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Pilot Study to Evaluate the Effectiveness of DTBird® in Reducing Risk of Golden Eagles and Other Raptors Colliding with Operational Wind Turbines

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Photo by S. Rottenborn

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Study Goal

- Evaluate effectiveness of DTBird® automated detection and audio deterrent system in reducing the risk of Golden Eagles and other raptors entering the rotor swept zone (RSZ) of operating turbines
- First rigorous pilot study of technology in North America

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Project Sponsors/Collaborators

American Wind Wildlife Institute
– Research Sponsor/Facilitator

Liquen Consultoría Ambiental, S.L. – DTBird Vendor

Avangrid Renewables – Facility Operator & Funding

EDF Renewables – Funding Partner

Alta Environmental Services – UAV Provider & Pilot

AUV Flight Services – UAV Provider & Pilot

DTBird System Overview

- Video cameras (4; 6 MP) track objects against daytime skies, calibrated for targeted wingspan(s)
- When turbine spinning, speakers (4) emit *warning* and stronger *dissuasion* deterrent signals at trigger distances calibrated for focal birds
- System records timestamped detection and deterrent event data and video clips
- Analysts use on-line digital analysis platform to classify / evaluate detected objects and export data / video clips for further analysis

DTBird Detection System

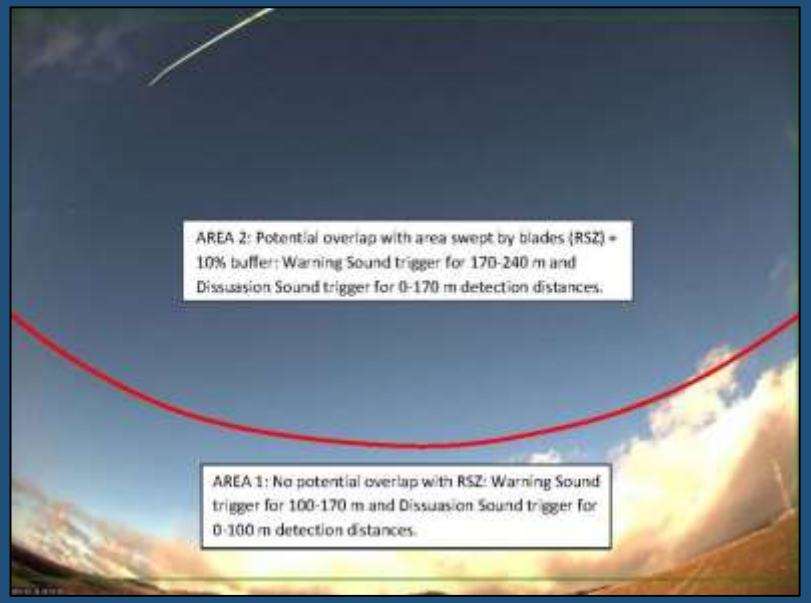
- Detection and tracking based on expected pixel occupancy for birds of targeted size
- Theoretical maximum detection range of 240–300 m for eagle (1.8–2.3 m wingspan) with wings fully exposed to camera
- Smaller birds trigger events at closer distances proportional to size

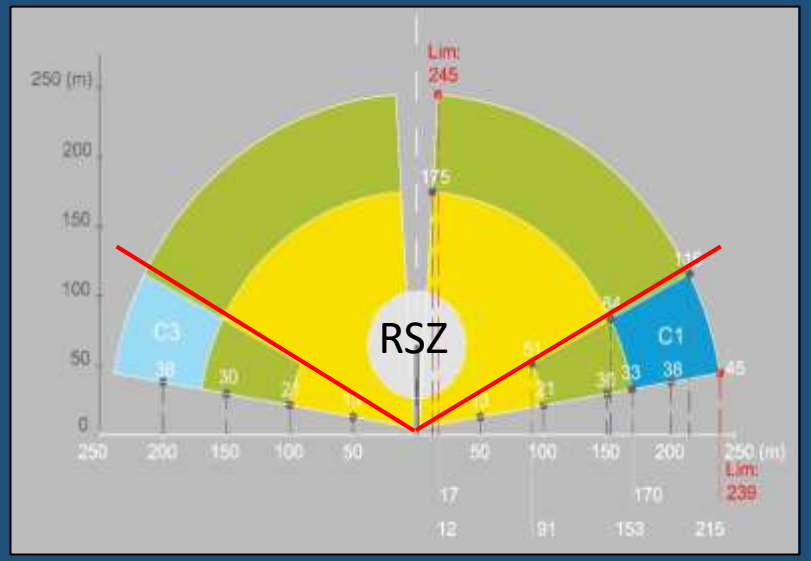
Species-specific ID is difficult

- System does not distinguish birds from other airborne objects, but filtering reduces *false positives* (detections of non-target objects)
- Simultaneous tracking of multiple birds across camera viewsheds, but does not produce independent DAP event records

DTBird Deterrent System

- Audio deterrents trigger at calibrated distances depending on potential risk level
- Above red line: high risk of entering RSZ
  - Warning 170 – 240 m
  - Dissuasion 0 – 170 m
- Below red line: lower risk
  - Detection only 170 – 240 m
  - Warning 100 – 170 m
  - Dissuasion 0 – 100 m
- Signaling continues (no new event records) until all tracked objects exit response envelope + 25 sec





Study Objectives

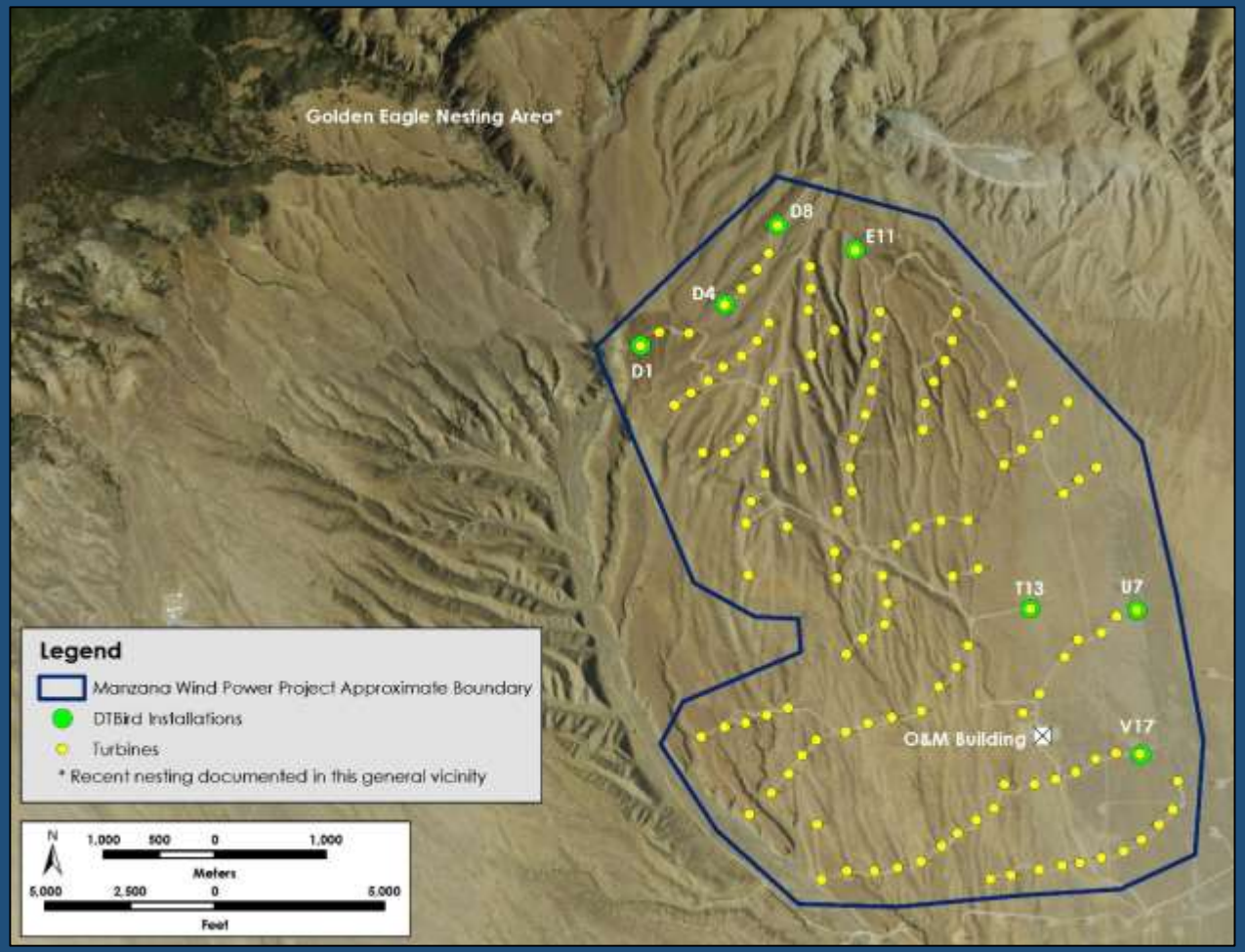
- Evaluate detection module using eagle-like UAVs (drones)
  - Rigorous evaluation of detection and deterrent-triggering response envelopes and influence of flight and visibility factors
  - Estimate probability of detection
- Evaluate deterrence module by assessing behavioral responses of *in situ* Golden Eagles and other raptors revealed in DTBird videos
  - Estimate probability of deterrence
- Probability of detection X probability of deterrence
  - Estimate potential for reducing risk of entering RSZ
- Evaluate false-positive rates and system performance reliability

Study Site – Antelope Valley, California

- Manzana Wind Power Project – Avangrid Renewables
- 126 1.5-MW turbines
- Mojave desert foothills of Tehachapi Mountains
- Known local eagle activity

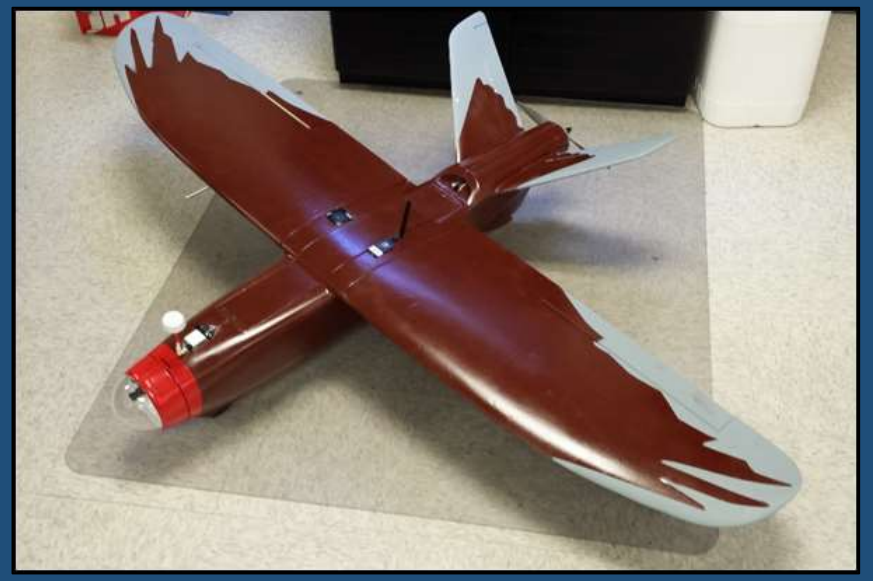
DTBird Study Setup

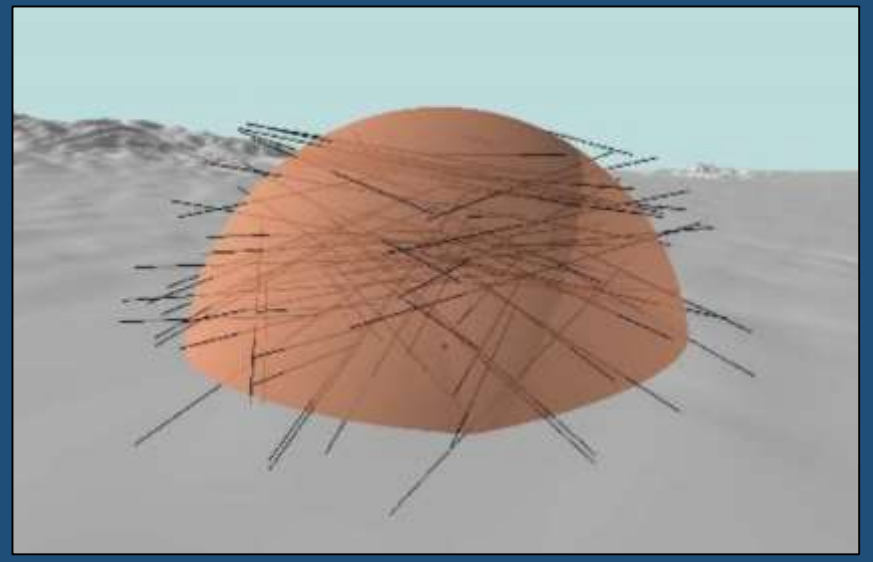
- Seven systems installed
- Strategic placement:
  - known eagle activity
  - habitat diversity
  - efficient network integration
  - UAV flight trial logistics
- Analyzed event data from December 2016 through August 2017



UAV Flight Trials

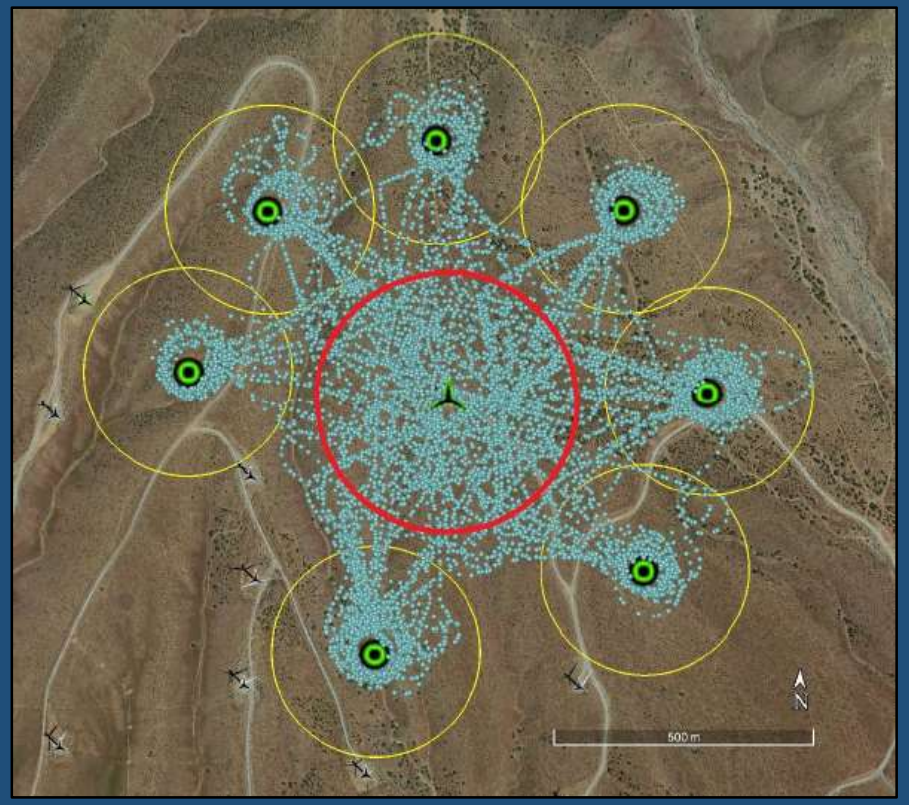
- Eagle-like UAVs – high-precision GPS tracking and avionics flight-data recording
- Multi-season sampling at all installations
- Stratified – distance, altitude, orientation, and trajectory – random transect arrays
- Automated missions plus manual low-altitude flights
- Limited by winds >10 m/sec and moisture in air





UAV Flight Trials

Example Session Array of Flight Tracks and Triggered DTBird Events



- Detection
- Warning
- Dissuasion

- UAV Flight Tracks
- 240-m detection range
- Auto-loiter protocol ensures independent flight segments

- Inner sphere represents RSZ
- Outer hemisphere represents 240-m theoretical maximum detection range for UAV / Golden Eagle with 1.8-m wingspan

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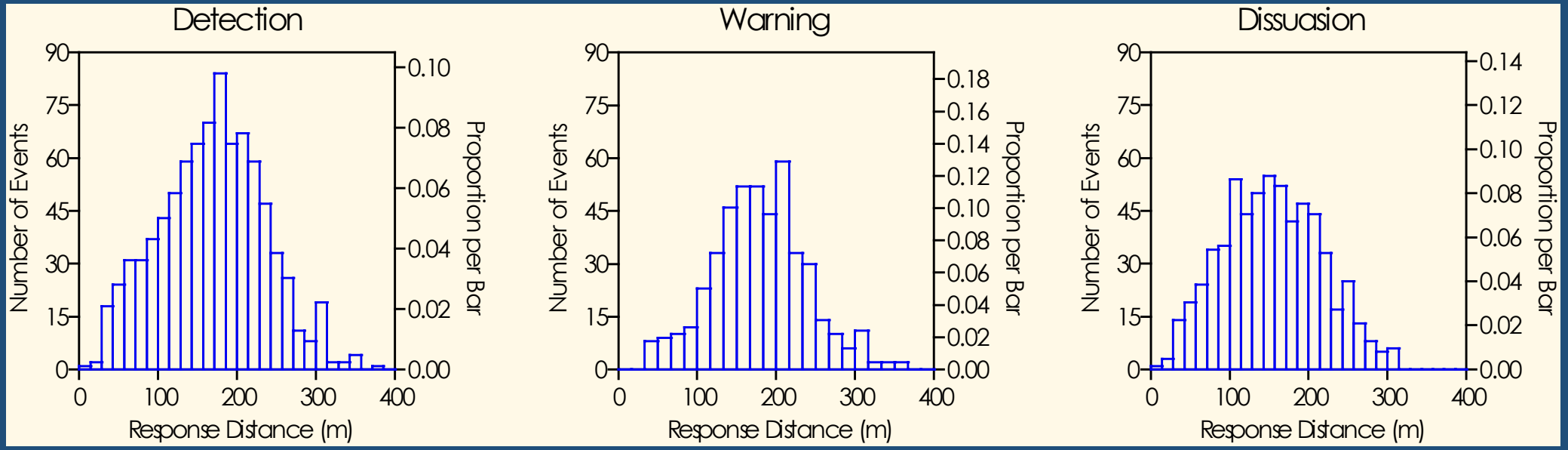
Results: Response Distances

- Response distances highly variable (mean ± SD)
  - Detection: 169 ± 66.0 m (*n* = 856; range 14–375 m)
  - Warning: 179 ± 59.6 m (*n* = 458; range 35–353 m)
  - Dissuasion: 154 ± 61.8 m (*n* = 625; range 14–310 m)



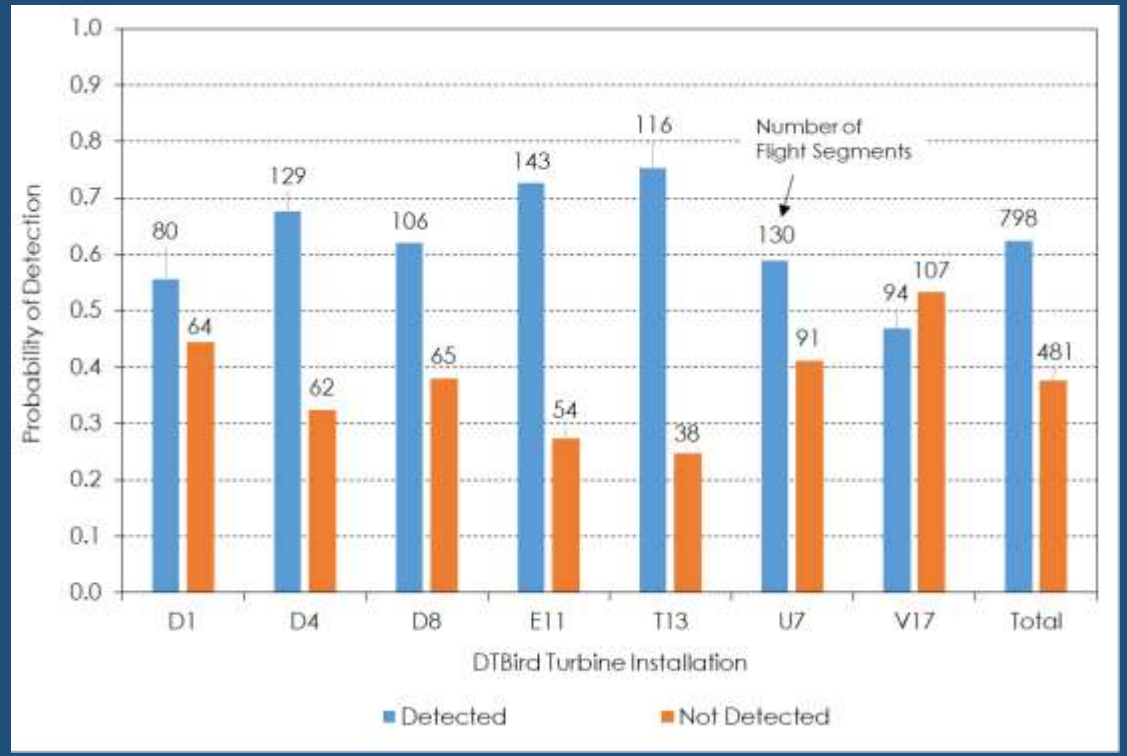
Results: Response Distance GLMM

- AIC-based evaluation of generalized linear mixed-effects models:
  Response distance ≈ Turbine ID (random effect) + Event Type + UAV ID + visibility factors + flight/position variables + selected 2-way interactions

- Flight / position / visibility predictors retained in top model:
  - Cloud Cover: Highest detectability under whitish mostly cloudy skies and poorest under highly variable partly cloudy skies
  - Solar Irradiation: Reduced detectability when sun at moderate elevation angles produces more glare
  - Roll/Pitch, Climb Rate, and Wind Speed: Improved detectability when variable movement increases relative exposure of UAV profile
  - UAV Elevation Angle x Relative Altitude: Improved detectability mid-viewshed; poorer for low approach or when high overhead

Results: Probability of Detection

- Flight segments isolated as independent sampling units
- Proportion matched with a DTBird detection event = overall probability of detecting eagle-like UAV

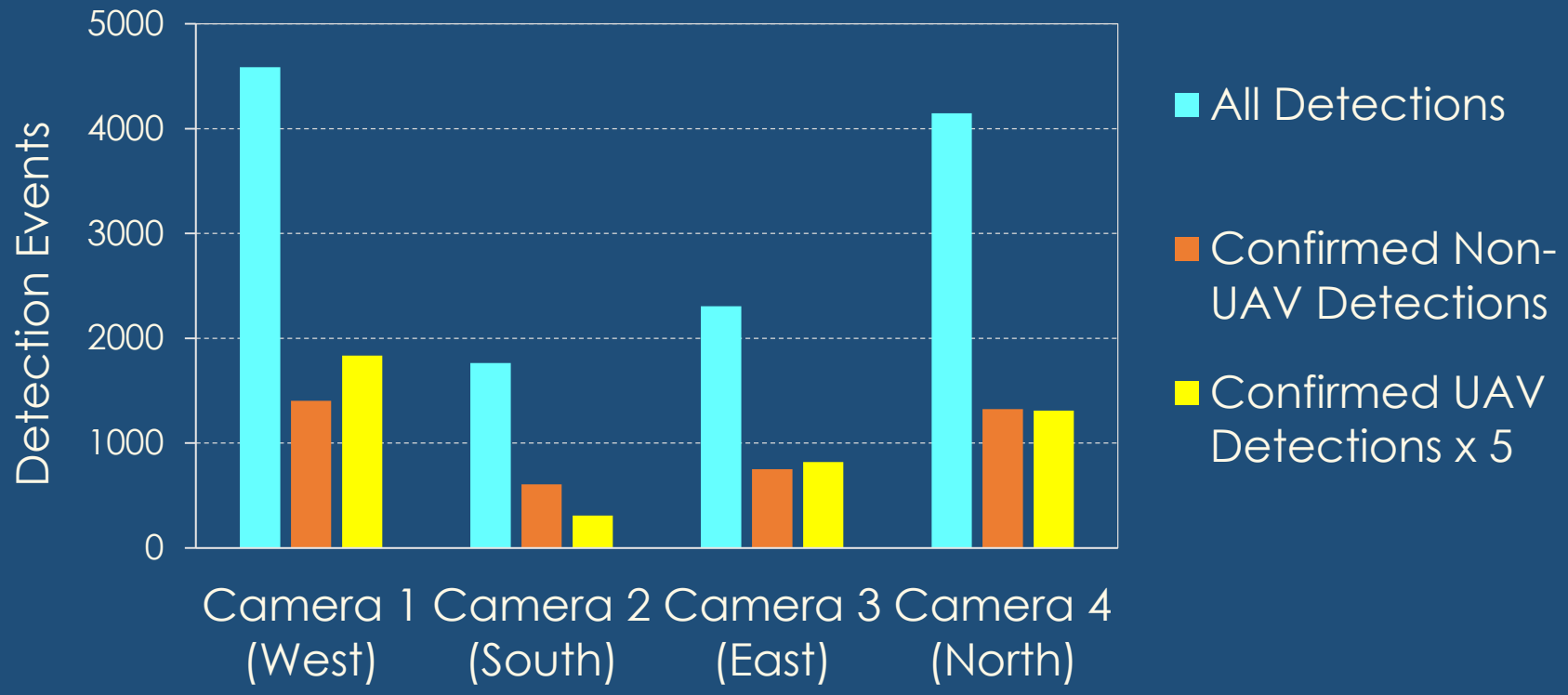


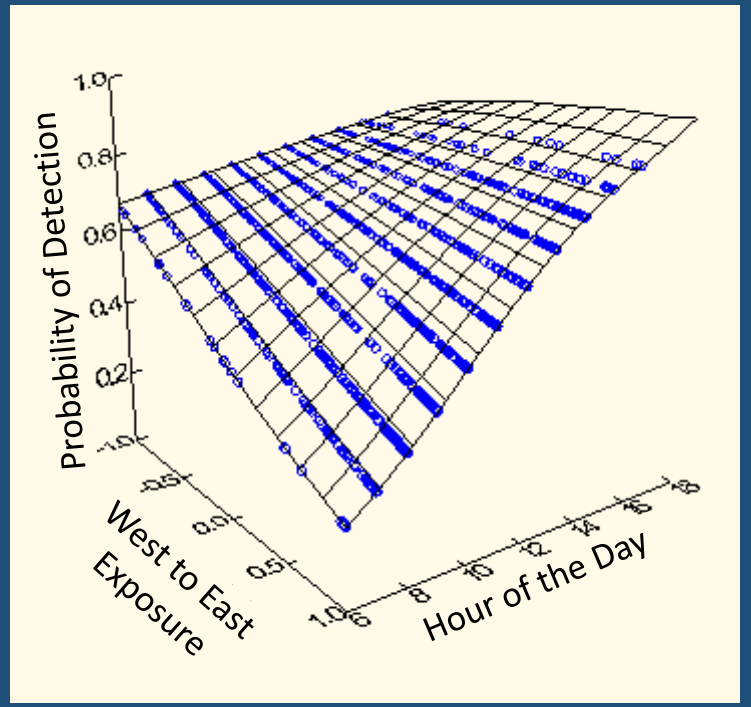
Average overall detectability across turbines:
63 ± 10% (SD)

Detectability in selected distance bands:
>230 m: ≈51% 80–140 m: >85% <80 m: <60%

Results: Probability of Detection

- Reduced for south-facing cameras - sun glare
- Reduced toward E-SE with morning sun
- Improved with midday sun overhead





GLMM relating probability of detection to hour-of-day and sun exposure

Evaluating Deterrent Responses of *In Situ* Raptors

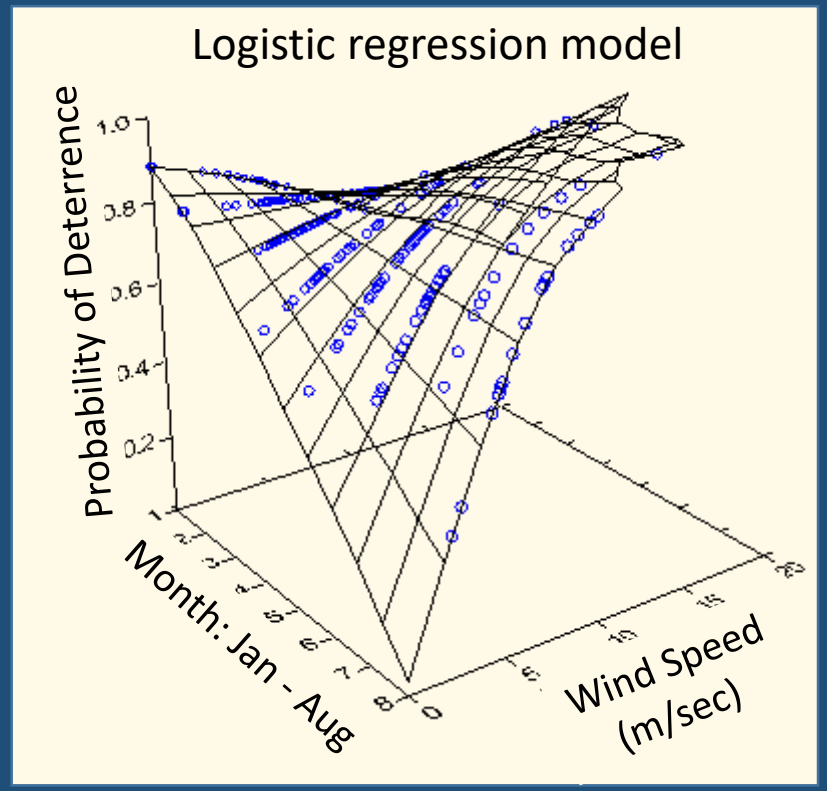
- Randomized sampling of ≈5,000 of 16,000 DTBird event records from January–August and classification of raptor deterrent responses
- Flight diversions >15° away from risk and attendant changes in flight style indicative of successful deterrence
- Logistic regression to evaluate influence of wind speed and month on probability of deterrencea

Photo by G. Lau

Photo by B. Schmoker

Results: Probability of Deterrence

Species	Golden Eagle	All Buteos	Unknown Raptors	All Raptors
Number of Cases	42	46	152	255
Deterred	52%	39%	31%	36%
Possibly Deterred	31%	39%	43%	40%
Ineffective Response	5%	9%	5%	6%
No Response	12%	13%	21%	18%



Effects of wind speed – all raptors combined:

January-February: higher during low winds

By August: high during strong winds (rapidly spinning blades); low during low winds

Seasonal effects or evidence of habituation (?)

Results: Estimated Reduction in Risk of Entering RSZ

- Golden Eagles: 33–53%
  - Minimum = estimated probability of detecting eagle-like UAV (63%) X "successful" probability of deterring Golden Eagle (52%)
  - Maximum = 63% probability of detection X "successful + possible" probability of deterring Golden Eagle (83%)
- All Raptors: 24–62%

Photo by P. LaTourette

Photo by S. Rottenborn

Caveats

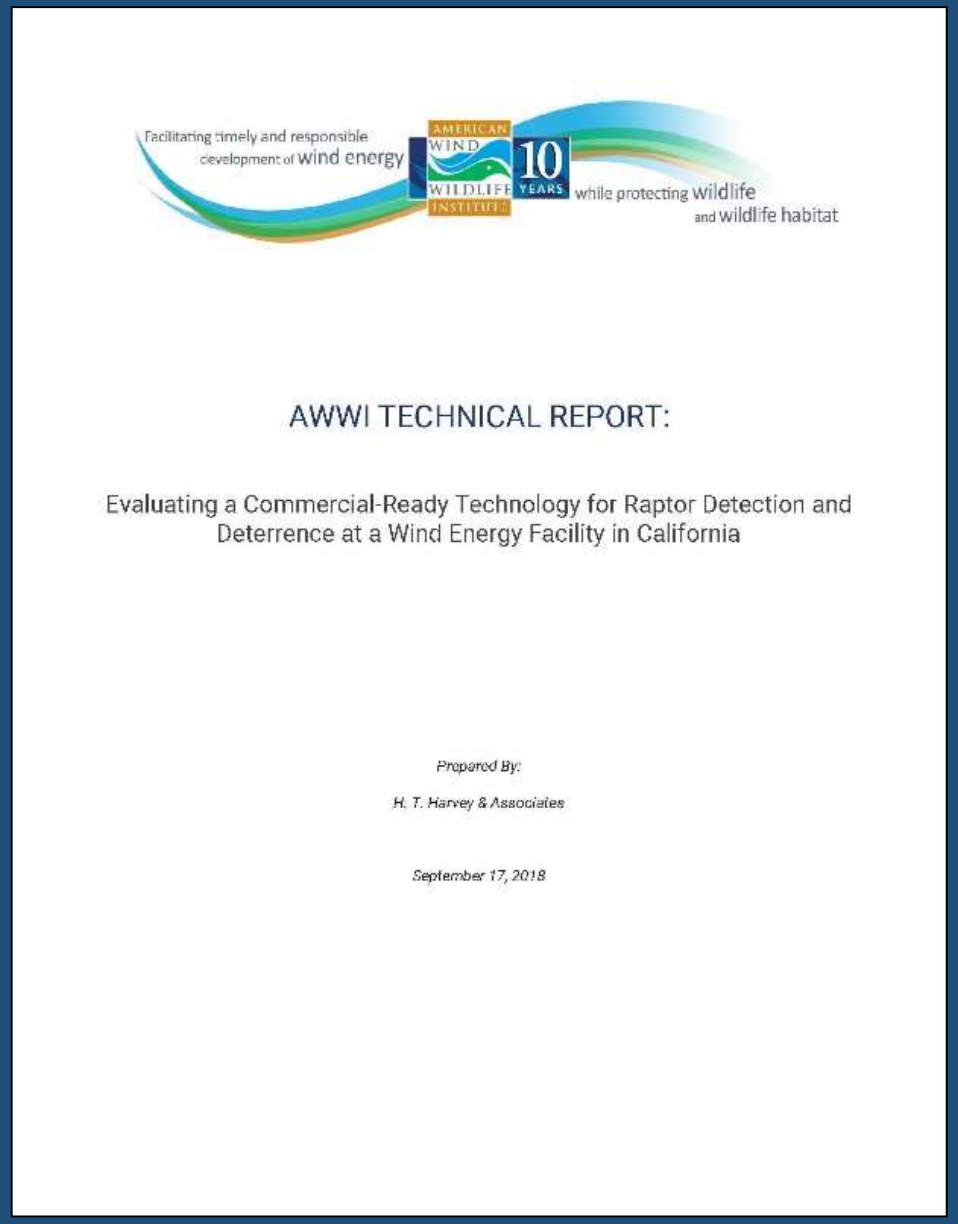
- Results indicative of potential for risk reduction at individual turbines – not at facility level – in similar circumstances
- Ultimate feasibility and effectiveness dependent on:
  - Site layout and placement of DTBird systems
  - Landscape setting and environmental conditions
  - Site-specific eagle/raptor occurrence and behavior
  - False-positive deterrent triggering – potential habituation effects and disturbance of nearby residents and nontarget wildlife
  - Feasibility and cost of integration into existing infrastructure
  - Longevity, durability, and maintenance needs of equipment

Photo by S. Rottenborn

Management Implications & Further Research

- Technology has potential to reduce collision risk for eagles / raptors
- Results mostly consistent with other European pilot studies
- Further testing required to:
  - Expand/refine analyses of performance nuances
  - Evaluate potential for habituation to influence long-term deterrent effectiveness
  - Conduct similarly rigorous testing at facilities in other landscape settings
  - Formulate robust recommendations for system improvement

Photo by E. Baker



Publicly Available Technical Report

https://awwi.org/resources/dtbird-technical-report

Forthcoming Research

2019–2021 expansion to WA study site sponsored by U.S. Department of Energy

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