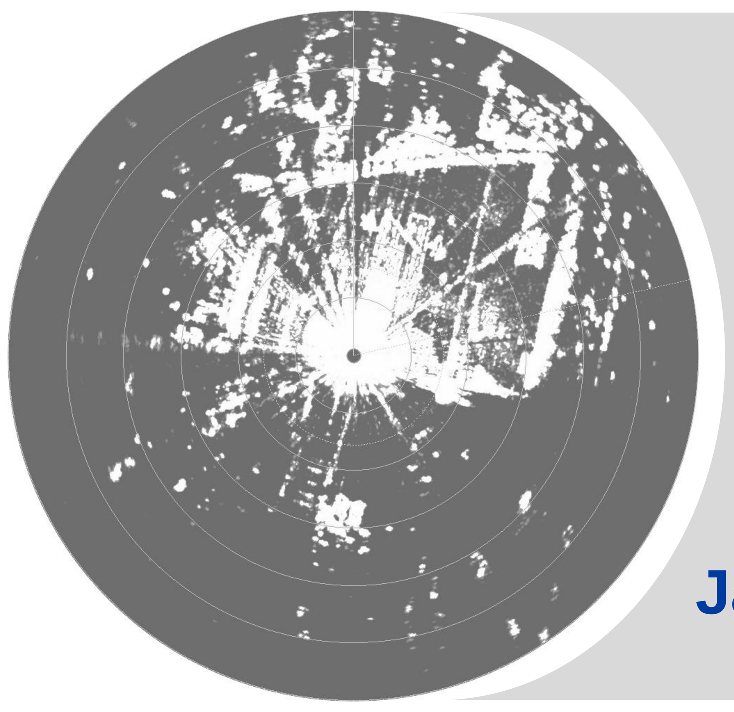

Development of Risk Mitigation Methods for the Protection of Bats in Close Proximity to Onshore Wind Turbines (FLEDERWIND)

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HAW HAMBURG

Introduction

The fast growing number of wind parks has significant impact on bats. Beside bat casualties during migration flights, wind turbines (WT) seem to attract bats [1] and can cause additional lethal damage. Direct collision with the WT rotor blades or the barotrauma are currently seen to be most harmful. However, this is in contrast with the European law, which lists all European bat species, their breeding sites and resting places as being protected.

Since it is currently unclear what attracts bats to WT, our aim is to investigate the attraction and further risk mitigation methods to protect the bat species and also to develop a bat-friendly WT design and operation.

We therefore propose the following steps

- **Development of a spatial detection system for bats**
  - 2D spatial detection in a defined area of a WT
  - Definition of the bat quantity and species
  - Acquisition of the flight paths
- **Development of risk mitigation methods**
  - Research of a bat-friendly illumination for WT

Available Equipment

- Furuno FAR 2117 Radar
- Individual Power Meter for pulsed X-Band radiation
- Measuring station at the windfarm “Curslack“
- Batcorder
- Infrared Camera

Associates and Cooperation

Leibniz Universität Hannover · Umweltplanung – Informationsverarbeitung – Naturbewertung (UIN) · Bio Consult SH · Hamburg Behörde für Umwelt und Energie · FURUNO Deutschland · ENERTRAG

Optimization of Radar Bat Detection

- Radar system: Furuno X-Band navigation radar with 12 kW pulsed power output and 8 ft. slotted waveguide antenna (fig. 1).
- Fine tuning of the radar settings for a radar range ≤1,5 km covering a small windfarm and also providing reasonable radar resolution cells (fig. 2)
- The max detection range (visible on the PPI – Plan-Position-Indicator) of the radar was found to be approximately 800 m for the *Nyctalus noctula* species. This result was revealed with experiments utilizing a bat model as well as dead bats (fig. 1).

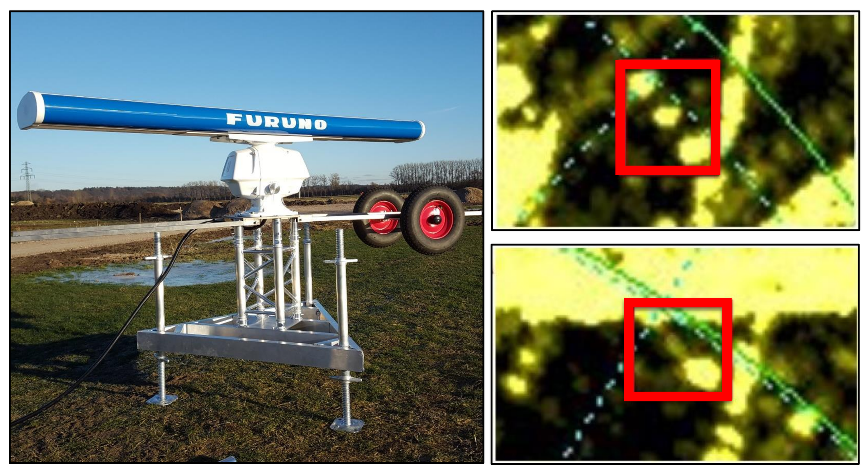


Figure 1. Antenna und transceiver on radar stand (left). Experimental set-up of the bat model fixed to a string between two poles produces three echoes on the PPI (right). Echo of the model in the middle is visible at 600 m from radar (top), invisible at 900 m (bottom).

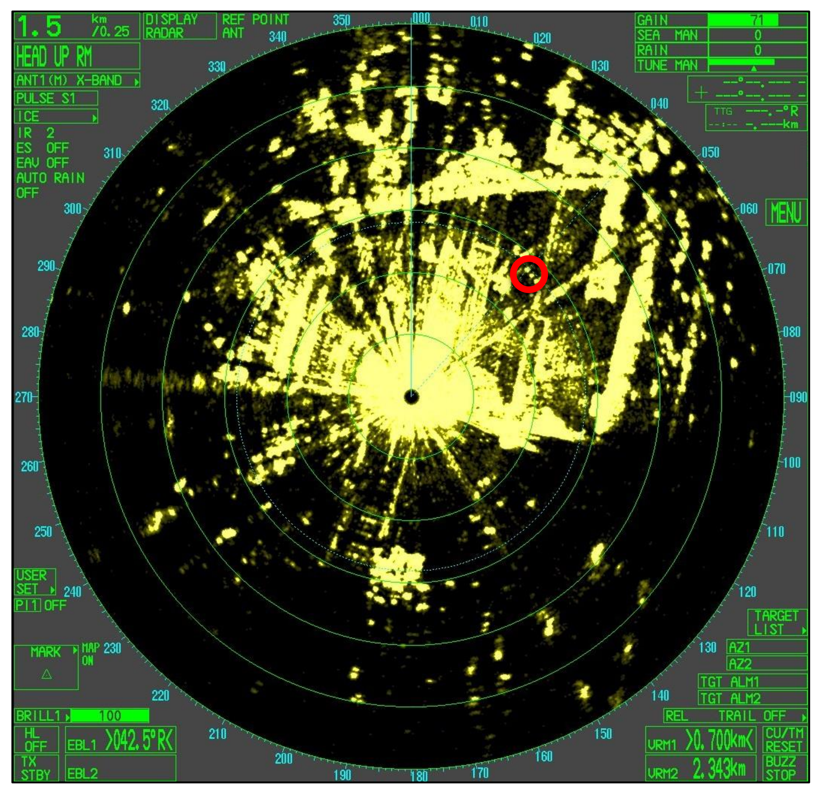


Figure 2. The PPI of the radar with a range setting of 1.5 km and no clutter reduction. The motorway (passing from west to east, approx. 800 north from the radar) shows strong reflection. The small red circle depicts three strong echos from a bat sized object.

Methodology: Detection of Bats with Radar, Acoustic Hardware and Infrared Camera

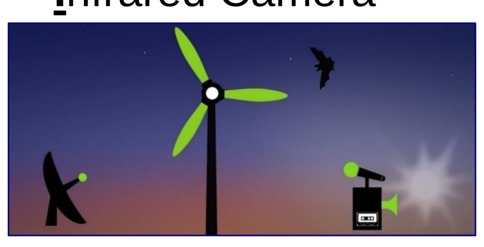
RAI Method

Covering a large area: → radar

Quantity: → acoustic + radar

Species: → acoustic

Flight paths: → **R**adar + **A**coustic + **I**nfrared Camera



Step 1: Understanding all single components (e.g. properties of the electromagagnetic radar and rays)

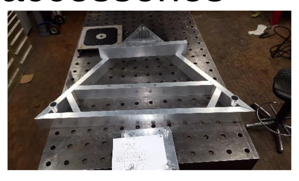
Step 2: Correlation between different data outputs (e.g. time & position)

Radar detection in detail

Commiss-ioning → Adjust-ment → Opti-mization → Manual bat detection → Automation & Correlation

Commissioning: Assembly of the measuring station

Construction of accessories

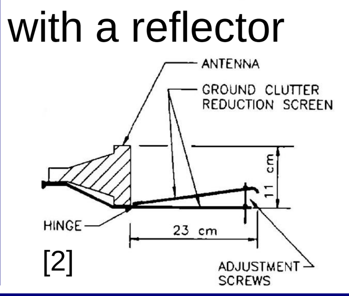


Adjustment: 1. Theoretical calculation of the detection range

2. Verification with model tests

Optimization: Clutter Reduction:
1. Development of a clutter fence

2. Modifying the antenna diagram with a reflector



Manual bat detection: Experiments with the optimized radar system
- Boundaries are known
- Verification: Batcorder, infrared cam.

Automation & Correlation: Automated analysis of radar image:
- Image recognition with Matlab, Python
- Target tracking

Correlation with acoustic data & development of a data base

Design of acoustic hard- and software

Compre-hensive	Determina-tion of position	Determina-tion of species
Determina-tion of quantitiy	Live	Individual discrimina-tion
Operational time	Costs	Size & installation expenditure
Computing time	Complexity	Correlation RAW

Radar Optimization - Reduction of Ground Clutter

- Significant ground clutter reduction when radar shield with clutter fence, which is highly impermeable for X-band electromagnetic radiation.
- The layout of the fence leads to a diffraction pattern, strongly affecting the likelihood of bat detection (Fig. 3).

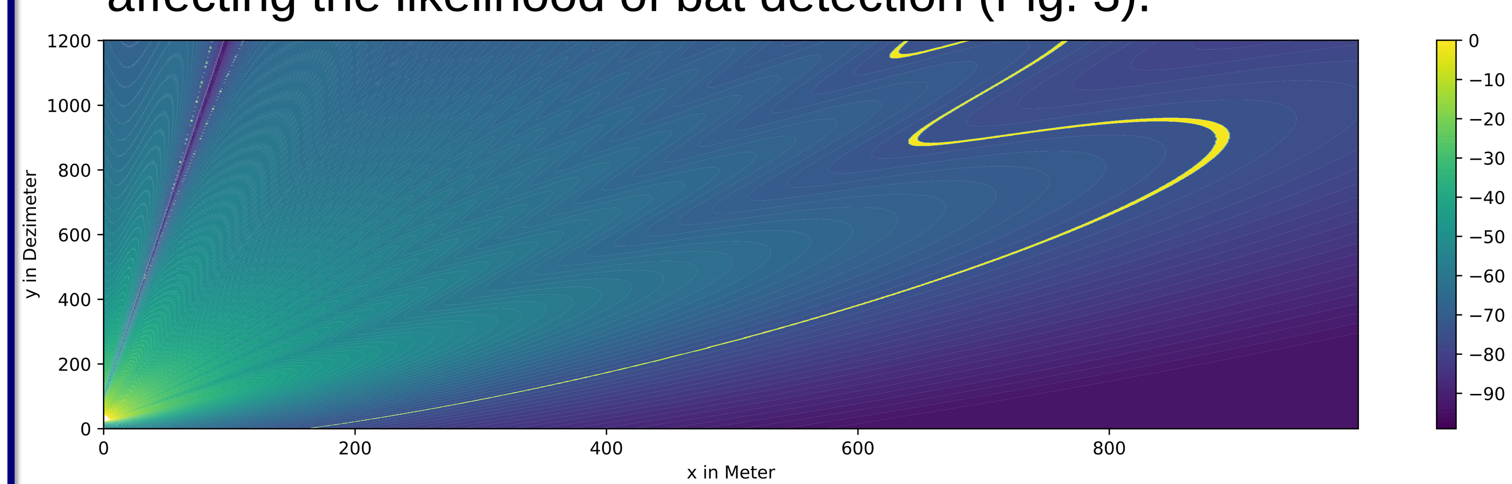


Figure 3. Simulated received power of a Furuno FAR-2107 radar behind a clutter fence (as defined in Fig. 4) for bat sized objects for different distances and heights. The diffraction leads to the wiggeled isolines (1 dBm), where the yellow line shows the detection limitation of the radar.

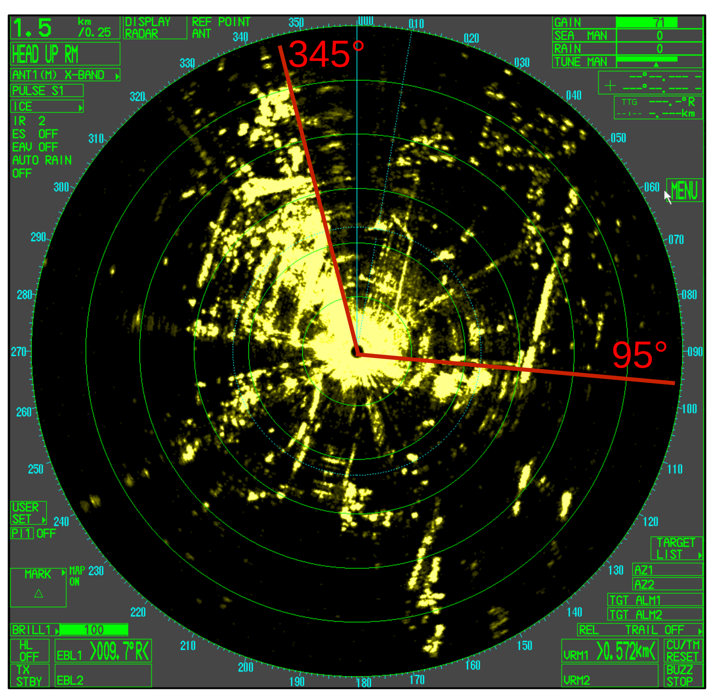


Figure 4. The PPI of the radar shows clutter reduction (see fig. 2, 3) between 345° and 95° (red sector), where the antenna is surrounded by a clutter fence. Radius: 6 m, fence height: 2.155 m, antenna height: 1.934 m.

Conclusions

- To further improve bat-friendly WTs, more insight into the attraction of bats to WT must be obtained. Therefore the behavior of bats and especially their flight paths must be investigated. To succeed, we have to involve several detection methods (RAI).
- The RAI detection method has several advantages compared to a single detection system (e.g. batcorder or radar only).
- Spatial detection of bats with radar and reduced surface clutter has proven to dramatically increase radar resolution. Likewise, a clutter fence is recommended to further reduce clutter and optimize system sensitivity and performance.

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