Assessment of Spectrum Management Approaches in Offshore Private Industrial 5G Networks

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Abstract. Wireless communication research has recently expanded to address the use of 5G in enterprise application, which has led to the introduction of local private industrial networks. At the same time, the use of wireless communication services offshore has increased both in improving the productivity of the incumbent oil and gas segment, and particularly in enabling sustainable windmill park implementations. These developments call for novel, flexible and scalable spectrum management models to meet the operational requirements of these critical infrastructure verticals. This paper investigates spectrum management approaches and regulatory decisions for private mobile industrial communication networks for the offshore applications. The findings indicate that in offshore areas where significant natural resources, such as oil have been utilized, the regulators have defined mechanisms to make spectrum available while the regulation varies between countries. Traditionally, the regulators have been oriented towards public mobile networks and their service areas have been land oriented. The basis for the jurisdiction for offshore deployments is very different, and also the radio environment at sea differs significantly from that on land which calls for new authorization mechanisms and coordination approaches, and different technical requirements.

Keywords: Cognitive Radio; Private Networks; Offshore; Radio Access; Radio Spectrum Administration; Radio Spectrum Management; Spectrum Sharing; 5G Mobile Communication

1 Introduction

Wireless solutions are increasingly targeting to digitalize different sectors of society, especially, through the use of 5G. To help the different verticals in serving of their end users, the concept of local micro-operators was introduced to 4G discussions way before the 5G spectrum awarding decisions were made [1]. As a result, private industrial networks have emerged, and local spectrum licenses have been made available for them. Ever-expanding variety of frequencies allocated to wireless communication from sub-giga Hertz to mm-wave spectrum bands with novel local requirements of verticals industrial use cases have fragmented spectrum regulation [2]. Traditional long-term spectrum assignments with nationwide coverage obligation are being complemented with local licensing [3], shared spectrum access [4][5][6] and license-exempt access [7], which signifies a transformation in spectrum administration and management for mobile communication networks. The 3.5 GHz citizens broadband radio service (CBRS) system in the US [5] and licensed shared access (LSA) [6] managed spectrum sharing concept in Europe were found to extend business models towards locality [8] and openness [9]. Furthermore, studies on the valuation of spectrum [2] and spectrum pricing models [3] in the context of private local networks found the spectrum sharing concepts essential enablers in the spectrum regulation. Assessment of spectrum management requirements [7], approaches to private industrial networks was addressed in [10], and the feasibility of the CBRS concept in [11]. Vuojala et al. [12] reviewed different spectrum access options to meet the 5G vertical sectors' requirements and urged regulators to make versatile spectrum access options available to boost vertical network service provider businesses. A recent study [13] describes a coordinated space, terrestrial and ocean network architecture and discusses related spectrum management challenges.

To the authors' knowledge, this is the first paper assessing the applicability of recent spectrum management approaches in the context of private offshore industrial 5G mobile networks. The focus is on private networks deployed at sea for installations such as oil platforms or wind farms. The rest of this paper is organized as follows. Chapter 2 presents an overview of spectrum management approaches, and Chapter 3 presents the use cases for offshore communications, an overview of offshore spectrum requirements and the regulation for offshore private wireless networks. Chapter 4 introduces the state of the art of offshore spectrum management approaches globally, and Chapter 5 discusses their applicability for offshore applications. Finally, suggestions for future research and conclusions are provided in chapter 6.

2 Overview of Spectrum Management Approaches

Spectrum management generally aims at maximizing the value of spectrum by allocating spectrum bands among different radio communication services and assigning related spectrum access rights. Here, we consider three types of spectrum management approaches: administrative allocation, market-based mechanisms, and the unlicensed commons approach, especially from the viewpoint of offshore private industrial networks [2].

Administrative allocation is a method for regulators to decide themselves through their own criteria who gets spectrum access rights. Examples include beauty contests or direct awards. Typically, rules are created to minimize harmful interference between different users. Several countries have introduced local licenses that allow different stakeholders to establish local private networks and award them through administrative allocation, for example on first come first serve basis. In *market-based mechanisms* the regulator relies on market forces to define who gets the spectrum access rights. Typically, auctions are used by the regulators to assign spectrum access rights to deploy cellular mobile communication networks in many countries. Additionally, the right to sell or lease the rights of use is a form of market-based mechanisms where the licensee can allow another stakeholder to use the band or part of the band, depending on the licensing agreement terms. For example, in Europe, licenses awarded through auctions for mobile communication networks come with this right, which would allow different stakeholders to gain access to spectrum locally on a mobile network operator (MNO) band if they reach a commercial agreement. The *unlicensed commons* approach is based on spectrum sharing and allows a number of systems to access the same spectrum band under pre-defined rules and conditions, typically on maximum transmission power and duty cycle. Often the transmission power limits set the operational area to be local. Thus, local networks could also be established in these bands, but without guarantees for the service quality as the band is often shared with an unlimited number of systems.

3 Offshore Private Industrial Networks

This chapter introduces offshore applications and discusses their implication to spectrum requirements and regulation.

3.1 Applications and Use Cases

Trustworthy communication is essential for the critical offshore infrastructure applications and services characterized by remoteness, harsh sea conditions, strong and unpredictable winds, extreme temperatures, and distance from the shore. Traditional oil and gas industry is exploring ways to improve productivity and reduce costs through digital automation leveraging technologies such as Internet of things (IoT), machine learning (ML), robotics and 5G. 5G connectivity platforms add value by providing reliable and secure ultra-high speed low latency connectivity between drilling sites, service vessels, and offshore platforms. Compared to “voice only” dedicated satellite link technology widely utilized today, 5G can provide substantial cost savings [14]. While the global offshore oil and gas market has flattened out, the offshore windmill market is set to expand significantly over the next decades matching investments in gas- and coal-fired capacity over the same period [15]. Reinforced by the sustainability development goals and the lower cost technology innovations, the capacity of offshore windmill farms is projected to increase fifteen-fold to 2040, becoming a $1 trillion industry. Trustworthy and reliable high speed broadband connectivity is essential to enable digital automation beyond current supervisory control and data acquisition (SCADA) capabilities [16] and further to trigger growth as expected. Key offshore applications and use cases utilizing 5G-ACIA categorization [17] consist of employee voice and video group communications, as well as broadband data for safety, productivity and general corporate services; campus area connectivity for fixed-position or mobile devices such as drives, robots, machines, sensors, actuators, screen terminals, and other interacting systems; remote monitoring, surveillance and awareness analytics for process automation via IoT sensors, high definition video, thermal and radar; remote control-to-control communication for autonomous devices that normally interact with their local controller and only need remote communication occasionally or for maintenance; remote control and management of mobile robots and automated guided vehicles (AGVs) such as drones, cranes and robot arms; closed-loop control of interacting components within a control loop, such as sensors, actuators and control units for process automation, and Service Operation Vessel (SOV) services on-site, roaming to land mobile network. These applications set distinct technical requirements for reliability and availability, security, end-to-end (e2e) latency, quality diagnostics, and network privacy and isolation.

3.2 Spectrum Requirements

Building on the above-mentioned applications and use cases, we will next define high level spectrum requirements for private offshore networks. The use of harmonized bands, e.g. 3GPP defined bands, provides economies of scale through existing device ecosystem. Therefore, their use is also desirable for the considered offshore operations. The spectrum assignments should include wide enough bandwidths for parallel wideband applications. As many of the applications are related to safety and critical reliability services, guaranteed spectrum availability and protection from harmful interference are required. Both indoor and outdoor coverage is typically required, as well as mobility around the facility. Transmit power levels allowing for outdoor coverage are needed, as well as flexibility of the uplink/downlink (UL/DL) ratio that enables capacity flexibility for various applications. Individual authorizations, i.e. licensing, are the preferred authorization method, and license application submission should be possible any time. The authorization duration should facilitate regulatory certainty and flexibility within the expected facility lifetime. The license fees should be known in advance and affordable industry grade pricing is preferred. Table 1 summarizes the identified high level spectrum requirements for offshore private networks.

Table 1. Spectrum requirements for offshore private networks

	Private offshore network preference
Band type	Harmonized for the scale and device ecosystem, low to medium frequencies for wide area coverage
Bandwidth	Support for multiple wideband applications
Availability	Guaranteed full time availability
Interference protection	Exclusive, protected band preferred
Sharing conditions	Static, pre-defined conditions, locally exclusive coverage
Mobility	Support for employee, machine and SOV mobility
Location and coverage area	Local outdoor (farm/rig wide) and indoor (service platform) coverage. One or multiple areas. Coverage for SOV service.
Transmit power	High output power outdoors
UL/DL ratio	Flexible, uplink orientated

Authorization method	Individually authorized, application possible any time, time-to-deployment critical.
Authorization duration	Flexible and renewable. In line with typically long facility life cycle and varying service contracts.
Cost/pricing	Known, stable and affordable industrial license fee
Regulatory certainty	High, beyond authorization duration

3.3 Offshore Spectrum Regulation

Traditionally, offshore radiocommunication has comprised of UHF and VHF radio services focused on safety issues, such as on monitoring radio frequencies for distress messages and broadcasting of weather warnings. The emergence of cellular communications created new opportunities at sea, especially close to the shore. The United Nations Convention on the Law of Sea (UNCLOS) defines the maritime zones from the shore towards the sea and the rights of the states within those zones [18] as illustrated in Fig. 1. Individual states have sovereign rights to regulate spectrum use within their territories, including the territorial waters. Terrestrial mobile networks are typically authorized to provide coverage over the land area, but also, depending on the country and the band, in many cases, towards the sea. The Radio Regulations (RR) of the ITU-R define the global framework for utilization of specific frequencies for specific purposes globally, regionally or per country [19]. Therefore, border coordination is dealt by bilateral agreements between the countries including border coordination towards the sea. There is a need to ensure the offshore usage of spectrum for the required services, while the creation of harmful interference by offshore applications towards the land-based spectrum usage must be avoided.

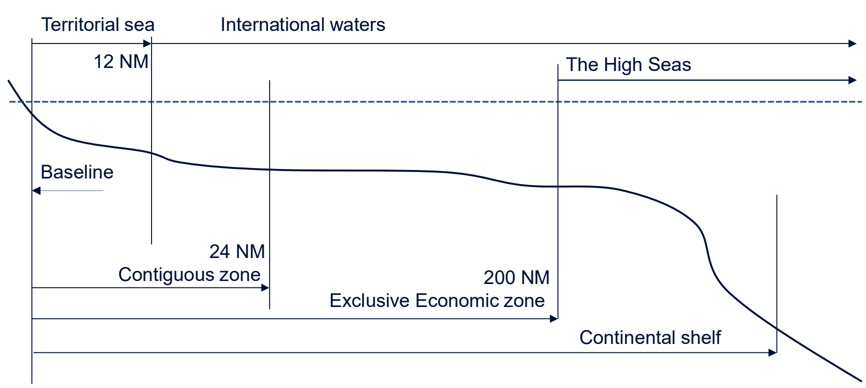

Fig. 1. Maritime zones (1 NM = 1852 m).

As an overall rule, based on UNCLOS, spectrum use within the territorial waters, reaching 12 nautical miles (NM) from the baseline, i.e, the low water line of the coast, falls into the jurisdiction of the state by the sea and is therefore regulated by the national authorities. Spectrum use outside the terrestrial waters is generally outside of the national jurisdiction. This has an impact on private mobile networks on board vessels. On-board networks operating on 3GPP bands are authorized by the flag state, and the networks can be used in international waters, in the "high seas" as long as they operate in accordance with the applicable provisions of the RR. When the vessel enters the territorial waters, unless the system use is specifically authorized by the local authorities, the on-board mobile system must be switched off to avoid harmful interference to local terrestrial mobile networks, as shown in Fig 2. The crew and the passengers should get then connected to the local terrestrial mobile networks. Similar operational restrictions do not apply to on-board Radio LAN or other networks operating on license exempt bands.

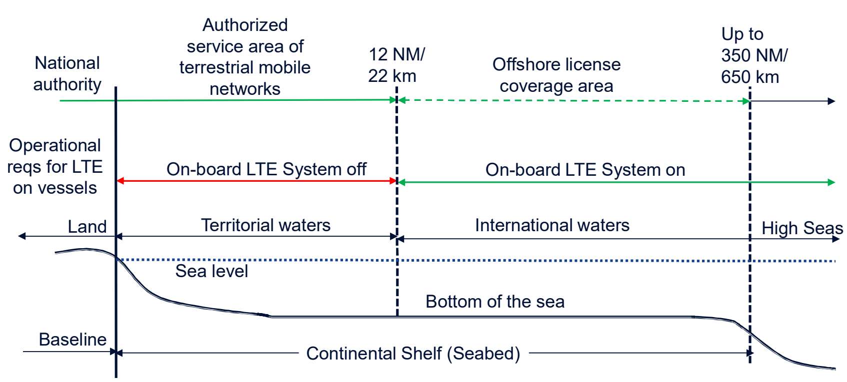

Fig 2. Authorizations and operational rules depend on distance from baseline.

In practise, there are specific cases, where the deployment and operation of networks beyond the territorial waters is to be authorized by the authorities. The countries have sovereign rights to utilize the water column and the continental shelf within their Exclusive Economic Zone (EEZ) extending up to 200 NM from the baseline. These rights include, e.g. fishing and utilization of wind and oil. Furthermore, beyond the EEZ the countries have the sovereign rights to utilize the continental shelf. Due to these rights, several countries are regulating the spectrum use of installations and devices related to petroleum activities or to utilization of renewable energy resources within their EEZ or ever further on the continental shelf, as illustrated in Fig 2. This is the case for example on the North Sea, where the surrounding states authorize mobile spectrum use within their "sectors", i.e. portions of the North Sea dedicated as their EEZs. Due to oil drilling at the North Sea, there is a need for wireless and mobile communications on oil platforms and vessels. Depending on which sector this takes place, the corresponding country can authorize spectrum use within the sector, ensuring that there is no harmful interference to the mobile networks using the same bands at shore or in the neighboring sectors. For example, the regulators of Norway, Germany, Denmark, and the Netherlands have agreed on the coordination measures, which include maximum field strength limits and coordinated use of preferential Physical Cell-layer Identifiers (for LTE, 5G) and Scrambling Codes (for 3G) [20].

4 Spectrum Management Approaches for Offshore Private Industrial Networks

Next, we analyze spectrum management approaches for offshore operations and particularly private industrial networks in different places. Selected regional and national offshore spectrum regulatory frameworks from the UK, Norway, Germany, the US, and Finland, together with the European regional offshore framework are introduced. Those countries have defined novel frameworks due to the required offshore use of frequencies. Moreover, Mexico, Brazil and several African countries are in the process of defining their offshore regulatory frameworks. The role of satellite in offshore radiocommunications is also addressed.

4.1 UK Offshore Licenses

Supporting the utilization of natural resources and the related activities within the British sector of the North Sea, the UK regulator Ofcom issues spectrum access offshore mobile licenses [21]. They are granted only to areas that are not covered by the rights of existing mobile network operators, i.e. areas outside of the 12 NM limit. Such licenses can cover the most common mobile bands of 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2.3 GHz, and 3.4 GHz. There is no restriction on the number of licenses, and none of the licenses will be technically coordinated by Ofcom. However, the licenses for the 2.3 GHz and 3.4 GHz bands need to be coordinated with the Ministry of Defense. There is an administrative fee of 5000 £ /every 5 years for the license. The offshore license authorizes use of spectrum on a non-protection/non-interference basis. The licensees need to coordinate between themselves to resolve any emerging interference problems. The emissions must meet at the UK coast the transmission levels defined by Ofcom, and in the borders of the UK EEZ the coordination agreements with the neighboring states when the systems are deployed.

4.2 Norwegian Offshore Licenses

In 2019, the Norwegian regulator Nkom announced that it makes available spectrum for offshore use in the 900 MHz and 700 MHz bands with updated regulation. The bandwidths were 2 x 5 MHz and 2 x 10 MHz. As the demand exceeded the supply, the spectrum was auctioned. There were 4 participants, and spectrum was awarded to three companies. The prices paid by each licensee ranged from 92 k€ to 120 k€. The auctioned spectrum can be traded or leased, which can be an opportunity for deployment on new offshore networks. 70 km was used as a coordination distance between the land-based networks and the offshore spectrum use, but the rules allow other arrangements if so agreed between the land based and offshore license holders. In late 2020, the Nkom offered further 2 x 5 MHz from both bands based on applications to be used at facilities in connection with petroleum activities on the continental shelf, on Norwegian ships, and at facilities for utilization of renewable energy resources at sea [22]. Coordination with neighboring countries is carried out by Nkom and based on international coordination values for field strength. The licenses will be valid until end of 2033. The annual license fee for 2020 is approximately 13500 € per 5 MHz duplex block. If the demand will exceed the supply, auctions will be arranged.

4.3 Local Licensing in Germany

The German regulator BNetzA issues licenses for local use of the 3.7-3.8 GHz band [23], and the same regulation applies to offshore areas within the German Exclusive Economic Zone EEZ. The frequencies 3.7-3.8 GHz are available for local broadband networks at sea and can be applied for via the standard application process. The deployment areas can be defined by the applicants and the regulator performs the compatibility calculations for protection of incumbents. The neighboring operators are requested to coordinate between the networks. For border coordination, the maximum allowed field strength at the border is 32 dBµV/m/5MHz at a height of 3m. In the Baltic Sea, the border is the dividing line between the exclusive economic zones of the countries. The bandwidth can be a multiple of 10 MHz. The license period is 10 years and there is an annual fee, depending on the used bandwidth, requested license duration and the deployment area. The eligibility to apply for frequencies in the 3.7-3.8 GHz range is connected to the ownership of a piece of land or any other right to use the land, therefore the Federal Maritime and Hydrographic Agency (BSH) may have to approve the use of the frequency at sea.

The 26 GHz band is also available for locally deployed, licensed broadband networks, both for mobile network operators (MNOs) and other entities including industry. The licensing conditions are rather similar to those of the 3.7 GHz band. Assuming that the band can be used also offshore, it can provide sufficient bandwidth for future industrial offshore applications.

4.4 US Offshore Regulation

The US regulator FCC authorizes spectrum use within the territory of the United States, usually not covering the sea. In general, the FCC rulings do not address offshore spectrum use and there are no mechanisms for offshore authorizations. However, the FCC regulates spectrum use within their side of the Gulf of Mexico (GoM): there are specific service areas covering the gulf area, reaching outside of the 12 NM from the baseline down to the southern edge of the continental shelf. This applies to spectrum bands for several services, for example to use of the AWS bands [24]. Usage for any application is allowed and not only for those related to the utilization of natural resources of the continental shelf. The 1.7/2.1 GHz AWS band can offer room only for 2 x 5 or 2 x 10 MHz bandwidths. Spectrum for private networks in the GoM area has to be acquired from the secondary market, and the cost may be high, as the licensee had to buy it from an auction. On the other hand, the access will be dedicated. In the US, the CBRS band, 3550-3700 MHz is available for private LTE and 5G networks, but it cannot be used airborne or at sea, due to the requirement for naval incumbent protection [5].

4.5 Mobile Network Coverage on the Gulf of Finland

Mutual agreements between coastal states can override the generic geographical limitations of frequency use and the mobile network coverage. The coverage of the Finnish 700 MHz band is allowed to reach near the Estonian coast, and the Estonian coverage is allowed to reach near the Finnish coast, spanning over the narrow international area between the two countries [25]. Similar agreements exist between Finland and Sweden over the Gulf of Bothnia, as well as between Finland and Russia in the eastern part of the Gulf of Finland for the use of the 700 MHz band. The coordination agreement facilitates a continuous mobile network connection on board boats and ferries traveling at sea between Finland and the neighboring countries. Such network coverage would be usable by SOVs, but for the actual private network, a separate and preferably a dedicated band would need to be made available. In Finland, 20 MHz from the 2.3 GHz band is available for local private deployments, and spectrum from all auctioned bands can be leased to 3rd parties. The license conditions for the 3.5 GHz band require that unused spectrum resources are made available for third parties, which could be owners of private networks. Spectrum from the 26 GHz band was auctioned recently for public mobile use, and the sub-band 24.25–25.1 GHz is reserved for local/private 5G networks. Availability of the band for offshore use will depend on the final regulation.

4.6 EU Regulation for Visiting Vessels

The mobile communication systems on board vessels (MCV) must usually be switched off within the territorial waters, i.e. closer than 12 NM from shore, to avoid causing harmful interference to land based networks as depicted in Fig.2. In Europe, the EU/CEPT regulation allows the visiting vessels to use certain 3G and 4G frequencies down to distance of 2 or 4 NM from the shore under specific technical and operational restrictions [26]-[28]. For LTE systems using the 1800 MHz or 2.6 GHz bands the rules are: between 0 and 4 NM (0-7.4 km) from the baseline the on board LTE system shall be off, between 4 and 12 NM (7.4-22 km) from the baseline the LTE system outdoor antennas shall be off and the maximum UE transmission power is limited to 0 dBm, and for distances between 12 and 41 NM (22-76 km) from the baseline the EU recommends that the UE transmit power would be restricted to a defined, distance-depending value [29]. There are also other technical and operational requirements that apply. This regulation provides an opportunity for SOVs to communicate in the area of offshore facilities and towards the shore down to a distance of 2 or 4 NM, from where there is a possibility to roam to land based public networks. MCV's operating under this regulation may cause interference to offshore operations within territorial waters if they use the same frequencies. Similar regulation is adopted also outside of Europe, e.g. by the UAE [30].

4.7 Role of Satellite

Fixed and mobile satellite services have also an important role in offshore communications. Backhaul connections for vessels and offshore platforms which are not within the coverage of terrestrial fixed links, mobile systems or underwater cables must be implemented through satellites. Several companies and international organizations such as Inmarsat, Intelsat and Eutelsat provide such services. Furthermore, there are mobile satellite systems (MSS) such as Globalstar and Echostar that offer the connectivity. The MSS systems can have a terrestrial network as a component of the overall system: a Complementary Ground Component (CGC) or Ancillary Terrestrial Component (ATC). The use of a MSS system, and especially the use of the associated ground component requires an individual authorization from the national regulatory authority. Both MSS systems have been authorized by a number of countries, Globalstar by the US, Canada [31], two other American countries and six African countries, Echostar satellite component by the EU [32] and its CGC by a few European countries. The MSS systems can provide connectivity over the whole country, not only over the land-based area, but also over the territorial sea and beyond. A private LTE network may be used as part of the CGC or ATC. The capacity of the MSS systems is limited as the available bandwidth is typically not more than 10 MHz. The pricing is determined by the MSS provider.

5 Discussion on Spectrum Options

The regulation for offshore spectrum use is highly fragmented between countries as analyzed in Chapter 4. The consideration of spectrum options for the specific vertical use cases is of utmost importance in making the wide-spread use of mobile communication technology a reality for vertical usage. The 4G and 5G networks are typically authorized and deployed to provide coverage over the land areas, but in some countries the authorizations can extend over the territorial waters or even further. In areas where significant natural resources, such as oil are exploited, some regulators have defined mechanisms to make spectrum available for offshore use.

The level of regulatory radio environment coordination varies between no coordination, and coordination towards the incumbents. Typically resolving harmful interference between the offshore licensees is left to the licensees; that is the case in the UK and Germany. In the UK, the license is issued on non-protection/non-interference basis. In the previous examples the available bands are all harmonized 3GPP bands. The available bandwidth can be wide, several tens of MHz's, in the UK and Germany, while the Norwegian 700 MHz and 900 MHz bands offer bandwidths that can only support voice and basic data. The same applies to the US, where the cellular bands can be utilized through a secondary market. For example, the AWS band, 3GPP band 4, available in the Gulf of Mexico can offer only limited bandwidths, i.e. 2 x 5 MHz, or 2 x 10 MHz. In Finland, the band 40 can allow access to the full 20 MHz sub-band, but even this will not allow for several parallel wideband services. In the future, the release of the 26 GHz band can provide wide bandwidths, as the total amount of spectrum in the band is 850 MHz. The EU regulation for MCV is based on usage of voice-oriented services and simple data, which can be supported by the designated bands. The analyzed available carrier frequencies and bandwidths and related interference coordination mechanisms vary a great deal between countries, making it a highly case-specific decision to for connectivity in offshore operations.

None of the presented local licensing examples can offer guaranteed spectrum availability, although in Norway, Germany, US, and Finland the bands are dedicated to the licensees and in Germany available only in a defined, authorized local area. In Europe, the visiting ships can use any regionally allocated mobile band in the international waters but within the territorial waters only specific bands defined under the EU/CEPT regulation. The sharing conditions for offshore use are defined by the regulator, and thus known beforehand.

Mobility within and around the offshore network deployment is not restricted in the example cases, though a possible field strength limit at the edge of the coverage area must be considered. This can have a significant impact on the possible transmit power, especially if the transmitter is several meters above the sea level, e.g. on oil platform. The UL/DL ratio can be changed in the TDD bands, which are available in the UK, Finland, and Germany. In case there are networks operating in the same band in adjacent locations, synchronization between TDD networks could be beneficial as the regulation allows in some cases, like within the North Sea, higher maximum field strengths at the borderline if the networks are synchronized. The decision on actual synchronization is left to the licensees.

A wide range of authorization methods is used: the UK has no restriction on the number of authorizations (all-come-all-served), Norway has used auctions in case the demand exceeds the supply, Germany uses administrative authorization, in the US and Finland the access is based on secondary markets. The authorization duration is relatively long in all cases. The duration in the US and Finland depends on the duration of the license of the lessor. The EU regulation is valid on a permanent basis, like the UK Offshore licenses. The pricing is based on a fee in the UK, Germany, and Norway. But in case of high demand Norway uses an auction for awarding the licenses. The pricing for spectrum leasing depends on negotiations with the licensee, that is the case with examples from the US and Finland.

Satellite connections can have a significant role in providing the backhaul connection between the offshore network and the shore. In addition, 4G or 5G based ground component network of an MSS system could act as an offshore private network. The band for the ground component would be a 3GPP band, spectrum assignment would be dedicated, and its availability guaranteed, but the bandwidth in the MSS bands would be limited.

6 Conclusions

The use of 5G to serve vertical sectors' specific needs has gained increasing attention while the actual deployment of private industrial networks involves a number of spectrum regulatory challenges. These challenges further depend on the vertical sector in question. Regarding offshore private networks, globally only a few countries have so far introduced offshore regulatory frameworks. Mainly countries, where offshore oil drilling takes place, have defined their regulatory frameworks and the related authorization mechanisms. Additional demand for such regulation is emerging when offshore wind farms are being deployed worldwide in new countries. One challenge for the regulators is the fact that traditionally the mobile communications has been very much oriented towards public mobile networks and their service areas have been land oriented. This challenge appears more widely in the use of mobile communication technology for vertical specific service delivery and needs to be thoroughly addressed. In the specific case on for offshore deployments, the basis for the jurisdiction is very different, and also the radio environment at sea differs significantly from that on land which calls for new authorization mechanisms, coordination approaches and different technical requirements. Many of the spectrum preferences for offshore use are still partly or fully similar to the requirements of locally deployed terrestrial industrial networks, e.g. requirement for harmonized bands, guaranteed spectrum availability, protection from harmful interference, wide bandwidths, application based assignment, fee based costs, etc. Therefore, it would be very beneficial, if the ITU-R or the regional organizations such as the CEPT in Europe could define a common basis for offshore spectrum requirements, taking into account the specific radio environment and if the regional organizations would provide guidance on suitable authorization mechanisms and frameworks in support of individual regulators facilitating offshore radio communication. The common basis and guidance should take into account the ongoing regulatory trend to reserve spectrum for land based industrial local use. Expanding local licensing and spectrum sharing to sea could be a viable basis, especially when realizing the specific nature of offshore operations – the physical locations of these connectivity solutions are often away from other spectrum usage, which makes interference coordination more viable.

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