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Horns Rev 3 Offshore Wind Farm

AIR TRAFFIC

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SUMMARY

Horns Rev 3 will be the third and most recent of the Horns Rev offshore wind farms, positioned off the coast of Jutland in western Denmark. Its proximity to the shore means there are a range of potential impacts upon aviation receptors, all of which are considered in full in this report. For the purposes of this assessment, Air Traffic covers multiple receptors and includes aeronautical search and rescue activities, civilian and military airfields, controlled airspace, military training and exercise areas, meteorological, civilian and military radar systems (related to aviation), and offshore helicopter activities.

The report details the methodology followed for the impact assessment based on current national and international best practice, before setting out the existing Air Traffic baseline for each of the receptors considered. Where no mechanism for adverse impact exists, the receptor in question is scoped out of the assessment. Where possible adverse impacts are identified, these are carried through to the impact assessment stage for more detailed consideration. The study found that potential for adverse impacts exist in relation to civilian aeronautical radar systems, military training and exercise areas, and aeronautical search and rescue activities. These receptors are considered in detail and a range of potential mitigation measures are provided.

SAMMENFATNING

Horns Rev 3 vil være den tredje og nyeste af de havmølleparker, der etableres på Horns Rev ud for den Jyske vestkyst. Nærheden til land betyder, at der kan være en række mulige effekter på luftfartsrelaterede emner, som alle behandles I nærværende rapport. I forbindelse med denne vurdering dækker emnerne relateret til luftfart eftersøgnings- og rednings aktiviteter, civile og militære lufthavne, kontrolleret luftrum, militære trænings- og øvelsesområder, meteorologiske-, civile- og militære radarsystemer relateret til luftfart og offshore helikopter aktiviteter.

Metodikken, der er benyttet til vurderingen af effekter, baseres på de bedste nationale og internationale erfaringer på baggrund af basistilstanden for hver enkelt af de vurderede receptorer. Hvor der ikke har kunnet identificeres nogen påvirkninger er emnet udeladt af vurderingen. Hvor der til gengæld er identificeret en effekt er denne vurderet mere indgående.

Det er konkluderet, at der kan forekomme påvirkninger af civile luftovervågningsradarer, militære trænings- og øvelsesområder samt eftersøgnings- og redningsaktiviteter. Disse receptorer er beskrevet i detaljer og en række afværgeforanstaltninger er foreslået i rapporten.

1. INTRODUCTION

This technical report is input to the Environmental Impact Assessment of the Horns Rev 3 and describes the existing environment in relation to Air Traffic, and assesses the potential impacts of the proposed Horns Rev 3 offshore wind farm during the construction, operation and decommissioning phases of the project. Where the potential for significant impacts upon Air Traffic receptors are identified, mitigation measures and residual impacts are presented.

The term 'Air Traffic' covers the spectrum of aeronautical receptors that may be impacted by the construction, operation and decommissioning of Horns Rev 3. Within this report, the term Air Traffic covers possible impacts upon the aeronautical interests and activities of the Danish Transport Authority (DTA) (Trafikstyrelsen - the state regulator for civil aviation in Denmark), Naviair (state-owned and run Air Traffic Control (ATC) service provider), offshore helicopter operators, Search and Rescue (SAR-Eftersøgnings- og redningstjenesten) helicopter operators and airfields (for the purposes of this assessment, the term 'airfields' covers all sites used for aircraft take-off and landing operations and therefore includes grass airstrips and private airfields, regional airports, international airports and military airfields). The chapter also covers military activities such as training and exercises areas, both on land, at sea, and comprising of airspace, in the area surrounding Horns Rev 3 and regardless of whether operated by the Danish Air Force, Navy or Army or by a foreign power. The chapter considers the potential effects on a range of radar users including civil and military air traffic control radar as well as meteorological radar.

2. GUIDANCE AND CONSULTATION

2.1. Policy and relevant guidance

The Air Traffic assessment has been undertaken with specific reference to relevant national and/or international planning documents. Where relevant, and in the absence of specific documentation produced by Danish authorities, information and guidance from other countries has been referenced as it was deemed to be beneficial for inclusion in this assessment. The documents that are relevant to Horns Rev 3 are:

- European Guidance Material on Managing Building Restricted Areas, 2nd edition, 2009. International Civil Aviation Organisation (ICAO, 2009);
- United Kingdom Civil Aviation Authority (CAA), 2013. CAP764 – CAA Policy and Guidelines on Wind Turbines (CAA, 2013).
- Regulations on air traffic marking of wind turbines (Trafikstyrelsen, 2013).
- Air traffic marking of wind turbines (Trafikstyrelsen, 2012)

2.2. Consultation

Pre-application consultation provides valuable input into the production of the actual report. Through allowing the developer to engage with stakeholders at an early stage, particular concerns that the stakeholder has can be addressed at an early stage. In addition, the sensitive nature of military activities may mean that information relating to activities undertaken may only be available through the consultation process. To date, consultation undertaken has involved the following stakeholders:

- SOK's (Naval Operative Command - Søværnets Operative Kommando)) MAS (Maritime Assistance Service); and
- SOK's Material and Logistics department for Coastal Radar (Materiel- og Logistikafdeling)
- FTK (The Danish Air Force-Flyvertaktisk Kommando).

The outputs of consultation undertaken to date have been fed into the impact assessment.

3. HORNS REV 3

Horns Rev 3 is a proposed 400 MW (Megawatt) offshore wind farm that will be developed 20-30 km north-west of Blåvands Huk – the most westerly point in Denmark – north-west of the town of Esbjerg. The site is named after the shallow reef – Horns Rev (reef in English) – that is located immediately to the south. It will be the third offshore wind farm in the vicinity of Horns Rev, and will cover an area of approximately 80 km^2.

The layout of the wind farm has not yet been finalised which will be decided by the future licensee by the end of the tender process for Horns Rev 3. However, a number of scenarios have been proposed in the assessment. Which design is ultimately used will be determined by the size of turbines, costs and logistical considerations associated with export and inter-array cables, and the turbine foundations. Indicative layouts utilising 3, 8 and 10 MW turbines have been developed. Horns Rev 3 will produce approximately 400 MW of electricity with the total number of turbines being between 50 and 133, depending on the size (and thus power output) of the units installed, and whether a combination of unit sizes are selected. It is anticipated that the wind farm will become operational by 2020 following a construction start date of app. 2016/2017. The largest turbines that may be used are 10MW turbines with a tip height of around 220m above mean sea level (AMSL). In addition to the turbines, a transformer platform – known as Horns Rev C - will be constructed and sited within the centre of the project area, Figure 4.1. The platform will be constructed with a heli-platform. To ensure safe approach for helicopters to the platform wind turbines shall not be placed within 1,000 m in an angle of 210 degrees from the platform. .

4. METHODOLOGY

4.1. Study area

The study area for the assessment of Air Traffic interests for Horns Rev 3 covers a geographic extent commensurate with the scale and nature of the anticipated receptors, as shown in Figure 4.1, and discussed below. Doing so ensures that any potential constraints which may be present and related to activities undertaken by the range of potential receptors as set out in section 1 are taken into consideration.

The study area therefore takes into account shore-based aeronautical installations, including Esbjerg International Airport, small private and recreational airfields, radar sites, military practice and exercise areas, helicopter routes (between the mainland and offshore platforms) and oil and gas platforms themselves (where associated with offshore helicopter operations).

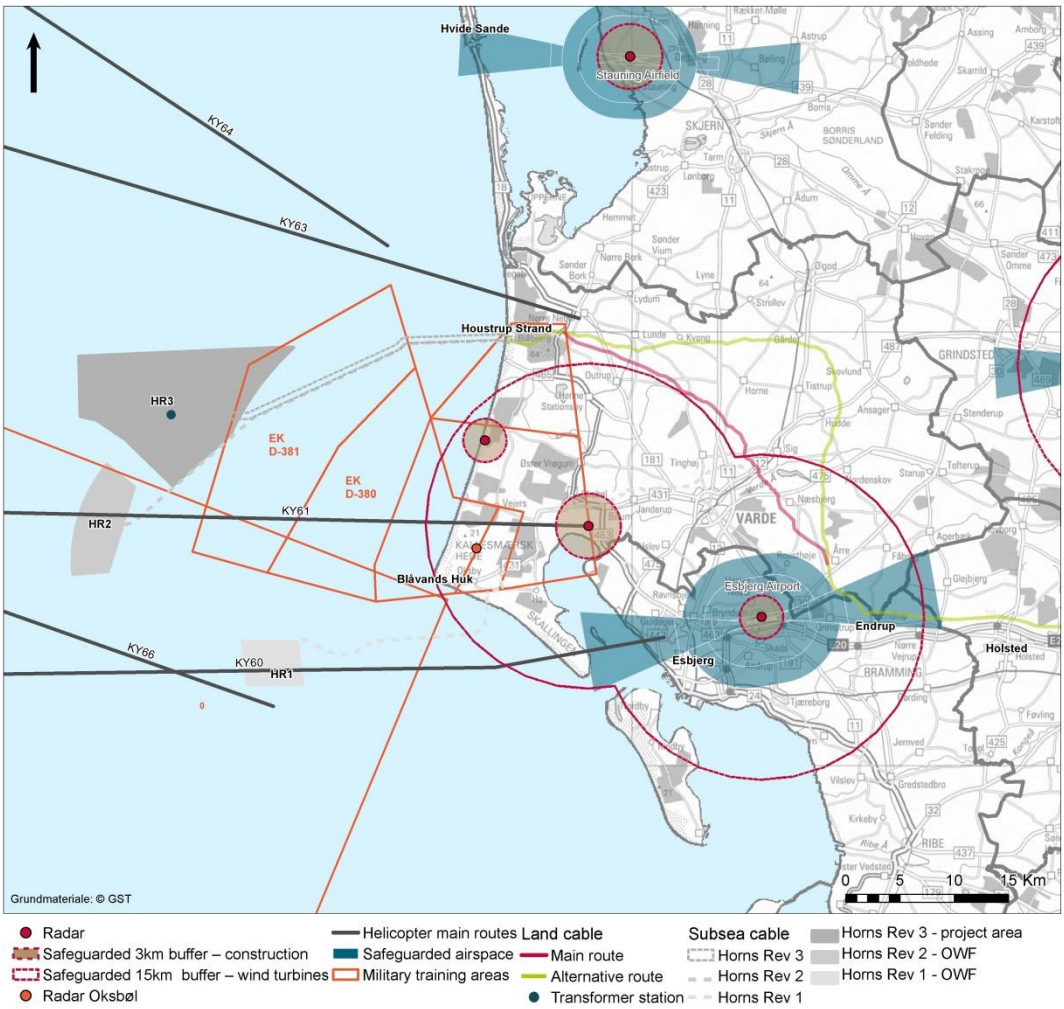

Figure 4.1.Overview of air traffic interests at Horns Rev 3.

4.2. Characterisation of the existing environment

A desk-based study of available data has been undertaken to gain a clear understanding of the spectrum of aeronautical activities in the defined study area; i.e. the area within which aeronautical receptors could be affected by the construction, operation and de-commissioning of Horns Rev 3. The following sources of information have been consulted:

- The Danish Aeronautical Information Publication (AIP) (as published by the DTA) which details amongst other things Helicopter Main Routes, arrival and departure procedures for major airfields and the location and nature of activities undertaken within prescribed military practice and exercise areas;
- The Danish Military AIP which details aeronautical procedures and operations related to military activity, as published by the Royal Danish Air Force (RDAF);
- Aeronautical charts covering the study area; and
- Other publically available information (internet based) detailing Danish SAR capabilities, airport activity, locations of radar sites, etc.

Figure 4.1 provides an overview of all relevant Air Traffic interests in the vicinity of Horns Rev 3.

4.3. Assessment of impacts – methodology

How far an offshore wind farm development is from airfields, the flight paths flown by arriving and departing aircraft, shore-based communication, navigation and surveillance (CNS) infrastructure, helicopter main routes and military training and exercise areas is vitally important in determining whether the wind farm will impact these activities, and the nature and extent of these impacts. Horns Rev 3 will be located close to the shore; being minimum 20 km from the mainland, meaning it can be reasonably assumed that impacts upon aeronautical receptors will arise.

Utilising a wide range of resources including stakeholder consultation, consideration has been given to the location of Horns Rev in relation to the full scope of aviation constraints detailed in Section 1. Each receptor has been considered individually as set out in the following paragraphs with an assessment of whether or not adverse impacts can be anticipated, the extent of these impacts and whether or not the receptor is being carried forward to the impact assessment.

In order to assess impacts upon aeronautical receptors, this chapter follows a descriptive approach as opposed to a matrix-based magnitude and sensitivity approach sometimes used. The reason for this is that the magnitude and sensitivity approach to impact assessment can lead to ambiguity in relation to the types of impacts typically encountered in the assessment of Air Traffic receptors. In addition, making a determination of the level of impact upon these receptors is subject to a high level of subjectivity.

Should a development have the potential to adversely impact Air Traffic receptors, it is invariably because there are implications upon flight safety. This may be because the

wind farm creates a physical obstruction and a collision risk, or because the performance of a radar system is degraded, for example. Regardless of the perceived magnitude of the effect, or the assessment of sensitivity of the receptor, there is risk to flight safety and this will have to be addressed before permit for commissioning can be given.

The impact assessment for this chapter therefore adopts a descriptive approach, based upon related existing guidance, the results of consultation undertaken and expert opinion of the likely impacts upon each receptor considered. Discussion in relation to each impact ensures that the reader is able to clearly understand how that impact arises, the nature and extent of this impact, and the possible mitigation measures that can be adopted.

Utilising numerous resources, this chapter therefore considers the development of Horns Rev 3 offshore wind farm in relation to Air Traffic receptors.

5. REVIEW OF AVIATION AND RELATED ACTIVITIES RELEVANT TO HORNS REV 3

5.1. Commercial and other civil aviation activity

5.1.1 Airspace

Airspace is classified depending upon the way that the airspace is used. Airspace around major airports is under Air Traffic Control (ATC) meaning all flights are under the supervision of control of Air Traffic Controllers; airspace used heavily by the military is often restricted meaning civilian aircraft may not be permitted to fly through it; other airspace may be uncontrolled and is open and accessible to all.

The airspace above and adjacent to Horns Rev 3 is utilised by both military and civil aircraft. The airspace is uncontrolled (i.e. it is not under the radar control of an aeronautical station) and is said to be in the 'Copenhagen FIR' (Flight Information Region). It is known as 'class G' airspace, meaning the airspace is essentially open for anyone who wishes to use it and without requiring an air traffic control (ATC) clearance. This is the case up to and above flight level 195 (FL195) which equates roughly to 19,500ft, above which the airspace is classified as 'class C' and can only be flown through with ATC clearance. With a large volume of uncontrolled airspace, the presence of Horns Rev 3 is not expected to result in any adverse impacts on airspace. European and intercontinental commercial flights operating within this controlled airspace and above FL195 may be following one of a number of airways or routings and will be under the control of Danish air traffic controllers. Nearby controlled airspace, though not overhead Horns Rev 3, bounds the airspace surrounding Billund and Esbjerg airports.

It can reasonably be expected that the airspace above the wind farm will be used by a variety of civilian aircraft. These will comprise of commercial flights flying into and out of larger airports such as Esbjerg (see section 5.1.2 below) and Billund, light aircraft undertaking recreational flights, commercial helicopter traffic operating between the mainland and offshore platforms (see section 5.1.3 below) and military aircraft. Where such aircraft are present, good airmanship, combined with procedures as set out for commercial aircraft and air traffic controllers, dictates that they will not be flying at an altitude at which the presence of an offshore wind farm could have any impacts upon controlled airspace.

A patchwork of 'danger, restricted or prohibited' areas (for ease these will collectively be termed 'danger areas' in this chapter) are situated in the vicinity of Horns Rev 3. Overlying part of the Horns Rev 3 site is a danger area designated EK D 381 which extends from sea level to a height of 16,500ft. Discussion of this and other danger areas of relevance is undertaken in full in section 5.3.3 below.

5.1.2 Airfields

Being relatively close to shore, the potential exists for Horns Rev 3 to have an adverse impact upon flight safety for aircraft operating from airfields in the vicinity. The largest airport nearby is Esbjerg, which at its closest is approximately 50 km from Horns Rev 3. Esbjerg airport is a regional airport situated north-east of the town of Esbjerg that is used primarily by helicopters servicing offshore oil and gas platforms. Commercial (airline)

services link the airport with Stavanger in Norway and Aberdeen in Scotland. The runway is aligned approximately east-west with prevailing winds meaning the majority of arrivals are from the east (i.e. over land) and the majority of departures westbound towards the North Sea. Analysis of the official aerodrome charts, as produced by the Danish aviation authorities, reveal that neither inbound nor outbound aircraft, operating on either runway, are expected to be impacted by the presence of Horns Rev 3. The wind farm is a sufficient distance from both the airfield itself, and the published approach and departure flights paths, that aircraft will not come into conflict with the development; i.e. they will be sufficiently high either while inbound or outbound that the presence of the wind farm will be of no consequence.

Billund Airport - the most important airport in Jutland – is situated more than 80 km from the project area for Horns Rev 3. This place Horns Rev 3 well outside (34 km) the airspace comprising the initial minimum approach clearance altitude 2,100 ft (600 m) for IFR operations above all objects located within the sector (Trafikstyrelsen, 2011) and for VFR as stated in Visual Flight Rules (Trafikstyrelsen, 2010).

A number of small airfields are situated along the coastal fringe of this part of Denmark. The closest is the airfield at Varde which is approximately 40 km to the south-east. With a combination of grass and paved runways, these airfields are used for recreational flying, gliding and parachuting. Light aircraft flying from these private airfields operate primarily under so-called 'Visual Flight Rules (VFR)' which means flights can only be conducted when weather conditions (cloud base and visibility) are greater than a prescribed minimum. In other words, unlike airliners which can operate in almost all weather conditions, day and night and largely irrespective of cloud base and visibility, light aircraft are typically flown visually with pilots responsible for maintaining visual contact with the ground and any obstructions such as radio masts or wind turbines. Good airmanship dictates that a pilot would not attempt a flight in poor visibility and at a height that would present a collision risk with obstacles such as wind turbines. As the proposed development does not present a collision risk to aircraft landing or taking off at these airfields, there should be no impacts upon these receptors.

Commercial airports and private airfields are therefore scoped out of the impact assessment and are not considered further.

5.1.3 Offshore helicopter operations

There are a large number of helicopters services to offshore oil and gas platforms throughout the eastern North Sea from the Danish mainland, transporting crew and equipment. Such flights are typically conducted along helicopter main routes (HMR) which serve to organise inbound and outbound helicopter traffic to ensure that aircraft flying between fixed points (i.e. an airfield and an oil platform) do not come into conflict with one another. A HMR is a single line rather than a corridor denoting an approved flight path. The British Civil Aviation Authority detail in their guidance, that a corridor 2 nm wide should be maintained on both sides of the HMR for safety purposes. In Denmark no HMR exist for helicopter traffic to offshore wind farms. All helicopter traffic servicing offshore wind farms operates under VFR (visual flight regulations). A large wind farm devel-

opment beneath an HMR may lead to difficulties by forcing a helicopter to fly higher (and thus risk entering cloud) to avoid compromising the minimum vertical separation height above the turbines. This is of particular significance where the 0° isotherm (i.e. the level at which the air temperature reaches freezing) is at 2,000 ft or below and a low cloud base is present, due to the risks associated with ice build-up on helicopter rotor blades.

A desk study of the existing HMRs in the vicinity of the proposed Horns Rev 3 development location was undertaken which revealed that there are no HMRs overlying the project site. Four routes exist in the local area to enable the safe and coordinated flow of helicopters into and out of Esbjerg Airport. Routes A and B extend west into the North Sea to an aeronautical reporting point called 'Pegam' which is situated south of Horns Rev 1. Routes C and D are short routes, that extends just a few miles from the airport and do not cross the North Sea coast.

HMR KY63 is located north of Horns Rev 3 by a distance of approximately 10 km at its closest. To the south of Horns Rev 3 is HMR KY61 which is approximately 3 km away from the development at its closest. Neither of the two closest HMRs overlie the development and it is therefore not expected that Horns Rev 3 will have any impact on existing offshore helicopter operations.

Offshore wind farms have the potential to impact helicopter operations to oil and gas platforms, if the wind farm is within typically 9 nautical miles (nm). This is due to procedures which must be used by helicopters when the weather conditions dictate flight in Instrument Meteorological Conditions (IMC). Such procedures dictate the way in which arrivals and departures to and from offshore platforms are undertaken, allowing the pilot to manoeuvre the helicopter at night and/or in poor visibility without compromising safety. IMC is present when the cloud base and/or visibility are below a set minimum, meaning that a helicopter flying in these conditions will be flying with reference to its instruments, rather than visually and with reference to the ground and/or the horizon. An approach to an offshore platform under IMC is perfectly safe; however the area surrounding the platform must be largely free of obstacles out to a certain range, to ensure that a helicopter on approach does not collide with a structure. However, there are no offshore platforms in the vicinity of Horns Rev 3 (the closest being over 100 km west), meaning this development will not have any adverse impacts upon offshore helicopter operations to existing oil and gas platforms.

Given the proximity of the development to the mainland, it is anticipated that helicopters will play only a minimal role in the construction, operation or decommissioning of Horns Rev 3 As is common for offshore wind farms such as this one, it is anticipated that the vast majority of transfers concerning turbines will be made by boat. Concerning construction and decommissioning work and during maintenance of the transformer platform and facilities the primary mode of transport will be helicopters. Based on experiences from maintenance work on the Horns Rev 1 "Alpha" and the Horns Rev 2 "Bravo" transformer platforms a total of 20 helicopter return trips are anticipated to service the Horns Rev 3 transformer platform (Klein, 2013). Any helicopter movements that are required will be rare and will be strictly governed by the regulations as set out by the Danish aviation au-

thorities, ensuring safe operations in all weathers. The offshore helicopter services that are required will be new services, specific to Horns Rev 3 and additional to the existing services being undertaken across this part of the North Sea. Horns Rev 3 is not expected to have any adverse impacts on existing helicopter operations; consequently they are scoped out of the impact assessment and not discussed further.

5.1.4 Lighting and marking

Horns Rev 3 will be marked on the appropriate aeronautical charts as required by the Danish Transport Authority, (Trafikstyrelsen, 2012; Trafikstyrelsen, 2013). It will also be lit in a way that meets the requirements of both aviation (civilian and military) and marine stakeholders. Lighting will be required to make the development visible to both aircrew and mariners. It is likely that two separate systems will be required to meet aviation standards and marine safety hazard marking requirements.

Danish regulation and guidance specifies that wind turbines in excess of 150 m high, and not in the vicinity of an airfield, shall be marked with two aviation warning lightings on the top of the nacelle. However, specific lighting requirements and obstacle marking of the wind farm will be the focus of on-going consultation with appropriate stakeholders as the design phase of Horns Rev 3 progresses.

Obstacle markings of wind farms with turbine heights between 150 m and 220 m can be made by lighting the top of the nacelle according to regulations for one turbine, (Trafikstyrelsen, 2013). However, only turbines marking the periphery (corners or bends) of the wind farm need to be equipped with aviation warning lighting. The distance between these obstruction lights must not exceed 900 m. Single turbines outside the periphery of the wind farm shall be marked according to regulations for one turbine.

The lighting of offshore turbines can in itself be an environmental impact, potentially affecting landscape receptors and ornithology for example.

5.2. Communication, Navigation and Surveillance infrastructure

5.2.1 Effect of wind farms on radar

A radar operates by transmitting a stream of high powered radio pulses and then ‘listening’ for signals which will be reflected off an object (i.e. an aircraft) that is within range. The return signal is interpreted by the radar to (depending on the type of radar) provide information such as target range, height, bearing and direction of travel. Two main types of radar are in use. Primary Surveillance Radar (PSR) is able to determine both the azimuth and range of an aircraft from the radar receiving unit, but it cannot interpret the height of the target/aircraft. Both military and civilian PSR covers the Horns Rev 3 area, as shown in Figure 5.1. A more comprehensive picture is provided by Secondary Surveillance Radar (SSR) which interrogates a piece of equipment on-board the aircraft known as the transponder. The transponder responds to the radar signal with information including the aircraft’s height, therefore providing air traffic controllers with a three-dimensional picture of aircraft velocity and height.

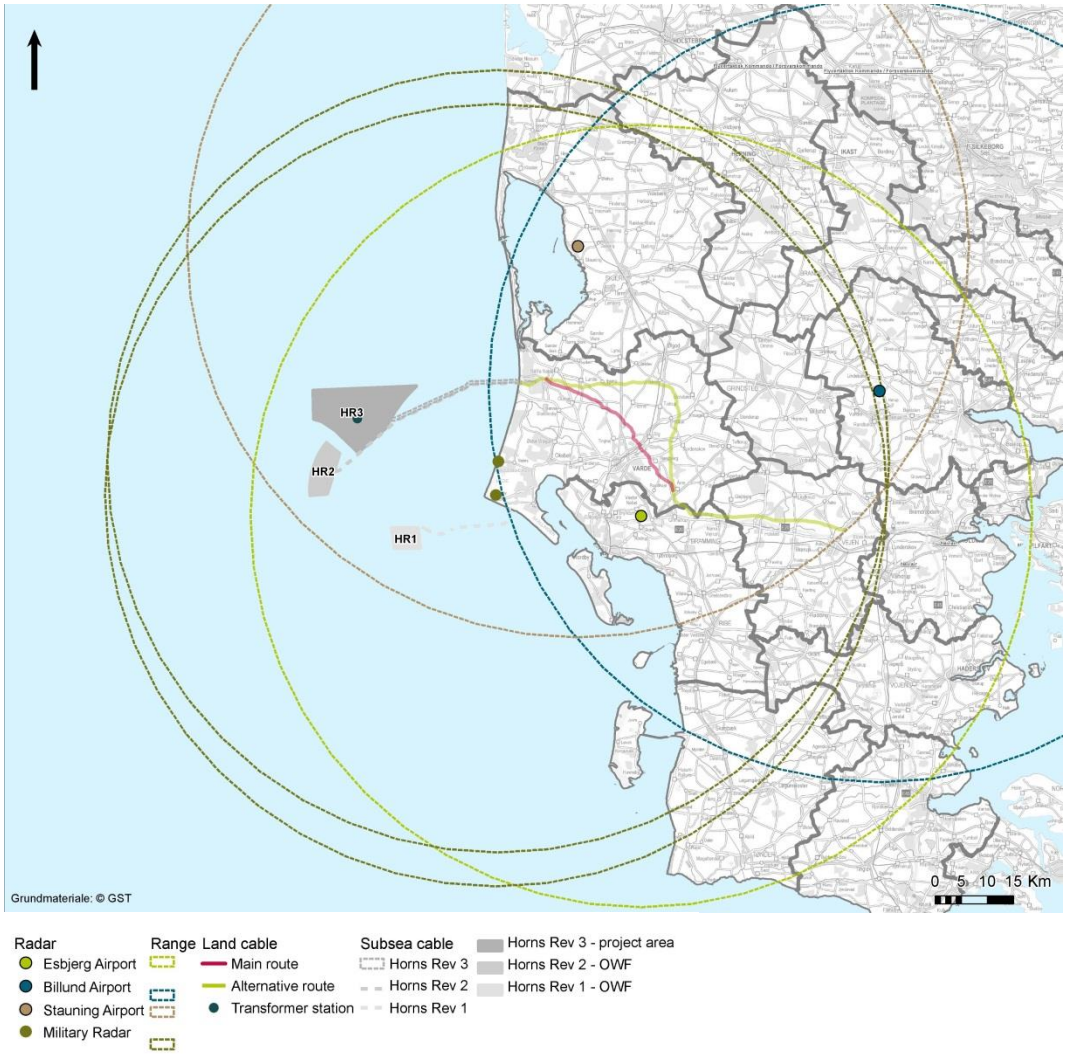

Figure 5.1.Air traffic surveillance radars covering Horns Rev 3 Offshore Wind Farm within a 75 km radius.

5.2.1.1. Effect of turbines upon Primary Surveillance Radar (PSR)

The nature of wind turbines and wind farms (multiple tall objects with large rotating blades), can cause significant problems for radar systems. A wind farm development can generate false returns (often known as 'clutter) on an ATC screen as the rotating blades of the turbine trigger what is known as the 'Doppler Threshold' of the radar, (Beeden, et al., 2013). Essentially this means that the radar receiver is 'tricked' into thinking that it is receiving signals from an airborne and moving target; i.e. an aircraft. As modern (and future) wind turbines become taller, with longer blades, they will generate ever-larger radar cross-sections resulting in greater impacts on radar systems. The false returns generated by the turbines may generate a blind spot on the radar, masking the area behind the turbine along with any 'genuine' aircraft that may be there. Should this occur it would typically be regarded as presenting an unacceptable hazard to flight safety as it compromises the ability of an Air Traffic Service Unit (ATSU) to manage flights for which they have responsibility.

5.2.1.2. Effect of turbines on Secondary Surveillance Radar (SSR)

SSR interrogates the aircraft's on-board transponder; the information received providing the controller with the aircraft's height, in addition to the information received from the primary radar return indicating target bearing and range. If a wind turbine is sufficiently close to an SSR and within its line of sight, reflections from the turbine can generate false signals. Furthermore, the presence of obstructions within the line of sight of the radar may result in a shadowing effect in the lee of the obstruction, thus potentially masking the presence of aircraft within that area from the SSR.

The British aviation regulator, the Civil Aviation Authority (CAA), in CAP764 'CAA Policy and Guidelines on Wind Turbines', advise that a distance of 13 nm (24 km) between the wind turbine(s) and a radar receiver is the 'trigger' distance within which discussion with the radar operator in question should be undertaken. No such regulation exists in Denmark. Whilst most impacts could be expected to occur within this range, the CAA make it clear that impacts can still occur beyond this distance. In the absence of specific figures by the Danish authorities, the CAA figures provide useful indicative guidance.

A range of site/project-specific mitigation measures can be employed where a proposed wind farm development is likely to adversely impact radar and the provision of air traffic services.

5.3. Military Activities

5.3.1 Aeronautical Search and Rescue (SAR)

Aeronautical SAR activities within Denmark and its associated waters are coordinated by the Danish Joint Rescue Coordination Centre (JRCC-SOK) in Aarhus. At all times, three helicopters are on standby, operating from different locations to facilitate the comprehensive coverage of the land and sea areas they have responsibility for. In addition to the dedicated fleet of SAR assets, all Government aircraft can be called upon to assist in SAR operations as required. Responsibility for the southern SAR area falls to the Skrydstrup-based unit, approximately 56 km south-east of Esbjerg.

The area for which Denmark has SAR responsibility is known as the Danish Search and Rescue Region (SRR) and covers all vessels, aircraft and persons within this area. The Danish SRR approximately follows national boundaries to the north, east and south (owing to proximity of other nations). To the west however the Danish SRR extends well into the North Sea and into the Scottish Flight Information Region (FIR) following the position of the median line to ensure that incidents are dealt with initially by the closest country, Figure 5.2.

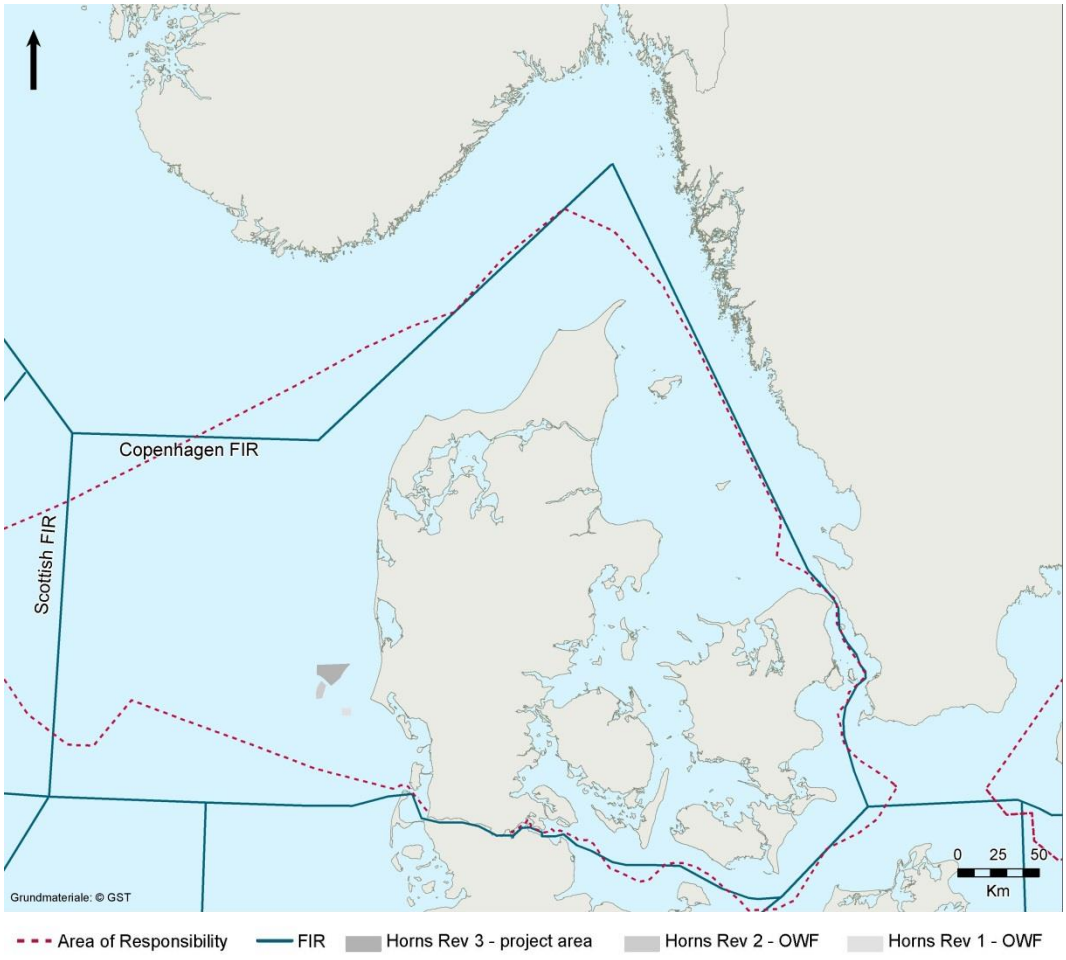

Figure 5.2. The area for which Denmark is responsible for coordination of rescue operations - Search and Rescue Responsibility (SRR) and the Danish Flight Information Region (FIR), After (Flyvertaktisk Kommando, 2010).

Search and Rescue helicopter activities are featured in the baseline assessment because of the ways in which an offshore wind farm could adversely impact airborne SAR operations; i.e. by presenting a collision risk. Particularly in poor weather conditions (when SAR is often required), the presence of a large number of obstacles relatively close to the shore (where vessel traffic will be heaviest) presents a number of challenges for undertaking SAR activities. Trials undertaken in the UK demonstrated the SAR helicopters can operate safely within the confines of an offshore wind farm, whilst recognising a number of effects posed by the turbines, including impacts upon on-board radars and how to affect rescues in poor visibility (Brown, 2005). The scale of offshore wind development around the coast of Denmark means the challenges posed by operating in this environment will however be familiar to SAR agencies.

5.3.2 Low flying

Low flying training by the military is permitted in Denmark, both above land and over its territorial waters. Liaison with the appropriate authorities to ensure that the development

is marked on the necessary aeronautical charts will help safeguard low flying military aircraft; essentially highlighting an area which should be avoided.

Denmark's proximity to the North Sea means that large areas of sea are available for low-level flying training. Such training could reasonably be expected to take place away from near-shore areas to minimise disturbance to coastal communities and recreational vessels. Furthermore, with a near-shore environment with extensive existing offshore wind development, it is not an area which lends itself to this type of flying training. It is therefore anticipated that Horns Rev 3 will have no adverse impacts upon existing military low flying areas. This has been confirmed by FTK in the consultation. FTK has no concerns regarding conflicts between military operations and wind farms marked according to regulations. This receptor is subsequently scoped out of the assessment and is not considered further.

5.3.3 Training and exercise areas

Danger areas are abundant in the area around Horns Rev 3. Horns Rev 3 partially underlies Danger Area 381 (D381) which is used for the firing of live (ground launched) ammunitions. The Danger Area, known as Kallesmærsk Øst, forms a 'block' of airspace that starts at sea level and extends up to approximately 16,500 ft AMSL. Overlying a section of the export cable route and the onshore works is Danger Area EKR35, also known as Henne, which extends from ground level to FL (Flight Level) 125; approximately 12,500ft.

The beach at Vejers, west of Oksbøl and south of the export cable landfall, supports military exercises and is used as a practice landing area for RDAF Hercules transport aircraft.

The nature of activities undertaken within these aeronautical danger areas when considered in the context of the Horns Rev 3 development means that adverse effects to military aviation are not expected.

5.3.4 Military airfields

Like major civil airfields, military installations will be 'safeguarded' from nearby developments that may have an adverse impact upon their operations. There are no military airfields in proximity to Horns Rev 3. The closest is at Skrydstrup, home to Fighter Wing Skrydstrup of the Royal Danish Air Force and located in excess of 100 km from Horns Rev 3. All wind farm developments, and Horns Rev 3 is no exception, will be marked on the appropriate aeronautical charts and registries to ensure military aircrew are aware of its presence. Given the distance between Horns Rev 3 and the nearest military airfield, there is no mechanism through which impacts could arise for this receptor. Military airfields are therefore not considered further within the assessment.

6. SOURCES OF IMPACTS

A review of the aviation receptors as undertaken in section five of this report reveals that the potential exists for adverse impacts to arise from the development of Horns Rev 3 Offshore Wind Farm. The receptors which may be impacted by the development are:

- Primary Surveillance Radar systems (civilian and military);
- Secondary Surveillance Radar systems (civilian and military);
- Aeronautical Search and Rescue activities; and
- Military training and exercise areas.

The similarities between Primary and Secondary radar systems, in terms of the ways in which a wind farm may impact them, mean that these two receptors are considered collectively to avoid repetition in the following sections. The following section investigates the nature and extent of these potential impacts during the three phases of the project. The chapter also considers potential mitigation measures in relation to each stakeholder.

7. ASSESSMENT OF EFFECTS

7.1. Construction Phase

7.1.1 Civilian radar systems

Impacts upon civilian radar systems will be most prevalent during the operational phase. Discussion of this impact is therefore undertaken within the operational section below.

7.1.2 Aeronautical Search and Rescue

The potential exists for impacts upon aeronautical SAR operations through the following mechanisms:

- General interference to helicopter operations owing to the presence of increasing numbers of obstructions (wind turbines, anemometer masts, accommodation platforms, cranes, etc.) in an area that was previously open water; and
- The introduction of a possible collision hazard for helicopters undertaking SAR activity in poor weather, at night or in other conditions of low visibility.

The ability to perform SAR will be made more difficult owing to multiple obstructions and the impact of the presence of increasing number of wind turbines upon on-board systems such as radar. Furthermore, an increase in vessel movements associated with the construction and operation of a wind farm will increase the risk of incidents that may require SAR assistance. However, in the case of Horns Rev 3 proximity to shore means theses inshore waters can be reasonably expected to see high baseline levels of vessel activity.

In the absence of specific guidance from Danish SAR authorities in relation to offshore wind farm developments and consultation on this development, a worst case scenario is considered for the impact assessment. The worst case scenario comprises:

- The greatest spatial extent of the Horns Rev 3 development area;
- The tallest turbine towers and largest (i.e. greatest diameter) rotors;
- Maximum number of ancillary structures (i.e. anemometer masts, platforms, etc); and
- The minimum spacing between turbines.

This worst case scenario does however draw upon information produced by UK SAR authorities in relation to offshore wind farm interactions, as well as experience of undertaking SAR impact assessments in relation to offshore wind farms in UK waters. Without mitigation, there is the potential for adverse impacts upon SAR activities. However, mitigation measures can be introduced to ensure that the existing SAR capability is not compromised. Potential mitigation measures that could be adopted are presented in the following paragraphs and are relevant to phases of development.

- Inclusion on aeronautical charts. Structures over a specific height above ground level (typically 300 ft (~90 m)) must be charted on civil and military aeronautical charts. The appropriate civilian and military charting organisations will be in-

formed of specific project details such as development location, the location, size and height of each wind turbine generator, and construction schedules;

- Lighting. Aeronautical and maritime regulators will have guidance on the requirements for wind farm lighting. Such lighting must ensure that the site is sufficiently conspicuous to aircraft and boats and that it meets respective industry requirements.

- The obstruction lights must permit unobstructed visibility for 360 degrees around the turbine in the horizontal plane, regardless of the position of the turbine blades,

- Marking. Wind turbine generators are individually marked so that any unit can be identified, from a specified distance, by SAR helicopter crews to expedite the coordination and completion of a SAR operation. In addition, specific requirements in relation to the marking of blades; colours, high visibility banding/marking that may be required will be incorporated as necessary. Information currently available from national regulations specifies that wind turbines must be painted white on their blades, nacelle and on the upper two thirds of the tower, (Trafikstyrelsen, 2013).The transition piece of the tower is often painted yellow as used at Horns Rev 2 and Anholt offshore wind farms.

Adverse impacts arising from the Horns Rev 3 development will be minimised through adherence to the mitigation measures set out above. A SAR operation within a wind farm under construction will be more challenging than one undertaken over open water, with helicopters only able to get within a specified distance of a turbine or mast. Whilst the presence of a wind farm significantly alters the operating environment, SAR operations can be safely performed through adherence to revised procedures that take into account the changes caused by the development.

The widespread construction of offshore wind farms throughout Danish waters indicates that the operating environment must be acceptable for those agencies tasked with performing SAR in Danish waters. By the time construction commences, improvements in technologies on-board SAR helicopters will further reduce the extent to which wind farms impede SAR activity. The developer will continue to work with SAR operators to ensure that Horns Rev 3 places the minimum constraint on SAR activity.

7.1.3 Military training and exercise areas

The proposed development may result in adverse impacts upon military activities in the numerous training and exercise areas that exist in the vicinity of Horns Rev 3. Information within the public domain on the nature of activities undertaken in these training areas is understandably limited. The nature of activities undertaken in Danger Area 381 Kallesmærsk Øst (live firing), and the fact that the base level of the danger area is sea level, it is likely that the presence of Horns Rev 3 will impact some element of operations undertaken in this area. Clearly, significant safety issues will arise if construction of an offshore wind farm gets underway in an area used for the live firing of munitions.

The Danish Air Force (FTK) uses the airspace over the whole Nord See area for low flying military training. For this reason any obstacle elevated above sea-level constitutes potential risks. Besides the turbines the wind farms often include anemometer masts typically sited within or just outside the wind farm area. Anemometer masts are extremely slender rendering them potential inconspicuous to aviators flying over the sea. The FTK recommends that anemometer masts above 30 m shall be marked on aeronautical charts. Recommendations made by the CAA specify the installation of one medium intensity steady red light positioned as close as possible to the top of the structure (CAA, 2013).

7.2. Operational Phase

7.2.1 Civilian radar systems

The relatively short distance between Horns Rev 3 and the nearby civilian radars at Borsmose and Vestas means that the development will be clearly visible to these radars. As the generating capacity of wind turbine generator units grows, the corresponding increase in maximum tip heights increases the distance within which a given turbine or wind farm development will be visible to radar. At the same time however, technologies are evolving which better enable radar systems to minimise or negate these problems.

At the time of writing, no guidance in relation to the impacts of offshore wind farm developments upon radar systems has been prepared by the Danish authorities. However, a number of studies have been undertaken in Denmark investigating the ability of specific types of radar to provide unhindered coverage in the vicinity of offshore wind farms (Hansen, et al., 2012; Thomsen, et al., 2011; Thomsen, et al., 2013). The results of these studied showed that the extent of impacts is dependent upon turbine density. As the density of the wind farm reduces (i.e. the turbines are spaced further apart; this being increasingly common as the size of individual turbines increases), the ability of the radar to track targets close to/overhead the wind farm is reduced. A number of mitigation measures exist to enable the continuation of safe radar coverage where the presence of the wind farm impedes radar coverage.

When Horns Rev 3 becomes operational, in the absence of any mitigation it is anticipated that radar performance will be degraded in relation to aircraft flying over or in the vicinity of the wind farm. It could be that these impacts are tolerable given the air traffic ‘environment’ in this area; i.e. the wind farm is not underneath an arrival or departure flight path for a major airport. However, without details of the specific types of radar within range, and any consultation with the respective radar operators, it is not possible to detail the nature and extent of anticipated impacts.

Mitigation measures that can be used where a wind farm is expected to adversely impact radar coverage include:

- The re-routing of aircraft around the wind farm to avoid radar returns being lost against the wind farm and associated radar ‘clutter’;

- The use of 'in-fill' radar whereby the target data from another radar, for which the wind farm in question is not visible, is used to 'replace' the airspace around the wind farm. The nearby radar therefore no longer sees the wind farm; and
- Adjusting the elevation of the radar antenna.

7.2.2 Aeronautical Search and Rescue

Potential impacts upon SAR activity during the operational phase of Horns Rev 3 are not anticipated to be any greater than those experienced during the construction phase. The narrative provided in section 7.1.2 above is therefore relevant to the operational phase and is not repeated in this section.

7.2.3 Military training and exercise areas

Potential impacts upon military training and exercise areas during the operational phase of Horns Rev 3 are not anticipated to be any greater than those experienced during the construction phase. The narrative provided in section 7.1.3 above is therefore relevant to the operational phase and is not repeated in this section.

7.3. Decommissioning Phase

7.3.1 Civilian radar systems

The impact that wind farms have on radar systems is in large part due to the rotating nature of the blades which creates a much more significant radar return than if they were stationary. As the project enters the decommissioning phase, the impact that it has on shore-based civilian radar systems will materially reduce over the time. This chapter assumes that the turbines will be decommissioned and removed, along with associated infrastructure including the anemometer monitoring masts, accommodation and servicing platforms (if relevant) and offshore substations.

The removal of each item is therefore an obstacle or a 'radar return' that will no longer be visible to nearby radar. The removal of all above-surface infrastructures will therefore remove all potential sources of interference associated with the wind farm. No impacts above or beyond those experienced during the operational phase are anticipated.

7.3.2 Aeronautical Search and Rescue

Potential impacts upon SAR activity during the operational phase of Horns Rev 3 are not anticipated to be any greater than those experienced during the construction phase. The narrative provided in section 7.1.2 above is therefore relevant to the decommissioning phase and is not repeated in this section.

7.3.3 Military training and exercise areas

Potential impacts upon military training and exercise areas during the operational phase of Horns Rev 3 are not anticipated to be any greater than those experienced during the construction phase. The narrative provided in section 7.1.3 above is therefore relevant to the decommissioning phase and is not repeated in this section.

8. CUMULATIVE IMPACTS

This section describes the approach to cumulative impact assessment for Air Traffic, taking into consideration other plans, projects and activities.

When additional projects within the same region affect the same receptors at the same time, they are said to have cumulative impacts. In other words, cumulative impacts are those impacts which can occur on a cumulative basis between the wind farm project subject to the application (i.e. Horns Rev 3) and other wind farm projects, activities and plans. A project should be included in the cumulative impact assessment if it meets one or more of the following requirements:

- The project and its impacts are within the same geographical area as Horns Rev 3;
- The project affects some of the same or related receptors as Horns Rev 3; and
- The project has permanent impacts during the operational phase that interfere with impacts arising from Horns Rev 3.

The two wind farms Horns Rev 1 and Horns Rev 2 are both located in the same geographical area as Horns Rev 3 (Figure 4.1). The nature of activities undertaken by the receptors considered within this study means that for any offshore development to take place (be it a wind farm, a gas platform etc.), the appropriate regulators will have to be satisfied that it will not adversely impact flight safety primarily. Consequently, this assessment assumes that appropriate mitigation measures will have been introduced for similar projects in the same geographical area; i.e. Horns Rev 1 and Horns Rev 2, to ensure that these developments did not adversely impact the operation of radar systems, military training areas, or the operation of SAR helicopters.

Consideration was given to the fact that a growing number of offshore wind farms could result in cumulative impacts for SAR assets. Such impacts may arise when a helicopter is flying between its base and an incident offshore and a wind farm lies along this route. Thus a transit of the wind farm in poor weather may result in a helicopter having to divert around the wind farm which would result in an inevitable penalty on flight time and therefore the time it takes to reach the incident. Such a diversion would occur if a helicopter was unable (owing to the height of the freezing level) to climb over the wind farm (and maintain the specified minimum obstacle clearances) without entering cloud.

A review of the trails undertaken in the UK showed that SAR helicopters can operate safely within the confines of an offshore wind farm. Therefore, the presence of a wind farm along the route flown by a SAR helicopter should not present any problems, especially with the introduction of new navigation and on-board equipment that will be operational by the time construction of Horns Rev 3 starts.

Cumulative impacts may arise in relation to military activities owing to the proximity of Horns Rev 3 to Horns Rev 1 and especially Horns Rev 2. The result of this could be to limit the available area for military training and exercise in the coastal area of the North Sea, as specified in the consulting response from FTK.

Consideration has been given to potential cumulative impacts arising from the development upon shore-based aeronautical radar systems.

9. SUMMARY OF IMPACT ASSESSMENT

This Technical Report to the EIA has considered the existing baseline and likely impacts of the proposed development in relation to Air Traffic receptors. It has established that development of Horns Rev 3 will change the operating environment and possibly constrain certain elements of SAR activity. Furthermore, the presence of the wind farm is expected to have adverse impacts upon nearby military training and exercise areas, and the functionality of civilian radar systems on the Danish coast.

Following an investigation of the baseline environment, it was possible to scope out a number of potential receptors prior to undertaking the impact assessment:

- Commercial aviation activities due to the location of the development site, its distance from Esbjerg Airport and the prescribed departure and arrival procedures used at that airport;
- Meteorological radar installations due to the distance between the closest such installation and Horns Rev 3;
- Civilian controlled airspace owing to the distance between Horns Rev 3 and the closest areas of controlled airspace;
- Military bases and private/recreational civilian aerodromes due to the distance between such sites and Horns Rev 3;
- Helicopter Main Routes and offshore helicopter operations owing to the location of Horns Rev 3 relative to existing HMRs and its position in relation to both the onshore operating bases and offshore platforms; and
- Military low-flying training areas due to the location of Horns Rev 3 offshore wind farm and the good availability of suitable training areas (i.e. open water) elsewhere.

The development does however have the potential to result in adverse impacts upon the following aeronautical receptors as detailed in full in Table 9.1 below:

- Civilian primary and secondary surveillance radar systems;
- Aeronautical search and rescue activities; and
- Military training and exercise areas.

Table 9.1 Summary of predicted impacts of Horns Rev 3 on Air Traffic receptors.

Description of impact	Mitigation measures	Residual impact
Construction phase		
Adverse impacts upon civilian primary and secondary surveillance radar systems.	Most prevalent during the operational phase. Discussed under 'operational phase' below.	**See below**
Aeronautical search and rescue activities.	Potential measures are specified below as well as those actions arising from consultation with Danish SAR and	**SAR operations can continue**

Description of impact	Mitigation measures	Residual impact
	other stakeholders: - Inclusion of HR3 on aeronautical charts, position of individual wind turbines plotted for use in GPS/radar datasets; - Lighting of wind farm/wind turbines in accordance with requirements of Danish transport and aeronautical regulators, the Danish military and MOD and maritime/shipping regulators; and - The marking of wind turbines and blades in accordance with requirements to ensure maximum possible conspicuity.	**provided the appropriate procedures, taking account of the change in operating environment owing to Horns Rev 3, are followed.**
Military training and exercise areas.	Numerous potential mitigation measures are available, however, consultation with the Danish MOD at a later stage will enable a determination to be made of potential impacts and if mitigation is necessary, what form this will take.	**No adverse impact anticipated**
Operation phase		
Adverse impacts upon civilian primary and secondary surveillance radar systems.	Numerous potential mitigation measures are possible including those detailed below. The nature and extent of actual mitigation required in part depends upon consultation responses from the relevant radar operators to determine impacts: - The re-routing of aircraft around the wind farm to avoid radar returns being lost against the wind farm and associated radar 'clutter'; - The use of 'in-fill' radar whereby the target data from another radar, for which the wind farm in question is not visible, is used to 'replace' the airspace around the wind farm. The nearby radar therefore no longer sees the wind farm; and - Adjusting the elevation of the radar antenna.	**No adverse impact upon radar functionality.**
Aeronautical search and rescue activities.	Refer to construction phase above.	**See above**
Military training and exercise areas.	Numerous potential mitigation measures are available however consultation with the Danish MOD will enable a determination to be made of potential impacts and if mitigation is necessary, what form this will take.	**No adverse impact anticipated**
Decommissioning phase		
Adverse impacts upon	Refer to operation phase above.	**See above**

Description of impact	Mitigation measures	Residual impact
civilian primary and secondary surveillance radar systems.		
Aeronautical search and rescue activities.	Refer to construction phase above.	**See above**
Military training and exercise areas.	Numerous potential mitigation measures are available however consultation with the Danish MOD will enable a determination to be made of potential impacts and if mitigation is necessary, what form this will take.	**No adverse impact anticipated**

In summary it is concluded that, the severity of impact upon air traffic as a result of Horns Rev 3 and following mitigation will be low.

10. REFERENCES

Beeden, D., Jensen, F., Leonhard, S. & Bøthun, L., 2013. *Radio Communicatiion and Radars,* s.l.: Energinet.dk.

Brown, C., 2005. *Report of helicopter SAR trials undertaken with Royal Air Force Valley 'C' Flight 22 Squadron on March 22nd 2005,* s.l.: Maritime and Coastguard Agency.

CAA, 2013. *CAA Policy and Guidelines on Wind Turbines CAP 764 5th Edition,* s.l.: s.n.

Flyvertaktisk Kommando, 2010. *Restricted Airspace within København FIR and adjacent waters. ENR 5.1-7 16. DEC 2010.* s.l.:Trafikstyrelsen.

Hansen, K. et al., 2012. *Detection and Tracking of Aircraft over Wind Farms using SCANTER 4002 with Embedded Tracker 2.* Glasgow, UK, IET.

ICAO, 2009. *European uidance Material on Managing Building Restricted Areas. 2'nd Edition,* Paris: International Civil Aviation Organization.

Klein, T., 2013. *(pers. com).* s.l.:Energinet.dk.

Thomsen, A. et al., 2011. *Air Traffic Control at Wind Farms with TERMA SCANTER 4000/5000.* Kansas City, USA , IEEE.

Thomsen, A., Riis, M. & Marqversen, O., 2013. *Air Coverage Test with SCANTER 4002 at Horns Rev Wind Farm I and II.* [Online]
Available at:
http://www.terma.com/media/155657/air_coverage_test_report_hornsrev_i_and_ii-mar_akt.pdf

Trafikstyrelsen, 2010. *ENR 1.2 Visual Flight Rules.* s.l.:s.n.

Trafikstyrelsen, 2011. *AMDT Flight Procedures IFR.* s.l.:Danish Transport Authority.

Trafikstyrelsen, 2012. *Luftfartsafmærkning af vindmøller. Rapport fra en tværministeriel arbejdsgruppe,* s.l.: Trafikstyrelsen.

Trafikstyrelsen, 2013. *Bestemmelser om luftfartsafmærkning af vindmøller. BL 3-11.* s.l.:Danish Transport Authority.