WT-BIRD®: BIRD COLLISION MONITORING SYSTEM FOR MULTI-MEGAWATT WIND TURBINES

E.J. Wiggelinkhuizen, **S.A.M. Barhorst, L.W.M.M. Rademakers**, ECN
H.J. den Boon, E-Connection Project
S. Dirksen, Bureau Waardenburg

Energy research Centre of The Netherlands (ECN)
P.O. box 1, NL-1755 ZG Petten, The Netherlands
wiggelinkhuizen@ecn.nl, tel. +31 224 564049, fax +31 224 568214

SUMMARY: A new method for detection and registration of bird collisions has been developed that is suitable for continuous remote operation in both onshore and offshore wind farms. The characteristic sound of a collision is detected by sensors in the blades, which triggers the storage of video registrations and sends an alert message to the operator. A prototype has been tested successfully on a Nordex N80/2.5MW turbine at ECN's Wind turbine Test park Wieringermeer.

Compared to other methods employed so far this monitoring system will reduce the uncertainty in the number of birds killed by collisions with wind turbines. Further, the system enables the operator to identify species and to study the collision mechanisms. It has been found that this system can also be used for monitoring of other events in order to save costs for inspection and repair after incidents. For offshore wind farms, the WT-Bird system is currently the only alternative to count the number of bird collisions.

Functional tests with tennis balls that were shot against rotating blades showed that the majority of the impacts were detected. The flight track of these dummies and the collision events were clearly visible on the video registrations. During the monitoring period of about one year two bird collisions were detected. The video recordings confirmed that a collision took place and showed that the location of both collisions was near the blade root, which resulted that in both cases the bird was not (immediately) killed. Therefore no corpses could be found beneath the turbine after these events. Also during the rest of the monitoring period no corpses were found beneath the turbine.

1. INTRODUCTION

With the increasing penetration of wind energy on land and the large-scale implementation of offshore wind farms more and more attention is paid to the environmental effects. Bird collision risk is considered as an important effect that may affect bird populations and in particular long-lived marine birds. The risk of bird collisions can hamper or even stop the realization of wind farms and a few examples of badly sited farms have harmed the reputation of wind energy.

To predict collision risks and assess population effects collision risk models have been developed, which are applied in environmental impact studies [1, 2]. These models are mainly developed for on land locations and species, and in most cases validation has been performed on a small scale.

Therefore there is an urgent need for monitoring data on a large scale, especially for offshore sites, to validate and improve collision risk models. This will result in reliable and more accurate estimates, leading to better planning of wind farms (macro- and micro-siting) and a shorter permitting process. Other reasons to monitor collisions are to study collision mechanisms and to develop and evaluate mitigating measures. Yet no reliable cost-effective method is available to measure the number of casualties for offshore wind farms [3, 4].

A new method for continuous remote detection and registration of bird collisions has been developed by ECN in co-operation with ornithologists. The system, named WT-Bird® [5, 6], is suitable for large-scale application in both onshore and offshore wind farms. A prototype has been tested successfully on a Nordex N80/2.5MW turbine at the ECN Wind turbine Test park Wieringermeer.

2. WT-BIRD® OPERATING PRINCIPLE

Bird collisions produce a characteristic impact sound that is recognized by acoustical sensors in the blades. For each detected collision a trigger is generated that causes that the relevant sound and video fragments are stored permanently, which is shown schematically in figure 1. To alert the operator a detailed email message of each event is sent. Then the operator can remotely access the triggered recordings to verify whether a collision actually took place and to identify the species.

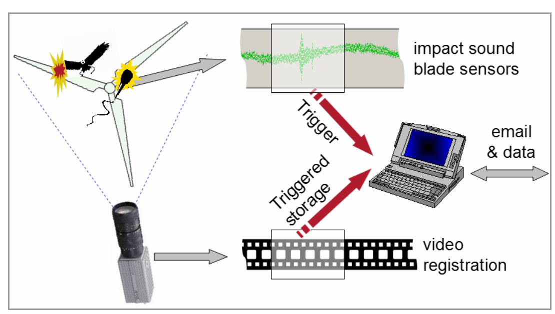


Figure 1: Principle of WT-Bird operation

The acoustical trigger drastically reduces the amount of data that has to be analyzed by the operator, so that monitoring can take place over several years continuously and on a number of turbines in parallel, spread over several sites.

The triggered sound and video recordings provide useful information of the collision event. The online processed acoustical signals alone provide information about the exact time of the event, the blade position, the approximate impact location, turbine operation details (rotor speed, yawing and pitching) and some local weather details (precipitation, wind direction). Some of these parameters can also be deducted from the video fragments, but more important are the bird's avoidance response and species characteristics.

Compared to other methods employed so far this monitoring system will reduce the uncertainty in the numbers of casualties from collisions with wind turbines and provide valuable information so study bird collision mechanisms. However it should be noted that this monitoring method is mainly complementary to existing methods, such as radar and visual observation.

3. WT-BIRD® IMPLEMENTATION

The WT-Bird system was developed according to specifications that have been agreed with ornithologists. The prototype was installed on a 2.5MW turbine with a rotor diameter of 80 meters and hub height of 80 meters, as shown in figure 2.

The video cameras are highly sensitive 1.45 megapixel industrial CCD cameras with exposure control. The infrared LED lights are invisible to humans and birds and produce almost no heat. The indoor equipment consists of industrial acceleration sensors, two in each blade. The sensors are connected to a compact industrial signal processing platform in the rotor hub with wireless LAN connection to an industrial PC in the tower base. A detailed description is provided in [5, 6].

Since the installation in summer of 2005 and some technical improvements later on that year the prototype has been in operation continuously for over one year without any maintenance.

4. FIELD TEST RESULTS

Functional tests with bird dummies (tennis balls of 50 grams and 7 centimeters in diameter), which represent the smallest abundant bird species along the Dutch coastal region, hitting the rotating blades showed that about half of impacts were detected. Of the 90 dummies that were launched 15 (17%) hit an upward moving blade. From these 15 hits 6 (40%) led to a trigger event, see figure 3. Another 6 (40%) fell below the trigger level and 3 (20%) were not identified as a collision.

The signal levels show a large spread because of the different impact locations and speeds that occur. Therefore it is clear that the numbers of this test are too small to draw statistically founded conclusions about detection percentages. Furthermore only one type of dummies has been used in these tests. Therefore additional validation is required by means of long-term monitoring in combination with ornithological field searches at sites with significant collision risk.

Figure 2: WT-Bird prototype with cameras left and right of the tower and with infrared LED lights and WLAN antennas in front and behind of the tower

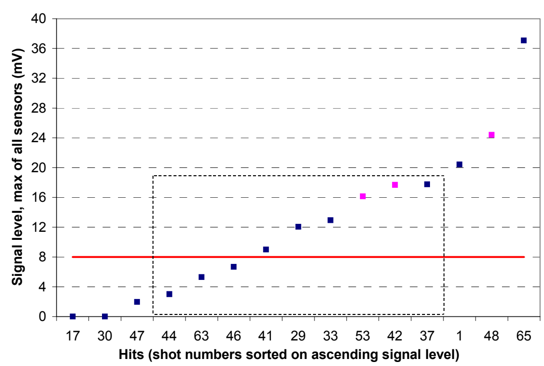
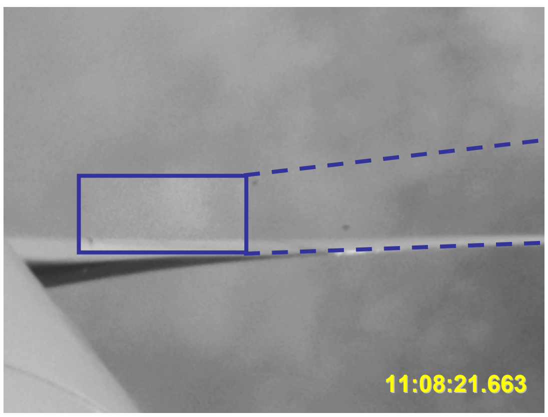


Figure 3: Signal levels of colliding dummies, sorted. (blue: detected, violet: cancelled, red line: trigger level)

The flight track of the dummies and the collision events were clearly visible on the recordings. Figure 4 shows three consecutive video images from a selected from a 1-minute fragment that was stored automatically. To enhance the visibility of the dummy the images were cropped to about 10% of the original area and the dummy is marked with a dashed circle. Some video fragments of field tests are available at [7].

Figure 4: Triggered registration of dummy collision on 20 June 2006.



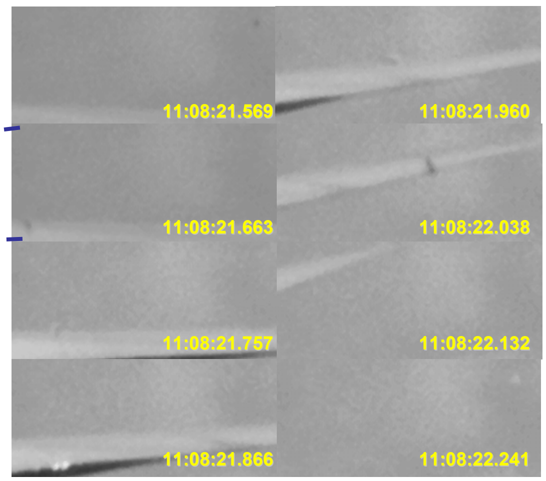


Figure 5: Bird collision on 19 March 2007
above: several birds visible in rotor plane
right: sequence of close-up images

5. ENDURANCE TEST RESULTS

An endurance tests of about one year proved that the system operated reliably. During the first months some improvements were made to the signal processing software to suppress some operational sounds, e.g. blade noise during high winds and typical sounds from the pitch bearings. This resulted in a low average number of false alarms, about 5 to 10 a day at a trigger level shown in figure 3.

Later on two sensors showed disturbance peaks, probably due to wear of the cabling caused by pitching. The signal processing was improved to automatically identify and suppress these short events.

During the monitoring period only two bird collisions were detected. The video recordings confirmed that the collisions took place, see figure 5, and showed that the location of both collisions occurred near the blade root, which resulted that in both cases the bird was not (immediately) killed. Therefore dead birds could be found beneath the turbine after these events. Also during the rest of the monitoring period dead birds were found beneath the turbine.

Figure 6 shows the video registration of a passing bird at high altitude, which was stored manually. The silhouette and flap movements can be recognized.

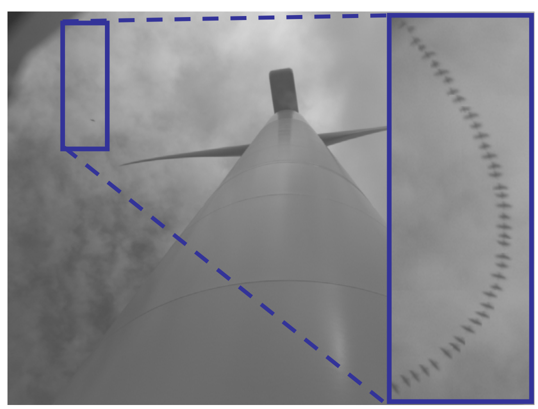


Figure 6: Video registration of passing bird

The image quality at night is still insufficient for species recognition. However rapid improvements are ongoing in the field of cameras and infrared lighting and frequently new cameras are being tested.

6. APPLICATION

Field tests for one year on a 2.5MW turbine proved the system is reliable and suitable for its purpose.

Operation holds checking proper system operation, checking (false) alarms, analyzing detected collisions and other events. Because the data amounts are very limited due to the acoustical trigger, data from a large number of turbines can be handled by a single operator.

The installation on site takes about one day for the acoustical detection system in the rotor, two days for the video equipment and one day for the equipment in the tower base and testing. Main requirements for the installation are suitable locations and provisions for mounting the sensors and video equipment. It also requires a mains connection in the rotor hub and in the tower base and a broadband Ethernet connection. No modifications to the turbine are required. For new turbines the acoustical detection system can already be installed during production and is fully functional, as it operates independently from the video equipment.

For new types of turbines the installation requires substantial preparation, e.g. to determine suitable mounting locations and provisions for the acoustical sensors and video equipment. Further, the signal processing algorithm needs to be tuned to the specific operating noises of the turbine. For turbines with collective pitching this will be rather straightforward.

7. DEVELOPMENTS

Main priority is to calibrate the WT-Bird system by means of comparing the measurements system with results from daily field searches by ornithologists. ECN is in contact with several parties to select suitable sites with respect to the expected number of collisions, the turbine type and local environmental conditions.

A possible location is the North-sea Oosterschelde storm flood barrier in the Dutch province Zeeland, where a number of 3MW wind turbines have been installed last year. There the WT-Bird systems are exposed to offshore conditions with respect to wind, background-noise and corrosion. The abundant bird species at these sites are coastal birds and also bird migration occurs over these sites. Earlier field investigations on this site provide a good knowledge base on local and seasonal bird movements, which shortens the period to collect enough data in order to determine the efficiency of the WT-Bird system with sufficient statistical confidence.

ACKNOWLEDGEMENT

This work is funded by SenterNovem, an agency of the Dutch Ministry of Economic Affairs (project number: 2020-03-11-10-003) and by the We@Sea foundation (project number: 2004-029).

REFERENCES

1. Dirksen S, Winden J van der, Spaans AL, Nocturnal collision risks of birds with wind turbines in tidal and semi-offshore areas. *RATTO, C.F. & G. SOLARI (eds): Wind Energy and Landscape*. Balkema: Rotterdam, 1998; 99-108.

2. Tulp I, Schekkerman H, Larsen JK, Winden J van der, Haterd RJW van de, Horssen P van, Dirksen S, Spaans AL, Nocturnal flight activity of sea ducks near the windfarm Tunø Knob in the Kattegat, www.buwa.nl

3. Vertegaal CTM, Preliminary Study into Bird Research Method for the MEP-NSW. *National Institute for Coastal and Marine management,* www.rikz.nl/thema/ikc/rapport2003/rikz2003045.html

4. Int. Council for the Exploration of the Sea (ICES), *Report of the Working Group on Seabird Ecology, 6.4*, www.ices.dk/reports/occ/2002/WGSE02.PDF

5. EJ Wiggelinkhuizen, LWMM Rademakers, SAM Barhorst, HJ den Boon, Bird collision monitoring system for multi-megawatt wind turbines WT-Bird; Prototype development and testing, http://www.ecn.nl/publications/default.aspx?nr=ECN-E--06-027

6. EJ Wiggelinkhuizen, LWMM Rademakers, SAM Barhorst, HJ den Boon, S Dirksen, H Schekkerman, WT-BIRD: Bird collision recording for offshore wind farms. *Proc. EWEC 2006, Policies and Programmes,* http://www.ecn.nl/publications/default.aspx?nr=ECN-RX--06-060

7. EJ Wiggelinkhuizen, CA Westra: Video fragments of field tests, 2006, http://www.ecn.nl/en/wind/products-services/services/wt-bird/