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WT BIRD

Bird collision recording for offshore wind farms

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WT-BIRD
BIRD COLLISION RECORDING FOR OFFSHORE WIND FARMS

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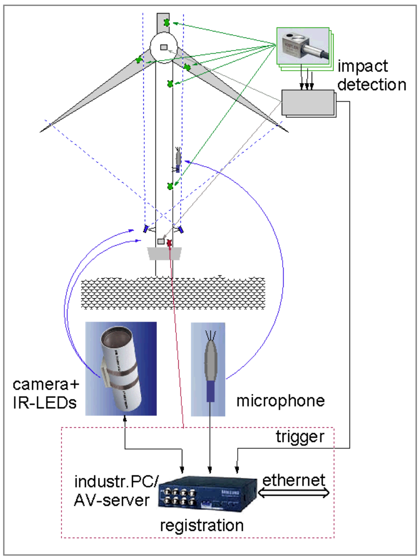
Summary: A new method for monitoring of bird collisions has been developed using video and audio registrations that are triggered by sound and vibration measurements. Remote access to the recorded images and sounds makes it possible to count the number of collisions as well as to identify the species. After the successful proof of principle and evaluation on small land-based turbines the system is now being designed for offshore wind farms. Currently the triggering system and video and audio registration are being tested on large land-based wind turbines using bird dummies. Tests of three complete prototype systems are planned for 2005.

Keywords: birds, environment, offshore, monitoring.

1. INTRODUCTION

The large-scale implementation of wind energy is hampered by the unknown effects that wind turbines may have on the environment. In that respect the effects of wind farms on bird populations, as casualties from collisions with turbines, are a topic of great concern. In environmental impact studies collision risks and the effects on populations are estimated prior to installation and assessed afterwards [1,2]. Yet no reliable cost-effective method is available to measure the number of casualties for offshore wind farms [3,4].

Figure 1: Schematic overview of WT-BIRD system.



A new monitoring system for registration of bird collisions, WT-BIRD, has been developed at ECN [5]. It uses video cameras and microphones combined with event triggering by sound and vibration measurements. Figure 1 shows a schematic overview of the system.

Compared to other methods employed so far, this registration system will reduce the uncertainty in the results of the number of casualties from collisions with wind turbines. The monitoring system runs continuously and at several turbines in parallel. Video and audio registrations of collisions are stored automatically and can be accessed at any time to count the number of collisions as well as to identify the species.

After the successful proof of principle and evaluation on small land-based turbines, this system is now being designed for offshore wind farms. The huge size of the structures of offshore wind turbines, the hash environmental conditions and limited access set new and more challenging requirements to the performance and reliability of the system.

Therefore the triggering system and camera registration, which form the key parts of the system, are now being tested on large land-based wind turbines using bird dummies. This paper describes the intermediate results of the development, viz. the working of the triggering system and the camera registration.

Tests of complete prototypes are planned in 2005.
It is also being investigated whether this system can also be used for monitoring of other events in order to save costs for inspection and repair after incidents.

2. IMPACT DETECTION

To obtain reliable detection of the bird impacts with the large turbine structure sensors need to be mounted at several locations in the rotor blades and in the tower. Impacts with different magnitudes at different spots on the turbine structure generate a response that should be picked up by at least one sensor. The turbine itself produces significant "operational" noise, which may also contain impulses, e.g. from brakes or relays. Because of this interference it is crucial to characterize both the sensor response to the turbine noise under different operational conditions and the response to impacts without these disturbances.

A series of tests is being performed to choose proper sensor types and locations and to set up design specifications for the signal processing that generates the trigger signal.

3. IMPACT DETECTION TESTS

For the selection of sensor types and sensor locations as well as for the characterization of impacts, tests with dummies of birds have been performed on still-standing blades up to a length of 30m. Tennis balls filled up with sand were used as dummies, because the stiffness hardly changed after an impact. Other advantages are the good aerodynamic shape and visibility. The launcher that was used is able to control the dummy speed between 15 and 55m/s with an accuracy of ±5m/s and the elevation can be set to vertical position.

The shape and frequency content of the sensor response have been assessed for about 100 impacts with varying dummy mass, speed, impact location and sensor location. Impact locations near the blade root, near the tip and in between were generated as well as direct impacts against the leading edge and grazing impacts against the pressure and suction side. By analyzing video registrations the exact position, impact speed and loss of impulse of the dummy were measured.

When the distance between the impact location and the sensor was increased a rapid decrease of the amplitude and higher harmonics of the sensor signal was observed, cf. fig 2. However at larger distances this decrease was smaller. It seems that the energy from the impact spreads out near the impact location and then vibration surface waves move through the blade with only little damping. Therefore sensors near the blade root can still detect an impact near the tip as the impact speed is high. Beside the distance and impact speed, the compressibility of the dummy influences the impact signal significantly.

4. INSTRUMENTATION AND PROTOTYPES

Currently the instrumentation for the registration of operational sounds is implemented in one of the Nordex N80 turbines at ECN's test site in the Wieringermeer.

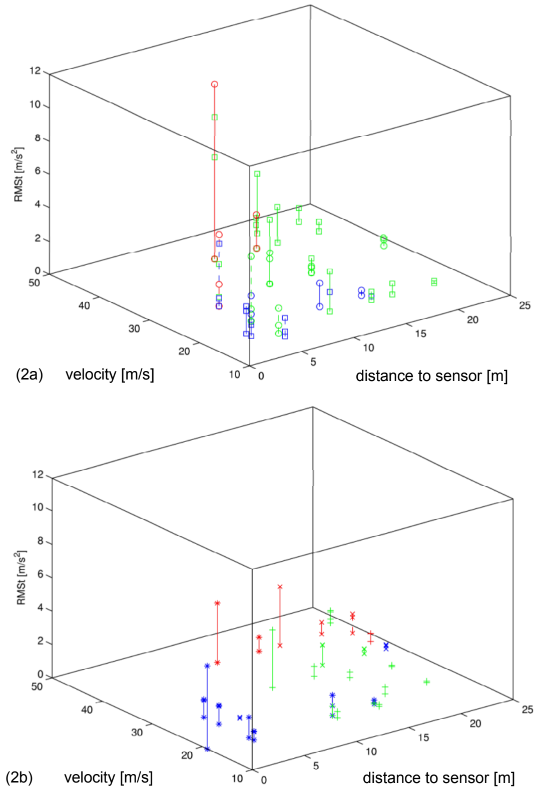


Fig. 2: Impact energy vs. distance to sensor and speed.
colors: blue-green-red: increasing mass
symbols (2a): □ frontal, O frontal-suction side,
symbols (2b): ∗ grazing, + suction side, x pressure side

This instrumentation is also used to register impacts of dummies against still-standing and rotating blades and against the tower. As the maximum impact speed is about 80m/s, which is the tip speed, measurement and dynamic impact calculations were performed which show that damage to the blades is unlikely to occur. During these tests video registrations are made to assess the capabilities of the cameras as well as to find optimal locations for the cameras and infrared beamers.

The next step is to set up design specifications for the impact detection system. Figure 3 shows a possible block scheme of the triggering system. One system will be installed in the rotor and one in the tower base. If a broadband (wireless) transmission from the rotor to the tower base is possible, only the signal conversion plus filtering is sufficient for the system in the rotor.

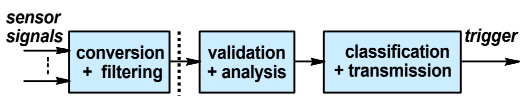


Fig.3: Block scheme of impact detection system.

5. REGISTRATION

The optical requirements for this application prove to be extremely demanding. Firstly the camera has to adapt to extreme changes in exposure conditions (roughly from 10^{-2} lux up to 10^{5} lux) and contrast variations. Secondly the target must be visible up to a distance of about 100m and over a wide viewing angle of at least 60°, which requires a high resolution. Thirdly both the birds and the blades move, so that extended integration time cannot be applied, as this would cause so-called motion smear. Finally the frame rate should be high enough to measure the flap frequency of the birds, as this is an important method to identify the species.

A number of products in the top range of different application categories has been tested: (i) Security cameras are very sensitive, but have limited resolution. (ii) Web cams are not sensitive enough and usually use long integration times to compensate for this. Only a few web cams have a good resolution and use a video compression technique that preserves the picture quality. (ii) Industrial cameras are usually applied indoors and therefore lack proper control to adapt for varying exposure conditions. (iv) Scientific cameras probably are suitable, but are far too expensive.

On the other hand the capabilities of digital video equipment improve rapidly and in the WT-BIRD system easy upgrading of this equipment is taken into account. Due to camera limitations and bad weather conditions as fog, good video registration of birds may not always be possible. Therefore audio recording will be implemented to improve and facilitate species recognition.

Since the start of the project a number of video cameras has been tested in combination with infrared beamers. Pre-selection of cameras is now finished. An affordable industrial camera is being modified such that it can adapt to varying outdoor exposure conditions and that it can withstand the harsh environment. With this camera and a scientific camera as a reference tests will be carried out at ECN's test site in the Wieringermeer and in a coastal bird reserve.

6. FUTURE WORK

Complete WT-BIRD prototypes will be tested in 2005 over a period of 6 months. For these tests two onshore large-scale turbines and one smaller turbine at a coastal location are selected. As a result of these tests the technical specifications should be set, such as the system performance and availability in different conditions and O&M needs.

During these tests the number of casualties detected by the WT-BIRD system will be calibrated by means of field research. This will be a critical aspect, as the expected number of casualties is too small to be statistically significant.

To accommodate to this problem and to gain more experience a new test is proposed that will start around the end of the 6-months period test. The main objectives are to obtain statistically significant numbers and to prove that the system preforms well in a wind farm in offshore-like conditions.

7. SUMMARY

Sensor responses to impacts of bird dummies with still-standing rotor blades have been characterized from about 100 impacts with different speed, location, etc. Instrumentation for the registration of impacts of bird dummied and the disturbing operational sounds of a 2.5 MW wind turbine is operational.

Registration of birds colliding with offshore wind turbines is an extremely demanding application. Several nightly camera tests have resulted in a pre-selection of a camera, but tests with cameras and microphones are still ongoing. Complete WT-BIRD prototypes will be tested in 2005 during a period of 6 months.

ACKNOWEDGEMENT

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