# Bat-friendly operation algorithms: reducing bat fatalities at wind turbines in central Europe

Oliver Behr, Klaus Hochradel, Jürgen Mages, Martina Nagy, Fränzi Korner-Nievergelt, Ivo Niermann, Ralph Simon, Florian Stiller, Natalie Weber, Robert Brinkmann

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Projektträger Jülich Forschungszentrum Jülich

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

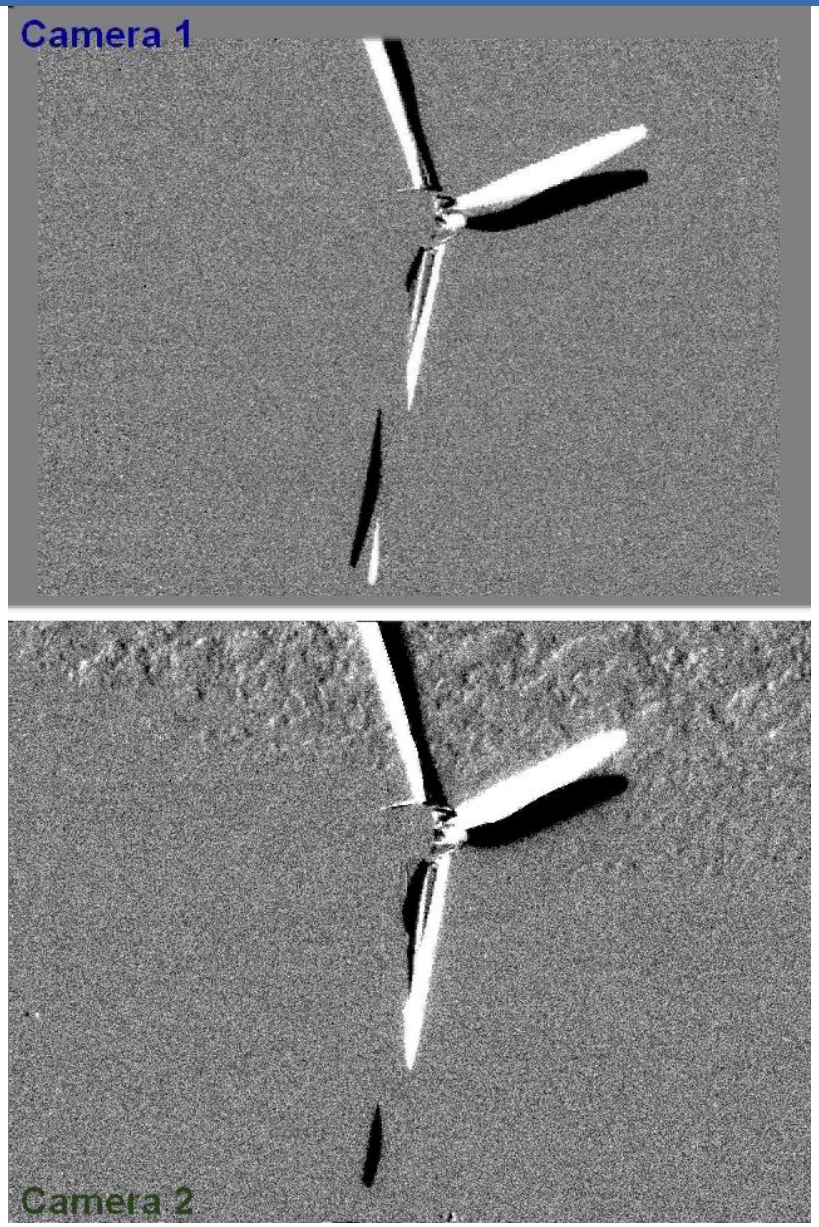
Leibniz Universität Hannover

Fraunhofer IOSB

ENERCON ENERGY FOR THE WORLD

oikostat.ch

Collision risk



# Legal issues

- All European bat species are strictly protected
- Habitats Directive EU, national and state regulations (federal structure of nature conservation agencies in Germany)
- Possible impact on bats has to be studied and considered during the planning process
- In Germany, at some sites operation is heavily restricted or a permission is denied all together
- Methods to estimate and deal with bat collisions are not standardised
- **→Uncertainty in the permission process for agencies involved, developers, and investors**

Objectives

Standardised method to

- Estimate the number of bats being killed at a specific turbine (Mixture model)
- Predict times of high mortality risk (GLMM)
- Mitigate the impact on bats by stopping the rotor during times of high mortality risk (Bat friendly operation algorithms)

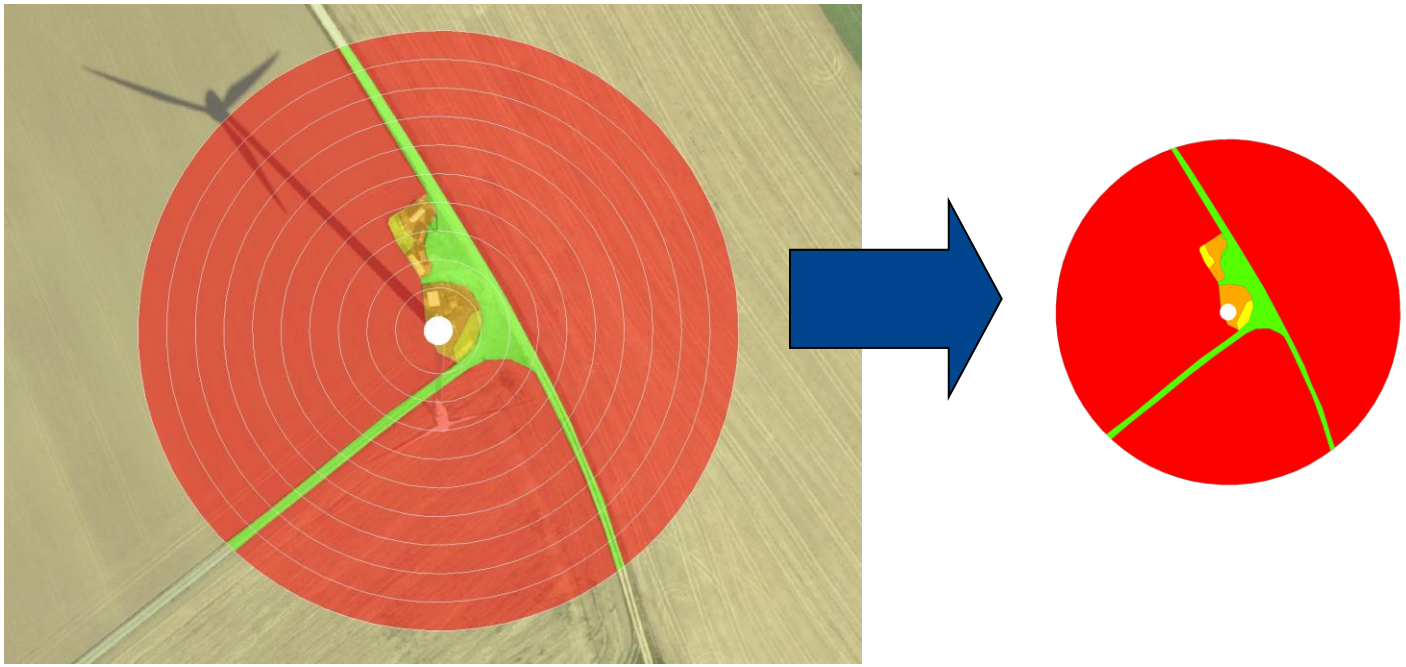
➔ **Experimental validation of models and bat friendly operation algorithms**

Methods

1. Fatality searches
2. Acoustic monitoring of bat activity

# Fatality searches

- Fatality searches are **expensive** and in Central Europe they are rarely performed with adequate **search intervals**
- In Europe, many studies do not account for **search biases**



# Fatality searches

- Fatality searches are **expensive** and in Europe they are rarely performed with adequate **search intervals**
- In Europe, few studies account for **search biases**

# Fatality searches

- Fatality searches are **expensive** and in Europe they are rarely performed with adequate **search intervals**
- In Europe, few studies account for **search biases**
- If **less tha** around the turbine can be sea e is intermediate or high, it is **r** lity rate with reasonabl
- At many si **informative** value

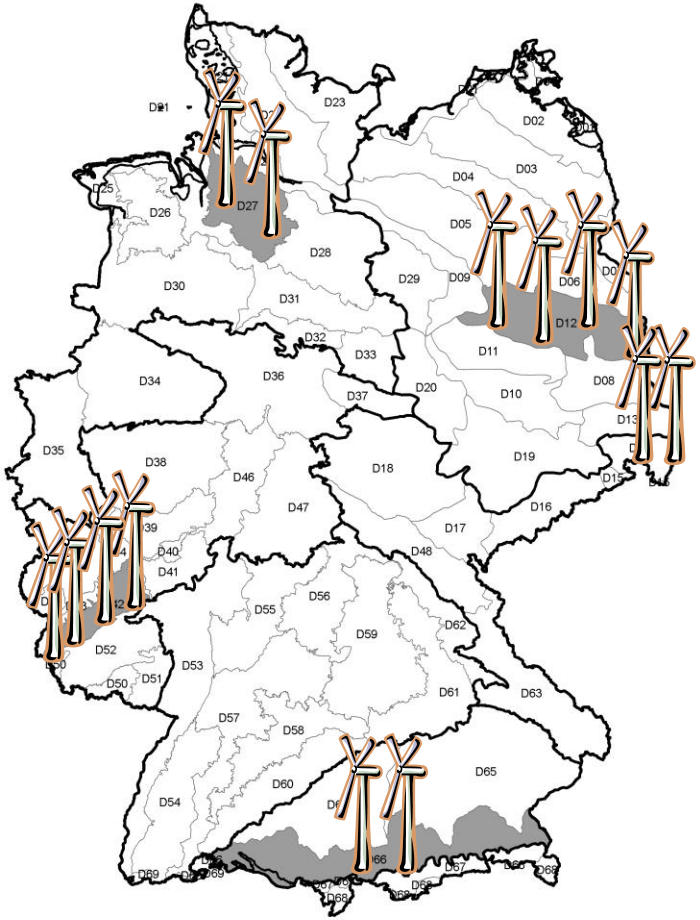
→ **Alterr** sion risk

→ E.g. **a** ty at the nacelle

Acoustic data

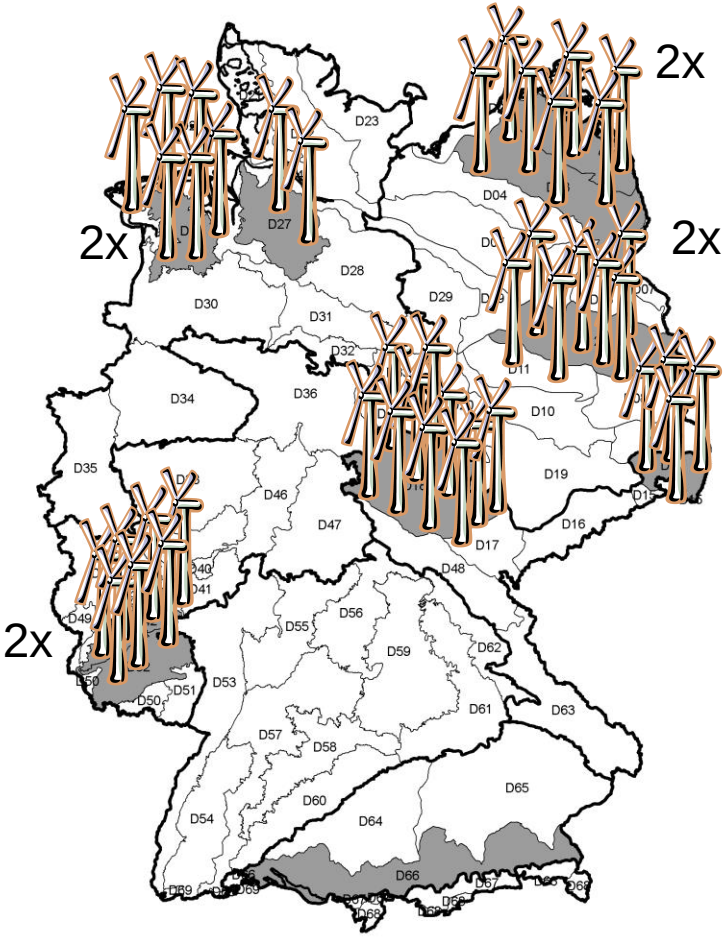
2007

14 Turbines



2008

70 Turbines



Acoustic monitoring

# Estimating fatality numbers

## We measure

Per turbine and night

Number of acoustic recordings

Wind speed

Number of fatalities found

Per turbine

Scavenging rate

Fraction of area searched

Per searcher

Search efficiency

## We want to know

mixture model

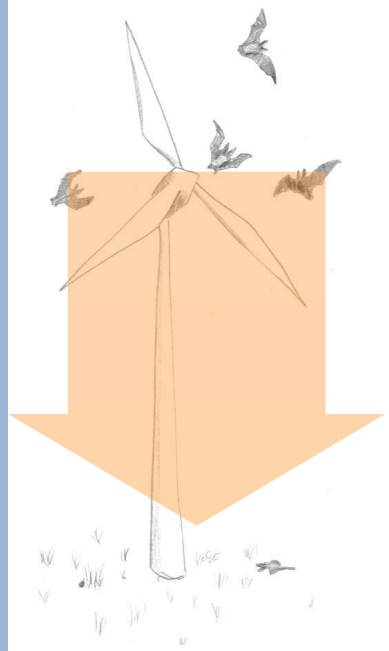
(*Korner-Nievergelt et al. 2013 Plos One*)

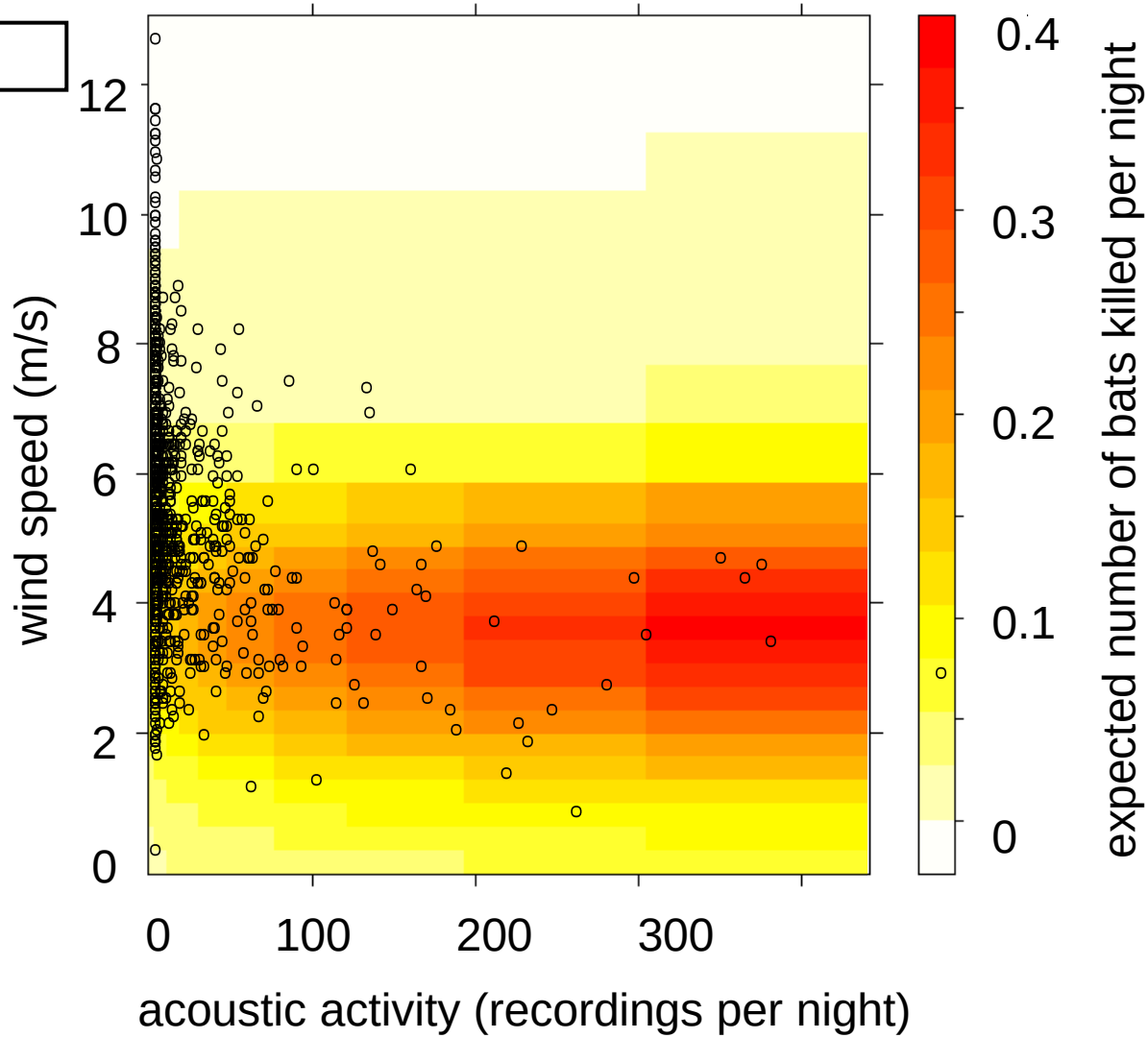
Number of bats killed

Estimation

(*Huso 2010 Environmetrics; Korner-Nievergelt et al. 2011 Wildlife Biology*)

Mixture Model





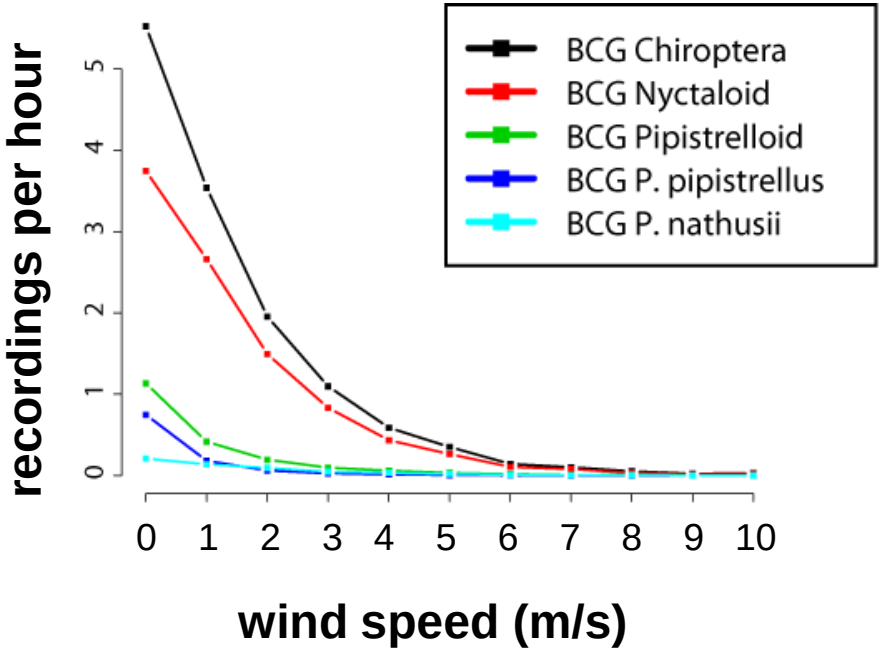
# Estimated fatality numbers

| Fatality searches | Acoustic data |
|---|---|
| **6.0** | **5.0** |

Median of bats killed per turbine during 92 days

(approx. x2 per year)

# Activity and wind speed



BEHR, O. und O. VON HELVERSEN (2006):

Gutachten zur Beeinträchtigung im freien Luftraum jagender und ziehender Fledermäuse durch bestehende Windkraftanlagen - Wirkungskontrolle zum Windpark „Roßkopf" (Freiburg i. Br.) im Jahr 2005.

Erlangen, **unpublished report**.

BAERWALD, E. F., J. EDWORTHY, M. HOLDER und R. M. R. BARCLAY (2009):

A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities.

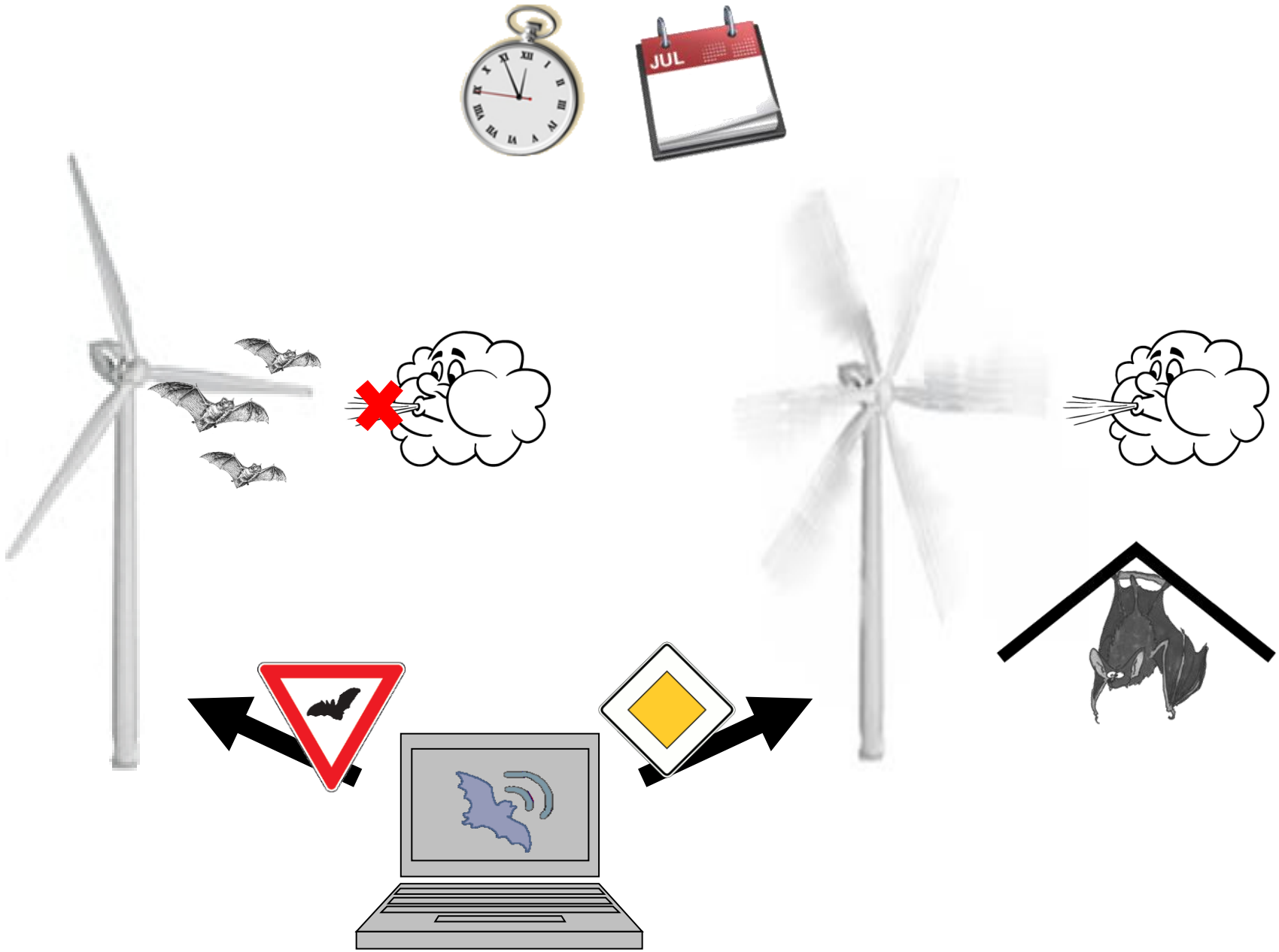
Journal of Wildlife Management 73: 1077-1081.

ARNETT, E. B., M. M. P. HUSO, M. R. SCHIRMACHER und J. P. HAYES (2010):

Altering turbine speed reduces bat mortality at wind-energy facilities.

Frontiers in Ecology and Environmental Studies doi10.1890/100103.

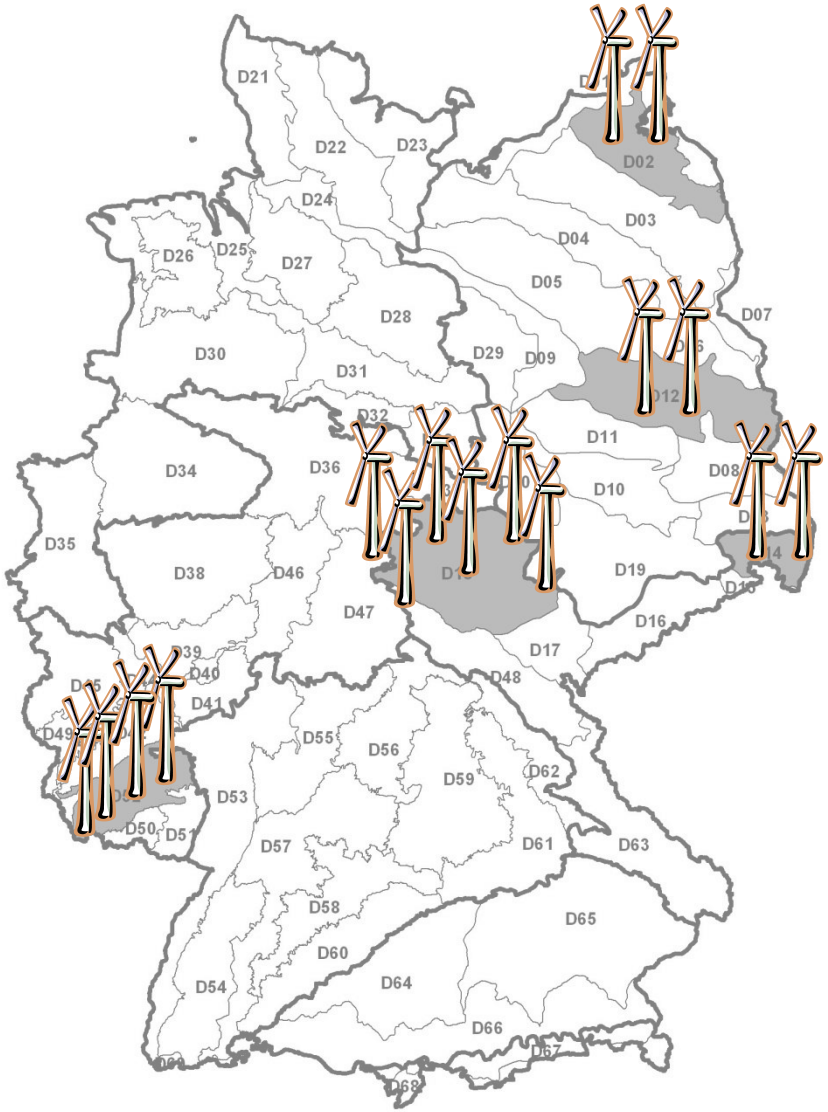
Times of high risk



# Measuring and mitigating the risk of bat-collisions at wind turbines

Mitigation experiment 2012

- 16 wind turbines at 8 sites
- Acoustic recordings and daily fatality searches
- 3 months (July – September)



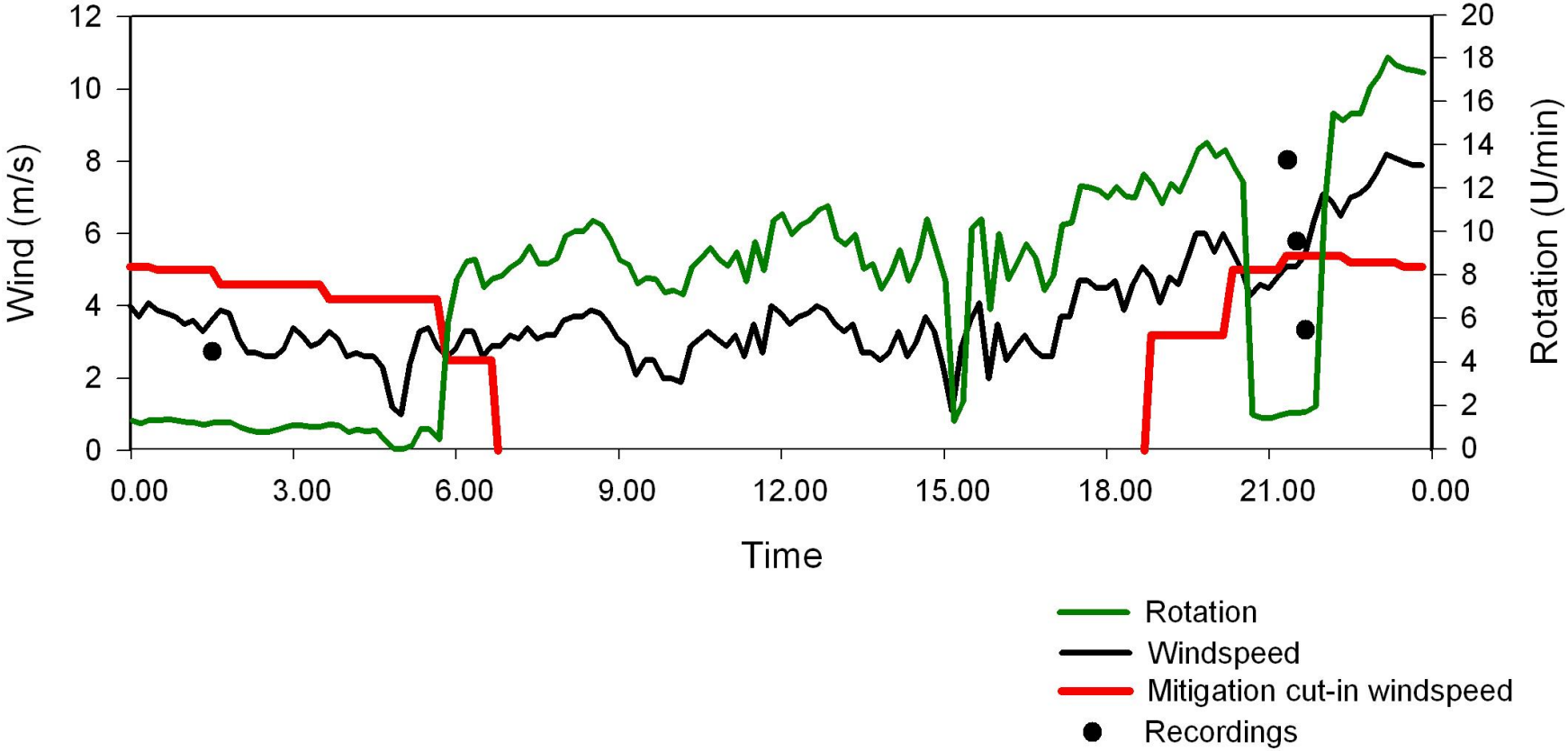
# Mitigation experiment 2012

- Per site: Weekly alternating operation of turbines with and without mitigation algorithm

- Reduction of mean fatality rate from 12 to 2 per year

  → **ratio 6 : 1**

Curtailment

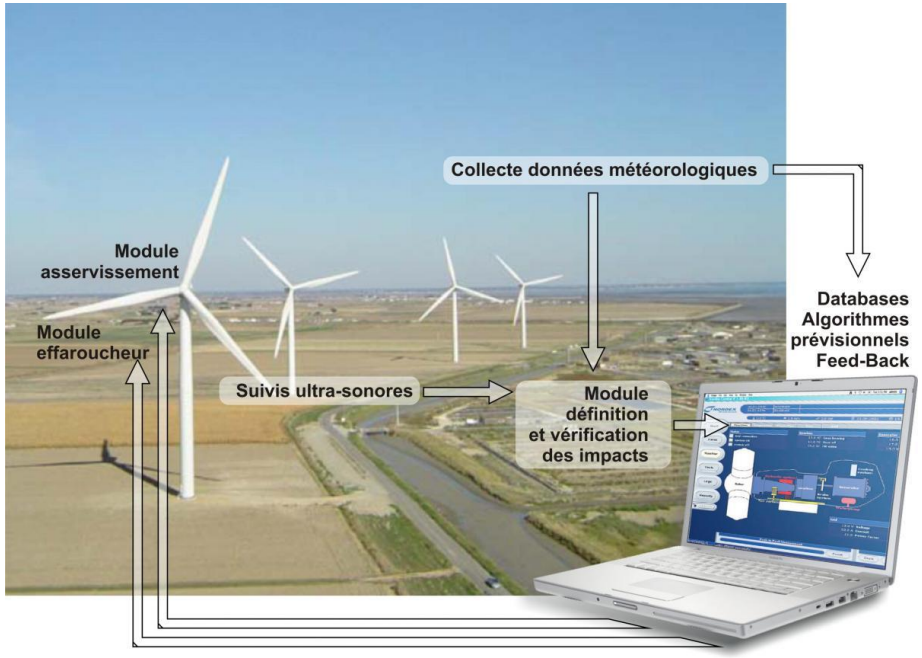


## EU and Federal states in Germany

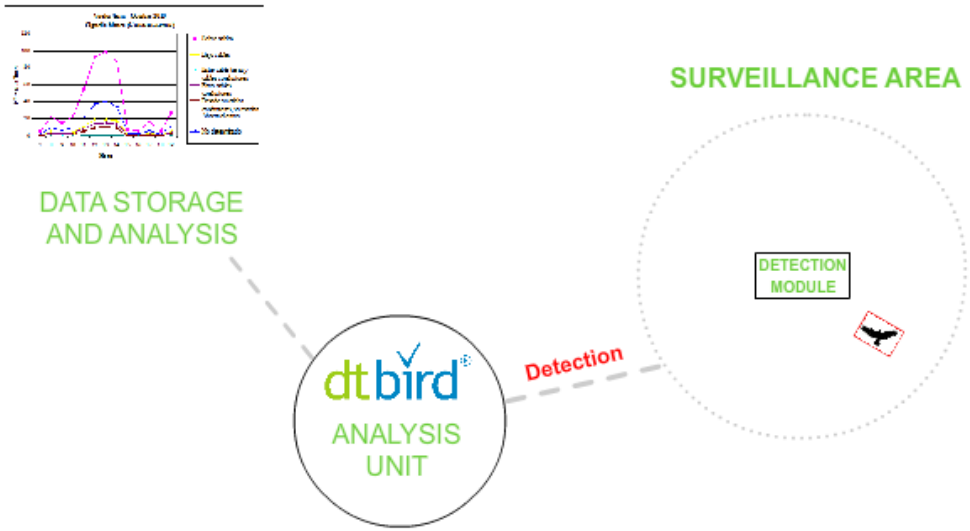
| Regulation of | EU-Commmission (2010) | BfN (2011) | BaWü (2006) | BaWü (2012) | Bayern (2011) | Bayern (2013) | Brandenburg (2011) | Hamburg-(2010) | Hessen (2010) | Hessen (2012) | Meck.-Vorp. (2012) | Niedersachsen (2011) | NRW (2011) | NRW (2012) | NRW (2013) | RLP (2012) | RLP (2013) | Saarland (ohne Jahr) | Saarland (2012) | Saarland (2013) | Sachsen (2001) | Schl.-Holst. (2008) | Schl.-Holst. (2012a) | Schl.-Holst. (2012b) | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Planning process | X | X | | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | **21** |
| Preconstruction survey | X | X | X | X | X | X | X | | | X | | X | | X | X | X | X | | X | X | | X | | | **16** |
| Postconstruction survey | | X | | | X | X | X | | | X | | | | X | X | X | | | | X | | | | X | **10** |
| Mitigation algorithms | | X | X | | X | X | X | | | X | | X | | X | X | X | X | | | X | | X | | X | **14** |
| Compensation | | | | X | | X | X | | | X | | X | | | X | X | X | | | X | | | | | **9** |

Brinkmann et al. 2014

## France: Chirotech by Biotope




## Spain: DTBird



Technics

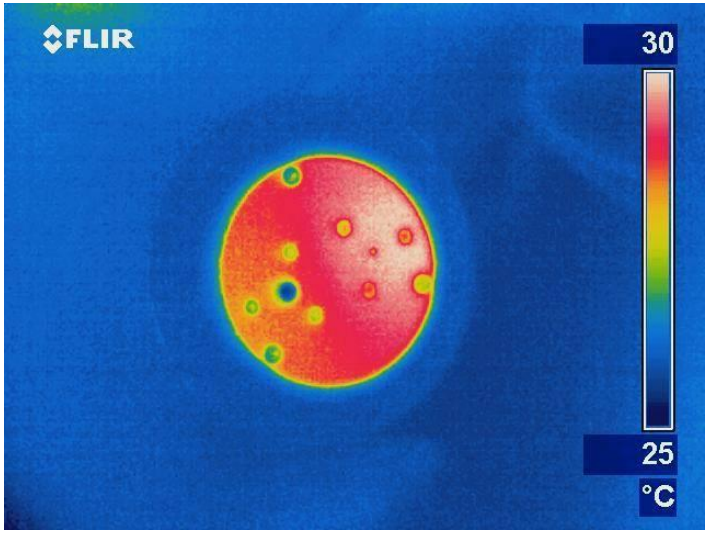
Development of new technology for

- Acoustic sampling
- Software analysis

# BATmode-System

## WIFI, GSM/UMTS:

- Full remote access via Laptop, Tablet or Smartphone
- Transmission of monitoring data
- Status messages




## Inbuilt AVISOFT-System:

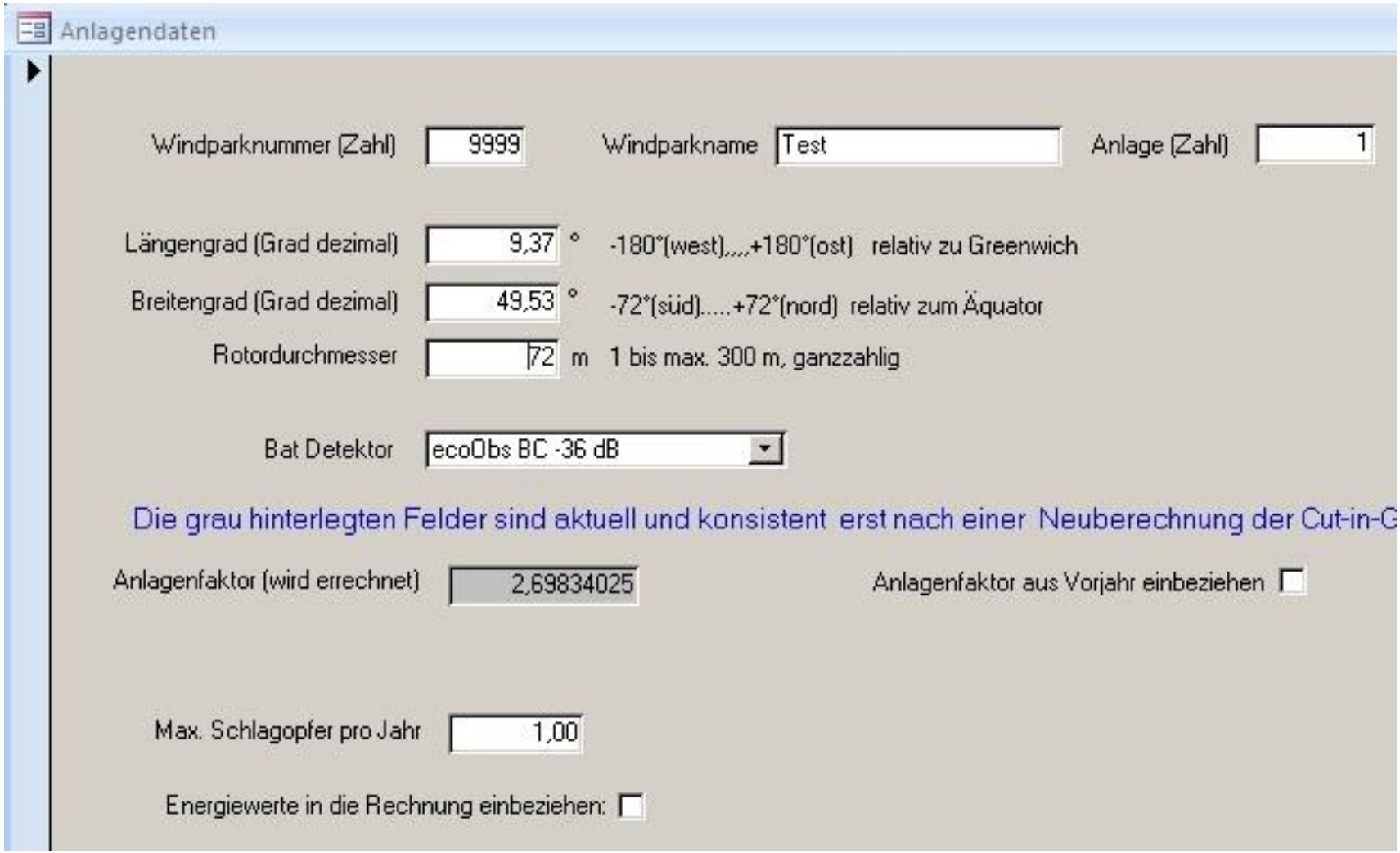
- Bat call filter
- High sensitivity
- Increased detection range
- Complies with BMU-specifications

Benefits

- Resistance to ultrasonic noise
- Low maintenance requirements

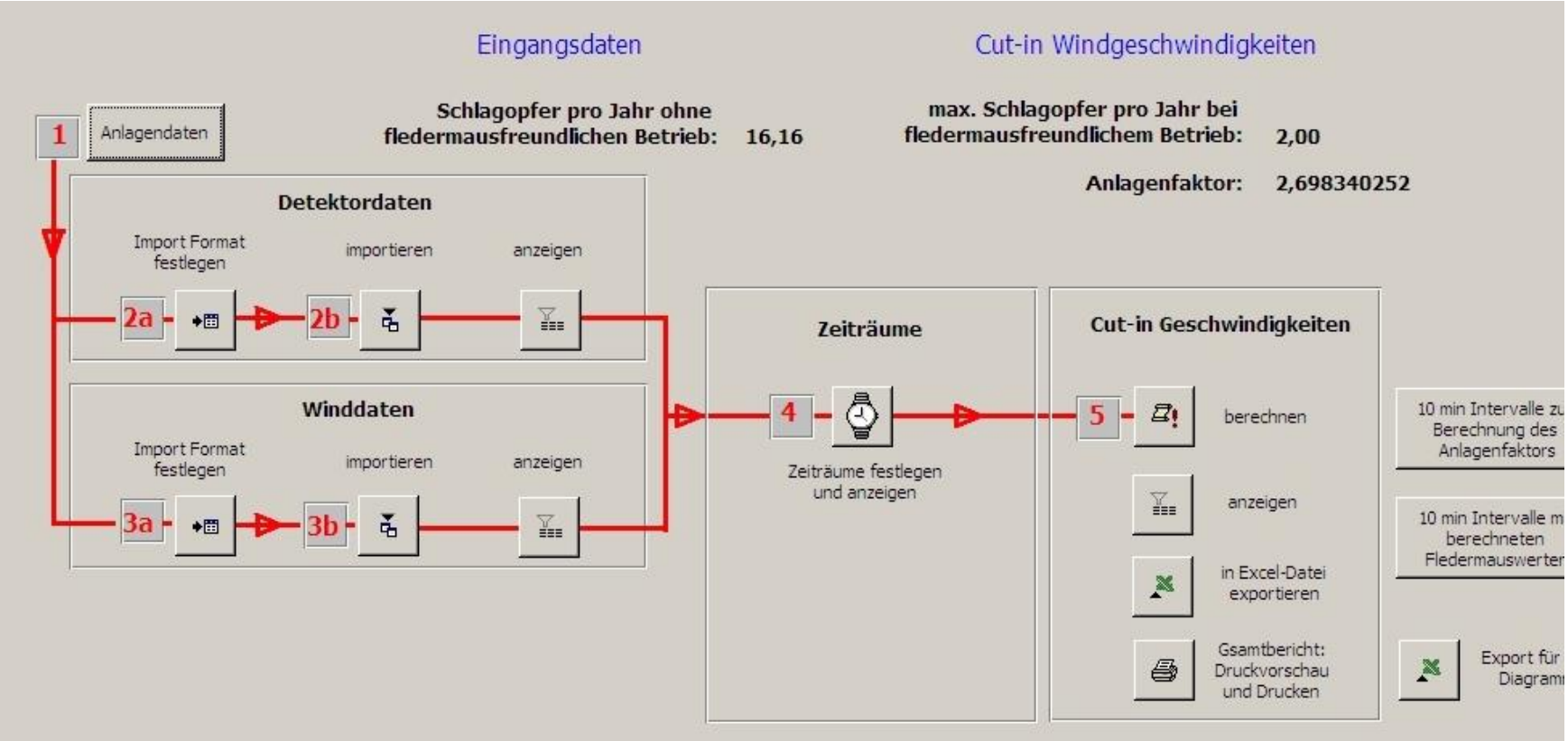
Bio Acoustic Technology

BATmode




- Since May 2014
- windbat.techfak.fau.de

ProBat user interface




- MS-Access-runtime-based
- Calculates the expected number of fatalities per year
- Calculates a bat friendly operational algorithm for a number of bat fatalities per year defined by the user.
- Currently for data recorded with Batcorder (-36 dB), until 2015: also Batcorder -27 dB, Anabat SD1, and Avisoft System

ProBat - Report

Windpark 9999 xxxxxx Anlage 1

Geographische Lage: Längengrad 9,99 Breitengrad 44,44

Jahr der Beprobung: 2011

Rotordurchmesser (m): 90,00

Bat Detektor: **"ecoObs BC -36 dB"**

Schlagopfer pro Jahr ohne fledermausfreundlichen Be trieb: 16,18

Schlagopfer pro Jahr bei fledermausfreundlichem Bet rieb: 2,00

Das Dämmerungsinterval wurde in die Berechnung nich t einbezogen.

## Gemeinsame Beprobungsintervalle: Detektor und Wind

| | | | | | |
|---|---|---|---|---|---|
| von | April | 1 | bis | Septembe | 4 |
| von | Oktober | 1 | bis | Oktober | 2 |

## Beprobungsintervalle nur Wind

| | | | | | |
|---|---|---|---|---|---|
| von | April | 1 | bis | Septembe | 4 |
| von | Oktober | 1 | bis | Oktober | 15 |

## Mindestanforderungen an die Beprobung

Proben einer Nacht galten, wenn für mindestens 80% der Nachtintervalle Winddaten vorlagen

Im Gesamtzeitraum von März 15 bis Oktober 31 gibt es 231 Nächte

davon sollten 173 Nächte, müssen 154 Nächte beprobt werden, wurde 159 Nächte beprobt

In der Kernzeit von Juli 1 bis September 30 gibt es 92 Nächte

davon sollten 68 Nächte, müssen 61 Nächte beprobt werden, wurden 66 Nächte beprobt

## Cut-in Windgeschwindigkeiten



| Monat | Nachtzeit | Cut-in Windgeschwindigkeit (m/s) |
|---|---|---|
| 04 | -0,15-0 | 3,1 |
| 04 | 0-0,1 | 5,0 |
| 04 | 0,1-0,2 | 5,4 |
| 04 | 0,2-0,3 | 5,2 |
| 04 | 0,3-0,4 | 5,2 |
| 04 | 0,4-0,5 | 5,2 |
| 04 | 0,5-0,6 | 4,9 |
| 04 | 0,6-0,7 | 5,0 |
| 04 | 0,7-0,8 | 4,5 |
| 04 | 0,8-0,9 | 4,3 |
| 04 | 0,9-1 | 2,5 |
| 05 | -0,15-0 | 3,7 |
| 05 | 0-0,1 | 5,3 |
| 05 | 0,1-0,2 | 5,7 |
| 05 | 0,2-0,3 | 5,4 |
| 05 | 0,3-0,4 | 5,4 |
| 05 | 0,4-0,5 | 5,4 |
| 05 | 0,5-0,6 | 5,2 |
| 05 | 0,6-0,7 | 5,2 |
| 05 | 0,7-0,8 | 4,8 |
| 05 | 0,8-0,9 | 4,7 |
| 05 | 0,9-1 | 3,1 |
| 06 | -0,15-0 | 3,6 |
| 06 | 0-0,1 | 5,4 |
| 06 | 0,1-0,2 | 5,8 |
| 06 | 0,2-0,3 | 5,5 |
| 06 | 0,3-0,4 | 5,5 |
| 06 | 0,4-0,5 | 5,4 |
| 06 | 0,5-0,6 | 5,1 |
| 06 | 0,6-0,7 | 5,1 |
| 06 | 0,7-0,8 | 4,7 |
| 06 | 0,8-0,9 | 4,6 |
| 06 | 0,9-1 | 2,9 |
| 07 | -0,15-0 | 4,0 |
| 07 | 0-0,1 | 5,5 |

Objectives RENEBAT III

- Necessary sample sizes to measure bat activity
  - Temporal variability
  - Within-site variability
- Effect of the rotor diameter on fatality numbers
- Effect of the cut-in wind-speed on fatality numbers
- Are we able to model effects of fatality numbers on populations?
- Stereo-infrared sampling of bat activity in the rotor-swept area
- Testing new detector hardware
- Implementing the solutions found in planning processes

# Temporal variability

- Variability in between different years and seasons
- Acoustic sampling of the bat activity in the rotor-swept area
- 16 turbines at 8 sites in different geographical areas
- Data are already available for the years 2008 and 2012

2014 → 2016…2018 ??

# Spatial variability

- Acoustic sampling of the bat activity in the rotor-swept area
- Variability between turbines withins sites
- 32 turbines at 8 sites in different geographical areas

# Effect of the rotor diameter

- Effect of the rotor diameter on fatality numbers
- Until now, the effect is extrapolated from the spatial distribution of bat activity in the rotor-swept area
- 14 turbines at 7 sites in different geographical areas
- Rotor diameters > 70 m
- Fatality searches and acoustic sampling of bat activity

←

→

Summary

- Model predicts collision rate from acoustic data
- Bat friendly operational algorithms work properly (2 fatalities predicted - 1.9 fatalities observed)
- Bat friendly operational algorithms are becoming a standard method in Germany
- Hardware and Software tools are being refined

Thanks!

**Prof. Dr. Otto v. Helversen †**

Volker Brunckhorst, Rüdiger Dittmann, Uwe Gerhardt, Marion Gerhardt, Michael Göttsche, Axel Griesau, Christine Griesau, Anne-Katrin Hagendorf, Peter Harsch, Marta Lein, Gerhardt Liebert, Kristine Mayer, Anne Koch, Sandra Möller, Sarina Pils, Wolfram Poick, Miriam Puscher, Axel Roschen, Horst Schauer-Weisshahn, Anne Simang, Christian Sparn, Katha Talacek, Kilian Weixler, Petra Wiese-Liebert, Andreas Wilczek und Tina Zipf

Pascal Baumann, Dagmar Dachlauer, Patrick Daum, Volker Hahn, Christian Jobst, Nicolai Kondratiev, Philipp Malz, Stephanie Müller, Peter Übel, Eveline Schmidt, Maja Schmidt, Wolfram Schulze, Johannes Thein, Wolfgang Zierer, Michael Charbonnier, Hilda Frank, Christopher Groß, Tomasz Kniola, Kristine Mayer, Johannes Rehhausen, Dorothea Schwarze, Anne Sennhenn, Janine Syberts und Stefanie Wilke

Manuela Huso, Pius Korner, Claus Schuster, Volker Runkel, Ulrich Marckmann, Michael Vock, Klaus Echle, Gerhard Mäscher, Frank Willutzki, Tobias Petrovic, Michael Reich, Lothar Bach, Fabio Bontadina, Jasja Decker, Hermann Hötker, Ommo Hüppop, Thomas Grünkorn, Ulf Rahmel, Andrea Schaub, Björn Siemers, Tobias Dürr, Susanne Findeisen, Thomas Frank, Friedhelm Igel, Friedrich Kretzschmar, Günter Ratzbor, Hartwig Schlüter

Bundesministerium
für Wirtschaft
und Energie