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Monitoring radar performance, data collection and data quality

A guidance document

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Preface

In current practice, collision risk models like the Band model are often used in impact assessments of offshore wind farms. The results of Band model calculations are generally strongly dependent on estimates for a limited number of parameters, and the outcome may vary widely with minor changes in just a few of the input estimates. Therefore, it is important to validate the assumptions used in the collision modelling, in order to improve the confidence around mortality estimates. To achieve this goal, Rijkswaterstaat (RWS) has installed a 3D Fixed Robin Radar in the offshore wind farm Luchterduinen (LUD). This radar is the first radar system in an expected series of six radars that will be placed in offshore wind farms in the near future.

RWS has commissioned Bureau Waardenburg to continuously monitor the performance of the radars at LUD and the quality of the collected data, in order to prevent (as far as possible) data loss and to facilitate efficient troubleshooting and radar optimization. This report serves as a guidance document in which we describe and standardize our methods and experiences for the daily monitoring of radar performance, data collection and data quality. Based on this document, monitoring of bird radars at other offshore wind farms in the future can be carried out in a standardized way.

The following persons contributed to the realisation of this report:

Jacco Leemans	monitoring, reporting;
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Daniel Beuker	monitoring;
Abel Gyimesi	monitoring, project managing;
Ruben Fijn	quality control.

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1 Introduction

1.1 Background

Recent research in the Ecology and Cumulation Framework (KEC - Rijkswaterstaat 2015, 2019) and the EIAs of various offshore wind farms showed that substantial numbers of collisions with offshore wind turbines are to be expected among different species of seabirds and migratory birds. For some of these species, this additional mortality may be evident at the population level due to either their small natural populations, or because a significant proportion of the world population flies over the Dutch North Sea, or because a large proportion of the population flies in concentrated flyways during migration between the Netherlands and the UK.

Within the framework of aforementioned studies, the numbers of collision victims have been calculated with the Band model (Band 2012), currently the most frequently used model for predicting bird collisions in wind farms at sea (Masden & Cook 2016). The results of Band model calculations are generally strongly dependant on estimates for a limited number of parameters, and the outcome may vary widely with minor changes in just a few of the input estimates. Therefore, it is important to validate the assumptions used in the collision modelling, in order to improve the confidence around mortality estimates. This mainly concerns assumptions about avoidance behaviour, fluxes, flight speeds and flight altitudes. Such a validation can be carried out by a detailed field study in an offshore wind farm. For this, data collected by specialized bird radars, camera recordings and visual observations are currently the best available methods.

To achieve this goal RWS has purchased a 3D Fixed Robin Radar, consisting of a horizontal and vertical radar (in short: RWS bird radar). This is installed in the offshore wind farm Luchterduinen (LUD). Currently, Eneco (the owner of LUD) has also an obligation to conduct research into bird collisions and fluxes in the wind farm. The aforementioned two projects will complement and reinforce each other and thereby provide new knowledge about bird fluxes, number of collisions and macro-, meso- and micro-avoidance.

The RWS bird radar consists of a horizontal Furuno magnetron-based S band radar and a fixed vertical Furuno magnetron-based X band radar. The aim of the horizontal radar is to detect and track birds within a 6 km scanning range, while the aim of the vertical radar is to detect birds and estimate fluxes within a 1,500 m scanning range. These radars collect information on bird movements in and around LUD during several years. The bird radar in LUD is the first radar system in an expected series of six radars that will be placed in offshore wind farms in the near future.

RWS has commissioned Bureau Waardenburg to continuously monitor the performance of the radars at LUD and the quality of the collected data. The purpose of the daily monitoring of radar performance is to prevent (as far as possible) data loss and to facilitate efficient troubleshooting and radar optimization. Because eventual major problems or discrepancies in the data are noticed within 24 hours of occurrence, long periods of undetected radar failure or suboptimal data collection can potentially be avoided.

1.2 Scope of this report

This report serves as a guidance document in which we describe our methods and experiences for the daily monitoring of radar performance, data collection and data quality. Based on this document, monitoring of bird radars at other offshore wind farms in the future can be carried out in a standardized way.

2 Monitoring tools

The daily monitoring of radar performance, data collection and data quality of the radars in wind farm Luchterduinen was performed with the aid of three different tools. These tools have complementary purposes for the monitoring, which means that all three tools should be used to ensure that no irregularities in the data collection are overlooked. The following paragraphs provide a description of each tool and how it can best be used for monitoring, in order to guide an efficient method of monitoring.

2.1 Robin Visualiser

Description

The Robin Visualiser (figure 2.1) enables to remotely view the live performance of the horizontal and vertical bird radars. It plots all bird movements currently tracked by the radar, together with their altitude (in case also detected by the vertical radar), velocity and distance to the radar. Furthermore, within the Visualiser it is possible to playback radar images up to one and a half months back in time. Tracks of different classifications (e.g. different sized birds, flocks, aircrafts etc.) are displayed in different colours. Both the horizontal and the vertical radar image can be viewed separately, with possibilities to adjust the zoom level. In order to enhance spatial orientation, also geo-referenced marker files can be added to the image, which can contain any object helpful to be depicted, such as wind turbines, waterways, platforms, etc.

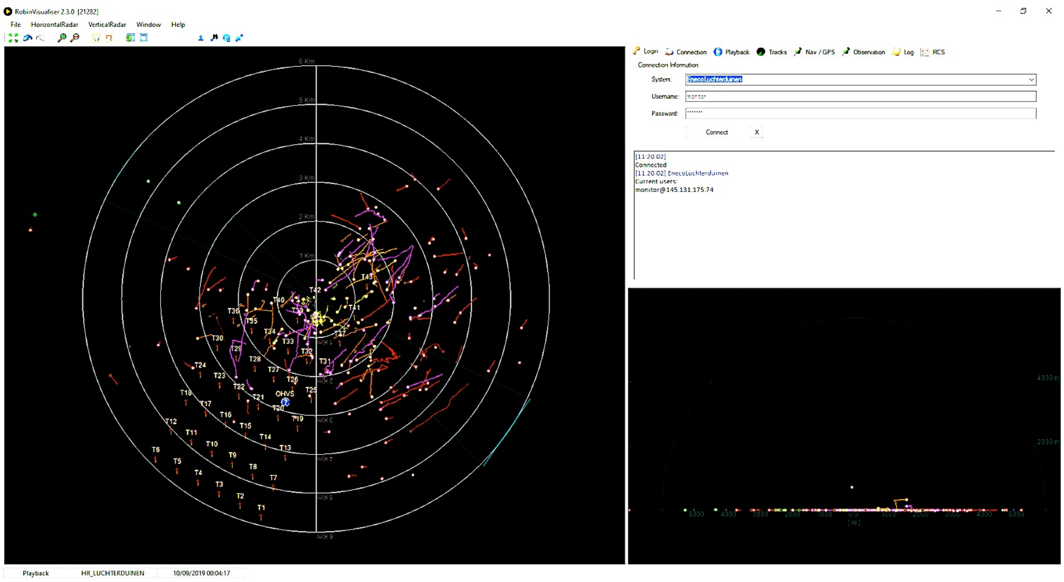

Figure 2.1 Example of the Robin Visualiser showing the horizontal radar image on the left side and the vertical radar image on the right side.

Purposes for monitoring

The Visualiser can be used as a first check to see whether the radars are currently operating. If the radars are operating, it provides a good impression of the real-time bird movements in the wind farm. With some experience, tracks displayed on the Visualiser can fairly readily be divided in true bird tracks and false echoes (i.e. clutter: tracks other than birds, like reflections, waves or rain). The Visualiser also facilitates spatial data exploration, which is almost impossible to carry out in the (tabular) database. It is therefore a suitable tool to examine the data quality that is currently recorded, by checking to what extent clutter is contaminating the radar database and where this clutter is located. Furthermore, the playback function of the Visualiser may be used to check what the radar has detected under different circumstances or at different times of the day. This may be particularly useful when trying to interpret irregularities found while examining the Report Viewer or the database (see below).

2.2 Report Viewer

Description

The Report Viewer is an interface developed by Robin Radar that provides a convenient summary of the data collected by the radar by means of graphs and maps (figure 2.2). The Report Viewer offers possibilities to select temporal periods and spatial areas that should be analysed. For example, it provides plots of the number of bird tracks over time, or heatmaps showing the spatial distribution of the bird tracks detected by the radars (figure 2.2). These all can be categorized and selected per altitude, flight direction and speed. Moreover, measurements can be directly related to for example diurnal cycles, but also to all sorts of weather circumstances, such as temperature, precipitation, wind speed and –direction (figure 2.2). The summaries take into account all data collected up to the previous hour.

Purposes for monitoring

The Report Viewer is a suitable tool to detect any irregularities in the amount and type of data that has been collected. For example, periods with a distinctively high or low number of bird tracks may easily be detected within the graphs provided by the Report Viewer. Additionally, where the Visualiser merely indicates whether the radars are currently operating, the Report Viewer provides a quick overview whether data has been collected for the entire period since the last monitoring check, or whether there are any gaps in the data. The Report Viewer also provides plots of the number of bird tracks and different weather conditions over time, which may be used to interpret observed patterns. For instance, the Report Viewer can easily trace peaks in migration during the night, when often no live controls are carried out. The temporal occurrence of such peaks throughout a longer study period can also be directly visualized.

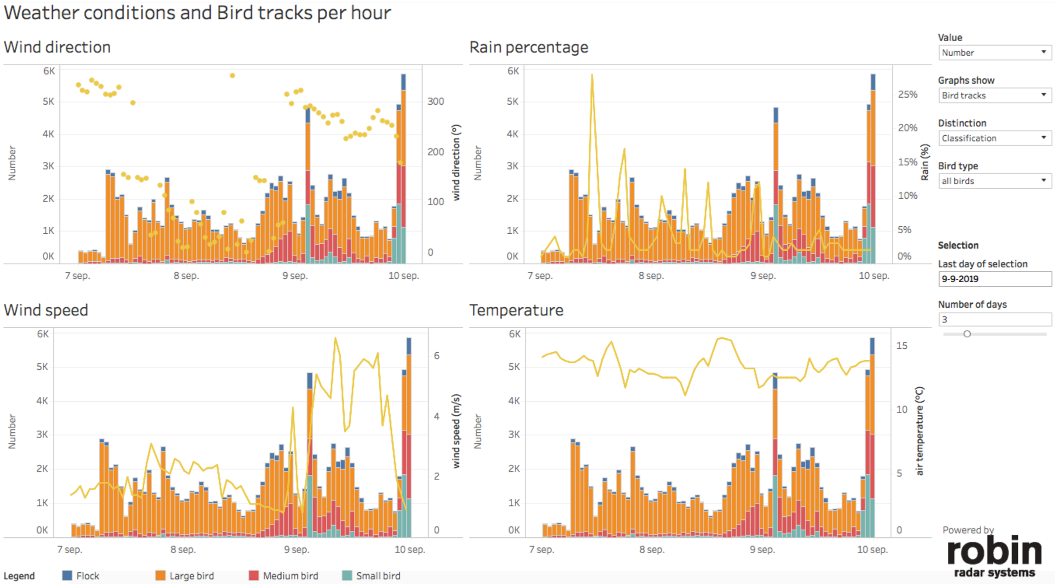

Figure 2.2 Example of several graphs generated by the report viewer. The graphs show the number of bird tracks (divided in different bird size classes) per hour for three days in September, plotted together with weather variables.

2.3 Database

Description

The database contains all data collected by the radars, and therefore it is essential to monitor whether this data is stored properly. It is composed of several tables of which a few are relevant for daily monitoring. All radar images and tracks recorded by the horizontal and vertical radars are stored in the tables named ‘image’ and ‘track’, in which the unique identification number of each image and track can be found, alongside their properties. Each track is composed of different track points, which are stored in the table ‘trackestimate’. The track points from this table can be linked to the corresponding tracks in the ‘track’-table using the unique identification number of each track (figure 2.3). Furthermore, the database for example contains information about the extent to which filters are being applied on each radar image. This information is stored in the table ‘ip_metainfo’ and can be linked with the ‘image’-table using the identification number of each image.

Purpose for monitoring

When radar images are shown in the Visualiser, and thus the radar is operating, it does not necessarily mean that these images are being stored in the radar database. Although the report viewer could indicate whether the connection to the database was active in the previous hour, a quick check in the database itself provides information about what is currently happening. An efficient method to monitor current activity is to sort the data in the tables ‘track’ or ‘image’ in chronological order and then check whether new rows with data are being added to the database. Furthermore, the database may be used to look in more detail to (characteristics of) tracks or images at specific times (e.g. to interpret irregularities or explain observed patterns). For example, relevant columns to examine the influence of weather on the radar image are the column ‘rain_percentage’ in the table ‘ip_metainfo’ and different columns in the table ‘weather’. Also, radar images can be reconstructed through GIS-software (similar to the playback function of the Visualiser), based on the geometry data of each track and image stored in the database. Depending on the context, much more data from the database can be relevant for monitoring. However, a thorough explanation of all functionalities of the database is beyond the scope of this report.

	id [PK] bigint	internal_id bigint	timestamp_start timestamp without time zone	timestamp_end timestamp without time zone	assignable_properties t_assignableproperty[]	classification_id bigint	species_id bigint	rho_diff real	phi_diff real	theta_diff real
1	115746329	10454183	2019-09-18 07:44:43	2019-09-18 07:45:06	{MHT}	6	[null]	221.997	1.07382	-0.101953
2	115746328	10454172	2019-09-18 07:44:39	2019-09-18 07:45:03	{MHT}	6	[null]	173.922	0.906696	0
3	115746327	10454163	2019-09-18 07:44:38	2019-09-18 07:45:02	{MHT}	7	[null]	248.427	1.42646	0
4	115746326	10454112	2019-09-18 07:44:28	2019-09-18 07:45:03	{LOITERING}	7	[null]	15.8335	-0.959936	-0.138994
5	115746325	10454180	2019-09-18 07:44:42	2019-09-18 07:45:01	{}	6	[null]	300.939	-2.70296	0
6	115746324	10454170	2019-09-18 07:44:39	2019-09-18 07:45:01	{MHT}	6	[null]	226.282	-2.05439	0
7	115746323	10454184	2019-09-18 07:44:43	2019-09-18 07:45:01	{}	6	[null]	139.352	-0.129316	0
8	115746322	10454138	2019-09-18 07:44:33	2019-09-18 07:45:00	{LARGE,MHT}	6	[null]	223.079	-1.41792	0

	id [PK] bigint	radar_id bigint	timestamp timestamp without time zone	position geometry	velocity real	airspeed real	heading real	heading_vertical real	peak_mass real	mass real	mass_correction real	track_id bigint
1	1841842895	6	2019-09-18 07:45:06	01010000A0E61...	10.3981	10.291	1.40371	1.97971e-05	11.6279	16.956	23.7955	115746329
2	1841842894	6	2019-09-18 07:45:05	01010000A0E61...	14.4133	14.5648	1.06558	1.25126e-05	10.9752	14.9168	23.7602	115746329
3	1841842893	6	2019-09-18 07:45:02	01010000A0E61...	21.1585	23.7429	0.830745	5.7574e-06	8.3932	12.7887	23.6359	115746329
4	1841842892	6	2019-09-18 07:45:01	01010000A0E61...	20.2457	22.857	0.792806	-5.24213e-06	14.8086	20.0485	22.6834	115746329
5	1841842891	6	2019-09-18 07:45:00	01010000A0E61...	20.1975	21.8991	1.12152	5.27658e-05	15.0099	19.7501	24.598	115746329
6	1841842890	7	2019-09-18 07:44:57	01010000A0E61...	10.6579	11.4405	1.2049	-0.00735251	18.1424	23.0836	29.3503	115746329
7	1841842889	6	2019-09-18 07:44:57	01010000A0E61...	8.0275	9.00204	1.25456	-5.07662e-05	26.7358	33.904	22.9079	115746329
8	1841842888	6	2019-09-18 07:44:56	01010000A0E61...	8.78896	10.0645	0.530798	-4.57594e-05	12.6292	16.3151	22.9171	115746329

Figure 2.3 Example of the first columns of the tables ‘track’ (above) and ‘trackestimate’ (below). Tracks in both tables can be linked to the corresponding ‘track_id’.

3 Efficient communication and documentation

The purpose of the daily monitoring is to prevent (as far as possible) data loss and to facilitate efficient troubleshooting and radar optimization. Therefore, if irregularities in radar performance, data collection or data quality are detected during daily monitoring, the monitoring party should inform RWS and Robin Radar about these irregularities, and discuss potential follow-up and/or adjustments to the radar system (figure 3.1). These irregularities could for example concern radar failure, database errors, reflections, large amounts of clutter, changes in radar orientation, or unrealistic tracks.

On the other hand, it is important that RWS and Robin Radar communicate events that might influence radar performance, data collection or data quality that are known beforehand (figure 3.1). For example, RWS should communicate to the monitoring party if and when the radars will be turned on and off, for example due to planned maintenance. Similarly, planned adjustments in the hardware or software of the radars (e.g. new clutter filters, algorithms, antennae, etc.) should be communicated by Robin Radar. In this way, the monitoring party can anticipate on changes in radar performance, data collection or data quality, which enables efficient monitoring and prevents the monitoring party taking unnecessary actions.

Lastly, it is essential that irregularities found during daily monitoring will be documented. This may ideally be done by the monitoring party by means of a standard log file, that includes the date, time, and description of the irregularity, and, if applicable, also the (probable) cause, the follow-up action, some form of documentation (e.g. a link to an email, or a screenshot of the radar image), and/or any other relevant information (figure 3.2). This log file allows tracing back any events that might have influenced data collection. Also, the log file could act as a handbook based on which recurring problems could be solved more easily in the future.

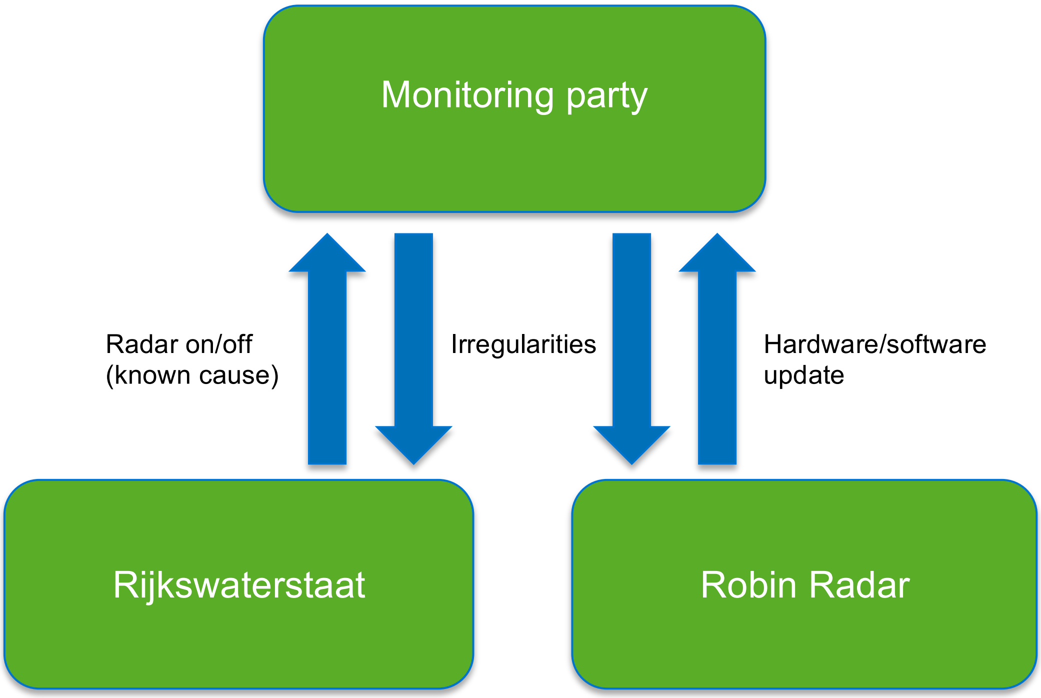

Figure 3.1 Communication scheme for monitoring radar performance, data collection and data quality. Note that only direct communication with the monitoring party is depicted in the scheme, thus not between Rijkswaterstaat and Robin Radar, which is beyond the scope of this report.

	A	B	C	D	E	F	G
1	**Date**	**Time start**	**Event**	**Cause**	**Solution**	**Documentation**	**Remarks**
2	20-01-20xx	08:33	Radar off	Maintanance		link to email	
3	20-01-20xx	12:40	Radar on			link to email	exact time unknown
4	23-02-20xx	09:22	Strange clutter	Rain		link to screenshot	
5	11-03-20xx	11:33	No tracks added to database	Software failure	Software update	link to screenshot/email	
6	13-03-20xx	10:31	Software update / tracks added again			link to email	

Figure 3.2 Example of a log file that may be used to document any events that might have influenced radar performance, data collection or data quality.

Literature

Band, W., 2012. Using a collision risk model to assess bird collision risks for offshore windfarms. SOSS, The Crown Estate, London, Uk.

Masden, E.A. & A. Cook, 2016. Avian collision risk models for wind energy impact assessments. Environmental Impact Assessment Review 56: 43-49.

Rijkswaterstaat, 2015. Kader Ecologie en Cumulatie t.b.v. uitrol windenergie op zee Deelrapport B - Bijlage Imares onderzoek Cumulatieve effecten op vogels en vleermuizen. Ministerie van Economische Zaken en Ministerie van Infrastructuur en Milieu, Den Haag.

Rijkswaterstaat, 2019. Kader Ecologie en Cumulatie 3.0 t.b.v. uitrol van windenergie op zee 2030. Ministerie van Landbouw, Natuur en Voedselkwaliteit, Den Haag.