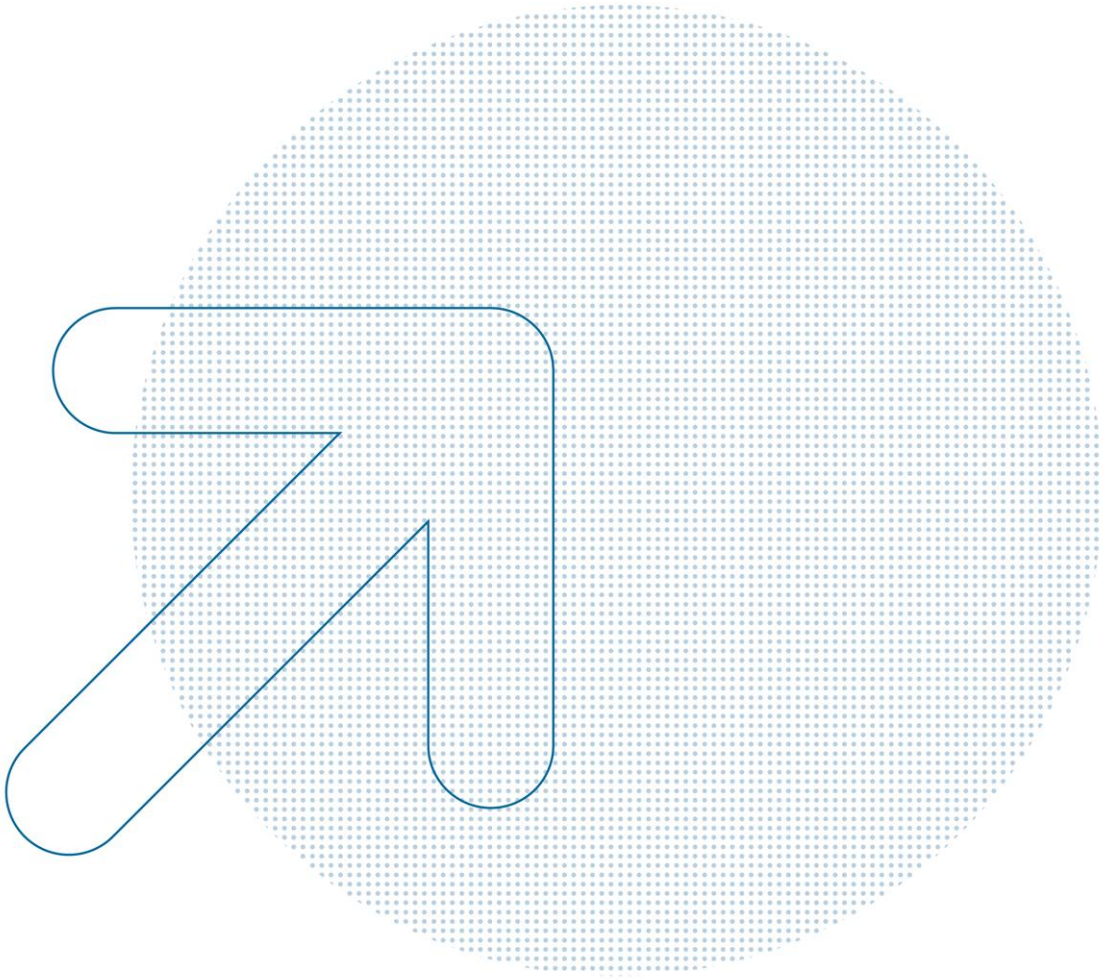
WIK-Consult • Report

Study for Ministry of Economic Affairs and Climate Policy



Study on the Complementarity and Substitutability of Frequency Bands for Mobile Communications

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Executive Summary

In the Netherlands, licences for the 800 MHz, 900 MHz, 1,800 MHz and 2,600 MHz frequencies will expire in early 2030. In preparation for the spectrum assignment process, the Ministry of Economic Affairs and Climate Policy has requested an economic and technical analysis of the frequencies to be assigned. In particular, the Ministry needs to understand the extent to which these bands complement or substitute each other. The analysis should also take into account additional frequencies, including those already allocated and new ones (particularly the upper 6 GHz band).

In this report we will answer the questions in the table below.

Table 0-1: Research questions

Question 1:	**What is the role in terms of coverage, capacity and service continuity of each of the four bands?**
Question 2:	**What is their importance for both incumbent operators as well as for new entrants?**
Question 3:	**Which band(s) is (are) expected to be most important for the introduction of 6G?**
Question 4:	**Are there any linkages between the before mentioned four bands on one hand and the future upper 6 GHz band on the other?**
Question 5:	**What would be the advice on the minimum lot size in each of the bands?**
Question 6:	**To what extent is the substitutability and/or complementarity between the 800, 900, 1,800, and 2,600 MHz bands?**
Question 7:	**Are there any linkages between these four bands of a technical/technological and/or business economical nature which would make it necessary for mobile operators to obtain certain combinations of the frequencies at stake?**
Question 8:	**To what extent are MNO decisions to acquire spectrum in the 800/900/1,800/2,600 MHz bands affected by the prospect of the upper 6 GHz band becoming available in the near future?**
Question 9:	**Which 3GPP standardised technologies are currently supported in the four bands?**
Question 10:	**Are there important differences to report?**

Current mobile networks still indicate a significant difference between spectrum below and above 1 GHz. Whereas frequency spectrum below 1 GHz is essential for providing coverage and capacity in sparsely populated areas and providing (basic) capacity and indoor coverage in all other geographical regions (suburban, urban and dense urban areas), spectrum in the two other frequency bands (1,800 MHz and 2,600 MHz) are

predominantly used for capacity reasons. Consequently, 1,800 MHz and 2,600 MHz can be considered as complementary to low-band frequencies.

Since the frequencies in the 800 MHz and 900 MHz band have similar propagation characteristics, there are strong arguments for substitutability of these frequencies. However, the MNOs use 800 MHz and 900 MHz for different mobile technologies.

Therefore, one could argue that, due to network characteristics and individual deployment strategies, there is path dependency regarding spectrum demand. A loss of already assigned frequencies can therefore impact service continuity and costs.

As it is becoming increasingly difficult to find locations for mobile sites, MNOs are keen to maximise the reuse of existing sites. Modern mobile technologies such as massive MIMO and beamforming increase the coverage of cells using mid-band frequencies and higher frequencies (e.g. 3,5 GHz). The use of more antennas and beamforming gains can compensate for the path losses of higher frequencies. Consequently, the use of new radio technologies will make it easier to reuse existing sites. That said, it is in the interest of MNOs that frequencies in the low and mid-bands (including 3.6 GHz) become more interchangeable, at least in urban and suburban areas. Consequently, deploying modern radio access technologies facilitate to avoid congestion in low-band frequencies (with their limited bandwidth) by steering traffic to mid-band frequencies.

Taking into account technical improvements in radio access technologies, mid-band frequencies will however not be able to fully substitute low-band frequencies (e.g. 800 MHz and 900 MHz). In particular, indoor applications require low-band frequencies. From the perspective of MNOs, retaining existing rights of use in the 800 MHz, 900 MHz, 1,800 MHz and 2,600 MHz bands is considered to be essential to safeguard service continuity and network capacity.

Continued access to these frequencies is particularly important because each MNO has configured its network, most likely differing from its competitors, including site locations, on the basis of its individually assigned and usable spectrum portfolio. Adapting the network to a substantially different spectrum allocation could especially require the deployment of additional sites, involving significant implementation costs and long lead times, while also being constrained by the limited availability of suitable locations and rooftops, as well as difficulties in obtaining the necessary permits.

Since the widespread deployment of low-band frequencies is essential for incumbent MNOs, the same applies for a potential new entrant, if not more, as a new entrant doesn’t possess any spectrum yet. Access to sub-1 GHz spectrum is important to provide area and indoor coverage. Without having access to frequencies below 1 GHz, market experience in the past and today illustrates that a competitive offer of the respective MNO (new entrant) in the end user market (and wholesale market) would hardly be possible. However, the concrete amount of spectrum in the low-band (2 x 5 MHz, 2 x 10 MHz, etc.)

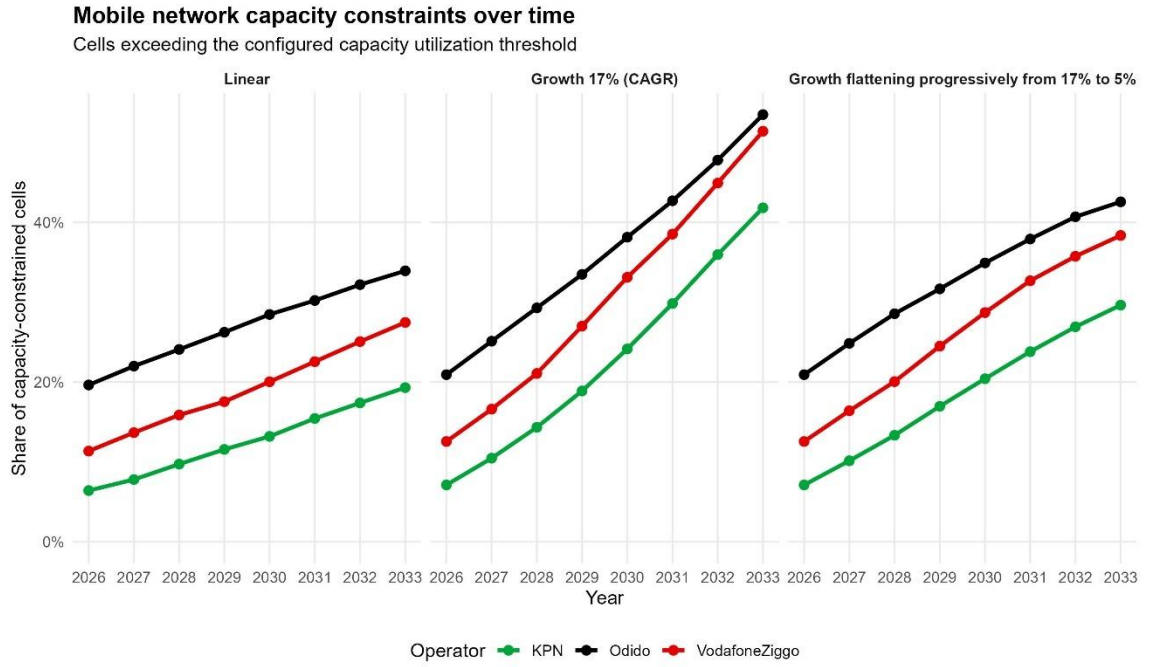
required to be competitive, depends on the number of customers and business proposition of the new entrant concerned and the network structure. The smaller the cells, the more frequencies > 1 GHz can cover the same area than frequencies < 1 GHz. Furthermore, the demand for 1,800 MHz and 2,600 MHz depends on the concrete business case. A market-based assignment is the most efficient way to determine the amount needed to enter the Dutch market.

Since MNOs across Europe have already expressed their interest in using 6 GHz frequencies in the future, the question comes up whether there will be traffic congestion in mobile networks which could be dissipated by 6 GHz? As 6 GHz might be a primary frequency band for the introduction of 6G, the possible deployment of the newest mobile generation in the 2030s will also come into play.

Although models which aim at quantifying demand of end users and supply provided by each MNO, have always limitations because not all input parameters of network planning used by the MNOs are public, we used a model to quantify the possible value added of 6 GHz frequencies. We estimate that the current spectrum portfolio of each MNO can already constrain data throughput at certain locations and therefore the ability of the MNO to catch up with demand. Those Dutch MNOs who have not deployed 3.5 GHz nation-wide (yet), have still the technical resources to balance demand and supply.

These technical constraints will become increasingly important in 2030s. Based on different scenarios of how demand will evolve, we expect that all MNOs will face challenges to keep up with existing demand and with demand possibly arising from innovative applications (e.g. AI based applications with higher technical requirement on uplink capacity).

Figure 0-1: Share of congested cells in the future, different scenarios



Source: WIK-Consult based on Dutch Authority for Digital Infrastructure (RDI/Antennebureau), August 2026.

Depending on future growth in mobile traffic, we expect that more than 40% of cells could experience permanent congestion. Timely assignment of the upper 6 GHz band could therefore enable MNOs to maintain the high quality of their mobile services after 2030. This however requires completion of the regulatory process on European and national level and, to some extent, a developed eco-system (e.g. availability of handsets).

In general terms, the 6 GHz frequencies will complement the existing use of frequencies already assigned. Consequently, we do not anticipate that utilising 6 GHz will have a noticeable impact on demand for the 800 MHz, 900 MHz, 1,800 MHz and 2,600 MHz bands. As the 6 GHz band may be applicable for 6G, excluding it would mean an MNO would have to risk 6G being available only in other bands. On the other hand, a separate and later assignment of the upper 6 GHz frequencies, could also be helpful to MNO's who at that time know the outcome of the 800, 900, 1800 and 2600 MHz assignment, and thereby have the more necessary information to determine their possible need for upper 6 GHz frequencies.

1 Introduction

In the Netherlands, licences for the 800 MHz, 900 MHz, 1,800 MHz and 2,600 MHz frequencies will expire in early 2030. In preparation for the spectrum assignment process, the Ministry of Economic Affairs and Climate Policy has requested an economic and technical analysis of the frequencies to be assigned. In particular, the Ministry needs to understand the extent to which these bands complement or substitute each other. The analysis should also take into account additional frequencies, including those already allocated and new ones (particularly the upper 6 GHz band).

1.1 Research questions

In this report we will answer the following questions:

Question 1: What is the role in terms of coverage, capacity and service continuity of each of the four bands?

Question 2: What is their importance for both incumbent operators as well as for new entrants?

Question 3: Which band(s) is (are) expected to be most important for the introduction of 6G?

Question 4: Are there any linkages between the before mentioned four bands on one hand and the future upper 6 GHz band on the other?

Question 5: What would be the advice on the minimum lot size in each of the bands?

Question 6: To what extent is the substitutability and/or complementarity between the 800, 900, 1,800, and 2,600 MHz bands?

Question 7: Are there any linkages between these four bands of a technical/technological and/or business economical nature which would make it necessary for mobile operators to obtain certain combinations of the frequencies at stake?

Question 8: To what extent are MNO decisions to acquire spectrum in the 800/900/1,800/2,600 MHz bands affected by the prospect of the upper 6 GHz band becoming available in the near future?

Question 9: Which 3GPP standardised technologies are currently supported in the four bands?

Question 10: Are there important differences to report compared to the previous assignment procedure for these bands?

1.2 Methodology

The above-mentioned questions will be answered by applying the following methodologies.

1. Qualitative analysis of market interests and regulatory practices with regard to the assessment of the different frequencies
2. Quantitative analysis of technical aspects

In addition to reviewing literature, we send a questionnaire to MNOs which contained some of the research questions. Other market parties were invited by the Ministry to bring in their views as well. All MNOs replied to the questionnaire.

To answer some of the research questions we applied a technical model to estimate current network capacities. The assumptions of the model are documented in the annex to this report. The MNOs were informed about the major outcome of the model.

Knowing that the download and upload capacity is a product of various (technical, commercial) parameters (e.g. massive MIMO, beamforming), we will analyse supply and demand by referring to model considering several, but not all parameters used for network planning (e.g. service of quality measures). Therefore, the output of the model can only indicate the capacity at given sites (see Annex 5.1).[1] However, the model provides us data to analyse how end users utilise the potential capacity within a defined timeframe (to take a forward-looking approach).

The model shows where and when demand will exceed the available capacity. Thus, we can address the second driver of spectrum demand. In areas where demand exceeds supply, a MNO can deploy modern technologies to increase spectrum efficiency (e.g. massive MIMO, beamforming), build new sites to densify the network, or deploy additional frequencies if they are available. In the latter scenario, the MNO can avoid additional costs for passive and backhaul infrastructure.

Like many models, our bottom-up model has limitations and uncertainties since, for instance, not all technical parameters of the mobile networks are in the public domain. However, the model can provide information about future congestions in mobile networks. Furthermore, the model helps to assess the complementarity/substitutability of frequencies because the model deals with inter-site-distances which usually take into account propagation characteristics of frequencies deployed.

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1 The model provides a number for the maximum throughput that a sector can deliver. To determine the actual capacity per sector, a traffic model and a quality-of-service (QoS) criterion are needed. A more stringent QoS requirement can reduce the capacity of a sector—that is, the amount of traffic a sector can handle on average while still meeting the QoS requirement. Since these input parameters might differ among the MNOs and services we did not consider them in the model. Consequently, we might overestimate the capacity provided.

More precisely, we will estimate the demand for data capacity during the busiest hour in a geo-based grid (for example, a 1x1 km grid cell). To calculate the demand for data capacity in each grid cell, we estimate the number of users (based on the number of households) during the busy hour and their average data demand per second over this period. Data about average data consumptions are public. Data for other users (e.g. moving users in cars and/or on trains, tourists, etc.) have not been considered. Consequently, demand is underestimated.

The next step is to analyze how frequencies are deployed by the Dutch MNOs. Data in the public domain show the location of sites and the frequencies deployed. Using this additional GIS-based information, we can calibrate the model.

Then, the calculated capacity will be matched with the data consumption of users. For this purpose, we will analyze the population density across the Netherlands to calculate the number of potential customers and their traffic consumption per 1 km^2.

1.3 Report structure

The report is structured as follows: The next chapter contains an analysis of how mobile network operators (MNOs) generally use the frequency bands assigned to them. As frequency usage is directly influenced by the demand for mobile services, we will analyse the status of mobile traffic in the Netherlands and make assumptions about future traffic growth. As MNOs are embedded in a specific ecosystem, we will discuss how this ecosystem might facilitate or constrain frequency usage. Furthermore, we will analyse the regulatory and technical situation in the 6 GHz band. Chapter 5 gives answers to the research questions. The study concludes with a summary.

2 Aspects of frequency usage

Against the background of the purpose of this report, we will analyse four external aspects which have an impact on current and future use of frequencies. These four aspects can already answer some questions, at least in part.

2.1 Supply side: Capacity / traffic in mobile networks

Modern mobile networks have come a long way since the early days of mobile voice telephony and large cell sizes (up to 30 km radius). Nowadays, they enable various broadband applications based on radio access networks with significantly smaller cell sizes.

The geographic and technical availability of mobile services, as well as the upload and download capacity provided by mobile networks and experienced by each end user, depends on various parameters.

Firstly, the frequencies deployed and their bandwidth significantly impact cell sizes and capacity. Furthermore, the area covered by a cell depends on various factors, including the surrounding buildings, topography and vegetation, as well as the heights of the transmitter and receiver antennas, the antennas used for transmitting and receiving, the transmit power and the mobile communication standard employed. It also depends on the current load on the surrounding cells (e.g. the number of users and the type of telecommunications services used), and the speed of a moving subscriber.

As it becomes increasingly difficult to find locations for mobile sites, MNOs are keen to maximise the reuse of existing sites. Modern mobile technologies such as massive MIMO and beamforming increase the coverage of cells using mid-band frequencies. The use of more antennas and beamforming gains can compensate for the path losses of higher frequencies. Therefore, for stationary applications (e.g. fixed wireless access) and outdoor applications (e.g. in-car), the link budget[2] of mid-band frequencies may be better than that of sub-1 GHz frequencies. That said, it is in the interest of MNOs for frequencies in the low and mid-bands to become more interchangeable, at least in urban and suburban areas.

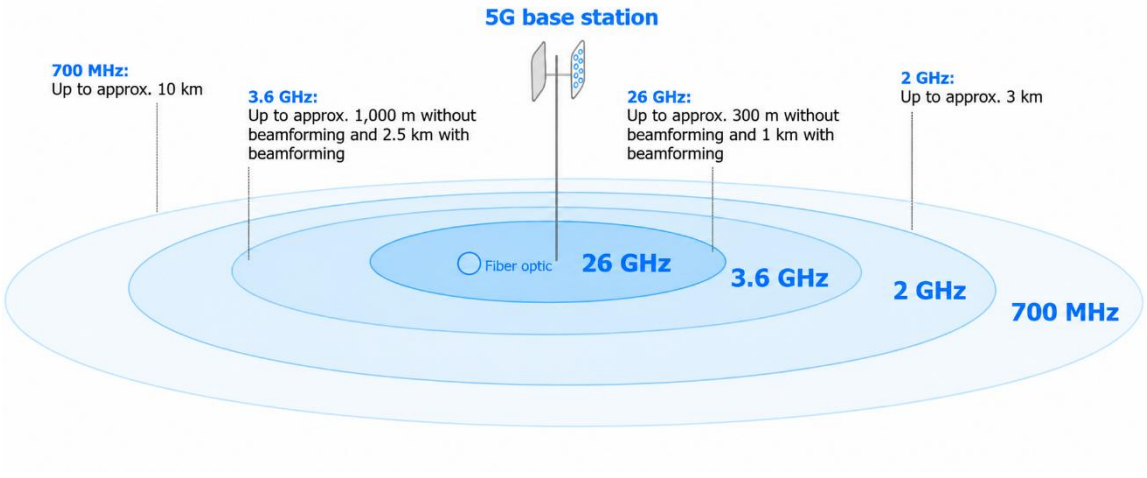
However, two constraining factors must be considered. Even with mMIMO and beamforming technology, mid-band frequencies will struggle to provide the same level of indoor coverage as low-band frequencies. Secondly, handsets must also support the new

2 The link budget is an accounting of all power gains and losses in a mobile network, from the transmitter through the medium to the receiver.

technologies (i.e. more antennas).[3] These two factors limit the interchangeability of the various frequency bands.

Although improvements of radio access technologies will increase substitutability of different frequency bands, today's mobile networks do not reflect the technological possibilities. Figure 2-1 illustrates how new technologies (e.g. beamforming) might increase cell ranges.

Figure 2-1: Frequencies and cell ranges



Source: Deutsche Telekom.

The analysis of Dutch mobile networks confirms some of the data displayed in the figure above (see Table 2-1). According to the inter-site distances in rural areas the average cell ranges in the lower frequency bands are of about 2,600m to 2800m. Given this inter-site distance, mid-band frequencies enable mobile services only in areas close to the antenna site. Therefore, in such cell coverage and capacity can only be provided by low-band frequencies. In urban and in particular in dense urban area, all frequencies assigned to the MNO enable mobile services in each cell. The inter-site distance is significantly shorter.

3 Please note that in the mass-market user terminals (e.g. smartphones) are more frequently exchanged than in the IoT-contexts (due to high costs of changing terminals in the field). Thus, mass market handsets will support new radio technologies sooner.

Table 2-1: Inter-site distances in Dutch mobile networks

MNO	Rural (m)	Suburban (m)	Urban (m)	Dense Urban (m)
KPN	5734	3385	2153	1303
VodafoneZiggo	5394	3329	2076	1287
Odido	5885	3435	1894	1030

Note: Population density categories are based on NUTS-3 regional population density: Rural (<100 inhabitants/km²), Suburban (100 to <500 inhabitants/km²), Urban (500 to 3,500 inhabitants/km²), and Dense urban (>3,500 inhabitants/km²).
Source: WIK-Consult. Antenna Register data provided by the Dutch Authority for Digital Infrastructure (RDI/Antennebureau), August 2026;

Empirical data and simulations using propagation models show that, due to the physical propagation characteristics, MNOs use spectrum bands below 1 GHz in rural, suburban and urban areas, including dense urban areas. In all geographic areas, these frequencies contribute to both indoor and outdoor coverage.

Mid-band frequencies (1–2.6 GHz) and 3.5 GHz frequencies offer greater capacity and lower latency thanks to their higher bandwidth. In some mobile markets, 2.6 GHz frequencies are only deployed in areas with very high traffic, whereas 1.8 GHz frequencies are used across almost all geographical areas.

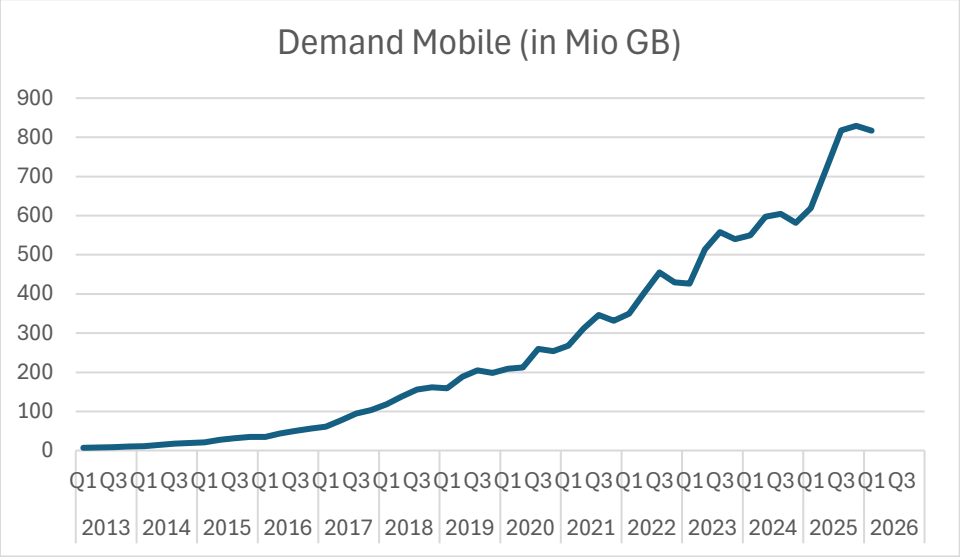
The capacity for uploads and downloads in mobile networks can be improved by either densifying sites or implementing new technologies, such as carrier aggregation, beamforming and massive MIMO (mMIMO). These technologies help MNOs to keep pace with the accelerating demand. Beamforming and mMIMO are also suitable for increasing the cell radius (see Figure 2-1). Carrier aggregation is already used in 4G and 5G cellular networks. This involves combining multiple frequency bands – and thus their transmission capacities – to create a single, wider frequency band. Mobile users with a device that supports this transmission method can therefore achieve a particularly high data rate, provided the available frequencies and the number of users in the cell permit it. With 4G, the combination of frequencies is limited to 100 MHz, which limits the possible total data rate. Additionally, the devices must support this feature. In principle, carrier aggregation is possible in both the downlink and the uplink. With 5G, this technology has been further developed to offer significantly more flexibility.

Against the background of the current applications currently used in the mass market, MNOs have a strong interest to improve download capacity. However, since the segment of IoT connectivity is growing, the importance of uplink capacity should not be neglected. Provided that AI will be used more frequently in mobile devices, MNOs might focus more on uplink capacity soon.

2.2 Demand side: current and future mobile traffic

The demand for mobile data services has increased continuously in recent years. This development is also reflected in the evolution of mobile traffic in the Netherlands (see Figure 2-2).

Figure 2-2: Mobile traffic in the Netherlands



Source: ACM Telecommonitor.

The increasing demand for mobile data requires mobile network operators to continuously expand their network capacity. RAN capacity is influenced by technical improvements (e.g. massive MIMO and beamforming) in the network, the use of various frequencies, and the technical capabilities of handsets to support advanced RAN technologies. It should therefore be sized in such a way that the quality of service can be maintained, and that current and future demand can be met. Future traffic growth is therefore a key factor in assessing future network capacity and spectrum requirements.

The future development of mobile data demand is subject to considerable uncertainty, but available industry forecasts point to continued strong growth. Since future demand is an important input for several research questions, the analysis therefore considers forecasts for the development of mobile data services. According to the Ericsson Mobility Report (June 2026), total mobile network data traffic, including Fixed Wireless Access (FWA), is forecast to increase at a compound annual growth rate of 17% between 2025 and 2031.[4]

Over the same period, Ericsson forecasts mobile data traffic per active smartphone in Western Europe to increase from 25 GB per month in 2025 to 59 GB per month in 2031,

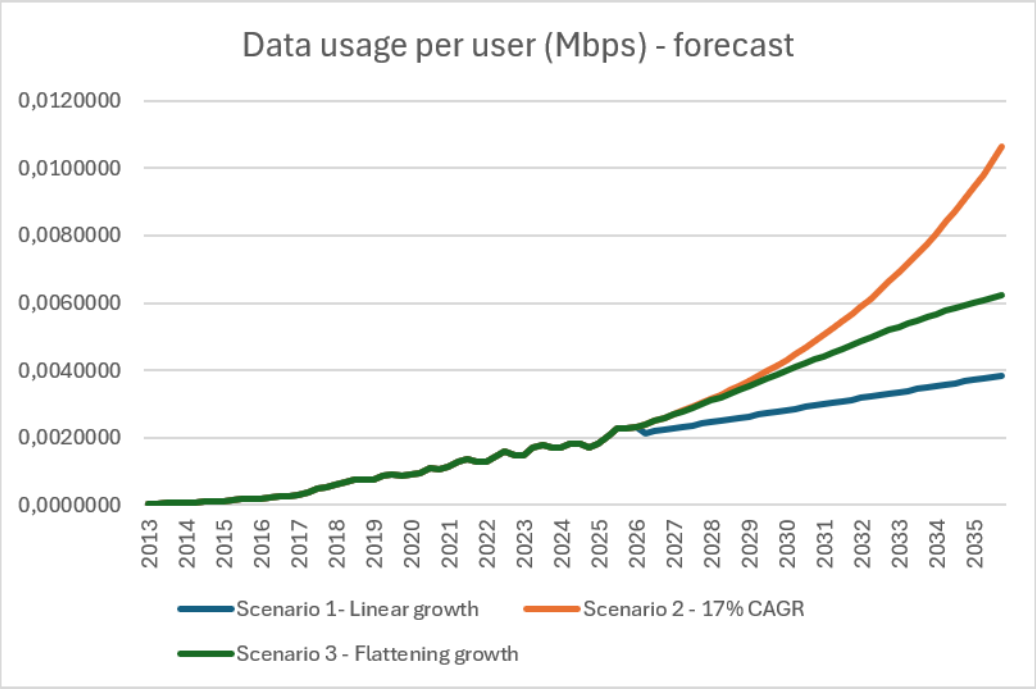
4 https://www.ericsson.com/en/reports-and-papers/mobility-report

corresponding to a CAGR of 15%. The GSMA estimates that mobile data traffic per connection in Europe will increase from 17 GB per month in 2023 to 71 GB per month by 2030, corresponding to a CAGR of 22%.[5]

The 17% Ericsson forecast relates to total mobile network traffic, including FWA, whereas the 15% forecast relates specifically to traffic per active smartphone. This distinction is particularly relevant for the Netherlands, where FWA plays a role in mobile network traffic and therefore total network traffic provides a more relevant reference point than smartphone-only traffic. As the present analysis focuses on overall network traffic and capacity requirements rather than on individual smartphone usage, the broader traffic indicator provides a relevant reference point for the scenario analysis.

Given the uncertainty around future demand, three scenarios are considered. They build on observed data usage but apply different assumptions about future growth, allowing capacity and spectrum requirements to be assessed across a range of demand trajectories rather than relying on a single forecast. Potential additional traffic from direct to device satellite services is not modelled separately, as its future uptake and traffic impact remain highly uncertain.

Figure 2-3: Future mobile traffic scenarios



Source: WIK-Consult GmbH

5 https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-economy/wp-content/uploads/2024/02/260224-The-Mobile-Economy-2024.pdf

Scenario 1: Linear growth

The linear growth scenario assumes that data usage per user continues to increase by approximately the same absolute amount each year. Consequently, the percentage growth rate declines over time as the underlying level of data consumption increases. This scenario represents a comparatively moderate development in which mobile data consumption continues to grow, but the strong percentage growth observed in earlier periods gradually gives way to a more mature demand trajectory.

Scenario 2: Constant annual growth of 17%

The second scenario assumes that data usage per user increases by 17% per year throughout the forecast period. The 17% assumption is derived from Ericsson's forecast CAGR for total mobile network data traffic, including FWA, between 2025 and 2031. In this analysis, the rate is applied to data usage per user as a sensitivity assumption. Since annual growth is compounded, the scenario produces an increasingly steep demand trajectory over time. It therefore represents a sustained high growth case for assessing future network capacity and spectrum requirements.

Scenario 3: Flattening growth

The third scenario assumes a gradual flattening of mobile data traffic growth over time. Starting from an annual growth rate of 17% in 2026, the growth rate declines progressively to 5% by 2035. This reflects a transition from the currently high growth phase towards a more mature market, in which further increases in data consumption continue but at a steadily lower pace. The scenario therefore captures continued strong demand growth in the short term while allowing for increasing market saturation, efficiency gains, and a gradual moderation of incremental data usage over the longer term.

The three scenarios are used to assess the sensitivity of future mobile network capacity and spectrum requirements to different developments in data demand. Together, they cover a range from comparatively moderate growth to sustained high growth and therefore allow the subsequent analysis to examine whether conclusions regarding additional spectrum requirements remain robust under different demand assumptions. The scenarios do not separately quantify potential additional traffic generated by emerging direct to device satellite services. At present, the scale, timing and usage patterns of such services remain too uncertain to derive a sufficiently robust additional traffic assumption.

2.3 Impact of worldwide mobile ecosystem on frequency use

The mobile ecosystem encompasses mobile network operators, service providers, mobile virtual network operators, vendors, handset manufacturers, chipset

manufacturers, software platforms, standardization bodies (e.g. 3GPP), academia and (technical) regulators. The ecosystem has been evolved over a period of more than 30 years. The ecosystem is worldwide.

To a certain extent, the development of the ecosystem has been influenced by the emergence of new mobile standards and the allocation of additional frequencies across a range of bands. In particular, the technical characteristics of network components and end-user devices have been influenced by a stepwise assignment of frequencies. It should be noted that not all network components and end-user devices are compatible with all frequencies. For instance, the Dutch band plan for 2,600 MHz TDD deviates from the European band plan and is not supported by commercially available radio equipment from Radio Access Network (RAN) suppliers.

As only the 900 MHz low-band spectrum was initially made available for mobile communications, the first MNOs licensed deployed a network grid that mirrored this frequency band's strong propagation characteristics. Along with additional frequencies in the 700 and 800 MHz bands that were assigned later, low-band frequencies are considered essential for providing coverage and capacity in sparsely populated areas and providing (basic) capacity and indoor coverage in all other geographical regions (suburban, urban and dense urban areas).

In the second wave of MNO licensing, mid-band spectrum and 3.5 GHz frequencies have been assigned. Some later entrants still operate a network grid that reflects the propagation characteristics of mid-band spectrum (e.g. one operator in Sweden). In this case, spectrum demand is determined not only by demand of end users including IoT, but also by grid structures. Therefore, one could argue that, in some mobile markets, there is path dependency with regard to spectrum demand.[6]

In some markets, it then became clear that operating a mobile network with only mid-band spectrum could be a disadvantage, particularly in countries with a large rural population. An economic analysis of Germany showed that providing the same quality of GSM-enabled mobile services as with 900 MHz would require three to four times more base stations and sites with 1,800 MHz.[7]

With the auctioning of 2.1 GHz frequencies and, at a later stage, frequencies in 800 MHz, 700 MHz, 1.4 GHz and 3.5 GHz mobile network operators were able to improve coverage and keep up with rising demand. 800 MHz is the core band for LTE. This band is supported by almost all (mass-market) handsets.

The impact of the subsequent licensing is that both network components and user terminals do not support all frequency bands in the same way. Therefore, from a customer perspective, the frequency bands are not fully interchangeable due to technical limitations

6 Nett, L., Lucidi, S., Sörries, B. (2026), Internationale Entwicklungen bei Frequenzvergabeverfahren. Bad Honnef forthcoming (publication expected by end-2026).

7 Stumpf, U., Kiesewetter, W. & Nett, L. (2005). Der Einfluss der Frequenzausstattung auf die Wettbewerbsbedingungen im deutschen Mobilfunkmarkt. Bad Honnef 2005.

in the terminals. For example, 2G/3G devices do not support the 800 MHz band, and not all 4G devices support the 900 MHz band (older/lower spec smartphones, LTE-M devices for IoT). Provided that the end user considers frequencies not fully substitutable, the same applies to MNOs.

However, due to constant technical change of handsets at least in the mass market and customer behaviour, to purchase new handsets every 2-3 years,[8] the number of handsets with technical limitations with regard to frequency usage will be negligible in the near future. This assumption is backed by the practice how MNOs switch off GSM. Before GSM is completely switched off, MNO have a strong interest to provide alternatives to end users.[9]

Once again, we must conclude that to some extent a path dependency with regards to the usability of the frequencies subject to this analysis. This path dependency is caused by the way the mobile ecosystem has reacted to the introduction of new radio technologies (e.g. 4G, 5G).

The take-up of 3.5 GHz might indicate how MNOs will deal with additional frequencies in midterm future. The international harmonisation of 3.5 GHz created a virtuous circle, expanding marketplaces for handsets which in turn creates a wider ecosystem, while lowering costs.

Assuming handsets were available, allocating 3.5 GHz frequencies helped MNOs to achieve two goals simultaneously. Firstly, it increased capacity at sites where MNOs had already experienced network congestion, particularly in urban areas. Secondly, 5G, as a new technology, provided the technical basis for reducing costs per bit. Consequently, in combination with new frequencies, 5G has enabled the entire industry to enhance cost efficiency while offering improved services to customers. Therefore, the speed at which 3.5 GHz has been deployed has been influenced by the level of traffic experienced and the availability of network components.

2.4 Regulatory and technological situation in the upper 6 GHz band

The frequency band 5.925 GHz to 7.125 GHz is called the 6 GHz and from the nomenclature is split into the lower 6 GHz band ranging from 5.295 GHz to 6.425 GHz and the upper 6 GHz band ranging from 6.425 GHz to 7.125 GHz. The latter is currently discussed for used by 3GPP systems and is subject to the analysis in this section.

While the standardisation of 6 G targets at using all frequency bands currently used, the operators have expressed their requirement to have one clean new band, which can be

8 GSMA Intelligence (2017), The Future of the SIM: potential market and technology implications for the mobile ecosystem. P. 24.

9 Lucidi, S., Niedick, L., Sörries, B. (2025), Implikationen einer Mobilfunk-Grundversorgung für den Infrastrukturwettbewerb.

used to launch 6G. Such a situation has been the case with the introduction of all previous generations (900/1,800 MHz with 2G, 2100 MHz with 3G, 2,600 MHz with 4G and 3500 MHz with 5G).

Clean spectrum enables the introduction of a new generation without the immediate need to refarm the spectrum, which can be introduced gradually. This will yield a seamless transition, where the refarming can be adapted to the availability of radio equipment and end user devices minimizing the risk of service degradation for the customers in case of a hard switch of spectrum use.

In addition, beyond 2030 , the available spectrum in the upper 6 GHz band can be used to enhance the capacity in otherwise congested areas or frequency bands.[10]

The situation in the upper 6 GHz is quite complex with a variety of different wireless systems used in this frequency band in different parts of the world[11]. While in some countries and regions in the world a decision on the use of the spectrum has been already made for the use of the spectrum by 3GPP-based or IEEE 802 based systems, the discussion in Europe is currently ongoing. The Stratix study[12] has described four scenarios for spectrum allocation by the regulators:

- Allocation of the whole upper 6 GHz band for use by 3 GPPP (6G)
- Allocation of the whole upper 6 GHz band for IEEE Std 802.11 (Wi-Fi)
- Allocation of spectrum for hybrid use
- Postponing the decision

The investigations described in the following sections go beyond the findings of the Stratix study by also taking into account recent developments. Therefore, we will first describe the regulatory situation and the status of standardisation, followed by an overview of decisions in various parts of the world including a summary of more recent and ongoing consultations.

2.4.1 Regulatory situation

At WRC 23 the upper 6 GHz has been identified for the use by mobile service (IMT). WRC-23 adopted a new footnote RR 5.457E, according to which the frequency bands 6425 - 7125 MHz in Region 1 and 7025-7125 MHz in Region 3 are identified for use by administrations wishing to implement the terrestrial component of IMT. It is noted that these frequency bands are also used for the implementation of wireless access systems (WAS), including radio local area networks (RLANs), i.e. Wi-Fi. This identification

10 Please see 2.1.
11 S. Cousins, “Wi-Fi and Cellular Industries Duke It Out Over 6-GHz Band”, IEEE Spectrum, 25 June 2026, https://spectrum.ieee.org/6g-wifi-united-states-china
12 Stratix, “Stratix Rapport: Beleidsopties Upper 6 GHz band”, Rapport uitgebracht aan Ministerie van Economische Zaken, 30 November 2025

preserves full flexibility for Europe to use the spectrum for 3GPP, Wi-Fi or shared use. In this context also the ITU-R Resolution 220 (WRC-23), which addresses provisions for the protection of the existing services like fixed Service (FS), Fixed Satellite Service (FSS) or Earth Exploration Satellite Service (EESS) and Radio Astronomy Service (RAS), applies. Annex 5.2 shows an excerpt of the Radio Regulations in the upper 6 GHz, which establishes the upper 6-GHz band in region 1 as a flexible, multi-use spectrum resource. WRC-23 enables administrations to implement terrestrial IMT in 6425–7125 MHz, but it deliberately avoids assigning exclusive priority to IMT and explicitly preserves the use of the band by WAS/RLANs. The final balance between 6G, Wi-Fi, fixed links, passive services and satellite services is therefore determined primarily through national and regional implementation, subject to the conditions laid down in the Radio Regulations.

The RSPG-report[13] states details of the situation Europe. With regard to the passive service the reports provides information on the use for EESS, especially on passive microwave sensor measurements for sea surface temperature in the frequency ranges 6425-7075 MHz and 7075-7250 MHz, where several satellites are already in orbit and are carrying out measurements in this band, some other are planned.

With regards to RAS, it states that the 6650-6675.2 MHz band has been used in the past for observations of the methanol spectral line by ASTRON at the observatory at Westerbork in the Netherlands.[14].

WRC-27 does not include an agenda item specifically dedicated to the upper 6 GHz band., However, Agenda item1.7[15] of WRC-27 addresses the potential use of the 7125 to 8400 MHz frequency range for IMT. The outcome of WRC-27 with respect to this band could potentially have a major impact on the spectrum environment to the adjacent 6-GHz Wi-Fi/RLAN range, particularly in Europe, even though the band 6425–7125 MHz itself is not on the WRC-27 agenda.

In parallel, CEPT is conducting technical studies under a mandate from the European Commission to assess the future use of the upper 6 GHz band, including the possibilities for spectrum sharing between IMT and Wi-Fi/RLAN and coexistence with incumbent services.[16] The results of these studies, documented in CEPT reports, will provide an important technical basis for the European Commission's subsequent decision-making process through the Radio Spectrum Committee (RSC), potentially leading to a Commission Implementing Decision (CID) establishing harmonised technical conditions for the band. These studies are particularly relevant for densely populated countries such as the Netherlands, where opportunities for geographical separation between different spectrum users are limited. The future regulatory framework for the upper 6 GHz band

13 RADIO SPECTRUM POLICY GROUP, Draft Opinion on Long-term vision for the upper 6 GHz band, 17 June 2025, RSPG25-018 FINAL, https://radio-spectrum-policy-group.ec.europa.eu/document/download/1436dce2-8160-470e-9db0-0b70ec9e7a74_en?filename=RSPG25-018final-Draft-RSPG_Opinion_Upper_6GHz.pdf
14 https://www.astron.nl/wp-content/uploads/2021/01/50_Years_Westerbork_Radio_Observatory.pdf
15 ITU-R resolution 256 (WRC2023) https://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C0A0000110007PDFE.pdf
16 https://cept.org/files/1412/Mandate%20to%20CEPT%20upper%206%20GHz%20band.pdf

will therefore depend not only on decisions by national administrations but also on the outcome of the ongoing CEPT studies, the European harmonisation process and potentially relevant developments at WRC-27. Consequently, the timing and conditions under which the band may become available for mobile services remain subject to regulatory and technical uncertainties.

2.4.2 Status in standardisation

Both 3GPP and IEEE 802 have systems operating in that band standardized. At 3GPP bands at 6GHz have been standardized since 3GPP Release 17. In IEEE this was done with the publication of IEEE Std 802.11ax™-2021[17] (also denoted as Wi-Fi6), which has been published in February 2021 and covers also the upper 6 GHz band[18] as depicted in Annex 5.3. The most recent version of this standard is IEEE Std 802.11be™-2025[19] (also denoted as Wi-Fi7) has been published in July 2025.[20] In Annex 5.3 also IEEE Std 802.15.4™-2020 and IEEE Std 802.15.4z™-2020 are mentioned, which partly define the use ultra-wideband technology capable of using both 6425–7025 MHz and 7025–7125 MHz. This is also reflected most recent standard IEEE Std 802.15.4™-2024[21] superseding the two mentioned standards. In IEEE 802 there are currently ongoing discussions on the co-existence between Wi-Fi and IEEE 802.15.4 standards in the whole 6 GHz band. In 3GPP the upper 6 GHz band was introduced in Release 17[22] as band n104 which was frozen in June 2022. The most recent version of the standard (Release 19V5.0) has been published in August 2026,[23] from which the channel table depicted in Annex 5.4 has been taken.

The Study Item for 3GPP Rel-20 considers amongst others the whole FR1 range up to 7.125 GHz for 6G. This means that all four bands considered in this study as well as the upper 6 GHz band are candidates for 6G and are very likely to be standardised. This is

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17 "IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems Local and Metropolitan Area Networks--Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 1: Enhancements for High-Efficiency WLAN," in *IEEE Std 802.11ax-2021 (Amendment to IEEE Std 802.11-2020)* , vol., no., pp.1-767, 19 May 2021, doi: 10.1109/IEEESTD.2021.9442429.

18 IEEE 802's Wireless Standards Table of Frequency Ranges; December 2022, https://mentor.ieee.org/802-ec/dcn/22/ec-22-0266-00-WCSG-ieee-802-s-wireless-standards-table-of-frequency-ranges.xlsx

19 "IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 2: Enhancements for Extremely High Throughput (EHT)," in *IEEE Std 802.11be-2024 (Amendment to IEEE Std 802.11-2024, as amended by 802.11bh-2024)*, vol., no., pp.1-1020, 22 July 2025, doi: 10.1109/IEEESTD.2024.11090080.

20 Although IEEE 892 standards are not subject to this study, the regulatory situation in some countries allows IEEE 802 systems in the 6GHz band only. Therefore the details in IEEE 802 standards are listed here.

21 "IEEE Standard for Low-Rate Wireless Networks," in *IEEE Std 802.15.4-2024 (Revision of IEEE Std 802.15.4-2020)* , vol., no., pp.1-967, 12 Dec. 2024, doi: 10.1109/IEEESTD.2024.10794632.

22 3GPP ETSI TS 138 104 V17.6.0 (2022-08).

23 3GPP ETSI TS 138 104 V19.5.0 (2026-08).

also reflected in 6G Spectrum White Paper published by Ericsson in 2024[24]. The band 6,425–7,125 GHz is a particularly important candidate for additional/new IMT spectrum and has already been specifically studied by 3GPP for earlier release, see above. The Study Item is expected to be completed in June 2027.

This situation means, that that Wi-Fi 6E/7, IEEE 802.15.4 UWB and potentially future 6G/IMT systems all have competing spectrum interests in 6,425–7,125 GHz.

2.4.3 Options for the use of spectrum

It is up to national administrations[25] to decide, which system the identified spectrum. A more recent analysis of the current situation has been published in IEEE Spectrum in June 2026 (reference see above). The article examines the international dispute over the allocation of the 6 GHz frequency band from 5,925 to 7,125 GHz between unlicensed Wi-Fi systems and licensed cellular networks. The band is technically attractive because it provides 1,2 GHz of contiguous spectrum, enabling wider channels, higher data rates, lower latency, and increased network capacity for both Wi-Fi and future 6G systems.

A short summary of the status is provided in the following:

- United States: the entire 1.200 MHz band is designated for unlicensed use.
- China: the upper 6 GHz range, 6,425–7,125 GHz, is reserved for licensed cellular systems, with Wi-Fi excluded from that portion.
- European Union: the lower 500 MHz, 5,925–6,425 GHz, is intended for unlicensed applications, while approximately 540 MHz of the upper band is prioritized for licensed mobile services. The allocation of the remaining 160 MHz is deferred until the World Radiocommunication Conference in 2027.
- India: a nominal division exists between lower band unlicensed use and upper band licensed use, although decisions concerning upper band auctions have been delayed.
- United Kingdom: dynamic spectrum sharing is being considered in the upper 6 GHz band. Automated frequency coordination could allocate frequencies according to local congestion and incumbent-user protection requirements

The decision made by Ofcom in the United Kingdom including the reasoning has been published on 20 July 2026[26] following an intense consultation on enabling Wi-Fi and

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24 Ericsson White Paper. "6G spectrum - enabling the future mobile life beyond 2030, https://www.ericsson.com/en/reports-and-papers/white-papers/6g-spectrum-enabling-the-future-mobile-life-beyond-2030.

25 In case of Europe, the EC is heading towards a legally binding harmonisation decision for the EU.

26 Ofcom: Statement: Expanding access to the 6 GHz band for commercial mobile and Wi-Fi, 20 July 2026, https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-3-4-weeks/consultation-expanding-access-to-the-6-ghz-band-for-commercial-mobile-and-wi-fi-services/main-document/statement-expanding-access-to-the-6-ghz-band-for-commercial-mobile-and-wi-fi-services.pdf?v=422807service.

mobile in the upper 6 GHz band. Ofcom decided to implement a proposal for a prioritised spectrum sharing framework in the upper 6 GHz band comprising:

- a Wi-Fi priority portion in the lower 160 MHz of the band (6,425–6,585 MHz); and
- a mobile priority portion in the upper 540 MHz of the band (6,585–7,125 MHz).

Within this framework Ofcom is making the Wi-Fi priority portion of the band available on the same licence exempt basis as the lower 6 GHz band. This includes low power indoor use and very low power use. Outdoor and higher power use is also permitted, but only where devices operate under the control of an Automated Frequency Coordination (AFC) system. Ofcom also allows licence exempt Wi-Fi access to the mobile priority portion – but only for those devices under the control of an AFC system. This will enable Wi-Fi use of the full 6 GHz band while ensuring that such use can be managed as mobile deployment occurs.

Due to the fact, that countries with very large populations have made contradictory decisions enabling the rollout of either Wi-Fi[27] or 3GPP systems, it can be expected that equipment for both systems will be available at latest with the introduction of 6G. Whether a solution similar to the one proposed by Ofcom could be an option for the Netherlands depends on the use of Wi-Fi in the Netherlands along with ongoing coexistence studies.

3 Research Questions

In the following subsections we examine and address the research questions formulated by the Ministry.

3.1 The role of 800, 900, 1,800 and 2,600 MHz frequencies for MNOs

This subsection addresses the following questions with regard to the use of frequencies and their importance for MNOs and potential new entrants.

Question 1: What is the role in terms of coverage, capacity and service continuity of each of the four bands?

Question 2: What is their importance for both incumbent operators as well as for new entrants?

27 There is already Wi-Fi equipment in the market that supports the full 6 GHz band.

3.1.1 Coverage, capacity and service continuity

Over the course of several years Dutch MNOs obtained frequencies in low-bands (< 1 GHz) and higher frequencies (1.8 GHz to 3.5 GHz).

Table 3-1: Spectrum assignments to MNOs in the Netherlands

Frequency band	KPN	Vodafone	Odido
700 MHz (Band 28)	2×10 MHz	2×10 MHz	2×10 MHz
800 MHz (Band 20)	2×10 MHz	2×10 MHz	2×10 MHz
900 MHz (Band 8)	2×10 MHz	2×10 MHz	2×15 MHz
1400 MHz SDL (Band 32)	15 MHz	15 MHz	10 MHz
1,800 MHz (Band 3)	2×20 MHz	2×20 MHz	2×30 MHz
2100 MHz (Band 1)	2×20 MHz	2×20 MHz	2×20 MHz
2,600 MHz FDD (Band 7)	2×10 MHz	2×30 MHz	2×25 MHz (2×20 + 2×5 MHz)
2,600 MHz TDD (Band 38)	30 MHz		20 MHz
3500 MHz (Band n78)	100 MHz	100 MHz	100 MHz

Source: https://antennekaart.nl/page/frequencies.

All three Dutch MNOs have a comparable foundation for nationwide coverage, with each holding 2 x 10 MHz in both the 700 MHz and 800 MHz bands. Additional low-band spectrum is available at 900 MHz, where KPN and VodafoneZiggo each hold 2 x 10 MHz, while Odido holds 2 x 15 MHz.

Spectrum assignments in higher-frequency bands are less uniform. Odido holds the largest amount of spectrum at 1,800 MHz, while VodafoneZiggo has the largest 2,600 MHz FDD holding. By contrast, the operators have equal assignments at 2100 MHz and 3500 MHz, with each holding 2 x 20 MHz and 100 MHz, respectively.

All Dutch MNOs currently support 4G, including IoT and machine to machine services, 5G New Radio (5G Stand Alone) and 5G non standalone. Whereas KPN and VodafoneZiggo[28] have already switched off UMTS (3G), Odido still runs a UMTS (3G)

28 The availability of legacy radio access technologies differs among operators in the Netherlands. Vodafone discontinued its 3G network on 4 February 2020. KPN began phasing out its remaining 3G network on 31 March 2022 and reported that the shutdown had been completed in all regions by 10 May 2022.

network.[29] With regard to GSM (2G) the situation is the other way round. KPN and VodafoneZiggo are in a process to shut down this mobile technology.

An analysis of a database with mobile sites in the Netherlands reveals that the three low-bands are nationwide deployed but differently used.

Table 3-2: 4G and frequency bands per MNO

MNO	4G locations	Share of 4G locations using 700 MHz	Share of 4G locations using 800 MHz	Share of 4G locations using 900 MHz
KPN	5,055	0	99%	99%
Odido	5,319	93%	0	95%
VodafoneZiggo	5,279	78%	97%	1%

Source: WIK-Consult based on Dutch Authority for Digital Infrastructure (RDI/Antennebureau), August 2026.

According to Table 3-2 Dutch MNOs pursue slightly different deployment strategies with regard to the use of 700 MHz and 800 MHz. Whereas KPN provides 4G coverage with 800 MHz and 900 MHz, Odido uses 700 MHz and 900 MHz primarily for 4G.

Table 3-3: 5G and frequency bands per MNO

MNO	5G locations	Share of 5G locations using low-band frequencies	Share of 5G locations using 3.5 GHz frequencies
KPN	5,014	98%	39%
Odido	5,107	96%	90%
VodafoneZiggo	5,189	79%	31%

Source: WIK-Consult based on Dutch Authority for Digital Infrastructure (RDI/Antennebureau), August 2026.

The table above shows that the current pattern of using 3.5 GHz frequencies is different. While Odido already makes widespread use of these all frequencies, the other two MNOs have deployed 3.5 GHz frequencies in considerably fewer locations. Therefore, it can be assumed that the traffic load on the three networks is very different. In terms of frequency

29 Odido committed to maintaining 3G until at least 1 August 2026. Its current customer information states that 3G will remain available somewhat longer, but no definitive switch-off date has yet been established. Odido has committed to informing customers at least six months before the shutdown process begins. Consequently, the retirement of 3G in the Netherlands is an operator-specific transition rather than a single nationwide switch-off event

usage, KPN and VodafoneZiggo still have the option of increasing capacity by making wider use of the 3.5 GHz band.

In addition, in order to increase capacity MNOs can do the following:

- Make use of 4x4 DL MIMO capability in low-bands
- The 1400 MHz SDL band comprehensively adds download (DL) capacity with 4 TX capability.
- Make use of 4T4R configuration in 1,800 MHz and 2,100 MHz
- Running pilots with FDD massive MIMO.

Currently, KPN and Odido have limited 2,600 MHz TDD deployment. This is largely because the Dutch band plan deviates from the European band plan and is not supported by commercially available radio equipment from our RAN supplier.[30]

In order to address the demand, achieve a better performance and to provider higher data throughput), MNOs make use of different types of carrier aggregation, using typically multiple bands in combination (for 5G NSA: Dual Connectivity (EN-DC)).

Due to increasing demand from end users, the low-bands are becoming increasingly congested. Therefore, techniques such as mMIMO, beamforming and 8Rx, in combination with high-efficiency antennas, are being introduced to the FDD mid-bands to extend their coverage and capacity. This will allow them to partially offload the low-bands where propagation conditions permit. As the mid-bands offer greater capacity thanks to their higher bandwidth, MNOs have a strong incentive to direct traffic to the higher frequency bands. Consequently, mid-band frequencies with TDD technologies could be utilised to absorb traffic that was previously processed by the FDD mid-bands.

As MNOs adopt divergent deployment strategies for 5G, ensuring continuity of future services will be contingent on the accessibility of various frequency bands. For instance, if 2 x 10 MHz in 700 MHz were no longer available, the MNO would have no substitutes (in particular in rural and suburban areas) because other low-band frequencies are used for different technologies (either 4G or 5G). Consequently, the remaining bands would become more congested, which would have a negative impact on 5G service quality and thus user experience.

3.1.2 Importance of frequencies for incumbent operators and new entrants

Importance for established mobile network operators (KPN, Vodafone, Odido)

The following table provides an overview of the general significance of the various spectrum bands for mobile network operators, distinguishing between their primary roles

30 However, the Ministry of Economic Affairs has announced that it will adopt the European band plan after the current licences expire in 2030, which will make use of this band more attractive.

as coverage and capacity layers. It includes all spectrum bands currently assigned to mobile network operators in the Netherlands.

Table 3-4: Expected coverage and capacity layers of different spectrum bands

Area type	Coverage and mobility layer	Expected capacity layers
Rural	700, 800 and 900 MHz on wide-area macro sites	1,800 or 2,100 MHz at larger villages, roads and seasonal hotspots; 1,400 MHz SDL where downlink traffic warrants it
Light suburban	Low-band for edge and indoor continuity	1,800 and 2,100 MHz as normal macro capacity; selective 1,400 and 2,600 MHz
Suburban	Low-band remains the mobility and indoor anchor	1,800 and 2,100 MHz broadly; 1,400, 2,600 and selected 3,500 MHz for growth
Urban	Low-band for continuity, indoor reach and uplink resilience	1,800, 2,100 and 2,600 MHz as dense macro layers; 3,500 MHz as the main wide-band 5G layer
Dense urban	700, 800 or 900 MHz for control, mobility and hard-to-reach indoor areas	1,800, 2,100, 2,600 and 3,500 MHz on dense macro and small-cell grids; future upper 6 GHz at the busiest sites

Source: WIK-Consult

As shown in Table 3-1, spectrum holdings are distributed relatively evenly across the operators in most frequency bands. As such, all MNOs have the prerequisites to fulfil license obligations.

Furthermore, the balanced distribution of frequencies indicates no significant differences in market strategies or future MNO-specific spectrum requirements. However, when considering the structure of the networks, the utilisation of 3.5 GHz and the distribution of mobile traffic in the Dutch mobile market, where Odido represents more than 50% of total traffic, there are significant differences among the MNOs. Odido's data supports the hypothesis that as the volume of traffic handled by the mobile network increases, the respective MNO becomes increasingly reliant on higher frequencies for offloading purposes, thereby freeing up other congested frequencies. The alternative option would involve densification, which is costly and sometimes not feasible.

The MNOs expressed their view, that , retaining the existing rights of use in the 800 MHz, 900 MHz, 1,800 MHz, and 2,600 MHz bands is essential to safeguard long term service continuity, network capacity, and technological evolution. The frequency rights due to expire account for more than two thirds of the spectrum currently assigned to MNOs below 1 GHz in the Netherlands, as well as 2 × 75 MHz in the extensively deployed 1,800 MHz and 2,600 MHz frequency ranges.

Continued access to these frequencies is particularly important because each MNO has configured its network, including site locations, on the basis of its individually assigned and usable spectrum portfolio. Adapting the network to a substantially different spectrum allocation could especially require the deployment of additional sites, involving significant implementation costs and long lead times, while also being constrained by the limited availability of suitable locations and rooftops, as well as difficulties in obtaining the necessary permits.[31] However, that does not mean, that from a technical point of view the exact amount of spectrum already assigned, is necessary for future business. If frequencies are interchangeable, there is flexibility. Consequently, if the frequencies will be (re-)assigned in an auction, the MNOs have flexibility to express their specific demand.

In order to support the transition from 5G non-standalone to 5G standalone networks and, subsequently, to 6G, it is also necessary to maintain comparable spectrum holdings. This transition requires multiple frequency bands to be migrated to 5G New Radio, primarily because customer devices do not support all possible combinations of bands.

Given emerging network congestion, growing traffic demand, and the considerable time required to deploy additional infrastructure and advanced antenna technologies, continued access to all four bands should be regarded as a critical prerequisite for the sustainable operation and evolution of mobile networks. In light of the imminent large-scale reassignment of spectrum used by established mobile network operators — encompassing over two-thirds of their existing spectrum assignments below 1 GHz — it appears that MNOs require extensive spectrum usage rights.

Importance of the 800 MHz, 900 MHz, 1,400 MHz, 1,800 MHz and 2,600 MHz for a potential newcomer

Since the widespread deployment of low-band frequencies is essential for incumbent MNOs, the same applies for a potential new entrant. Access to sub-1 GHz spectrum is important to provide area and indoor coverage. Without having access to frequencies below 1 GHz, market experience in the past and today illustrates that a competitive offer of the respective MNO in the end user market (and wholesale market) would hardly be possible. However, the concrete amount of spectrum in the low-band (2 x 5 MHz, 2 x 10 MHz, etc.) required to be competitive, depends on the number of customers and business proposition of the MNO concerned and the network structure. The smaller the cells, the more frequencies > 1 GHz can cover the same area than frequencies < 1 GHz.

The Dutch Authority for Consumers and Markets previously found that 800 MHz or 900 MHz could be essential for a new entrant seeking to become a full competitor because low-band spectrum lowers the barrier to non-urban and nationwide coverage. The 2012 Dutch auction[32] accordingly reserved 2 x 10 MHz at 800 MHz and 2 x 5 MHz at 900 MHz

31 Dialogic (2025), Analyse schaarste van antenne-opstelpunten in Nederland, commissioned by Monet, 8 September 2025

32 The explanatory memorandum considered 2 × 10 MHz at 800 MHz the minimum amount needed for a nationwide mass market newcomer to compete effectively. However, the reservation was divided into

for entrants. In the auction only the 800 MHz frequencies were assigned to a new entrant. This new entrant, Tele 2, was taken over in 2019 by one of the three incumbent operators, T-Mobile at that time.

Currently, the spectrum requirements of a new entrant are subject of an ongoing discussion in Germany. The new entrant 1&1 Mobilfunk entered the mobile market with spectrum assignments in 3.5 GHz. Therefore, the new MNO asked the German regulator to assign low-band frequencies. This call is motivated with the need to provide indoor coverage. Relying only on mid-band frequencies is considered by the MNO as a considerable competitive disadvantage.

With regard to mid-band frequencies, the same method of reasoning can be applied. Demand for mobile services and applications is increasing, and customers (particularly in the business sector) are requesting dedicated quality of service (e.g. low latency, guaranteed data throughput). All MNOs, irrespective of their market position, require an appropriate set of capacity frequencies.

The precise amount of spectrum required would depend on the new entrant's strategy, including:

- its target customers and expected traffic volumes;
- whether it intends to build a nationwide or regional network;
- the extent to which it relies on national roaming;
- its use of passive or active network sharing;
- access to wholesale capacity;
- its planned service quality and network differentiation;
- whether spectrum is used exclusively for 5G or initially shared with LTE.

As such, the need for spectrum in the mid-bands can hardly be defined ex-ante. It largely depends on the business proposition. Any kind of ex-ante determination may run the risk of promoting less efficient use of frequencies.

two 2 × 5 MHz licenses, allowing either one newcomer to obtain 2 × 10 MHz or two newcomers to obtain 2 × 5 MHz each. At 900 MHz, 2 × 5 MHz was considered the minimum amount required for a newcomer pursuing voice, limited data, or machine to machine services. (See Regeling aanvraag- en veilingprocedure vergunningen 800, 900 en 1,800 MHz, Staatscourant 2012, No. 392, 6 January 2012, available at https://zoek.officielebekendmakingen.nl/stcrt-2012-392.pdf?, last call 25 August 2026.

3.2 Frequencies and technological developments

This section addresses the questions related to technological developments.

Question 3: Which band(s) is (are) expected to be most important for the introduction of 6G?

Question 9: Which 3GPP standardised technologies are currently supported in the four bands?

Question 10: Are there important differences to report compared to the previous assignment procedure for these bands

3.2.1 Frequency band for the introduction of 6G?

The introduction of 2G, 3G, 4G and 5G has generally been accompanied by the identification and assignment of additional radio spectrum. Concurrently with the introduction of new technologies, MNOs began to consider the refarming of already assigned frequencies. The phasing out of legacy technologies is dependent on a number of factors, including demand for these technologies, the costs of running multiple radio networks in parallel, and vendor support. Spectrum authorities have therefore sought to identify, harmonise and award spectrum in a timely manner to support market developments and facilitate a smooth transition.[33]

5G illustrates that the primary launch band of a new standard is not necessarily the only band in which the technology can be deployed. Although 3.5 GHz have been assigned for 5G, MNOs started to roll out the new technology in other bands as well (e.g. 700 MHz, 800 MHz). The RSPG expects the same layered approach for 6G: 6G could be implemented in all bands already harmonised for wireless broadband, while the upper 6 GHz band is identified as the primary European band for introduction by 2030.[34]

Within the four expiring bands, no single frequency range can perform every 6G function. The 800 MHz and 900 MHz bands will remain most important for nationwide, indoor and mobility coverage, while 1,800 MHz and 2,600 MHz can provide additional urban and suburban capacity after refarming. Within this four-band portfolio, 800 MHz is therefore likely to remain the most important coverage asset, whereas 2,600 MHz is the strongest early capacity asset. Outside this set, 3.5 GHz is likely to provide the principal bridge from 5G Advanced to 6G because operators can reuse an existing massive-MIMO grid. Upper

33 Radio Spectrum Policy Group, Opinion on a 6G Spectrum Roadmap, RSPG26-013 FINAL, June 2026; available at https://radio-spectrum-policy-group.ec.europa.eu/document/download/469641a9-dec2-4c74-8415-b1ec44258a82_en?filename=RSPG26-013final-RSPG_Opinion-6G_Spectrum_Roadmap.pdf, last call: 23 August 2026.

34 Radio Spectrum Policy Group, Opinion on a 6G Spectrum Roadmap, RSPG26-013 FINAL, June 2026; available at https://radio-spectrum-policy-group.ec.europa.eu/document/download/469641a9-dec2-4c74-8415-b1ec44258a82_en?filename=RSPG26-013final-RSPG_Opinion-6G_Spectrum_Roadmap.pdf, last call: 23 August 2026.

6 GHz should be considered as a contingent capacity layer rather than a certain substitute for 1,800 or 2,600 MHz. That said, we expect, that the deployment pattern of 6G will copy the deployment path experienced with 5G. Consequently, 6 GHz will come into play when other frequency resources are not available.

Which of the already used frequency bands will be available first in mobile handsets is difficult to predict. For example, with the introduction of 4G although it was expected that 4G would be deployed at 800 MHz and 2,600 MHz first, the first available devices provided 4G at 1,800 MHz, which has significantly changed the rollout strategies with many operators. The 1,800 MHz band (3GPP LTE Band 3) was one of the most important bands for the early deployment of LTE[35]. Its importance came primarily from refarming existing GSM 1,800 spectrum for LTE**,** rather than from allocating a completely new band. The GSM Association explicitly calls 1,800 MHz the LTE band with the largest device ecosystem.

Ericsson likewise anticipates a layered migration in which 6G reuses existing 5G spectrum and coexists with 6G, while additional capacity is introduced in the upper 6 GHz band and, later, in centimetric ranges between 7 GHz and 15 GHz. WRC-27 Agenda Item 1.7 is studying 125 MHz at 7,125 to 7,250 MHz and 650 MHz at 7,750 to 8,400 MHz for possible IMT identification in region 1, as well as 550 MHz at 14.8 to 15.35 GHz worldwide. The combined 1,325 MHz is only a study range and should not be treated as a forecast of spectrum that will be harmonised or awarded in Europe.[36]

Table 3-5: Potential spectrum layers for the introduction and evolution of 6G

Spectrum layer	Potentially available spectrum	Expected 6G role and assessment
800/900 MHz	Existing licensed spectrum only. Availability for 6G depends on licence renewal, refarming and the migration of legacy services.	Essential nationwide, indoor, control and mobility layer. Scarce bandwidth limits its contribution to headline 6G capacity.
1,800/2,600 MHz	Existing licensed holdings can be reused after refarming. No additional spectrum is created by the technology transition.	Early coexistence and capacity layer with mature infrastructure. Within the four expiring bands, 2,600 MHz offers the strongest capacity contribution, while 1,800 MHz provides broader macro reach.

35 https://www.gsma.com/solutions-and-impact/connectivity-for-good/public-policy/mobile-policy-handbook/wp-content/uploads/2019/01/MPH7_ENG_web_spreads.pdf

36 See ITU, WRC-23 results and WRC-27 Agenda Item 1.7 for IMT in the 4400-4800 MHz, 7125-8400 MHz and 14.8-15.35 GHz ranges. , available at: https://www.itu.int/en/ITU-R/seminars/rrs/rrs-24-asia%26pacific/Plenaries/1.%20Plenaries%20Monday%2016-Sept/8.%20WRC-23%20results%20and%20WRC-27%20terrestrial.pdf, last call 23 August 2026; Ericsson, 6G: connectivity and beyond for the 2030s. available at: https://www.ericsson.com/en/reports-and-papers/white-papers/6g-connectivity-and-beyond-for-the-2030s, last call: 23 August 2026 and Ericsson, 6G spectrum: enabling the future mobile life beyond 2030, available at: https://www.ericsson.com/en/reports-and-papers/white-papers/6g-spectrum-enabling-the-future-mobile-life-beyond-2030, last call: 23 August 2026.

Spectrum layer	Potentially available spectrum	Expected 6G role and assessment
3.5 GHz	Existing 5G spectrum can be reused for 6G, subject to operator migration strategies and equipment support.	Likely bridge from 5G Advanced to 6G, supported by the existing massive-MIMO site grid and wide channels.
Upper 6 GHz 6,425-7,125 MHz	700 MHz nominally. RSPG prioritises 540 MHz for mobile use. Depending on WRC-27 on 7 GHz band and subsequent EU decisions, approximately 665 MHz or up to 700 MHz could potentially support mobile networks.	Principal new European 6G launch candidate. It offers wide channels and potential reuse of the 3.5 GHz macro grid, but actual availability will depend on coexistence, harmonisation and award decisions.
WRC-27 candidates 7-15 GHz	1,325 MHz is under study for IMT: 125 MHz at 7,125-7,250, 650 MHz at 7,750-8,400 and 550 MHz at 14.8-15.35 GHz. None of this amount is guaranteed for Europe.	Potential later capacity expansion for dense urban and specialised use cases. Fragmentation, incumbent services and uncertain European harmonisation reduce near-term certainty.
26/42 GHz	Several GHz are already harmonised in Europe, but national assignment, deployment and device support remain limited.	Very high-capacity hotspot layer. It cannot replace mid-band spectrum for wider-area capacity and is more likely to remain a specialised supplement.

Source: WIK-Consult, based on RSPG, ITU and Ericsson (sources cited in the text)

Ultimately, the order in which bands will be introduced for 6G depends on 3GPP standardisation and the capabilities of initial 6G devices, which are expected to become clearer as we approach 2030.

3.2.2 3GPP standardised technologies supported frequency bands

The current 3GPP based technologies support all frequency bands mentioned in the study. Since business continuity is vital for stakeholders in the mobile ecosystem, we do not expect any limitations in mid- and long-term future. Currently, frequency bands standardized for 5G are subject to the study item in 3GPP Release 20. We do not expect that any of these bands will be excluded from considerations in 6G.

3.2.3 Are there important differences to report compared to the previous assignment procedure for these bands?

We are currently not aware on any new compatibility issues in these frequency bands (apart from the already existing ones (e.g. GSM-R, DECT[37])). In the future GSM-R will be replaced by FRMCS (Future Railway Mobile Communication System). There are documented coexistence issues between FRMCS and 3GPP-based public mobile networks in the 1900–1920 MHz band.[38] However, it is important to note that FRMCS is itself based on 3GPP NR, meaning the issue is not "FRMCS versus 3GPP" as two fundamentally different radio technologies. Rather, it is primarily a matter of the FRMCS spectrum versus other 3GPP-based public networks operating in adjacent or nearby bands.

3.3 Complementarity and substitutability of frequencies

This subsection addresses the following questions:

Question 4: Are there any linkages between the before mentioned four bands on one hand and the future upper 6 GHz band on the other?

Question 6: To what extent is the substitutability and/or complementarity between the 800, 900, 1,800, and 2,600 MHz bands?

3.3.1 Linkages between frequency bands and the future upper 6 GHz band

As stated above, the upper 6 GHz can support MNOs in keeping up the increasing demand. As we will show in chapter 3.54 we anticipate already areas where the current frequency portfolio is hardly able to address the requested capacity. However, due to its propagation characteristics, this band cannot economically and technically replicate sub-1 GHz bands.

There is also infrastructure complementarity. Upper 6 GHz deployment is likely to reuse fibre-connected macro sites, power systems and active-antenna capabilities developed for 3.5 GHz. Operators with dense urban grids and modern massive-MIMO sites may therefore value upper 6 GHz more highly.

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37 In the case of DECT, which operates in the 1880–1900 MHz band, potential interference may arise from mobile networks operating in adjacent frequency bands, particularly due to unwanted emissions and receiver blocking. Appropriate technical conditions and coordination measures are therefore important to ensure coexistence. (See https://docdb.cept.org/download/3466)

38 ECC Report 314: Co-existence between Future Railway Mobile Communication System (FRMCS) in the frequency range 1900-1920 MHz and other applications, May 2020. https://docdb.cept.org/download/1425

Table 3-6: Linkages between frequency bands

Linkage	Mechanism	Implication for award policy
Coverage/capacity	Low-band provide reach; upper 6 GHz provides bandwidth	Do not treat upper 6 GHz as a substitute in a low-band spectrum cap
Uplink/downlink	Low-band uplink can support higher-band downlink	Band combinations affect value but do not require tied lots
Sites and backhaul	Upper 6 GHz reuses dense, fibre-connected macro grids	Auction values depend on existing infrastructure
Technology migration	Existing bands can host 5G and 6G coexistence	Licence conditions should remain technology neutral

Source: WIK-Consult

In the Netherlands, upper 6 GHz would be linked most strongly to the identical 100 MHz 3.5 GHz holdings of the three MNOs and to their existing urban site grids. In dense urban areas it can become an additional capacity carrier above 3.5 GHz when capacity scarcity emerges in those areas. In ordinary urban and suburban areas, it is more likely to be deployed selectively, while 1,800, 2,100 and 2,600 MHz continue to carry much of the macro traffic. In rural and light suburban areas, upper 6 GHz has little direct substitution effects because the low-band site layer remains the economical coverage solution.

Portfolio asymmetry affects the strength of the linkage. VodafoneZiggo and Odido have larger 2,600 MHz FDD holdings, which they can use as an intermediate layer before adding the upper 6 GHz. KPN has fewer 2,600 MHz FDD holdings, meaning its 1,800, 2,100 and 3,500 MHz layers may need to carry out more of this intermediate function. For all three operators, supporting networks and devices can increase the usable footprint of higher-band capacity through aggregation or dual connectivity, providing low-band uplink and mobility support.

3.3.2 To what extent is the substitutability and/or complementarity between the 800, 900, 1,800, and 2,600 MHz bands?

As outlined in chapter 2, low-band frequencies can be considered complementary to 1,800 MHz and 2,600 MHz. However, 1,800 MHz frequencies can be seen as additional frequencies providing coverage. Therefore, 1,800 MHz could be a partial substitute to low-band frequencies.

Due to propagation characteristics the footprint of 1,800 MHz and in particular 2,600 MHz is much smaller than the regional footprint of low-band frequencies. The analysis of the inter-site distances in Dutch mobile networks confirms this assessment (see chapter 2.1).

The disparities in coverage could have substantial ramifications for costs. To illustrate, should low-band frequencies become less accessible to an MNO, the repercussions could be considerable. In the event of this occurrence, the MNO would be required to construct new sites, which would consequently result in a shortage of available sites.[39]

Beside the difference in coverage, there are differences due to the implementation of capacity enhancement technologies. Those technologies (e.g. like massive MIMO) can be more easily applied to mid-band spectrum than to low-band frequencies.

Analysing the frequencies in the low-band, propagation characteristics show that 800 MHz and 900 MHz are quite common which would argue for substitutability. Their free-space frequency difference corresponds to only about 1 dB of additional loss at 900 MHz relative to 800 MHz at the same distance. In current networks, antenna configuration, clutter, power limits and bandwidth can outweigh that small difference. In addition, 700 MHz frequencies which are deployed as well, could substitute frequencies in other low-bands. However, some operators currently deploy 5G in 700 MHz and provide 4G services in 800 MHz.

But there are also technical aspects (e.g. limited support of legacy network components and user terminals) that limit substitutability. The number of limitations on substitutability include the following aspects.

- The terminal ecosystem: Vendors restrict the number of band combinations implemented in terminals. There is now good visibility on supported combinations for 4G and 5G NSA, but this was not the case in the years following their launch. Therefore, when deciding on a radio technology, support for terminals had to be taken into account. For 5G SA, this is only just beginning to develop, and it will only become clearer around 2030 for 6G. For example, we currently know that the combination of the 700 and 900 MHz bands is hardly supported by terminals, making 800 MHz essential for achieving optimal performance of both the low-band and general band combinations. This would also negatively affect 6G performance when a low-band combination is beneficial.[40]
- For 5G NSA, 4G and 5G carriers are combined: Also, here terminal support allowing this (with wider bandwidth) in a single band is very limited, negatively impacting performance where this would be required. Wider bandwidths in the same band can also lead to additional intermodulation products, impacting performance.
- For 4G IoT/M2M the support for the 900 MHz band appears to be better. Additionally, there is a need for continuity of service for 4G IoT/M2M terminals that have already been deployed and may lack 800 MHz support.

39 See Dialogic (2025), Analyse schaarste van antenne-opstelpunten in Nederland. Report 2025.026-2533 for Vereniging Monet, 8 September 2025.

40 This would require the 700 and 800 MHz bands, and both implementing 6GR (with or without MRSS).

The two bands are therefore interchangeable to some extent, but complementary in multi-layer macro networks. In addition, the following must be considered:

- The 1,800 MHz band has better propagation characteristics than the 2,600 MHz band. We only expect antenna technology enhancements in this band to improve coverage sufficiently to partially offload traffic currently carried on the low-bands.
- Enhancements on 2,600 MHz antenna technology would in turn offload part of the traffic currently handled at 1,800 MHz.

Table 3-7: Substitutability and complementarity

Pairing	Substitutability	Complementarity	Overall assessment
800 vs 900	Very high for coverage	Some additional low-band capacity and migration flexibility	Closest substitutes
1,800 MHz vs 2.6 GHz	Medium for urban capacity	Different cell radii and traffic layers, however new technologies might compensate path loses	Currently partial substitutes, strong complements
800/900 vs 1.800 MHz	Limited for wide-area coverage; 1,800 might substitute 800/900 in some regions	Very high coverage/capacity synergy	Predominantly complementary
800/900 MHz vs 2.6 GHz	Low	Very high base-layer/hotspot synergy	Strong complements

Source: WIK-Consult

For each Dutch MNO, 700 MHz, 800 MHz and 900 MHz are close operational substitutes at the coverage-layer level, but not perfect substitutes once installed equipment, carrier bandwidth and legacy services are considered. Because all three operators already hold 2 x 10 MHz at both 700 and 800 MHz, a loss of 800 MHz would not eliminate nationwide coverage, but it would reduce low-band capacity, indoor resilience and migration flexibility. Odido has more 900 MHz and therefore a somewhat stronger low-band substitute than KPN or VodafoneZiggo.

At higher frequencies, the Dutch portfolios show partial substitution. Odido can use its 2 x 30 MHz at 1.800 MHz to perform more of the general macro capacity role. VodafoneZiggo can rely more heavily on its 2 x 30 MHz at 2,600 MHz FDD in urban areas. KPN has balanced 1.800 and 2.100 MHz holdings but less 2,600 MHz FDD. In rural and light suburban areas, 1.800 and 2,.00 MHz are more useful substitutes for each other than either is for 2.6 GHz or 3.5 GHz. In urban and dense urban areas, 1.800, 2.100, 2.6 GHz and 3.5 GHz form a complementary capacity stack.

Answering the questions about substitutability and complementarity, we have to consider frequency usage in adjacent bands which are used for other purposes. The RAS bands 1718.80-1722.2 MHz (secondary allocation) and 2,655-2,670 MHz (primary allocation) which are also included in the National Frequency Plan, directly border one of the mobile bands under consideration. Protection thresholds from ITU-R RA.769/2 apply in these bands.

3.3.3 Are there any linkages between these four bands of a technical/technological and/or business economical nature which would make it necessary for mobile operators to obtain certain combinations of the frequencies at stake?

3.3.3.1 Qualitative assessment

There is no empirical or technical indication, that a specific combination of the four bands is technically mandatory for an MNO. A national MNO does, however, need the functions normally supplied by a combination of low-band coverage spectrum and mid-band capacity spectrum.

Those functions can be supplied by bands outside the award. For example, 700 MHz can substitute for 800 or 900 MHz, while 2,100 and 3,500 MHz can substitute for part of the capacity function of 1,800 or 2,600 MHz Densification, national roaming and network sharing provide further, although imperfect, alternatives.

Carrier aggregation and dual connectivity create portfolio synergies. 3GPP standardises many LTE and New Radio (NR) band combinations, but support remains device-specific.

Table 3-8: Necessity to combine specific frequencies

Required function	Possible spectrum sources	Is one of the four bands mandatory?
Nationwide coverage	700, 800 or 900 MHz	No, but some sub-1 GHz access is highly valuable
General macro capacity	1,800, 2,100 or 2,600 MHz	No
High urban capacity	2,600, 3,500 or upper 6 GHz (once assigned)	No
Service continuity	Existing operator-specific holdings and migration plan	Potentially important for a particular operator, not universally mandatory
Carrier aggregation	Supported combinations across low and mid-bands	No ownership requirement imposed by 3GPP

Source: WIK-Consult

No (current) Dutch MNO needs a prescribed combination from the four expiring bands because all three already hold 700 MHz, 2,100 MHz and 3.5 GHz. Nevertheless, each MNO needs a functional combination. Rural and light suburban networks require at least one strong low-band layer plus enough 1,800 or 2,100 MHz capacity at busier sites. Suburban networks normally need low-band together with 1,800 and 2,100 MHz, with 1,400 or 2,600 MHz added where traffic grows. Urban and dense urban networks benefit from the full progression to 2,600 and 3,500 MHz.

The following aspects should be considered as well: the equipment already deployed is an input parameter for spectrum valuation. Both in terms of capabilities and price. For radio units and (active) antennas the capability of integrating frequency bands is very important. Many base station sites have stringent restrictions on space for antennas, associated wind load and weight of the installation. As long as such an equipment is used, the MNO will take it into account.

With regard to a potential entrant, an assignment of spectrum in the low-band is necessary (for coverage and indoor). Furthermore, a new entrant needs frequencies in the higher bands as well.

3.3.3.2 Quantitative assessment

Against the background of the technical characteristics of the three mobile networks and the current demand, as outlined in model methodology in chapter 1.2, we estimate that the MNOs are already challenged by network congestions.

Table 3-9: Results of quantitative model of demand and capacity; estimations end of year 2026

	KPN	VodafoneZiggo	Odido
Percentage of sites with high load	6,4	11	19

Source: WIK-Consult

Consequently, one can expect that the current frequency portfolio will constrain customer experience and the ability of the MNO to catch up with future market requirements. 6 GHz might improve the situation mainly in dense urban and urban areas. In rural areas, MNOs must adopt different approaches to increase capacity (e.g. densification).

However, among the three MNO the possibility to balance capacity and demand in urban and dense urban areas is unevenly distributed: For instance, KPN can make more widespread use of 3.5 GHz frequencies, whereas Odido has already achieved a very high number of sites, where 3.5 GHz improves the quality of services. Regardless of whether 6G is introduced, some MNOs will seek to utilize the 6 GHz band.

3.4 Future demand and additional frequencies

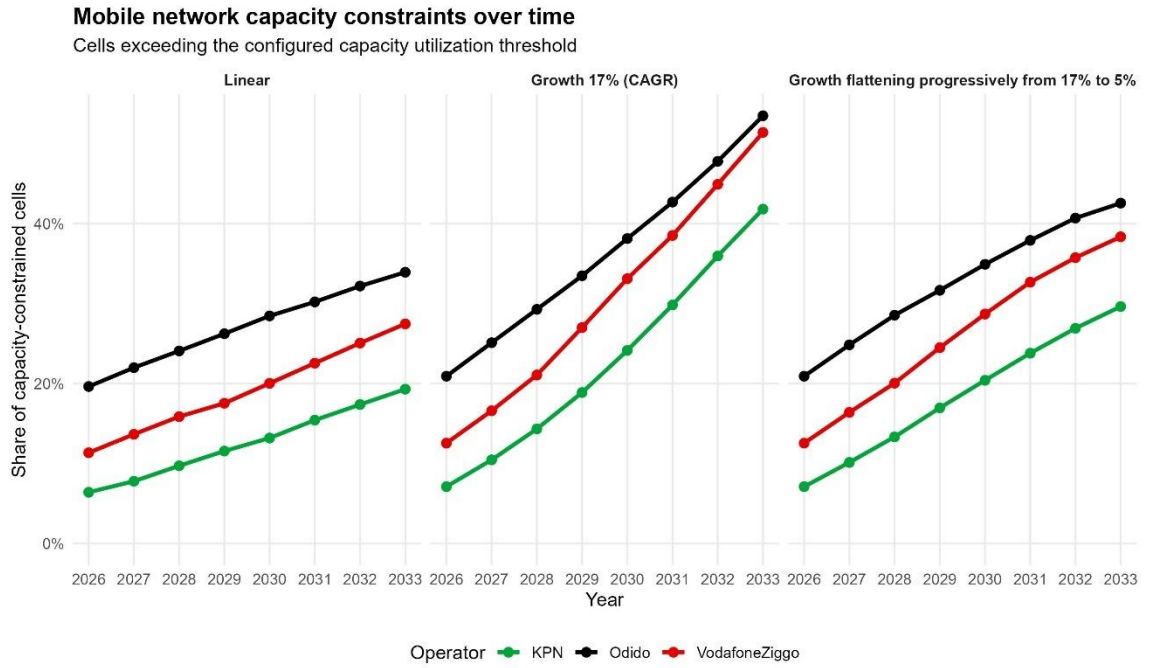
This section addresses the future demand and how additional frequencies in the mid-band the following questions.

Question 8: To what extent are MNO decisions to acquire spectrum in the 800/900/1,800/2,600 MHz bands affected by the prospect of the upper 6 GHz band becoming available in the near future?

3.4.1 Value of the upper 6 GHz band

It is assumed that capacity constraints can be detected in the mobile networks (see Figure 3-1). These constraints will become increasingly important in the near future. As outlined in Chapter 2.2, we have determined that there are significant benefits to be gained from the allocation of 6 GHz frequencies. The 6 GHz frequency will, in general terms, complement the existing use of frequencies. Consequently, we do not anticipate that the utilisation of 6 GHz will exert a discernible influence on the demand for spectrum in the 800 MHz, 900 MHz, 1,800 MHz and 2,600 MHz bands. As the 6 GHz band may be applicable for 6G, excluding this band would mean that an MNO would have to take the risk that 6G is available in other bands from the outset.

Figure 3-1: Share of congested cells in the future, different scenarios



Source: WIK-Consult based on Dutch Authority for Digital Infrastructure (RDI/Antennebureau), August 2026.

Figure 3-1 shows that depending on the future growth of mobile traffic, more than 40% of cells will face permanent traffic congestions.[41] As stated above, the option of the MNOs to address future demand with 3.5 GHz frequencies is not available to all MNOs.

3.4.2 When are those frequencies available?

For the Netherlands, the prospect of the upper 6 GHz band becoming available is relevant to MNOs' valuation of the 800, 900, 1,800 and 2,600 MHz bands, particularly because the existing licences in these bands expire in or around 2030.

The Dutch government's draft policy as was published in June 2026 envisaged making at least 6,585 to 7,125 MHz available for nationwide public mobile communications around the year 2030.

The relevant amendment to the National Frequency Plan underwent public consultation, which closed on 10 July 2026.[42]

3.4.3 Impact on MNO demand for 800 MHz, 900 MHz, 1,800 MHz and 2,600 MHz

The upper 6 GHz band should primarily be regarded as a complement to the existing spectrum portfolio rather than a substitute for it. This is particularly clear from the June 2026 RSPG 6G Spectrum Roadmap.[43] The RSPG expects 800 and 900 MHz to remain important for nationwide and indoor 6G coverage, while 1,800 and 2,600 MHz will continue to provide capacity in suburban and urban areas. Upper 6 GHz is identified as the primary additional band for the introduction of 6G around 2030, providing large contiguous bandwidth on existing or broadly comparable macro site grids.

The implications for spectrum valuation are therefore different for each band.

41 Please see for the interpretation of data chapter 1.2.
42 https://www.internetconsultatie.nl/nationaal_frequentieplan/document/15686.
43 https://radio-spectrum-policy-group.ec.europa.eu/document/download/469641a9-dec2-4c74-8415-b1ec44258a82_en?filename=RSPG26-013final-RSPG_Opinion-6G_Spectrum_Roadmap.pdf.

Table 3-10: Impact on demand

Band	Main economic role	Substitutability by upper 6 GHz	Likely impact on MNO acquisition incentives
800 MHz	Wide-area and indoor coverage	None	None
900 MHz	Wide-area and indoor coverage, voice and data	None	None
1,800 MHz	Coverage plus capacity	None	None
2,600 MHz	Primarily capacity in higher-traffic areas	Small	Potentially the strongest effect. A large upper 6 GHz assignment reduces the scarcity of capacity spectrum and could therefore reduce the willingness to pay for incremental 2,600 MHz holdings. However, 2,600 MHz remains more mature and has better propagation.

Source: WIK-Consult

A further relevant distinction is that 3GPP band n104, covering 6,425 to 7,125 MHz, operates in TDD mode, whereas the 800, 900 and 1,800 MHz bands, as well as a substantial part of the 2,600 MHz spectrum, use paired FDD. As a result, these bands are not fully interchangeable from a network perspective.[44]

Consequently, the expected availability of the upper 6 GHz band is likely to reduce the scarcity value of capacity focused spectrum, particularly in the 2,600 MHz band and, to a lesser extent, the 1,800 MHz band, while having only a limited impact on the strategic importance of the 800 and 900 MHz bands.

The upper 6 GHz prospect could nevertheless be material in the 2030 award because operators will value all bands as parts of a portfolio. The Dutch government itself appears to recognise this interaction by considering the upper 6 GHz assignment in as close as possible connection with the frequencies expiring around 2030.[45]

The practical assumption for an MNO considering the upcoming Dutch multiband award(s) should therefore be that 540 MHz of upper 6 GHz offers credible additional mobile resources around 2030, but not yet a guaranteed substitute today.

44 ETSI TS 138 104 V18.13.0 (2026-04).
45 https://www.internetconsultatie.nl/nationaal_frequentieplan/document/15686

3.4.4 Interference and coexistence with existing users

The upper 6 GHz band is not vacant. Existing Dutch users include fixed microwave links, particularly over the North Sea, fixed satellite service uplinks, radio astronomy, Earth exploration satellite applications and low-power UWB devices. TNO's detailed inventory identifies commercial satellite earth stations, as well as Defence satellite use.[46]

The Dutch geography creates a particular issue for satellite uplinks. Because the Netherlands is relatively far north, satellite dishes use comparatively low elevation angles. A high-power earth station transmission can consequently travel over a relatively long terrestrial distance and potentially interfere with upper 6 GHz mobile base-station receivers. The Dutch draft NFP therefore notes that further national coexistence analysis is required.[47]

Fixed links create another issue, although the Dutch situation is somewhat more favourable than in countries where large numbers of upper 6 GHz microwave links are deployed across the entire territory. In the Netherlands, a substantial share is concentrated over the North Sea. The government nevertheless identifies possible coexistence problems near the coast and intends to examine the distances and technical conditions required for mobile networks and offshore fixed links to coexist.[48]

Co-existence with tadio astronomy is particularly important around **Westerbork**, where there is an interest in observations in the 6,650 to 6,675.2 MHz band. This falls directly inside the 6,585 to 7,125 MHz block proposed for prioritised mobile use. The RSPG therefore explicitly recommends coordination and protection of radio astronomy installations in countries where these observations take place. The Ministry is currently engaged in national technical co-existence assessments and policy considerations regarding the future of the Upper 6 GHz in this respect.[49]

There is also an adjacent-band issue with European Wi-Fi in the lower 6 GHz band, 5,945 to 6,425 MHz. The proposed European band plan uses 6,425 to 6,585 MHz temporarily in part to protect this WLAN use while the final technical conditions are determined. CEPT completed Report 92 in June 2026 on potential shared use of 6,425 to 7,125 MHz, while ECC Report 375 specifically addresses compatibility between mobile networks and incumbent users. This means coexistence is technically feasible in principle, but the precise European limits and national coordination arrangements are still under development.[50]

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46 FNS template.
47 FNS template.
48 https://www.internetconsultatie.nl/nationaal_frequentieplan/document/15686
49 https://radio-spectrum-policy-group.ec.europa.eu/document/download/3301c2fd-7bff-4ecf-bfcd-cfb572a5972f_en?filename=RSPG25-031final-RSPG-Opinion-Upper_6GHz_band.pdf
50 CEPT Report 92

3.4.5 When is equipment available?

The equipment situation is significantly more advanced than the regulatory situation. Upper 6 GHz has already been standardised by 3GPP as NR band n104, covering 6,425 to 7,125 MHz in TDD mode. The band was introduced in Release 17 and remains part of current Release 18 specifications. Thus, there is no fundamental standards barrier to using upper 6 GHz for 5G-Advanced or subsequently 6G.[51]

However, there is an important difference between standardisation and a mature commercial ecosystem. Upper 6 GHz radios and terminals already exist for trials, but European n104 equipment is still predominantly at the trial or pre-commercial stage. Nokia and Telia have tested a 128-transceiver Massive MIMO upper 6 GHz radio with test user equipment, and Nokia's 2026 technical paper explicitly describes the n104 equipment used in those tests as pre-commercial and contrasts it with future standardised commercial equipment.[52] In November 2025, Telefónica, Nokia and the Polytechnic University of Valencia conducted an n104 pilot in Spain. The trial found that Massive MIMO could compensate substantially for the additional propagation loss and allow coverage broadly comparable with 3.5 GHz using existing base-station locations.[53]

A reasonable expectation is therefore that network equipment will not be the critical bottleneck for a Dutch assignment around 2030. We expect a broad commercial availability of both RAN equipment and handsets because European harmonisation should support of the ecosystem in the 2030s.

3.4.6 Will spectrum still be scarce?

In the short term, there is no strong evidence of an acute Dutch mobile spectrum shortage. The independent 2025 upper 6 GHz study commissioned by the Ministry of Economic Affairs concluded that both mobile networks and Wi-Fi have sufficient capacity in their existing bands for the coming years. It nevertheless expects both to need additional spectrum over the longer term, although the extent and timing of traffic growth are uncertain. The study therefore recommended examining a hybrid solution providing at least 300 MHz to mobile networks and at least 320 MHz to WLAN rather than treating the entire band as immediately indispensable to either side.[54]

With the assignment of the 3.5 GHz spectrum in 2024 operators are equipped with a substantial relatively recent source of mid-band capacity which further reduces the argument that upper 6 GHz is required immediately.

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51 ETSI TS 138 104 V18.13.0 (2026-04)

52 https://www.nokia.com/newsroom/nokia-and-telia-complete-successful-outdoor-trial-in-6-ghz-range-with-massive-mimo-radio/

53 https://www.telefonica.com/es/sala-comunicacion/prensa/telefonica-nokia-upv-validan-piloto-utilidad-banda-6-ghz-comunicaciones-moviles/

54 https://www.rijksoverheid.nl/documenten/2025/11/30/beleidsopties-upper-6-ghz-band

Over the medium and long term, scarcity remains relevant. The RSPG's 2026 roadmap states that demand continues to increase particularly for low and mid-band spectrum and identifies upper 6 GHz as the main new wide-area mid-band opportunity for 6G. Industry submissions to the RSPG indicate a desired additional contiguous bandwidth of about 200 MHz per operator.[55]

Overall, it is important to highlight, that the upper 6 GHz solves only one dimension of scarcity. It can substantially increase capacity spectrum, particularly in dense urban and suburban locations, but it does not create additional coverage spectrum. Consequently, 800 and 900 MHz are likely to remain highly scarce strategic resources even after upper 6 GHz becomes available. Scarcity of 1,800 and particularly 2,600 MHz capacity spectrum should be somewhat reduced but not eliminated.

In this regard Sweden provides an interesting counterweight to more aggressive spectrum-demand forecasts. The Swedish regulator PTS concluded that it does not expect an urgent shortage of spectrum for either mobile or WLAN during the next five years and intends to protect existing upper 6 GHz fixed links at least until 2033. This is broadly consistent with the Dutch independent assessment that additional spectrum will probably be useful in the longer term but is not immediately indispensable.[56]

3.5 Demand and (re)assignment of frequencies

This section addresses the following questions:

Question 7: Are there any linkages between these four bands of a technical, technological and/or business-economic nature that would necessitate mobile operators obtaining certain combinations of the frequencies in question?

There are technical, technological and business economic linkages between the 800, 900, 1,800 and 2,600 MHz bands, as the different frequency ranges perform complementary functions within a mobile network.

3.5.1 Technical linkages

From a technical perspective, the strongest linkage is therefore between a coverage layer and a capacity layer. The 800 and 900 MHz bands have comparatively favourable propagation characteristics, enabling signals to travel over longer distances and

55 https://radio-spectrum-policy-group.ec.europa.eu/document/download/469641a9-dec2-4c74-8415-b1ec44258a82_en?filename=RSPG26-013final-RSPG_Opinion-6G_Spectrum_Roadmap.pdf

56 https://www.pts.se/en/news-and-press-releases/future-needs-for-radio-usage-in-the-upper-6-ghz-band/

penetrate buildings more effectively. This makes them particularly valuable for nationwide and indoor coverage. The 1,800 and 2,600 MHz bands have less favourable propagation characteristics but provide additional capacity and are therefore particularly useful in areas with higher traffic demand. However, taking into account that technological improvements will narrow the gap between low-band and mid-band spectrum, at least for outdoor use cases.

The Dutch spectrum cap framework reflects this distinction by imposing a separate cap on spectrum below 1 GHz and by explicitly recognising the particular importance of low frequency spectrum for cost efficient nationwide and indoor coverage.[57]

3.5.2 Technological linkages

There is also a technological linkage because modern mobile networks can use several frequency bands simultaneously. Carrier aggregation allows operators to combine spectrum from different bands in order to exploit their respective advantages. The European Commission has found that aggregation between spectrum below and above 1 GHz is technically feasible and beneficial, as lower frequency spectrum can extend coverage while higher frequency spectrum can provide additional capacity. In particular, the Commission has referred to the feasibility of aggregating 800 MHz and 1,800 MHz spectrum.[58]

3.5.3 Business/economic linkages

These complementarities do not, however, imply that an MNO must necessarily acquire a specific combination of the 800, 900, 1,800 and 2,600 MHz bands. There is a degree of substitutability both within these four bands and through other spectrum holdings. In broad terms, 800 and 900 MHz perform similar coverage functions, while 1,800 and 2,600 MHz are more capacity oriented, although their propagation characteristics differ. Moreover, operators can partly compensate for more limited spectrum holdings by using other frequency bands, deploying additional network sites or introducing more spectrum efficient technologies. The Dutch government expressly notes that additional capacity can also be created through network expansion and technological improvements. Whereas the first depends on the availability of sites and is therefore an exogenous factor that latter one is open to the MNOs.

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57 Dutch Ministry of Economic Affairs, *Capregeling frequenties mobiele communicatie 2020*, section 4.2: Staatscourant 2020, 13724

58 European Commission, Case M.7612, *Hutchison 3G UK / Telefónica UK*, decision of 11 May 2016, in particular para. 2397: Commission decision

Accordingly, the relevant question is not whether operators require a specific combination of the four bands as such, but whether their overall spectrum portfolios provide an adequate balance between coverage and capacity at reasonable network cost.

3.6 Regulatory aspects

In this context we address the question on the advice on the minimum lots size in each band.

Question 5: What would be the advice on the minimum lot size in each of the bands?

Assessment framework

The assessment should distinguish three concepts that are related but not interchangeable:

- The technical channel raster is determined mainly by European harmonisation measures, duplex arrangements, block edge masks and the carrier bandwidths supported by LTE and NR equipment.[59]
- The minimum auction lot is the smallest unit on which a bidder may express demand. It is a regulatory design choice and should be granular enough to reveal differences in bidder demand and existing portfolios.
- The economically efficient holding is the contiguous amount that permits cost-effective deployment of the intended services. It is therefore normally larger than one auction lot and depends on the band, network architecture, traffic profile and the operator's existing spectrum portfolio.

This distinction is decisive. A 2 x 5 MHz FDD lot can be a suitable bidding unit without being a sufficient stand-alone national holding. Conversely, packaging spectrum only in large operational blocks may reduce bidder flexibility, impede portfolio rebalancing and create an unnecessary barrier to entry. BEREC notes that small granularity gives bidders

59 Ministry of Economic Affairs, Evaluation of the Dutch Multiband Auction (2014). Official evaluation containing the 2012 lot structure, entrant reservation, use obligations and auction outcome. Source link; Government of the Netherlands, Regulation on spectrum caps for mobile communications. The explanatory memorandum links the cap regime to the reassignment of the 800, 900, 1,800 and 2,600 MHz bands and the expiry date of 31 December 2029 (see https://zoek.officielebekendmakingen.nl/blg-914509.pdf;European Commission, Decision 2010/267/EU. Harmonised technical conditions for the 790-862 MHz band; 3GPP TS 36.101, E-UTRA User Equipment radio transmission and reception. LTE user-equipment radio requirements and supported operating bands and bandwidths; 3GPP TS 38.101-1, NR User Equipment radio transmission and reception, Range 1 Standalone. NR user-equipment radio requirements and supported operating bands and bandwidths. (see https://www.3gpp.org/dynareport/38101-1.htm)

greater freedom of choice and that contiguity can be secured through the assignment stage; it also records 5, 10, 15 and 20 MHz lot sizes in European practice[60]

Band-specific recommendation

The values below should be treated as initial design hypotheses. The proposed auction lots follow the harmonised band arrangements and the successful logic of the Dutch 2012 multiband auction, which used 2 x 5 MHz FDD lots and 5 MHz TDD lots while enabling bidders to assemble contiguous holdings.[61] The indicative efficient holdings are planning benchmarks, not legal or technical minimums.

Table 3-11: Lot size analysis

Band segment	Recommended minimum auction lot	Indicative efficient holding	Rationale and qualifications
800 MHz FDD	2 x 5 MHz	Normally at least 2 x 10 MHz	The 5 MHz building block is consistent with the harmonised 800 MHz arrangement and Dutch precedent. One lot supports price discovery and portfolio adjustment, but a wider aggregated carrier is normally preferable for robust national coverage and capacity[62]
900 MHz FDD	2 x 5 MHz	Normally 2 x 10 MHz or more, subject to GSM and M2M migration	The harmonised framework supports large blocks of at least 5 MHz, while the band must also accommodate any remaining narrowband legacy use. Units below 2 x 5 MHz would add complexity without comparable LTE or NR value[63]
1,800 MHz FDD	2 x 5 MHz	Normally 2 x 15 to 2 x 20 MHz	Granular lots allow operators to address different portfolio gaps and aggregate spectrum into wider contiguous LTE or NR carriers. The final quantity should be determined by

60 BEREC, Study on Implications of 5G Deployment on Future Business Models (2018). Notes that recent auctions have tended to offer spectrum in small blocks, typically 5 MHz. BEREC, Report on practices on spectrum authorisation and award procedures and on coverage obligations (2018). Discusses lot-size granularity, technical harmonisation, bidder flexibility and assignment-stage solutions for contiguity.

61 Ministry of Economic Affairs, Evaluation of the Dutch Multiband Auction (2014). Official evaluation containing the 2012 lot structure, entrant reservation, use obligations and auction outcome.

62 Ministry of Economic Affairs, Evaluation of the Dutch Multiband Auction (2014). Official evaluation containing the 2012 lot structure, entrant reservation, use obligations and auction outcome, European Commission, Decision 2010/267/EU. Harmonised technical conditions for the 790-862 MHz band.

63 European Commission, Implementing Decision (EU) 2022/173. Harmonisation of the 900 MHz and 1,800 MHz bands. 3GPP TS 45.005, GSM/EDGE Radio transmission and reception. Technical specification relevant to residual GSM use in the 900 MHz band. 3GPP TS 36.101, E-UTRA User Equipment radio transmission and reception. LTE user-equipment radio requirements and supported operating bands and bandwidths. 3GPP TS 38.101-1, NR User Equipment radio transmission and reception, Range 1 Standalone. NR user-equipment radio requirements and supported operating bands and bandwidths.

Band segment	Recommended minimum auction lot	Indicative efficient holding	Rationale and qualifications
			demand and competition safeguards.[64]
2,600 MHz FDD	2 x 5 MHz	Around 2 x 20 MHz or more	The 5 MHz lot preserves competition for a capacity band, while wider contiguous holdings improve capacity and deployment economics. Frequency position may matter where edge conditions or adjacent uses differ.[65]
2,600 MHz TDD	10 MHz generic core lots; 5 MHz only for residual or restricted edge spectrum	Normally at least 20 to 40 MHz contiguous; 40 to 50 MHz preferable for a stand-alone high-capacity layer	The legal and equipment framework permits smaller units, but 10 MHz increments reduce the risk of stranded or low-value fragments. TDD synchronisation, frame structure, guard arrangements and edge restrictions must be resolved before generic lots are defined.[66]

Source: WIK-Consult.

Generic lots are preferable where blocks are materially substitutable. Frequency-specific or asymmetric lots may be needed where edge conditions, incumbent use, transition obligations or coexistence restrictions affect value. These issues should be resolved before the principal bidding stage, not left entirely to the assignment phase.

The Dutch 2012 experience provides direct support for granular lots. The award used 2 x 5 MHz for FDD spectrum and 5 MHz for TDD spectrum, allowing bidders to determine the amount and composition of their portfolios, and ultimately assigned all spectrum in

64 Ministry of Economic Affairs, Evaluation of the Dutch Multiband Auction (2014). Official evaluation containing the 2012 lot structure, entrant reservation, use obligations and auction outcome, European Commission, Implementing Decision (EU) 2022/173. Harmonisation of the 900 MHz and 1,800 MHz bands. BEREC, Report on practices on spectrum authorisation and award procedures and on coverage obligations (2018). Discusses lot-size granularity, technical harmonisation, bidder flexibility and assignment-stage solutions for contiguity.3GPP TS 36.101, E-UTRA User Equipment radio transmission and reception. LTE user-equipment radio requirements and supported operating bands and bandwidths.3GPP TS 38.101-1, NR User Equipment radio transmission and reception, Range 1 Standalone. NR user-equipment radio requirements and supported operating bands and bandwidths.

65 European Commission, Implementing Decision (EU) 2020/636. Updated technical conditions for the 2500-2690 MHz band. 3GPP TS 36.101, E-UTRA User Equipment radio transmission and reception. LTE user-equipment radio requirements and supported operating bands and bandwidths.3GPP TS 38.101-1, NR User Equipment radio transmission and reception, Range 1 Standalone. NR user-equipment radio requirements and supported operating bands and bandwidths.

66 European Commission, Implementing Decision (EU) 2020/636. Updated technical conditions for the 2500-2690 MHz band; 3GPP TS 38.101-1, NR User Equipment radio transmission and reception, Range 1 Standalone. NR user-equipment radio requirements and supported operating bands and bandwidths; Dialogic (2020), Onderzoek kavelgrootte veiling 3,5 GHz-vergunningen. Project 2019.170 v1.1.9 for the Ministry of Economic Affairs and Climate Policy, 25 March 2020. On the basis of the analysis and conclusions regarding substitutability and complementarity execution of a simultaneous auction of the four bands.

contiguous blocks.[67] Current Dutch holdings are also largely expressed in 5 MHz multiples. This makes 2 x 5 MHz a practical elementary FDD unit for KPN, VodafoneZiggo and Odido, while leaving the quantity decision separate from the frequency-position decision.

The minimum lot should not vary by area type for nationwide rights. Geography affects spectrum value and the efficient total holding, but not the basic bidding unit. Rural coverage can often be supported with comparatively modest low-band bandwidth, whereas dense urban traffic raises demand for wider holdings across 1,800 and 2,600 MHz and other capacity bands. The lot design should therefore permit operators to assemble different portfolios without fragmenting the band.

Competition safeguards should be assessed at portfolio level. ACM has emphasised the role of sub-1 GHz spectrum in cost-efficient coverage and the value of both total-spectrum and low-band caps.[68] Granular lots are complementary to those safeguards: they facilitate entry and rebalancing but do not, by themselves, guarantee that an entrant can assemble a viable national portfolio.

Dialogic's analysis for the Dutch 3.5 GHz award illustrates the broader design principle that the smallest technical divisor need not be the preferred auction increment. It supported 10 MHz TDD increments because they preserved demand flexibility while reducing the risk of suboptimal fragmentation, and it coupled granularity with an explicit view of the minimum operationally useful quantity.[69] Applied to 2,600 MHz TDD, this supports 10 MHz generic core lots, with 5 MHz retained only where needed for residual or edge spectrum. It does not justify mechanically imposing 10 MHz lots on the paired FDD bands.

The final lot structure should be confirmed shortly before the award through technical analysis, demand assessment, competition analysis, network modelling, stakeholder interviews and auction testing. The technical work should cover the harmonised channel arrangement, duplex configuration, standard LTE and NR carrier bandwidths, block edge masks, guard requirements, TDD synchronisation, contiguity, interference and coexistence, incumbent and adjacent band uses, and equipment and device availability. Demand and auction testing should then determine whether bidders can assemble efficient portfolios without excessive aggregation risk, stranded spectrum or avoidable barriers to entry.

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67 Ministry of Economic Affairs, Evaluation of the Dutch Multiband Auction (2014). Official evaluation containing the 2012 lot structure, entrant reservation, use obligations and auction outcome.

68 Dutch Authority for Consumers and Markets, advice on mobile spectrum caps. Explains the importance of sub-1 GHz spectrum for cost-efficient national coverage and the role of total-spectrum and low-band caps. (see https://www.acm.nl/en/publications/acm-ministry-economic-affairs-set-caps-mobile-frequencies-maintain-competition)

69 Dialogic (2020), Onderzoek kavelgrootte veiling 3,5 GHz-vergunningen. Project 2019.170 v1.1.9 for the Ministry of Economic Affairs and Climate Policy, 25 March 2020. Supplied source document; summarised in Annex C.

The recommended starting point is therefore 2 x 5 MHz for the 800, 900, 1,800 and 2,600 MHz FDD segments, and 10 MHz for the generic core of 2,600 MHz TDD, with 5 MHz retained only where edge or residual conditions require it. These are bidding units, not target holdings. Efficient outcomes depend on aggregation into wider contiguous blocks, a separate assignment mechanism, transparent treatment of restricted spectrum and portfolio-level competition safeguards.

4 Summary

With the ongoing digitalisation of society and the economy, reliable and high-quality mobile connectivity is becoming increasingly important for consumers, businesses and vertical industries. At the same time, mobile data traffic is expected to continue growing and the transition from 5G towards 5G standalone and eventually 6G will place additional requirements on mobile networks. Against this background, the spectrum licences in the 800 MHz, 900 MHz, 1,800 MHz and 2,600 MHz bands expiring in 2030 remain strategically important for the continuity and future development of Dutch mobile networks. The analysis shows that these bands perform different but strongly complementary functions and therefore need to be considered as part of an overall spectrum portfolio rather than in isolation.

The analysis confirms a clear functional distinction between low-band and mid-band spectrum. The 800 MHz and 900 MHz bands are particularly important for nationwide coverage, indoor connectivity and rural areas. Due to their similar propagation characteristics, they are relatively substitutable, although existing network configurations, deployed technologies and terminal support limit full interchangeability. By contrast, the 1,800 MHz and 2,600 MHz bands primarily provide capacity and therefore strongly complement the low-bands. 1,800 MHz can partly contribute to wider coverage, while 2,600 MHz is more strongly focused on high traffic areas.

For incumbent MNOs, continued access to the four bands is particularly relevant because networks and site grids have been designed around existing spectrum portfolios. Significant changes to these holdings could require additional sites, investment and lengthy network adaptations. The quantitative analysis also indicates that operators already face different levels of capacity constraints, reflecting differences in traffic, network structure and deployment of 3.5 GHz. Depending on future traffic growth, the share of permanently congested cells could increase substantially.

The transition to 6G is expected to follow a layered spectrum approach. The 800 MHz and 900 MHz bands will remain important for coverage and mobility, while 1,800 MHz and 2,600 MHz will continue to provide capacity after refarming. The 3.5 GHz band is likely to provide an important bridge from 5G Advanced to 6G, while the upper 6 GHz band is expected to become an additional capacity layer. No single frequency band can therefore fulfil all future 6G requirements.

The expected availability of upper 6 GHz around 2030 does not fundamentally change the demand for the four expiring bands. Upper 6 GHz should mainly be regarded as a complement rather than a substitute, which based on our forecasts, probably becomes necessary after 2030, depending on actual traffic growth figures in the coming years. It can provide substantial additional capacity in urban and suburban areas but cannot replicate the coverage and indoor propagation characteristics of 800 MHz and 900 MHz. Its availability may reduce the scarcity value of 2,600 MHz and, to a lesser extent, 1,800 MHz, but the strategic importance of low-band spectrum is expected to remain largely unchanged.

For the 2030 assignment, the findings therefore support a flexible multiband approach that allows operators to assemble portfolios combining coverage and capacity spectrum.

5 Annex

5.1 Methodology for Distance-Dependent Mobile Network Capacity Estimation

The capacity model combines a simplified radio propagation model, a link-budget calculation, and a truncated Shannon capacity model. The resulting distance-dependent capacity estimates are subsequently applied to the spatial extent of each mobile network site using concentric distance rings. This allows the spatial variation in achievable capacity within each Voronoi service area to be represented without explicitly intersecting the population grid with additional distance zones.

- **Simplified capacity model**[70]
  - Path-loss model

Path-loss is calculated as a function of distance between the base station and the user and the corresponding carrier frequency.[71]

The model is defined as:

$$PL(d,f) = 32.4 + 20\log_{10}(f_{GHz}) + \alpha\log_{10}(d_m)$$

where:

- $PL(d,f)$is the path loss in dB,
- $f_{GHz}$is the carrier frequency in GHz,
- $d_m$is the distance between the base station and the user in metres,
- $\alpha$is the propagation coefficient in dB per decade.

A propagation coefficient of

$$\alpha = 39$$

is assumed. This value is taken from 3GPP 38.901 Version V18.0.0, where a = 39 is selected as the propagation coefficient for urban macro cells in NLOS conditions. This

70 The simplified capacity model is intended to estimate the maximum achievable throughput per cell or sector under the assumed network conditions. It therefore represents a theoretical throughput calculation rather than a comprehensive model of network capacity.

71 The dependence of Shannon capacity on distance and frequency is implicitly captured through the path loss, which determines the signal-to-noise ratio (SNR). The calculated Shannon capacity represents the theoretical maximum data rate under the assumption that all users are located at the same distance from the base station. This dependence could be made explicit by expressing the SNR as SNR(d,f) and, consequently, the Shannon capacity as C(d,f).

value is more at the upper end of its typical values. However, since we assume that capacity becomes critical in built-up areas and we try to estimate the cases where the capacity becomes critical, this value can be justified.

The path-loss model is evaluated separately for each frequency band used by the mobile network operators.

- Receiver noise power

Receiver noise power is calculated from the physical channel bandwidth:

$$N = -174 + 10\log_{10}(B_{Hz}) + NF$$

where:

- N is receiver noise power in dBm,
- -174 dBm/Hz is the assumed thermal noise density,
- B_{Hz} is the physical channel bandwidth in Hz,
- NF is the receiver noise figure.

A noise figure of 7 dB is assumed.

For TDD bands, the full physical channel bandwidth is used for the noise calculation. The reduction of available downlink resources in TDD is applied later in the throughput calculation.

- Link-budget calculation

The received link quality is derived using a simplified link budget.

The signal-to-noise ratio in dB is calculated as:

$$SNR_{dB} = P_{Tx} + G_{BS} - N - IM - FM - BL - PL_{penetration} - PL(d, f)$$

where:

- P_{Tx} is the base-station transmit power in dBm,
- G_{BS} is the base-station antenna gain in dB,
- N is receiver noise power in dBm,
- IM is the interference margin in dB,
- FM is the fade margin in dB,

- BL is the body loss in dB,
- $PL_{penetration}$ is the penetration loss in dB,
- $PL(d, f)$is the distance- and frequency-dependent path loss in dB.

The following common parameters are assumed:

$$P_{Tx} = 46 \text{ dBm}$$
$$IM = 3 \text{ dB}$$
$$FM = 6 \text{ dB}$$
$$BL = 3 \text{ dB}$$

Base-station antenna gain and penetration loss vary by frequency band. We assume the following antenna gains:

Frequency/MHz	BS antenna gain/dB
700-900	15
1,500-2,600	18
3,500	25

For 3,500 MHz we assume the use of beamforming and a maximum transmit power for a maximum of 8 beams to be 160W. We further assume that not all 8 beams are used at the same time. For an assumed average of 2.5 beams the transmit power per beam increases from the generally assumed 46 dBm to 48 dBm.[72]

For outdoor capacity calculations, the penetration loss is assumed to be 0 at all frequency bands.

Before applying the Shannon formula, the SNR is converted from the logarithmic dB scale to a linear power ratio:

$$SNR_{linear} = 10^{SNR_{dB}}$$

This conversion is necessary because the Shannon formula requires a linear signal-to-noise ratio.

72 While using a single beam with a higher transmit power of 52 dBm could improve performance, particularly in rural and suburban areas, the assumed multi-user MIMO configuration provides a reasonable match with observed 3.5 GHz network data. Moreover, the analysis focuses on capacity-constrained scenarios with multiple simultaneously active users, where the full transmit power cannot be allocated to each user. A single-beam configuration with full transmit power would therefore be more appropriate for coverage assessments than for the capacity analysis undertaken here.

- Effective bandwidth

For FDD bands, the full physical bandwidth is assumed to be available for downlink transmission:

$$B_{eff} = B$$

For TDD bands, only 50% of the physical bandwidth is assumed to be available for downlink transmission:

$$B_{eff} = 0.5B$$

The physical bandwidth $B$is used for the receiver noise calculation, while the effective bandwidth $B_{eff}$is used for the throughput calculation.

Operator-specific spectrum holdings are applied separately for KPN, Odido, and VodafoneZiggo.

- Shannon-based throughput

The achievable data rate is calculated using a Shannon-based capacity function:

$$C_{Shannon}(d, f) = B_{eff} \times R_{MIMO} \times \log_2(1 + SNR_{linear})$$

where:

- B_{eff} is the effective downlink bandwidth in MHz,
- R_{MIMO} is the assumed MIMO rank,
- SNR_{linear} is the linear signal-to-noise ratio.

Because bandwidth is expressed in MHz, the resulting throughput is expressed in Mbit/s.

An average MIMO rank of 2 is assumed rather than the maximum one of 4, which could be achieved for a 4x4 MIMO system.

- Maximum throughput constraint

To avoid unrealistically high throughput values close to the base station, the Shannon capacity is capped using a predefined maximum throughput for each frequency band and operator.

The final distance-dependent capacity is therefore:

$$C(d, f) = \min\big(C_{max}(f), C_{Shannon}(d, f)\big)$$

The maximum throughput is based on an assumed maximum SISO data rate of 50 Mbit/s per 10 MHz. This value is calculated assuming 256 QAM, a code rate of 0.92, 15 kHz sub-carrier spacing and the assumption of 20% signalling overhead.

For FDD bands:

$$C_{max} = 50 \times R_{MIMO} \times \frac{B}{10}$$

For TDD bands, the effective bandwidth is used:

$$C_{max} = 50 \times R_{MIMO} \times \frac{B_{eff}}{10}$$

With the assumed 50% downlink share for TDD, this is equivalent to:

$$C_{max} = 50 \times R_{MIMO} \times \frac{B}{20}$$

These maximum throughput values are calculated separately using the spectrum bandwidth available to each operator.

Please note that the penetration loss is not specified. The results are based entirely on outdoor coverage assumptions

5.2 Spectrum Allocation in the 6 GHz Band

Figure 5-1: Excerpt of the Radio Regulations covering the frequency band of interest (6.425 MHz to 7125 MHz)[73]

Allocation to services		
Region 1	**Region 2**	**Region 3**
5 925-6 700	FIXED 5.457 FIXED-SATELLITE (Earth-to-space) 5.457A 5.457B MOBILE 5.457C 5.457D 5.457E 5.457F 5.149 5.440 5.458	
6 700-7 075	FIXED FIXED-SATELLITE (Earth-to-space) (space-to-Earth) 5.441 MOBILE 5.457D 5.457E 5.457F 5.458 5.458A 5.458B	
7 075-7 145	FIXED MOBILE 5.457E 5.457F 5.458 5.459	

5.457A In the frequency bands 5 925-6 425 MHz and 14-14.5 GHz, earth stations located on board vessels may communicate with space stations of the fixed-satellite service. Such use shall be in accordance with Resolution **902 (Rev.WRC-23)**. In the frequency band 5 925-6 425 MHz, earth stations located on board vessels and communicating with space stations of the fixed-satellite service may employ transmit antennas with minimum diameter of 1.2 m and operate without prior agreement of any administration if located at least 330 km away from the low-water mark as officially recognized by the coastal State. All other provisions of Resolution **902 (Rev.WRC-23)** shall apply. (WRC-23)

5.457B In the frequency bands 5 925-6 425 MHz and 14-14.5 GHz, earth stations located on board vessels may operate with the characteristics and under the conditions contained in Resolution **902 (Rev.WRC-23)** in Algeria, Saudi Arabia, Bahrain, Comoros, Djibouti, Egypt, United Arab Emirates, Jordan, Kuwait, Libya, Morocco, Mauritania, Oman, Qatar, the Syrian Arab Republic, Sudan, Tunisia and Yemen, in the maritime mobile-satellite service on a secondary basis. Such use shall be in accordance with Resolution **902 (Rev.WRC-23)**. (WRC-23)

5.457C In Region 2 (except Brazil, Cuba, French overseas departments and communities, Guatemala, Mexico, Paraguay, Uruguay and Venezuela), the frequency band 5 925-6 700 MHz may be used for aeronautical mobile telemetry for flight testing by aircraft stations (see No. **1.83**). Such use shall be in accordance with Resolution **416 (WRC-07)** and shall not cause harmful interference to, or claim protection from, the fixed-satellite and fixed services. Any such use does not preclude the use of this frequency band by other mobile service applications or by other services to which this frequency band is allocated on a co-primary basis and does not establish priority in the Radio Regulations. (WRC-15)

5.457D In Cambodia, Lao P.D.R. and the Maldives, the frequency band 6 425-7 025 MHz is identified for the terrestrial component of International Mobile Telecommunications (IMT). This identification does not preclude the use of this frequency band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. Resolution **220 (WRC-23)** applies. (WRC-23)

5.457E The frequency bands 6 425-7 125 MHz in Region 1 and 7 025-7 125 MHz in Region 3 are identified for use by administrations wishing to implement the terrestrial component of International Mobile Telecommunications (IMT). This identification does not preclude the use of these frequency bands by any application of the services to which they are allocated and does not establish priority in the Radio Regulations. Resolution **220 (WRC-23)** applies.

The frequency bands are also used for the implementation of wireless access systems (WAS), including radio local area networks (RLANs). (WRC-23)

5.457F In Brazil and Mexico, the frequency band 6 425-7 125 MHz is identified for the terrestrial component of International Mobile Telecommunications (IMT). The use of this frequency band for the implementation of IMT is subject to seeking agreement under No. **9.21** with neighbouring countries. This identification does not preclude the use of this frequency band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. Resolution **220 (WRC-23)** applies.

The frequency band is also used for the implementation of wireless access systems (WAS), including radio local area networks (RLANs). (WRC-23)

5.458 In the band 6 425-7 075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7 075-7 250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the Earth exploration-satellite (passive) and space research (passive) services in their future planning of the bands 6 425-7 075 MHz and 7 075-7 250 MHz.

5.3 IEEE 802 Table of Frequencies

Figure 5-2: Excerpt of IEEE 802's Wireless standards table of frequency ranges; December 2022

Start frequency (MHz)	End frequency (MHz)	Standard-Year / Project	Clause number in standard or draft standard (if available)	PHY amendment (Date of initial approval)
5786	10370	IEEE Std 802.15.4z™-2020	10.1.1, 19	IEEE Std 802.15.4z-2020
5850	5925	IEEE Std 802.11™-2020	17	IEEE Std 802.11p-2010
5850	5925	P802.11bd	32	
5945	7125	IEEE Std 802.11ax™-2021	27	IEEE Std 802.11ax-2021
5945	7125	P802.11be	36	
5945	7125	P802.11bf		
5948	10.163	IEEE Std 802.15.4™-2020	10.1.1, 16.2.3	
5948	10.163	IEEE Std 802.15.4z™-2020	10.1.1, 16.2.3	IEEE Std 802.15.4z-2020

73 Radio regulation 2024, https://www.itu.int/pub/r-reg-rr

5.4 3GPP Table of frequencies

Figure 5-3: NR operating bands in FR1

NR *operating band*	Uplink (UL) *operating band* BS receive / UE transmit $F_{UL,low}$ – $F_{UL,high}$ (MHz)	Downlink (DL) *operating band* BS transmit / UE receive $F_{DL,low}$ – $F_{DL,high}$ (MHz)	Duplex mode	Notes
n1	1920 – 1980	2110 – 2170	FDD	
n2	1850 – 1910	1930 – 1990	FDD	
n3	1710 – 1785	1805 – 1880	FDD	
n5	824 – 849	869 – 894	FDD	
n7	2500 – 2570	2620 – 2690	FDD	
n8	880 – 915	925 – 960	FDD	
n12	699 – 716	729 – 746	FDD	
n13	777 – 787	746 – 756	FDD	
n14	788 – 798	758 – 768	FDD	
n18	815 – 830	860 – 875	FDD	
n20	832 – 862	791 – 821	FDD	
n24	1626.5 – 1660.5	1525 – 1559	FDD	Note 7
n25	1850 – 1915	1930 – 1995	FDD	
n26	814 – 849	859 – 894	FDD	
n28	703 – 748	758 – 803	FDD	
n29	N/A	717 – 728	SDL	
n30	2305 – 2315	2350 – 2360	FDD	
n31	452.5 – 457.5	462.5 – 467.5	FDD	
n34	2010 – 2025	2010 – 2025	TDD	Note 12
n38	2570 – 2620	2570 – 2620	TDD	
n39	1880 – 1920	1880 – 1920	TDD	
n40	2300 – 2400	2300 – 2400	TDD	
n41	2496 – 2690	2496 – 2690	TDD	
n46	5150 – 5925	5150 – 5925	TDD	Note 3, Note 12
n48	3550 – 3700	3550 – 3700	TDD	
n50	1432 – 1517	1432 – 1517	TDD	
n51	1427 – 1432	1427 – 1432	TDD	Note 12
n53	2483.5 – 2495	2483.5 – 2495	TDD	Note 12
n54	1670 – 1675	1670 – 1675	TDD	Note 12
n65	1920 – 2010	2110 – 2200	FDD	
n66	1710 – 1780	2110 – 2200	FDD	
n67	N/A	738 – 758	SDL	
n68	698 – 728	753 – 783	FDD	
n70	1695 – 1710	1995 – 2020	FDD	
n71	663 – 698	617 – 652	FDD	
n72	451 – 456	461 – 466	FDD	
n74	1427 – 1470	1475 – 1518	FDD	
n75	N/A	1432 – 1517	SDL	
n76	N/A	1427 – 1432	SDL	
n77	3300 – 4200	3300 – 4200	TDD	Note 11
n78	3300 – 3800	3300 – 3800	TDD	
n79	4400 – 5000	4400 – 5000	TDD	
n80	1710 – 1785	N/A	SUL	
n81	880 – 915	N/A	SUL	
n82	832 – 862	N/A	SUL	
n83	703 – 748	N/A	SUL	
n84	1920 – 1980	N/A	SUL	
n85	698 – 716	728 – 746	FDD	
n86	1710 – 1780	N/A	SUL	
n87	410 - 415	420 – 425	FDD	
n88	412 - 417	422 - 427	FDD	
n89	824 – 849	N/A	SUL	
n90	2496 – 2690	2496 – 2690	TDD	
n91	832 – 862	1427 – 1432	FDD	Note 2
n92	832 – 862	1432 – 1517	FDD	Note 2
n93	880 – 915	1427 – 1432	FDD	Note 2
n94	880 – 915	1432 – 1517	FDD	Note 2
n95	2010 – 2025	N/A	SUL	Note 1
n96	5925 – 7125	5925 – 7125	TDD	Note 3, Note 4, Note 12
n97	2300 – 2400	N/A	SUL	Note 5

n98	1880 – 1920	N/A	SUL	Note 5
n99	1626.5 – 1660.5	N/A	SUL	Note 6
n100	874.4 – 880	919.4 – 925	FDD	Note 10
n101	1900 – 1910	1900 – 1910	TDD	Note 10, Note 12
n102	5925 – 6425	5925 – 6425	TDD	Note 3, Note 4, Note 12
n104	6425 – 7125	6425 – 7125	TDD	
n105	663 – 703	612 – 652	FDD	
n106	896 – 901	935 – 940	FDD	
n109	703 – 733	1432 – 1517	FDD	Note 2
n110	1390 - 1395	1432 - 1435	FDD	

NOTE 1: This band is applicable in China only.
NOTE 2: Variable duplex operation does not enable dynamic variable duplex configuration by the network, and is used such that DL and UL frequency ranges are supported independently in any valid frequency range for the band.
NOTE 3: This band is restricted to operation with shared spectrum channel access as defined in TS 37.213 [20].
NOTE 4: This band is applicable only in countries/regions designating this band for shared-spectrum access use subject to country-specific conditions.
NOTE 5: The requirements for this band are applicable only where no other NR or E-UTRA TDD operating band(s) are used within the frequency range of this band in the same geographical area. For scenarios where other NR or E-UTRA TDD operating band(s) are used within the frequency range of this band in the same geographical area, special co-existence requirements may apply that are not covered by the 3GPP specifications.
NOTE 6: UL operation is restricted to 1627.5 – 1637.5 MHz and 1646.5 – 1656.5 MHz per FCC Order DA 20-48 [25].
NOTE 7: DL operation is restricted to 1526-1536 MHz frequency range. UL operation is restricted to 1627.5 – 1637.5 MHz and 1646.5 – 1656.5 MHz per FCC Order 20-51 [24].
NOTE 8: Void
NOTE 9: Operating band n200 is a reserved value.
NOTE 10: This band is applicable to CEPT countries subject to ECC Decision (20)02 [21], for the RMR application.
NOTE 11: In the USA this band is restricted to 3450 – 3550 MHz and 3700 – 3980 MHz. In Canada this band is restricted to 3450 – 3650 MHz and 3650 – 3980 MHz.
NOTE 12: This TDD band is not applicable to SBFD operation.

Source: 3GPP ETSI TS 138 104 V19.5.0 (2026-08)