# Upper 6 GHz band

## Overview of current and potential future use in The Netherlands

***White paper***

¤

# Document properties

| | |
|---|---|
| Document title | Upper 6 GHz band - Overview of current and potential future use in The Netherlands |
| Authors | Olga Batura, Pieter Nooren, Lotte Paulissen, Prachi Sachdeva, Yohan Toh |
| Reviewer | Ljupco Jorguseski |
| Dissemination level | Public |
| Status of the document | Final |
| Version | 1.0 |
| Work Package | WP4.5 Technology-Policy Co-Development |
| Deliverable | Part of FNS Milestone M4.5.1 |
| Contractual delivery date | December 2024 |
| Delivery date | 11 December 2024 |
| File name | FNS6G_20241211_Current_and_Future Use_Upper_6_GHz_v1.0 |

# Summary

During the 2023 World Radiocommunication Conference (WRC-23), the needs for additional spectrum for International Mobile Telecommunications (IMT) have been discussed. This has led to studies for several bands for IMT for future WRCs and the identification of the Upper 6 GHz band (U6, 6 425 – 7 125 MHz) for IMT. The identification of the U6 band for IMT is technology-generation neutral. It is expected to be relevant for 6G technology development and also for 5G-Advanced.

This report presents an inventory of current and potential future use of the U6 band per radio service, also taking into account the technologies that are used to provide the services. The inventory covers Fixed Service (FS), the Earth to space component of Fixed Satellite Service (FSS_ES, both commercial and Defence), Ultra-Wideband (UWB), Earth Exploration-Satellite Service (EESS), Radio Astronomy Service (RAS), Mobile Service (MS, relevant for IMT) and Wireless Access System/Radio LAN (WAS/RLAN, relevant for Wi-Fi). The inventory is based on interviews with over twenty stakeholders and desk research on the services and technologies involved.

The inventory has been made as a part of the Future Network Services (FNS) programme, the Dutch multi-year public-private program on 6G development. For the creation of new economic earning power in The Netherlands around 6G, it is key to provide technology developers with early insights in the spectrum bands that are candidates to become available for IMT, with the U6 band as a key candidate in the mid band. Also, for companies looking to commercially deploy 6G technology and for spectrum policy makers it is important to have early insights in the use of the U6 band, including the options and considerations for safeguarding the interests of existing users and providing timely access to spectrum for new users.

As expected, the inventory shows strong demand for the U6 spectrum:

- Current users see the need to continue their use of the U6 band. They expect to use the band to respond to a growing demand for connectivity (FS on the North Sea, FSS for Defence use, UWB) or to a continued need (FSS for commercial use, radio astronomy, EESS).
- Potential new users of the band (IMT, Wi-Fi) see the need to use the band to expand the capacity for broadband connectivity to meet the growing demand for data traffic they expect.

A particular focus of this report is to identify features in the use of the U6 band that are specific to The Netherlands. Two such features have been identified:

- The ground stations in The Netherlands that use the U6 for Earth-to-space communication operate with their dishes at lower elevation angles than those in most other parts of Europe. In combination with the flat landscape this may lead to underestimation of the interference from FSS_ES ground stations on other services, such as IMT and Wi-Fi.
- The FS microwave links in the U6 band are almost all located on the North Sea, with a limited number of links to sites on land. This is different from situations in several other countries where many U6 microwave are used throughout the country.

CEPT (the European Conference of Postal and Telecommunications Administrations) is currently investigating the feasibility of shared use between IMT and RLAN/Wi-Fi. This topic has been generating substantial discussion. At this point, it is unclear whether there are elements that are particularly relevant for The Netherlands.

In its future work, the FNS programme will look further into the co-existence of the services, by combining the inventory from this report with the relevant studies from CEPT. The focus will be on combinations

where the specific use (or potential future use) of one of the services in The Netherlands has an effect on the feasibility and approaches for co-existence.

# Table of contents

# 1. Introduction

## 1.1. 6G and the Upper 6 GHz band

6G or the sixth generation in mobile communications technology is positioned as the successor to 5G technology that is now widely implemented in many countries worldwide. 6G is aimed to be introduced in mobile networks from 2030 onwards, alongside the 5G (and perhaps 4G) technologies present in the networks at that time. As with earlier technology generations used in International Mobile Telecommunications (IMT), the availability of suitable spectrum is a key point for 6G. During the 2023 World Radiocommunication Conference (WRC-23), the needs for additional spectrum for IMT have been discussed. This has led to studies on several bands for IMT for future WRCs and the identification of the Upper 6 GHz band (6 425 – 7 125 MHz) for IMT. The identification of this band for IMT is technology-generation neutral, making it relevant for 6G technology development, but also for 5G-Advanced (introduction expected from 2027 onwards) and potentially later mobile generations.

This report addresses the current and potential future use of the Upper 6 GHz (U6) band in The Netherlands. It presents an inventory of current and potential future use per radio service, also taking into account the technologies that are used to provide the services. The inventory covers Fixed Service (FS), Fixed Satellite Service (FSS, commercial and Defence), Ultra-Wideband (UWB), Earth Exploration-Satellite Service (EESS), Radio Astronomy Service (RAS), Mobile Service (MS) and Wireless Access System (WAS). For this report, it is relevant to note that part of the MS covers IMT. Also, WAS includes Radio Local Area Networks (RLANs), which in turn cover access and services based on Wi-Fi technology. In future work, the research question will be whether and how the potential future uses can co-exist in the U6 band, as this can provide useful input for policy makers. In this first report, the analysis of interference and feasibility of co-existence between services and technologies are out of scope.

The analysis in this report has been developed in the Future Network Services (FNS) programme [1], the Dutch multi-year public-private program on 6G development. FNS works on specific and connected topics in 6G: intelligent radio components and antennas, intelligent networks, and leading applications in key sectors. This is combined with work aimed at strengthening the 6G ecosystem through a large-scale testbed and standardisation. Although FNS is a Dutch 6G programme, it is firmly embedded in the larger European and international effort on 6G development.

For the successful uptake of the technology, it is important that its development is well aligned with existing and future policies. This is the motivation for including research on policy-technology co-development in the FNS work on the 6G ecosystem, with spectrum as one of the key topics. For the creation of new economic earning power in The Netherlands around 6G, it is key to provide technology developers with early insights in the spectrum bands that are candidates to become available for IMT, with the U6 band as a key candidate in the mid band. Also, for companies looking to commercially deploy 6G technology and for spectrum policy makers it is important to have early insights into the use of the U6 band, including the options and considerations for safeguarding the interests of existing users and providing timely access to spectrum for new users.

The FNS partners contributing to the policy-technology work are (in alphabetical order): the Dutch Authority for Digital Infrastructure, Ericsson, KPN, Liberty Global, Ministry of Economic Affairs, Nokia, Odido and TNO. It is important to note that the role of FNS as a research and innovation project is to provide analysis and inputs for policy makers at the Dutch and EU levels. FNS does not have a role in policy decisions themselves.

## 1.2. Outline of this report

Chapter 2, Section 2.1, provides a recapitulation of some key concepts in spectrum. Readers familiar with mobile networks, spectrum bands and their management may want to skip this section. After that, Section 2.2 briefly examines the outcomes of WRC-23 and how that motivates the analysis of the current and potential use of the U6 band in The Netherlands made in this report. Chapter 3 outlines the status of the U6 band in the current frequency allocation tables and plans in Europe, NATO and The Netherlands. Then, Chapter 4 presents the inventory of the current use of the U6 in The Netherlands, based on interviews with stakeholders and desk research on the services and technologies involved. Chapter 5 provides the inventory for the potential future use of the band. Here, both the current uses and potential new uses such as IMT and Wi-Fi are important. Chapter 6 closes this report by pointing at features in the use of the U6 band that are particularly relevant for The Netherlands and that may affect co-existence. The next steps related to that include suggestions for future research in FNS on the topic of the need and feasibility of co-existence, including that between IMT and Wi-Fi.

# 2. Future spectrum for International Mobile Telecommunications

## 2.1. Key notions of IMT and spectrum

In spectrum policy and regulation, mobile broadband networks are referred to as International Mobile Telecommunications (IMT [2]) and in Europe also as Mobile/Fixed Communications Networks (MFCN). IMT as such does not distinguish between mobile network technology generations. Within IMT, the requirements of IMT-2000 have led the development of 3G mobile technology. A similar correspondence exists between 4G and IMT-Advanced, and 5G and IMT-2020. 6G should correspond to the requirements of IMT-2030 that are currently under development in ITU-R [3].

In IMT, frequencies below 1 GHz are considered as low. The radio waves at these low frequencies can provide wide area coverage. Low frequencies also offer the best building penetration characteristics that are relevant when creating indoor coverage from outdoor base stations. To scale up capacity in areas with higher densities of mobile users, operators use bands in the mid-band spectrum between 1 GHz and (currently) 3.8 GHz. The propagation loss and building penetration loss of signals in the mid band is higher, and more base stations are necessary to provide sufficient coverage, performance and capacity. In The Netherlands, with its relatively high population density, the mid bands are also widely deployed in suburban and rural areas. Up to 4G (LTE), mobile network technology was based only on frequencies in the low and mid-band spectrum [4]. This can be seen in Figure 1, where the blue bars provide a general illustration of the frequencies used for the implementation of 2G up to 5G technologies in The Netherlands.

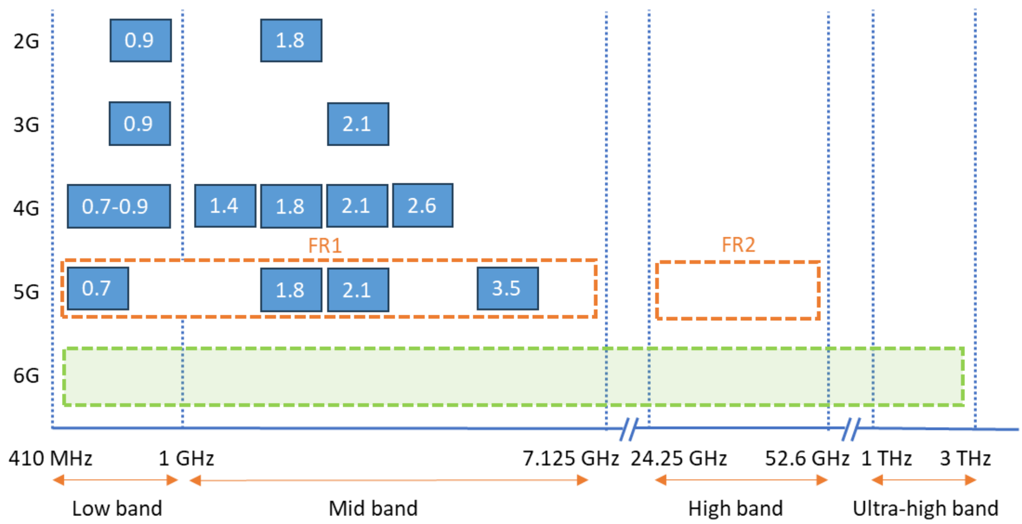


*Figure 1: General impression of frequency bands used for cellular technologies in The Netherlands from 2G onwards.*

In the 5G specifications, the frequency bands come in two sets, as shown by the orange dotted lines in Figure 1. Frequency range 1 (FR1) covers the low and mid-band frequencies, and frequency range 2 (FR2) covers higher frequencies between 24.25 GHz and 52.6 GHz, often referred to as the millimetre-wave range (mmWave). In the FR2 band, spectrum is relatively less scarce and wider bandwidths are available, opening options for higher data rates, albeit with a range that is too limited for nationwide coverage. Although it is possible to use the FR2 band for 5G, this band has not been made available for IMT in The

Netherlands, and only a small portion of 5G device models support the mmWave bands [5]. As will be seen later, for IMT-2030 further bands in the low, mid and high spectrum bands are considered, as well as the 7 – 24 GHz band and the spectrum above FR2. This is indicated by the green bar in Figure 1. Based on announcements by mobile operators, it can be expected that 2G and 3G technology will no longer be used in a few years from now. In general, operators will then use the bands used earlier for 2G and 3G in their 5G radio access. In addition to IMT, there are many other users of the radio spectrum, such as Wi-Fi (WAS/RLAN), various satellite services, TV broadcast and air traffic control.

Radio spectrum is a scarce resource. The growing demand for spectrum from users means that it should be used as efficiently as possible, and even then, there are situations where not all demand for spectrum can be met. Radio spectrum can be managed through spectrum licences, giving the licensee the exclusive right to use the specific spectrum and, through that, specific abilities to control and optimise the service quality. Common examples of applications that use licenced spectrum are IMT and satellite communications. Next to licenced spectrum, certain parts of the spectrum are unlicenced. This spectrum is often used for services with small range and that allow local re-use of the spectrum. Examples of services that use unlicenced spectrum are Wi-Fi, Bluetooth, Zigbee and Ultra-Wideband. The services allowed in the unlicenced spectrum are clearly defined and come with usage conditions.

Cross-border coordination of spectrum use is necessary for services that use radio spectrum to cover large distance communications, such as satellite communications and communications for ships and aviation. Cross-border coordination is also needed to prevent or reduce interferences between services with shorter ranges including terrestrial mobile communication networks.

Harmonisation of spectrum bands is important for vendors manufacturing communications equipment, such as base stations, access points and user devices, so that they can achieve economies of scale. The worldwide regulations on radio spectrum are developed by the International Telecommunication Union (ITU). This is done through the ITU Radio Regulations (ITU-RR [6]), an international treaty between over 190 ITU member states, which is periodically reviewed and adjusted via the ITU's World Radiocommunication Conferences (WRCs), the latest WRC-23 held in December 2023. The ITU-RR allocates frequencies to the radio services defined by the ITU. In the case that frequencies are allocated to multiple services, the ITU-RR also indicate priorities between those services: services with a secondary allocation are not allowed to cause harmful interference to services with a primary allocation. The ITU provides radio regulations for three different Regions in the world, with Europe, Middle East and Africa included in Region 1.

## 2.2. Potential new spectrum bands for IMT from WRC-23

During WRC-23, the ITU-RR have been revised. This includes several points that are of direct relevance for the spectrum that can become available for IMT. Additional spectrum was identified for IMT to cope with the increasing demand of mobile data traffic in mobile networks. The key outcomes of WRC-23 [7] on spectrum for IMT ***in Region 1*** are:

- The 6 425 – 7 125 MHz band, also known as the Upper 6 GHz (U6) band, is identified for the terrestrial component of IMT (Resolution 220). Importantly, footnote 5.457E [7] states that this identification does not preclude the use of this frequency band by other applications to which it is allocated, nor does it establish priority to IMT. In addition, the footnote states that the frequency band is also used for the implementation of WAS, including RLANs. This covers access and services based on Wi-Fi technology.

- The band 470 – 694 MHz is allocated to the mobile service (except aeronautical mobile) on a secondary basis in a large group of countries (footnote 5.295A), including The Netherlands, subject to coordination between administrations (Resolution 235). The band remains allocated on a primary basis to the terrestrial television broadcasting service, at least until the spectrum needs of the broadcasting and mobile services have been reviewed at WRC-31. As noted earlier, part of mobile service covers IMT.
- For the bands 4 400 – 4 800 MHz, 7 125 – 7 250 MHz and 7 750 – 8 400 MHz (or parts thereof) and 14.8 – 15.35 GHz, sharing and compatibility studies will be carried out for WRC-27 (Resolution 256). These studies will be used to consider the identification of these frequency bands for the terrestrial component of IMT.
- For the bands 102 – 109.5 GHz, 151.5 – 164 GHz, 167 – 174.8 GHz, 209 – 226 GHz and 252 – 275 GHz, studies will be carried out for WRC-31 to determine the spectrum needs for IMT in those bands (Resolution 255). The studies will be used to consider the identification of these frequency bands for the terrestrial component of IMT.

From the perspective of this project, 6G FNS, all of these outcomes are relevant as they are about potential future spectrum for IMT and therefore also for 6G networks. Based on the preferences of the FNS partners contributing to the policy-technology co-development work, it was decided to start the analysis of future spectrum with the U6 band (6 425 – 7 125 MHz). The reasons for this are that the potential IMT use of band is closest in time[1], with a specific identification, and that it is mid-band spectrum that is in strong demand by mobile network operators. The focus of this deliverable is therefore on the U6 band. The other bands may be analysed in later deliverables.

## 2.3. Existing and potential new use in the Upper 6 GHz band

Before WRC-23, the U6 spectrum was already allocated in the ITU-RR on a co-primary basis to FS, FSS in the earth-to-space direction and MS. Aside from these services that have allocations, the band (or portions of it) is used for other purposes, such as the Radio Astronomy Service and passive microwave sensor measurements. During WRC-23, the U6 band was identified for IMT use for some Regions and countries, including in ITU Region 1, noting that U6 could also be used for the implementation of WAS, including RLANs. Importantly, as mentioned above, WAS/RLANs cover access and services based on Wi-Fi technology.  Because of the interests of both existing and new users, the use of the U6 band is the subject of technical and policy-related studies across Europe. This deliverable presents our insights on the current and potential future use of the U6 band in The Netherlands. However, it is important to note that the key question on how to balance the interests of existing and potential new users is addressed primarily at the European level.

## 2.4. European context for spectrum policy making for the Upper 6 GHz band

The WRC-23 outcomes discussed in section 2.2 apply to Region 1, consisting of Europe, Middle East and Africa. In Europe, further discussions and decisions on spectrum take place in the European Conference of Postal and Telecommunications Administrations (CEPT). The members of CEPT are 46 European

[1] Note that the secondary allocation in the 470 – 694 MHz band also opens up the potential use of this band for mobile services. The availability and timing depend on the use of the band for the broadcasting service that has a primary allocation.

countries. They include the 27 Member States of the European Union (EU). In addition, EU Member States have to implement the spectrum policy decisions made by the EU. Figure 2 shows the relationship between the EU (European Commission, the Radio Spectrum Policy Group (RSPG) and Radio Spectrum Committee (RSC)) and the Electronic Communications Committee (ECC) in CEPT in spectrum policy and harmonisation. This section explains this relation for the case of the U6 band. The goal here is not to formally describe the relations but to explain the status and the expected next steps in the policy making for the U6 band.

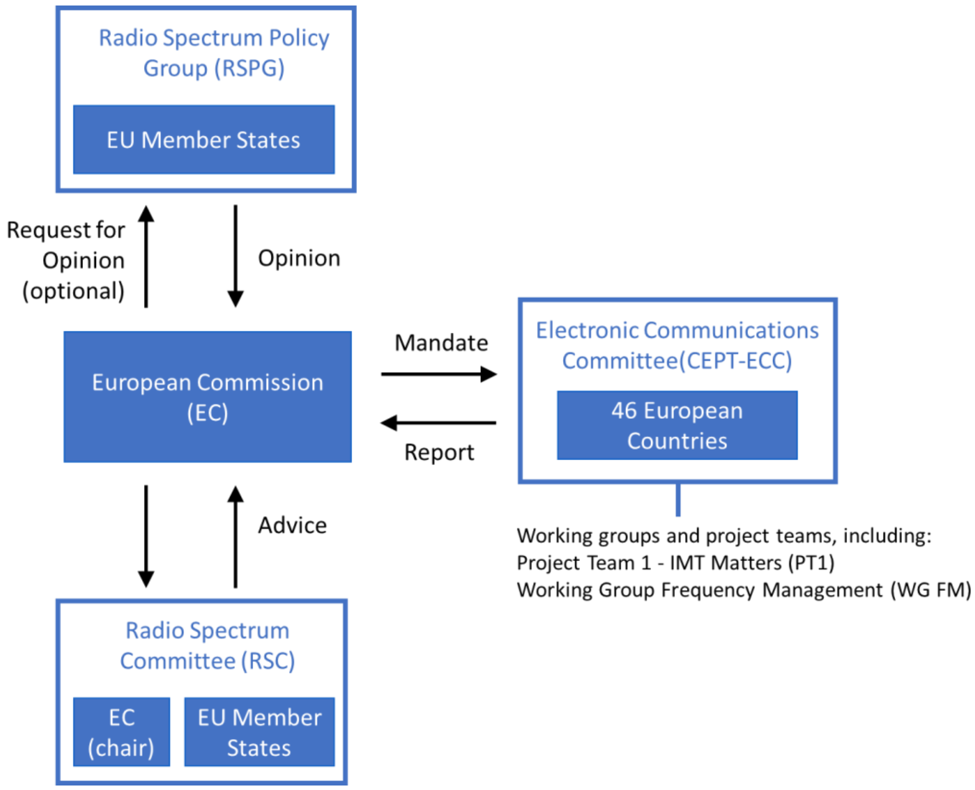


*Figure 2. Institutions and groups involved in European spectrum policy process.*

The RSPG's role is to provide high-level advice (in its opinions) to the European Commission on radio spectrum policy. The work items on the RSPG work programme are selected in consultation with spectrum stakeholders. The European Commission can also make a request for opinion to the RSPG on a specific topic that can be added to the work programme. Representatives of the EU Member States analyse the topic with the goal to come to a common opinion. In the 2024 RSPG work programme [8], the work item *on Long-term vision for the upper 6 GHz band* has been requested by the European Commission. The RSPG has subgroups that examine specific topics, such as the Upper 6 Band subgroup that held a public consultation on the *Long-term vision for the upper 6 GHz band* [9]. The 6G Strategic Vision subgroup is also relevant for the U6 band.

The RSC's role is to assist the European Commission in developing technical implementing decisions in cases where harmonisation is required for availability and efficient use of spectrum. The RSC consists of representatives of the European Commission and the EU Member states. The European Commission can issue a mandate to CEPT for the development of these technical implementing decisions. The RSC typically assists the European Commission in formulating the mandate. In this way, the European Commission and RSC benefit from the extensive and deep expertise of ECC (and its project teams and working groups) in technical spectrum aspects. The European Commission is expected to issue a mandate to ECC to investigate potential co-existence between several services in the U6 band: FS, IMT, Wi-Fi and FSS.

Within CEPT, the ECC considers and develops policies on electronic communications in a European context. Its decisions, recommendations and reports are non-binding for the 46 CEPT members, but they are widely supported and adopted. For EU Member states in particular, the ECC work is very relevant as it is often used as the technical basis for European Commission decisions, which are binding for EU Member States. Within ECC, Project Team 1 (PT1) on IMT Matters and the Working Group Frequency Management (WG FM) are expected to contribute to the work on the mandate for the U6 band. There is already work ongoing in PT1 on the U6 band, in its work item on *Feasibility of shared use of the 6425-7125 MHz frequency band by MFCN and WAS/RLAN*. This work has been initiated at the request of a number of individual countries, including The Netherlands.

The Dutch government participates in RSPG, RSC and ECC (and selected subgroups) through representatives from the Ministry of Economic Affairs and the Dutch Authority for Digital Infrastructure (Rijksinspectie Digitale Infrastructuur, RDI). The ECC subgroups are also open to other, non-governmental spectrum stakeholders. ECC PT1, for example, has active participation and contributions from several companies in the mobile and wireless industry.

The Dutch Ministry of Economic Affairs, responsible for national spectrum policy, recognises the relevance of the U6 band for both IMT and Wi-Fi, strongly favours investigations by CEPT into possible IMT-RLAN sharing arrangements and keeps all options open at this early stage. According to the Ministry, national studies to be conducted in the coming time should point out what is likely to be the best U6 scenario for The Netherlands and how incumbent use should be weighed against new usage possibilities. Ultimately, a revised band plan for the U6 will be proposed, consulted and adopted, leading to a change of the National Frequency Plan (NFP) for this band. The national band plan will be subject to EU harmonisation requirements, still to be developed.

# 3. The Upper 6 GHz band in frequency plans and tables

The starting point for the analysis of the existing use of the U6 band are the frequency plans and tables at European, NATO and national levels. The Dutch National Frequency Plan (NFP) has the central role for The Netherlands, as it regulates the use of U6 band as well as the conditions of its use. This chapter also sets the context for the NFP by providing an overview of the content and role of the frequency table maintained by CEPT and the NATO Joint Civil/Military Frequency Agreement on NATO harmonised bands.

## 3.1. CEPT

Within CEPT, the ECC maintains the European Table of Frequency Allocations and Applications (the ECA table [10]). This table contains the radio service allocations and applications across the CEPT countries for the frequency range 8.3 kHz to 3 000 GHz. The listing of the radio services in the ECA table contains ITU-RR allocations for Region 1 and RR footnotes that are applicable to CEPT, as well as the actual allocations of major use or of major interest in CEPT member countries.

Various services are allocated to the U6 band in the ECA table. Primary allocations are assigned in all or portions of the band to Fixed Service (FS), Fixed Satellite Service Earth-to-Space (FSS_ES), Fixed Satellite Service Space-to-Earth (FSS_SE) and Mobile Service (MS). Additionally, the ECA table contains a secondary allocation to Earth Exploration-Satellite Service (EESS).

Next to the allocations, the ECA table also refers to relevant ECC documents, and actual radio applications for each frequency band. Radio applications refer to the ECA and national frequency utilisation (application) planning and often contain more details than allocations[2]. Therefore, the ECA table also provides a comprehensive overview of the use of the frequency bands across CEPT countries.

The applications that are included in the U6 band are FSS Earth stations, FS point-to-point links, passive sensors (satellite), radio astronomy, radiodetermination applications[3], Ultra-Wide Band (UWB) applications, feeder links[4], and programme making and special events (PMSE). Figure 3 shows which portion of the U6 band can be used by each application.

[2] A radio application is added to a frequency band in the ECA table, if: i) an ECC/ERC decision, EC Decision or ECC/ERC Recommendation exists which harmonises or designates the band, ii) at least 10 CEPT administrations have made the frequency band available for a radio application, iii) ECC's Working Group Frequency Management has decided to include it.

[3] Applications for the determination of the position, velocity and/or other characteristics of an object, see ITU-RR [6] for details.

[4] A feeder link is a radio link from an earth station at a given location to a space station, or vice versa, conveying information for a space radiocommunication service other than for the FSS, see ITU-RR [6] for details.

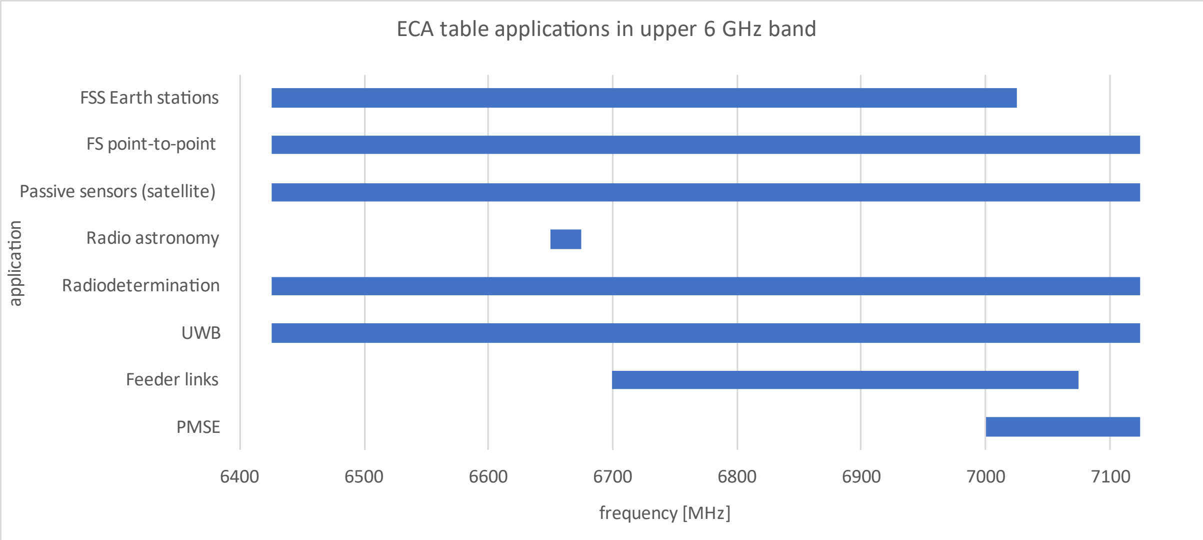


*Figure 3: Frequency applications in the U6 band according to the ECA table.*

## 3.2. NATO

NATO has identified frequency bands that are in general military use by NATO nations throughout Europe. The NATO Joint Civil/Military Frequency Agreement [11] (NJFA) refers to such frequency bands as "harmonised". The NJFA defines a NATO harmonised band as a frequency band identified by NATO where a permanent essential military requirement exists in NATO Europe or a band which fulfils an important military requirement. Such a frequency band forms a basis for military use. The band can be shared between civil and military users according to national requirements and legislation. The military use of radio spectrum is based on the relevant provisions of the ITU Regulations and in accordance with national frequency allocation tables of the NATO nations. The purpose of harmonised bands is to satisfy the requirement for mobility and interoperability of NATO forces, and to improve commonality in radio spectrum utilisation for military operations.

The NJFA document [11] provides an extract releasable version of the joint agreement between the civil and military authorities of the NATO nations on the current use of radio spectrum for military purposes required by NATO forces or in support of NATO. In this document, the frequency range between 5 850 MHz and 7 250 MHz, covering the complete U6 band, is not allocated. Although the U6 is thus not allocated in this NJFA context, the document does point out that when specific military requirements cannot be met using the harmonised radio spectrum, military requirements may be satisfied nationally in other radio allocations. An example of this in The Netherlands is the FSS_ES allocation in the NFP for Defence in the U6 band described in Section 4.2.2. Furthermore, the NJFA states that it does not include extended military requirements and the conditions of radio spectrum use during states of emergency and in times of crisis or war.

## 3.3. National Frequency Plan

The Nationaal Frequentie Plan (NFP [12]) is the national frequency allocation plan in The Netherlands, managed by the Ministry of Economic Affairs. It is updated regularly in accordance with international agreements made at the level of ITU and ECC and with changes decided at the national level.

At the time of writing (Q4 2024), the NFP contains primary spectrum allocations for FS and for FSS_ES in the U6 band. The licenses for these services given out to organisations specify technical details related to the service, such as transmission frequency, bandwidth, transmit power and antenna height. The FS and FSS_ES licenses in the U6 band are granted in the order in which the applications are received (first come first served).

Next to assigning spectrum to organisations for use for their services, the Ministry can allocate spectrum to public tasks, such as defence, security, public safety and scientific use. This spectrum can be allocated to the Ministry responsible for the public task, based on the evaluation of a plan that substantiates the need and efficient use of the fulfilment of the public task. This is called a 'Behoefte OnderbouwingsPlan' (BOP). In the U6 band, part of the FSS_ES allocation is allocated to defence in this way.

Next to the allocations for public tasks and primary allocations, there are also services that can use radio spectrum licence free, on a non-interference, non-protection basis. The U6 band can be used on a licence-exempt basis for UWB, EESS, and radio astronomy service (RAS).

Figure 4 shows the current frequency allocation and applications in the U6 band, where the blue bars depict the frequencies in which services are allocated according to the NFP. It also shows an orange bar for FSS_ES specifically for defence. It falls under the FSS_ES allocation in the ECA table. Some services are allocated to the U6 band in the ECA table but are not allocated to the U6 band in the NFP. These are the MS and FSS_SE and they cannot use the U6 band in The Netherlands at the time of writing of this report (Q4 2024).

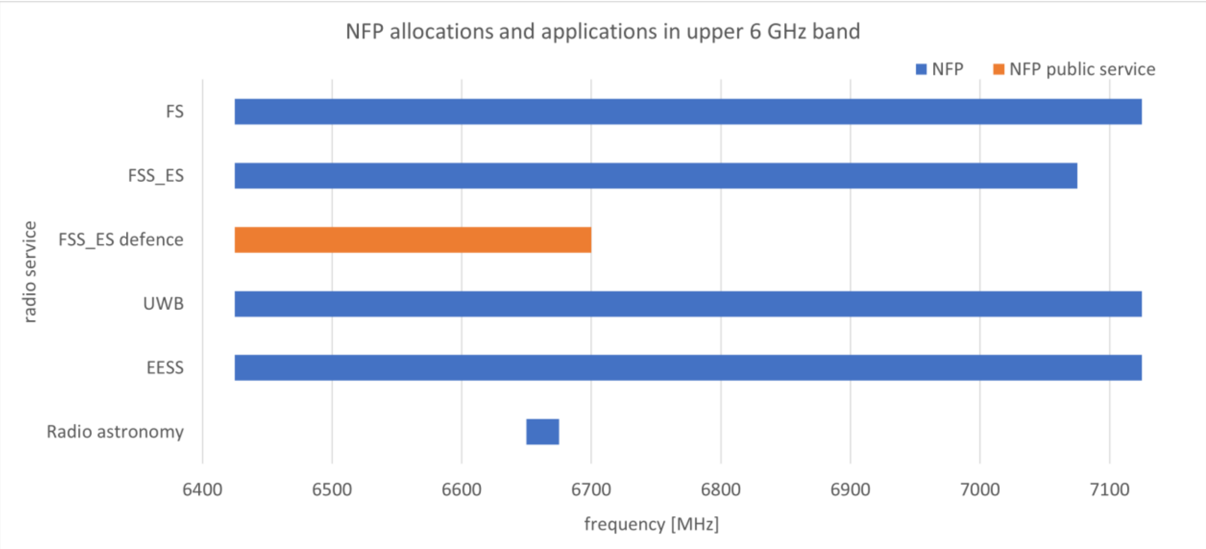


*Figure 4: Frequency allocations and applications in U6 band according to the NFP table.*

# 4. Current use of the Upper 6 band in The Netherlands

The WRC-23 outcomes and analysis of the U6 band are very relevant for the current and potential future uses of this spectrum. In the end, it is in the interest of all stakeholders to have a balanced analysis of the needs for the U6 band that can provide input into policy decisions at the European level and the Dutch national frequency plan. Therefore, a series of interviews with a wide range of stakeholders (listed in Annex A) are central to the inventory of the current use and potential future use of the U6 band. The explicit goal has been to collect the perspectives from the providers of FS, FSS, defence, Wi-Fi, IMT, UWB, EESS and RAS in addition to the perspectives provided by the organisations in the FNS work package on technology-policy co-development. In addition to the interviews, publicly available reports and industry sources have been used to compile the inventory. This chapter provides the inventory of the current use of the U6 band. The potential future use is analysed in the next chapter.

## 4.1. Fixed Services

The Dutch Authority for Digital Infrastructure (Rijksinspectie Digitale Infrastructuur, RDI) has provided data on the current use of FS in the U6 band. This data is also publicly available in the Dutch Antenna Register. Starting from the public data, RDI has filtered out the data on the FS licences as of early June 2024 to make it ready for the use in this report. RDI provided only technical data on the licences and omitted company names and contact details, as these are not needed for the analysis made below. FS licences are granted in order of receipt of the applications.

The data from the antenna register show that there are 242 FS links in total. Geographically, the links are spread over 27 locations as shown in Figure 5. Almost all FS links are located in the Dutch Exclusive Economic Zone in the North Sea. The centre frequencies of the FS are those between 6 460 and 7 080 MHz. The Dutch band profile for FS in the U6 allows for 20 and 40 MHz bandwidths [13]. The current FS links all have 40 MHz bandwidth. All available centre frequencies are licensed, which means that FS services cover almost all of the U6 band: from 6 440 to 7 100 MHz. The frequency distribution of the FS links in The Netherlands is shown in Figure 6.

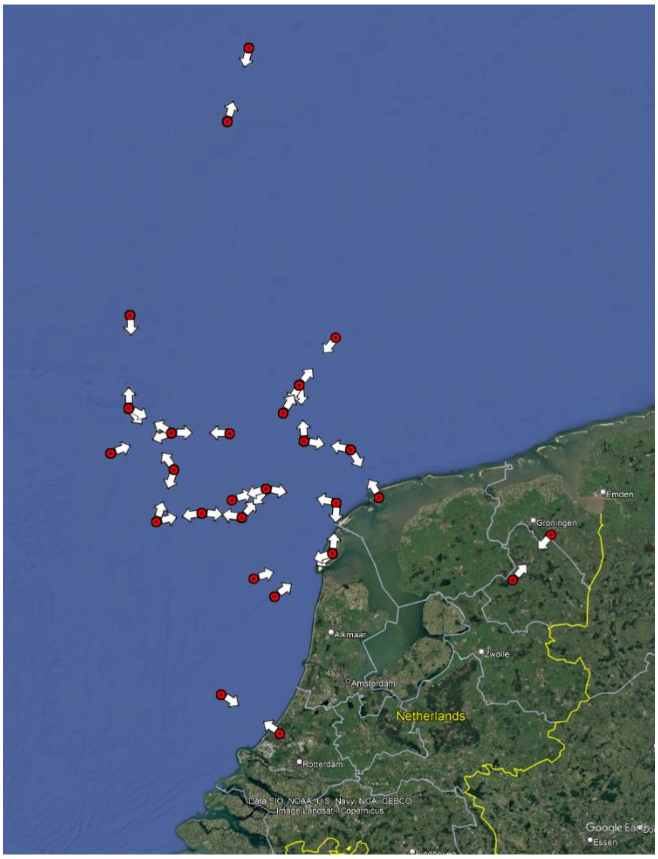


*Figure 5. Locations of the FS links in The Netherlands based on RDI data.*

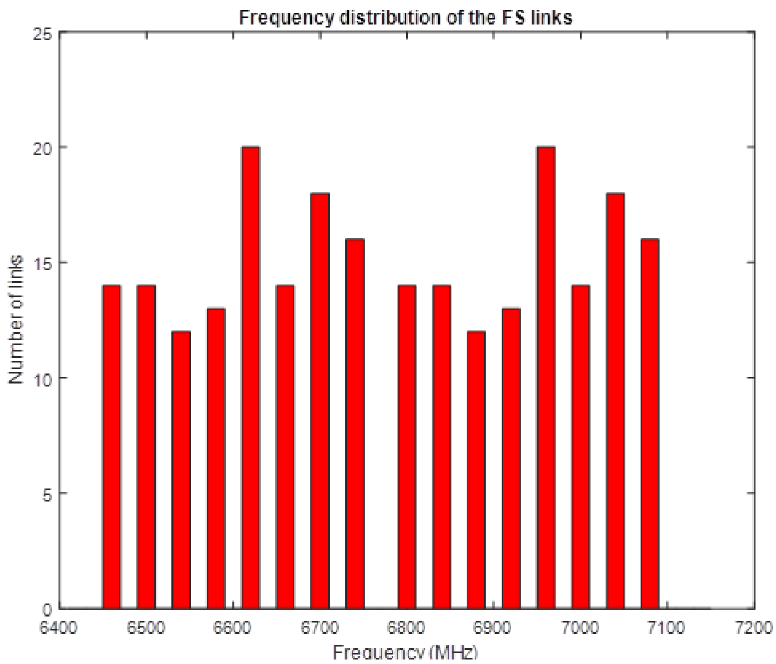


*Figure 6. Frequency distribution of the FS links based on RDI data.*

### 4.1.1. North Sea

Based on the interview input and publicly available data, the following overview of the use of the FS on the North Sea can be created. The FS links are mainly used to create microwave ring networks as the basis for providing communication services on the North Sea. The main use cases are in the oil and gas sector. The communication is critical for the operations in these use cases, therefore the communications services have strict service-level agreements (SLAs) on service performance and availability, typically with stipulations on financial penalties. Aside from the traditional oil and gas use cases, often related to the control of production locations, there are new initiatives, for example in the field of carbon capture. There are also use cases in the wind energy sector, although many wind turbines have their own fibre connectivity.

The U6 microwave rings can be combined with submarine cable infrastructure in the core network, but this is done mainly outside the Dutch exclusive economic zone. In this zone, the microwave links are crucial as there is limited fibre infrastructure. Furthermore, the links are connected with mobile radio access networks and other (higher-frequency, shorter-range) microwave links to create access networks for the users. This is illustrated in the coverage map of Tampnet [14], the major provider of these services in the North Sea. The rings start and end on land. Three important landing points are in The Hague and on the islands of Texel and Terschelling.

The U6 links are used for the long microwave links (or “hops”) in the rings, typically longer than 25 km and up to 60 km. Together with microwave links in the Lower 6 GHz (L6, 5.925-6.425 GHz) and in the 7.5 GHz band, the U6 links are the best suited links currently available for these long hops as their relatively low frequency provides the range needed. Earlier microwave links with frequences below 6 GHz are no longer available. As the frequencies are below 10 GHz, the links are also rather insensitive to rain fading. This is a key property given the strict performance and availability required by the SLAs. Another factor that makes the L6, U6 and 7.5 GHz suitable is a good availability of affordable equipment for these bands.

The links in the rings are typically used at maximum capacity, with multiple channels (e.g., four) in a link, each using the full bandwidth available in the band plan (40 MHz for U6). This gives a capacity in the hundreds of Mbit/s.

Technical alternatives to microwaves below 10 GHz are fibre connections and LEO satellite services. Both have specific disadvantages. Fibre is considered too expensive for the Dutch section of the North Sea. Fibre may be deployed in specific situations where the infrastructure used to host a microwave site is lost and the resulting longer hop cannot be covered. Even though LEO satellite service is providing increasingly more capacity, it cannot guarantee the capacity and SLAs required by the offshore use cases.

### 4.1.2. Land

The data from the antenna register show that, in addition to the landing locations for the microwave links on the North Sea, there are U6 microwave links between two locations further inland. A closer inspection of the data shows that one location is at 221 m height on the TV tower in Hoogersmilde. The other location is in Hoogezand (Kiel-Windeweer) at 40 m height on a smaller tower. An earlier report mentions the use of such links to carry digital feeds to radio transmitters [15].

## 4.2. Satellite Services

RDI provided data on the current use of FSS_ES in the U6 band as of early June 2024. Similar to the approach used for the FS, the data is publicly available in the Dutch Antenna Register, and RDI omitted company names and contact details.

### 4.2.1. Commercial Satellite Services

Fixed Satellite Services (FSS) are satellite communication systems that connect ground stations (also known as Earth stations) to geostationary satellites in space. This means that ground stations with fixed beam configurations can be used to communicate with the satellites. The Netherlands has commercial ground stations in the two locations shown in Figure 8: Burum and Biddinghuizen. In total, there are seven FSS_ES links. Six links are used to provide services from Burum, and one link is used in Biddinghuizen. Note that these links are used for communication from Earth to space. The ground stations do not receive radio signals from space in the U6 band and there is therefore no need to protect these ground station locations from radio signals from other services in the U6 band.

For each FSS_ES link, the spectrum licence specifies the geostationary satellite and its corresponding orbital position with which the ground station can communicate. The antenna dish at the ground station is configured to a specific elevation angle, such that a line-of-sight link is created to the satellite. The elevation angle is therefore dependent on the orbital position of the satellite, and the location and height of the ground station. Due to the relatively high latitude of The Netherlands, ground stations operate with lower elevation angles than ground stations in many other parts of Europe. The same holds for ground stations with similar or even higher latitudes in Europe, so it is not a purely Dutch characteristic.

FSS mainly use the C-band (4 – 8 GHz), Ku-band (12 – 18 GHz) and Ka-band (27 – 40 GHz) frequencies, with different technical characteristics for each band. The operation of FSS in the C-band, the lowest of the three bands, offers several advantages for use cases. A single geostationary satellite using the C-band can provide coverage over about one third of the Earth's surface. Another advantage is that the C-band is less susceptible to rain fade than the higher frequency bands, allowing reliable services independent of weather conditions. Additionally, there is an existing ecosystem of geostationary satellites operating in the C-band, which are designed to have a life span of around 15-20 years.

In the satellite services sector, often a further distinction is made in the C-band spectrum. The L6 is part of the 'standard C-band', and part of the U6 band is included in the 'extended C-band' (6 425 – 6 725 MHz). In general, geostationary satellites operate in the standard C-band, and fewer satellites operate in the extended C-band. The frequency distribution of the FSS_ES links in the U6 band in The Netherlands is shown in Figure 7. The FSS_ES links are operating in the lower end of the U6 band, with frequencies ranging from 6 439 to 6 500 MHz. The associated FSS_SE (Space to Earth) links used by the satellites are not in the U6 band but in other frequency bands, e.g. in lower portions of the satellite C-band.

In the ECA table, there is also an allocation for FSS_SE services in the U6 band, in the 6 700 – 7 075 MHz portion of it. This allocation is limited to space-to-Earth feeder links for non-geostationary satellite systems of the mobile satellite service. Although this allocation is included in the ECA table, it is not in the Dutch NFP. Therefore, there are no licences for the space-to-Earth feeder links in The Netherlands.


*Figure 8. Locations of the commercial FSS_ES groundstations in The Netherlands based on RDI data.*

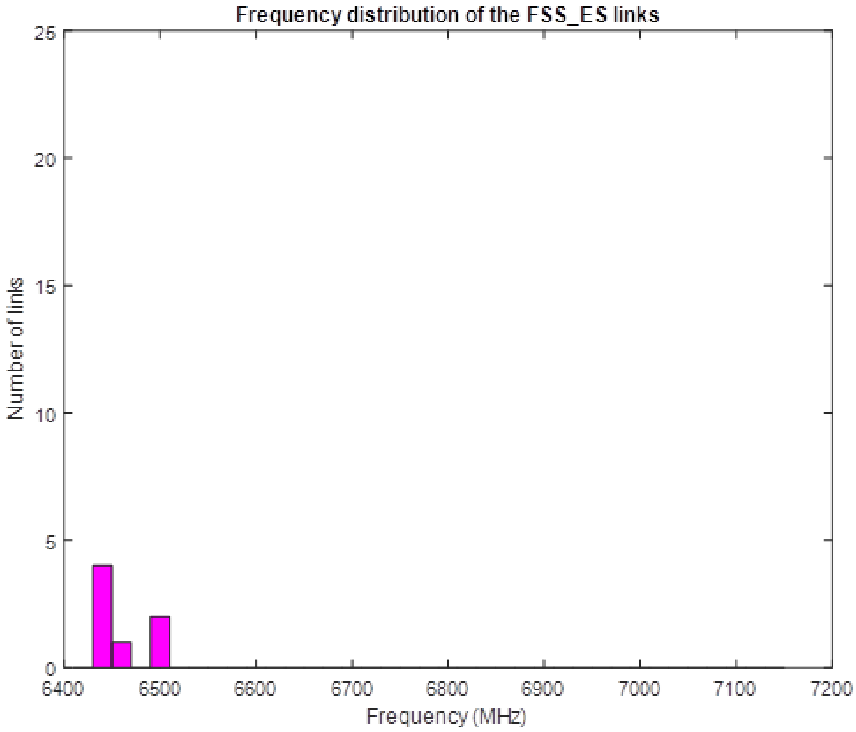


*Figure 7. Frequency distribution of the commercial FSS_ES links in The Netherlands based on RDI data.*

### 4.2.2. Satellite Services for Defence

A good portion of the U6 band (i.e., the part between 6 424 – 6 700 MHz) in The Netherlands is specifically allocated to Defence, which is intended for FSS_ES according to the Dutch NFP. The satellite service over the full territory of The Netherlands is of crucial importance for Defence. It is key that the use is not further limited nor degraded by the introduction of other services in the U6 band. Apart from the use of the U6 band for FSS as described above, Defence could use the U6 band for other services, for example during crises or war time.

## 4.3. Ultra-Wide Band

Ultra-Wide Band (UWB) is a wireless radio technology for short-range applications. Worldwide many devices use UWB technology in the 6 – 8.5 GHz range for various applications, such as measurements, communications, localisation, surveillance and medical systems. Key features of UWB are its centimetre accurate positioning, robustness to interference and low latency [16].

The accurate positioning in UWB technology is only possible because of the wide bandwidth that UWB systems use, which is 500 MHz or more. This is a substantial amount of spectrum. In order to use this spectrum, UWB systems have to comply with strict transmit power limitations and can only use extremely low transmit power. The transmit power limitations for UWB systems in The Netherlands are stated in the *Regeling gebruik van frequentieruimte zonder vergunning en zonder meldingsplicht* (Regulation on the use of frequency space without a licence and without a notification requirement) [17]. This ensures that UWB systems do not cause harmful interference with other services operating in the same frequency band.

UWB systems are permitted to operate in the unlicenced spectrum and are exempted from individual licencing in the 30 MHz – 10.6 GHz band. Thus, UWB systems operate on non-interference, non-protected basis. The 6 – 8.5 GHz is often used for UWB systems as it has a higher power spectral density limit than the other parts of the spectrum available for UWB [18].

## 4.4. Earth Exploration-Satellite Service

The Earth Exploration-Satellite Service (EESS) is a radiocommunication service which gathers information relating to the Earth's characteristics through active or passive sensors on satellites. The satellites collect environmental data for scientific and environmental purposes, including weather patterns, ocean currents, sea-surface temperature, and climate change indicators.

The U6 band is important for EESS as the passive sea-surface temperature (SST) measurements have peak sensitivity in this band [19]. This means that SST measurements can be more accurately measured in the U6 band compared to other bands, which is important for weather prediction models.

There is no EESS allocation in the U6 band, but the ITU-RR note that parts of the band are used for passive EESS measurements. The ITU-RR mention that administrations should take the needs of passive EESS into account in the future planning of the U6 band. The ITU-RR do not offer any protection from interference.

## 4.5. Radio Astronomy Service

Radio astronomy is the study of celestial objects and phenomena in the universe by observing radio waves that they have emitted. Radio waves are detected through radio telescopes that are located on Earth' surface. With the telescopes, radio waves that come from stars, gas clouds, planets, galaxies, and spectral-line emissions from atoms and molecules can be detected at various frequencies throughout the radio spectrum. Within the U6 band, the observation on the methanol spectral line takes place in the 6 650 – 6 675,5 MHz band. Observations in this specific band are essential to study the formation of massive stars.

Radio Astronomy Service (RAS) is a passive service, as it does not transmit radio waves and does not cause interference to other radio services. Due to very low power of cosmic radio emissions, radio astronomy observations are very susceptible to interference from other radio signals on Earth. In order to protect radio astronomy, ITU-RR footnote 5.340 states various frequency bands that are exclusively allocated to passive services. The U6 band is not part of these frequency bands. Although RAS takes place in the U6 band, the U6 band is not specifically allocated to RAS. This is captured in ITU-RR footnote 5.149, which lists various bands including the 6 650 – 6 675.5 MHz band that are important for radio astronomy observations and urges administrations to take all practical steps to protect the radio astronomy service from harmful interference in those bands [6].

The Netherlands plays an important role in radio astronomy internationally and has been at the forefront of radio astronomy for decades. There are two radio observation telescopes located in The Netherlands, out of which one can receive in the U6 band. This is the Westerbork Synthesis Radio Telescope (WSRT). The telescope is located in Drenthe, and interference-free zones are instated a few kilometres around the telescope ( [20], [21]). In the interference-free zones, motorised vehicles or active radio transmitters, such as mobile phones, are prohibited.

# 5. Potential future use of the Upper 6 band

The analysis of the potential future use of the U6 band is based on the input from the interviews with stakeholders and publicly available documents. In several areas, the views that stakeholders have on the potential future use in The Netherlands are closely linked to the discussion on the European level, e.g. in CEPT. Many of these views are publicly available in the responses to RSPG's recent Questionnaire on Long-term vision for the upper 6 GHz band [9] and the material presented during the RSPGs hearing on "6G strategic vision" [22].

A finding from the interviews and the available documents is that several stakeholders expect to support or use multiple services (and underlying technologies), a prominent example being IMT and Wi-Fi. This section describes per service how different stakeholders foresee and prefer to use the U6 band in the future. In the cases where organisations prefer to use the U6 band for multiple service, they typically have a clear view on the value they expect for each service and the requirements related to achieving that value. At the same time, they realise that the use of the U6 band for two or more services (and underlying technologies) often introduces co-existence challenges, for which they may or may not see specific solutions at the moment. This has led to the current set-up of this chapter: it reflects the expectations per service without a cross-check of whether the combination of the services is feasible. This will be dealt with in later deliverables. This report provides initial observations on potential next steps for this in the next chapter.

## 5.1. IMT (MS)

Following up on the identification of the U6 band for IMT in Europe and the rest of ITU Region 1, the mobile operator community, and the mobile network and component vendors, express strong interest for the use of the U6 band for IMT. These stakeholders have explained and illustrated their case for using the U6 band in public mobile networks in a range of vision papers and consultation responses. The owners and providers of local networks also show a strong interest in the U6 band that they combine with a focus on the bands that are available, or expected to become available, before the U6. In the next two subsections, the views on the use of the U6 for IMT are summarised.

### 5.1.1. Public mobile networks

The European mobile operator community sees an important role for the U6 band in ensuring sufficient mid-band spectrum for their mobile networks and services in the mid to long term future. They expect to require around 2 GHz of mid-band spectrum per country by 2030 ( [23], [24]). This 2 GHz consists of already available and new spectrum. The 700 MHz of spectrum offered by the U6 band is seen as a key component of the new spectrum. The U6 band may be combined with the adjacent 125 MHz in the 7 125 – 7 250 MHz band that is under study for WRC-27 as a portion of the 7 125 – 8 400 MHz band (see Section 2.2). Besides the 2 GHz of mid-band spectrum for which the U6 band is relevant, the mobile operator community also sees a need for low-band spectrum (below 1 GHz) and higher frequencies (e.g., mmWave and sub-THz). The low-band and mid-band spectrum are used by the operators in so-called macro networks, built with macro cells that use high transmit power to cover areas with a radius of typically several kilometres, including indoor coverage. In more densely populated urban and suburban areas, macro networks can also have cells with smaller radiuses, down to a few hundreds of metres. For the mmWave and sub-THz spectrum with their different propagation characteristics, much more local deployments are foreseen that would complement the macro networks.

Now that the 3.5 GHz band has become available, the U6 band is seen as the only mid-band spectrum left to become available for IMT on macro networks in the time frame for 5G-Advanced (from 2027) and 6G (from 2030). In The Netherlands, the use of 3.8 – 4.2 GHz spectrum, the other mid band that may become available for IMT before the U6 band, is still under discussion. The expectation is that this band will be relevant for local networks but not for nationwide macro networks because of anticipated power level limitations likely to be included in a European Commission's Harmonisation Decision for this band.

The need for the U6 mid-band spectrum is driven by the growing demand for mobile data that the mobile operators expect. They have several projections of the data growth centred around the growth of the overall enhanced mobile broadband (eMBB) traffic ( [25], [26]). The consensus is that it is difficult to predict which specific use cases will drive the demand. A generic use case family that several stakeholders expect to drive data traffic is immersive (or extended) reality, both indoors and outdoors. Furthermore, it is noted that several research projects, such as Hexa-X-II, are investigating use case families for the European 6G ecosystem. Some organisations note that in other world regions and countries, notably China, the U6 band will be available for IMT as well. This may provide further use cases, depending on whether they match the European needs and requirements at the time.

The expected and desired timing of the first IMT deployments in the U6 band varies between stakeholders, with some emphasising its use for 5G-Advanced around 2027-2028, and some looking at potentially combined 5G-Advanced and 6G deployments starting around 2030. All stakeholders agree that, although the U6 band has been identified for IMT in general, it could be an important harmonised band for the introduction of 6G. They note that in the US, Canada and most other countries in Region 2, the U6 band will not be available for IMT, but consider that with the identification of the band for IMT in China there is clearly critical mass for an IMT ecosystem in the U6 band.

Geographically, the U6 band would be deployed from macro networks (also referred to in CEPT as MFCN - Mobile/Fixed Communications Networks). The deployment would start in dense urban areas, of which The Netherlands has many. From there, the deployment would be extended to other areas. Compared to countries with lower population densities, a larger portion of The Netherlands would be covered, eventually potentially the whole territory to enhance the network capacity and performance for the widest group of customers. Depending on development of antenna and base station technology, relatively compact systems that combine multiple spectrum bands including the U6 can stimulate a wide roll-out. Some stakeholders mention use cases that would benefit or even drive such a wide roll-out, such as providing capacity on highways and Fixed-Wireless Access (FWA) services.

Given this expected use of the U6 band, the mobile operators, network and component vendors see the following key requirements:

- Mobile operators want to use the U6 band to provide a service that covers both outdoor and indoor users. The majority of traffic carried on mobile networks is from indoor users, and the operators want to serve these users with the U6 band as well. This means that the U6 band should be available for use with standard power levels from the base stations. Mobile operators and vendors have measurements that indicate to them that the U6 band is suitable to provide at least so-called shallow indoor coverage. Through carrier aggregation, the indoor capacity and speed provided by the U6 band (and also the 3.5 GHz band) can be combined with downlink and uplink capacity of lower bands to optimise the network performance.
- Mobile operators want to deploy the U6 band from the same grid of radio sites as the 3.5 GHz band. This makes the U6 band economical to deploy and removes the need to acquire new radio sites which is challenging in The Netherlands. With the advances in radio technology (such as the

further development of massive MIMO and beam steering), mobile operators, network and component vendors expect to be able to provide good quality coverage from the existing sites, despite the less favourable propagation characteristics intrinsic to the higher frequency. Thus, they see that the U6 band can provide both capacity and coverage. This use of the U6 band does depend on the ability to use it with standard power levels. With lower power levels, operators expect they would need to densify their radio access networks, leading to what they see as a prohibitively expensive roll-out. Some stakeholders put this roll-out challenge in a wider industry perspective where mobile operators need to handle ever increasing traffic volumes in a market where prices and revenues increase only gradually.

A specific requirement on the power levels in IMT use of the U6 band has already been introduced at ITU WRC-23 (Resolution 220 [7]): a limit for the expected EIRP (Equivalent Isotropic Radiated Power). In order to protect the receivers on board of satellites used in FSS, a mask has been defined that limits the power emitted by base stations as a function of the angle above the horizon. The mask is taken into account in the development of mobile network equipment and is not expected to stand in the way of the deployment approach outlined above.

Some of the mobile network and component manufacturers emphasise the lessons learned from mmWave. For public mobile networks, they prefer to introduce new technology that is not too distinct from the existing radio ecosystem in terms of frequency ranges. Building on and extending the existing ecosystem and infrastructure is expected to be easier than creating new ones, as was tried with limited success for mmWave for 5G earlier. In this respect, the U6 band is attractive as it is closer to bands currently used in mobile networks than some of the other potential new bands.

### 5.1.2. Local networks

The owners of local networks[5] expect an increasing demand for spectrum to support existing and new use cases in their sectors. They prioritise making the best use of licensed spectrum for local networks in the 3.5 GHz band, for which the licences in The Netherlands have become available since the end of 2023. The next band expected to be relevant for local networks is the 3.8 – 4.2 GHz band. In mid-2024, ECC carried out a public consultation on the draft CEPT report on this band [27], developed in response to an earlier European Commission mandate. The use of this band is currently being examined in The Netherlands as well.

Some stakeholders also offer a view on the opportunities that the U6 band brings after these two earlier bands (see BTG answer to RSPG consultation on *Long-term vision for the upper 6 GHz band* [9]). A specific proposal is that the U6 band can be allocated partly to unlicensed use and partly to licenced use, both in the technology-independent way so that the spectrum can be used for both IMT and Wi-Fi. If the band 6 425 – 6 875 MHz would be allocated to unlicensed use, this would align with the UNII-6 and UNII-7 bands for Wi-Fi already in use in the US. The 6 875 – 7 125 MHz band could be allocated to licensed use, aligned with the UNII-8 band. This would give organisations that prefer to deploy a local network in a clearly demarcated location the flexibility to choose between IMT and Wi-Fi technologies. A subject for investigation is how to enable co-existence between these technologies in the same or adjacent spectrum bands.

It is also noted that for the business viability of local network propositions, the presence of a well-developed equipment ecosystem for both network equipment and devices is key. It is also crucial for the

[5] In the specific case of the 3.8 – 4.2 GHz band, the Dutch NFP refers to *perceelgebonden netten ("plot-bounded networks")*.

choice between (potentially) available bands. For IMT, this ecosystem is typically created and shaped by the needs of public mobile operators. For Wi-Fi in the U6 band, the ecosystem is being shaped by the Wi-Fi stakeholders in the US market.

## 5.2. Wi-Fi (WAS/RLAN)

The community of Wi-Fi stakeholders is varied and includes vendors of Wi-Fi access points and management systems, vendors of (components for) smartphones and augmented reality (AR) devices, and providers of applications on those devices. Also converged fixed-mobile operators are Wi-Fi stakeholders, as they typically provide Wi-Fi routers for their fixed broadband customers to wirelessly extend the fixed connectivity to devices indoors.

Several, but not all, of the Wi-Fi stakeholders have a strong wish to use the U6 band for Wi-Fi. There are two main uses foreseen the U6 band.

The first use of the U6 band in Wi-Fi is to handle the growing internet traffic indoor, in consumers' homes, in offices, and other business settings. All stakeholders that favour the U6 band for Wi-Fi foresee that the U6 band will be needed for this in the traditional Low-Power Indoor (LPI) mode of operation. They note that the majority of internet traffic originates and terminates via Wi-Fi access points and expect this to remain the case as more and more Wi-Fi-connected devices enter homes and offices. A wide set of applications and use cases will drive the traffic growth over Wi-Fi access. It is difficult to point out specific ones, perhaps with the exception of AR and immersive applications. Some stakeholders refer to a recent study [28] arguing that the current amount of spectrum available for Wi-Fi in Europe, including the L6 band (5.925 – 6.425 GHz) can only support 1 Gbit/s coverage to 50-60% of residential building areas [28].

In combination with the spectrum in the L6 band that is already available for Wi-Fi, the U6 band can be used to extend the Wi-Fi capacity. It can be used to create more and wider channels, for example seven channels of 160 MHz each. Wider channels help to increase the maximum bandwidths for end users. More channels help to reduce interference between access points in situations where they need to be densified because of higher overall demand for capacity. Densification is a well-known approach in office, healthcare and education environments, but it is also relevant for homes. With the U6, there is also the option to use 320 MHz channels for even higher performance.

Stakeholders note that in The Netherlands, a growing number of consumers have a 1 Gbit/s connection, while there are already connections up to 4 Gbit/s commercially available. The XGS-PON fibre technology used for this is ready to provide up to 10 Gbit/s. Further steps in the evolution of PON technology have been demonstrated already (e.g., to 25 Gbit/s). In the decade after the U6 band becomes available, 2030-2040, stakeholders expect that Wi-Fi will need to play its key role in delivering this bandwidth to devices in the home. Most Wi-Fi access points that support that U6 band are commercially available in several large markets, including the US (but excluding China). Wi-Fi in the U6 band is also supported in the latest two generations of smartphones, showing that there is already a critical mass driving economies of scale.

At the same time, most of the converged fixed-mobile operators do not expect to need the U6 band as additional spectrum for Wi-Fi. They expect that with the L6 band that has been added to the earlier 2.4 and 5 GHz bands, there is sufficient spectrum for Wi-Fi to handle the traffic growth. Apart from the L6 band spectrum, they expect that Wi-Fi technology upgrades, and densification of indoor Wi-Fi networks can play an important role in the expansion of the Wi-Fi capacity for consumers and businesses.

For outdoor wide-area coverage, such as large manufacturing plants, harbours and airfields, the stakeholders do not see a role for Wi-Fi. They see public or private mobile networks as better suited for providing connectivity in these situations.

The second use of the U6 band in Wi-Fi is for very local connectivity, using the Very Low Power (VLP) mode of operation. This use is advocated by some of the (AR) device vendors and providers of applications on those devices. They expect to use very local, very short-range but also very high-capacity connections to connect devices in a personal area network. The example mentioned most is offloading the processing from AR glasses to a smartphone. Here, the purpose of the offloading is to provide an advanced experience for AR glasses despite its very limited thermal and battery capacities. For this VLP use, Wi-Fi channels of 160 or 320 MHz are desirable that cannot overlap with channels in use for the LPI used by Wi-Fi access points, as these would drown out the VLP signals. With the combination of the L6 and U6 bands, there can be a distribution of channels between the LPI Wi-Fi from the access points used for regular internet access and the VLP Wi-Fi used for device-to-device communication.

## 5.3. Fixed Services

As described in Section 4.1, the dominant use of FS links in the U6 band in The Netherlands is for microwave ring networks on the North Sea. The expectation is that these networks and the links in them will remain critical for offshore use cases. The offshore industry has made some initial steps in digitalisation, and the industry view is that further digital technologies such as Internet of Things (IoT) and camera supervision will be introduced. This new demand will bring a need for more capacity in the ring networks. AR technology would provide further growth. New offshore use cases, such as new platforms for carbon capture, have the potential to cause a step increase as such platforms are expected to include multiple digital technologies from the start.

The basic role of the microwave links remains the same: they make up the core network that is the basis for providing connectivity services through mobile and other (higher-frequency, shorter-range) microwave links. The availability of spectrum for microwave links in the 6 – 10 GHz range is crucial here, as these are the frequencies suitable to connect the long hops and insensitive to rain fading. The U6 band is one of three key bands for FS, together with the L6 and 7.5 GHz bands. In principle, the current primary users could migrate to alternative bands in the 6 – 10 GHz range, if such bands are available and offer equivalent performance. Other key determinants are the availability of affordable equipment from renowned vendors and the overall costs involved in a potential migration.

## 5.4. Satellite Services

### 5.4.1. Commercial Satellite Services

Fixed Satellite Services have been using the U6 band for decades, and no change is foreseen to the current FSS uses in the future. One of the main reasons for this is the existing ecosystem of geostationary satellites using the C-band that are already orbiting the world. There are also several geostationary satellites being manufactured for launch in the near future. Geostationary satellites have a lifespan of approximately 15-20 years with potential of expansion due to technological advances. Changing the frequency bands used by these satellites cannot be done without extreme costs.

Even though the C-band offers many advantages for satellite services as mentioned in Section 4.2.1, no strong growth in required satellite capacity is foreseen in the C-band. Next to the C-band, the satellite industry will continue developing new systems in higher frequency bands. However, it will continue requiring access to the C-band as well, especially for applications requiring high reliability. It is expected that satellite services will continue using the C-band in a similar way as now.

### 5.4.2. Satellite Services for defence

The *Nationaal Programma Ruimte voor Defensie* (National Programme "Room for Defence") states that the transformation towards a future-proof Defence organisation brings other needs for its operating space and with that also other spectrum needs. Therefore, amongst other reasons, it is anticipated that Defence's spectrum requirements will increase in the coming years. Defence is relying on the spectrum allocated to their use, in the U6 band and in other bands to help meet these needs. The BOP (Behoefte OnderbouwingsPlan or Requirement Substantiation Plan) describes Defence's spectrum needs for the coming years. Defence expects to provide a new BOP to the Ministry of Economic Affairs later in Spring 2025.

The satellite service over the full territory of The Netherlands will remain of crucial importance for Defence. Defence considers it key that the use is not further limited nor degraded by the introduction of other services in the U6 band.

## 5.5. Ultra-Wide Band

The commercial use of UWB is growing at a rapid pace. According to ABI Research, the number of UWB-enabled device shipments is expected to reach over one billion annual shipments by 2025 [29]. For example, Apple has implemented UWB in its iPhone 11 and later models, and in several of its other devices such as watches, tracking tags, speakers and earbuds. Next to the smartphone industry, UWB systems are also implemented in the automotive sector and in IoT applications.

Due to the rapid increase of UWB systems, UWB will continue to require access to the U6 band in the future and expects a continued expansion of spectrum needs in this band. However, UWB does not need exclusive access to the spectrum. UWB systems allow for other users to use the spectrum as well, due to the extremely low transmit power of UWB systems. According to the national regulations, UWB systems operate on non-interference, non-protected basis i.e. should not cause interference to other users nor should claim protection from other users.

## 5.6. Earth Exploration-Satellite Services

Within EESS, the U6 band is predominantly used for sea-surface temperature (SST) measurements due to its peak sensitivity to water temperature variations [19]. Continuing the measurements in this band is important, as a history of measurements has been built for many decades. The Copernicus Imaging Microwave Radiometer (CIMR), a mission of the EU Earth Observation Programme Copernicus developed by ESA, has a constellation of two satellites to observe the SST. The mission is due for launch in 2028, and it is expected that the SST measurements will be performed well beyond 2030.

The EESS are not protected to interference from other users, including the current users of the U6 band. The passive SST measurements can also be impacted if the band is used for new services. WRC-27 will consider a possible co-primary allocation to the EESS in the frequency bands 4 200 –4 400 MHz and 8 400 – 8 500 MHz (Resolution 674 [7]) to provide additional possibilities for SST measurements.

## 5.7. Radio Astronomy Services

The radio astronomy services continue to require the 6 650 – 6 675.5 MHz band for methanol observations in the future. Due to the specific characteristics of methanol at this frequency, it is impossible to shift the observation frequency to another band. Harmful interference from other radio services or losing access to this band in The Netherlands would obstruct the ongoing study of the formation of massive stars.

# 6. Conclusions and next steps

## 6.1. Conclusions

Based on desk research and a series of stakeholder interviews, an inventory has been created of the current use and the potential future use of the U6 band in The Netherlands. The inventory follows the definitions of the ITU's radiocommunication services to stay aligned with the approach in the ITU and CEPT. This means that some organisations have provided inputs on multiple services. In the cases where organisations prefer to use the U6 band for multiple services, they typically have a clear view on the value they expect for each service and the requirements related to achieving that value. At the same time, they realise that use of the U6 band for two or more services (and underlying technologies) introduces co-existence challenges, for which they may or may not see specific solutions at the moment.

In The Netherlands, the U6 band is already used for several services. The current users see the need to continue their use of the U6 band. They expect to use the band to respond to a growing demand for connectivity (FS on the North Sea, FSS for defence use, UWB) or to a continued need (FSS for commercial use, radio astronomy, EESS).

The use of the U6 band is expected to widen in the future. Potential new users of the band (IMT, RLAN/Wi-Fi) see the need to use the band to expand the capacity for broadband connectivity to meet the growing demand for data traffic they expect.

A particular focus has been to identify features in the use of the U6 band that are specific to The Netherlands. The aim is to make stakeholders and policy makers aware of those features so they can take them into account when interpreting or contributing to the U6 discussion at the European level. Two situations with Dutch-specific features have been identified:

- The ground stations in The Netherlands that use the U6 for Earth-to-space communication operate with their dishes at lower elevation angles than those in most other parts of Europe. This is a direct consequence of the higher latitude of The Netherlands. The same holds for ground stations in countries with similar or higher latitudes in Europe. In The Netherlands, this low elevation angle is combined with a flat landscape that causes a wide propagation of the signals.
- The FS microwave links in the U6 band are almost all located on the North Sea, with a limited number of links to sites on land. This is different from situations in countries like France and Italy where many U6 microwave are used throughout the country.

## 6.2. Next steps and further research

The scope of this report has deliberately been restricted to the inventory of current and potential future use per technology. In the next step, the research question is whether and how the potential future uses can co-exist in the U6 band. The earlier discussion at WRC-23 and the current discussion at the European level show that this is an important and non-trivial question. From the interviews conducted for this report, many contributions to CEPT (in particular to the ECC PT1 working group), and responses to the recent RSPG questionnaire on the U6 band, we conclude that there are several combinations of services where stakeholders question the need and the feasibility of co-existence options. At the same time, there are combinations of services for which stakeholders explain the need for co-existence and their preferred approach for it. As a part of this ongoing discussion, the European Commission is expected to issue a mandate to CEPT to investigate co-existence between several services: FS, IMT, Wi-Fi and FSS.

For all organisations using or planning to use the U6 band, regulatory certainty in access to the spectrum is key. This concerns both safeguarding the investments of current users and timely access to spectrum for new users. Another key point is the European alignment with global ecosystems for services and equipment. At this point, it is difficult but also necessary to determine the options that bring the most benefits for the Dutch digital infrastructure and for the Dutch society as a whole. These options also need to fit the European framework for spectrum policy.

For FNS, the aim is to find topics where there is a need to contribute to the European discussion from the Dutch perspective, for example, if the current use is different from that in most other parts or countries of Europe. The first step is, therefore, to analyse the co-existence of the services from our inventory, with a focus on combinations where the specific use (or potential future use) of one of the services in The Netherlands has an effect on the feasibility and approaches for co-existence. This analysis can be done by combining the inventory from this report with the relevant studies by CEPT.

Based on the findings in the first step, in the second step specific combinations of services that require more attention can be investigated further, with the aim to identify the Dutch-specific elements of potential co-existence. Without forestalling outcome of the analysis, some specific issues can be expected to require attention:

- The ground stations with satellite dishes with relatively low elevation angles used in FSS_ES services. This point is important, as these angles are smaller than the typical angles used in CEPT studies on interference from FSS_ES ground stations on other services, such as IMT and Wi-Fi. Because of the smaller angles and the flatness of the Dutch landscape, such studies will tend to underestimate the level of interference.
- The concentration of the FS microwave links in the North Sea makes the geographical overlap with IMT and Wi-Fi smaller than in other countries. In itself, this does not remove the co-existence challenge, but it can be expected that the coordination that could be involved in the co-existence is made easier.
- CEPT is currently investigating the feasibility of shared use between IMT and Wi-Fi [30]. This topic has been generating substantial discussion in CEPT. It has also received much attention in the responses to the RSPG questionnaire. At this point, it is unclear whether there are elements that are particularly relevant for The Netherlands that need to be introduced in the European discussion. Annex B presents a proposal to investigate this, based on scenarios for the dense urban use of IMT and Wi-Fi to enhance broadband connectivity to end-users in homes and business settings in The Netherlands.

# 7. List of acronyms

| | |
|---|---|
| AR | Augmented Reality |
| BOP | Behoefte-OnderbouwingsPlan (Dutch for Requirements Substantiation Plan) |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| ECA | European Common Allocation (Table) of CEPT |
| ECC | Electronic Communications Committee of CEPT |
| EESS | Earth Exploration-Satellite Service |
| EIRP | Equivalent Isotropic Radiated Power |
| ERC | European Radiocommunications Committee |
| EU | European Union |
| eMBB | Enhanced Mobile BroadBand |
| ESA | European Space Agency |
| FNS | Future Network Services |
| FS | Fixed Service |
| FSS | Fixed Satellite Service |
| FSS_ES | Fixed Satellite Service Earth-to-Space |
| FSS_SE | Fixed Satellite Service Space-to-Earth |
| FWA | Fixed-Wireless Access |
| GHz | GigaHertz, $10^9$ wave cycles per second |
| IMT | International Mobile Telecommunications |
| IoT | Internet of Things |
| ITU | International Telecommunications Union |
| ITU-R | ITU Radiocommunication Sector |
| ITU-RR | ITU Radio Regulations |
| L6 | Lower 6 GHz |
| LEO | Low Earth Orbit |
| LPI | Low-Power Indoor |
| MFCN | Mobile/Fixed Communications Networks |
| MHz | MegaHertz, $10^6$ wave cycles per second |
| MIMO | Multiple-Input Multiple-Output |
| mmWave | Millimetre-Wave Range |
| NATO | North-Atlantic Treaty Organization |

| | |
|---|---|
| NFP | National Frequency Plan |
| NJFA | NATO Joint Civil/Military Frequency Agreement |
| PMSE | Programme Making and Special Events |
| PON | Passive Optical Network |
| RDI | Rijksinspectie Digitale Infrastructuur (Dutch Authority for Digital Infrastructure) |
| RAS | Radio Astronomy Service |
| RLAN | Radio Local Area Network |
| RSC | Radio Spectrum Committee |
| RSPG | Radio Spectrum Policy Group |
| SLA | Service-Level Agreement |
| SMEs | Small and Medium-sized Enterprises |
| SST | Sea-Surface Temperature |
| THz | TeraHertz, $10^{12}$ wave cycles per second |
| U6 | Upper 6 GHz |
| UWB | Ultra-Wideband |
| VLP | Very Low Power |
| WAS | Wireless Access System |
| WRC | World Radio Conference |
| WSRT | Westerbork Synthesis Radio Telescope |
| XGS-PON | 10-Gigabit Symmetric Passive Optical Network |

# 8. References


[1] "Future Network Services: 6G for and by the Netherlands," [Online]. Available: https://futurenetworkservices.nl/en/. [Accessed 10-10-2024].

[2] ITU-R, "Handbook on International Mobile Telecommunications (IMT)," 2022 edition.

[3] ITU-R, "Future technology trends of terrestrial International Mobile Telecommunications systems towards 2030 and beyond," Nov. 2022.

[4] Ericsson, "Leveraging the potential of 5G millimeter wave," Stockholm, 2021.

[5] GSA, "5G Market Snapshot," Nov. 2024.

[6] ITU, "Radio Regulations," Switzerland, 2024.

[7] International Telecommunication Union, "World Radiocomunication Conference 2023 (WRC-23) Final Acts," ITU Publications, Geneva, 2024.

[8] Radio Spectrum Policy Group (RSPG), "Work Programme for 2024 and beyond," Brussels, 7 February 2024.

[9] Radio spectrum policy group (RSPG), "Consultations," [Online]. Available: https://radio-spectrum-policy-group.ec.europa.eu/consultations-0_en. [Accessed 2-12-2024].

[10] Electronic Communications Committee (ECC), "The European Table of Frequency Allocations and Applications in the Frequency Range 8.3 kHz to 3000 GHz (ECA Table)," Approved October 2021, Editorial update 8 March 2024.

[11] NATO, "NATO Joint Civil/Military Frequency Agreement (NJFA)," 2017.

[12] Ministerie van Economische Zaken, "Nationaal Frequentieplan 2014".

[13] Agentschap Telecom, "Bandprofiel Upper 6 GHz," Jan. 2006.

[14] Tampnet, "Coverage maps," [Online]. Available: https://www.tampnet.com/coverage-maps. [Accessed 10-10-2024].

[15] Stratix, "Dynamic Spectrum Management & Sharing," Jul. 2021.

[16] Qorvo, "Getting Back to Basics with Ultra-Wideband (UWB)," May 2021.

[17] Ministerie van Economische Zaken, "Regeling gebruik van frequentieruimte zonder vergunning en zonder meldingsplicht 2015".

[18] ETSI, "ETSI EN 302 065-1 v2.1.1," 2016.

[19] A. G. O'Carroll et al., "Observational needs of sea surface temperature," *Frontiers in Marine Science*, vol. 6, Aug. 2019.

[20] Provincie Drenthe, “Zonering radioastronomie zone I,” [Online]. Available: https://zoek.officielebekendmakingen.nl/dc-2024-1444/1/html. [Accessed 10-10-2024].

[21] Provincie Drenthe, “Zonering radioastronomie zone II,” [Online]. Available: https://zoek.officielebekendmakingen.nl/dc-2024-1438/1/html. [Accessed 10-10-2024].

[22] Radio spectrum policy group (RSPG), “Events - 27 September 2024 - 6G Hearing,” [Online]. Available: https://radio-spectrum-policy-group.ec.europa.eu/events-0_en. [Accessed 10-10-2024].

[23] GSMA, “The 6 GHz IMT Ecosystem - Demand Drives Scale,” Jun. 2024.

[24] GSMA, “Mobile Evolution in 6 GHz - The Impact of Spectrum Assignment Options in 6.425-7.125 GHz,” Sep. 2024.

[25] A. D. Little, “The Evolution of Data Growth in Europe,” 2023.

[26] Ericsson, “Ericsson Mobility Report,” Jun. 2024.

[27] CEPT, “Draft CEPT Report 088 - Report from CEPT to the European Commission in response to the Mandate on shared use of 3800-4200 MHz by terrestrial wireless broadband systems providing local-area network connectivity (WBB LMP),” Jul. 2024.

[28] PLUM, “Wi-Fi Spectrum Requirements,” Mar. 2024.

[29] A. Zignani and S. Tomsett, “Ultra-Wideband (UWB) for the IoT - a Fine Ranging Revolution?,” ABI research, Jun. 2021.

[30] CEPT ECC PT1, “Feasibility of shared use of the 6425-7125 MHz frequency band by MFCN and WAS/RLAN,” [Online]. Available: https://eccwp.cept.org/WI_Detail.aspx?wiid=829. [Accessed 10-10-2024].

# Annex A: List of interviewed organisations

The authors of this report thank the following organisations for providing their inputs on the current and future use of the U6 band. Most information was gathered in on-line interviews with the individual organisations, structured through a standard list of questions. Some organisations have provided written inputs.

Astron

BTG

Cisco

Ericsson

ESA

Eurofiber

Huawei

KPN

Liberty Global

Meta

Ministry of Defence

Nokia

NXP

Odido

Port of Rotterdam

Qualcomm

RDI

Rijkswaterstaat

SES

Speedcast

Strict

Tampnet

Viasat

# Annex B: Suggestions for next steps around scenarios for IMT and Wi-Fi in the Upper 6 GHz band

The interviews show that there are organisations that see value in using the U6 band for IMT, organisations that see value in using the U6 band for Wi-Fi, and organisations that see value in both, either from a vendor or from an operator perspective. Furthermore, all organisations are aware of concepts and proposals for sharing (or co-existence). Several organisations see benefits in sharing, while others do not see the need or have concerns about the technical feasibility of shared use and the complexities of agreements required.

- Much of the value seen in the future use is concentrated in dense urban areas, including indoor. This can be seen as creating a geographical overlap that is difficult to handle as spectrum scarcity is most prominent there. It can also be seen as providing a point of convergence at the end user of connectivity provided by IMT and Wi-Fi.
- A harmonised approach is a key requirement for all organisations involved to ensure economies of scale in equipment, devices and service offerings.

At this level of analysis, it is unclear whether there are Dutch-specific elements that would need to be introduced in the European discussion, while it is important to know if any exist.

- Identifying Dutch-specific elements would start with examining the overall potential use of the U6 in The Netherlands, based geographic characteristics, demographics, fixed and mobile network infrastructure, types of buildings and fibre roll-out. The combination of these factors could make the Dutch profile and usage scenarios unique, while at the same time would probably have elements that are relevant in other countries, such as dense urban indoor.
- Then, it can be checked whether the scenarios are covered by the existing studies in ECC PT1 or whether there are gaps. Such gaps can be brought forward to ECC PT1.
- In parallel, it can be checked with the technical program lines in FNS whether the specific scenarios inspire ideas for new solution directions for co-existence. Such ideas can be based on existing concepts like Cognitive Radio, potential new AI-based concepts, beam steering and combinations of those. Specific scenarios can be used to formulate a specific research challenge.
- Where needed, the research can include or be supported by simulations and trials mimicking the typical Dutch scenarios with specific power levels, base station and access point densities. This can provide insights in the interference levels with and without co-existence measures, from the FNS research or from the European policy discussion. It can also provide insights on the end user benefits and how they relate to the potential complexity introduced by the co-existence mechanisms (which is in turn linked to the alignment with global ecosystems and the timeline for introduction of the systems in Europe).