Chapter 9. Research strategy and equipment for studying flying birds in wind farms in the Belgian part of the North Sea

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Table of contents

9.1. Introduction .............................................................................................................. 225
9.2. Method .................................................................................................................... 227
   9.2.1. Equipment to monitor flying birds ................................................................. 227
   9.2.2. Monitoring collisions ...................................................................................... 227
   9.2.3. Location .......................................................................................................... 227
   9.2.4. Visual observations ......................................................................................... 228
9.3. Results ................................................................................................................... 228
   9.3.1. ARS equipment ............................................................................................... 228
   9.3.2. Bird collisions ................................................................................................. 231
   9.3.3. Location .......................................................................................................... 232
9.4. Discussion ............................................................................................................. 233
9.5. Conclusions .......................................................................................................... 234
9.6. References ............................................................................................................. 234

Abstract

The effects of offshore wind farms on flying birds are still uncertain at this time. Therefore it remains a necessity to study the impact of newly built wind farms on the flight movements of local and migrating birds. The biggest concern is the mortality risk due to collisions with the offshore constructions. This preliminary study aims to determine a research strategy and to select the right equipment to meet the long term research goals. According to De Groote & Roggeman (2006) the desired monitoring needs to be conducted with an Automated Radar System (ARS). The different ARS that were compared, in this study, are fit for purpose. In compliance with European legislation a public call for tender will be published and the received quotations will be evaluated on several criteria. The best suited ARS within the limits of the allocated budget will be purchased. The offshore high voltage stations seem to be the most appropriate locations for mounting the ARS. Before a platform is installed at sea it would be useful to install and test the ARS at an onshore location. This will give the researchers the ability to spend time with the system, which is not always possible offshore, and to get acquainted with the data. To estimate the mortality risk seems useful to calculate the number of collision victims with existing models. The data from the vertical scanning radar (fluxes, altitudes) will be used as input for the collision models. This is more reliable than results based on visual flux counts.

Samenvatting

De effecten van windmolenparken in zee op vogels zijn momenteel nog onzeker. Er is dus nood aan studies naar de impact van nieuwe windmolenparken op de vliegbewegeningen van lokale en migrerende vogels. De grootste bezorgdheid is de mortaliteit van vogels als gevolg van aanvaringen met de constructies. Deze voorstudie heeft tot doel om een onderzoeksstrategie op te stellen en de geschikte apparatuur te selecteren om de lange termijn doelstellingen te bereiken. Volgens De Groote & Roggeman (2006) is een automatisch radar systeem (ARS) het meest geschikt voor dergelijke monitoring. De verschillende ARS die in deze studie vergeleken werden zijn geschikt. Conform de Europese wetgeving zal een algemene offerteaanvraag gepubliceerd worden. De aangeboden offertes zullen geëvalueerd worden volgens verschillende criteria. Rekening houdend met het voorziene budget zal het meest geschikte systeem aangekocht worden. De offshore hoogspanningsplatformen zijn het best geschikt om het ARS te installeren. Vooraleer een platform in zee gebouwd is zou het nuttig zijn om het ARS aan wal te testen. Zo kunnen de onderzoekers veel tijd doorbrengen met het systeem en vertrouwd raken met de data. Om een schatting te maken van het mortaliteitsrisico kan het aantal aanvaringsslachtoffers berekend worden met bestaande modellen. De data van de verticale scanning radar (fluxes, hoogtes) zullen als input voor die modellen gebruikt worden. Dit is meer betrouwbaar dan de resultaten gebaseerd op visuele flux tellingen.
9.1. Introduction

The effects of offshore wind farms on flying birds are still uncertain at this time. Therefore it remains a necessity to study the impact of newly built wind farms on the flight movements of local and migrating birds. De Groote and Roggeman (2006) made a preliminary study of the possibilities to monitor flying birds at the Thorntonbank with a radar system. This report further elaborates on the findings of that study and presents the research strategy for the monitoring that is planned in the first five years of exploitation of the wind farms.

The research goals of the long term monitoring are:

- to study the avoidance behavior of flying birds in the vicinity of the wind farms by using a continuous monitoring strategy (with attention to temporal differences, different behavior by different species, differences during an operating wind farm and during a shut down, flight altitude, etc.);
- to quantify the flux of flight movements on site (with attention to diurnal differences of that flux and differences during varying weather conditions);
- to assess the number of collision victims and the impact of this mortality on the NW-European population of the concerned species.

The designated zone for the production of electricity from wind (figure 1) is far from the coast, with the nearest point at a distance of about 20 km. Vanermen et al. (2006) say that the species spectrum at the Thorntonbank, which is in that zone, is dominated by typical offshore birds such as guillemot, razorbill, kittiwake, lesser black-backed gull, etc. The near shore species great crested grebe, common scoter and divers are less frequent.

Every year, from one to 1.3 million birds pass through the Southern North Sea (Stienen et al., 2007). The southern North Sea is funnel shaped, which makes that a huge number of migrating birds are concentrated in the Channel. A lot of migration movements are happening over the sea, both at nighttime as at daytime. Sometimes the migration of, for instance, passerines is very intensive far at sea (Buurma, 1987; Alerstam, 1990). This was observed in the Belgian part of the North Sea by the Institute of Nature and Forest Research (INBO) and so this is also of importance for the zone for wind energy. The designated zone for wind energy is perpendicular to the dominant migration direction and if the zone becomes filled with wind turbines it could form a considerable barrier.
This preliminary study aims to determine a research strategy and to select the right equipment to meet the long term research goals, and has the following objectives:

- to make a selection of existing radar systems taking into account the recommendations made by De Groote & Roggeman (2006);
- to define the method to determine the number of collision victims;
- to evaluate different location alternatives from which the research can be carried out (meteo mast, transformation platform, wind turbine);
- to investigate a possible collaboration with field ornithologists to validate the radar data with visual observations.
Chapter 9. Seabirds radar

9.2. Method

9.2.1. Equipment to monitor flying birds

According to De Groote & Roggeman (2006) the desired monitoring needs to be conducted with an Automated Radar System (ARS) that meets the following requirements:

- The ARS needs to be an automatic system that registers data on a continuous basis without the presence of an observer. The data (track identifications or TID’s) must be recorded automatically in a database.

- The system will use a dual radar configuration consisting of a horizontal surveillance radar (HSR) and a vertical scanning radar (VSR). The HSR scans in the horizontal plane providing x-y data 360 degrees around the research site and shows the spatial distribution of the birds. The VSR scans in the vertical plane providing y-z data from the ground level to a minimum altitude of 1.5 km. Figure 2 illustrates dual radar coverage with the VSR beam scanning from horizon to horizon and the HSR beam with 360 degree coverage.

- The system includes specialized sea-clutter suppression software to optimize bird target detection in an offshore environment.

In this study the available existing systems were examined by consulting the literature, by visiting radar research sites and by contacting external experts. Based on those results the best available system will be sought via a call for tender.

9.2.2. Monitoring collisions

The available methods (systems, models) to monitor collisions of birds with wind turbines were evaluated in a similar way as was done for the ARS.

9.2.3. Location

The wind farm area is located too far from the coast to be monitored with an ARS on land. To mount the ARS on a ship is less suited because the data need to be corrected with the movement of the ship and because a ship cannot be present at the research site continuously. De Groote & Roggeman (2006) advise to mount the ARS on an offshore platform in the vicinity of the wind farm.

To monitor the spring migration it would be best to mount the ARS on a platform located NW or SW of the wind farm, during autumn migration NE or SE is better to register the passing birds (De Groote & Roggeman, 2006).

The best available research location at sea will be looked for, taking into account the recommendations of De Groote & Roggeman (2006) and the practical hindrances that can be anticipated.
9.2.4. Visual observations

Visual observation and registration of birds are very important to validate the data delivered by the radar. They also give additional information that is not recorded by the ARS. A limitation of all available systems is that they are not species specific. To determine which species fly in the area, at what altitudes, how their behavior differs, etc., periodic visual observations are necessary.

De Groote & Roggeman (2006) propose some observation techniques. Those observations need to be made by researchers with thorough knowledge of field ornithology. The institutions that are eligible for such observations were contacted.

9.3. Results

9.3.1. ARS equipment

Information was gathered by consulting the internet, from accounts of research done abroad, and by contacting radar experts. The following systems were found to meet the recommendations made in 2.1:

- the Robin Lite system of the Dutch Organization for Applied Nature Scientific Research (TNO);
- the Merlin system of DeTect;
- the Mobile Avian Radar System (MARS) of Geo Marine Incorporated (GMI).

9.3.1.1. Robin Lite

We@sea, a consortium of the offshore wind energy sector contracted the research and development institute TNO to design an automatic bird radar system to assess the effects of offshore wind farms on birds. The result is the Robin Lite system, in which ‘Robin’ stands for Radar Observation of Bird Intensity. The system consists of a horizontal X- or S-band\(^1\) radar and a vertical X-band radar, a user console and specialized software. The choice for the X- or S-band horizontal radar depends on the study aims: for instance, the smaller wavelength of the X-band is more appropriate to track small birds like passerines, but it is also more sensitive to sea clutter.

The software does the signal and image processing and the automatic data storage. Clutter filtering is of great importance in the signal processing. TNO developed a sea clutter filter, called DEKODO, which improves the signal / noise ratio by filtering the sea wave induced clutter. Figure 3 shows an image with and without sea clutter filtering. In the picture on the right hand side the typical wave pattern is reduced by the sea clutter filter which makes it possible to track birds (yellow dots) in a high clutter environment.

\(^{1}\) an X-band radar has a signal wavelength of 3 cm, the S-band a wavelength of 10 cm.
The recorded data are presented as bird tracks in a geographical information system and can, for example, be visualized in Google Earth where it is possible to zoom on individual tracks. This is shown in figure 4.

In the database every bird echo is stored. Those data have a lot of different parameters (for example speed, size, direction, time, etc.) that can be consulted and can be post-processed.
The range of the VSR is from ground level up to 3.5 km, the HSR has a maximum range of 10 km for large birds and flocks of birds (A. Borst pers. comm.). Smaller birds can be detected up to 6 km.

The Robin Lite is being tested at a military airport in Woensdrecht (The Netherlands), the results of these tests are used to fine-tune the algorithms of the signal processing. On April 15, 2008 the site in Woensdrecht was visited. It was possible to see the system function and to simultaneously watch birds and see if the radar recorded them. Pigeons, crows and a hawk were visually spotted and also seen on the radar viewing system.

9.3.1.2. Merlin

The company DeTect (USA, Florida) developed the ‘Merlin radar system’ specifically for detection and tracking of birds and bats. The system is automated, can operate unattended and can be remotely controlled and data accessed via wireless and network connectivity. It is a dual radar system with an S-band HSR and an X-band VSR. The effective range of the VSR is 3 to 5 km and 5 to 7 km for the HSR. Merlin software processes, analyses and records the radar information. The top image in figure 5 shows a raw (unprocessed) radar screen image. The white spots are birds during heavy migration. The concentrated white is clutter. The bottom image is processed with the Merlin software. The bird targets are converted into clear symbols with history tracks (target trails).

![Figure 5. Heavy migration seen on horizontal radar; before and after processing by Merlin software (Source: DeTect).](image)

The Merlin software has several clutter suppressing algorithms to improve bird detection in high clutter environments. In addition, several new clutter features will be available standard on 2009 Merlin radars. Furthermore, DeTect is designing new adjustments to minimize sea clutter. For instance, a sea clutter filter is being designed that takes wave characteristics into account.

To validate the radar data and to collect additional information, the Merlin software has a bar in the interface in which you can assign a radar registration to a species in the list of the bar. Those links are directly recorded in the database. This technique is called ‘flagging’ (Krijgsveld et al., 2005).

Data can also be displayed in real-time or exported to GIS and Google earth. The target records in the database can be queried and analyzed.

Additionally DeTect developed the *detect & deter* software as a controller system for high bird mortality risk projects. It is possible with this software to interconnect with the SCADA (Supervisory Control and Data Acquisition) software of the wind turbines in high risk conditions (ex. heavy migration) and automatically idle the turbines.
Merlin has been used to conduct offshore pre-construction surveys of proposed wind farm projects. In 2003 Bureau Waardenburg (BuWa) was contracted by Shell to assess the effects of offshore wind turbines on birds at the Near Shore Windpark Noordzeewind site (Egmond aan Zee, The Netherlands). BuWa tasked DeTect to design, construct, install, start-up and support a Merlin ARS. The pre-construction study started in September 2003, the post-construction survey in December 2006.

The radar hardware at the Noordzeewind site works well and has no problems with very high wind speeds. The VSR delivers a sound dataset with little clutter. Those data are very useful to know the altitude of the birds and to determine the flux in that area. The HSR data of the pre-construction were highly influenced by sea clutter. Those data were post-processed by DeTect and they provided additional clutter suppression algorithms and queries. The range of the HSR radar was set by BuWa at 3 nm (per. comm. K. Krijgsved). In the Beatrice Wind Farm (Scotland) the University of Aberdeen uses a Merlin ARS to do similar research as BuWa. The Central Science Laboratory (CSL) from the UK does on- and offshore research with two Merlin ARS.

9.3.1.3. Mobile Avian Radar System (MARS)

MARS is developed by GMI (Dallas, USA) and is a similar system to Merlin and Robin Lite. The producer never replied to the question if it would be applicable for an impact study of an offshore wind farm in the Belgian part of the North Sea. Therefore this system will not be described in this report.

9.3.2. Bird collisions

It is impossible to register bird collisions with an ARS (Desholm et al., 2006). The risk of birds colliding with turbines can be assessed with collision models or with specially designed devices. To carry out surveys underneath offshore wind turbines to find collision victims (possibly during heavy migration) is not realistic and will not deliver reliable data because of the loss of collision victims by sinking, drifting off and scavenging.

The Wind Turbine Bird system (WT Bird) was developed by the Energy Research Centre of the Netherlands (ECN) to register bird strikes on continuous remote operation. It is a combination of acoustic detection and video registration. The system consists of acoustic sensors that are placed on each blade. It registers the vibrations that are generated by the impact of a bird collision. The video runs continuously and registers the images just before and after the collision and makes species identification possible (Wiggelinkhuizen et al., 2006). Several prototypes were tested on onshore wind turbines with bird dummies. Tests on offshore turbines have not yet been done. The price for one WT Bird is in the order of 30,000 € (pers. comm. E. Wiggelinkhuizen).

Thermal Animal Detection System (TADS) is a remote technique for counting and estimating the number of bird collisions with a wind turbine based on infrared imaging (Desholm et al., 2006). The device creates pictures based on the heat energy emitted by objects. The advantage of these devices is that birds can be registered during the night and adverse bad weather conditions. When an object in the field of view exceeds a temperature threshold the video sequence is stored onto the hard disk. So not only colliding birds are recorded, also birds passing in the view of the camera are registered. TADS have been used in the Nysted offshore wind farm (Denmark) since 2003 on one turbine. To date no collisions have been registered (Desholm et al., 2006). The cost price of a TADS is in the order of 40,000 €.

In the wind farm on Smøla (Norway) a remote control camera and an infrared camera were mounted on a turbine. No collisions are reported to date.
9.3.3. Location

From several contacts with DeTect and TNO it is clear that the location for installing the ARS needs to comply with the following requirements:

- room on the top height\(^2\) of the platform to install the radar antennas;
- power supply of 220 V AC;
- a data uplink to shore with a limited band width (the fiberoptic in the electrical cables of the windfarms can be used; 1 fiberoptic pair would be sufficient to transfer the data);
- a dry space to put an air conditioned computer cabinet;
- a room were two monitors can be placed and were two persons can work and stay for several days.

Practically there are three possibilities to install the ARS in or close to the wind farms that comply with the above mentioned requirements: namely the platform at the base of a turbine, an offshore high voltage station (OHVS) or a meteo mast.

The two already licensed wind farm projects chose not to install the ARS on a single turbine because of safety reasons and limited space. From radar technical point of view it is also not ideal because of the shadow effect of the turbine.

Every wind farm will install one or two OHVS. Those stations meet all requirements but are located inside the wind farm. According to Christensen & Hounisen (2004) the shadow effect of the surrounding turbines makes an OHVS inside a wind farm unsuited as a location for an ARS. But consultation with the ARS developers indicated that this is not a big problem: it just results in blind spots in the study area. The Robin Lite and Merlin software try to remedy that problem: when a bird is registered, then disappears behind an obstacle and then becomes registered again, the software will combine those registrations as one bird track. The ARS on Smøla (Norway) is set up in the middle of the wind farm and this gives no problems to register birds.

C-Power will build one OHVS, its location being shown in figure 6. Belwind will place two OHVS in the windfarm (figure 7). They will probably be built in 2010 and 2011.

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2 There is no health risk when you are at another height than the radar antenna. Therefore it would be ideal to mount the radar antennas on the top level of the platform. Long term exposition with radar signal at eye height is harmful. Therefore it is advised to put the antennas in stand-by when you are closer than 10m. This is the procedure that Bureau Waardenburg follows (pers. comm. A. Smith, DeTect).
A meteo mast would also be suitable for the installation of an ARS. At this time the number of meteo masts and their location is not clear.

9.4. Discussion

The ARS that were described comply with the requirements made by De Groote & Roggeman (2006). They are basically very similar systems with the same abilities and limitations. Merlin, however, is the only system that has been used to conduct offshore surveys since 2003. DeTect has gained a lot of experience with the Merlin system in conditions similar to the Belgian part of the North Sea and has led to improvements of the system. Robin Lite has been intensively tested onshore, but not yet offshore. It must however be emphasized that TNO has developed a sea clutter filter (DEKODO) and that consequently Robin Lite is an operational system ready for offshore use. A third system (MARS) is available in the USA, but our enquiries there met with no success.

The Robin Lite system can be used with a X- or S-band HSR. However, for an offshore survey it would be best to work with an S-band radar. An X-band radar is better to register small birds like passerines, but it is more sensitive to clutter because the wavelength of the radar signal is shorter. Clutter will be the biggest problem in this research so it might be better to choose the option that is the less sensitive to clutter, with the disadvantage that it is less appropriate for registering small birds.

The currently available systems for registering collisions of birds with turbines do not seem useful at this stage of the monitoring.
There are several disadvantages with those systems:

- high cost price of individual system;
- WT Bird has not been tested on large turbines like the types used offshore;
- one or a few systems in a wind farm do not generate a large amount of data which makes it difficult to extrapolate the data to an entire wind farm and conclude what the effect is at te population level.

At this time it seems more useful to calculate the number of collision victims with existing models. In the framework of an existing contract between MUMM and INBO, INBO is measuring the flux of birds in the wind farm area on a monthly basis. INBO uses the results of those surveys to estimate the mortality risk using collision models. The data from the VSR (fluxes, altitudes) will be used as input for the collision models. This will calculate the mortality risk calculates more reliable than the results based on visual flux counts.

The different OHVS and the meteo masts seem to be the most appropriate locations for mounting the ARS as apposed to a single wind turbine. There will not be an OHVS installed at sea before 2010, so that before that time it would be useful to install and test the ARS at an onshore location. This will give the researchers the ability to spend time with the system, which is not always possible offshore, and to get acquainted with the data. The harbour of Zeebrugge seems a suitable location: there is intense bird activity, there are wind turbines on the jetty, the sea can be overviewed with the radar so the sea clutter filter can be tested and the data can contribute to research on the tern colony in the harbor.

MUMM has several scientists who would be able to do the flagging observations. But collaboration with INBO is a valid option because of their yearlong experience in monitoring birds in the Belgian part of the North Sea with standardized methods.

9.5. Conclusions

- The systems that were compared are both fit for purpose. In compliance with European legislation a public call for tender will be published and the received quotations will be evaluated on several criteria. The best suited ARS within the limits of the allocated budget will be purchased.

- The wind farms developers were asked to take the location requirements (3.3) into account in the design of their OHVS. So several locations will be suitable to mount the ARS. If needed, the ARS can be moved after a certain period to another platform. Before a OHVS is installed, the ARS will be mounted in the harbour of Zeebrugge.

- The bird mortality risk will be estimated by INBO with existing models based on visual and radar fluxes.

- The flagging and other visual techniques to validate the radar data and to gather species specific information (Krijgsveld et al., 2005; De Groote & Roggeman, 2006) will be tested during the time that the ARS is installed onshore.

9.6. References

Chapter 9. Seabirds radar


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