00%	80.00%	100.00%
Latvia	100.00%	87.50%	0.00%
Lithuania	66.67%	75.00%	0.00%
Luxembourg	100.00%	82.50%	0.00%
Malta	0.00%	75.00%	0.00%
Netherlands	100.00%	0.00%	0.00%
Poland	0.00%	100.00%	0.00%
Portugal	83.33%	100.00%	0.00%
Romania	50.00%	65.00%	0.00%
Slovakia	100.00%	100.00%	0.00%
Slovenia	100.00%	95.00%	100.00%
Spain	100.00%	95.00%	100.00%
Sweden	66.67%	100.00%	85.00%
Number of countries that have assigned at least 50% of the band	23	26	11

International trends in spectrum allocation

The three pioneer bands harmonised by the EU Commission roughly fit into the three categories of 5G frequencies often used by spectrum policy makers: mid-band, low-band, and high-band.

Although there are international discrepancies on which bands are used in each category, classifying the spectrum in this way allows for an easier international comparison of the state of 5G spectrum harmonisation and assignment. The following table provides an overview of which spectrum bands are assigned for 5G in various international markets.

Table 5: Overview of which spectrum bands are assigned for 5G in various international markets[99]

Country	Low-band (<1 GHz)	Mid-band (1 - 6 GHz)	High-band (>6 GHz)
China	700 MHz	2.6 GHz 3.6 GHz 4.9 GHz	-
South Korea	-	3.6 GHz	28 GHz
Japan	700 MHz	3.6 GHz 3.7 GHz 4 GHz 4.5 GHz	28 GHz
USA	600 MHz	2.5 GHz 3.45 - 3.55GHz 3.5 - 3.7 GHz 3.7 - 3.98 GHz	24 GHz 28 GHz 39 GHz 47 GHz
EU	700 MHz	3.6 GHz	26 GHz

Internationally, the mid-band 5G spectrum has been established as the workhorse band for 5G. It has been assigned in most major markets, including China, South Korea, Japan, and the US. Japan is leading with mid-band 5G assignments. The country has allocated 880 MHz of spectrum in the band for 5G services. China comes in second with 860 MHz assigned.

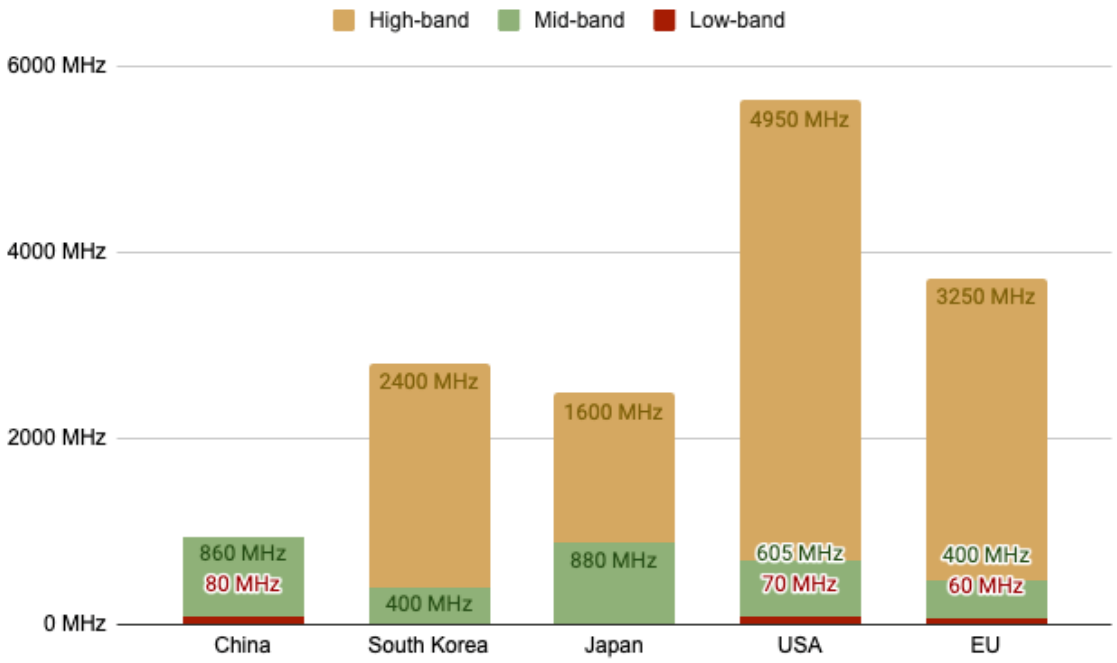
The low-band spectrum has proven to be slightly less popular. South Korea has yet to assign frequencies in this range. In fact, in South Korea's initial 5G auction in 2016, the 700 MHz low-band spectrum remained entirely unsold.

A recent development in China, however, could indicate that the low-band spectrum is becoming more popular. A new telecom player called China Broadcasting Network (CBN) recently struck a deal with China Mobile to begin deploying 5G using its 700 MHz spectrum. This is notable as the country previously relied entirely on the mid-band spectrum for its 5G deployment.

Initially, 5G frequencies in the high bands proved to be very popular. The US led the world in making the high bands available for 5G, and Japan and South Korea quickly followed. The United States leads with 4950 MHz of spectrum assigned in the high-band. However, it appears that there is less demand for this band in Europe, with only one country (Spain) assigning the band in 2022. In 2023, so far only Estonia has assigned 26 GHz.

99 Source: Data on international spectrum assignments is sourced from the Policy Tracker database.

Figure 2: Authorised 5G spectrum in international markets[100]



A note on methodology:

China, South Korea, Japan

The source of data for China, South Korea and Japan is the PolicyTracker spectrum database. This is a comprehensive database of spectrum assignments.

All national spectrum licences were added up to find the total amount of spectrum that was assigned to mobile operators in each country. Only bands shown on the left side of the scoreboard were included in this. All of these bands are used to provide 5G services in their respective country.

US

In the United States, licences are usually awarded regionally, a common example being the use of PEAs (partial economic areas) of which there are 406.[101] This makes it difficult to know how much spectrum mobile operators hold on a national level, as they hold different amounts of each band in each licence area.

Because of this, we have chosen to instead use the amount of spectrum that was initially made available to mobile operators by the country's spectrum regulator, the Federal Communications Commission (FCC), at auction. This data comes directly from the FCC, and the list of awards can be found in the table below.

100 Note: Due to the nature of spectrum assignments in the US being regional, only the three big national operators were included: T-Mobile; AT&T and Verizon. The final spectrum amount was divided by the number of licenses to give a picture of how much spectrum is assigned in an average licensing area. For the EU, the data shows how much spectrum has been harmonized at an EU-level. Some individual countries may have more spectrum assigned for 5G, while some may have less or none. Source: Data on international spectrum assignments is sourced from the Policy Tracker database.

101 https://www.fcc.gov/oet/maps/areas

In the 2.6 GHz band spectrum, licenses are held by educational institutions. These are called Educational Broadband Service (EBS) licenses. T-Mobile leases a majority of these licences and has purchased some.[102] The total number of spectrum that T-Mobile holds in these licences is unknown. However, an estimate made by the FCC suggests the operator holds 155 MHz of spectrum in this band. [103] This is the estimate used in our data.

Regarding the CBRS auction, we have only counted the priority access licences (PAL), and the other spectrum made available is on an unlicensed basis.

Not all spectrum made available at these auctions will have been sold to operators. However, the amount of unsold spectrum licenses in these auctions is small. Furthermore, the amount of spectrum was cross-checked with the PolicyTracker spectrum database. This is a comprehensive database of spectrum assignments in over 100 countries.

Low-band spectrum	MHz	Source URL
600 MHz (Incentive auction)	70	https://auctiondata.fcc.gov/public/projects/1000

Mid-band spectrum	MHz	Source URL	Comments
CBRS (PAL licences)	70	https://www.fcc.gov/auction/105/factsheet	70 MHz was awarded as priority licences. However, operators may be able to use the entire CBRS range of 100 MHz in some circumstances.
3.45 - 3.55 GHz (Auction 110)	100	https://www.fcc.gov/auction/110/factsheet	
3.7 - 4.2 GHz (Auction 107) (C-band auction)	280	https://www.fcc.gov/auction/107/factsheet	
2.6 GHz (T-Mobile's holdings of education spectrum)	155	https://www.fcc.gov/reports-research/reports/consolidated-communications-marketplace-reports/CMR-2020	FCC estimate from 2020 marketplace report (p.24)
Total	605		

High-band spectrum	MHz	Source URL
28 GHz (Auction 101)	850	https://www.fcc.gov/auction/101/factsheet
24 GHz (Auction 102)	700	https://www.fcc.gov/auction/102/factsheet
37 GHz and 39 GHz (Auction 103)	2400	https://www.fcc.gov/auction/103/factsheet
47 GHz (Auction 103)	1000	https://www.fcc.gov/auction/103/factsheet
Total	4950	

[102] https://www.lightreading.com/5g/inside-the-messy-world-of-t-mobiles-midband-5g-spectrum-licenses/d/d-id/774745
[103] https://www.fcc.gov/reports-research/reports/consolidated-communications-marketplace-reports/CMR-2020

European Union

Because spectrum assignments differ amongst EU Member States, the number used in the scoreboard shows how much spectrum has been harmonized at an EU-level. Some individual countries may have more spectrum assigned for 5G, while some may have less.

A1.5 5G verticals and trials

Overview

Whereas previous generations of mobile technologies primarily focused on human communication, including voice, data, and the internet, 5G has the ability to provide services for a range of industries where mobile telecoms have so far had little purchase. Because 5G features low latency and high speeds, it is well suited to enter the so-called "vertical" markets such as industrial and agricultural automation, the automotive industry, transport and healthcare. Early in the development of 5G/IMT-2020, the ITU identified 5G as a "key driver" for industrial and societal changes.

The 3GPP standardisation body released the first 5G specification in 2017 (Release 15). After the release of Release 15, the focus quickly turned to optimising 5G for vertical domains in Release 16, which is informally referred to as '5G Phase 2'.

In June 2020, Release 16 was published, focussing on the verticals' needs. Enhancements were made to 5G System enablers for verticals, including industrial automation, including time-sensitive communication (TSC), Ultra-Reliable and Low Latency Communication (URLLC) and Non-Public Networks (NPNs). Enhancements were also made to the Cellular Internet of Things (CIoT) and support for 5G system Vehicle-to-Everything (V2X) communication.

Release 17, which was frozen in early 2022, included more features for 5G verticals, including a new IoT standard called NR-light and support for non-terrestrial networks (NTNs). Furthermore, more spectrum frequencies are now supported in the 52.6-71 GHz range.

5G verticals in the EU

With the announcement of the EU Digital Decade Communication, the European Commission has put emphasis on the importance of the digital transformation of business. The communication outlined that 5G will play an important part in this transformation. It states, *"digital technologies including 5G, the Internet of Things, edge computing, Artificial Intelligence, robotics and augmented reality will be at the core of new products, new manufacturing processes and new business models based on fair sharing of data in the data economy."*

In Europe, trials of 5G verticals have been encouraged through the 5G Public Private Partnership project (5G PPP), which is funded by European Union research funding grants totalling €700m matched by €3.5bn of private investment between the period 2014-2020.

Furthermore, the 5G-PPP Vertical Engagement Task Force (VTF) has been established to coordinate and monitor activities related to working with the vertical sector. The vertical sectors considered by 5G-PPP VTF are:

- Automotive
- Manufacturing
- Media
- Energy
- E-Health
- Public safety
- Smart cities

5G vertical spectrum: Is there a need for a dedicated spectrum?

The licensing model (or model***s***) needed for 5G verticals is subject of an ongoing debate in spectrum management circles. 5G verticals can either use spectrum already assigned to mobile operators or they can rely on dedicated spectrum licences issued by governments.

Some stakeholders argue in favour of a dedicated spectrum. They say that dedicated spectrum access regimes enable innovation and competition, as they provide a new spectrum access option for industries.[104] It is also argued that a dedicated spectrum is better suited for some applications which have particularly demanding quality of service (QoS) requirements, such as utilities.

There are also arguments against the dedicated spectrum. The mobile industry association, the GSMA, says[105] that doing so may cause fragmentation. The organisation says that this could make it harder for operators to achieve contiguous blocs – which will then result in reduced speeds and QoS.

Despite this ongoing debate, an increasing number of countries are adopting a local licensing model that uses dedicated spectrum for 5G verticals. Germany was the first country to decide to reserve the 3700-3800 MHz band for verticals. This may be because of the potential benefits for industrial companies, which account for about 20% of the country's GDP.[106]

In total, 10 EU countries have proposed or implemented a local licensing model. These countries are as follows:

- Austria
- Belgium
- Croatia
- Denmark
- Finland
- France
- Germany
- Netherlands
- Poland
- Portugal
- Sweden

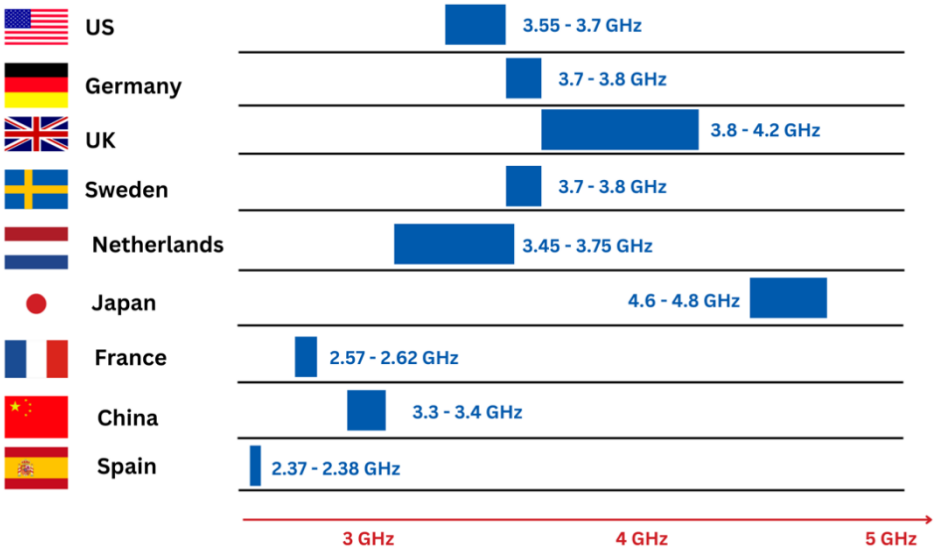
Although many European countries have adopted the approach of dedicating spectrum for verticals, the exact portions of spectrum used for these licences vary across Europe. This can cause issues when it comes to harmonisation efforts or standardising equipment. However, the 3.8-4.2 GHz band is emerging as a potential solution for this problem. The band has the potential to become the de facto vertical band for Europe.

[104] https://www.rcrwireless.com/20221118/5g/americas-inventive-spirit-at-its-finest-cbrs-model-must-be-extended-says-cbrs-industry

[105] https://www.gsma.com/spectrum/resources/mobile-networks-for-verticals/

[106] https://www.statista.com/statistics/295519/germany-share-of-economic-sectors-in-gross-domestic-product/

Figure 3 Variation of spectrum frequencies for 5G verticals in different countries



Source: Variation of original graphic from ARCEP[107]

The UK was the first European country to release[108] the band in 2019 exclusively for local private and shared networks. France has also followed in the UK's footsteps by opening up the 3.8-4.0 GHz band for 5G verticals licences.[109] Norway has also begun offering free trial licences in the 3.8-4.2 GHz range.[110] Meanwhile, the Belgian regulator BIPT is considering opening up the band. It launched a consultation on the issue in September 2022.[111]

The European Radio Spectrum Policy Group (RSPG) has previously published a consultation recommending Member States to explore the use of the 3.8 – 4.2 GHz band for 5G verticals.[112] In 2021, the European Union's Radio Spectrum Committee (RSC) mandated CEPT to develop harmonised technical conditions for the shared use of 3.8-4.2 GHz. However, the work on these efforts is still ongoing within the technical body.

In Asia, the notion of 5G private networks has some traction. In Japan,[113] a significant number of major companies have already acquired a spectrum licence.[114] The country's communications ministry started to issue licences for the deployment of local 5G networks in 3.7 GHz, 26 GHz and 28 GHz frequency bands as early as December 2019. In South Korea, the Ministry will offer 100 MHz in the 4.7 GHz band and 600 MHz in the 28 GHz band for campus networks at a fee of up to USD 88 per block.[115]

In China, The Ministry of Industry and Information Technology (MIIT) granted its first 5G private network licence in December 2022 to a domestic aeroplane manufacturer. The company will receive spectrum in the 5925-6125MHz and 24.750-25.15 GHz bands. The Chinese government is trying to promote industrial 5G networks, which it says is key to "boosting manufacturing prowess".[116]

In the US, the FCC is hoping that its three-tier CBRS (Citizens Broadband Radio Service) approach will allow enterprises to deploy private 4G and 5G networks and verticals. Agricultural equipment

[107] https://www.lesnumeriques.com/pro/5g-industrielle-la-france-est-encore-loin-du-compte-n177861.html
[108] https://www.policytracker.com/ofcom-makes-3-8-4-2-ghz-available-for-private-networks/
[109] https://www.policytracker.com/france-seeks-to-expand-industrial-5g/
[110] https://www.policytracker.com/norway-offers-free-3-8-4-2-ghz-private-network-test-licences-to-businesses/
[111] https://5gobservatory.eu/belgian-regulator-considers-spectrum-for-private-5g-networks/
[112] https://www.policytracker.com/3-8-4-2-ghz-gains-momentum-after-rspg-backing/
[113] https://www.policytracker.com/japan-awards-its-first-commercial-licences-for-local-5g/
[114] https://www.policytracker.com/japan-awards-its-first-commercial-licences-for-local-5g/
[115] https://www.policytracker.com/south-korea-to-allocate-local-5g-spectrum-for-the-first-time/
[116] https://5gobservatory.eu/china-grants-first-5g-private-network-licence/

manufacturer John Deere has already announced plans to use its CBRS spectrum to install a private 5G network in its factories.[117]

Nevertheless, internationally, the vast majority of the countries have not yet reserved frequencies for enterprises. In these markets, verticals will have to rely either on unlicensed spectrum, services provided by MNOs or secondary access to mobile spectrum. Unlicensed spectrum may prove to be successful for certain private network scenarios, but mission-critical applications are wary of unlicensed spectrum, which could have severe interference issues from other users.

Trends related to vertical trials

The 5G Observatory has been tracking the announcements of 5G trials in Europe and Internationally since 2018. The initial purpose of this was to monitor progress toward the 5G Action Plan. However, as commercial 5G networks have now launched in all EU-27 countries and the EU Digital Decade has realigned policy priorities, the 5G Observatory will now focus on vertical trials.

5G verticals are still in the early growth phase. 3GPP Release 16, which specifically focused on 5G vertical needs, was only finalised in early 2020. Work on Release 17, which will also introduce new features for 5G verticals, only recently concluded in March 2022. Some industry stakeholders have referenced this as a potential reason for the slow development of 5G verticals, particularly when compared to the rollout of commercial 5G. Furthermore, the COVID-19 pandemic may have also contributed to delays.

5G verticals appear to be particularly developed in ports and have been extensively tested in several countries. Notable examples include:

- **Germany**: The Hamburg Port Authority, Deutsche Telekom and Nokia have conducted an 18-month field test at the 'smart seaport' in Hamburg, Germany. This test focussed on the integration of 5G in traffic and infrastructure control.[118]
- **Belgium**: Proximus and the Port of Antwerp have announced a 6-month trial of a private 5G network.[119]
- **Belgium**: The Port of Zeebrugge and Citymesh have launched a private 5G network in the Port of Zeebrugge. In the first phase, this involved connectivity for tugboats, air pollution detectors, cameras and quay sensors.[120]
- **Estonia**: Tallinn, Telia, Ericsson and Intel have created a 5G test and exploration area in the Port of Tallinn. This trial enabled internet connectivity for commercial cruise ship passengers while in port.[121]
- **Spain**: Telefónica and APM Terminals have trialled 5G at the port of Barcelona. This test included connecting cranes, vehicles and people.[122]

5G verticals in other industries appear to be in an earlier stage. Various trials are taking place in the transport and automotive sector, although these are mostly early-stage tests and demonstrations. Examples include:

- **Germany**: Nokia and Deutsche Bahn are testing 5G for autonomous trains and rail operations.[123]

[117] https://www.fiercewireless.com/private-wireless/john-deere-foresees-private-5g-at-its-factories-worldwide
[118] https://www.telekom.com/en/media/media-information/archive/port-of-hamburg-is-ready-for-5g-574536
[119] https://www.proximus.com/news/2020/20200205-Proximus-and-Port-of-Antwerp-are-preparing-for-the-port-s-digital-transformation-by-developing-a-private-5G-network-.html
[120] https://citymesh.com/en/news/port-of-zeebrugge-accelerates-innovation-by-investing-in-a-5g-network
[121] https://www.ericsson.com/en/cases/2017/5g-telia-tallink
[122] https://enterpriseiotinsights.com/20210311/channels/news/telefonica-apm-terminals-to-deploy-5g-and-c-v2x-port-of-barcelona?utm_campaign=20210311%20Enterprise%20IoT%20NewsletterThurs&utm_medium=email&utm_source=Eloqua
[123] https://www.nokia.com/about-us/news/releases/2019/12/12/nokia-wins-deutsche-bahn-tender-to-deliver-and-test-the-worlds-first-5g-based-network-for-automated-rail-operation/

- **Norway**: Ericsson, Telia and the Norwegian University of Science and Technology have carried out a demonstration of a 5G autonomous ferry.[124]
- **Germany:** Sony and Vodafone have conducted remote 5G car trials in Aldenhoven, Germany.[125]
- **Germany**: Volkswagen and Nokia trial private 5G network at manufacturing plant.[126]
- **Finland**: Nokia to build private 5G network in Finnish goldmine.[127]
- **Germany**: Vodafone Germany launches a standalone 5G network at a University Hospital in Kiel.[128]

From the verticals the 5G Observatory has been tracking, most appear to be occurring within private networks. See the private network subchapter for more on this, including country-by-country examples of private networks and their associated vertical trials.

A1.6 5G private local networks

Deployment of 5G private local networks is growing across EU countries. These networks are not typically utilised by consumers (for mobile voice and data services) but use network elements and resources to provide dedicated secure services to private enterprises such as factories, plants, large campuses, ports and airports.

The Observatory has produced a non-exhaustive list of private 5G networks, which is based on research of publicly available information. The Observatory team endeavour to obtain as much information on published private 5G network deployments as possible.

Over the past six months, the European landscape of private 5G network deployments has witnessed remarkable growth – with more than 20 new deployments identified since the last 5G Observatory report.

One of the most notable findings is the substantial increase in countries such as Belgium, France, Germany, and Spain. Germany continues to lead in 5G private networks, seeing rollouts in four new industrial locations. Spain has also made significant strides in the deployment of private networks. Notably, these networks have found their way into critical transportation hubs such as San Sebastian Airport and the Port of Barcelona, as well as the provision of a 5G network for the Ministry of Defence.

Meanwhile, France and Belgium have also seen remarkable progress with regard to deployments of private networks, particularly for local authorities in the cities of Toulouse and Wavre.

We have also observed new countries entering the private 5G network arena for the first time. Portugal, for instance, has taken the initial steps towards harnessing the potential of private 5G by setting up an innovation centre to incentivise deployments, including enterprise networks.

An overview of 5G private networks featuring a searchable table of major private network projects in the EU can be found here.

A1.7 Supply market trends (vendors): Major procurements, Open RAN, multivendor deployments

The telecoms equipment supply market is continuing to evolve with the expected emergence of Open RAN offers alongside those of traditional vendors. Several governments and regulatory bodies have expressed interest in these technologies, with the objective of further supporting a diversification of the vendor supply chain.

In recent times, major operators in European Union countries have continued to secure significant procurement deals. The 5G Observatory website offers a comprehensive table containing information

[124] https://www.teliacompany.com/en/news/news-articles/2019/telia-tests-5g-powered-autonomous-vessels/
[125] https://5gobservatory.eu/sony-and-vodafone-conduct-remote-5g-car-trial-in-germany/
[126] https://5gobservatory.eu/volkswagen-and-nokia-trial-private-5g-network-at-manufacturing-plant/
[127] https://5gobservatory.eu/nokia-to-build-private-5g-network-in-finnish-goldmine/
[128] https://5gobservatory.eu/vodafone-germany-launches-5g-standalone-network-at-university-hospital/

about which vendors have successfully secured contracts for the development of 5G networks in Member States.

A1.8 EMF developments related to 5G policy goals

An EMF explainer is available online here.

Key highlights

Application of EMF limits remains inconsistent across Member States

The Commission mandated[129] in June 2021 the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)[130] to provide an opinion on the need for a technical revision of the annexes to the Council Recommendation 1999/519/EC[131] and Directive 2013/35/EU[132] for the frequency range 100 kHz to 300 GHz in view of the latest scientific evidence available, in particular the ICNIRP guidelines updated in 2020. This mandate further tasks SCHEER to update the SCENIHR Opinion of 2015 in light of the latest scientific evidence with regard to frequencies between 1 Hz and 100 kHz.

In its opinion published in April 2023, SCHEER advises positively on the need for a technical revision of the annexes in Council Recommendation 1999/519/EC and Directive 2013/35/EU with regard to radiofrequency electromagnetic fields (100 kHz to 300 GHz), because there is a need to recognise the recently introduced dosimetric quantities and establish limits for them.

The EECC recommends setting limits on exposure to electromagnetic fields (EMF) in line with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, which are about 50 times less than the level where there has been substantiated evidence of health damage. However, these limits are not binding on Member States, and there is inconsistency in how they are applied, and this can restrict the economic and social benefits of including 5G. Current EMF policies in the Member States are shown in the table below.

Table 6: Current EMF policies in the Member States

Countries	ICNIRP limits used?	Details
Austria	Yes	
Belgium	No	More restrictive than ICNIRP. Each region has its own limits, but those in Brussels were relaxed in August 2021
Bulgaria	No	Public exposure limit of 0.1 W/m^2 (300 MHz to 30 GHz)
Croatia	No	Power density limits are 16% of the ICNIRP guidelines
Cyprus	Yes	ICNIRP limits adopted in 2004
Czech Republic	Yes	ICNIRP limits adopted in 2000
Denmark	Yes	
Estonia	Yes	ICNIRP limits adopted in 2002. No permit for ERP power <100W

[129] https://health.ec.europa.eu/system/files/2021-07/scheer_q_023_0.pdf

[130] https://ec.europa.eu/health/system/files/2021-07/scheer_q_023_0.pdf

[131] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:31999H0519

[132] Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013L0035

Countries	ICNIRP limits used?	Details
Finland	Yes	
France	Yes	ICNIRP limits adopted in 2002
Germany	Yes	
Greece	No	60% of ICNIRP guidelines for base stations located less than 300 m from schools, hospitals... 70% of ICNIRP guidelines in other areas
Hungary	Yes	ICNIRP limits adopted in 2004
Italy	No	20 V/m as a general limit in open areas. 6 V/m inside buildings used for more than four hours a day
Ireland	Yes	
Latvia	Yes	
Lithuania	Yes	
Luxembourg	No	Limit at 3 V/m per operator and per antenna system. About 0.2% of ICNIRP limit above 2 GHz
Malta	Yes	
Netherlands	Yes	
Poland	Yes	ICNIRP limits adopted in 2020
Portugal	Yes	ICNIRP limits adopted in 2004
Romania	Yes	
Slovakia	Yes	ICNIRP limits adopted in 2007
Slovenia	No	For sensitive and protected areas limits are lower
Spain	Yes	ICNIRP limits adopted in 2001
Sweden	Yes	
UK	Yes	ICNIRP limits adopted 2000

A1.9 5G corridors

Highlights (past 3 months):

- Under the first call for proposals of the CEF Digital framework, 15 corridor deployment projects, consisting of seven work projects and eight studies covering 5G coverage along transport corridors, were kick-started at the beginning of 2023.[133] More details on the projects can be found below.
- The second call for proposals was closed in March 2023, and more information will be published in due time.

For projects implemented under the first CEF Digital call, the projects concentrate on offering connected and automated mobility (CAM), including rail, and high-value commercial services with a focus on cross-border sections of corridors with the view to ensure addressing aspects such as uninterrupted coverage and service continuity meeting stringent requirements, in particular in terms of network security, low latency, high throughput and seamless end-to-end connectivity.

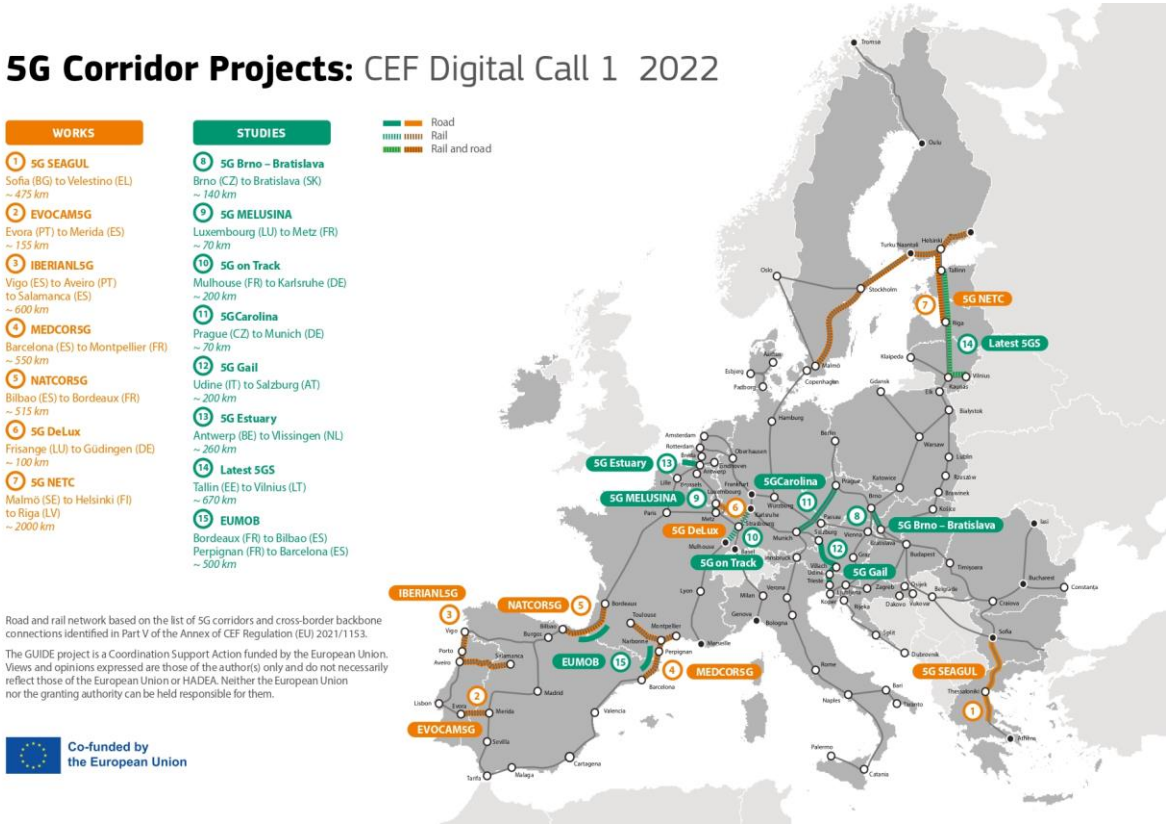
[133] 5G Coverage along Transport Corridors: first wave of projects selected for co-funding 5G corridor infrastructures | Shaping Europe's digital future (europa.eu)

The works encompass building passive infrastructure to explore new business models, designing and testing cross-border service continuity, testing network slicing and the rollout of the 5G network as an enabler for CAM, Future Railway Mobile Communication System (FRMCS) use cases, and Gigabit service provision to trains' passengers. The seven projects are reported to be on track with no major issues encountered in the current phase. Meanwhile, the inception studies include preparatory work for future deployment projects along the transport corridors, in which seven out of eight studies have been finalised, with one project still ongoing.

The 15 Call-1 projects were presented in the context of a workshop on 5G corridors held on 10 October 2023, organised by the CEF-funded project GUIDE.[134]

The map below displays each of the work project and inception studies granted under the first call of the CEF Digital Framework in conjunction to existing 5G corridors.

Figure 4: 5G Corridor Projects under the First CEF Digital Call



Source: COM

The table below outlines the projects, including the amount of financing and mileage of each project.

Table 7: 5G Deployment Projects under the CEF Digital first call

Title	Country	Grant Requested	Length Covered (km)
Study of 5G/FRMCS implementation on the railway corridor Brno (CZ) – Bratislava (SK)	CZ	300.000,00 €	140
Inception study for the deployment of 5G in the cross-border section of the Carnic and Gailtal Alps between Italy and Austria	IT	139.750,00 €	200

[134] GUIDe project, including CEF Digital projects' presentation material: 5G Corridors Event – October 2023 – GUIDE

Title	Country	Grant Requested	Length Covered (km)
5G METZ - LUXEMBOURG SILLON INTERNATIONAL	FR	255.377,00 €	70
5G on Track Karlsruhe – Mulhouse	DE	517.150,00 €	200
Cross-border Highway 5G Corridor Munich-Prague	CZ	238.000,00 €	70
5G Estuary	BE	300.000,00 €	260
Digitisation of European corridors for intelligent mobility	ES	146.800,00 €	500
5G Corridor Study for Latvia, Estonia and Lithuania	EE	249.302,00 €	670
Studies		**2.146.379,00 €**	**2.110**
5G Northern European Transport Corridor	SE	15.535.000,00 €	2.000
5G Seamless Roaming for the Greece-Bulgaria CBC	EL	5.748.000,00 €	475
Evora connected autonomous Merida corridor 5G and v2x network for future CAM and in cross border section between Portugal and Spain	ES	1.362.070,00 €	155
Iberian Corridor (Salamanca – Aveiro – A Coruña) 5G and v2x network for future CAM and FRMCS services in cross border section between Portugal and Spain	ES	2.556.165,00 €	600
Mediterranean Corridor 5G and v2x network for future CAM and FRMCS services in cross border section between France and Spain	ES	5.204.748,00 €	550
North Atlantic Corridor 5G and v2x network for future CAM and FRMCS services in cross border section between France and Spain	ES	2.681.942,50 €	515
Seamless cross border mobility 5G DeLux	DE	6.338.325,50 €	100
Works		**39.426.251,00 €**	**4.395**
Total Call 1		**41.572.630,00 €**	**6.505**

The analysis from the last quarterly report can be found here.

A1.10 5G cybersecurity toolbox implementation

Cybersecurity has been an important priority in the context of 5G development. The EU toolbox for 5G security is a set of robust and comprehensive measures for an EU-coordinated approach to secure 5G networks. The full paper providing an overview of the toolbox, as well as measures already taken by Member States can be found here.

Below are some highlights summarising the latest developments.

In June 2023, the NIS Cooperation Group published its second report on MS's progress in implementing the 5G cybersecurity toolbox. The report says that further progress has been made in the implementation of the key strategic measures of the EU Toolbox. However, the degree of progress is varied. According to information provided by Member States, nearly all (23) have now adopted the first measure set out in the Toolbox called SM01. This measure is designed to strengthen the role and powers of regulatory authorities.

However, only ten Member States have actually imposed restrictions to enhance 5G security, although three Member States are currently working on their implementation. The report says there is "a clear risk of persisting dependency on high-risk suppliers in the internal market with potentially serious negative impacts on security for users and companies across the EU and the EU's critical infrastructure".[135] The Commission has said that based on an assessment of the criteria set out in the Toolbox for identifying 'high-risk suppliers', it considers that decisions adopted by some Member States to restrict or exclude Huawei and ZTE are justified and compliant with the 5G Toolbox.[136]

A1.11 Next generation networks contribution to reaching Green Deal targets and addressing sustainability issues

Sustainability is another key topic accompanying 5G development. The full paper providing an overview of commitments taken up by the industry (telecom operators) to reduce emissions and the role of 5G in the context of the targets set by the Green Deal can be found in here.

[135] Second report on Member States' Progress in implementing the EU Toolbox on 5G Cybersecurity, Une 2023, p. 22: https://ec.europa.eu/newsroom/dae/redirection/document/96519

[136] https://ec.europa.eu/commission/presscorner/detail/%20en/ip_23_3309

Annex II: Detailed country situation

The detailed country situation is available online via this link.