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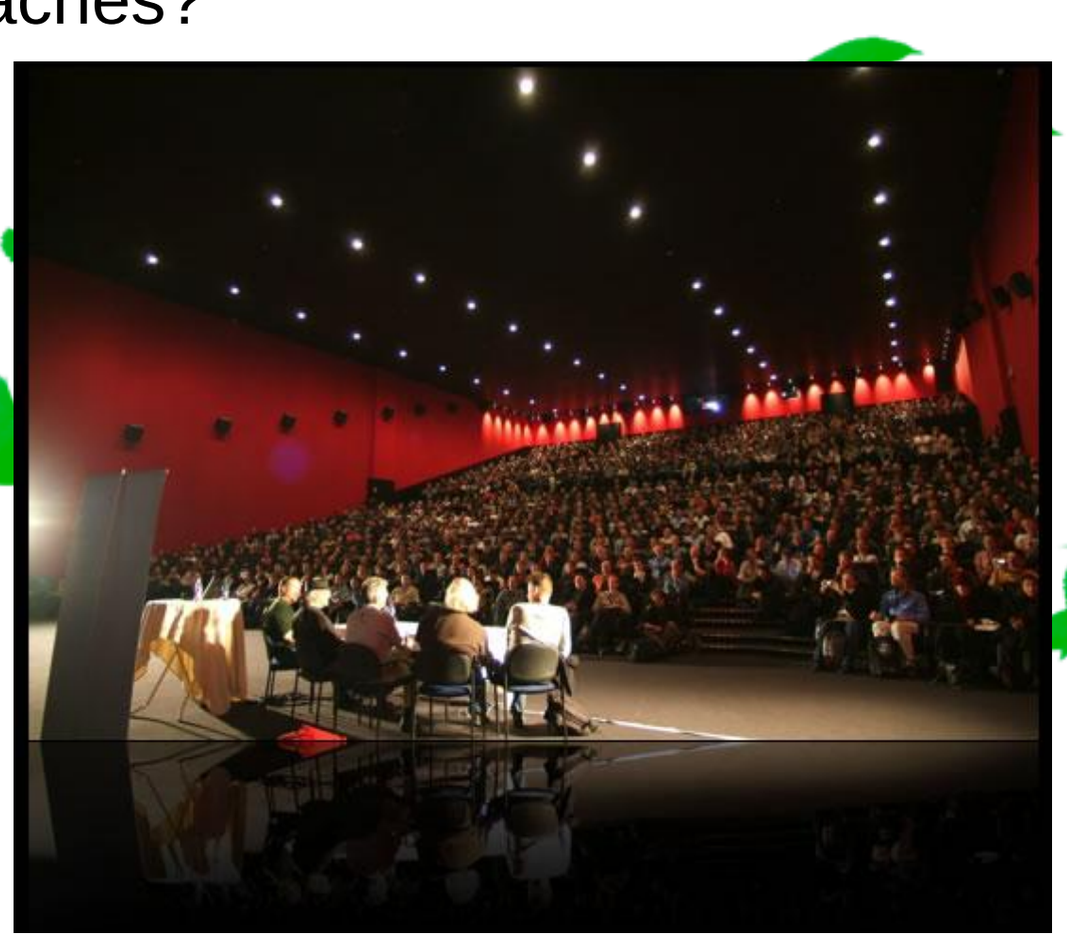
Be real; the effectiveness of avian radars!

Addy Borst MSc

A bold statement

The 30 IBSC conferences did not prevent the bird strike rate from increasing significantly worldwide ……

- …… but how far more worse would it be without this information exchange platform???
- Time for new approaches?



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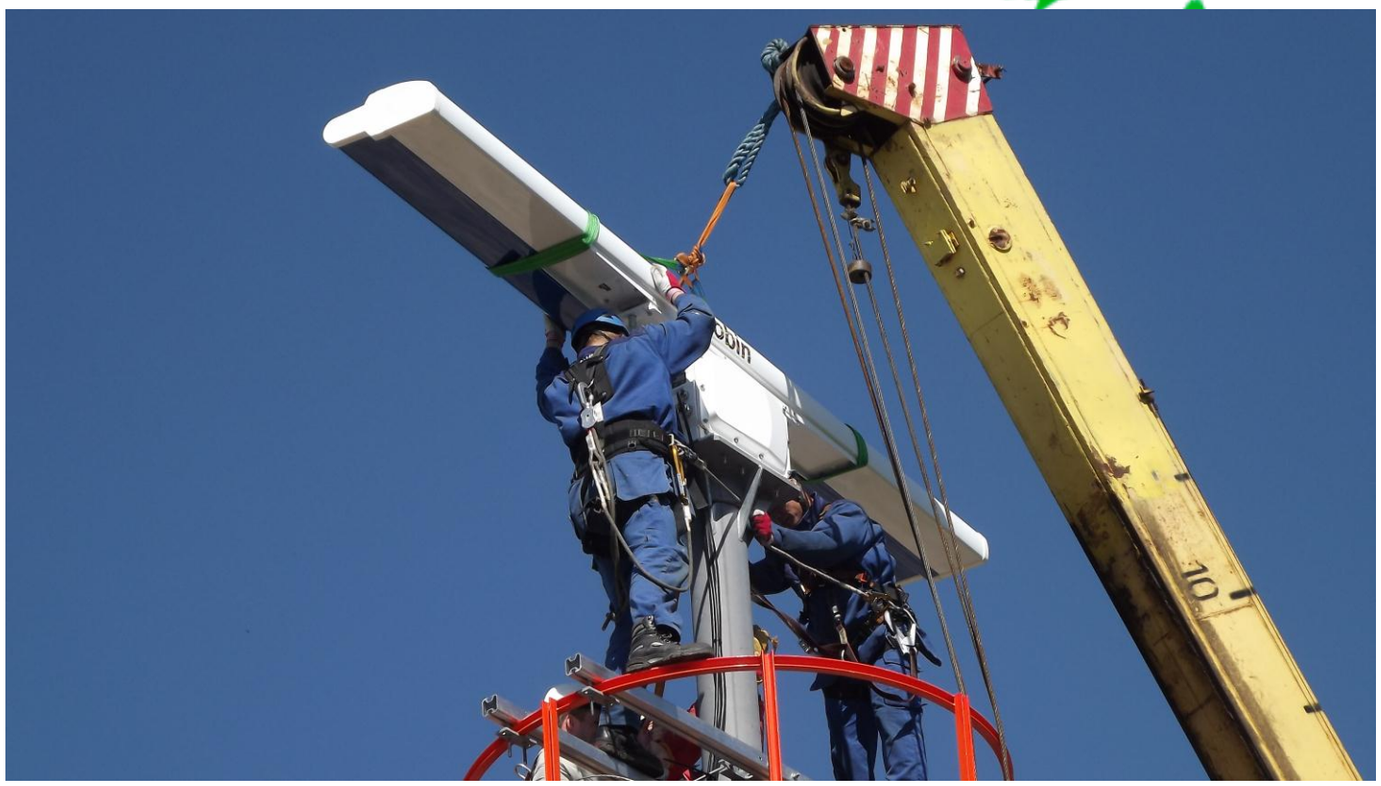
ROBIN Radar Systems

- We were 30 years part of R&D institute TNO in the Netherlands
  - Europe’s third largest dedicated R&D organization
  - 4500 employees (academic/PhD)
  - Highest rankings worldwide in radar technology
  - World’s oldest developer of bird radars



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- ROBIN Radar Systems spun out of TNO per July 1th, 2010
  - Making available TNO's bird detection capabilities for the world market
- Mission ROBIN Radar Systems:
  - Providing the best avian radars worldwide, with real operational capabilities
  - Having the best services and product support
  - Being European market leader within 2 years

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Some ROBIN clients

- Royal Netherlands Air Force
- Royal Belgian Air Force
- FlySafe program of European Space Agency (ESA)
- Turkish Airport Authorities (DHMI) for Hatay airport
- NINA Norwegian Institute for Nature Research
- Eesti Energia AS, Estonia
- IMARES Ecological and Marine Research Institute
- Food & Environmental Research Agency UK (FERA)
- EVN Austria/Bulgaria
- 3G s.c. Poland
- Azimut France

- (Potential) partners in biology/ecology: FERA UK, DHI Denmark /BioConsult SH Germany/Altenburg & Wymemga NL/ Avisure Aus

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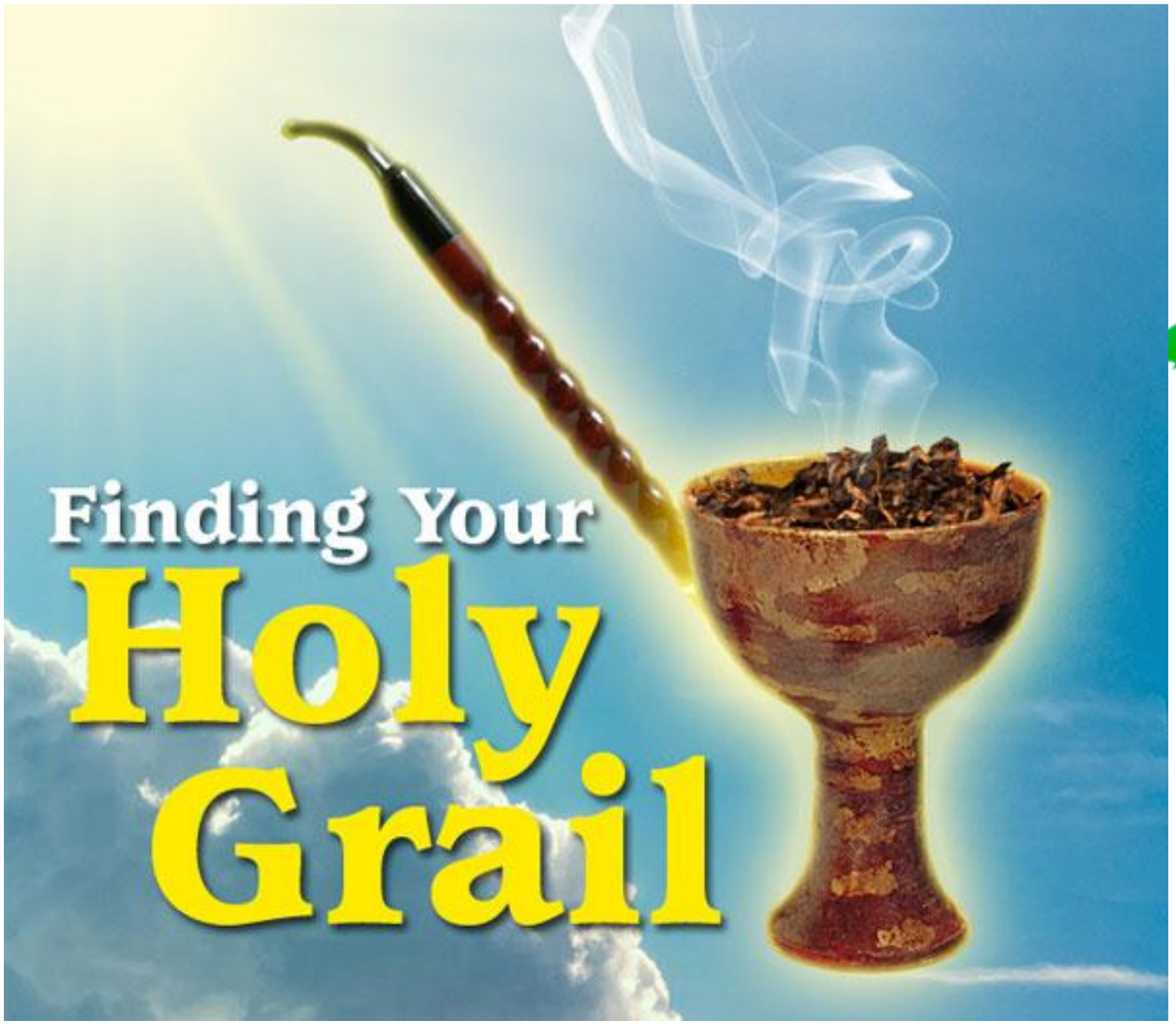
Solving the bird strike issue



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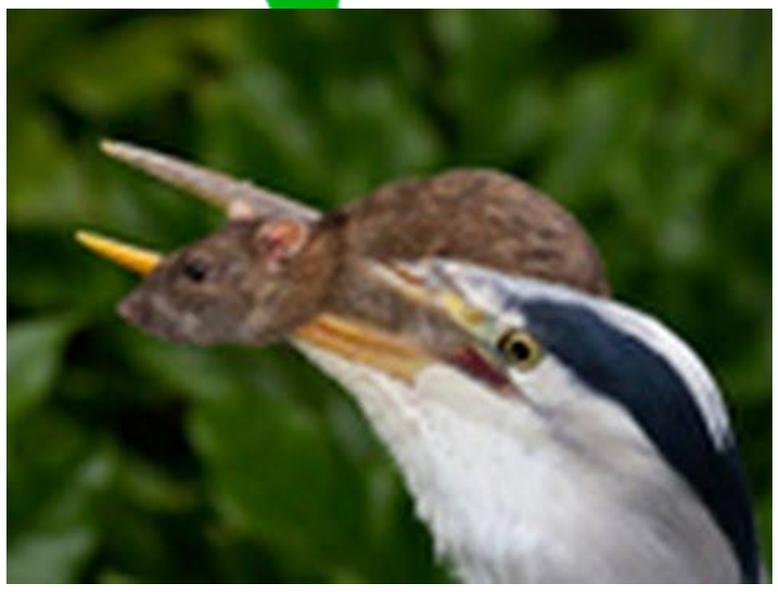
The hard truth…..

There is no ‘silver bullet’ solving the bird strike problem for ever, because:

- Different birds act differently when facing aircraft dangerous to them
- Young birds have to learn it the hard way
  (at the cost of bird strikes)
- Bird deterrence leads to habituation
- Bird populations continuously change
- Sounds silly: ‘bird strike prevention
  is a rat race’



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What is the value of using a Bird Radar?

- There are a few example programs with lasting bird strike reductions by using dedicated bird radar:
  - Israeli Air Force
  - Royal Netherlands Air Force/Royal Belgian Air Force
- Focus on en route bird strike prevention
- Reduction in (on route)bird strike shown > 50%
- Typical: multidisciplinary approach
  - Operational people
  - Radar technologists/system integrators
  - Biologists/ornithologists
- Nice example of integral approach: FlySafe program of the European Space Agency
- Now effective ‘on airport’ bird strike prevention programs based on radar being started

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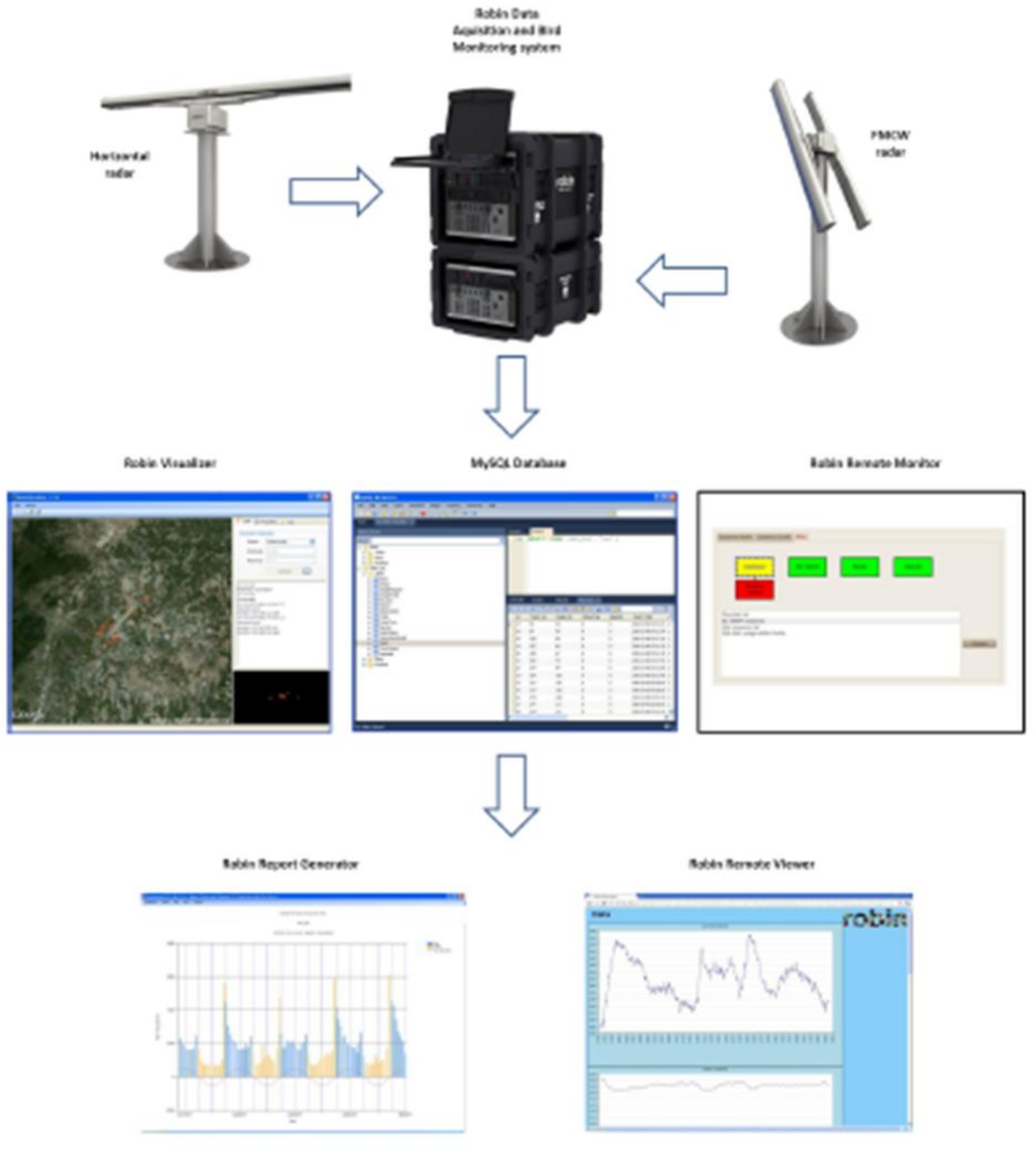
The hard truth for a bird radar: Be real!

- It is complex
- Using it is not easy
- It is expensive
- It requires integration in the airport infrastructure and operations to be effective



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Then why using a bird radar?

'If you can't measure it, you can't manage it'

Richard Dolbeer about the complex issues of bird strikes

2011 North American Bird Strike Conference

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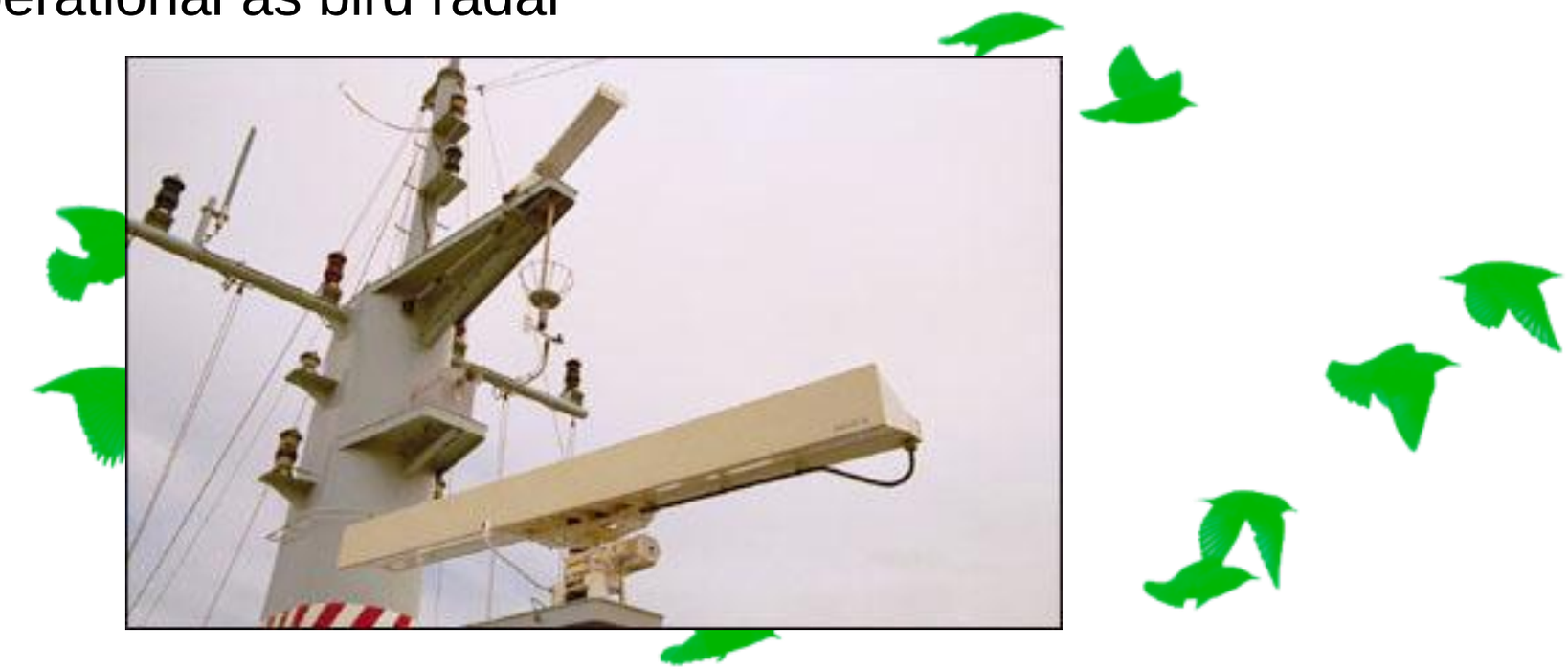
Most bird radars are based on marine radars

- Marine radar:
  - Designed for detection of individual ships having a very large radar reflection
  - Not designed for multiple targets in environment showing many more radar reflections
  - A marine radar is therefore always a sub-optimal solution
  - Whole radar data-chain of the marine radar has to be optimized to be really operational as bird radar



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A Bird Radar has limitations

- A bird is a very small radar target and is inherently difficult to detect

  the reflection of a bird in a radar image is like a grain of sand in the desert

- False alarms (false positives) & Missed Detections (false negatives) cannot always be prevented
- Radar reflections of ground, trees and large objects, ‘drowning’ the small radar reflections (‘Ground clutter’)
- Latency (degraded real-time display) because time needed for data processing of all radar data
- Sensitivity for rain, snow, etc. (‘Rain clutter’)
- Radar site issues:
  - Range restrictions
  - Obstruction of radar view by buildings, hangars etc. (no line of sight between radar and bird)

Optimal bird detection with radar means solving the issues above

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A Bird Radar has limitations

On a technology level

‘clutter-filtering’

is the name of the game.

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Why airports start using a bird radar

A bird radar has unique capabilities which humans or other systems do not have:

- Long range
- Detection at night/adverse visual conditions
- 24/7/365
- Realtime display
- Precise
- 360 Degrees detection around radar
- Automated
- Capable of tracking thousands of birds
- Digital recording & storage
- Long term trend analysis

… but a human being has qualities

a bird radar does not have:

For example to distinguish a 2 year old

male goose from a 10 years female one.

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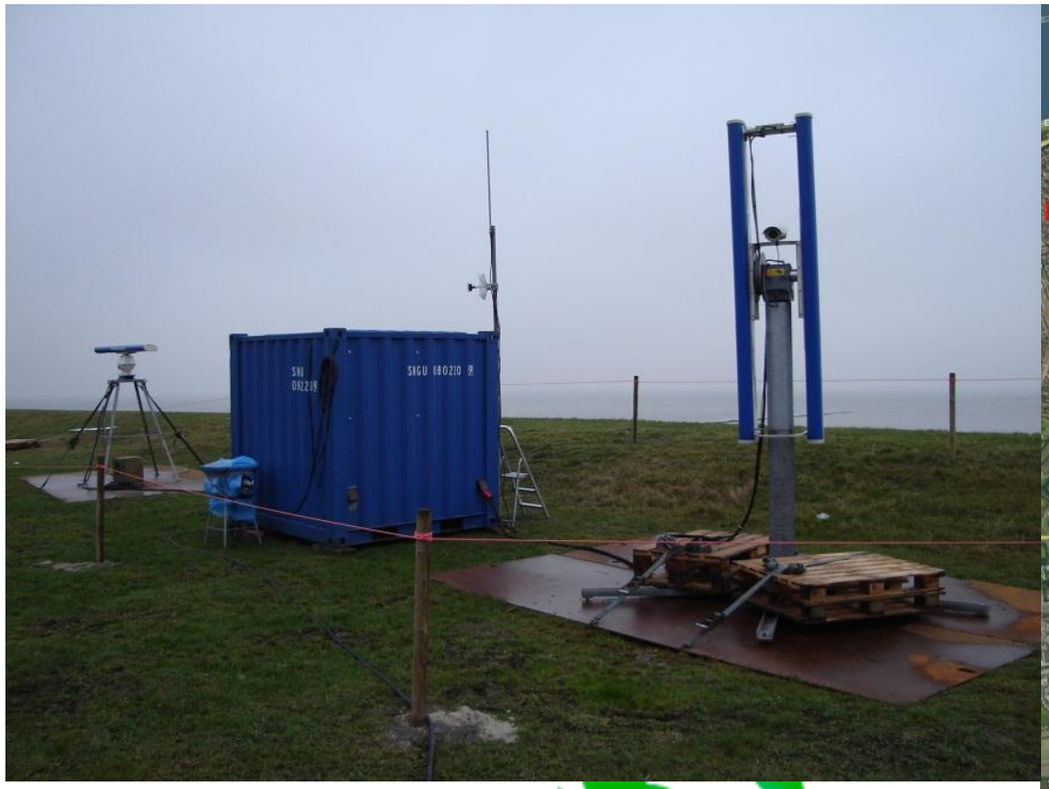
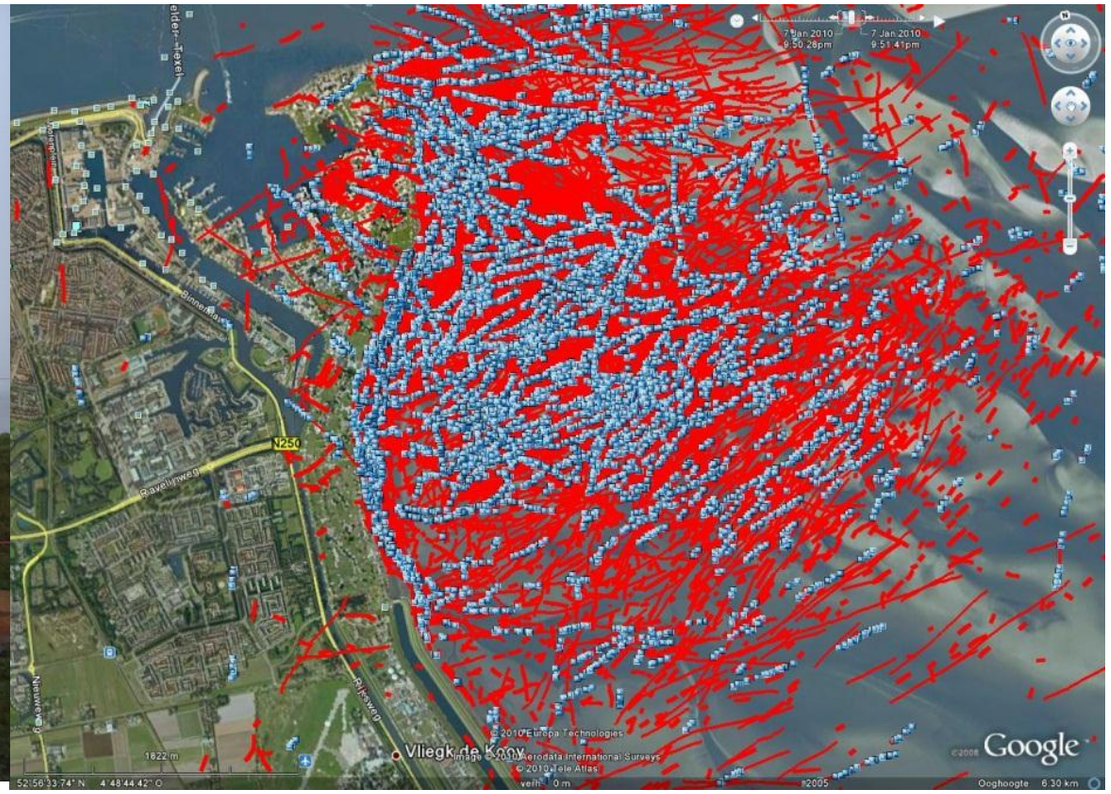
Example ROBIN 3D bird monitoring





- 24/7 bird detection in Dutch ‘Waddensea’ area
- hundreds of birds tracked and registrated at the same time
- all bird movements continuously stored in database

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Bird strike prevention – Tactical use bird radar

Tactical (real-time) use of bird radar:

- Provide Air Traffic Control info of (emerging) bird strike danger
  - to put take offs on hold for seconds when birds are on colliding course
- Extent the eyes of Bird Control Units in the field, giving them more time to pro-actively respond
  - Real-time display of bird migration around airport (on laptop or PDA) in bird control car provides early warning
- Automated bird deterrence based on radar information
- Enhance the ‘situational awareness’ by briefing pilots about the present risk level concerning bird strikes
  - ATIS provided warnings / improved NOTAM

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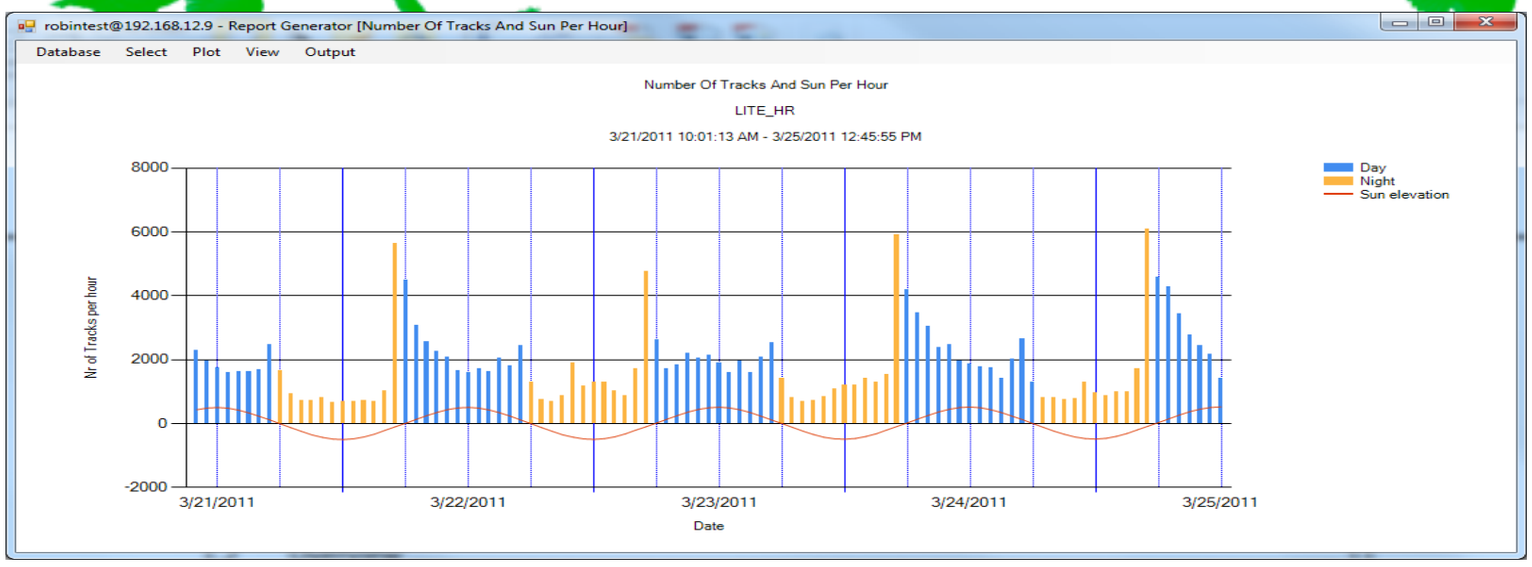
Bird strike prevention – Strategic use bird radar

Strategic (non real-time) use of bird radar: analysis of bird data over a longer period of time

- Provide analytical input to habitat management
  - Main migration routes, quantification, bird densities in space and time
- Evaluate the effectiveness of different deterrence techniques and adjustments in vegetation.
- Identify patterns, translate into risk profiles, use in operational planning
- Counting of near misses: indication of danger level



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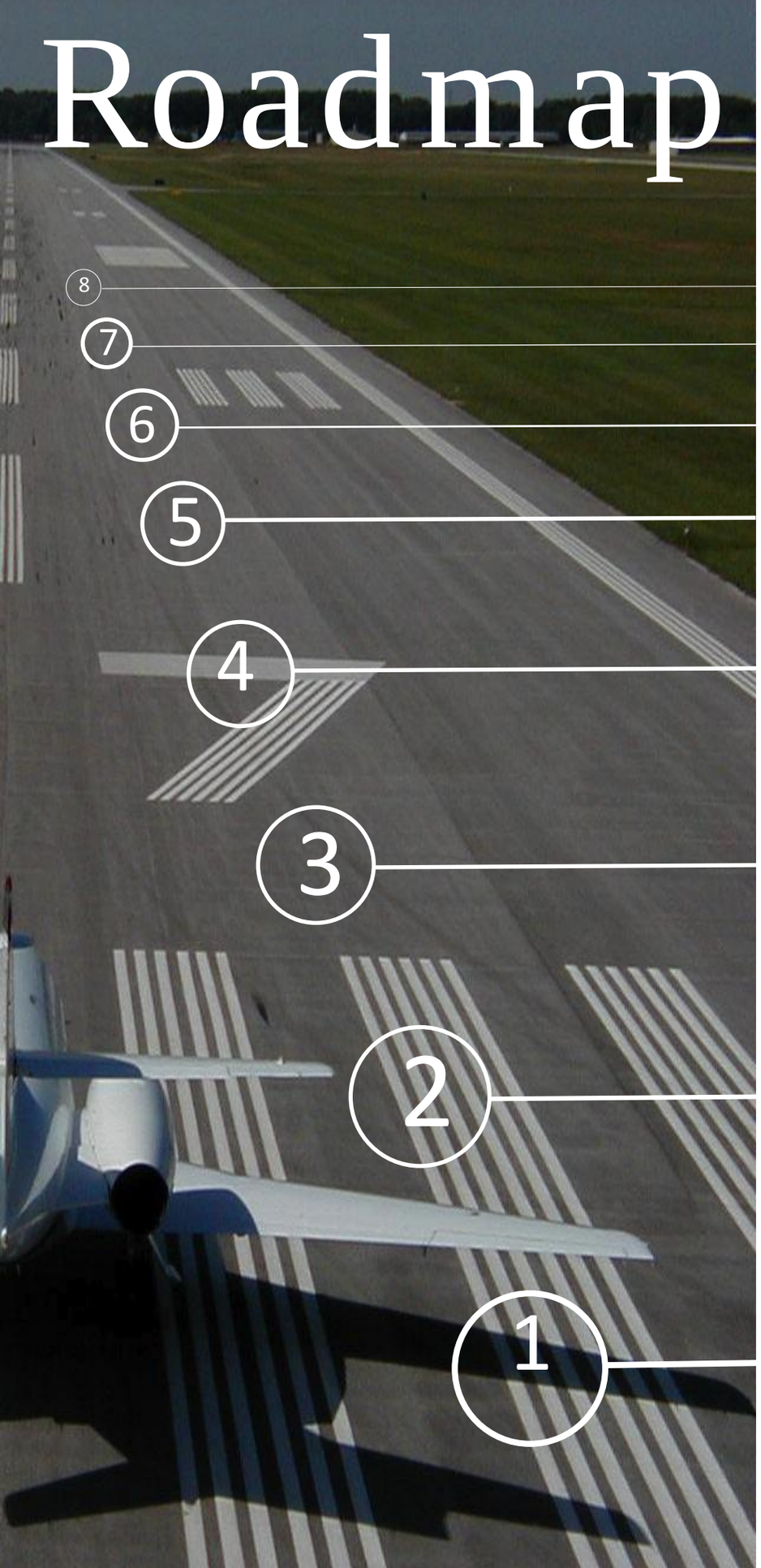
Roadmap



Real time automated CONCOPS & deterrence?

Real time ATC involvement: putting take-off on hold if needed and/or approach

Inform pilots, increase their situational awareness

Serve as an extension of the ‘eyes’ of bird control units

Providing analytical input for habitat management

Generate risk profiles to be used in planning

Measure the effect of precautionary actions that were implemented

Understand the issue by identifying patterns in behaviour

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Selection of a bird radar

I might be biassed, I’m from a supplier, but best advice to give:

- plan your operational usage areas of the bird radar
  - Strategic use
  - Tactical use
- thoroughly describe your needed bird information
- check how the vendors propositions match your requirements
- assess the vendor’s maintenance & continued product support
- perform your financial comparison (life cycle costs)
- systems of different vendors in mind: ask for a back to back test

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Technical requirements

Basic questions:

- Which bird data is needed?
  - Which target information (speed, direction, altitude,…)?
  - Species information?
- With which quality/resolution/sensitivity?
- At which range?
- For which locations?
- Which air volume is covered?
- With which latency/time delay?
- ….

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Selection criteria: Range

- Radar equation:

$$P_r = \frac{P_t G_t G_r \sigma \lambda^2}{(4\pi)^3 R^4}$$

- Main conclusions:
  - the received radar reflection decreases with the 4th power of range
  - for a given bird and a given radar the detection range is dependent on the sensitivity of the electronics

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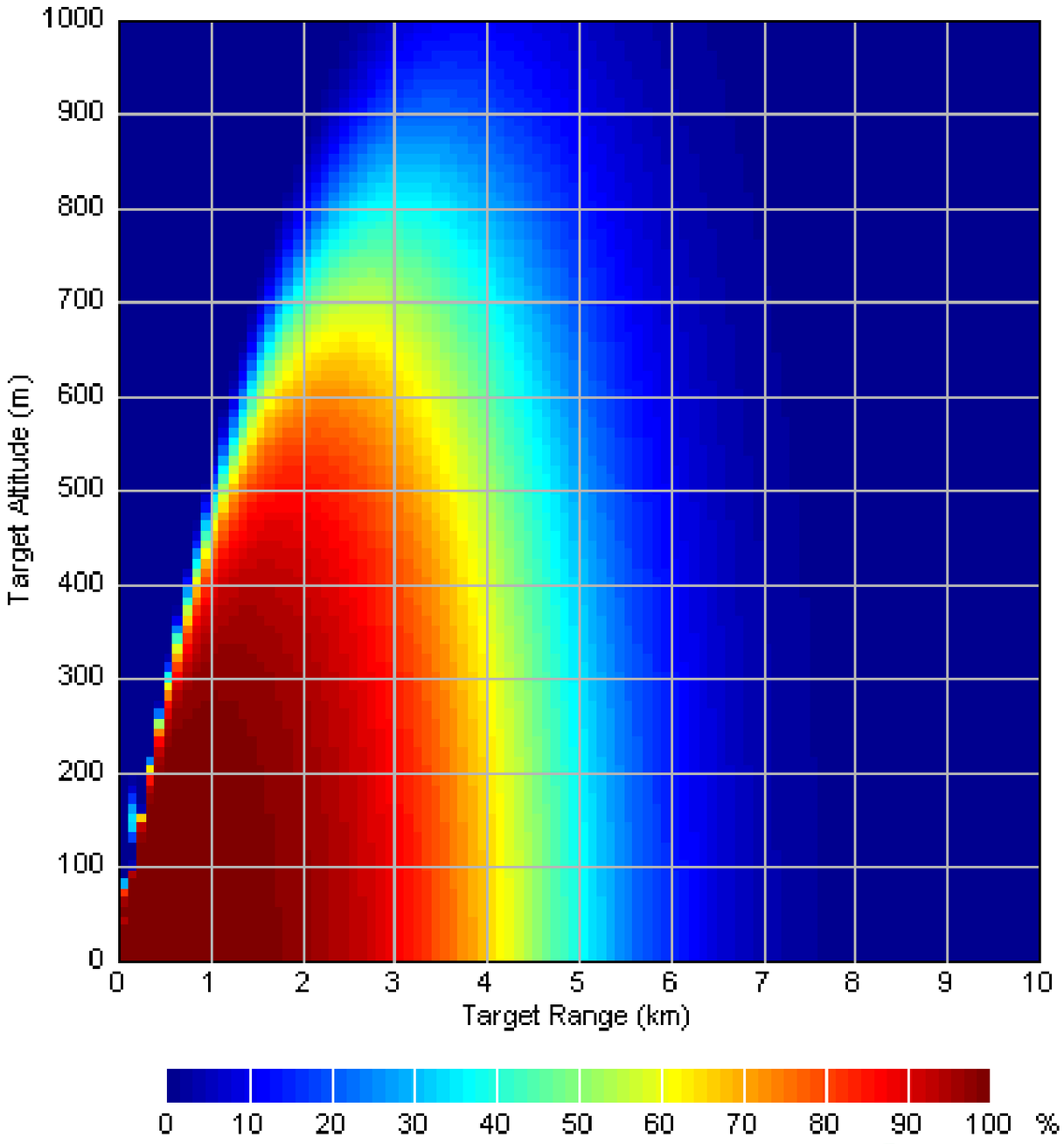
Range/altitude S-band radar (medium bird)



Carrier Frequency	:	3050	MHz
PRF	:	1.9	kHz
Peak Power	:	60	kW
Pulse Length	:	80	ns
Inst. Bandwidth	:	12.5	MHz
Antenna Altitude	:	4	m
Transmit Gain	:	26.8	dBi
Azimuth Beamwidth	:	1.80	°
Polarization	:	H	
Doppler Processing	:	none	
Number of Bursts	:	9	
False Alarm Prob.	:	3e-006	
Free space	:	on	
Target RCS	:	0.01	m²
Swerling Case	:	1	

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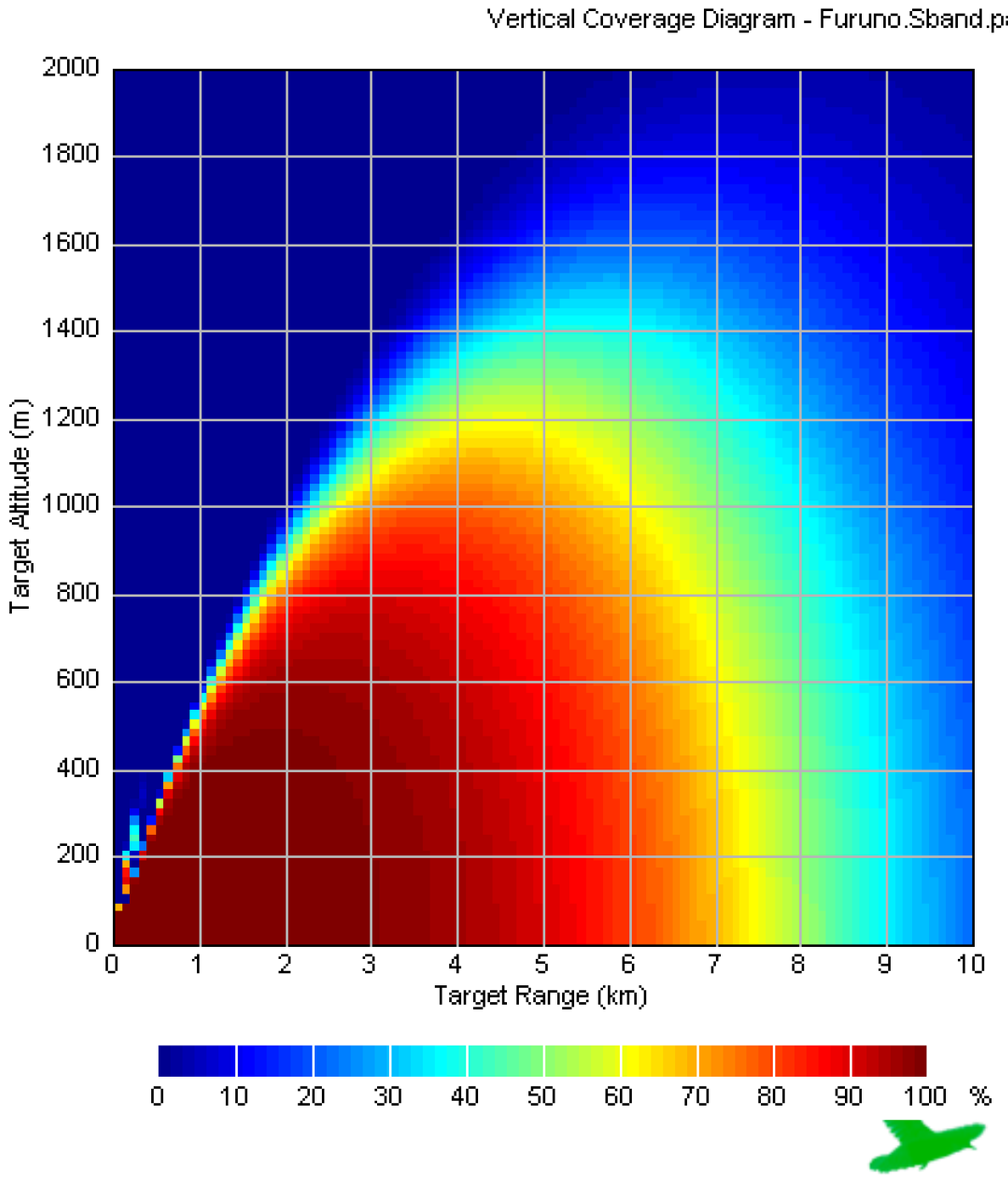
Range/altitude S-band radar (large bird)



Carrier Frequency	:	3050	MHz
PRF	:	1.9	kHz
Peak Power	:	60	kW
Pulse Length	:	80	ns
Inst. Bandwidth	:	12.5	MHz
Antenna Altitude	:	4	m
Transmit Gain	:	26.8	dBi
Azimuth Beamwidth	:	1.80	°
Polarization	:	H	
Doppler Processing	:	none	
Number of Bursts	:	9	
False Alarm Prob.	:	3e-006	
Free space	:	on	
Target RCS	:	0.10	m²
Swerling Case	:	1	

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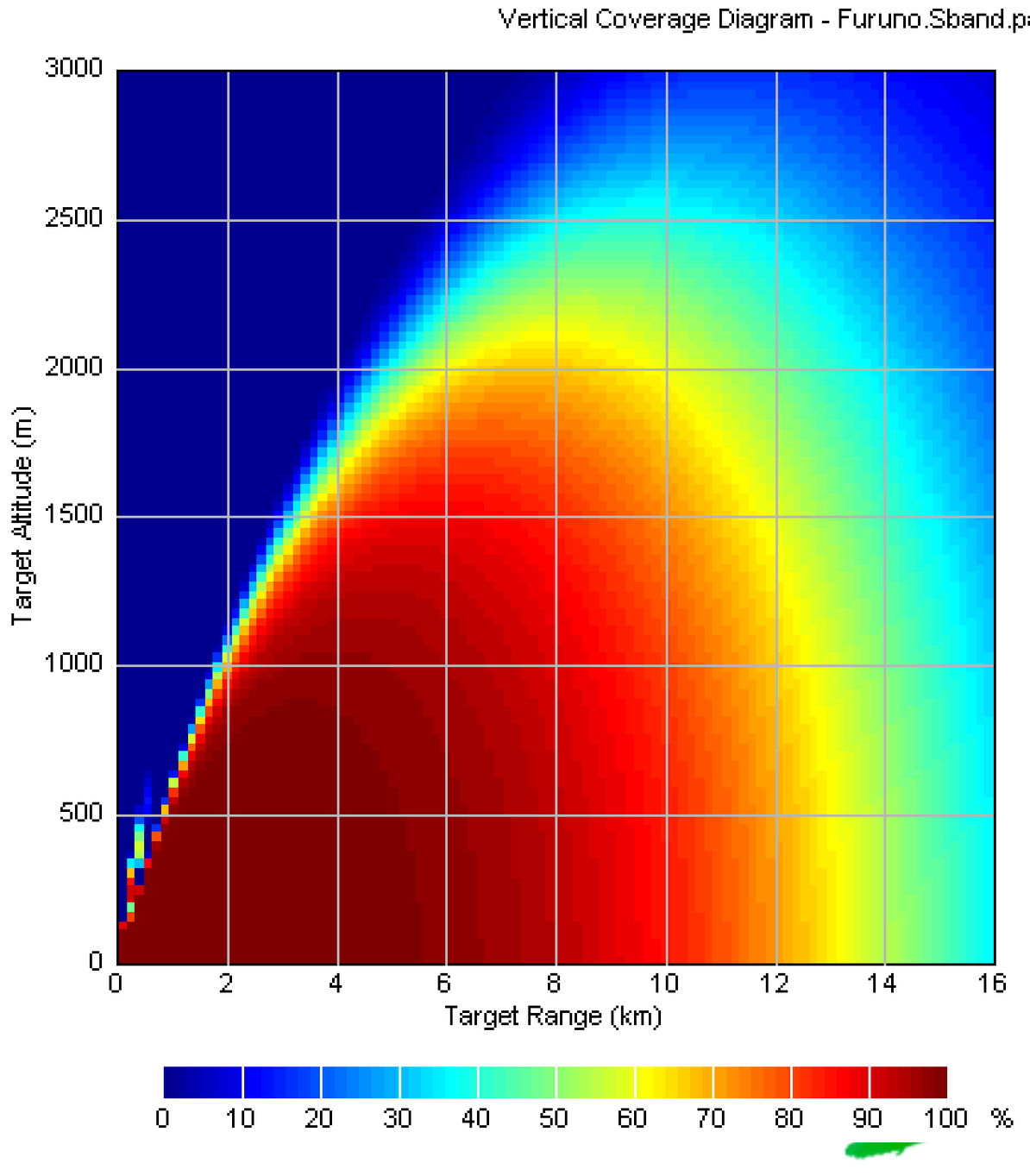
Range/altitude S-band radar (flock of large birds)



Carrier Frequency	:	3050	MHz
PRF	:	1.9	kHz
Peak Power	:	60	kW
Pulse Length	:	80	ns
Inst. Bandwidth	:	12.5	MHz
Antenna Altitude	:	4	m
Transmit Gain	:	26.8	dBi
Azimuth Beamwidth	:	1.80	°
Polarization	:	H	
Doppler Processing	:	none	
Number of Bursts	:	9	
False Alarm Prob.	:	3e-006	
Free space	:	on	
Target RCS	:	1	m²
Swerling Case	:	1	

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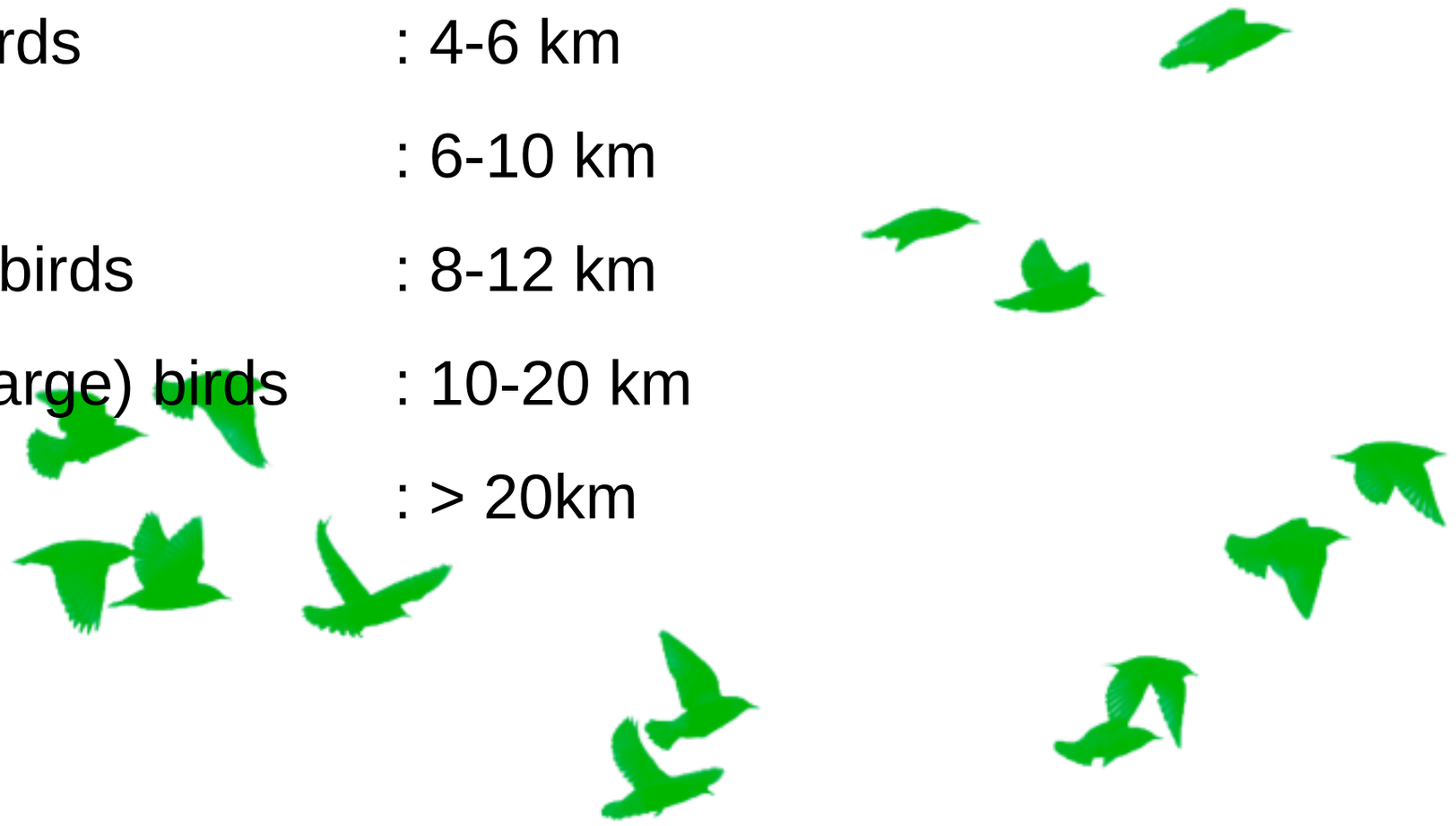
Detection capabilities

- Range (depending on viewing angle, atmosphere, clutter etc.):
  - small songbirds : 2-4 km
  - medium birds : 4-6 km
  - large birds : 6-10 km
  - very large birds : 8-12 km
  - flocks of (large) birds : 10-20 km
  - aircraft : > 20km



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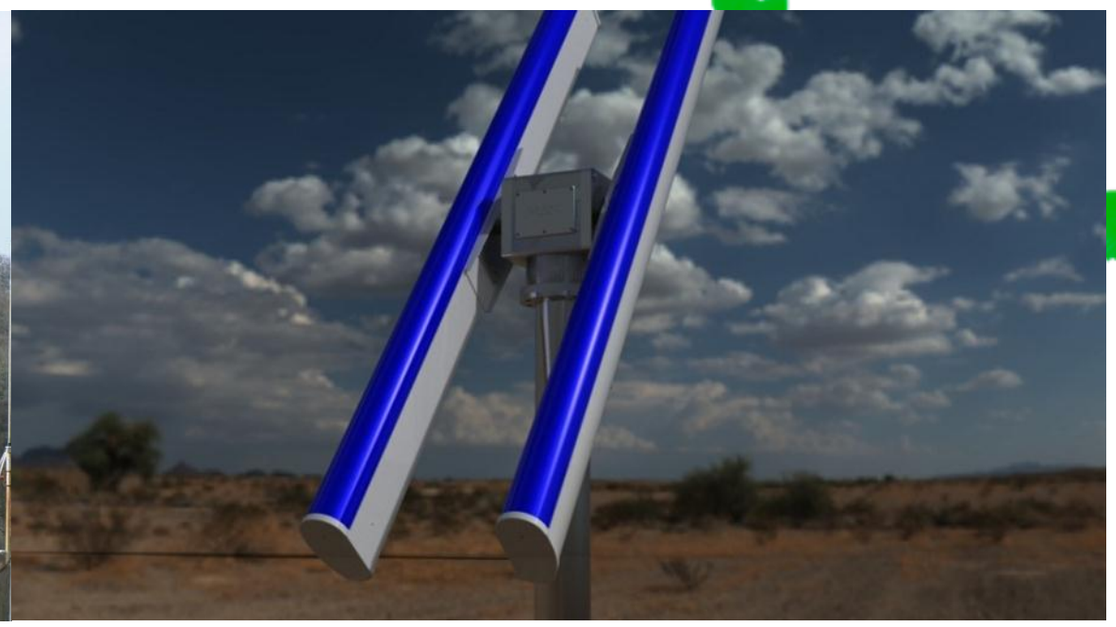
Sensitivity of bird detection

- Sensitivity issues:
  - Sensitivity of the data acquisition electronics
  - Clutter suppression capabilities
  - Quality and sensitivity of the bird tracking algorithm



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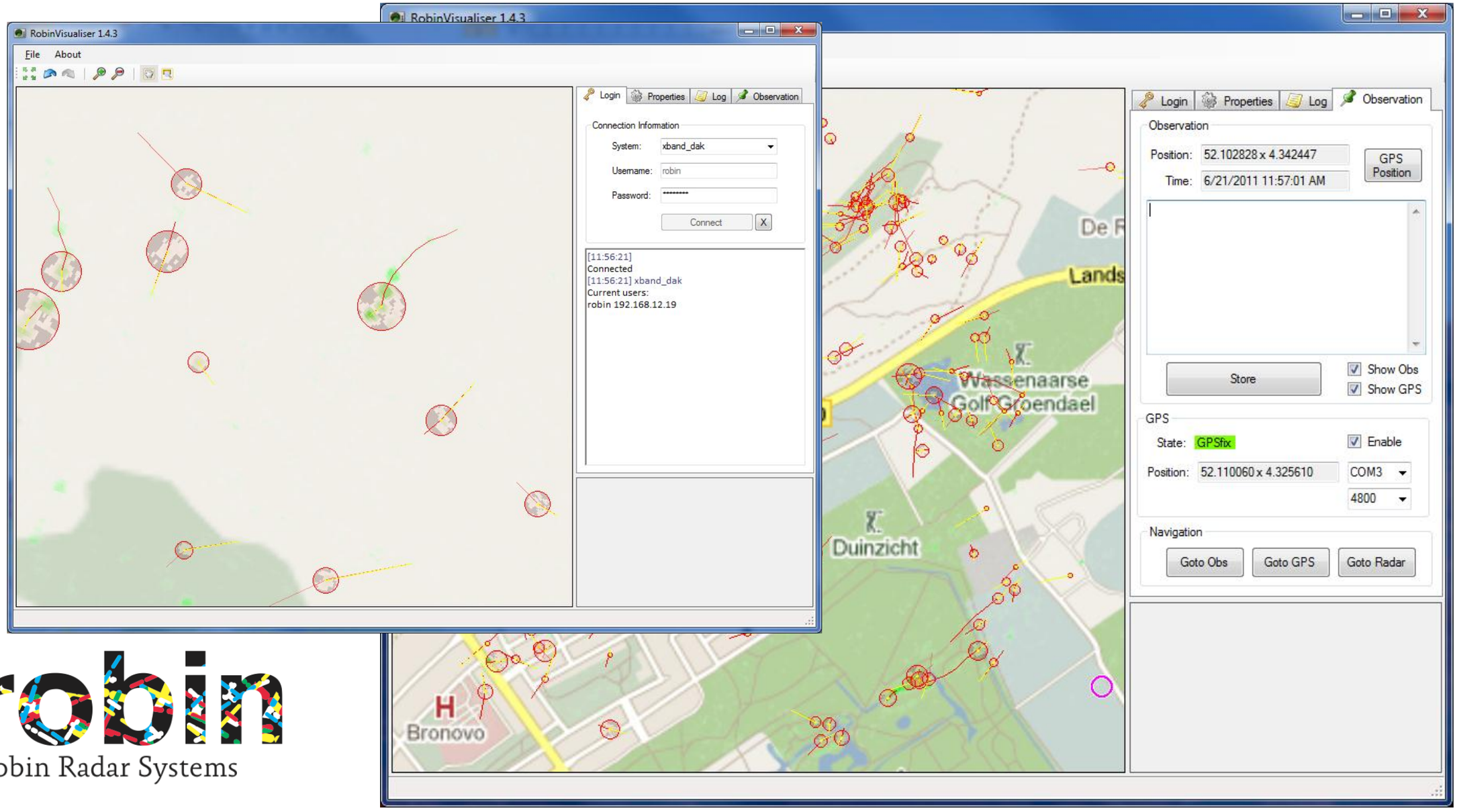
Bird tracker

Advice: ask your supplier to plot your bird tracks on top of the (processed) radar data in one view: quick judgement of quality of clutter suppression



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Validation

- Perform validation of sensitivity and quality of data processing
  - In clutterfree and clutterrich areas
- Define false alarms and missed detection (false positives & false negatives)

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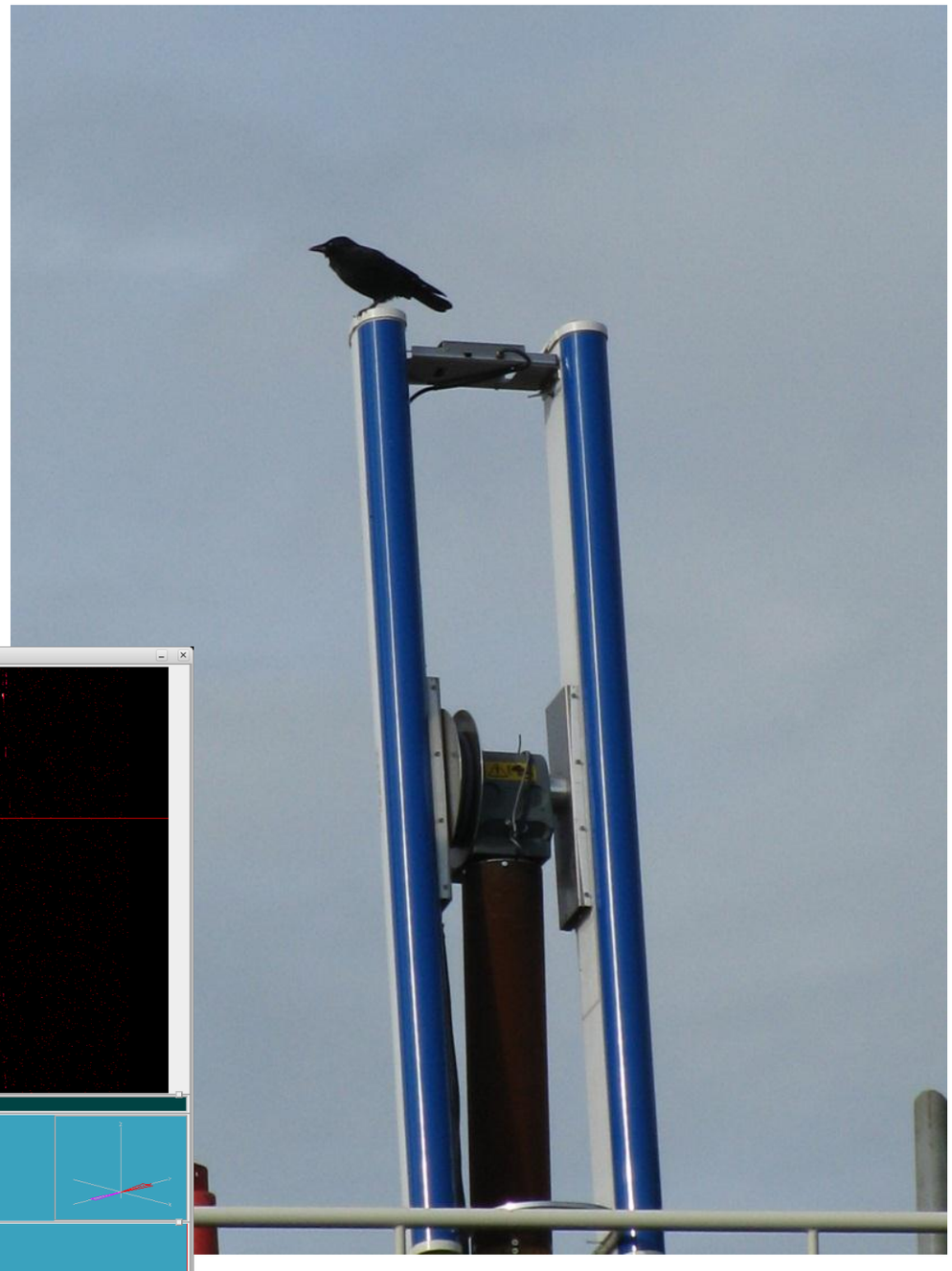
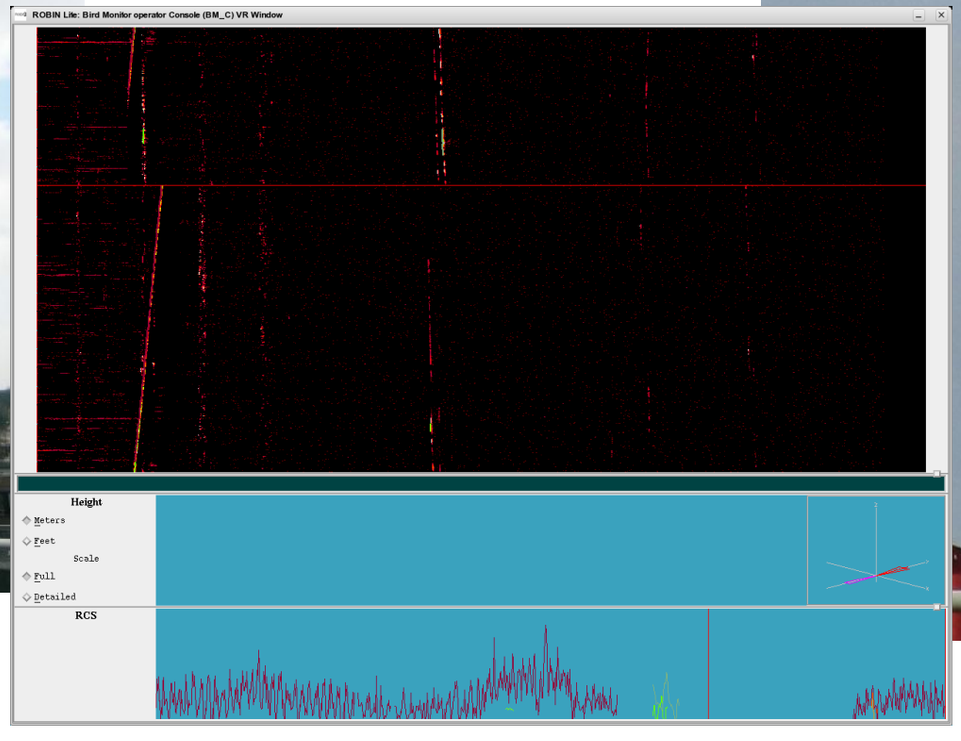
Selection criteria: Species determination

- Functionality of species detemination now available





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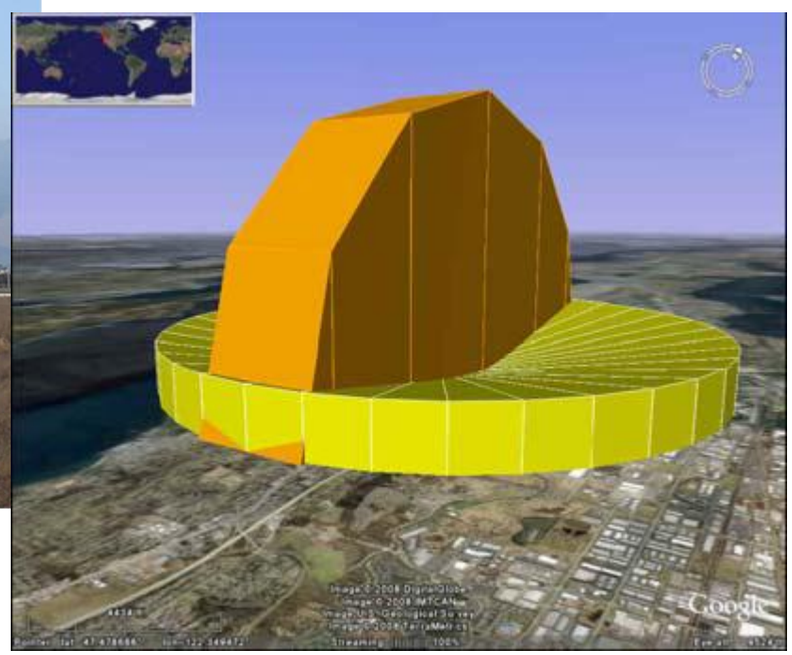
Selection criteria: 3D at 360° around

- a horizontal radar has 2D info only
- a vertical radar adds altitude information
  - is altitude information at 360° available?
    - only for a vertical radar which is tradable in azimuth direction
    - add altitude info to each track (data fusion)



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Selection criteria: How real-time?

- Advantage of high speed radar:
  - more hits/better tracking
  - shorter latency/time delay

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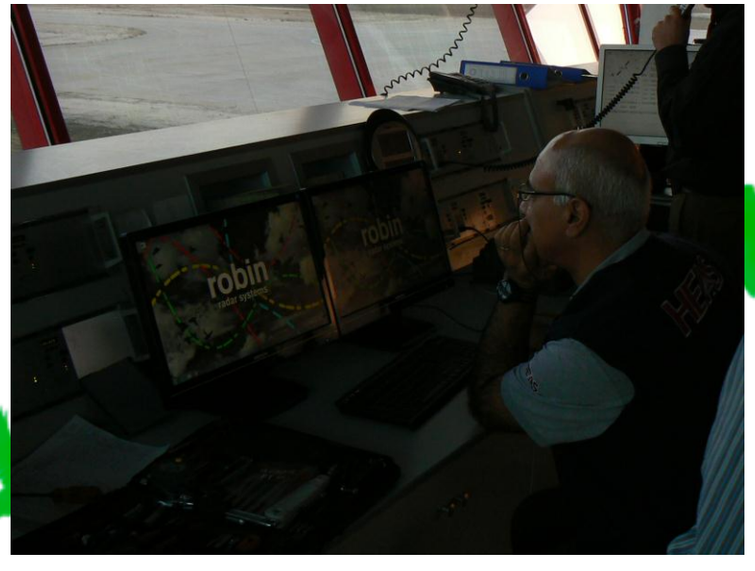
Integration in airport infrastructure

- Bird radar should not be a ‘black box’ system to facilitate integration
- Power
  - UPS
  - Power rectifier
- Data network
  - Security
  - Robustness data network
- Safety
  - Obstacle clearance criteria ICAO Annex 14
- Present information in the format needed by the user



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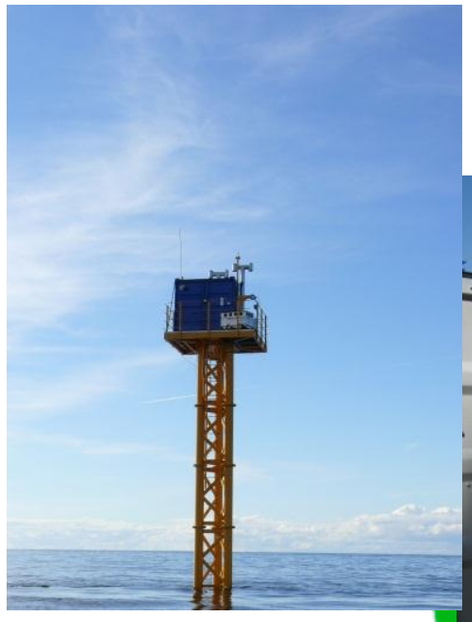
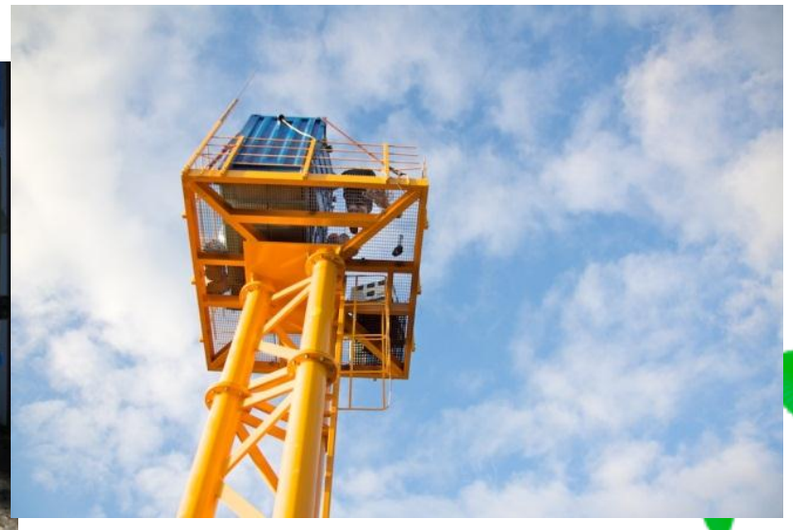
Site selection

- Radars covering all possible aircraft initial climb & approach trajectories
- Radars covering all possible birds trajectories
- Bird detection up to ground level should be possible
    - 70% of bird strikes < 200ft
    - While suppressing ground clutter effectively





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Operational capabilities

- Remote Login for system monitoring
- Remote Control (Start/Shutdown)
- Realtime and user defined visualization
- Inbuilt converter to GIS/Google Earth
- Data retention mechanisms and data mirroring for safeguarded availability of data

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Organizational issues

- Setting up the organization:
  - Multidisciplinary approach needed to tackle tough issue of bird strikes
  - Partnering with biologists/ecologists
- A bird radar delivers data, biologists are needed to make information of it
- Cooperative approach between avian radar vendor and customer

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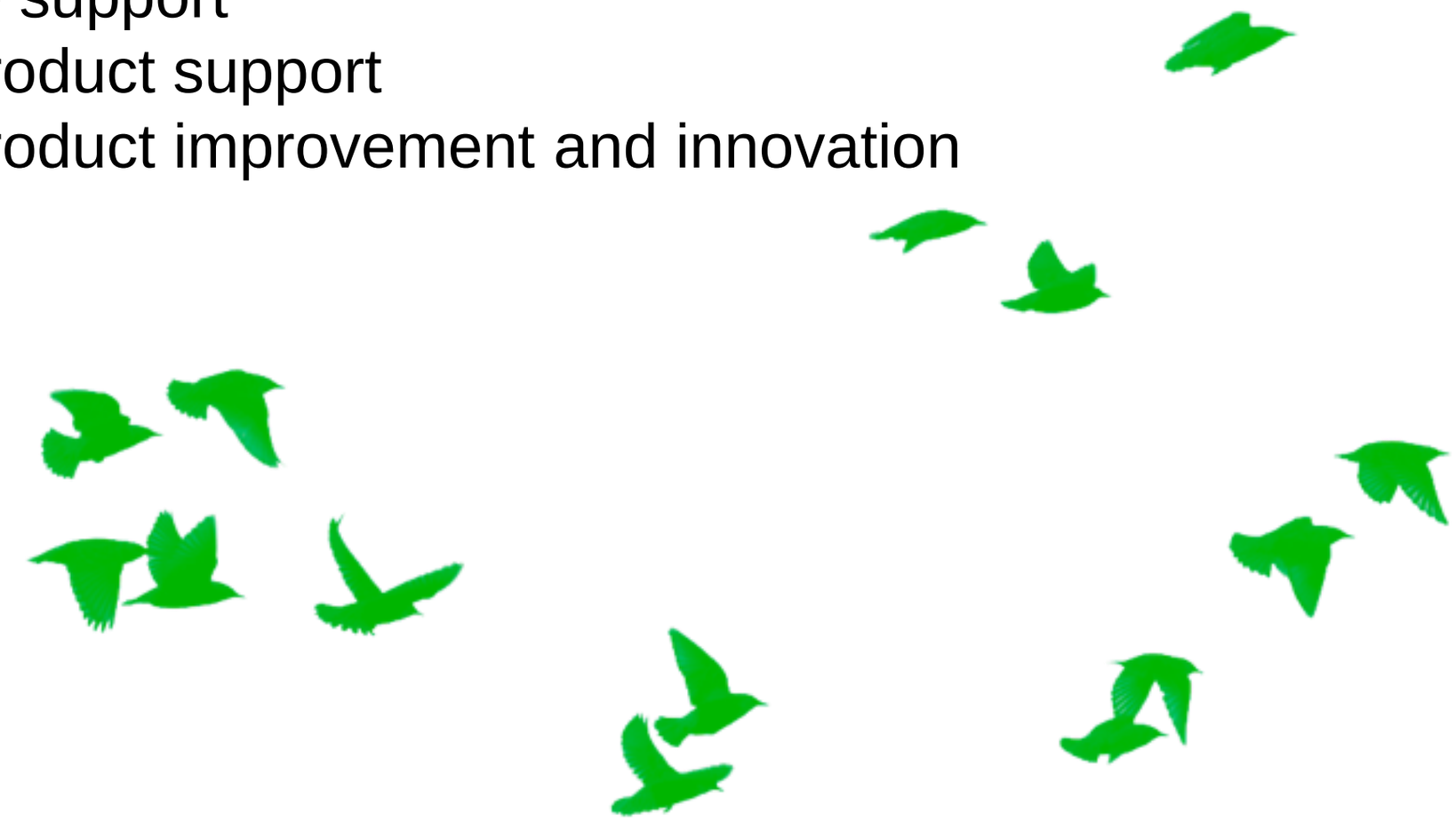
Optimal product support & services

- Helpdesk
- Training
- Spare support
- Maintenance support
- Continued product support
- Continued product improvement and innovation



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Last advice: beware of low flying elephants

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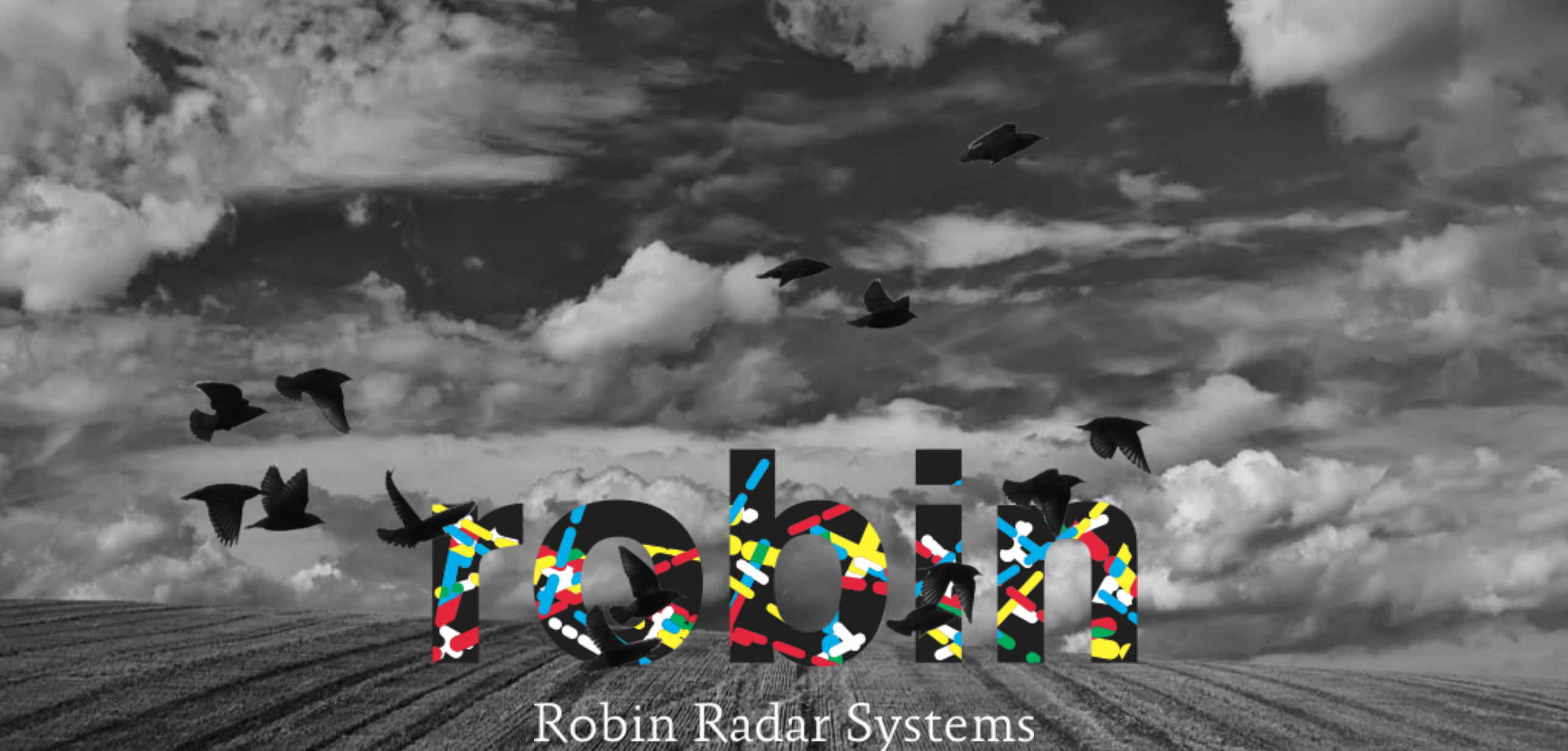

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