KNE | Kompetenzzentrum
Naturschutz und Energiewende

KNE CONFERENCE

Minimizing bird collisions with wind turbines

Can detection systems facilitate an environmentally sound wind energy development?

PROCEEDINGS OF THE KNE CONFERENCE
ON MAY 15–16, 2019 IN KASSEL

PREFACE

Dear Reader,

Climate protection and preserving biological diversity are central tasks of our time. The decarbonisation of the energy production and the transition to the—ultimately exclusive—use of renewable energies is the main way to meet these challenges. The large-scale use of wind energy is one of the most efficient technologies for the generation of renewable energies. However, the expansion of wind energy is increasingly reaching its limits in that areas that show only few potential conflicts with species protection regulations are becoming less and less available.

Nevertheless, there are ways to minimise conflicts by informed turbine siting and by the thorough application of planning and permitting instruments such as environmental impact assessments, impact mitigation regulations, and assessments following the species protection regulations.

An important goal of the environmentally sound energy transition is to avoid collision risks for birds and bats. To minimise the risk of collision, only a limited range of mitigation measures is currently available, including—in addition to turbine curtailments—habitat enhancement measures. Both measures also have disadvantages. For example, wind turbine shutdowns reduce efficiency, while the effectiveness of habitat enhancement to lure individual birds away from the risk zone is subject to uncertainty.

Automated detection and smart curtailment of wind turbines could make these measures more targeted and reduce uncertainties.

The Competence Centre for Nature Conservation and Energy Transition (KNE) has pledged itself to a nature-compatible energy transition. It is a fascinating challenge to support the further development of wind energy use by field testing and applying detection systems at least in certain cases. We are particularly committed to providing scientific support in the testing of reliable systems for bird detection and turbine curtailment.

Our conference "Minimizing bird collisions with wind turbines" on May 15–16, 2019 in Kassel was very well received. There is obviously a great need for discussion and knowledge transfer, but also for networking. I would like to take this opportunity to thank all participants once again for a very objective and active exchange of ideas. The KNE intends to continue this exchange in the future.

This publication includes all of the presentations available to us at the conference. They give a very good overview of the technical status of bird detection. I wish the readers an exciting read and good luck to all those who are involved in the development, field testing, approval, and application of the detection systems. We are available at any time to exchange ideas and provide information.

Torsten Raynal-Ehrke

Dr. Torsten Raynal-Ehrke
Director

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CHAPTER 1

How to prevent birds from colliding with wind turbines

Automated bird detection systems and smart curtailment— functioning and state of development

Dr. Elke Bruns

Issue at hand

As early as 2017, inquiries were submitted to the KNE as to whether automated bird detection systems could also be used for turbine siting or operational monitoring in view of uncertainties in the context of spatial use analyses. This question was broadened when it came to dealing with post-permit colonisation[1] of breeding birds within the project area. Could—in these cases and beyond—automated detection systems combined with turbine smart curtailment on demand[2] be a suitable and effective mitigation measure? What prompted this question was a case in which a local nature conservation authority was asked to assess whether an existing turbine in the vicinity of which a red kite had settled could continue to be operated using such a system. In Germany little was and, to a certain extent, still is known about bird detection systems that can detect not only flocks, but also individual birds and, in some cases, even identify them at the species level.

For some operators, using technical solutions is the last hope or means to operate a wind turbine that is compatible with conservation requirements.

1 Post-permit colonisation refers to cases, in which target species (see Footnote 4) settles in a critical distance (falling below the suggested minimum range) to a licensed wind turbine.

2 A minimization measure that reduces the risk of collision: the automated curtailment of a wind turbine in terms of a reduction of rotor speed in the event of an acute risk of collision of a wind-energy-sensitive bird species.

It seemed to the KNE to be a matter of urgency to acquire knowledge as quickly as possible about the performance[3] and application possibilities of the systems and to gather empirical data regarding their suitability and effectiveness—even beyond the individual project.

So it stood to reason to investigate the potential a technical solution aiming for collision reduction has. Because the spectrum of formally approved minimisation measures to reduce collisions and the associated leeway for environmentally compatible solutions is limited, there was an increased interest in looking at innovative solutions.

The conference aims to provide an overview of the current state of development of systems available on the market and their performance. The presentation of interim results from ongoing field tests in Germany serves to transfer the available knowledge and contributes associating potentials seen in the systems with the context of the current permitting practice. At the same time, we hope that the increasing level of knowledge will provide us with further incentive from and for practice.

How do detection systems work?

The radar- or camera-based bird detection systems recognise flying objects and/or flight activity in the area (e. g. distance, flight altitude, and flight direction). This results in large amounts of data. High-capacity servers are required to transfer and process the data.

Birds (including the "target species"[4]) approaching a turbine are detected as flying objects. The detection range (spatial coverage) of radar systems is greater than that of camera systems. System coverage is a decisive criterion in the validation of system performance, since timely turbine curtailment can only be carried out with sufficient range and spatial coverage.

The actual "identification" (synonym: classification) of the flying object takes place with the help of programmed algorithms or algorithms obtained by "deep learning". Classification can be based on the size of a bird (size classification). Moreover, automated image recognition systems should also be able to perform species-specific classification. Here, development has progressed to different degrees. As a general rule, the more reliable the classification, the more targeted the turbine curtailment can be carried out.

A system reaction is triggered if the distance between the bird and a turbine falls below a minimum distance to be defined. This can be a deterrence (e. g., acoustic signals) or the temporary shutdown of a turbine. The former aims to ensure that the bird does not fly into the rotor swept zone and instead turns away. The latter triggers a reduction in the rotor speed. The aim is to achieve a rotor speed that no longer poses a significantly increased risk of collision (spin mode).

The higher the flight speed and the longer it takes for the rotor to enter the spin mode, the greater (a) the distance of the bird from the wind turbine at the time of detection needs to be as well as (b) the detection range of the system.

3 The system performance only describes the ability of the system or its components to detect birds and does not include an assessment of effectiveness. It includes the criteria detection range, detection rate, flight object identification or classification, without initially taking into account site-related restrictions (e. g., limited visibility, system failures) or the subsequent reaction (deterrence or shutdown).

4 Target species are those species for which there is a significantly increased risk of collision and on which the minimization measure is focused on.

What has happened so far

To begin with, we created a synopsis of the radar and camera systems available on the market to date—without evaluating their suitability (KNE 2017, 2018, 2020). The most important system manufacturers introduced themselves at this conference ("Marketplace") thereby facilitating a comparison of development (see page 49).

Parallel to noting the systems available on the market, the KNE researched the knowledge currently available about their application—also abroad—and conducted discussions with experts to close knowledge gaps. In Europe, individual systems appeared in permit practice, but were not widespread.

Subsequent to the first event on this topic in Germany held by the "Klimaschutzagentur Region Hannover" (February 14, 2018), several project developers and/or authorities contacted the KNE for advice regarding the conflict resolution potential of detection systems. In detail, this involved

- clarifying uncertainties about the existence of a significantly increased risk of collision (e. g., remaining uncertainties about flight activity, frequency of overflight, etc.), especially in the case of rare or difficult to predict flight events (e. g., foraging flights);
- the reduction of predetermined shutdown requirements (during breeding and reproductive periods, during and after agricultural land use management events) for sites where the occurring flight activity is relatively low;
- ensuring sufficient minimisation effectiveness (e. g., insufficient effectiveness of or lack of availability of land for habitat enhancement measures);
- the handling of post-permit colonisation of breeding birds sensitive to wind energy in the vicinity of a licensed turbine.

An expert workshop on the key points as to how proof of suitability and effectiveness can be validly and scientifically provided in within the framework of a trial resulted in a "Profile of requirements" (KNE 2019). This is intended to support project developers in testing the suitability and effectiveness of the applied system in a comprehensive and comparable manner. Important points for the implementation of field trials are: Which method should be used for the validation in the field? Which devices should be used? Which criteria are essential for assessing the suitability and effectiveness of a) the automated "detection" and b) the "reaction" (triggering an incentive such as deterrence or a turbine shutdown)?

In cooperation with operators and experts on site, from a scientific viewpoint it is primarily a matter of gaining knowledge about essential parameters necessary for assessing suitability and effectiveness which include spatial and temporal coverage, detection rate and range as well as accuracy of classification.

There are first cases in which this proof is a prerequisite for obtaining a permit. In these cases, the KNE is available for consultation. The aim is to carry out field tests in specific cases in such a way that reliable results can be achieved. However, the KNE does not replace the commissioning of an independent consultancy firm for data collection and analysis.

The operator-initiated system validations complement the R & D project NatForWINSENT financed by the Federal Agency for Nature Conservation (see page 10). The field trails cover various bird species (e. g., red kite, white-tailed eagle, black stork) and different environmental as well as site-specific conditions. The results are intended to broaden the empirical basis and therefore enhance the current state of knowledge. In practice, the KNE sees itself as an independent consultant. In addition, the KNE also acts as a coordinator and mediator among those involved (exchange platform).

In addition to the topics described, the KNE also dealt with the influence of turbine curtailment on the turbine itself and the economic efficiency of turbine

More than 200 participants of all stakeholder groups involved in environmentally sound wind energy development came together to exchange information on the current state of detection systems for smart curtailment on demand to minimize bird collisions with wind turbines.

operation (expert workshop “Technical and economic aspects” on December 6, 2018 in Kassel). These aspects play an important role from the operator’s point of view when it comes to assessing the possible applications. Parallel to a validation of the detection systems, there is a need for further specification and clarification. To this end, system manufacturers and wind turbine manufacturers should seek closer cooperation.

Outlook

The validation of detection systems can pose numerous challenges: the theoretical performance of the systems can be restricted by visual obstacles (topography, buildings, vegetation) and unfavourable weather conditions. What happens if there are several individuals in the surveillance area at the same time? Can the system detect, locate, track, and identify all of their flight movements?

In the future, where will the “lower limits”, i. e. thresholds and minimum requirements be for the application of the systems? Which technical and economic framework conditions have to be observed? The KNE will continue to pursue these questions after the conference. Together with the German Federal Agency for Nature Conservation (BfN) and the “Fachagentur Wind an Land” (FA Wind), a joint paper is planned in which the progress is documented.

DR. ELKE BRUNS

has been head of KNE’s specialist information department since 2017. Thanks to her practical and scientific work on numerous research projects, among others at the TU Berlin (2000 to 2012), she has extensive knowledge of the instruments that foster the environmentally sound development of renewable energies. The current focus is on issues relating to species protection laws and possibilities for designing renewable energy uses that are compatible with nature.

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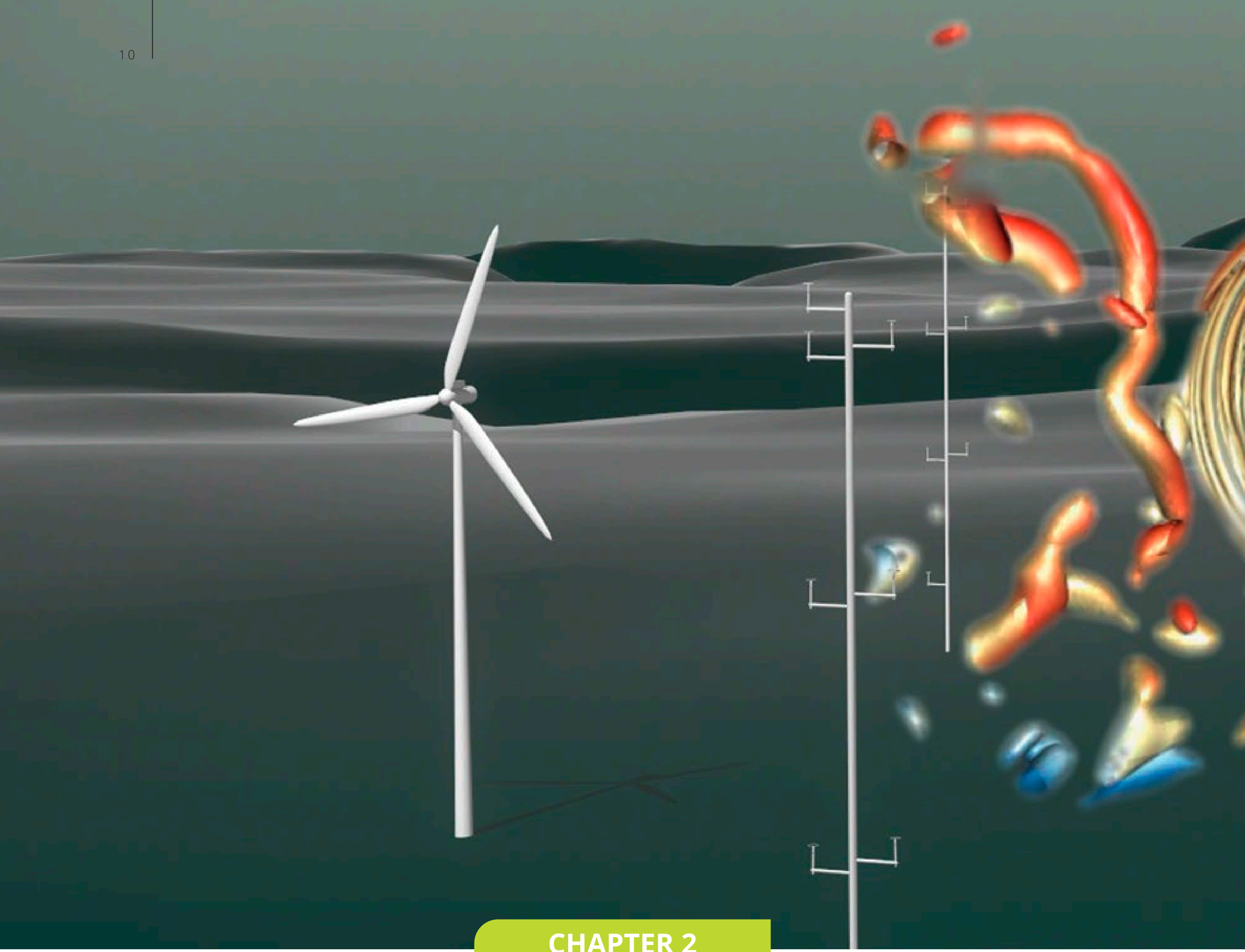


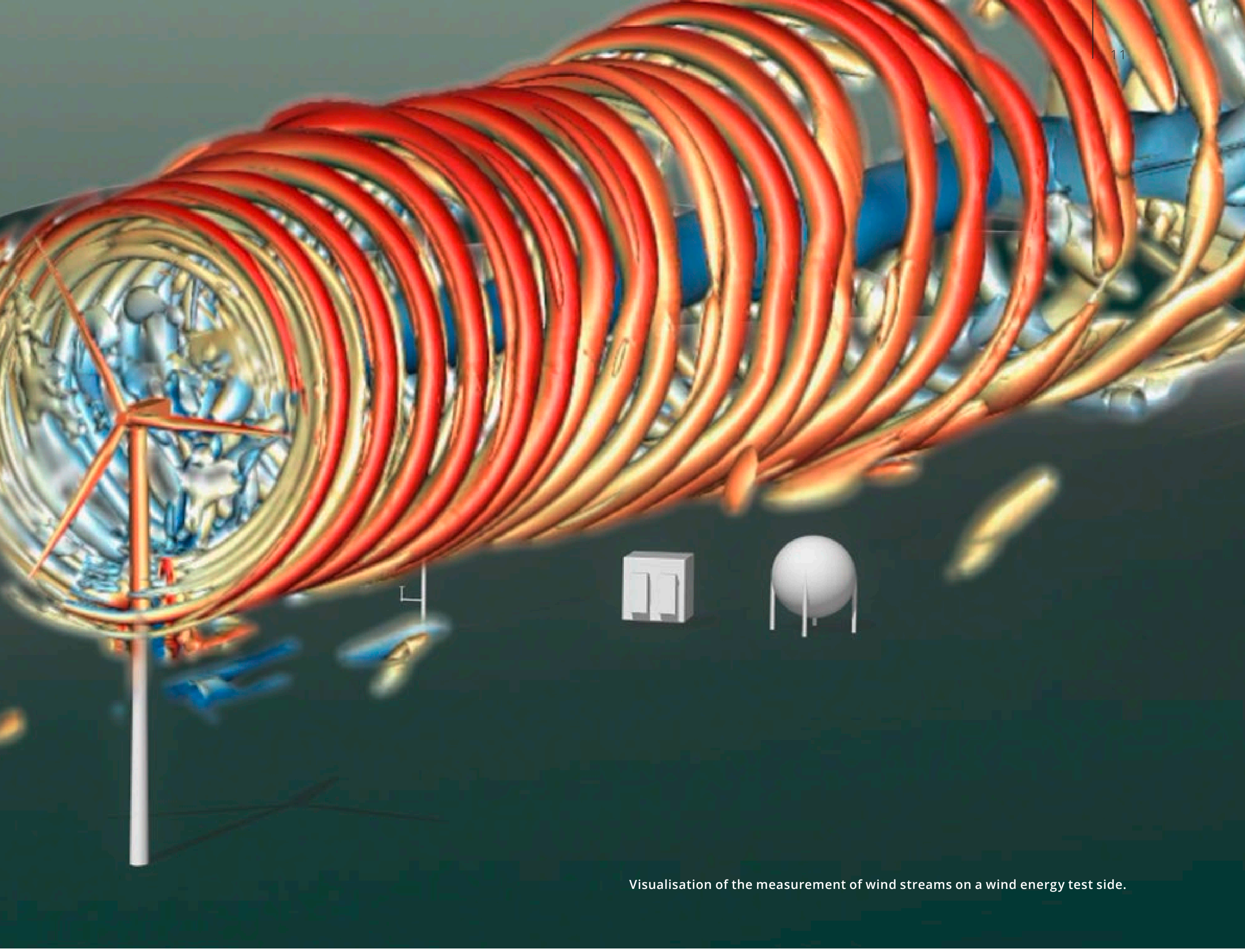
CHAPTER 2

NatForWINSENT

Validating detection systems in the context of nature conservation research on a wind energy test site

Dr. Janine Aschwanden and Dr. Frank Musiol

The project "NatForWINSENT—Nature Conservation Research on the Wind Test Site" is dedicated to the development and testing of innovative avoidance measures for birds and bats. For this purpose, the infrastructure of WINSENT is used, the first wind science and engineering test site in complex terrain initiated by the Wind Energy Research Cluster South (WindForS) and operated by the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW). Testing automated bird detection systems is part of this mitigation research.



Visualisation of the measurement of wind streams on a wind energy test side.

Nature conservation research on the wind test site

The Wind Energy Research Cluster South (WindForS) has initiated the first wind energy test site in complex terrain. The commissioning of the test site consisting of two research wind turbines (WT) and four wind meteorological masts (see Figure 1) WINSENT is planned for spring of 2020 in the municipal area of Geislingen in the district of Göppingen. With its extensive infrastructure and measuring equipment, the project operated by the ZSW is also available for nature conservation research. For the first time, researchers will also have the opportunity to intervene in the operation of WT to investigate. Within the framework of the project "NatForWINSENT—Nature Conservation Research on the Wind Test Site" funded by the Germany Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) and the German Federal Agency for Nature Conservation (BfN), especially innovative avoidance measures for birds and bats are to be developed and validated. The ZSW as head of the project can ensure the close interlinking of technical and nature conservation research. Renowned partners in this field of expertise have been recruited for the design and implementation of nature conservation research.

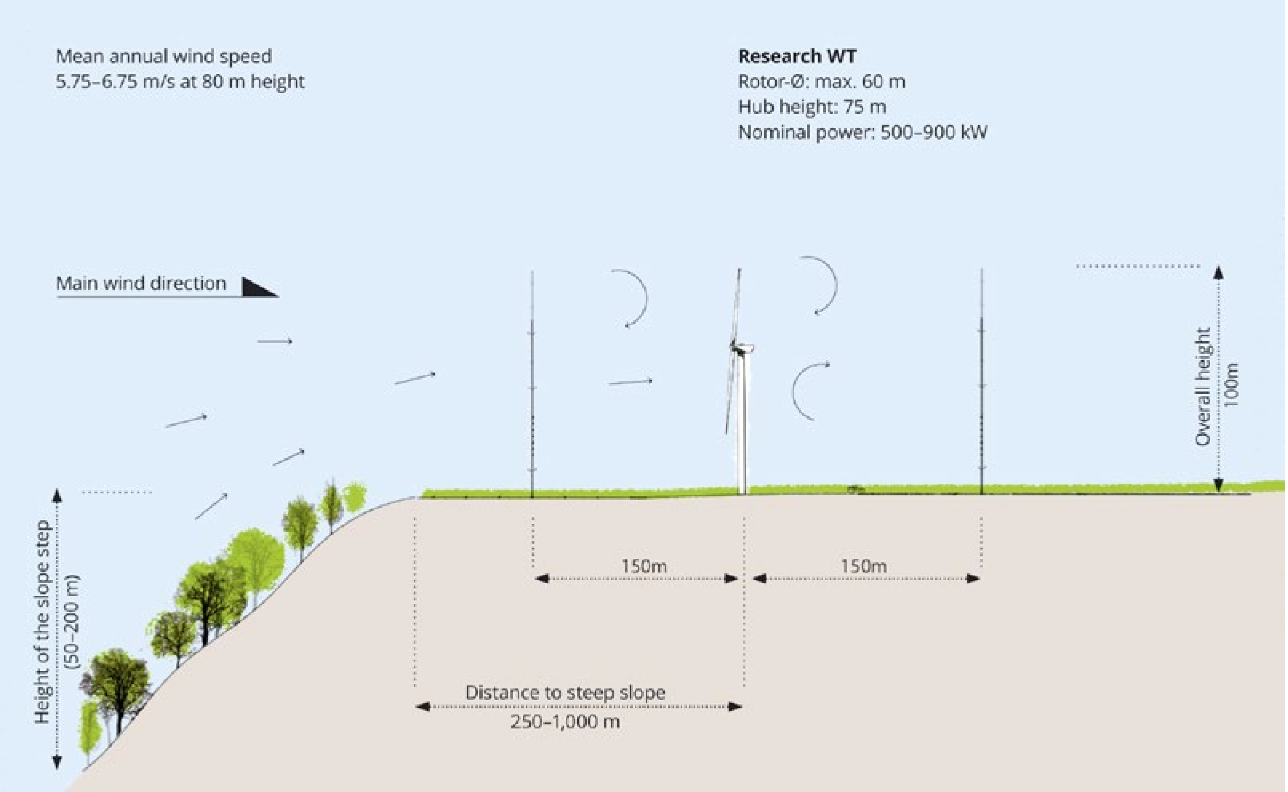


Figure 1: Schematic diagram (© LAREG, TU Munich) of the experimental set-up for one of the two research WT on the test site.

Validating detection systems

The Swiss Ornithological Institute is in charge of bird research. The main objective here is to design and validate mitigation measures to protect birds from colliding with WT. The measures include automatic bird detection systems to facilitate turbine curtailment on demand, triggered by the approach of individual birds belonging to a target species. Within the framework of the project, a requirement profile is to be developed which such systems must meet in order to be used reliably from a nature conservation point of view.

During the lead time until the construction of the WT in spring 2020, basic data on the flight behaviour of birds will be collected on the test site. In the summer/fall 2019, two automatic detection systems are expected to be validated. After the construction of the WT, the collection of basic data will continue. So far, field tests of two further detection systems are planned after construction in summer/autumn 2020 and as of 2021 also tests for smart curtailment. With an average flight activity of two flight paths per observation hour within a radius of around 500 meters around the test site, three to four weeks of observation time are expected per validation.

Validation methodology

The basic data comprises three-dimensional individual flight paths, mainly of red kites, which are recorded with a laser range finder (LRF), and of local red kites, which are equipped with a GPS transmitter. With the LRF, a trained observer can manually and optically track birds and record position data in three dimensions at short intervals. The GPS transmitters of the red kites are programmed in such a way that in the area of the test site data is available which is as to-the-second data as possible. Using the time stamp of the individual localisation points (LRF and GPS data), the individual flight paths are to be intersected with the flight objects detected by the detection and shutdown systems. Birds that have been observed in the surveillance area of a system specified by the manufacturer should also have been detected by the system and, if necessary, have triggered an operational shutdown (possible virtual implementation of operational adjustments). In addition, the target species recognition of the systems will be investigated by checking the false positive and false negative rates. Also of interest is the detection range at which target species identification is possible. The data of the detection systems together with the flight observations can also be combined with the detailed meteorological data collected on the test site so that at any time of a localisation, for example, visibility and wind conditions at different altitudes above ground can be included.

Expected results

After conducting the field tests, we expect to gain insights into the reliability of target species detection and identification with different systems, initial insights into automated, turbine shutdowns on demand, and more insight into creating a requirement profile that such systems, taking into account the insights into the flight behaviour of the target species, should fulfil for effective deployment. A requirement profile should be available by the end of 2020/beginning of 2021. The form and timing of the publication of test results are coordinated with system manufacturers and the BfN.

Providers wishing to have their system validated as part of NatForWINSENT can contact the project coordinator.

DR. FRANK MUSIOL

is a physical chemist and has been working in the ZSW's systems analysis department since 2006, where he has been focusing on statistics and funding instruments. Prior to that, he worked as an energy and climate advisor for Nature and Biodiversity Conservation Union (NABU) on issues such as conflict between the use of renewable energies and nature conservation. Since 2017, he has again been working on this topic in the Wind Energy Team as head of the NatForWINSENT project.

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DR. JANINE ASCHWANDEN

is a biologist and has been working as a research associate in the department of bird migration research at the Swiss Ornithological Institute in Sempach since 2010. Her tasks include the management of various projects in the field of wind energy and birds.

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Figure 1: Mobile BirdScan-System with two radars, weather sensor and internet connection.

CHAPTER 3.1

Spatial surveillance and protection of large birds

Testing the BirdScan system for monitoring and minimizing bird collision by means of smart curtailment of wind turbines at the Osterburg site in Saxony-Anhalt.

Daniel Früh

Initial situation

As part of the Osterburg project, three Vestas V136 wind turbines (WT) will be erected by "FEFA Ingenieurbüro für regenerative Energien". The entire area covered by the Osterburg wind farm was surveyed in advance by the independent "Stadt und Land Planungsgesellschaft mbH" that carried out an accompanying landscape conservation plan as well as an assessment relating to species protection regulations. A total of 86 bird species were identified in the course of these investigations. The Osterburg project is primarily concerned with the identification of birds of prey, in particular, the red kite.

The reason for using the BirdScan system from "Swiss Birdradar Solution AG" is the importance, as demonstrated in preliminary studies, of the suitability area as an important foraging ground for local bird species.

To monitor the wind farm area and to validate the system, the BirdScan is installed in the middle of the study area. The system looks to the north-east and monitors a large part of the feeding area. Furthermore, the system was included in the permit as an ancillary provision. Here it was established that after commissioning of the WT the system must monitor for two years. After these two years, it will be decided together with the Regional Nature Conservation Authority (UNB) and the State Bird Conservancy whether it has to remain installed on site or can be dismantled. Under these conditions, approval for the Osterburg wind farm was granted in October 2018.

Figure 2: Evaluation of a flight path of a red kite in 3D.

System configuration

The radar monitors the airspace for bird-like targets and tracks as well as classifies large objects such as the red kite fully automatically and in real time. Due to the number of sensors used, the detection range between 90 and 360 degrees can be selected according to the case-specific requirements. For validating purposes, the system consists of various modules: sensors (radar, camera, and weather sensor—on mast, see Figure 1) and Central Processing Unit (CPU, components installed in a rack).

Spatial coverage

The field of view of each radar sensor is a three-dimensional cone with horizontal coverage of 90 degrees and vertical coverage of 40 degrees. In the simplest case, four radar sensors are required for 360 degree monitoring.

Using state-of-the-art electronic beam shaping and intelligent algorithms, BirdScan permanently monitors the airspace and records all flight movements in 3D coordinates. The user can define criteria to determine which objects are tracked, classified, and recorded.

Validation method

A camera system has also been installed for the validation of the radar system so that the data recorded by the radar can also be checked outside the field observation times carried out by the ornithologists. The camera is steered by the radar to focus on the object to be viewed based on definable criteria. As soon as optical detections are made, the images are recorded. This way the images can be compared 'offline' by ornithologists with the results of the radar detections as well as field observations and transferred to the reference database of the classification algorithm.

Environmental factors have an effect on flight behaviour. To this end, a meteorological station at the site continuously measures air temperature, relative humidity, air pressure, wind direction and speed, precipitation quantity, intensity, and type, UV index, sun position, brightness, twilight, and radiation.

On 24 selected dates from April to October field observations by ornithologists take place on site. Tracks recorded by the radar are identified (birds, people, cars, cows, etc.) and entered into a database. In addition, the detection rate and range are investigated and optimised using a drone.

First results and optimisations

Initial results from drone flights and statistical evaluations have shown that the radar can detect red kites up to 1,200 meters, depending on the approach angle. The classifier is continuously optimised on the basis of camera data and field observations. The power supply is autonomous, therefore only minor outages occurred since commissioning in April 2019, but otherwise the system has permanently recorded 24 hours of data.

Observing the spatial distribution of flight activity

The system can be used by means of fully automatic long-term observation for the spatial distribution of flight activity of larger birds by day and by night. As a result of the findings, possible effects of the temporal and spatial activities of protected large birds on the operation of a future infrastructure can be better assessed, and, further, experience about the effectiveness and possibilities of a radar-based monitoring system can be gathered and evaluated already during the project planning phase.

Active collision risk management

The ability to monitor and identify birds also enables the system to be used for active collision risk management in the surrounding of WT. Using the real-time information available on the objects in the surveillance area and by way of an analysis combined with a shutdown algorithm, the potential risk of collision of protected large birds with WT can be minimised. This is done by a timely transfer of a stop signal to the wind farm controlling and management system.

Goals of the system validation

During the observation period, the flight altitudes at which bird activity is taking place will also be assessed in order to show the potential risk of collision in the altitude range covered by the rotor swept zone. The system validation and optimisation will take place during the construction of the new WT over a period of approximately six months before and three months after commissioning from April 2019. The aim of the validation is to demonstrate the effectiveness as an acknowledged system for spatial analyses of flight distribution and as mitigation measure to minimise collision risk of wind-sensitive species such as the red kite.

Outlook

The test will be carried out between April 2019 and March 2020. The schedule (see Figure 3) provides an overview of the main activities. The following parties are involved in the system validation:

- Swiss Birdradar Solution AG:
  Project management of system validation including installation and provision of sustained operation, optimisation of system components, development and optimisation of software for detection and identification, ongoing manual and static analysis of data, programming interface to WT and reporting.
- FEFA-Projekt GmbH:
  permits, wind farm site, site access, infrastructure, WT installation and operation.
- Stadt und Land Planungsgesellschaft:
  data acquisition, field observations.
- Competence Centre Nature Conservation and Energy Transition:
  Revision of validation method (e. g., implementation of validation criteria), integration of stakeholders, plausibility analysis and classification of findings (e. g., transferability), assistance for the publication and distribution of results.

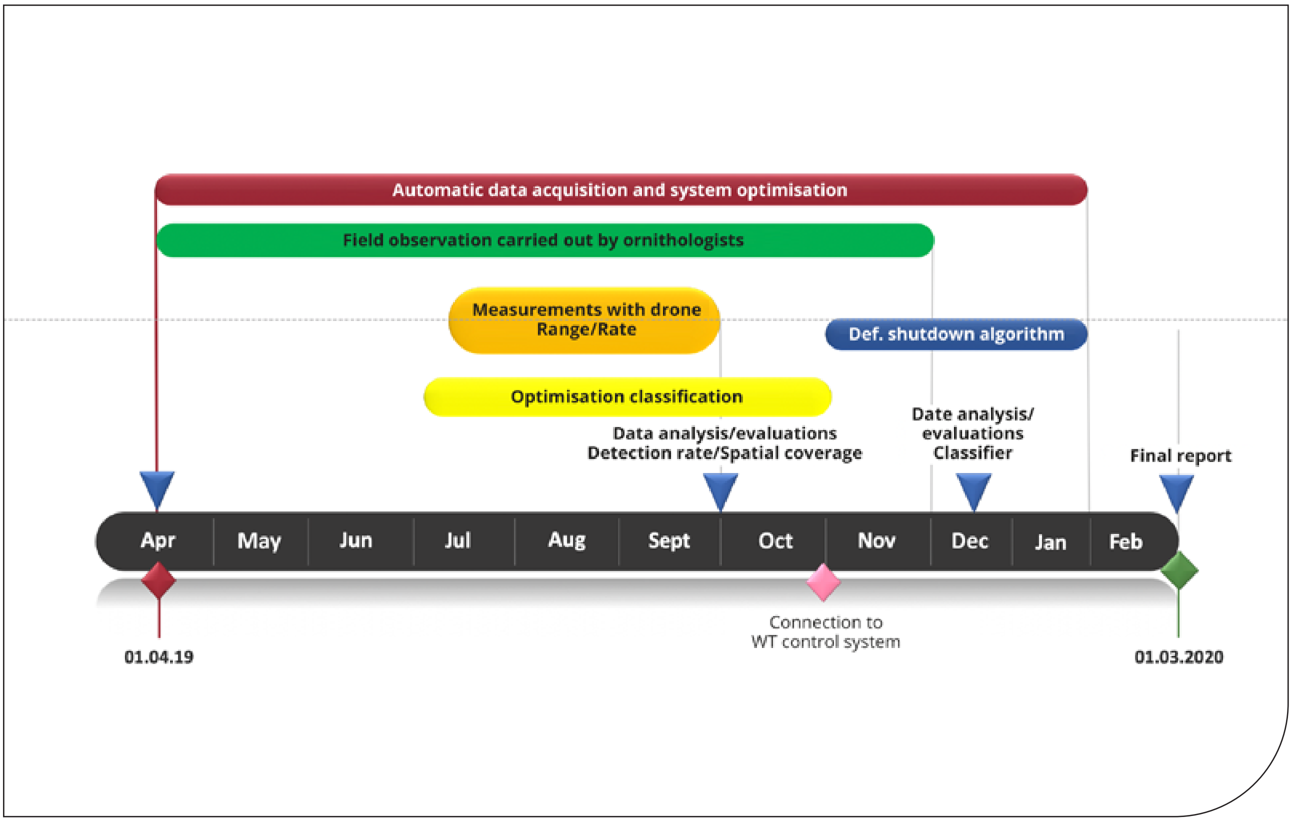

Figure 3: Time and work schedule.

DANIEL FRÜH

After completing his training as an electrical engineer, Daniel Früh headed up the electronics and high frequency technology research group at the University of Applied Sciences. He played a key role in the development of bird radars. For two years now he has been the technical director and a partner at Swiss Birdradar Solution AG and the main coordinator for development.

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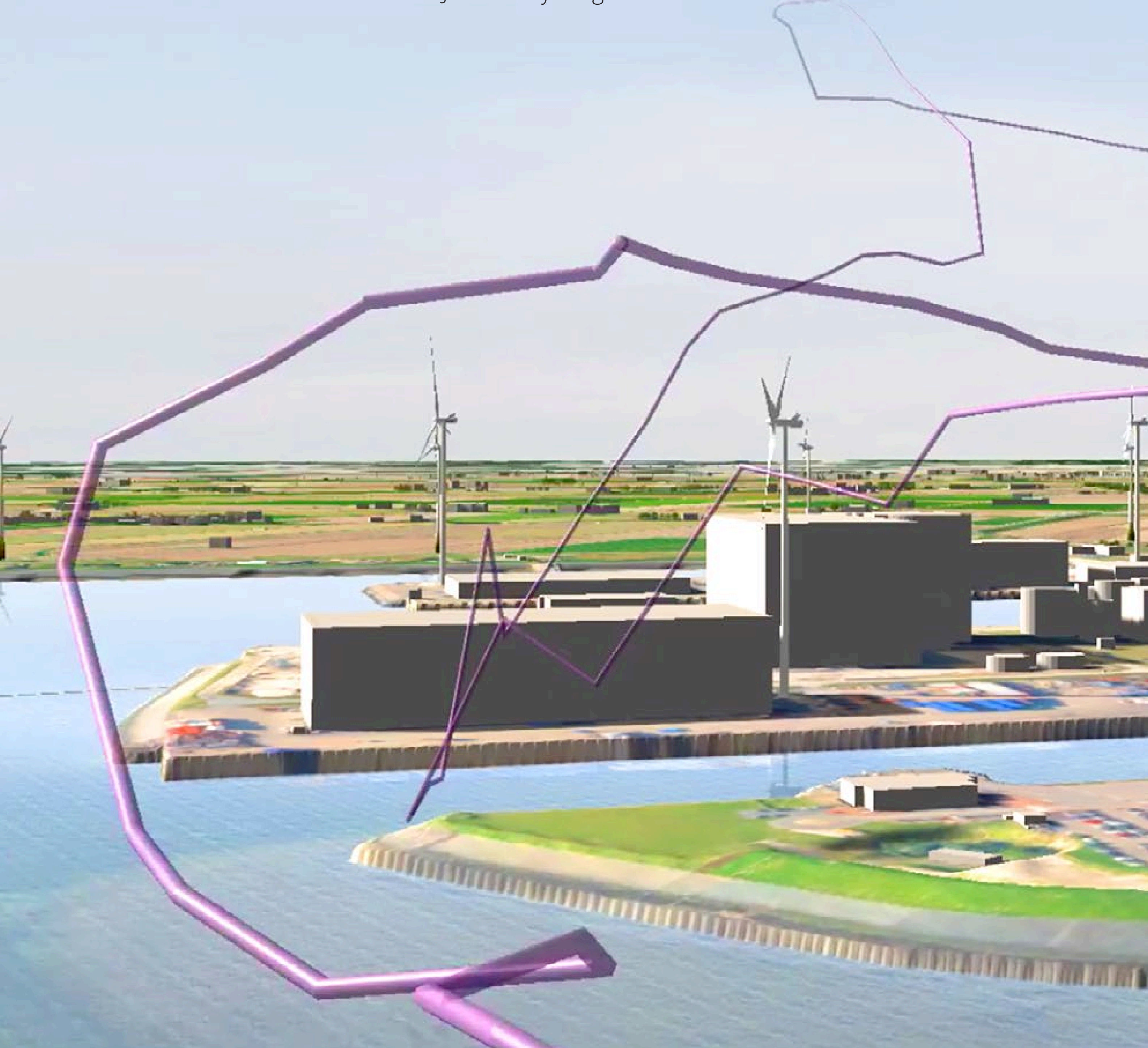
CHAPTER 3.2

Using full 3D bird radar

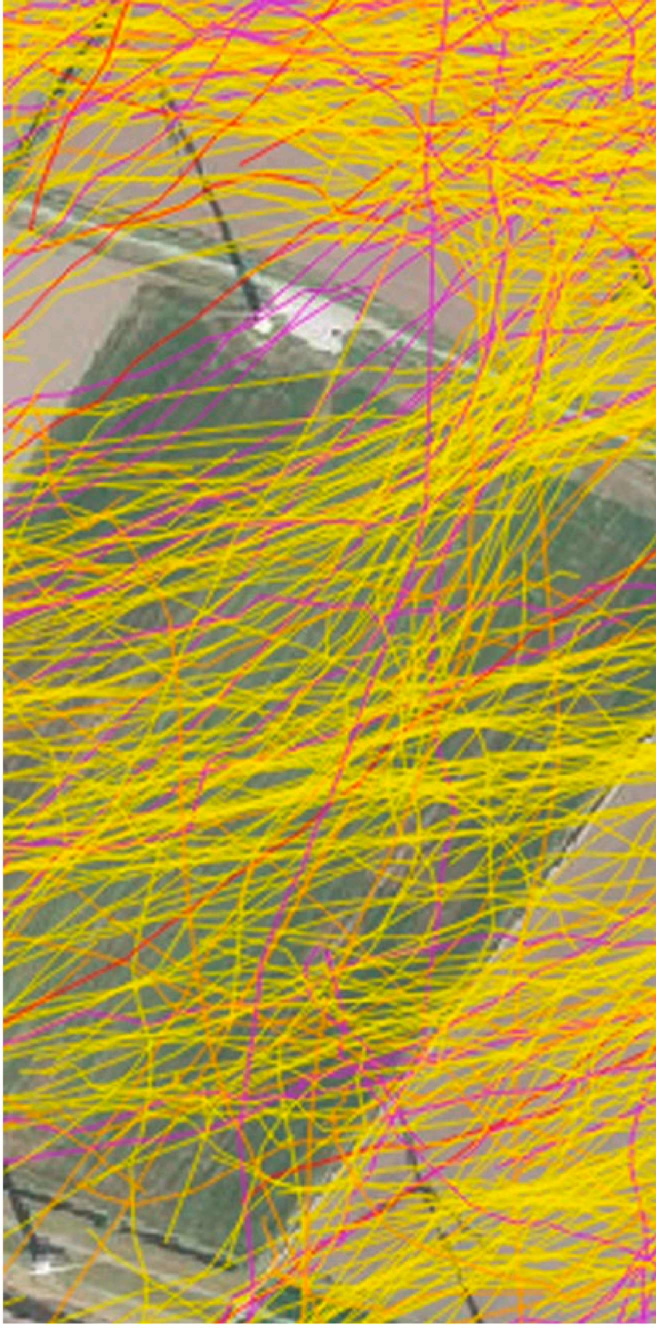
to assess bird flight behaviour in and around wind farms

Jonne Kleyheeg-Hartman



Since 2018, Bureau Waardenburg has been studying the flight behaviour of birds with the novel full 3D bird radar MAX®. We measured bird migration in the Eemshaven, a harbour area in the north-east of the Netherlands. This was part of a larger project, which aims to develop a predictive model for shutdown on demand for wind farms to reduce bird collisions. We share our first experiences with this radar concerning classification, species recognition, spatial and temporal coverage and detection range.

Figure 1. Part of a 3D flight path of a flock of Greylag Geese entering the Eemshaven, recorded by MAX. 3D visualisation



Full 3D bird radar MAX®

Since 2018, Bureau Waardenburg has been studying the flight behaviour of birds with the novel full 3D bird radar MAX®, manufactured by Robin Radar Systems. This radar generates a 3D image of the flight path of every bird within its range. Due to the stacked beam design of this radar its detection zone covers (almost) half a sphere. MAX is equipped with automatic clutter filters and tracking and classification software. Thereby, the live radar images do not include clutter and directly show tracks of birds and other moving objects. All information is automatically stored in a database ready for analysis.

The Eemshaven project

We gained our first experience with the 3D bird radar in a project in the Eemshaven where we quantified bird migration. The Eemshaven is a harbour area that is located in the north-east of the Netherlands in the province of Groningen. In autumn and spring, hundreds of thousands of birds migrate over the Eemshaven area. Most of these birds are songbirds like for instance several species of thrushes but especially in spring also large numbers of raptors, like for instance Marsh Harriers, migrate over the Eemshaven area. Under specific conditions the area is known to function as a funnel for migrating birds. The Eemshaven region currently accommodates almost one hundred wind turbines and the installation of another hundred is planned in the coming years. This combination of many wind turbines and many migrating birds leads to a large number of collision victims. An average of approximately 33 birds is killed at each turbine each year, of which almost half are migrating birds.

The Dutch government is seeking a way to reduce the number of collision victims of migrating birds. One method is to shut down wind turbines in periods of high collision risk. To prevent problems in the electricity grid, the moments of shutdown have to be predicted at least 48 hours in advance. Therefore, the government asked a research consortium to study the feasibility of the development of a predictive model for shutdown on demand for nocturnally migrating passerines. In this project we use data from the meteorological radars at Emden and Borkum, which measure large scale bird migration at high altitudes. Additionally, local (lower altitude) bird migration is measured in the Eemshaven with the 3D bird radar MAX. We did not use this radar to automatically shut down wind turbines, although it does offer this possibility. Finally, collision victim searches are performed in the existing wind farm to determine under which conditions nocturnally migrating passerines collide with the wind turbines.

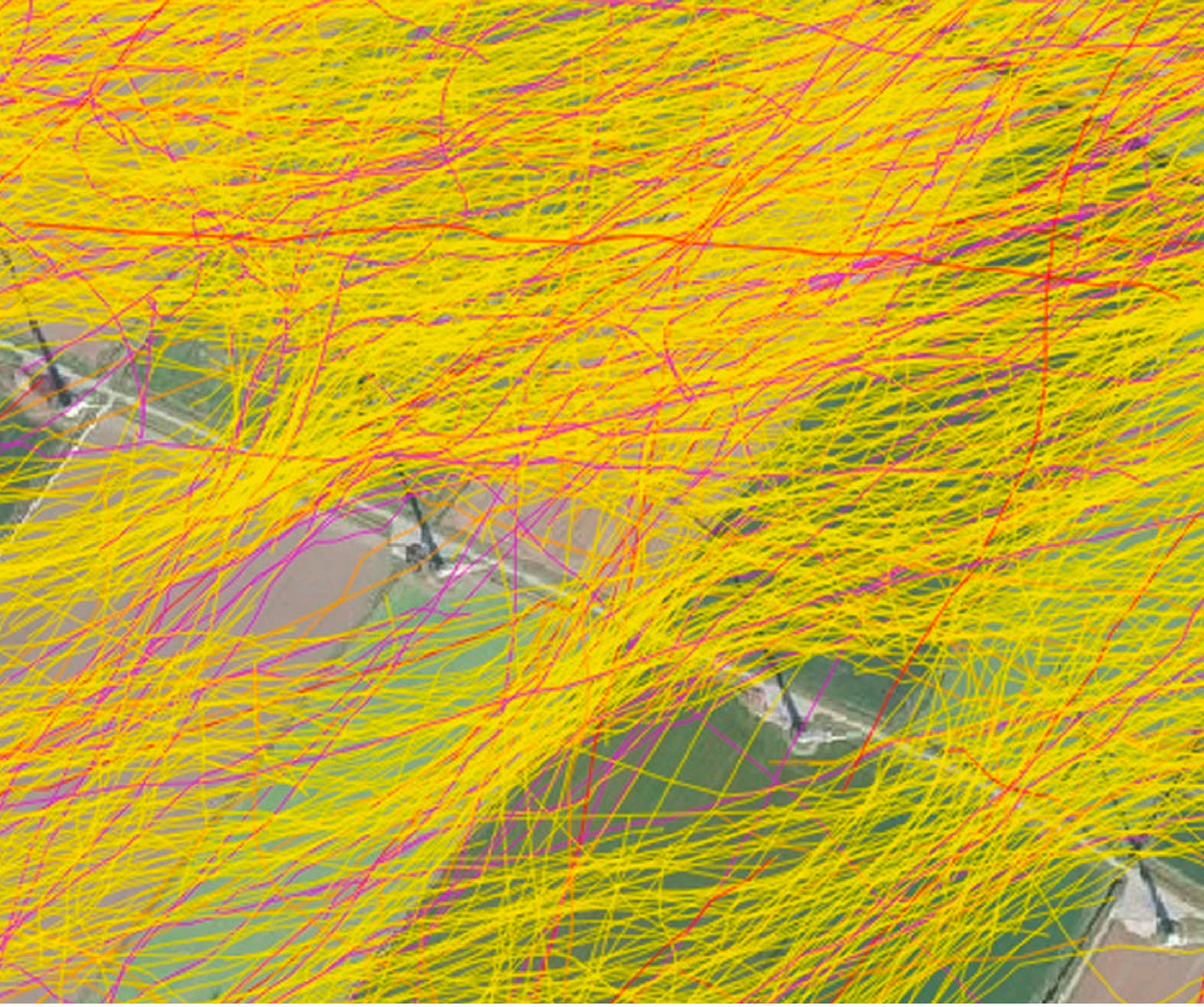


Figure 2. Indication of the spatial coverage of the 3D bird radar close to wind turbines. Shown are 30 minutes of bird tracks recorded during a night with intense migration in the Eemshaven. The 'gaps' around the wind turbines are not (only) caused by birds avoiding the wind turbines, but show areas where MAX cannot see birds due to the reflection of the wind turbine.

First experiences

We have not yet fully validated the system, so we are currently unable to quantitatively comment on the performance of the 3D bird radar. However, we can deliver anecdotal information based on our experiences in the Eemshaven to provide some preliminary insights into the capabilities of MAX®.

Tracking, classification and species recognition

MAX distinguishes birds from other moving objects like for instance vehicles, aircrafts and slow-moving targets. Birds are classified in four size categories:

large birds, medium birds, small birds and flocks. This classification gives a good indication of the identity of the object (birds are often correctly classified as birds) and it provides a useful idea of the size of the bird. It is, however, not always accurate. E. g., sometimes insects or tree seeds floating on the wind are classified as small birds and sometimes a large bird, like for instance a Buzzard, is classified as a small or medium sized bird. Currently, bats, insects and other smaller flying objects cannot be separated from small birds. In the future we would like to try to optimise the classification algorithm. At the moment we are, however, mainly focussing on the validation of the system. MAX is very well suited to detecting individual birds and following their flight paths in 3D (see Figure 1). Species recognition is, however, not possible. So far only the four size classes can be distinguished. The reason why species recognition is difficult for any radar is because the only available information concerns the reflection of the bird and its behaviour. As opposed to for instance camera systems, there is no information on colour, shape or actual size.

Spatial coverage

The radar covers a 360-degree area. The characteristics of the surroundings determine where the radar is able to detect birds and where any blind spots will be. The radar's detection was surprisingly good above the tidal area in the Wadden Sea. Here, even low flying birds were detected very well and we didn't experience any problems with sea clutter. Inland, the detection of the radar was blocked by objects such as wind turbines, buildings and ships. Close to a wind turbine (within several tens of metres) the radar cannot track birds due to the reflection of the wind turbine. This means that MAX cannot detect birds colliding with wind turbines (see Figure 2).

Detection range

The detection range is determined by the size of the bird and the presence of obstructions to the radar signal. In theory, the absolute maximum horizontal detection range of MAX is almost 15 kilometres for a very large bird or flock. In the Eemshaven, we saw significant numbers of large birds and flocks up to approximately seven kilometres from the radar and small birds up to about three kilometres. Some birds were seen at greater distances to the radar. For an area like the Eemshaven, with many obstructions to the radar signal, the realised horizontal detection range matched with our expectations. The theoretical maximum vertical detection range of MAX is about 0.5 to two kilometres depending on the size of the bird and the distance to the radar. The altitude profiles that we created with data collected in the Eemshaven in autumn 2018 concur with these maximum detection ranges, however, the amount of birds detected at higher altitudes is lower than we expected. Above approximately 500 metres, the radar detected almost no birds (only 2 % of all bird tracks). We shared our findings with Robin Radar and they are adjusting the software to improve the detection at higher altitudes. For measurements of bird behaviour in and around wind farms the vertical detection range is already sufficient.

Temporal coverage

MAX completes one full rotation every second and the created image is stored in the database. If there is a continuous power supply the radar can continue measuring for an unlimited amount of time. The data can be automatically transferred from the local radar system to a database at a preferred location, which ensures that the local storage capacity does not limit the amount of time that measurements can be made. This combination of a very high update rate with 24/7 measurements for an unlimited time period enables us to study bird behaviour on a broad scale (several months), but also to zoom in on a specific time window of for instance several hours.

4. Concluding remarks

The novel full 3D bird radar MAX realises a very high data resolution both spatially and temporally. This leads to the collection of huge amounts of data with a corresponding amount of possibilities for analyses. This radar is very well suited for the detection and study of flight paths of individual birds in 3D. The radar cannot track birds close to static objects like, for instance, wind turbines. This means that MAX is not suited for collision monitoring. It is possible to simultaneously follow an unlimited number of individual birds and flocks. Species identification is not (yet) possible, however, in the future we would like to try to develop algorithms for the automatic classification of distinctive species or species groups.

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Figure 1: One of the four camera units of the validated DTBird Day Detection Module at a height of 30 meters on the WT tower.

CHAPTER 4.1

Validating DTBird as a technical system for the protection of birds of prey

Martin Sprötge

With DTBird and ProBird, "planungsgruppe grün GmbH" is currently investigating two camera-based systems designed to minimise birds from colliding with moving rotor blades. The following illustrates the DTBird case study and presents initial experiences with the system as well as the methodology.

Camera-based systems capture the immediate surroundings of the WT using several camera units, detect objects on a collision course, and aim to warn birds (warning sounds) and/or reduce the danger of a possible collision by curtailing the WT in risk situations. Since 2018, "Energiekontor" has been validating the DTBird system at a wind turbine (WT) in north-eastern Lower Saxony.

The aim of the study carried out by "planungsgruppe grün" is to determine the accuracy (detection rate, classification by size) of the DTBird system when detecting birds in the vicinity of the turbine, the reliability of the system's response, and the birds' response to the DTBird avoidance measures (warning sounds, WT curtailment). Observations carried out in 2018 was mainly used to validate and optimise the validation method.

Turbine type and siting

The test WT belongs to a wind farm consisting of 18 WT and started operating in 2001. It has a hub height of 100 meters, a rotor diameter of 77 meters, therefore a total height of 138.5 meters, and a clearance below the rotor of 61.5 meters. In the broader vicinity of the turbine (more than 1,500 meters away) red kites (PGG 2018), common buzzards (more than 500 meters away), honey buzzards (more than 1,000 meters away), and marsh harriers breed. These species also use the area surrounding the test facility during foraging flights or during daily migration. In addition, numerous common songbird species of the agricultural landscape breed in the immediate vicinity of the turbine (skylark, yellowhammer, mistle thrush, etc.), and species such as wood pigeon, carrion crow, grey heron and other similar species regularly pass through the airspace around the rotor. The test turbine is located on a field that was cultivated with crop in 2018. The surrounding countryside is characterised by agriculture, mostly with groves along the paths. In the north, 510 to 660 meters away, there is a larger forest area in addition to smaller patches of trees. The view of approaching birds in the DTBird surveillance area is not restricted by the forest.

DTBird system

Systems are available from DTBird which detect birds close to the turbine and, depending on their distance and behaviour, either emit sounds or initiate a turbine shutdown. This should warn the birds and prevent a collision with the WT. The system manufacturer has one camera system for diurnal birds and one for nocturnal birds. The DTBird Day Detection Module is available in a model with four (V4) and a model with

Wingspan	Set-up range	System	
		V4	V8
Larger than 150 cm	200–320 m	×	
	350–600 m		×
75 to 150 cm	100–200 m	×	
	175–350 m		×
smaller than 75 cm	25–100 m	×	
	25–175 m		×

Table 1: Detectability of birds of different sizes at certain distances regarding the two possible system configurations with four (V4) or eight camera units (V8) according to the manufacturer (DTBird 2018).

Figure 2: The red kite, as a species sensitive to wind energy, is a frequent target species in ongoing field tests.

eight camera units (V8), which differ in their detection precision. The company indicates that with a higher number of cameras smaller birds can already be detected at a greater distance (see Table 1). Together the cameras cover an area of 360 degrees and, depending on the project, are mounted at a height of five to 80 meters on the WT tower (see Figure 1).

To emit the warning sounds, the Collision Avoidance Module is used, which consists of an amplifier and four to ten loudspeakers. These are attached to the turbine tower at a height of ten to 130 meters or to the nacelle, depending on the project. Depending on the proximity of the bird to the turbine, two different sounds can be emitted:

- The warning signal alerts a bird that might be on a collision course with the obstacle, but does not yet have a deterrent effect.
- Whereas the deterrence signal should be emitted when the bird continues to approach the turbine and should have an unpleasant effect on the bird, causing it to avoid the rotor sept zone.

In addition, the system manufacturer offers to install a Stop Control Module, which automatically puts the system into spin mode or significantly reduces the rotational speed of the rotor before a possible bird collision can occur.

The system installed on the test WT consists of a Day Detection Module with a V4 system at a height of 30 meters and a Collision Avoidance Module D10 with two ring levels of loudspeakers at a height of 50 and 85 meters respectively. It was assembled in spring 2018. The software of the DTBird system, however, could not correctly retrieve the alignment of the nacelle and the operational status of the rotor of the WT until some time in July. According to DTBird, this led to a lower probability of detection of bird flights and thus to a poorer efficiency of the Collision Avoidance Module, meaning the sending of warning and deterrence signals. And so, after an installation phase the system was in operation as of May 4, 2018, but only under the limited conditions described above.

The Stop Control Module could not be implemented due to a lack of communication on the part of the DTBird system with the WT up to the completion of the field observations in 2018.

Experiences from 2018

The studies in 2018 were carried out by one observer per observation date (a total of 12 dates) within a radius of 500 meters around the WT. Technical aids included long-range optics and a Zeiss rangefinder. The analysis of the observations resulted in the following:

- With 0.39 flights of birds per hour (maximum distance to the WT 350 meters) only a very small number of flights were observed near the rotor. This is due, among other things, to the great distance to the nesting sites of the target species (birds of prey, large birds) and the topography at the turbine site.
- At 32 percent, there was a very high proportion of system reactions without explainable triggers. The source of the error may be the insufficient number of observers (bird flights within a 500 meter radius are too easily overlooked) as well as technical sources of error (e. g., faulty communication between the DTBird system and the WT control). In addition, there are substantial inaccuracies in the distance and height estimates by the observer. Simple range finders are unsuitable as a second system.
- None of the observed flights (distance to the WT less than 500 meters) would have led to a collision. Many birds enter the detection area, but still keep sufficient distance from the rotor.
- In about half of the cases where a sound was emitted, the observer estimated that the large bird/bird of prey reacted. However, since it is often difficult to record the bird behaviour using visual observation, the rate is probably higher.
- The reactions to the sounds emitted by system consist, for example, in evasive movements which, however, never led to a fundamental "change of course" or to an acceleration of the flight speed of the bird flying by. The latter behaviour is difficult to observe and requires more accurate measurements and video analyses (not intended in 2018).

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Species	Average flight speed (km/h)	Number of evaluated measuring points
Lesser black-backed gull	34.2	198
Common buzzard	24.2	876
Carrion crow	35.2	68
Red kite	28.5	188
Herring gull	30.9	70

Table 2: Calculated average values of one date (April 12, 2019) for selected species.

Adaptation of validation method 2019

According to the experiences from the year 2018 and taking into account the "Profile of requirements" (KNE 2019, last updated 14.03.2019), the examination method for 2019 was adapted as follows:

- Increasing the number of observation dates to 20 and deploying two observers per appointment, additional tests by conducting drone flights,
- use of a more suitable second system: Safran Vectronix Vector 21 Aero (Rangefinder). Now a measuring technique is available that comes close to telemetric examinations,
- analyses of the video footage by the experts and comparison with the analysis results of DTBird.

The rangefinder mentioned provides an exact series of measurements of bird flights and a precise indication of the position and height of a bird at a high measuring point density (one measurement every five seconds). In this way, the species- and behaviour-specific flight speed can also be determined to assess the efficiency of DTBird (see Table 2). The project is scheduled to run for two years. Reliable results are not expected before the end of 2019.


IdentiFlight
CAMERA SYSTEMS
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CHAPTER 4.2

How well does IdentiFlight protect the Red Kite?

Initial results from ongoing studies

Dr. Marc Reichenbach and Dr. Hendrik Reers

IdentiFlight (IDF) is a camera system designed to prevent bird collisions with wind turbines (WT). Depending on their size, birds are optically recorded at distances of up to 1,000 meters, their distance, altitude, and flight direction are determined, and the bird species automatically identified. If the approach is too close, a shutdown signal is sent to the WT in question. After a successful test on eagles in the USA, the performance of IdentiFlight is now being tested on red kites in Germany.

The IdentiFlight system

Protecting birds of prey and larger birds from colliding with WT is of particular importance not only in Germany, but also in the USA. Given that there are severe fines in the event of proven killings of protected species such as golden eagles and bald eagles, Boulder Imaging in Colorado, has developed the IdentiFlight system to detect eagles at a sufficient distance from WT and to shut the turbines down in time in the event of a collision risk.[5] An IDF unit consists of a combination of eight fixed wide-angle cameras with a movable high-resolution stereo camera. The wide-angle cameras monitor a 360 degree radius and detect flying objects depending on their size up to a distance of approximately 1,000 meters, distinguishing between relevant and non-relevant flight movements (e. g., bird versus aircraft). As soon as a relevant object is detected, the stereo camera is directed to it and continuously determines distance, flight angle, size, and affiliation with a programmed object class (e. g., eagle, non-eagle). When tracking the flight path, ten photos per second are generated as the basis for classifying the object. This stored data enables a subsequent corresponding evaluation and comparison with other data collected simultaneously, for instance, by observers.

Starting from an initial "proof of concept" from the USA on relatively easy to detect eagles (McClure et al. 2018), the company "erneuerbare energien europa e3 GmbH" in Hamburg launched a study to determine whether IDF also has a comparable performance

5 https://www.identiflight.com

with red kites in Germany.[6] Under neutral control and quality assurance by "TÜV NORD", reference data is collected parallel to two IDF systems by the offices "Oevermann" and "Ökotop", which is analysed together with IDF data by "ARSU GmbH" and "OekoFor GbR". Objectives and questions are based on the assessment criteria presented by the KNE (2019), in particular with regard to detection range, detection rate, and classification of the flying object.

Methodology

From August 15 to October 16, 2018, an IDF system was installed in two study areas in Saxony-Anhalt (Helfta) and Mecklenburg-Western Pomerania (Plate) and was in permanent operation during the light phase. During this period and on 25 days for six hours per day, three observers recorded data simultaneously at two observation points respectively. This included, on the one hand, flight path observations with entries on paper maps, as is usual in the context of spatial flight distribution observations, and, on the other hand, tracking single individuals with a Laser Rangefinder (LRF) from Safran Vectronix. The LRF generated position tracks as accurately as possible, that can be compared with the recordings of IDF. The aim was to collect a sample of flight activity independent of IDF. After each day of observation, the data, including the observation protocols and weather data, was uploaded to a "TÜV NORD" server and made available for evaluation from there. This enables a complete and independent verification of the raw data and the data transmissions at any time.

The study areas were specifically selected for the high flight activity of the red kite; the areas do not have any WT. However, virtual WT were programmed in the systems to check the generation of shutdown signals. Both study areas are characterised by open and easily visible arable land, which has only a few woods. Beside the red kite, there are other medium-sized birds of prey like the black-kite, common buzzard and honey buzzard, and the marsh harrier.

Preliminary results

Basis for data

The two IDF systems generated 18,338 flight paths with a total of 387,442 points in the study period. According to a subsequent determination of the recorded photos, 103,076 points of this originate from 3,274 flight paths of red kites. The observers collected 1,045 individual observations on 25 days during the study period; 579 of the cases involved red kites. In addition, by using the LRF 241 precise red kite flight paths were sampled.

Detection range

A first test with a GPS-located drone at a distance of 150 meters to 350 meters from IDF exhibited very high location accuracy. The detection range of IDF for the reliable detection of subsequently identified red kites from 3,274 flight paths is approximately 750 meters in the horizontal direction. However, the absolute detection range refers to the radial distance to the object, which results from horizontal distance and flight altitude. Accordingly, red kites were recorded up to a maximum radial distance of 1,159 meters.

6 https://cdn2.hubspot.net/hubfs/195771/IdentiFlight%20e3%20release%209.4.18.pdf

Detection rate

The detection rate was determined on the basis of the flight paths measured with the LRF. Of the 241 LRF flight paths, only those recorded during IDF operating hours (without power failures) and located horizontally within a 750 meter radius of the IDF were used for further analysis. Of the remaining 140 LRF flight paths, a total of 90 percent was detected by the IDF, with Helfta showing significantly better detection rates with 96 percent than Plate with 77 percent. The lower rate in Plate was mainly due to a partial row of trees behind which red kites could be seen flying by observers, but not by IDF.

Classification

Out of 3,274 red kites, IDF correctly identified 2,702 (83 percent). In 572 cases (17 percent), the IDF did not recognise post-identified red kites (false negatives). Of the 3,059 flight paths identified by IDF as red kites, 2,702 (88 percent) were actually red kites, and 357 (twelve percent) were falsely identified (false positives). However, if one takes into account the identified black kites and unspecified kites, which were identified by the IDF as red kites, then in 91 percent of the cases one kite was identified by IDF as a red kite, resulting in a false positive rate of nine percent.

In the meantime, on the basis of the subsequent identification of the 18,338 tracks recorded by IDF in 2018, there has been another training of the classification software with half of the red kite images. The subsequent test with the second half of the red kite images, mixed with photos of other birds, showed a decrease in the false negative rate from 17 percent to ten percent, and the false positive rate from twelve percent to two percent. Further enhancement is expected from additional re-training with additional visual material.

The certainty of determination with regard to red kites up to a distance of 700 to 800 meters remains at a consistently high level (over 80 percent) and only then drops to around 60 percent.

System response

IdentiFlight works with a vectorial shutdown algorithm (Time To Collision Method) based on two distance radii. Every second, the position and flight direction of the detected red kite are calculated. If the bird in question maintains a certain outer distance (Dmax) around the rotor area of the WT monitored by IdentiFlight, no shutdown signal is output regardless of its flight direction. If the bird in question falls short of this distance, and at the same time its flight path depicts a vector that would cross the rotor area of a WT after a certain time (Tc) with the same flight direction and speed (collision course), a shutdown signal is sent to the respective WT. Irrespective of the flight direction, the shutdown signal is always sent if the bird falls below a certain minimum distance to the rotor area (Dmin). If the bird then flies outside this minimum range (Dmin) again for a certain period of time, the shutdown signal is cancelled, and the respective WT goes back into operation.

The mentioned parameters can be variably programmed and essentially depend on the required time of the WT from the shutdown signal to the spin operation as well as—in case of 'Dmin'—on the assumed flying speed of the bird. In the current test mode, 'Dmax' is 750 meters, 'Dmin' 200 meters plus rotor radius, and 'Tc' 30 seconds. After leaving 'Dmin', the shutdown signal is cancelled two minutes later. On this basis, in over 600 cases relating to the virtual WT, shutdown signals for red kites were generated during the 2018 test phase. This data is currently being evaluated for the correct implementation of the shutdown.

Outlook

In 2019, IDF will be tested in two new study areas with existing wind farms. On the one hand, the sample of LRF reference tracks is to be significantly increased, on the other hand, the sequence of steps from bird detection to the actual standstill (or spin operation) of the WT in real wind farms is to be tested. In addition, the study is to be expanded to include the white-tailed eagle as well as the red kite.

Another important aspect of the project is the conservation classification of the determined performance of IDF with regard to its contribution to reducing the risk of killing below the so-called significance threshold. The aim is to draw up indications as to the relationship between the risk reduction determined in each individual case and the special circumstances required by case law. A publication of the results is scheduled for 2020.

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CHAPTER 4.3

From a general shutdown algorithm to the application of a camera system (BirdVision)

Initial findings from operational monitoring at the Weißbach Wind Farm

Henning Mehrgott

At the Weißbach Wind Farm in Baden-Württemberg a camera system from the manufacturer BirdVision has been installed on two wind turbines since August 2018. This camera system is currently in the development and validation phase. The plan is to use the system in the future to implement smart curtailment on this site. Since March 2019, observations have been carried out during operations to validate the effectiveness of the BirdVision camera system as mitigation measure.

The situation on the ground

The Weißbach Wind Farm in Baden-Württemberg has been in operation since 2016 and has a number of avoidance measures in place to protect red kites, in particular a site-specific shutdown algorithm (several days of turbine curtailment after harvesting, mowing, and soil cultivation in the vicinity of the turbines) as well as deflecting areas outside the wind farm for habitat enhancement. In order to validate the effectiveness of the avoidance measures specified in the permit, a two-year monitoring of the spatial flight patterns of red kites and black kites during and after field management events in the wind farm was already carried out in 2016 to 2017. This showed that there is an increased attraction of red and black kites, especially on the day of field cultivation, but that the following days are much less frequented and, in most cases, there is no longer any attraction for the birds. On the basis of the monitoring results, the avoidance measures were adapted by way of modification approvals. Ultimately, it became apparent that the attraction of the cultivated areas is rather selective and temporary and that the wind turbines have been shut down for the greater part of the time relevant for shutdown, although no hazardous situations occur.

Given this, turbine shutdowns carried out manually had been already introduced in 2018 as an alternative to the general shutdown algorithm. In this case, the relevant facility remains in operation during field cultivation, but is manually curtailed using a tablet in case a risk situation occurs. The aim, however, is to replace a general shutdown algorithm with the use of a camera system.

Turbine curtailment and flight object identification

A BirdVision camera system is currently being tested at the wind farm. A camera system consisting of six high-performance industrial cameras at the base of the turbine tower at a height of approximately six to eight meters permanently observes the surrounding of the tested wind turbines with a 360 degree panoramic view. The individual images recorded by the camera system are examined in a deep learning network. The camera records an object which is compared in the network with images of reference objects. These reference objects consist of a “positive list” of images of birds of prey previously recorded inside the wind farm (currently around 360,000 images) and a “negative list” of images of non-target objects such as insects, small birds, aircrafts, water drops, rotor blades, clouds, trees, etc. (currently around 1.6 million images). If a detected object can be assigned to these non-target objects or does not match the images in the positive list, the object is not classified as a target object and is not pursued further. As soon as a target object is detected and classified as such, its flight path is tracked further. Both individual images and a video of the flight are generated from each tracking. The plan in the course of 2019 is for an automatic shutdown to take place in case of a potential risk situation.

Validating the camera system

The operational monitoring for validating the BirdVision camera system was already agreed upon with the responsible permit authority in advance and is methodologically geared to the “Profile of requirements” of the KNE (KNE 2019). For system validation, trained observers with ornithological experience in the field are used for monitoring as second system. They document all flight activities of birds of prey and other birds of comparable size from a view point overlooking a 300 meter radius around the turbines. Data is recorded using standardised protocol sheets. The time frame is based on the LUBW Directive (State Office for the Environment, Measurements and Nature Conservation of the Federal State of Baden-Württemberg) on the Recording of Bird Species in Wind Energy Planning (LUBW 2013) and should include at least 18 to 20 dates of at least three hours of observation time each. The time period can be increased if necessary. After recording the flight paths, in a second step the recorded results are compared with the data of the camera system and on the basis of this the false negative rate (how often are target objects not detected and/or identified?) and the false positive rate (how often are non-target objects incorrectly recognised as target objects?) can be determined. In addition, it is to be determined, which bird species can be reliably detected at which distance and under which weather conditions. A third step will investigate whether the automatic camera-based shutdown works on time and reliably, which has not yet been implemented.

Initial findings

The initial, preliminary results show that birds the size of a red kite or common buzzard are reliably detected by the camera system at a distance of approximately 300 meters. In cases where birds were not recognised by the camera system, this is due either to the shading by trees, which occurs at the edge of the forest, or when birds are not detected at very low flight altitude (about 0 to 15 meters) due to the lack of contrast to the ground. Also, birds with a flight altitude of more than 300 meters are usually not detected, which is connected with the limited range. After the first impressions, the automatic identification of large birds works even under different weather conditions (e. g., sunlight, rain, onset of darkness). The false positive rate is currently around twelve percent (n = 740 video recordings), which is still a snapshot. Reliable statements on a false negative rate are not yet possible at the present time.

Outlook for 2019: What is planned?

- Use of the BirdVision camera system at eight wind turbines in five different wind farms in Baden-Württemberg and Saarland (forest and open land sites) with monitoring during operation 2019/2020 to collect comprehensive data for a camera system validation.
- Further software development (implementation of automatic classification, stereo operation with distance measurement, automated shutdown).
- Set up a user interface (online database with analysis tools).
- Data analyses by university in coordination.
- If the BirdVision camera system is successfully tested, there are plans to implement the camera system by way of a modification permit as an avoidance measure to protect the red kite in the Weißbach wind farm.

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CHAPTER 5

Aspects of licensing law in the use of detection systems

Dr. Andreas Weiss

When it comes to the immission control approval procedure, detection systems raise licensing issues for the construction and operation of wind turbines. On the one hand, it must be clarified whether and how detection systems can overcome obstacles to approval as a mitigation measure under species protection law. On the other hand, as species protection mitigation measures, detection systems trigger their own requirements within the framework of an approval procedure.

Detection systems combined with turbine smart curtailment as a mitigation measure under species protection law

Immission control regulations apply to the construction and operation of wind turbines. A permit must be granted if the preconditions are met, specifically if there is no conflict with "other provisions of public law" (§ 6 para. 1 no. 2 of the Federal Immission Control Act—BImSchG). These other provisions of public law include the regulations of species protection pursuant to § 44 para. 1 of the Act on Nature Conservation and Landscape Management (Federal Nature Conservation Act—BNatSchG). Detection systems primarily focus on preventing injury and death as prohibited in § 44 para. 1 no. 1, para. 5 sentence 2 no. 1 BNatSchG. Consideration of the interference prohibition pursuant to § 44 para. 1 no. 2 BNatSchG and the destruction prohibition and/or the protection of habitats pursuant to § 44 para. 1 no. 3 para. 5 sentence 2 no. 3 BNatSchG may become significant in individual cases, specifically when acoustic deterrence is used. Hereafter, the prohibition of injuring and killing protected species is considered further.

Determining the significantly increased risk of killing

The premise that only a "significant increase of killing risk" amounts to a violation of § 44 para. 1 no. 1 BNatSchG was established by case law and is now

laid down in § 44 para. 5 sentence 2 no. 1 BNatSchG. The decision of the Federal Administrative Court (Bundesverwaltungsgericht—BVerwG) on the Elbe crossing of the freeway 20 (A 20)[7] and bat protection established that birds' habitats cannot be considered "untouched nature" but "man-made nature which bear inherent risks for species, due to human use". Like the construction of traffic routes and high-voltage power lines—the risk of collision-related losses of individual specimens must exceed this inherent risk which is always associated with a wind turbine in the natural environment. Thus, wind turbines are part of the natural habitat of animals and therefore special circumstances must be added to be able to speak of a significant danger by operating a new wind turbine. Zero risk is not required. Measures to avoid collision (so-called mitigation measures) must be implemented if necessary. These approved mitigation measures do not have to avoid collisions with virtually 100 percent certainty.

Whether or not the described "significance threshold" has been exceeded an issue on its own. Implementing smart curtailment based on automated bird detection is thus a highly complicated approach and should be considered carefully. However, the primary question in the licensing procedure is always whether the wind turbine bears a significant increase of the risk of killing.

Necessary and technically recognised mitigation measure

If the construction and operation of the wind turbine exceeds the killing risk significantly, mitigation measures (originally known as avoidance measures and reduction measures) may be applied pursuant to § 44 para. 5 sentence 2 no. 1 BNatSchG. These measures lead to a reduction of the killing risk below the significance threshold. Their mandatory implementation is then laid down in the permit.

The detection system itself does not itself qualify as a mitigation measure. It solely records the presence of birds and, if necessary, monitors collisions. However, combining the detection system with smart curtailment (i. e. deactivating the wind turbine) can

7 Federal Administrative Court, ruling from April 28, 2016—9 A 9.15—, marginal no. 141 (available at https://www.bverwg.de/280416U9A9.15.0).

be a mitigation measure. A similar approach has been approved by case law[8], with regard to bat height monitoring. Detection systems that do not facilitate turbine curtailment thus do not qualify as effective mitigation measure (e. g., pure detection systems such as sensor systems or acoustic detection systems). Applying the mitigation measure in the particular case needs to be necessary. In this respect, the mitigation measures previously provided for in the immission control permit remain applicable. With the increase of functioning detection systems combined with turbine curtailment, a tendency could develop whereby licensing authorities and environmental associations then doubt the effectiveness of the previously recognised mitigation measures because an even better mitigation measure is available. However, according to the case law of the Federal Administrative Court, no zero risk is required and therefore not the best mitigation measure, but a suitable mitigation measure is sufficient. It would be legally problematic if, in a comparable situation, an authorisation with conventional mitigation measures could presently be granted, but would be tied to the use of a detection system combined with operational curtailments in the future. Therefore, detection systems with turbine curtailment should not become a standard mitigation measure, because in most of the cases the current mitigation measures can still be effective. The scope of application thus remains limited to individual cases.[9]

To install detection systems under licensing law it is decisive whether and when they are technically recognised pursuant to § 44 para. 5 sentence 2 no. 1 BNatSchG and how any existing deficits and uncertainties can be resolved under licensing law.

The mere fact that detection systems are a new form of technology cannot be held against their professional approval. Every other form of mitigation measure was carried out for the first time at some point. However, some scepticism remains on part of the authorities, which could lead to stricter, legally uncalled, standards for professional recognition.

Generally, mitigation measures to do not have to meet a zero-risk requirement. Thus, it cannot be demanded that collisions will be avoided with 100 percent certainty. However, a positive prognosis regarding the effectiveness of the mitigation measure is essential. In trying to meet this standard, the question can be asked: What likelihood of birds in the area is generally tolerated without assuming a significant increase of the killing risk? Or phrased in accordance with the jurisprudence of the Federal Administrative Court: What movement of species can be considered movement in a man-made natural environment? Both, the papers of experts for the individual federal states (e. g., also on spatial use analyses) and the so-called 'Helgoland paper' make assumptions as to when no protection and restriction area is affected. A likelihood of birds in the area outside the so-called home range or regularly used flight corridors is tolerated. Insofar as a detection system combined with turbine curtailment ensures that a shutdown takes place to the same extent as the likelihood of birds being in the home range or regularly used flight corridors, a man-made natural area or a location outside of the protection and restriction area is simulated regardless of where the wind turbine is located with this mitigation measure. This could amount to meeting the threshold, which needs to be further developed.

Testing is also needed to ensure compliance with the threshold (evaluation phase). This can take place site-specifically or—provided the technology can be transferred—at a test site in order to generate a general applicability.[10] In this respect, an evaluation phase on detection frequency, operational curtailment, and system limitation is required before construction, at least before the wind turbine is in

8 Hessian Administrative Court, resolution from May 14, 2012—9 B 1918/11—, marginal no. 40, juris (for gondola monitoring; available at https://openjur.de/u/417816.htmlmarginal no. 45); High Administrative Court Saxony-Anhalt March 13, 2014—2 L 215/11—, marginal no. 39, juris (to monitor hit birds; available at http://www.landesrecht.sachsen-anhalt.de/jportal/portal/t/buq/page/bssahprod.psml?doc.hl=1&doc.id=MWRE140001709&showdoccase=1&doc.part=L&paramfromHL=true).

9 Thus in the case of Bavarian Administrative court, ruling from March 29, 2016—22 B 14.1875, 22 B 14.1876—, marginal no. 65 f., juris (available at http://www.gesetze-bayern.de/Content/Document/Y-300-Z-BECKRS-B-2016-N-47819?hl=true), whereby the technical protection measure (if recognized) could, as a last resort, remove the obstacle to authorization.

10 The presentations at the conference show that this is currently being done with various detection systems.

operation. An evaluation of the mitigation measure during operation of the wind turbine with the variant of manual parallel shutdown must be critically evaluated with regard to the effectiveness of the mitigation measure.[11] A high false trigger rate detected in the evaluation phase is irrelevant in terms of licensing law, but an economic disadvantage. The resulting high number of shutdowns does not mean that the privileged status of the wind turbine pursuant to § 35 para. 1 no. 5 BauGB (German Federal Building Code) can be dispensed with, because the economic viability of the project lies in the entrepreneurial risk of the operator and is not a prerequisite for privileged status. The basic suitability to operate the wind turbine with the intention of making a profit[12] is enough. This is indicated by the realisation and thus the financial feasibility of the project. The specific consideration under nature conservation law due to the interference with the landscape pursuant to § 15 para. 5 BNatSchG between the use of renewable energy on the one hand (§ 1 para. 3 no. 4 BNatSchG), compliance with the requirements of species protection and the usability of the property vis-à-vis the non-compensable landscape intervention[13] is unlikely to outweigh the interests of nature conservation and landscape management, even in the case of a high operating restriction. Additionally, it needs to be considered that the wind turbine sites are regularly bound by local planning laws.

The evaluation phase is followed by a validation phase after commissioning of the wind turbine. The results of the evaluation phase are then transferred to the actual operation of the wind turbine (e. g., shading effects) and enables fine adjustment if necessary.

Within the framework of the approval under immission control law, regulations can be made by auxiliary provisions pursuant to § 12 para. 1, 2a BImSchG (mixture of conditions, conditions precedent and conditions subject, reservation of subsequent conditions) accordingly. As a precautionary mitigation measure, the generalised operating restriction is limited to the species-specific and actual presence and activity time of the breeding bird concerned, which may be omitted if the territory is abandoned undisturbedly. Such a mitigation measure is permissible and effective.[14] This precautionary mitigation measure will then be replaced by the mitigation measure “detection system combined with demand-based operational curtailment”, for which the following prerequisites can be considered:

1) Implementation of the evaluation phase (see above),

2) Implementation of the validation phase (see above),

3) Ensuring full technical operability and, in the event of failure/technical limitation, reverting to the precautionary mitigation measure of the general operating restriction,

4) Documentation of the demand-based operating curtailment and possibility to switch in the event of failure/technical limitation,

5) Reservation of subsequent requirements for adaptation to subsequent technical improvements (as a typical content of a risk management system).

11 The Lower Saxony High Administrative Court ruling from October 25, 2018—12 LB 118/16—, para. 1, marginal no. 226, juris (available at http://www.rechtsprechung.niedersachsen.de/jportal/portal/page/bsndprod.psml?doc.id=MWRE180004083&st=null&showdoccase=1).

12 Bavarian Administrative Court, resolution from August 27, 2013—22 ZB 13.926—, marginal no. 10, juris (available at http://www.gesetze-bayern.de/Content/Document/Y-300-Z-BECKRS-B-2013-N-55737?hl=true).

13 This question only arises if there is no compensation for interventions in the landscape, which is in itself questionable.

14 Recognized in the context of the urgent procedure: Berlin-Brandenburg High Administrative Court, resolution from July 25, 2018—High Administrative Court 11 p. 4.18—marginal no. 27, juris (available at http://www.gerichtsentscheidungen.berlin-brandenburg.de/jportal/portal/t/279b/bs/10/page/sammlung.psml?pid=Document display&showdoccase=1&js_peid=Trefferliste&documentnumber=1&numberofresults=1&fromdoctodoc=yes&doc.id=JURE180012241&doc.part=L&doc.price=0.0#focuspoint).

Detection systems combined with demand-based operational curtailment under immission control law

In addition to issues of feature as a species protection mitigation measure, further aspects have to be considered within the framework of the approval procedure under immission control law when using detection systems with demand-based operational curtailment.

Approval procedure for the detection system combined with demand-based operational curtailment

The detection system can either be included in the wind turbine approval procedure under immission control law or be the subject of a separate approval procedure, but still be linked to the wind turbine approval procedure under immission control law, like it is done in cases of water law permits.

Decisive for this procedural question is whether the detection system qualifies as an ancillary facility of the wind turbine pursuant to § 1 para. 2 no. 2 of the 4^{th} BImSchV. In this case, the approval of the detection system is integrated into the wind turbine's approval procedure under immission control law. This is beneficial in that it is involved in the planning privileges of the wind turbine and reduces the effort in the licensing procedure. The prerequisites for an ancillary facility of the wind turbine pursuant to § 1 para. 2 no. 2 of the 4^{th} BImSchV are a spatial and operational connection, which will usually be the case because ancillary facilities are also permitted in the wider neighbourhood. Cumulatively, the ancillary facility must be capable of having significance for the occurrence or prevention of harmful environmental effects or other hazards, significant disadvantages, or significant nuisances, which, according to widely held opinion, may also emanate from the ancillary facility itself. At any rate, if a radar system is used, this can be demonstrated.

Provided that there is no ancillary equipment of the wind turbine according to § 1 para. 2 no. 2 of the 4^{th} BImSchV, a separate procedure to obtain a building permit must be carried out. In particular, the permissibility under construction planning law for external areas must then be demonstrated separately for a radar or camera tower. This may succeed, if necessary, on account of research and development of wind energy (§ 35 para. 1 no. 5 BauGB), the existence of a local operation with the conducting of an alternative test (§ 35 para. 1 no. 3 BauGB), or special requirements of the surroundings and the special purpose (§ 35 para. 1 no. 4 BauGB).

Licensing aspects of the detection system combined with demand-based operational curtailment

The detection system triggers its own licensing aspects—regardless of the procedure used for the inspection. The use of a radar system regularly involves a high frequency system which must meet the requirements of the 26^{th} BImSchV. This must be proven in the permit application. In addition, for such frequency systems the ordinance on the verification procedure for limiting exposure to electromagnetic fields must be observed; the Federal Network Agency is included in this procedure.

If a separate tower or a similar one is built for the detection system, this additional interference with nature and landscape must be compensated (§§ 14, 15 BNatSchG) and species protection concerns (§ 44 para. 1 and 5 BNatSchG) triggered by the site (mainly due to construction) will be taken into account in the environmental documents of the license application.

In addition, corresponding building application documents must be prepared and the building requirements of this construction (development, building regulations) have to be observed.

The detection system must also be included in the EIA report. An obligation to conduct an EIA should generally be given with respect to the particular way protected species are impacted. Even in the case of a separate permit procedure, an inclusion in the EIA report is advisable because of the link with the construction and operation of the wind turbine.[15] In the EIA, the following objects may be affected: human beings (in the case of electromagnetic fields from radar systems); animals (species protection measures); areas/soil (sealing); landscape (landscape image); cultural heritage (monument protection); and the detection system has to be named as an avoidance measure with regard to significant adverse impacts.

Preventive application for an overriding exception under species protection law

Finally, within the framework of an application for a permit under immission control law, a precautionary application for a so-called 'overarching species protection exception'[16] pursuant to § 45 para. 7 BNatSchG can be considered. This exception ensures additional legal protection if gaps in the effectiveness or in the regulations of the precautionary mitigation measure of the general operating restriction with replacement by the mitigation measure detection system should occur.

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15 See for example, Lower Saxony High Administrative Court, resolution from August 11, 2017—12 ME 81/17—, marginal no. 20 f., juris (available at http://www.rechtsprechung.niedersachsen.de/jportal/portal/page/bsndprod.psml?doc.id=MWRE170007212&st=null&showdoccase=1).

16 Federal Administrative Court, ruling from July 9, 2008—9 A 14.07—, marginal no. 128, juris (available at https://www.bverwg.de/090708U9A14.07.0); High Administrative Court Rhineland-Palatinate, ruling from July 8, 2009—8 C 10399/08—marginal no. 281, juris (available at http://www.landesrecht.rlp.de/jportal/portal/t/7qe/page/bsrlpprod.psml?pid=Dokumentanzeige&showdoccase=1&doc.id=MWRE090002185&doc.part=L).

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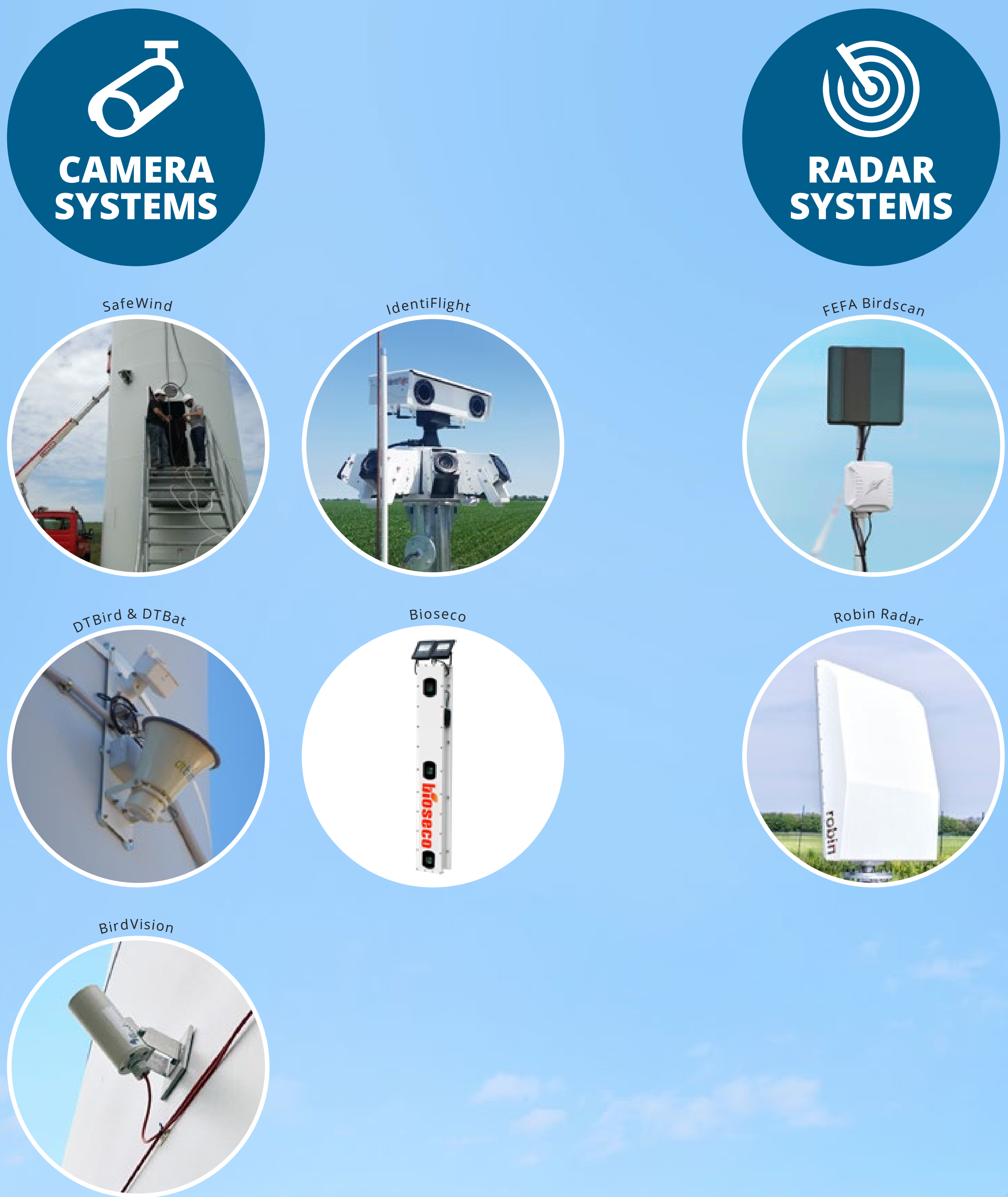

Figure 1: Overview of the detection systems presented in the manufacturer interviews.

CHAPTER 6

Detection systems as an opportunity for an environmentally sound wind energy development?

This was discussed at the conference.

Eva Schuster and Dr. Elke Bruns

Detection systems at a glance— The current state of development

In order to be able to assess whether detection systems provide an option to minimise bird collision that is to be taken seriously, it is necessary to obtain an overview of their performance. The conference in May 2019 offered the best prerequisites for this. Manufacturers could be asked questions directly about their systems on the "Marketplace". In addition, on the podium they faced not only a comparison, but also the questions of the audience.

It became apparent that many systems have undergone significant development compared with 2018 (cf. KNE 2018). However, the development status of the individual systems continues to vary greatly. Deficits, such as a limited detection rate and range, have been significantly enhanced. The flight object identification or classification of the newer or more advanced detection systems also show significant improvements (see also Table 1).

Technology	Detection systems	State of development	Automatic flight object identification	(Trial) operation in Germany	As licensing requirement
Radar systems	BirdScan	Demo phase (test operation and optimisation)	Yes, for single species	Yes	Yes (operational adjustments)
	Robin Radar	Market availability in Germany	Yes, for classes (Species recognition planned)	Yes	Planned for 2019
Camera systems	SafeWind	Market availability in Germany	No (Classification and partial species recognition planned)	Yes	No
	DTBird & DTBat	Market availability in Germany	No (Classification planned)	Yes	Yes (monitoring)
	BirdVision	Demo phase (test operation and optimisation)	Yes, for single species	Yes	Planned for 2020
	IdentiFlight	Market availability abroad	Yes, for single species	Planned for May 2019	Planned for 2019 and 2020
	Bioseco	Demo phase (test operation and optimisation)	No (Classification and partial species recognition planned)	Yes	No

Table 1: Current state of development of detection systems presented (as of May 15, 2019).

Detektionssysteme in der Erprobung

The aim of the trials is to further improve and consolidate knowledge of the performance and reliability[17] of detection systems. The conference provided an overview of testing method within the framework of research and practice. Acknowledged experts presented the first results from practice-initiated field trails. These show that both camera systems and radar systems

- can provide accurate three-dimensional real-time positioning for individual birds (here: IdentiFlight, RobinRadar, Bioseco, BirdScan).
- enable a flight object detection with a range of 750 meters for birds of the size of a red kite (here: IdentiFlight, RobinRadar, BirdScan).
- enable automated identification or at least classification of the flying object (here: BirdVision, IdentiFlight, Bioseco, RobinRadar, BirdScan).

The field testing will be extended to other, sometimes more complex sites for target species such as the red kite, the white-tailed eagle, and the black stork. The first test cases will be completed by the end of 2019 and in the course of 2020. The evaluation will lead to a much greater increase in knowledge.

17 Describes the resistance of a system in the face of prevailing conditions that can influence the efficiency of a basically effective and suitable detection system (e. g., weather-related system failures, unstable or inadequate power supply).

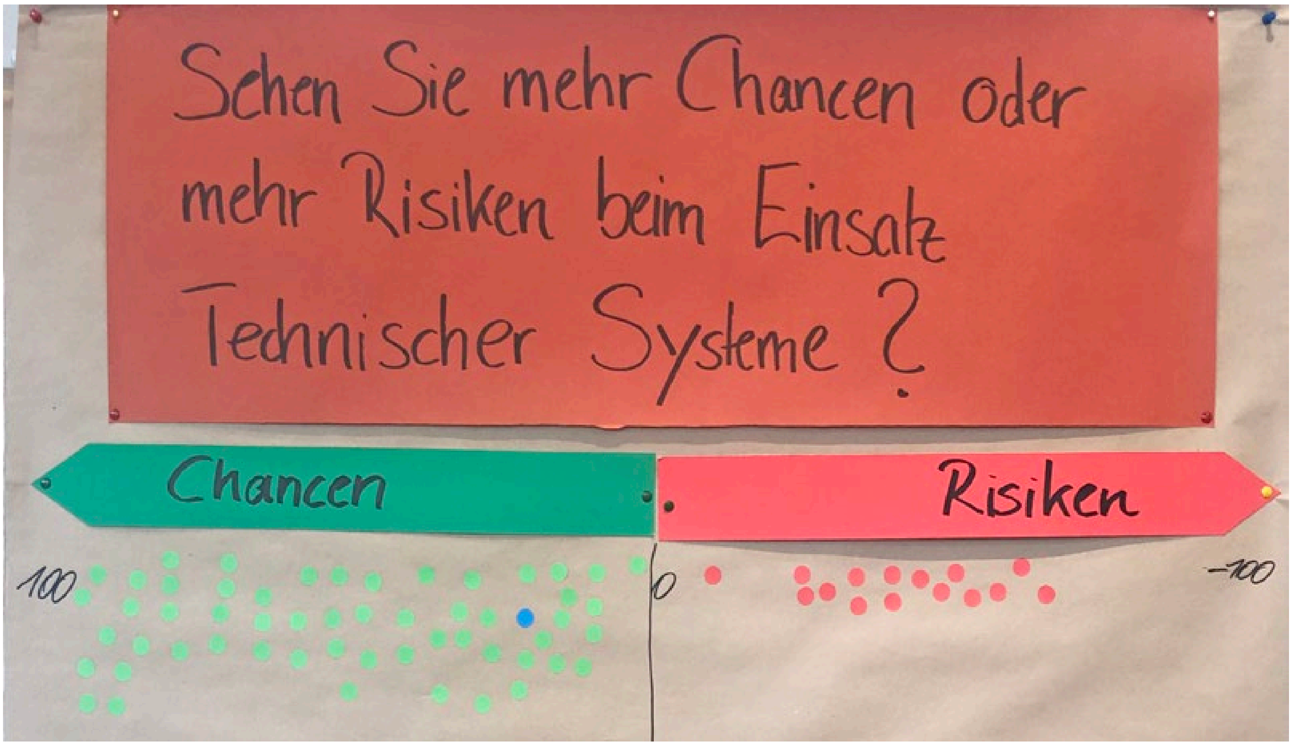

Figure 2: Assessment by the participants within the framework of the KNE conference on May 15, 2019. Stakeholders had been asked whether the introduction of detection systems in practice offers more opportunities or more risks.

Should detection systems be applied in practice? We asked the participants.

The aim of the conference was not just to transfer knowledge. It's goal was also to provide an opportunity for participants to express their views on the possibilities and limitations of detection systems.

As part of an interactive exchange, we asked what degree of urgency was seen if any for the introduction of further technical or non-technical mitigation measures in order to be able to cope with species protection requirements at the project level. The answers (n = 64) showed that the vast majority of respondents were of the opinion that this was 'very urgent' (n = 35) or 'urgent' (n = 12). Eight people replied that the need for action was merely 'rather urgent' or 'less urgent' (n = 9).

Forty-one people could imagine that the contribution of technical systems to the effective reduction of collision risks was 'rather high'. Twenty-four people even expect a 'high' contribution (moreover: 'rather low': n= 5; 'none': n = 1; 'don't know': n = 1).

The participants saw the opportunities and risks of a possible introduction of detection systems in a differentiated way, whereby the opportunities outweighed the risks (see Figure 2). The basic assumption that preceded this question was that the systems would prove effective in the future.

The participants regarded it as an opportunity that the introduction of detection systems for smart curtailment would make projects eligible for approval that are not eligible for approval under the current framework conditions. The use of detection systems would actually make it feasible to protect certain individual birds or individual breeding pairs from collision, according to one participant. Automated detection alone could also make a significant contribution to gaining knowledge and improving the data basis when assessing potential impacts. Improved clarification of the facts could thus lead to greater acceptance of individual projects. According to the participants, there would be less room to interpretation [than in spatial use analyses; d. author].

A whole series of possible, and at times quite specific opportunities and potential applications for detection systems were mentioned. On the one hand, the participants saw opportunities in using the detection systems for pre-construction monitoring and site assessment at the permit level. Here they could underpin expert assessments. The data availability would be improved, and remaining uncertainties could be reduced. In this sense, they could also contribute to gaining knowledge in research and practice by, for example, enabling long-term monitoring during operation. The flight behaviour in the vicinity of the wind turbine, the actual risk of collision, and the effectiveness of applied mitigation measures could be reliably observed on the basis of the data gathered by the systems at a reasonable cost. The systems could also be used to identify suitable sites at the spatial planning level.

On the other hand, opportunities and potential system applications—in combination with smart curtailment—are seen in the fact that

- predetermined shutdown times during breeding season or during and after agricultural land use management events could be reduced to the absolute minimum.
- costly and time-consuming contract negotiations with cooperation partners for the implementation of shutdowns during and after agricultural land use management events can be avoided.
- changes in the spatial distribution of flight paths could be better taken into account over the years.
- the recommended minimum distances to breeding sites could, where appropriate, be undercut without violating the permission requirements.
- they are used as an alternative to extensive habitat enhancement measures if, from a nature conservation point of view, suitable areas are not available or obtainable.
- they offer an opportunity to deal with the post-permit colonisation of species sensitive to wind energy inside the wind farm area.
- they make it possible to deal with changed conflicts under species protection law at the site in the course of repowering projects or an expansion of existing wind farms.
- they enable the complete use of designated priority areas, even if relevant species occurrences become known at the project level.

These opportunities are offset by risks. If detection systems were recognised as an effective minimisation measure, they could be required by default by the approval authorities. Authorities may provide for the use of a system on a regular basis without having sufficiently assessed the potential risk (significant increase of collision risk) and proportionality of the measure. Even projects that would actually be eligible for approval at a lower cost would then be provided with detection systems. Another concern is that in the future detection systems could also be required for bird species that are not yet included in the list of species sensitive to wind energy. As a result, the effort required to reduce the risk of collision (e. g. smart curtailment) would continue to increase.

From the operator's point of view, the use of detection systems is associated with uncertainties and liabilities that are detrimental to turbine operation:

- The frequency and duration of shutdowns are hardly calculable for the entire approval period, which limits the planning and investment reliability.
- Frequent shutdowns could lead to an increase in material wear of the WT and could shorten their service life. This might be an obstacle to economic operation. Detection systems would then have no advantage over predetermined shutdown periods.

- system manipulation as well as a missing or inaccurate automated species recognition could trigger unnecessary shutdowns and have an additional negative effect on the operating time and individual components of the WT.

The representatives of the wind industry expressed fundamental concern that the introduction of detection systems for smart curtailment would misjudge the existing problems posed by the lack of feasibility of the current species protection regulations and could even undermine the ongoing improvement efforts. In addition, effective species protection would require working with other mitigation concepts instead (e. g. measures to strengthen the local species population).

From the nature conservation point of view, detection systems—if they were recognised as a new minimisation measure—should not allow the development of wind energy within "sensitive areas". It needs to be ensured that these areas are not accessible for wind energy use. Furthermore, it is to be feared that the authorities would hardly be able to control whether and how reliably the smart curtailment is implemented at the respective site.

In answer to the question of which points still need to be clarified before technical systems could be used, the evaluation of the expected field testing results was cited:

- At what efficiency level, for example at what percentage, is a detection system considered effective by the authorities? Where is the threshold for significance set, and what remaining risk has to be tolerated?
- Which species-specific detection range should be required for a timely and therefore effective turbine curtailment?
- As of what speed of the rotor blade tip can it be assumed that the risk of collision is no longer significantly increased?
- Will it be required in the future to provide for a project-specific system validation or is a general approval of certain systems possible?

In addition to these questions, the participants saw the need for further clarification of specific framework conditions:

- In which planning and permitting situations could or should detection systems be used in the future?
- Is there a way to prevent systems being required as standard or possibly unnecessarily required?
- Which bird species should be considered?
- Would detection systems for smart curtailment replace conventional mitigation measures? Should or can they be provided for in addition?
- How can the authorities be enabled to control the accurate implementation at a respective site?
- Could the detection system be uninstalled, if, after some time during operation, it turns out that there is no significantly increased risk of collision?

The participants also saw an urgent need for clarification regarding the impact of the introduction of detection systems on economic efficiency:

- Can shutdowns of this extent generally be regarded as proportionate measures?
- Can future losses resulting from shutdowns be realistically predicted?
- How can the cost-benefit ratio be decided in advance and where should the limit of economic efficiency be set?

Questions about possible synergy effects were also raised. To be clarified is whether a coupling with radar systems for automated aviation obstruction lighting is technically possible in the future. Also, to be looked into is whether the extensive information resulting from the use of detection systems could be collected and further evaluated (keyword: nationwide database).

What was discussed on the podium?

On the podium, representatives from planning and permitting practice met with political representatives of the municipality, state, and federal levels (see Figure 3). There was a consensus that something urgently needed to be done to promote the expansion of wind energy—in a way that is compatible with nature. Detection systems could make an important contribution, but conventions would have to be established to regulate when, in which planning and permitting situations, the systems could or should be considered.

In their opening statements, the panellists addressed the aspects that were of particular urgency: The "Fridays for Future Movement" and the discussions in the context of the European elections had shown that the threat posed by climate change was being taken seriously. Nevertheless, the expansion of wind energy in Germany has almost come to a standstill, according to Eike Müller (Klimaschutzagentur Region Hannover). Species protection is important, but it must always be stressed that climate protection and species protection should not be played off against each other. Climate protection is rather an essential part of species protection, says Eike Müller.

Olrik Meyer, head of the Lippe district licensing authority (North Rhine-Westphalia), reported that his district is a major hotspot for red kites. He went on to say that debates with local parties involved were very emotional. The employees of the authorities are under great pressure and are subject to hostility. He added that meanwhile "everything" is lamented—be it the granting of permission or rejection. The legal proceedings would take years—time that is no longer available with regard to the consequences of climate change, which are already being felt today. He noted that there was hardly any prospect of project implementation in his area of responsibility. In view of this situation, it is also not surprising that the number of requests for approval has also declined strongly. According to Olrik Meyer, the intensive discussions going on right now about detection systems could offer a quick and timely solution to conflicts with species protection regulations—at least that is his hope.

For Eike Müller, the systems could also make a contribution to better dealing with spatial planning, which is an important tool to reach species protection goals, but is set for long-term and remains therefore "inflexible". Currently, designated priority areas could not be fully exploited due to species occurrences. Moreover, he explained there are only a few courses of action to deal with post-permit colonisation or the discovery of species occurrences at the project level. He added that permits would then not be granted or would only be granted subject to extensive mitigation requirements, such as predetermined shutdowns during the entire breeding season. In a case known to him, this measure would have resulted in annual losses of 22 to 25 percent.

Wolfram Axthelm, Managing Director of the German Wind Energy Association (BWE), confirmed the presentation of the current planning and permitting situation. Nature conservation is "a big obstacle for wind energy development". Many project developers hoped that the introduction of detection systems would lead to approvals for the currently withheld projects. Others, however, were also very concerned about the consequences of system recognition for the energy industry. The systems could gradually become the norm. The amount of electricity produced could no longer be reliably predicted due to unforeseeable shutdown times. The more extensive the shutdown times, the more wind turbines would have to be installed to produce the same amount of electricity. As a result, more land would have to be made available for the use of wind energy. Electricity production costs would rise, warned Wolfram Axthelm. It will be some time before the obstacles at the political level are removed and the "knowledge vacuum" is eliminated.[18] The BWE expects a clear commitment to the energy

18 Cf. Federal Constitutional Court, court order from October 23, 2018—1 BvR 2523/13—1 BvR 595/14.

Figure 3: Panel discussion at the KNE conference on May 16, 2019, from left to right: Olrik Meyer (Lippe District Approval Authority, NRW); Wolfram Axthelm (BWE German Wind Energy Association); Kathrin Ammermann (BfN Federal Agency for Nature Conservation); Eike Müller (Klimaschutzagentur Region Hannover); Lars Lachmann (NABU German Society for Nature Conservation). Moderated by Dr. Mathis Danelzik (KNE).

transition and more support from politicians. Until then, however, detection systems could serve as an interim solution to make projects eligible for approval.

Lars Lachmann, bird conservation expert at the German Society for Nature Conservation (NABU), reacted calmly to the question of whether the introduction of detection systems poses a threat for nature conservation by opening up sensitive areas for the use of wind energy. The topic of detection systems is viewed by the association with comparatively little concerns. He noted it is desirable to make rapid progress on this issue in order to promote a nature-friendly energy transition. Ultimately, it depends on the overall constellation of a project whether detection systems are suitable as mitigation measures. It is obvious that not all conflicts could be solved with the introduction of the systems and that not all areas could be made usable. In some “difficult” cases, smart curtailment could certainly lead to the eligibility for granting a permission and to more precise shutdown times. From a nature conservation point of view,

What are the challenges for a naturefriendly expansion of wind energy? What contribution could detection systems provide? These and other questions were discussed on the panel, moderated by Dr. Mathis Danelzik.

however, the combination with deterrence measures is rather problematic. However, according to Lars Lachmann, there is a great opportunity in using the systems to improve the data availability. This could generate facts that would make the controversial debates with wind energy opponents more objective. Furthermore, Lachmann argued that exceptions under the Federal Nature Conservation Act (cf. § 45 para. 7 no. 5 BNatSchG) should also be considered if the legal prerequisites (e. g., existence of planning alternatives) are met and if it can be ensured that "the local population of the species is doing well". The latter could be ensured by effective species protection programs on the basis of appropriate monitoring efforts.

According to Kathrin Ammermann, the Federal Agency for Nature Conservation (BfN) has the mission to contributing to the clarification and establishment of facts by bundling various research projects and improving knowledge of the effects of wind energy. Within the framework of the NatForWINSENT project, several detection systems will be tested in order to investigate, on the one hand, the detection performance and, on the other hand, the subsequent mitigation reaction (deterrence, deceleration of rotor speed) (see also talk by Aschwanden and Musiol on page 10). The aim is to "convert" the experimentally determined knowledge into solutions. Ammermann warned against exaggerated expectations with regard to problem-solving capabilities and against prematurely deciding in favour of the use of detection systems in ongoing permitting processes. She noted that detection systems would not be a suitable mitigation measure for all sites, especially for economic reasons. At the moment it is essential to close knowledge gaps about the reliability of the systems. A final decision on suitability can only be made on a case-by-case basis. In addition, it is imperative to establish conventions that regulate the use of detection systems in practice. Which species should be considered, whether and in what manner should, for example, the collision risks for migratory birds also be examined in the future, are only some of the many urgent questions to be answered. This is a difficult task and one is currently still at the beginning.

Outlook

The first trails in Germany will be completed by the end of 2019 and in the course of 2020. Further testing of different systems at different locations and with different target species will make it possible to further differentiate the knowledge of performance and thus the efficiency of detection systems.

On the basis of the results, it then has to be assessed whether and in which cases the systems comply with the requirements of species protection regulations. In order to find good solutions, the potential application possibilities must be realistically assessed. Provided that the systems prove to be effective, stipulations should be included in the guidelines of the German states (Bundesländer).

At the same time as with the field testing, a process should take place to develop thresholds on the basis of which the effectiveness of the systems can be assessed. There are further questions that need to be addressed (e. g., species-specific detection ranges, pursued rotation speed during spin mode).

It will also be necessary to discuss which of the potential applications mentioned as opportunities is actually suitable for the implementation in practice.

The KNE will continue to work on the topic of detection systems and will accompany and help to shape these processes as a neutral stakeholder. It is intended to develop a paper together with the Federal Agency for Nature Conservation (BfN) and the "Fachagentur für Windenergie an Land" (FA Wind) that summarises what is known and clarifies the remaining open questions from the point of view of research and practice.

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