# 5G Observatory
Quarterly Report 17
October 2022

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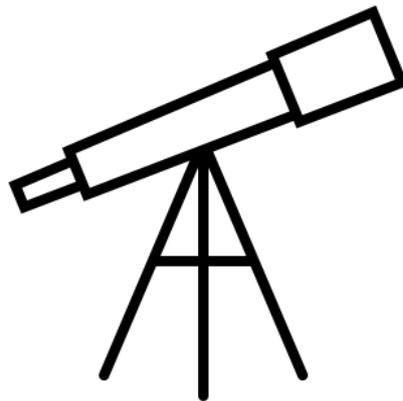
EUROPEAN COMMISSION

Directorate-General for Communications Networks, Content and Technology

NOTE

This is the 17th edition of an independent, quarterly 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 VVA, Policytracker and LS.

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1 What has happened in the past 3 months (focus on EU)

Estonia and Lithuania have completed several 5G auctions in the 700 MHz and 3.6 GHz bands, bringing the Member States closer to assigning all 5G pioneer bands.

Mobile operators and telecommunications companies are actively trialling next generation 5G technologies such as network slicing and non-terrestrial 5G. Ericsson and Nokia have both tested 5G network slicing in collaboration with Google, while German operator Vodafone has conducted field tests of the technology.

Major 5G private network initiatives are also being announced. German Airport operator Fraport announced that it has signed a deal with Japan's NTT to build "Europe's largest" 5G private network. Meanwhile, the Parisian district of La Défense opened bids for 5G projects using the 26 GHz band.

1.1 5G spectrum awards

In the past three months, several 5G auctions took place in the EU. Estonia completed its auction of the 3.6 GHz band in late July. The Consumer Protection and Technical Regulatory Authority (TTJA) says it raised a total of €17.3 million from the award with the country's three major mobile operators Elisa, Telia and Tele2 all securing 130 MHz licences in the band. Estonia has also started the auction process for the 700 MHz band, although this is still ongoing.[1]

Lithuania finalised the 3.6 GHz auction in early August[2], and completed the award of the 700 MHz band a few weeks later[3]. The country's three national operators Tele2, Telia and Bite all secured a total of 300 MHz in the 3.6 GHz band and 40 MHz in the 700 MHz band.

Ireland's regulator ComReg is considering temporary spectrum licences in the 700 MHz and 2.1 GHz bands after it was forced to delay its planned spectrum auction due to legal action from mobile operator Three. So far, Ireland has only awarded one 5G pioneer band, which is the 3.6 GHz band.

Internationally, India has completed its much-anticipated 5G auction which raised a total of €19 billion across a series of spectrum bands. India's government is targeting a 5G network rollout by October 2022.[4]

1.2 Public initiatives

Public funding of 5G and 6G projects continue both at EU and Member States levels. In particular, major developments are taking place in Spain where the government has launched the second phase of its 5G and 6G R&D fund. The government is also granting an additional €116 million for new projects in 2022 and 2023. The funding is split up into two programmes; one for the financing of 6G research infrastructures and the acquisition of scientific-technical equipment and another for the development of 5G+ R&D projects.

At an EU level, the European Commission launched on 12 October 2022 the second call of funding under the Connecting Europe Facility (CEF) Digital Programme. This specific call aims at funding projects providing 5G connectivity along transport paths, to smart communities as well as backbone connectivity for Cloud and digital global gateways The call will be remain open until the end of February 2023."

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[1] https://www.ttja.ee/uudised/tana-algab-5g-konkurss-sagedusalas-694-790-mhz

[2] https://5gobservatory.eu/lithuania-completes-3-6-ghz-auction/

[3] https://5gobservatory.eu/lithuania-completes-700-mhz-auction/

[4] https://www.policytracker.com/india-stages-record-breaking-auction/

The strategic debate about whether streaming services and other big tech platform companies should make a *"fair contribution"* to 5G network costs in Europe is still progressing. In September, the European Competitive Telecommunications Association (ECTA) issued a statement arguing that such a contribution is necessary to achieve the agreed digital targets in the EU.[5] CEOs from a diverse group of European telecom operators have also issued a similar call published by ETNO[6]. In this context, the EU industry Commissioner Thierry Breton has announced that the Commission will launch a consultation on this matter during the first quarter of 2023.[7]

Several EU Member States are now reaching the first intermediate milestones regarding the implementation of the EU Recovery & Resilience Fund, prompting the payment of several billions of euros in grants and loans for digital infrastructure, some part of it being allocated to connectivity.

1.3 Commercial developments

Mobile operators in Europe continue to improve service coverage and introduce new 5G functionalities based on stand-alone 5G, such as network slicing, as well as by ramping up RAN virtualisation.

Network slicing trials are continuing, with both Ericsson and Nokia teaming up with Google to showcase the technology using the latest Google Pixel handset, demonstrating that the technology could work on consumer end-devices.[8] Meanwhile, German mobile operator Vodafone announced in early September that it has trialled network slicing outside of the lab. The company says network slicing technology was used to cover a motor race in Nürburg which was live-streamed using its network. Vodafone did clarify however, that this trial used 4G network slicing because of the lack of device support for 5G standalone technology.[9]

5G private networks are emerging. In late July, Frankfurt Airport operator Fraport announced that it had signed a deal with Japanese telecommunications company NTT to build "Europe's largest" private 5G network which would eventually cover 20 km2. The network will be used for voice and data communication, but Fraport suggests it could be used for innovative projects such as autonomous driving on the airport runway in the future.[10]

Also in Germany, mobile operator Vodafone announced plans to launch a 5G private network inside a greenhouse. The network will be installed in pharmaceutical company Bayer's research greenhouse. Vodafone says its private network covers an area of 11,000 square metres.[11]

The Parisian district of La Défense opened bids for project to test 5G using the 26 GHz band. 'Paris La Défense' says it will open two lots of bids. The first lot is intended for projects that test the feasibility and viability of a carrier-neutral 5G network while the second lot targets projects exploring new innovative use cases in the 26 GHz band.

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[5] https://5gobservatory.eu/eu-telcos-say-streaming-companies-should-make-fair-contribution-to-5g-network-investment/

[6] https://etno.eu/news/all-news/8-news/753-ceo-statement-on-the-role-of-connectivity-in-addressing-current-eu-challenges.html

[7] https://www.reuters.com/technology/eu-consult-big-tech-contribution-telco-networks-by-end-q1-2023-2022-09-09/

[8] https://5gobservatory.eu/nokia-trials-network-slicing-with-google/

[9] https://5gobservatory.eu/vodafone-germany-trials-network-slicing/

[10] https://5gobservatory.eu/frankfurt-airport-and-ntt-to-build-europes-largest-private-5g-network/

[11] https://5gobservatory.eu/vodafone-germany-launches-5g-private-network-inside-a-greenhouse/

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 have now 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 256,074 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 72% of EU's population is covered by at least one 5G network.

5G deployment & coverage

72% population coverage achieved in EU27[1]

Non-EU country

Darker green indicates higher coverage
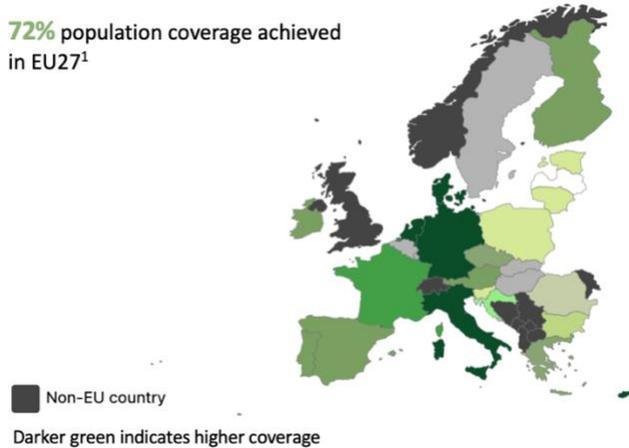
256,074 5G base stations total by end of August 2022 in EU27

5G base stations as a percentage of existing 4G base stations[2]

Category	Value
700 MHz base stations	6.53%
3.6 GHz base stations	6.99%
DSS base stations	18.22%
All 5G base stations	34.50%
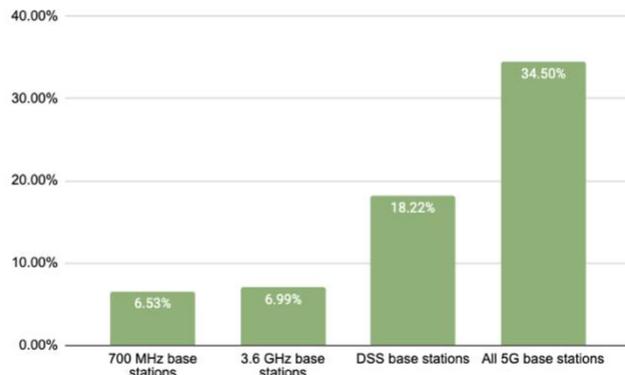
5G spectrum assignments

62% of pioneer bands assigned on average in EU27 (Each pioneer band is weighed 1/3rd)[3]

Band	Spectrum assigned	Change since last report	Total
700 MHz		+2.47%	74.07%
3.6 GHz		+5.79%	83.80%
26 GHz	29.07		

■ Spectrum assigned ■ Change since last report ■ Not assigned
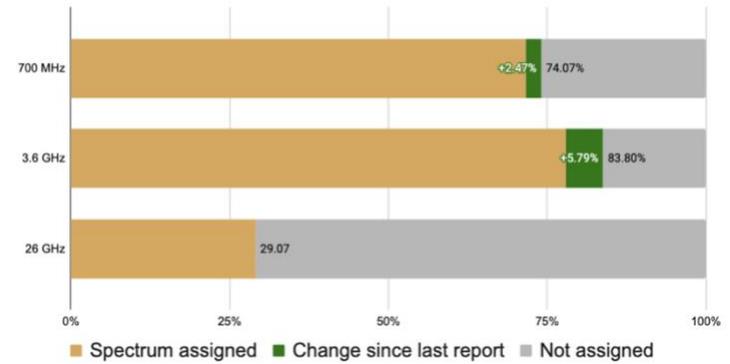
5G pioneer bands assigned across the EU27[3]

Weighted % of pioneer bands assigned

0%   100%

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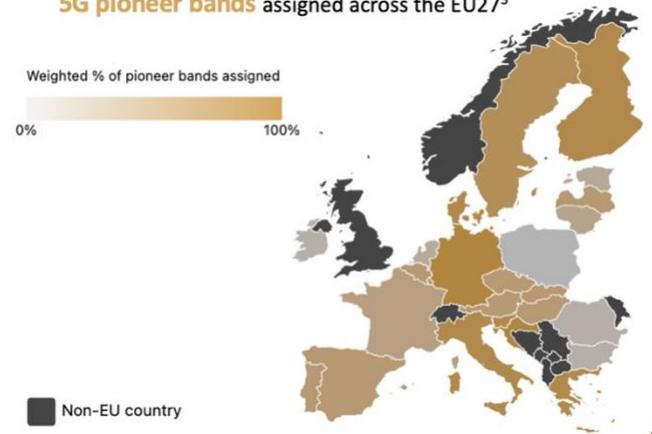
(Source: Data on population coverage, base stations and spectrum assignments is from the DESI index. This data is supplemented with data independently collected by the Observatory)

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 - 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. Excludes Italy, Estonia and Sweden as there was no base station data available. Additionally, some countries use bands that are not included in this chart and do no operate using a DSS configuration.

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

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 how widespread 5G is in each country. The following developments can be highlighted[12]:

- China has nearly 1.8 million installed 5G base stations: seven times more than the EU and 18 times more than the USA.

- South Korea has the most 5G base stations per million inhabitants: nearly seven times more than the EU and 13 times more than the USA.

- The United States has awarded the most high-band spectrum with a total of 4950 MHz assigned to operators.

- The most widely awarded 5G spectrum in Europe is the mid-band

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[12] 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

Comparison of 5G rollout in international markets[4]

5G rollout		China	South Korea	Japan	USA	EU
	5G Mode	NSA/SA	NSA/SA	NSA/SA	NSA	NSA/SA
	Approximate number of 5G base stations	1,850,000	215,000	50,000	100,000	256,074
	Total country population	1,402,000,000	51,780,000	125,800,000	329,500,000	447,706,000
	5G base stations per 100,000 inhabitants	132	415	40	30	57
	Indicative 5G subscribers	**357 million** (source: Ericsson 2022)	**25 million** (source: Ministry of Science and ICT)	**14.19 million** (source: Japan times)	**79 million** (including Canada; source: Ericsson 2022)	**31 million** (including all of western Europe; source: Ericsson 2022)

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

4 - 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

Assigned 5G spectrum in international markets (EU data represents average spectrum assigned)[5]

High-band   Mid-band   Low-band

China	South Korea	Japan	USA	EU
860 MHz (mid) / 80 MHz (low)	2400 MHz (high) / 380 MHz (mid)	1600 MHz (high) / 880 MHz (mid)	4950 MHz (high) / 605 MHz (mid) / 70 MHz (low)	291 MHz (high) / 335 MHz (mid) / 44 MHz (low)
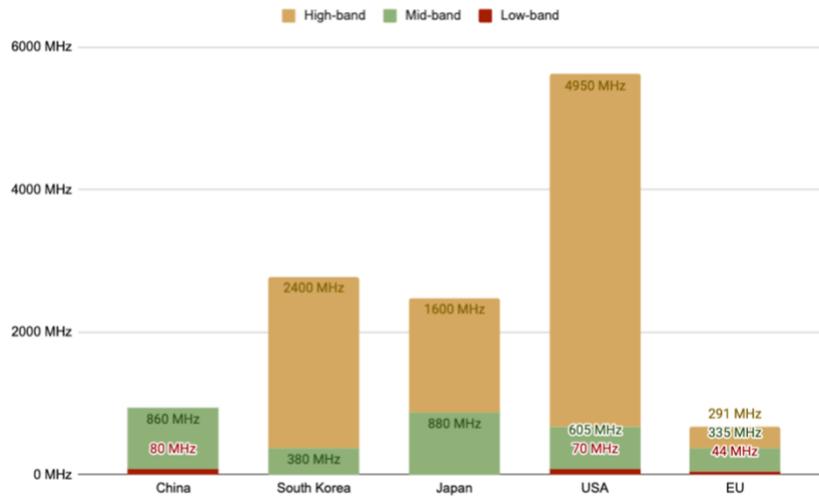
Assigned 5G spectrum bands in international markets[5]

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

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

5 - USA 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 on spectrum assigned has been averaged out across all EU27. Some individual countries may have more spectrum assigned for 5G, while some may have less or none.

3 Progress against monitored targets and strategic implications

The table below outlines major strategic implications referring to the overall performance of EU27 against relevant targets. 5G-related targets to be monitored throughout the publications have been sourced from EU Policy programmes, including the 5G Action Plan[13]; the Digital Decade policy[14] as well as the EU 5G Cybersecurity Toolbox[15]. This monitoring exercise will be the basis of a full strategic progress assessment, including relevant roadmaps, to be included in the final report:

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[13] https://digital-strategy.ec.europa.eu/en/library/communication-5g-europe-action-plan-and-accompanying-staff-working-document
[14] https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade
[15] 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
Commercial launch of 5G services at least in one major city in all EU countries	Since January 2022, commercial 5G is now available in all 27 EU Member States.[16] All deployments to date cover major cities and urban areas.	None	This EU target for end of 2020 is now fully achieved. Therefore, there will be no subsequent reporting on this target.
Uninterrupted 5G wireless broadband coverage for all urban areas and major roads and railways.	Based on data collected by the Commission in 2021 and operator announcements, the population coverage in the EU is estimated at 72%.[17]	As a result of research performed at Member State level, the study team identified a lack of consistent reporting at MS level (for example coverage of major roads and railways is only reported in Finland).	A part of the solution for improving reporting is expected to result from the upcoming Policy Programme, namely the "Path to the Digital Decade" Decision which has been already endorsed by the co-legislators. It includes a common EU monitoring mechanism for the attainment of the 2030 targets based on key performance indicators, reported by the Commission in the DESI on a yearly basis[18, 19].
"Digital technologies including 5G at the core of new products, new manufacturing processes and new business models"	The roll out of private 5G networks is still in a relatively early growth phase but will be an important contributor to the continued productivity of Member States and adoption of new technologies for enterprises that will support the ongoing development of the 5G ecosystem.	A potential bottleneck may be the lack of consistent spectrum policies regarding private networks. Some countries such as Germany offer local 5G spectrum licences for verticals while other	A recommendation regarding the optimal licensing regime for local 5G authorisation regimes could aid in harmonising deployment and cross border 5G projects.

In regard to spectrum consistency, in November 2020, the European Commission mandated 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[20]. While CEPT's studies are still ongoing, this |

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[16] Final launch in Lithuania announced in January 2020 by Telia

[17] DESI 2022

[18] Source: Proposal for a Decision establishing the 2030 Policy Programme "Path to the Digital Decade"

[19] For more information regarding 5G targets in the digital decade see: https://digital-strategy.ec.europa.eu/en/policies/5g-digital-decade

[20] 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
	5G verticals appear to be particularly developed in ports, whereas in other industries they are at an earlier stage. Most vertical industry trials appear to be occurring within private networks.	countries such as Ireland do not offer local licenses. Additionally, there is a lack of consistency in which bands are available for 5G verticals. For instance, Germany offers up the 3.7 – 3.8 GHz band while France is awarding licences in the 3.8 – 4.0 GHz band.	mandate may help resolve the existing lack of spectrum consistency as more Member States may choose to adopt the 3.8-4.2 GHz band for private network licenses.
Authorising 5G spectrum bands	The 3.6 GHz band has been most widely assigned. 25 out of 27 Member States have assigned this band. The second most popular band is the 700 MHz band, which has been assigned in 21 out of 27 Member States. The least popular band is the 26 GHz band, which has only been assigned in 8 Member States. Finally, 1 Member State has failed to assign any of the pioneer bands.	Lack of demand for the 26 GHz band. Further development of harmonised approach to spectrum sharing for local networks	Referring specifically to the 26GHz 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.[21] The identification of additional band/capacity for 5G should be initiated in a timely fashion to anticipate the expected growing business demand. In regard to 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.[22]

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[21] 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.

[22] 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
Promoting pan-European multi-stakeholder trials[23]/ 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. In addition, at least eight Member States refer to the European deployment of 5G corridors along TEN-T networks in the interest of Single Market and cohesion in their recovery plans.[24]	17 of 27 Member States are involved in the existing 12 cross-border corridors.	Upcoming projects (including the support of CEF2 framework) and commitments of Member States in their recovery and resilience plans are expected to bridge existing gaps.
5G toolbox implementation	A large number of Member States have already taken concrete steps to implement the various strategic measures.	Based on the latest NIS report (2020), there are visible differences in terms of implementation maturity for different types of individual measures.[25]	The analysis presented in the report by the NIS Directive provides specific recommendations (next steps) based on identified findings for each of the Toolbox measures, highlighting areas requiring special attention in the next phases of the Toolbox implementation and monitoring (both at EU and MS level). A specific NIS report[26] on open RAN architecture was published in May 2022 and is the subject of implementation discussions with Member States.

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[23] 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.

[24] CZ, ES, IT, LV, EL, LT plans. Source: Commission Staff Working Document

[25] https://digital-strategy.ec.europa.eu/en/library/report-member-states-progress-implementing-eu-toolbox-5g-cybersecurity

[26] Cybersecurity of Open Radio Access Networks | Shaping Europe's digital future (europa.eu)

The table below represents the most recent data[27][28] on the number of base stations per Member State and band type. When it is reported "n/a" it means that no recent updated numbers are available. Please, note that the 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	n/a	1,081	3,216	965	6,080	65,905	6,300	n/a	4,666	17,649	9,000	39,502	2,711	1,610	2,830	53,940	1,090	245	n/a	393	12,476	21,912	4,634	1,181	n/a	935	1,070
700 MHz band	n/a	2	0	560	731	9,922	3,209	0	330	6,394		14,826	1,210	532	0	6,807	931	n/a	n/a	0	n/a	6	2,622	0	n/a	251	18
3.4-3.8 GHz band	n/a	458	2,110	106	975	11,788	3,091	n/a	333	2,464		14,457	835	565	1,024	11,358	131	1,075[29]	n/a	77	0	70	1,811	396	n/a	402	249
in 4G spectrum bands (using dynamic spectrum sharing, DSS)	n/a	621	1,106	63	4,374	44,195	n/a	n/a	4,003	8,791		10,219	666	504	1,806	35,775	20		n/a	316	n/a	21,836	201	785	n/a	282	803

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[27] End of August 2022. The figures are indicative and do not engage responsibility of the 5G Observatory nor any other parties.

[28] Please note that when there are empty cells, it means it was not possible to gather the data per band type but only as a total number of base stations.

[29] Number of issued radio permits, no data on operating base stations.

4 5G perspectives: Commentary and observations on the need for further public initiatives

4.1 How could the achievement of the 5G coverage goal for 2025 be evaluated and measured?

One of the EU goals regarding 5G deployment (goal 2025) is to provide uninterrupted 5G for all urban areas and transport paths by 2025 and to cover all populated areas by 2030.

In the January 2020 5G Observatory Quarterly Report we suggested that the progress towards high speed 5G services could be measured by using as a "proxy" the number of 3.6 GHz base stations in a Member State (MS).[30] In this new reflection on the subject, we examine that approach in more depth, considering the extent to which the full benefits of 5G depend on higher speeds. We also examine whether the base station "tracking" approach captures the value of private networks.

The January Quarterly Report focused on the shorter term 2025 goal but in this section we consider now the prospect of the full 2030 Digital Decade goal in more detail.

4.1.1 Estimating the required number 3.6 GHz base stations

On the basis on the area which can be covered theoretically by an average reference configuration of a 3.6 GHz base station, it is possible to estimate the minimum number of such base station sites required to cover the urban areas in each MS. This would be an indicative estimate and would not take into account specific topographical factors meaning the actual number required is likely to be higher. This exercise was done in detail in the January 2022 Quarterly Report (p.111) and the table below shows the results already presented.

Table 3: Number of 3.6 GHz base stations needed for "optimal" 5G in urban areas

Country	Total area in km²	Urban areas as % of land mass	% pop living in urban areas	Minimum number of 3.6 GHz base stations needed for urban area coverage ("optimal" 5G)
Germany	354,600	21%	53%	28,700
France	554,000	8%	62%	17,100
Spain	505,800	7%	70%	13,700
Italy	300,800	11%	85%	12,800
Poland	311,700	7%	53%	8,400
Netherlands	36,100	47%	84%	6,600
Belgium	30,700	46%	83%	5,500
Romania	237,200	5%	48%	4,600
Czech Republic	78,900	11%	60%	3,340
Portugal	92,600	8%	82%	2,850

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[30] While 26 GHz also provides high speed 5G, operators' current plans are to deploy this as a specific solution for very high density locations like sports stadiums, tourist locations and train stations. (See PolicyTracker 28.3.22 and recent slides by BT) The very limited propagation characteristics of 26 GHz (200-400m radius cells) means the number of base stations in a country would not be a good indicator of the extent of population coverage, rather a list of traffic hot spots and some vertical deployments. 3.6 GHz, on the other hand is the basis of high speed 5G deployment to consumers in countries like Germany.

Country	Total area in km^2	Urban areas as % of land mass	% pop living in urban areas	Minimum number of 3.6 GHz base stations needed for urban area coverage ("optimal" 5G)
Hungary	92,500	8%	50%	2,850
Greece	132,200	4%	65%	2,040
Sweden	425,000	1%	52%	1,640
Austria	83,800	5%	53%	1,620
Denmark	43,100	9%	63%	1,500
Finland	322,300	1%	32%	1,240
Croatia	56,300	4%	43%	870
Bulgaria	111,200	2%	35%	860
Ireland	69,600	3%	62%	810
Slovenia	20,600	8%	56%	640
Estonia	43,300	3%	72%	500
Cyprus	8,900	9%	57%	310
Lithuania	64,800	1%	41%	250
Latvia	64,200	1%	51%	250
Luxembourg	2,600	19%	64%	200
Malta	300	92%	98%	120

The calculations are based on the minimum number of base stations needed to cover urban areas only, as earlier studies had indicated that extending high speed coverage to rural areas was not economically feasible at this point in time. We call 5G in 3.6 GHz "optimal" 5G because it enables the delivery of significantly higher speeds than 4G along with advanced features like lower latency at an economically feasible cost.

4.1.2 The benefits of mid-band spectrum

Mid-bands, and specifically the 3.6 GHz, are certainly needed to deliver the higher speeds and lower latency which distinguish 5G from 4G. This can be seen in some recent figures released by Opensignal, which measures network performance by an app on users' phones.

In contrast, lower bands do not deliver high quality/ high speed 5G as illustrated for example by the deployment of 5G in the 600 MHz band, which is the US equivalent of the EU's 700 MHz 5G pioneer band. In March 2020 Opensignal observed that in the US, T-Mobile's 4G in 600 MHz was achieving average download speeds of 20 Mbps. In September 2021 it measured T-mobile's 5G performance in the same band and found the average download speed was approximately 30 Mbps. There had been a 50% improvement, but speeds of 30 Mbps are already common in 4G networks.

In 2019 Opensignal found that all the major US operators had average 4G download speeds in excess of 20 Mbps, meaning that many of the speeds experienced were much higher. In 2018 Opensignal reported that European 5G networks had an average download speed of 20 Mbps and in 13 countries this was in excess of 30 Mbps[31].

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[31] These countries included Netherlands (average 4G download speeds of 42.1 Mbps), Norway (41.2 Mbps), Hungary (39.2 Mbps), Belgium (36.1 Mbps), Bulgaria (33.3 Mbps) and Denmark (33.1 Mbps).

In 2.5 GHz – T-Mobile's main mid-band for 5G - the increase in performance was much greater because of the wider bandwidths available. Opensignal's September 2021 metric showed average download speeds of 239.3 Mbps compared with 41 Mbps in on the 4G network in 2019.[32] This is an improvement of over 480%.

In short, 5G brings a small speed increase and welcome extra capacity in the lower bands but it is only in the mid-bands that we see a step change in performance over 4G.

4.1.3 How essential is "optimal' 5G?

Whether the high speeds and low latency provided by the 5G mid-bands are needed to secure the technology's full social benefits is a matter of debate.

These "optimal" attributes will be needed for some of the vertical use cases envisaged for 5G, particularly the low latency needed to control machinery used in automated factories. Optimal 5G's speed and bandwidth is also needed for some agricultural applications, such as weeding machines which could require live video feeds to a cloud-based server where image recognition would identify the plants. The speed of the mid or high bands could also make 5G an effective competitor to fixed line broadband services.

On the other hand, the revenue engine for MNOs is the consumer market and there is no universal agreement about the benefits of increasing speed beyond a certain point. A report published in 2015 by Boston Consulting Group (BCG) concluded that *"put simply, telcos have overrated the role that speed plays in customer satisfaction."* They found that for those watching videos *"once speeds reach 1.5 Mbps, further increases have little or no impact on users' perception of performance."* The same was true – but at much lower speeds – for the experience users reported for web browsing, email and social networks. The telcos' race for speed may be "a largely unnecessary endeavour that breaks the cardinal rule of focused investment: spend where the spending counts most," said BCG.

Figure 1: The relationship between web page load times and network speed (Source: Webb 2016)
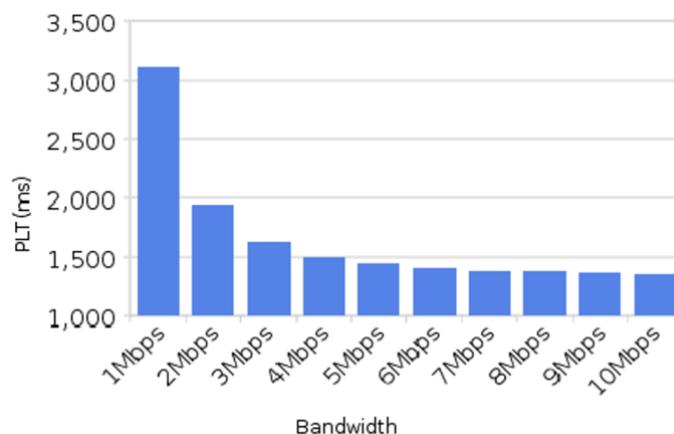
Professor William Webb has argued that network speeds above 4 Mbps have little impact in making web pages load faster – one of the most frustrating parts of net browsing (see graph). This is because page load speeds are constrained by the maximum turnaround time at the server and internet TCP/IP protocols.[33]

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[32] At that stage 2.5 GHz was owned by Sprint, but this merged with T-Mobile in 2020
[33] William Webb, The 5G Myth (2016) p15

Webb points out that Netflix's recommended network speed is 1 Mbps for Standard Definition and 5 Mbps for High Definition[34]. He said coding improvements are likely to lead to a reduction in the recommended network speed for Ultra High Definition and he had been proved right. It was 25 Mbps when the book was written in 2016 and is now 15 Mbps.

The opposite argument –recently put forward by the consultancy McKinsey – is that some users like gamers are willing to pay more for 5G's higher speeds and this can increase the Average Revenue Per Units (ARPUs) by 16-20 per cent. This is based on selling a greater variety of subscription packages, some at higher speeds, and by allowing a temporary "speed boost" as an impulse purchases. 5G-enabled experiences such as gaming will be another new revenue source. All these income streams require the significantly higher speeds that can only be achieved with mid or high band spectrum. McKinsey says these differentiated tariff structures have already boosted ARPUs in for several MNOs in Hong Kong.

5G's "need for speed" certainly seems to be a matter for debate. Does it matter if "optimal" 5G is not available in all areas?

The research above suggests that speed is not an important factor for most consumers, although for some smaller sub-groups – such as gamers - it may be. But will a lack of 5G speed prevent some consumers from using new applications, as yet undeveloped, which will bring economic and wider benefits to society? In fact, most trials and development work for new 5G applications relates to new verticals – such as industry, agriculture, transport and healthcare – rather than consumer uses.

This suggests that it would be these vertical users, rather than the majority of consumers who would be negatively affected by a lack of high speed 5G provided in the mid and high bands.

For most consumers high speed 5G in the mid and high bands would bring marginal benefits in providing better QoS in congested urban cells. This is welcome but without it services are not an impossibility, as they are for some new vertical applications which are dependent on higher speeds and lower latency.

4.1.4 Capturing the benefits of private networks

Most of the new and most innovative 5G applications for verticals are designed for private networks, and not all of these will be provided by existing MNOs. Many will be installed by companies themselves or by systems integrators using local rather than national licences. There have been nearly 200 applications for these local 5G licences in Germany in 3.7-3.8 GHz.

These creates a problem for the urban coverage approach inherent in our 3.6 GHz base stations estimate. Base station data is usually collected when MNOs make it available to regulators. What if there are thousands of local licence holders providing 5G private networks in each MS? It would be an arduous data-collecting exercise to find out how many each had deployed. Most regulators are only likely to know the deployment figures from the major MNOs, but is this likely to capture the full value of 5G? Trade bodies such as the GSA do track new announcements of private networks, but these are not always made public and the smallest scale deployments – a single small factory for example – are likely to be missed.

To take a theoretical example, suppose Romania only made 3.6 GHz 5G available in its urban areas, leaving 52% of the population in its rural areas accessing 5G at lower speeds using the lower frequency bands. The studies above suggest little harm to consumers and if 5G vertical services for industry, ,

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[34] Ibid p15

agriculture and ports etc were provided via local licences Romania's approach would seem to capture all the benefits of 5G currently foreseen.

The problem with the base station estimate approach is that it does not account for the 5G private networks which may be needed by verticals in rural areas for specific applications.

4.1.5 Can the Digital Decade targets be achieved?

Viewed from this perspective the Digital Decade policy goal of uninterrupted 5G for all urban areas by 2025 and coverage in all populated areas by 2030 does not look so daunting.

5G networks in the lower bands bring benefits for consumers in terms of a moderate speed increase and increased capacity. These are both enhanced by the use of mid-bands in urban areas and while this requires significant expenditure the research on consumer preferences does not suggest a justification for blanket mid-band coverage in rural areas.

Bringing 5G coverage to all populated areas is likely to be done using the lower bands which provide the coverage layer in 4G. While the speeds achieved will be a moderate uplift rather than the step change which the mid-bands can bring, the research above suggests the main benefits of higher speeds and lower latency are for verticals rather than consumers. The key issue is creating a regulatory environment where verticals have a competitive range of options to access optimal 5G. This can be delivered by a combination of local licenses to be used by verticals themselves and third parties in 3.6 GHz and other bands like 3.8-4.2 GHz or 26 GHz; as well as national licences for mobile operators.

Achieving the goal of 5G coverage in all populated areas by 2030 will also be achieved to some extent by the natural cycle of equipment renewal i.e. MNO's standard procedures for replacing outdated equipment. All new telecoms base stations are now ready for at least 5G NSA, and MNOs typically replace them every 5-10 years. This means that within the eight years between now and 2030 the majority of base stations will have been replaced using 5G equipment.

However, there is a danger that consumers in rural areas will not feel significant benefits from 5G unless there is good coverage and sufficient capacity in the lower bands to facilitate a moderate but consistent speed uplift. Improving coverage was a policy emphasis for 4G and should continue for 5G.

4.2 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.

4.2.1 Ericsson, Mobility Report[35], 2022. 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.

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[35] Ericsson, Mobility Report, June 2022

Outcome summary

In Western Europe, 5G subscriptions grew from 5 million in 2020 to 31 million in 2021. This number is expected to significantly increase reaching 150 million subscriptions by the end of 2023, while the penetration is foreseen to reach 82% by the end of 2027, counterbalanced by a decline in 4G subscriptions. In Central and Eastern Europe, the uptake is expected to be slower due to the reluctance of customers to switch to more expensive options as well as slower spectrum allocation processes. Currently, 4G is still the most dominant technology, whilst 5G is expected to be more dominant from 2024 onwards.

4.2.2 GSMA, "The Mobile Economy"[36], 2022. Scope: Global

Methodological framework/approach

Representing the interests of mobile operators worldwide, the GSMA is considered an industry reference point of global mobile operator data, analysis, and forecasts, publishing annually 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 GSMA data[37], in 2021 5G technology comprised 4% of the market in Europe, whereas 4G was still dominant representing 75%, with 3G and 2G accounting respectively for 15% and 6%. In 2025, it is expected a 5G market share of 44%, along with a reduced 4G market share of 51%, whereas 2G and 3G will account together for 5%. Moreover, subscriber penetration is expected to slightly increase from 86% to 87% in 2025, accompanied by an increase in the adoption of smartphones from 79% to 83%.

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[36] GSMA, The Mobile Economy, 2022
[37] Ibid.

Annex I: Latest developments per country

A1.1   Latest commercial developments

Since January 2022, commercial 5G is now available in all 27 EU Member States[38]. The full overview of commercial launches per operators offering 5G services across EU-27, detailing their frequency usage and where applicable, highlighting use of DSS technology, network configuration i.e. 5G Non Standalone (NSA) vs. Standalone (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:

- Germany:
    - In August 2022, German telecoms company 1&1 announced it has conducted the first live test of its in-deployment 5G network as it seeks to become the country's fourth mobile network operator (MNO). 1&1 expects to launch 5G services for home customers by the end of 2022, with mobile 5G for smartphone customers expected to follow in mid-2023.
    - In July 2022, Vodafone Germany announced that its 5G Standalone network now covers 15 million people. The company stated that 5G SA will be activated at each 5G station with the goal of achieving almost nationwide coverage by 2025. The network uses frequencies in both the 3.5GHz and 700MHz bands. Moreover, Vodafone added that it has activated 13,000 additional 5G antennas since the start of the year, bringing the total to 34,000, providing total combined 5G coverage to 55 million Germans.
    - In July 2022, Telekom Deutschland, the domestic fixed and mobile unit of Deutsche Telekom (DT), announced it has expanded the capacity and coverage of its mobile network at 855 locations nationwide. This includes 123 locations with 5G coverage and more than 2,000 areas across Germany using the 3.7GHz band. Across multiple frequency bands, Telekom's 5G network is considered to reach 92% of the population via over 100,000 antennas in more than 34,000 locations.
    - In July 2022, Telefonica Deutschland (O2) announced it has already reached its self-imposed goal of 50% of population coverage through its 5G network, originally foreseen by the end of 2022. Now the telecommunications provider aims to reach 60% of the population by the end of the year. The 5G network currently comprises around 14,000 5G antennas, 6,000 of which operate in the 3.6GHz band, with the remainder using 700MHz frequencies as well as the 1800MHz band through Dynamic Spectrum Sharing (DSS), which combines 4G and 5G.
- Greece
    - In July 2022, Greek fixed and mobile operator Cosmote, part of OTE Group, announced its 5G mobile network reached 70% population coverage. The firm stated it expects to reach 80% coverage level by the end of 2022 and 90% by the end of 2023. Moreover, Cosmote added that the implementation of 5G Stand Alone technology is expected to begin in 2023.

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[38] 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

- Italy

  - In July 2022, Italian fixed and mobile operator WINDTRE selected Ericsson to power its 5G Standalone (SA) network with a dual-mode 5G Core on cloud infrastructure. Building on an earlier 5G agreement signed in April 2018, this new long-term agreement will see WINDTRE bringing its 4G, 5G Non-Standalone (NSA) and 5G SA services into a dual-mode 5G Core combining Evolved Packet Core and 5G Core network functions into a common cloud native platform. The deal also includes end-to-end support services with Ericsson network orchestration and automation.

- Portugal

  - In July 2022, The Portuguese operator NOS announced an investment of EUR 1.8 M to create a 5G Hub in Lisbon to feature experiments and trials of 5G use cases and technologies. The Hub will have the first private Stand Alone 5G Core network to be implemented in Portugal.

- Spain:

  - In July 2022, Orange Spain announced it is currently offering 5G services through frequencies in the 3.5 GHz and 700 MHz bands in 1,222 towns and cities in 51 provinces across the country. According to the European operator, its 5G network infrastructure currently reaches 65% of the Spanish population. The operator announced it plans to reach 1,500 localities by the end of 2022.

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).

Some values regarding the population coverage may appear different than in previous reports. This is due to a change in methodology. While previously, the 5G Observatory relied on data collected by the Observatory, currently all reports will instead 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 (**72%**) in the table below is based on the sum of total number of people covered in each country (computed based on the percentage of population covered, obtained from operator/regulator reports where data was available) divided by the total EU27 population[39, 40].

Table 4: Population coverage

Country	Population coverage (Q3 2022)	People covered (Q3 2022)	Note (Q3 2022 figure)
Austria	76,8%	6.860.286	EC
Belgium	4,3%	491.557	EC
Bulgaria	40,1%	2.773.536	EC

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[39] Population statistics for 2021 accessed via Eurostat

[40] 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 (62% in Q3 2021). Source: ETNO State of Digital 2022

Country	Population coverage (Q3 2022)	People covered (Q3 2022)	Note (Q3 2022 figure)
Croatia	60%	2.421.813	Regulatory agency announcement[41]
Cyprus	100%	896.005	Operator announcement[42]
Czechia	70%	7.491.244	Operator announcement[43]
Denmark	99.3%	5.799.165	Operator announcement[44]
Estonia	33.3%	442.913	Operator announcement[45]
Finland	80%	4.427.034	Operator announcement[46]
France	84%	56.649.263	Operator announcement[47]
Germany	91%	75.671.078	Operator announcement[48]
Greece	70%	7.477.783	Operator announcement[49]
Hungary	17,6%	1.712.616	EC
Ireland	72,1%	3.609.980	EC
Italy	99,7%	59.079.793	EC
Latvia	0%	-	EC
Lithuania	33,3%	930.961	EC
Luxembourg	12,7%	80.611	EC
Malta	20%	103.220	EC
Netherlands	97%	16.951.153	EC
Poland	34,2%	12.941.280	EC
Portugal	75%	7.723.689	Operator announcement[50]
Romania	24,9%	4.777.364	EC
Slovakia	13,8%	753.450	EC
Slovenia	40%	843.591	Operator announcement[51]
Spain	80%	37.915.378	Operator announcement[52]
Sweden	17,7%	1.837.135	EC
EU 26	72%	320.661.898	Calculation only considering countries where information was available.
EU 27	**72%**	**As above**	

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[41] Based on HAKOM (Croatian Regulatory Authority for Network Industries) communication. It is reported that the coverage with the 5G network in Croatia has grown to 60-70%. Following a conservative approach, the lower percentage has been included in the table on population coverage.
[42] Based on CYTA (Cyprus Telecommunication Authority) communication.
[43] Based on Vodafone Czech Republic communication.
[44] Based on TDC NET communication.
[45] Based on Telia Eesti communication. Telia says it covers 1/3rd of Estonia's population with its 5G infrastructure.
[46] Based on Elisa communication.
[47] Based on Free Mobile communication.
[48] Based on Deutsche Telekom communication.
[49] Based on Cosmote communication.
[50] Based on NOS operator communication.
[51] Based on A1 Slovenija communication.
[52] Based on Telefónica communication.

A1.3   5G sector 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 USA 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 a good 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 162,099 5G base stations[53]. If we take into account the country's population, this equals 319 people per one 5G base station. Following South Korea's lead is China, which has now deployed 916,000 base stations. Despite China's significant population size, this works out to 1531 people per base station. The EU ranks just ahead of the US, with 147,308 base stations. This works out to 3039 people per base station.

In terms of assigned 5G spectrum, the 3.6 GHz band has proven to be the most used 5G band globally. All four countries 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 USA. In the EU the situation is a little 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 8 EU MS have assigned the 26 GHz band for which the demand has been lowest so far. See the spectrum assignment chart in 3.

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.

> Estonia has completed its 3.6 GHz band, while Lithuania finalized its 700 MHz and 3.6 GHz bands. These awards showcase how the 3.6 GHz band remains the workhorse 5G band, especially in the EU.
>
> On an international level, India has completed its much-awaited 5G auction in which is sold licences for a wide variety of spectrum bands.

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 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)

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[53] Source: Korea Communications Agency https://en.yna.co.kr/view/AEN20210927001500320

In the years following the release of the 5G Action Plan and the adoption of the EECC, the Commission successfully harmonised frequencies in these bands. The 26 GHz band was the final band to be harmonised. This occurred in May 2019 with a Commission Implementing Decision (EU) 2019/784[54] . Although the technical conditions for these three bands have been harmonised at an EU level, not all Member States have assigned the pioneer bands despite deadlines set out in the EECC stating that they should assign 700 MHz and 3.6 GHz by the 31 December 2020 provided that there is market demand and no significant constrains to clear the bands.

EU27 trends
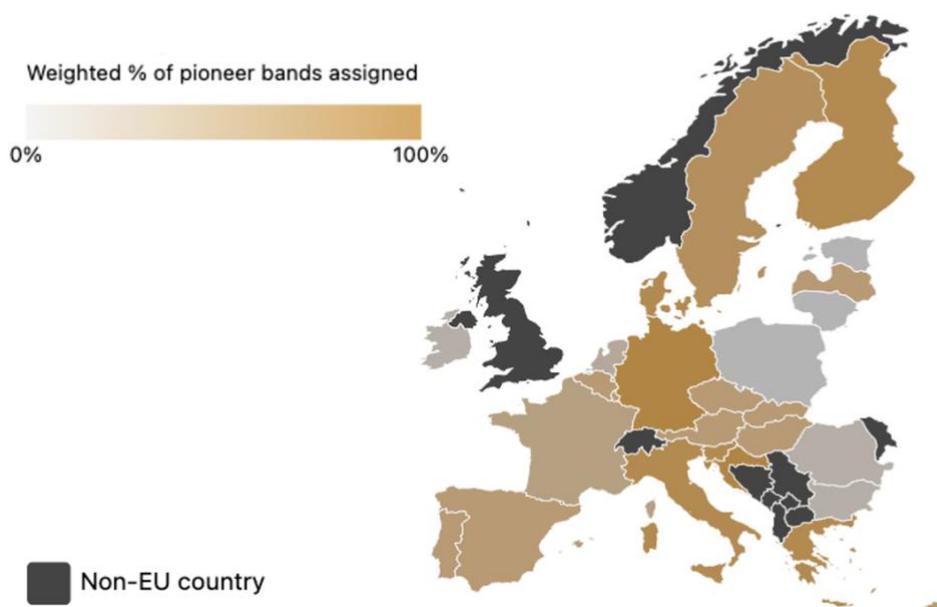
Source: Spectrum assignment data is based on the results of a European Commission survey of all 27 EU countries.

Pioneer bands assigned

The table below outlines how much spectrum each Member State has assigned in the pioneer bands. To achieve 100%, a country must assign 60 MHz in the 700 MHz band; 400 MHz in the 3.6 GHz band and 1000 MHz in the 26 GHz band. 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. 25 out of 27 Member States have assigned at least 50% of the targeted spectrum in this band. The second most assigned band is the 700 MHz band, which has been majority-assigned in 21 out of 27 Member States. The least assigned band is the 26 GHz band. The 26 GHz band has only been majority-assigned in eight Member States. Finally, one Member State has failed to assign any of the pioneer bands.

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

Table 5: Pioneer bands assigned in the EU[55]

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%	92.50%	0.00%
Bulgaria	0.00%	75.00%	0.00%
Croatia	100.00%	100.00%	100.00%
Cyprus	100.00%	100.00%	0.00%
Czech Republic	100.00%	100.00%	0.00%
Denmark	100.00%	97.50%	100.00%
Estonia	0.00%	97.50%	0.00%
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	0.00%	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%	0.00%	0.00%
Portugal	83.33%	100.00%	0.00%
Romania	0.00%	65.00%	0.00%
Slovakia	100.00%	100.00%	0.00%
Slovenia	100.00%	95.00%	100.00%
Spain	100.00%	95.00%	0.00%

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[55] Source: European Commission data collected for The Digital Economy and Society Index (DESI); supplemented with data collected by the 5G Observatory for the most recent auctions.

Sweden	66.67%	90.00%	85.00%
Number of countries that have assigned at least 50% of the band	21	25	8

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 6: 5G bands awarded in major economies outside of the EU[56]

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

Internationally, 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 USA. Japan is leading with

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[56] Source: Data on international spectrum assignments is sourced from the Policy Tracker database.

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. An average EU country has 312 MHz of mid-band spectrum assigned.

Low-band spectrum has proven to be slightly less popular, as both South Korea and Japan have yet to assign frequencies in this range. In fact, in South Korea's initial 5G auction in 2016, the 700 MHz mid-band spectrum remained entirely unsold.

A recent development in China however could indicate low-band spectrum 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 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 now appears that the band's popularity may have peaked as indicated by the lack of 26 GHz assignments in many European countries.

Figure 2: Amount of 5G spectrum assigned in international markets[57]

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 right side of the scoreboard were included in this. All of these bands are used to provide 5G services in their respective country.

USA

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.[58] 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 the table below.

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.[59] 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. [60] 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.

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[58] https://www.fcc.gov/oet/maps/areas

[59] https://www.lightreading.com/5g/inside-the-messy-world-of-t-mobiles-midband-5g-spectrum-licenses/d/d-id/774745

[60] https://www.fcc.gov/reports-research/reports/consolidated-communications-marketplace-reports/CMR-2020

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	

European Union

Because spectrum assignments differ amongst EU Member States, the number used in the scoreboard is an average. To calculate this average, the total amount of spectrum assigned in each of the 5G pioneer bands for each country was added up and then divided by the total number of Member States.

Spectrum assignment data was retrieved from the 5G readiness indicator which is produced for the Digital Economy and Society Index (DESI).

This data represents an average but the situation in individual countries may be very different. To see a full breakdown of spectrum assignments in the EU, please refer to section 5.4.

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 has 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, 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 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 policy initiative, the European Commission has put emphasis on the importance of the digital transformation of business. The communication outlines 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 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 dedicated spectrum?

The licensing model (or model**s**) needed for 5G verticals is on an ongoing debate in the spectrum management world. 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 dedicated spectrum, but there are also arguments against this. The mobile industry association, the GSMA, has warned[61] that doing so runs a serious risk of fragmenting the already-scarce 5G spectrum. This makes it harder for operators to achieve contiguous blocs – which will then have a result in reduced speeds and quality of service (QoS). Dedicating spectrum to verticals may also result in under-utilisation of 5G frequencies, as those frequencies cannot be reallocated dynamically to accommodate fluctuations in traffic.

Despite this ongoing debate, an increasing number of countries are adopting a local licensing model that use 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.[62]

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

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

Belgium and the Netherlands proposed a similar approach to Germany. Sweden has also adopted a local licensing model in the 3.6 GHz and 26 GHz bands.[63]

Although many European countries have adopted the approach of dedicating spectrum for verticals, the exact portions of spectrum used for these licences varies 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.

The UK was the first European country to release[64] 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.[65] Most recently, Norway has begun offering free trial licences in the 3.8-4.2 GHz range.[66]

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[61] https://www.gsma.com/spectrum/resources/mobile-networks-for-verticals/
[62] https://www.statista.com/statistics/295519/germany-share-of-economic-sectors-in-gross-domestic-product/
[63] https://pts.se/sv/nyheter/radio/2021/pts-oppnar-for-tilldelning-av-lokala-tillstand-i-37-ghz--och-26-ghz-banden/
[64] https://www.policytracker.com/ofcom-makes-3-8-4-2-ghz-available-for-private-networks/
[65] https://www.policytracker.com/france-seeks-to-expand-industrial-5g/
[66] https://www.policytracker.com/norway-offers-free-3-8-4-2-ghz-private-network-test-licences-to-businesses/

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.[67] 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[68] a significant number of major companies have already acquired a spectrum licence.[69] 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 later this year for campus networks at a fee of up to USD 88 per block.[70]

In the US, the FCC is hoping that it's three tier CBRS (Citizens Broadband Radio Service) approach will allow enterprises to deploy private 4G and 5G networks and verticals. Agricultural equipment manufacturer John Deere has already announced plans to use its CBRS spectrum to install a private 5G network in its factories.[71]

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 has 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.[72]
- **Belgium**: Proximus and the Port of Antwerp have announced a 6-month trial of a private 5G network.[73]

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[67] https://www.policytracker.com/3-8-4-2-ghz-gains-momentum-after-rspg-backing/
[68] https://www.policytracker.com/japan-awards-its-first-commercial-licences-for-local-5g/
[69] https://www.policytracker.com/japan-awards-its-first-commercial-licences-for-local-5g/
[70] https://www.policytracker.com/south-korea-to-allocate-local-5g-spectrum-for-the-first-time/
[71] https://www.fiercewireless.com/private-wireless/john-deere-foresees-private-5g-at-its-factories-worldwide
[72] https://www.telekom.com/en/media/media-information/archive/port-of-hamburg-is-ready-for-5g-574536
[73] 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

- **Belgium**: 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 and cameras and quay sensors.[74]
- **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.[75]
- **Spain**: Telefónica and APM Terminals have trialled 5G at the port of Barcelona. This test included connecting cranes, vehicles and people.[76]

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.[77]
- **Norway**: Ericsson, Telia and the Norwegian University of Science and Technology have carried out a demonstration of a 5G autonomous ferry.[78]
- **Germany:** Sony and Vodafone have conducted remote 5G car trials in Aldenhoven, Germany.[79]
- **Germany**: Volkswagen and Nokia trial private 5G network at manufacturing plant.[80]
- **Finland**: Nokia to build private 5G network in Finnish goldmine.[81]
- **Germany**: Vodafone Germany launches standalone 5G network at a University Hospital in Kiel.[82]

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 networks

Deployment of 5G private 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. The analysis from last quarterly report can be found on the website here.

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

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[74] https://citymesh.com/en/news/port-of-zeebrugge-accelerates-innovation-by-investing-in-a-5g-network

[75] https://www.ericsson.com/en/cases/2017/5g-telia-tallink

[76] 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

[77] 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/

[78] https://www.teliacompany.com/en/news/news-articles/2019/telia-tests-5g-powered-autonomous-vessels/

[79] https://5gobservatory.eu/sony-and-vodafone-conduct-remote-5g-car-trial-in-germany/

[80] https://5gobservatory.eu/volkswagen-and-nokia-trial-private-5g-network-at-manufacturing-plant/

[81] https://5gobservatory.eu/nokia-to-build-private-5g-network-in-finnish-goldmine/

[82] https://5gobservatory.eu/vodafone-germany-launches-5g-standalone-network-at-university-hospital/

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

There have been a number of major procurements by large operators across EU countries in recent months. The table of which vendors have won contracts for the provision of 5G network builds across Member State countries is available to search and extract on the 5G Observatory website.

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 in June 2021 the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)[83] to provide an opinion on the need for a technical revision of the annexes to the Council Recommendation 1999/519/EC[84] and Directive 2013/35/EU[85] 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 the light of the latest scientific evidence with regard to frequencies between 1 Hz and 100 kHz. In this regard, the SCHEER Committee has issued a preliminary Opinion[86] which is now open for public consultation for feedback from the scientific community and stakeholders. As for the second opinion, it is scheduled to be delivered in July 2023.

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 7: 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

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

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

[85] 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

[86] https://health.ec.europa.eu/system/files/2022-08/scheer_o_044.pdf

Countries	ICNIRP limits used?	Details
Czech Republic	Yes	ICNIRP limits adopted in 2000
Denmark	Yes	
Estonia	Yes	ICNIRP limits adopted in 2002. No permit for ERP power <100W
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):

- No significant updates in the past three months

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.

Since the publication of the last report, there have been no new developments in the implementation of 5G security toolbox amongst Member States.

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 (mobile 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.

- In its latest report, ETNO dedicates one chapter to how the European telecommunication networks can help meet sustainability targets. They re-emphasised the importance of 5G deployments in improving network efficiency in terms of power consumption, in which 5G technology can be up to 90% more efficient in terms of mobile data transmission per one kilowatt-hour of energy relative to 4G. Furthermore, in parallel with increasing 5G deployment, energy consumption dropped by 4% across ETNO member countries, which underlines the potential of expanding telecommunication consumption via 5G without adding to energy consumption.

- From the private sector, Ericsson recently announced the installation of a triple-band, tri-sector 5G radio that reduces energy consumption by 40% as well as minimising site footprint relative to the previous technology. The spectrum capabilities of these new radios would boost 5G deployments and expand their coverage while remaining sustainable and cost-effective.

Annex II: Detailed country situation

The detailed country situation is also available online via this link.

Austria

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	1,252[87]	
	- Network performance: speed	84.73 Mbps[88]	
	- Current usage of 5G pioneer bands	65.83%[89]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	76.8% (overall) 36.3% (rural)[90]	
	- 5G corridors	Brenner Corridor IT-AT-DE[91]	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	**Implemented[92]**	
	- 5G verticals (trials & initiatives	None identified	
Other (indirectly relevant) targets[93]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	53%**[94]**	
	-		

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[87] Source: EC

[88] Overall mobile data speed 08/22. Source: Ookla

[89] 1000 MHz temporary licences in 26 GHz band to academia in order to enable 26 GHz for a 5G launch. The 10 MHz as guard band in 3.6 GHz band.
Source: EC.

[90] Source: DESI (2021 data)

[91] https://5gcarmen.eu/

[92] Regional licences in 3400-3800 MHz

[93] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[94] €1.2 billion (improved digital connectivity; easing access to digital education; boosting future-oriented, transformative and innovative research)
Source: austria-recovery-resilience-factsheet_en.pdf (europa.eu)

Belgium

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	1,081[95]	
	- Network performance: speed	99.44 Mbps[96]	
	- Current usage of 5G pioneer bands	3.33%[97]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	4.25% (overall) 0% (rural)[98]	
	- 5G corridors	Antwerp-Rotterdam-North Sea (Vlissingen) BE-NL[99]	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives)	2 trials identified	
Other (indirectly relevant) targets[100]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	27%[101]	

Bulgaria

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	3,216[102]	
	- Network performance: speed	216.60 Mbps[103]	

[95] Source: EC.
[96] Overall mobile data speed 08/22. Source: Ookla
[97] 150MHz in 3.6GHz temporary licences to enable 5G launch.
Source: EC.
[98] Source: DESI (2021 data)
[99] https://5g-ppp.eu/5g-blueprint/
[100] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.
[101] € 1.1 billion (reinforcing cyber resilience and security; education 2.0; e-services)
Source: belgium-recovery-resilience-factsheet_en.pdf (europa.eu)
[102] Source: EC.
[103] Overall mobile data speed 08/22. Source: Ookla

	- Current usage of 5G pioneer bands	25%[104]	■
	- Number of km served across main transport paths (progress of deployments)	No data reported	■
	- Population coverage	40.1% (overall) 8.55% (rural)[105]	■
	- 5G corridors	Thessaloniki, Sofia-Belgrade EL-BG-RS[106]	■
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	■
	- 5G verticals (trials & initiatives)	1 trial identified	■
Other (indirectly relevant) targets[107]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	22%[108]	■

Croatia

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	2,711[109]	■
	- Network performance: speed	111.83 Mbps[110]	

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[104] Note:

- In 700 MHz band there is no interest in acquiring spectrum during 2020. A new public consultation is planned in 2022. The probable year announced by the operators for the acquisition of spectrum is 2023.
- In 3.4-3.8 GHz band in 2021 three operators acquired licences, total 3x100 MHz. In band 3.4-3.6 GHz there are free 70 MHz, 30 MHz are used for national security purposes. In 2023 a new public consultation is planned.
- In 26 GHz band available spectrum is 2.578 GHz. Consultations held at the end of 2020 - beginning of 2021, declared fundamental interest. There is use of fixed networks (point-to-point and FWA), envisaged managed shared use of fixed and terrestrial networks. In 2022, a new public consultation is planned.
Source: EC.

[105] Source: DESI (2021 data)

[106] https://digital-strategy.ec.europa.eu/en/news/new-5g-cross-border-corridor-connected-and-automated-mobility-announced-digital-assembly-2018

[107] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[108] Source: https://www.nextgeneration.bg/upload/36/Bulgaria_Recovery_and_Resilience_Plan_ENG.pdf

[109] Source: EC.

[110] Overall mobile data speed 08/22. Source: Ookla

Target	Indicator(s)	Performance	On Track
	- Current usage of 5G pioneer bands	100%[111]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	60% (overall)[112]	
	- 5G corridors	No agreement/project identified	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Proposed[113]	
	- 5G verticals (trials & initiatives)	0 trials identified	
Other (indirectly relevant) targets[114]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	20%[115]	
	-		

Cyprus

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	965[116]	
	- Network performance: speed	172.90 Mbps[117]	
	- Current usage of 5G pioneer bands	66.67%[118]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	100% (overall)[119]	

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[111] In band 3.4-3.6 GHz 80 MHz is licensed for 5G to regional operators and 120 MHz to national operators. Source: EC.

[112] Source: HAKOM (Croatian Regulatory Authority for Network Industries)

[113] Regional licences in 3410-3800 MHz

[114] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[115] € 497 million (digital transition of the public administration; digital connectivity of rural areas; digitalisation of higher education) Source: com-2021-401-croatia_factsheet_en.pdf (europa.eu)

[116] Source: EC.

[117] Overall mobile data speed 08/22. Source: Ookla

[118] Source: EC.

[119] Source: CYTA (Cyprus Telecommunication Authority)

Target	Indicator(s)	Performance	On Track
	- 5G corridors	No agreement/project identified	yellow
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	red
	- 5G verticals (trials &) initiatives	0 trials identified	
Other (indirectly relevant) targets[120]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	23%[121]	green
	-		

Czechia

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	6,080[122]	green
	- Network performance: speed	68.67 Mbps[123]	
	- Current usage of 5G pioneer bands	66.67%[124]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	yellow
	- Population coverage	70% (overall)[125]	
	- 5G corridors	Czech-Bavarian 5G corridor[126]	
"digital technologies including 5G"…."at the core of new	- specific provisions for verticals	**None**	red

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[120] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.
[121] € 260 million (supporting connectivity; digitisation of public services; promoting digital educations and skills; enabling the digital health transition)
Source: com-2021-398-cyprus_factsheet_en.pdf (europa.eu)
[122] Source: EC.
[123] Overall mobile data speed 08/22. Source: Ookla
[124] 1000 MHz in 26GHz band is reserved for experimental individual authorisation.
Source: EC.
[125] Source: Vodafone Czech Republic
[126] https://www.mpo.cz/en/guidepost/for-the-media/press-releases/thanks-to-the-cooperation-between-the-czech-republic-and-bavaria--europe-will-be-better-digitally-interconnected---253192/

products, new manufacturing processes and new business models" by 2030	- 5G verticals (trials & initiatives	0 trials identified	(red)
Other (indirectly relevant) targets[127]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	22%[128]	(green)

Denmark

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	6,300[129]	(green)
	- Network performance: speed	176.83 Mbps[130]	
	- Current usage of 5G pioneer bands	99.17%[131]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	99.3% (overall)[132]	
	- 5G corridors	Nordic Way2 NO-SE-FI-DK[133]	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Proposed[134]	(yellow)
	- 5G verticals (trials & initiatives	0 trials identified	

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[127] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.
[128] € 1.7 billion (digital skills for the digital age; e-services; fostering the digital transition of the economy)
Source: com-2021-419-czechia_factsheet_en.pdf (europa.eu)
[129] Source: EC.
[130] Overall mobile data speed 08/22. Source: Ookla
[131] The 10 MHz as guard band in 3.6 GHz band.
Source: EC.
[132] Source: TDC NET
[133] https://www.nordicway.net/
[134] 3740–3800 MHz under investigation

Other (indirectly relevant) targets[135]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	25%[136]	

Estonia

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	0[137]	
	- Network performance: speed	85.46 Mbps[138]	
	- Current usage of 5G pioneer bands	0%	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	33.3% (overall)[139]	
	- 5G corridors	5G-Routes (CAM, Rail, maritime) EE-LT-LV[140]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives)	3 trials identified	
Other (indirectly relevant) targets[141]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	22%[142]	

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[135] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[136]€ 89 million (digital strategy; high-speed internet; SME's digital transition)

Source: denmark-recovery-resilience-factsheet_en.pdf (europa.eu)

[137] Source: EC.

[138] Overall mobile data speed 08/22. Source: Ookla

[139] Source: Telia Eesti

[140] https://www.5g-routes.eu/

[141] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[142] € 204 million (Digitalising companies; Digitalising public administration; Increasing connectivity).

Source: factsheet-estonia_en.pdf (europa.eu)

Finland

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	9,000[143]	
	- Network performance: speed	110.35 Mbps[144]	
	- Current usage of 5G pioneer bands	99.17%[145]	
	- Number of km served across main transport paths (progress of deployments)	In late 2020, 100 Mbps 5G networks covered 17% of Finland's main roads and highways and 18% of the railway network.[146]	
	- Population coverage	80% (overall)[147]	
	- 5G corridors	- Nordic Way2 NO-SE-FI-DK [148] - E8 "Aurora Borealis" NO-FI	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Implemented[149]	
	- 5G verticals (trials & initiatives)	4 trials identified	
Other (indirectly relevant) targets[150]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	27%[151]	

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[143] Source: EC.

[144] Overall mobile data speed 08/22. Source: Ookla

[145] The 10 MHz as guard band in 3.6 GHz band. The 26 GHz area has been fully assigned, in total 3250 MHz; 24,25-25,1 GHz for local networks and 25,1-27,5 GHz for operators.
Source: EC.

[146] Fast 5G already available to more than 1.8 million Finnish households | Traficom

[147] Source: Elisa

[148] https://www.nordicway.net/

[149] 24.25–25.1 GHz

[150] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[151] € 301 (Digital connectivity; Rail services fit for future; Digital innovations for social welfare and health care services; Continuous learning; Recruiting international talent). Source: factsheet_finland_en.pdf (europa.eu)

France

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	39,502[152]	
	- Network performance: speed	108.22 Mbps[153]	
	- Current usage of 5G pioneer bands	59.17%[154]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	84% (overall)[155]	
	- 5G corridors	Barcelona-Perpignan, Santander-Biarritz ES-FR [156]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Implemented[157]	
	- 5G verticals (trials & initiatives)	3 trials identified	
Other (indirectly relevant) targets[158]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	21%[159]	
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[152] Source: EC.
[153] Overall mobile data speed 08/22. Source: Ookla
[154] Source: EC.
[155] Source: Free Mobile
[156] 5GMED – Future mobility in the Mediterranean Cross Border Corridor
[157] 2575–2615 MHz
[158] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.
[159] € 1 billion (digitalisation of companies; digitalisation of schools; digitalisation of public administration). Source: france-recovery-resilience-factsheet_en.pdf (europa.eu)

Germany

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	65,905[160]	
	- Network performance: speed	99.10 Mbps[161]	
	- Current usage of 5G pioneer bands	100%[162]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	91% (overall)[163]	
	- 5G corridors	- Brenner Corridor IT-AT-DE[164] - Metz-Merzig-Luxembourg FR-DE-LU[165] - CZ-Bavaria: Prague-Munich	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Implemented[166]	
	- 5G verticals (trials & initiatives)	17 trials identified	
Other (indirectly relevant) targets[167]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	52%[168]	
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[160] Source: EC.

[161] Overall mobile data speed 08/22. Source: Ookla

[162] Source: EC.

[163] Source: Deutsche Telekom

[164] Home page - 5G CARMEN

[165] 5GCroCo

[166] 3700–3800 MHz & 26 GHz

[167] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[168] € 5.25 billion (investment in microelectronics and communication technologies; next generation cloud infrastructures and services; digitisation of public services) Source: germany-recovery-resilience-factsheet_en.pdf (europa.eu)

Greece

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	4,666[169]	
	- Network performance: speed	93.39 Mbps[170]	
	- Current usage of 5G pioneer bands	99.17%[171]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	66.1% (overall) 17.3% (rural)[172]	
	- 5G corridors	Thessaloniki, Sofia-Belgrade EL-BG-RS	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	proposed[173]	
	- 5G verticals (trials & initiatives)	2 trials identified	
Other (indirectly relevant) targets[174]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	23.3%[175]	

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[169] Source: EC.

[170] Overall mobile data speed 08/22. Source: Ookla

[171] 3400-3410MHz reserved for 5G pilot, testing & research applications.
Source: EC.

[172] Source: Cosmote

[173] Greece has reserved spectrum in 733-736 MHz and 788-791 MHz, 3400-3410 MHz, as well as 200 MHz from the higher 26 GHz band.

[174] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[175] € 2.1 billion (development of 5G networks; digital transformation of public sector; digitalisation of businesses; digital transformation of education). Source: greece-recovery-resilience-factsheet_en.pdf (europa.eu)

Hungary

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	1,610[176]	
	- Network performance: speed	85.66 Mbps[177]	
	- Current usage of 5G pioneer bands	60.28%[178]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	17.6% (overall) 7.03% (rural)[179]	
	- 5G corridors	None identified	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives)	1 trial identified	
Other (indirectly relevant) targets[180]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	Recovery and Resilience Plan not approved yet	

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[176] Source: EC.

[177] Overall mobile data speed 08/22. Source: Ookla

[178] The 10 MHz as guard band in 3.6 GHz band. Regarding 26 GHz spectrum band, NMHH has already conducted 2 public consultations and no need for this band was indicated from the operators. NMHH held the 3rd public consultation on 22nd March 2022 about the use of this spectrum band. The analyses of the conclusion of the 3rd public consultation is underway. Source: EC.

[179] Source: DESI (2021 data)

[180] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

Ireland

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	2,830[181]	
	- Network performance: speed	68.83 Mbps[182]	
	- Current usage of 5G pioneer bands	29.17%[183]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	72.1% (overall) 36.2% (rural)[184]	
	- 5G corridors	None identified	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives	None identified	
Other (indirectly relevant) targets[185]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	32%[186]	

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[181] Source: EC.

[182] Overall mobile data speed 08/22. Source: Ookla

[183] The 10 MHz as guard band in 3.6 GHz band. Multi-band spectrum award which includes the 700 MHz band is under legal appeal. Recent report indicates no user cases for the 26 GHz band and no justification for its award. 60 MHz band in 700 MHz band issued to three MNO's under emergency COVID legislation - full technology and service neutrality. Source: EC.

[184] Source: DESI (2021 data)

[185] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[186] € 291 million (supporting the digitalisation of the public sector; digitisation of businesses; promoting digital skills). Source: com-2021-419-ireland_factsheet_en.pdf (europa.eu)

Italy

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	53,940[187]	
	- Network performance: speed	60.91 Mbps[188]	
	- Current usage of 5G pioneer bands	60%[189]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	99.7% (overall) 99.8% (rural)[190]	
	- 5G corridors	Brenner Corridor IT-AT-DE[191]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives)	9 trials identified	
Other (indirectly relevant) targets[192] -	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	25%[193]	

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[187] No data available.
Source: EC.
[188] Overall mobile data speed 08/22. Source: Ookla
[189] Source: EC.
[190] Source: DESI (2021 data)
[191] Home page - 5G CARMEN
[192] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.
[193] € 26.1 billion (development of ultra-fast and 5G networks; digitalisation of businesses; digitalisation of the public administration).
Source: italy-recovery-resilience-factsheet_en.pdf (europa.eu)

Latvia

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	245[194]	
	- Network performance: speed	71.15 Mbps[195]	
	- Current usage of 5G pioneer bands	62.50%[196]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	0% (overall) 0% (rural)[197]	
	- 5G corridors	5G-Routes (CAM, Rail, maritime) EE-LT-LV[198]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives)	None	
Other (indirectly relevant) targets[199]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	21%[200]	
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[194] Source: EC.

[195] Overall mobile data speed 08/22. Source: Ookla

[196] LV has recently released 50 MHz in 3.6-3.8 GHz band, so only 350 MHz remain awarded under 5G conditions. 112 MHz in 26GHz band has been assigned to Fixed Links.
Source: EC.

[197] Source: DESI (2021 data)

[198] Home - 5g routes project (5g-routes.eu)

[199] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[200] € 232.5 million: businesses digitalisation; digital upskilling; 5G deployment.

Source: latvia-recovery-resilience-factsheet_en.pdf (europa.eu)

Lithuania

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	1,090[201]	
	- Network performance: speed	84.67 Mbps[202]	
	- Current usage of 5G pioneer bands	5.42%[203]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	33.3% (overall) 0.8% (rural)[204]	
	- 5G corridors	- 5G-Routes (CAM, Rail, maritime) EE-LT-LV[205] - LT-PL Via Baltica Kaunas-Warsaw	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives	1 trial identified	
Other (indirectly relevant) targets[206]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	32%[207]	

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[201] Source: EC.

[202] Overall mobile data speed 08/22. Source: Ookla

[203] 100 MHz in 3.6-3.8 GHz band and 2x10 MHz in 700 MHz band to test 5G technology, temporary licence 65 MHz within the band 3.6-3.8 GHz has been assigned for one operator under technology neutral licence and partly used for 5G as well. Spectrum auctions in the 700 MHz and 3.4-3.7 GHz will take place during the Q2 and Q3 of 2022. Source: EC.

[204] Source: DESI (2021 data)

[205] Home - 5g routes project (5g-routes.eu)

[206] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[207] € 307 million: tailored technology for the Lithuanian language; customer-oriented services; 5G networks. Source: com-2021-386-lithuania_factsheet_en.pdf (europa.eu)

Luxembourg

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	157[208]	🟩
	- Network performance: speed	130.68 Mbps[209]	
	- Current usage of 5G pioneer bands	60.83%[210]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	🟨
	- Population coverage	12.7% (overall) 6.67% (rural)[211]	
	- 5G corridors	Metz-Merzig-Luxembourg FR-DE-LU[212]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	🟥
	- 5G verticals (trials & initiatives)	0 trials identified	
Other (indirectly relevant) targets[213]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	32%[214]	🟩
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[208] Source: EC.

[209] Overall mobile data speed 08/22. Source: Ookla

[210] Source: EC.

[211] Source: DESI (2021 data)

[212] 5GCroCo

[213] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[214] € 23.8 million: secure communications; digital services for public; digitise healthcare.

Source: luxembourg-recovery-resilience-factsheet_en.pdf (europa.eu)

Malta

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	393[215]	
	- Network performance: speed	79.07 Mbps[216]	
	- Current usage of 5G pioneer bands	25%[217]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	20% (overall) 0% (rural)[218]	
	- 5G corridors	None identified	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives	0 trials identified	
Other (indirectly relevant) targets[219]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	26%[220]	

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[215] Source: EC.

[216] Overall mobile data speed 08/22. Source: Ookla

[217] The MCA has assigned three spectrum licences in the 3.6 GHz 5G pioneer band following an expression of interest in such spectrum by the MNOs currently operating in Malta. Malta has currently issued a trial licence in the 700 MHz band to one of the MNOs for test and trial purposes.
Source: EC.

[218] Source: DESI (2021 data)

[219] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[220] € 59 million: digitalisation of public administration and public services; digitalisation of companies; digitalisation of the justice system. Source: factsheet-malta_en_0.pdf (europa.eu)

Netherlands

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	12,476[221]	
	- Network performance: speed	121.29 Mbps[222]	
	- Current usage of 5G pioneer bands	33.33%[223]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	97% (overall) 96.8% (rural)[224]	
	- 5G corridors	Antwerp-Rotterdam-North Sea (Vlissingen) BE-NL[225]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Proposed[226]	
	- 5G verticals (trials & initiatives)	4 trials identified	
Other (indirectly relevant) targets[227]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	26%[228]	

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[221] Source: EC.

[222] Overall mobile data speed 08/22. Source: Ookla

[223] Source: EC.

[224] Source: DESI (2021 data)

[225] 5G-BLUEPRINT ‹ 5G-PPP

[226] Plans to set aside 3750–3800 MHz

[227] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[228] € 622 million: quantum technology; digital skills for the digital age; improving rail connectivity. Source: 2022_09_08_factsheet_commission_endorses_nl_rrp.pdf (europa.eu)

Poland

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	21,912[229]	
	- Network performance: speed	55.85 Mbps[230]	
	- Current usage of 5G pioneer bands	0%[231]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	34.2% (overall) 13.5% (rural)[232]	
	- 5G corridors	LT-PL Via Baltica Kaunas-Warsaw	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Proposed[233]	
	- 5G verticals (trials & initiatives)	0 trials identified	
Other (indirectly relevant) targets[234]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	21.3%[235]	

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[229] Source: EC.

[230] Overall mobile data speed 08/22. Source: Ookla

[231] Source: EC.

[232] Source: DESI (2021 data)

[233] Considering allocation in 3.5 GHz

[234] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[235] € 4.2 billion: access to broadband infrastructure in rural areas; digital skills for the digital age; e-services; cybersecurity. Source: recoveryandresilience_poland-factsheet_en.pdf (europa.eu)

Portugal

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	4,634[236]	
	- Network performance: speed	112.02 Mbps[237]	
	- Current usage of 5G pioneer bands	61.11%[238]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	75% (overall)[239]	
	- 5G corridors	Porto-Vigo, Evora-Merida PT-ES[240]	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives)	2 trials identified	
Other (indirectly relevant) targets[241]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	22%[242]	
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[236] Source: EC.

[237] Overall mobile data speed 08/22. Source: Ookla

[238] Updated with the recent multiband auction (700 MHz / 900 MHz / 1800 MHz / 2.1 GHz / 2.6 GHz / 3.6 GHz). Source: EC.

[239] Source: NOS operator communication.

[240] 5G-MOBIX

[241] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[242] € 1.5 billion: vocational education and training institutions; digital health transition; digital transition of businesses. Source: portugal-recovery-resilience-factsheet_en.pdf (europa.eu)

Romania

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	1,181[243]	
	- Network performance: speed	67.60 Mbps[244]	
	- Current usage of 5G pioneer bands	21.67%[245]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	24.9% (overall) 2.04% (rural)[246]	
	- 5G corridors	None identified	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	
	- 5G verticals (trials & initiatives)	2 trials identified	
Other (indirectly relevant) targets[247]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	21%[248]	

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[243] Source: EC.

[244] Overall mobile data speed 08/22. Source: Ookla

[245] ANCOM conducted in 2021 a multiband auction that also included the 90 MHz still free in the 3.4-3.6 GHz band. Only 5 MHz were awarded with this occasion, to a new entrant in the band.
Source: EC.

[246] Source: DESI (2021 data)

[247] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[248] € 2.8 billion: digitalisation of public administration; digitalisation of health; digitalisation of education. Source: factsheet-romania_en.pdf (europa.eu)

Slovakia

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	1,070[249]	🟩
	- Network performance: speed	68.72 Mbps[250]	
	- Current usage of 5G pioneer bands	66.67%[251]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	🟨
	- Population coverage	13.8% (overall) 2.43% (rural)[252]	
	- 5G corridors	None identified	
"digital technologies including 5G"…."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	None	🟥
	- 5G verticals (trials & initiatives)	0 trials identified	
Other (indirectly relevant) targets[253]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	21%[254]	🟩

[249] Source: EC.
[250] Overall mobile data speed 08/22. Source: Ookla
[251] Source: EC.
[252] Source: DESI (2021 data)
[253] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.
[254] € 466 million: better services for citizens and businesses; digital infrastructure in schools; digitalising businesses. Source: slovakia-recovery-resilience-factsheet_en.pdf (europa.eu)

Slovenia

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	935[255]	
	- Network performance: speed	84.86 Mbps[256]	
	- Current usage of 5G pioneer bands	98.33%[257]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	40% (overall)[258]	
	- 5G corridors	None identified	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	No data reported	
	- 5G verticals (trials & initiatives	0 trials identified	
Other (indirectly relevant) targets[259]	- Member States spending on to the digital priority (%Recovery and Resilience Plans). -	21%[260]	

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[255] Source: EC.

[256] Overall mobile data speed 08/22. Source: Ookla

[257] The lower 20 MHz as guard band in 3.6 GHz planned for local use by auction in 2022/2023.
Source: EC.

[258] Source: A1 Slovenija

[259] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[260] € 241 million: strengthening digital literacy through education and life-long learning; digital health transformation; digital transition of businesses. Source: com-2021-384-slovenia_factsheet_en_0.pdf (europa.eu)

Spain

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	17,649[261]	
	- Network performance: speed	61.50 Mbps[262]	
	- Current usage of 5G pioneer bands	65%[263]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	80% (overall)[264]	
	- 5G corridors	Barcelona-Perpignan, Santander-Biarritz ES-FR[265]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Proposed[266]	
	- 5G verticals (trials & initiatives)	16 trials identified	
Other (indirectly relevant) targets[267]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	28%[268]	

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[261] Source: EC.

[262] Overall mobile data speed 08/22. Source: [Ookla](#)

[263] A Public Consultation on the existing demand and on the management and exploitation model of the 26 GHz frequency band (24.25 to 27.50 GHz) was launched in December 2021 and lasted till the end of January 2022. The report about the main information received from the contributions to this public consultation will be published in April. Currently, the band is available for tests applications having issued some. During 2022 it is foreseen to hold an auction for the band.
Source: EC.

[264] Source: [Telefónica](#)

[265] [5GMED – Future mobility in the Mediterranean Cross Border Corridor](#)

[266] Reports for industry allocation in 26 GHz

[267] Other targets identified:
-all European households are covered by a Gigabit network, and
-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[268] € 9.8 billion: digital skills training; digitalisation of public administration; digitalisation of business. Source: [spain-recovery-resilience-factsheet_en.pdf (europa.eu)](#)

Sweden

Target	Indicator(s)	Performance	On Track
-all populated areas are covered by 5G by 2030	- Number of base stations deployed (progress of deployments)	0[269]	
	- Network performance: speed	159.39 Mbps[270]	
	- Current usage of 5G pioneer bands	80.56%[271]	
	- Number of km served across main transport paths (progress of deployments)	No data reported	
	- Population coverage	17.7% (overall) 0.48% (rural)[272]	
	- 5G corridors	Nordic Way2 NO-SE-FI-DK[273]	
"digital technologies including 5G"...."at the core of new products, new manufacturing processes and new business models" by 2030	- specific provisions for verticals	Implemented [274]	
	- 5G verticals (trials & initiatives)	3 trials identified	
Other (indirectly relevant) targets[275]	- Member States spending on to the digital priority (%Recovery and Resilience Plans).	20.5%[276]	
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[269] Source: EC.

[270] Overall mobile data speed 08/22. Source: Ookla

[271] Part of 3.4-3.8 GHz band auctioned on 19/1/21, 40 MHz in 3,76-3,8 GHz and 850 MHz in 26 GHz band, released for local licences on 22/11/21. Source: EC.

[272] Source: DESI (2021 data)

[273] Nordicway2

[274] 3720–3800 MHz

[275] Other targets identified:

-all European households are covered by a Gigabit network, and

-In their Recovery and Resilience Plans, Member States are committed to dedicate at least 20% to the digital priority.

[276] € 527 million: digital connectivity; digitalisation of public administration; digital skills. Source: factsheet_en_assessment_final_0.pdf (europa.eu)