"The Future Can't Wait": An Urgent Paradigm Shift Towards Mitigating Off-Airport Damaging Strikes via Long-range Detection and Operational Avoidance

Tim Young

Program Manager / DoD Aviation

DeTect™ HARRIER MERLIN DRONEWATCHER

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Agenda

Image: Ivan Palacios

- Airport Wildlife Hazard Management
  - Current Model
  - Mitigation Gaps
  - Case Studies
- Paradigm Shift
  - Enhanced Detection
  - Operational Avoidance
  - Case Studies

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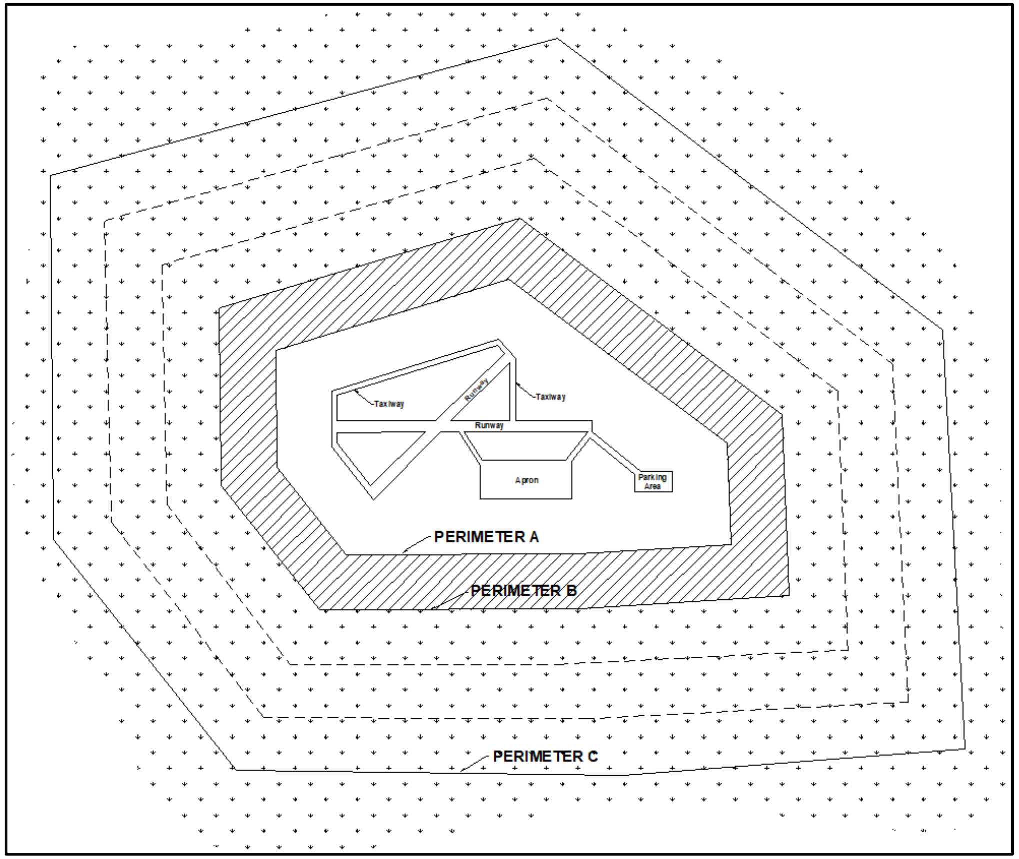
Current Airport Wildlife Hazard Management Model



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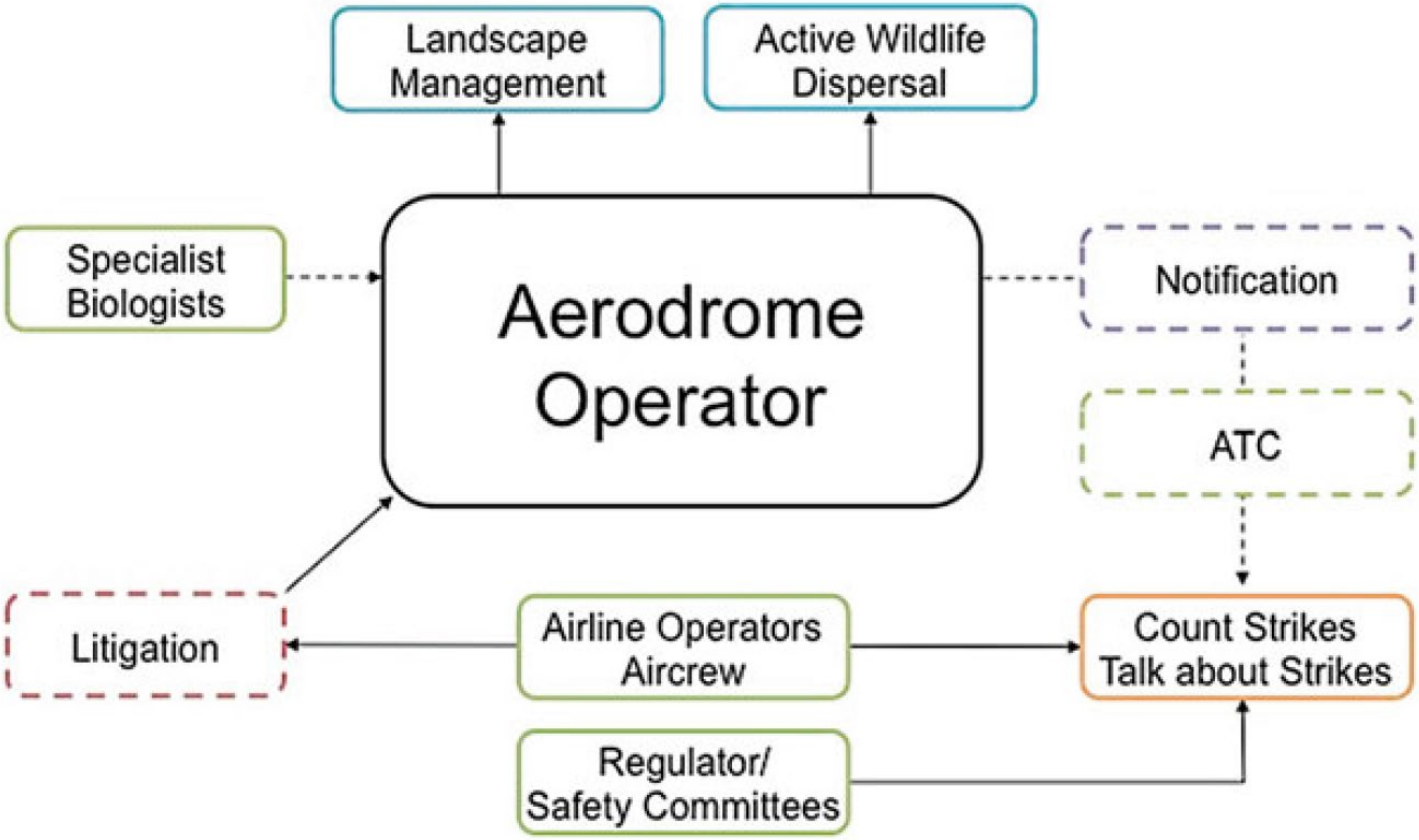

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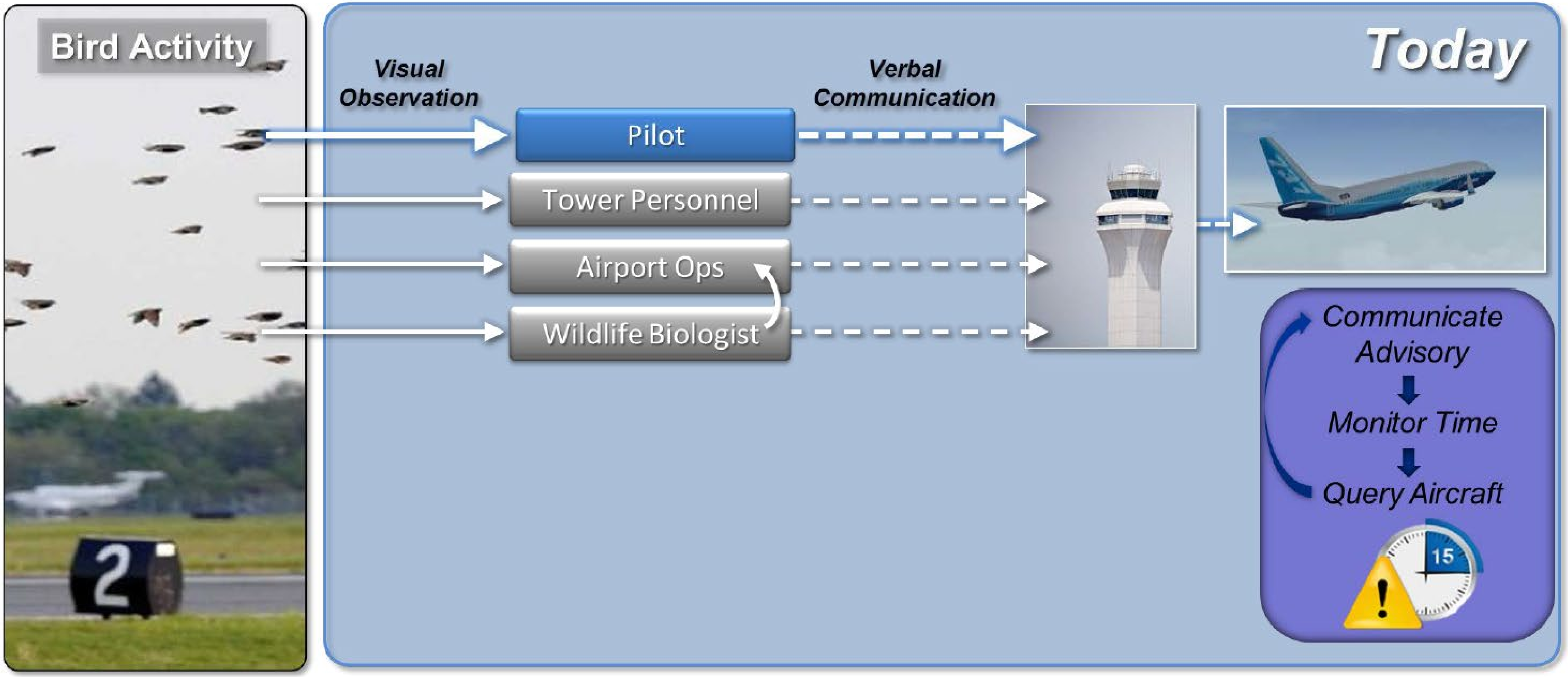

Hale, M. 2017. Enhanced Bird Threat Information in the Air Traffic Control Tower: Wildlife Surveillance Concept (WiSC) Research Update. FAA Technical Center/CSSI. BSC-USA meeting, Dallas TX, USA (https://birdstrike.org/2017-conference-presentations/)

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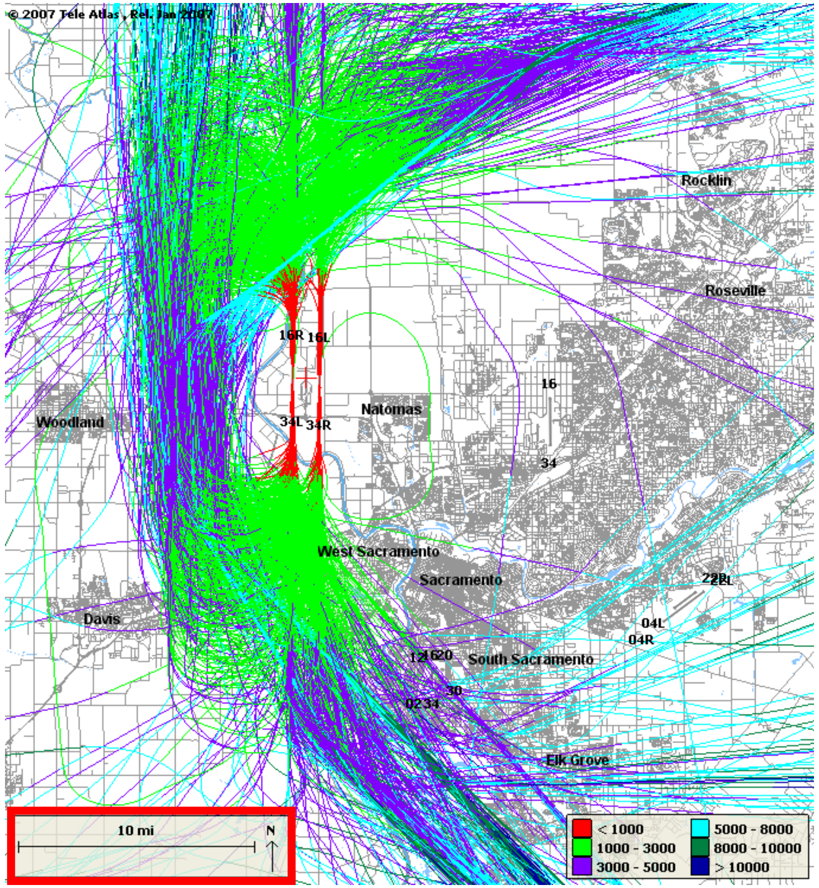
Aircraft Altitudes During Departure and Arrival

SMF Arrival Flows By Altitude



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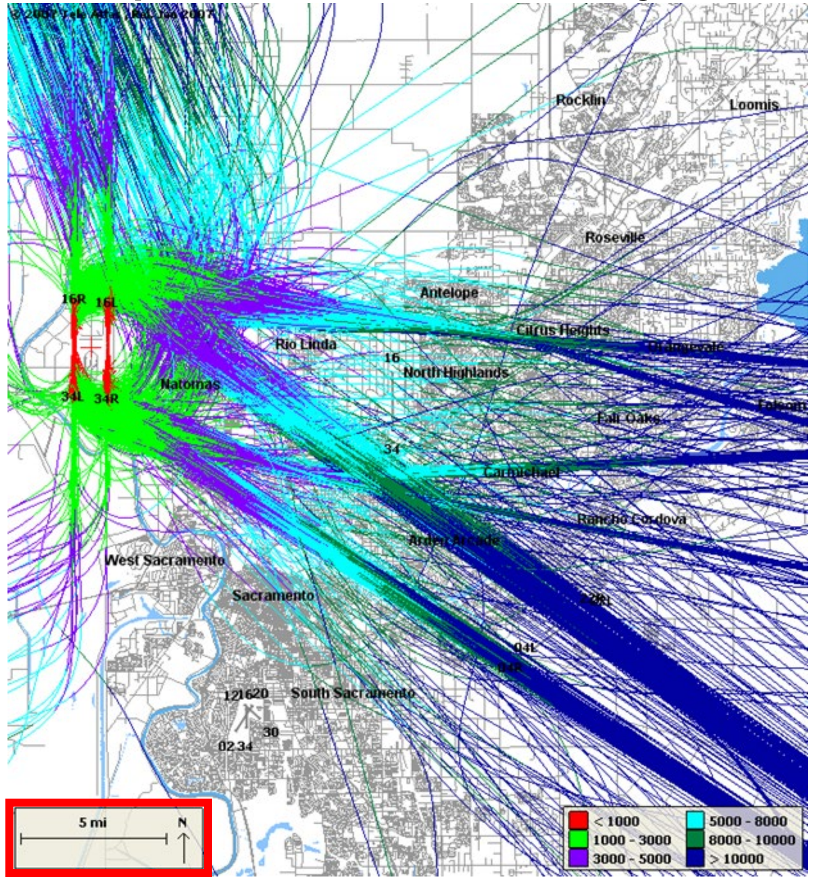

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1000 - 3000	8000 - 10000
3000 - 5000	> 10000

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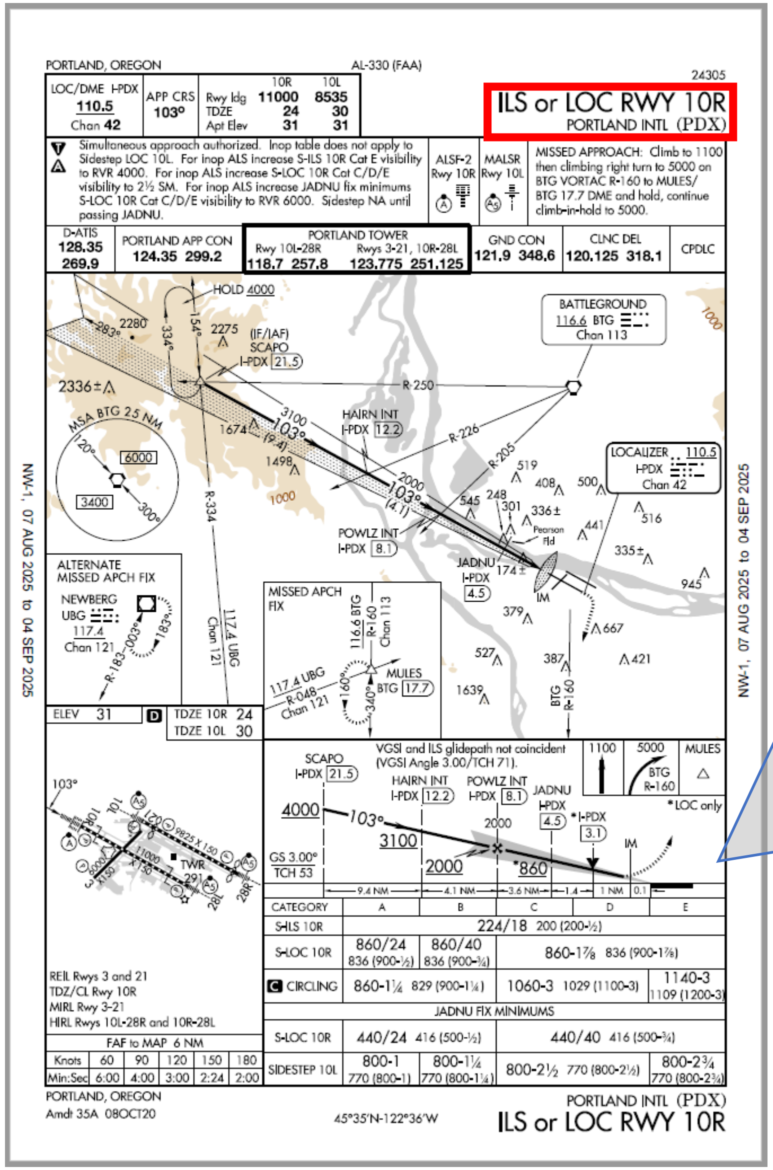
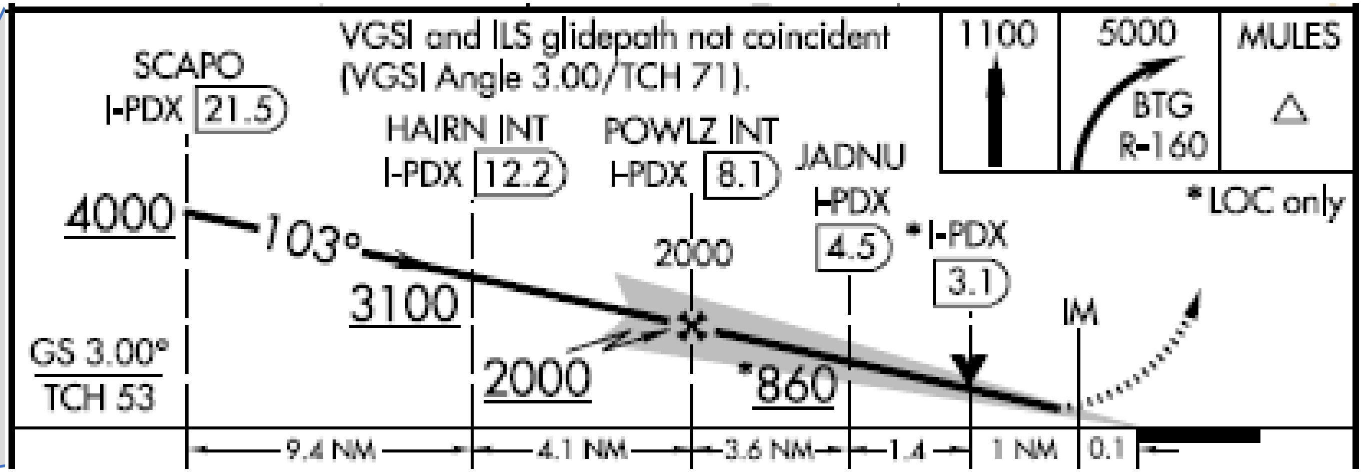
Aircraft Approach Profiles





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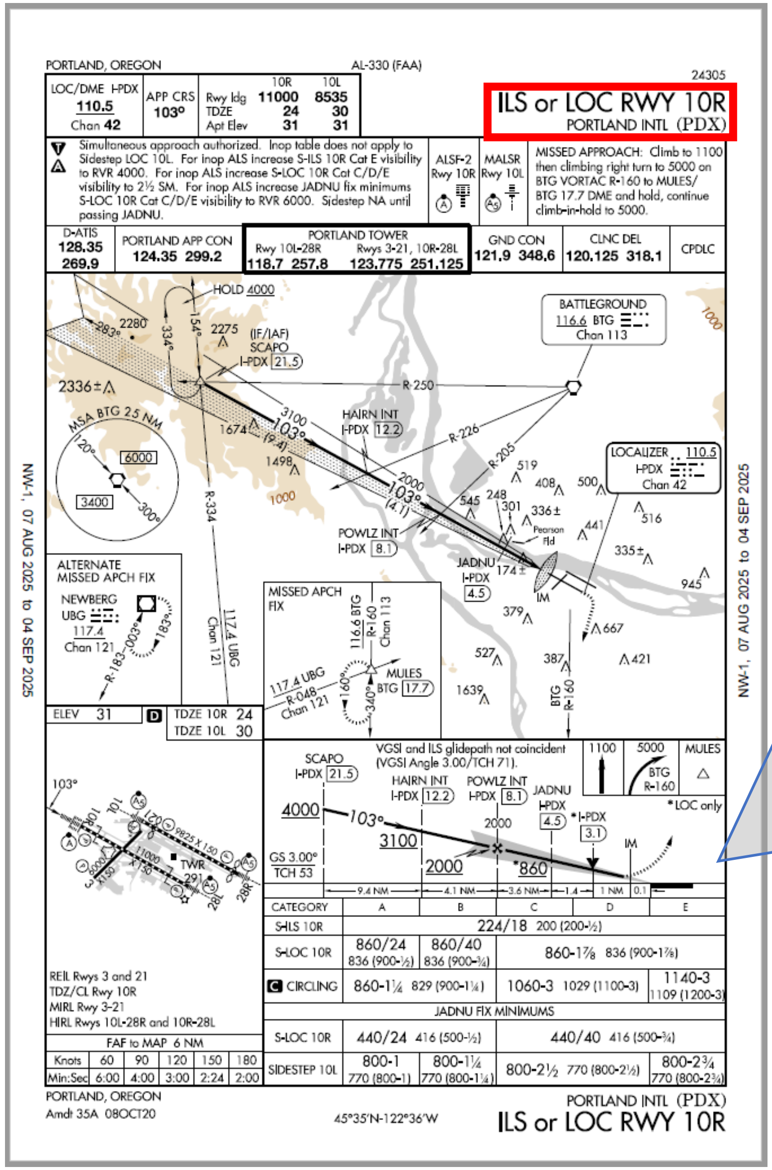
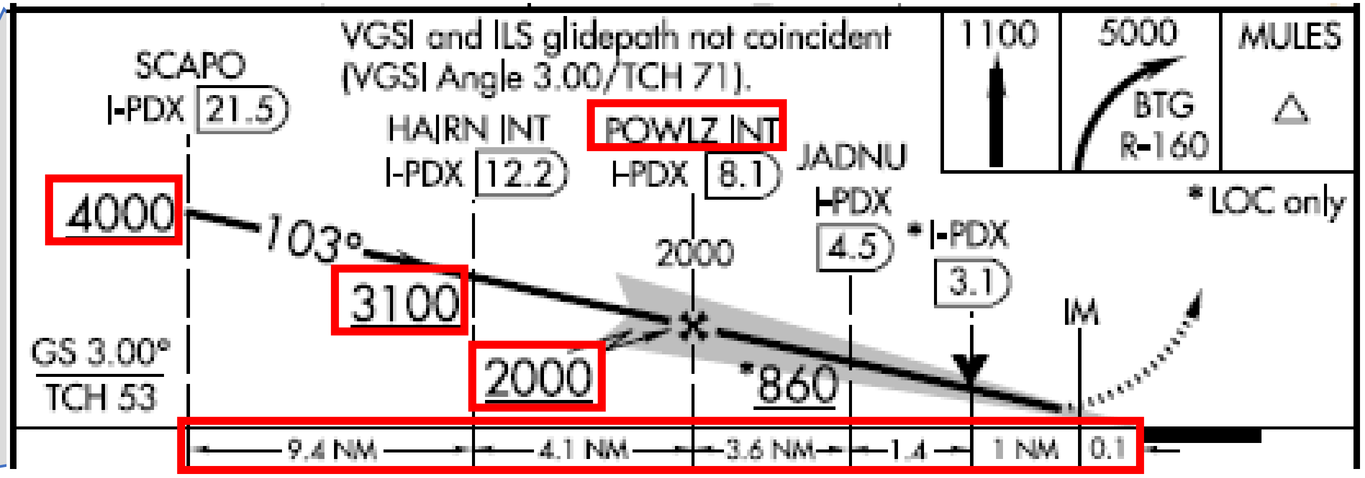
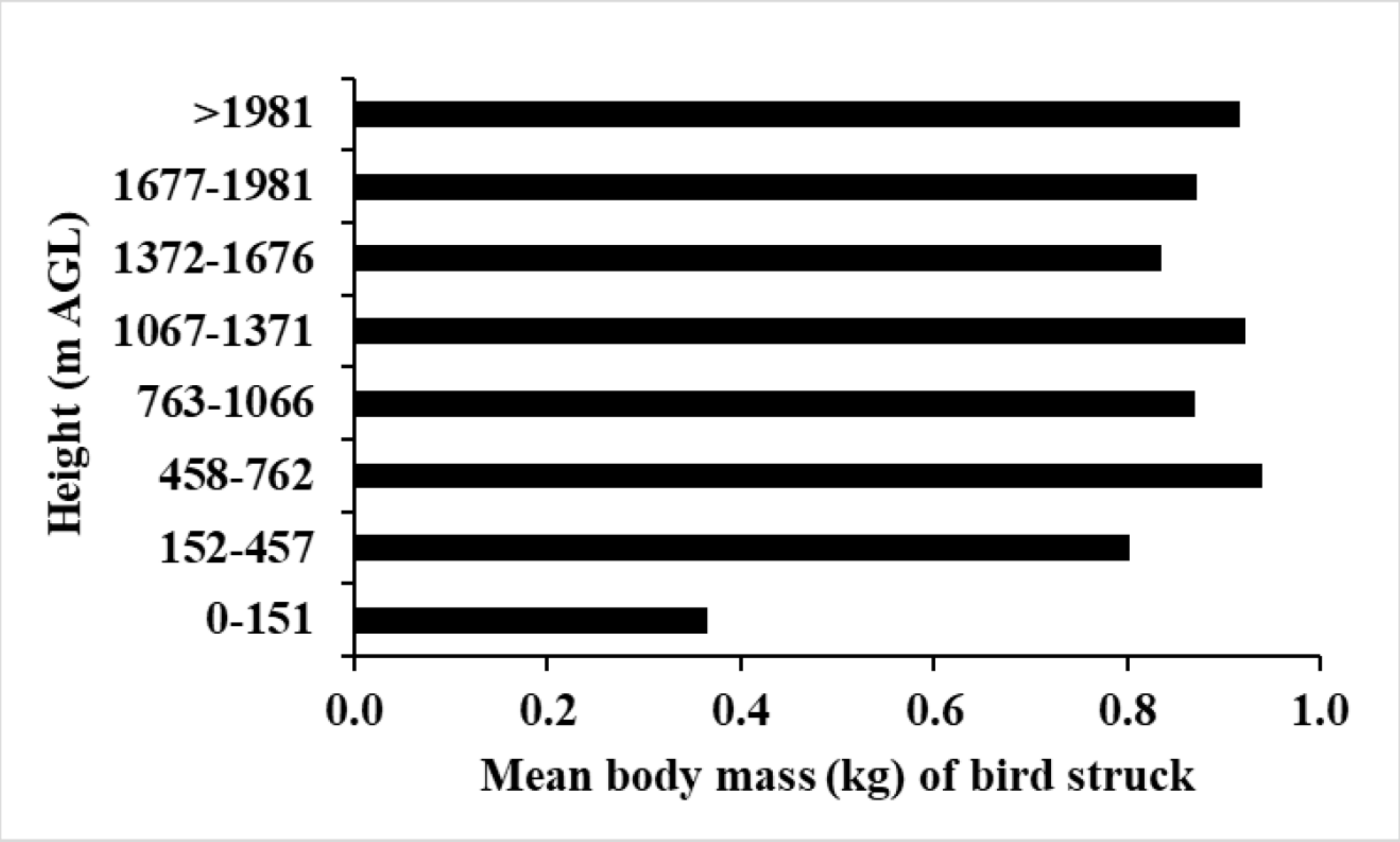




Mass of Birds Struck in Relation to Aircraft Altitude



Mean body mass of birds (all species, N = 39,046 strike events) struck by transport civil aircraft (>2,250 kg maximum take-off weight) during approach, landing roll, take-off run and climb at Part 139-certificated airports in relation to height above ground level (AGL), USA, 2009-2023.

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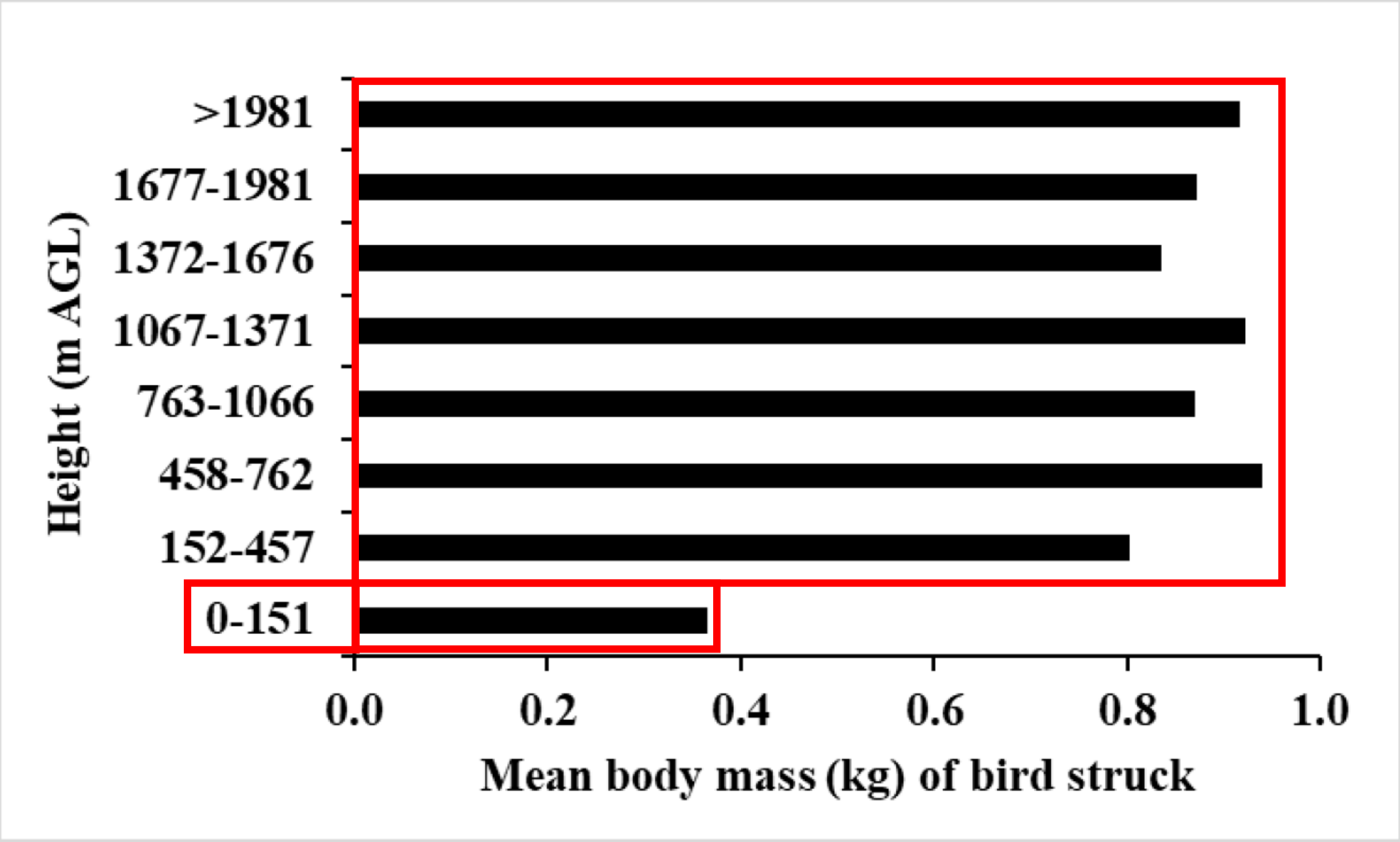

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Damaging Strikes in Relation to Bird Mass and Altitude

Number of strikes and strikes with damage for large and medium birds and transport civil aircraft during approach, landing roll, take-off run and climb at Part 139-certificated airports based on height above ground level (AGL, <152 m and >152 m), USA, 2009-2023.

	Large birds (≥1.8 kg)		Medium birds (1.1-1.7 kg)		Large + medium birds (≥1.1 kg)	
Height (m AGL)	0-151	≥152	0-151	≥152	0-151	≥152
Total strikes	1,791	1,841	2,737	458	4,528	2,299
Damage strikes	501	842	485	198	986	1,040
% with damage	28.0	45.7	17.7	43.2	21.8	45.2

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Kinetic energy $= {}^{1}/_{2}MV^{2}$

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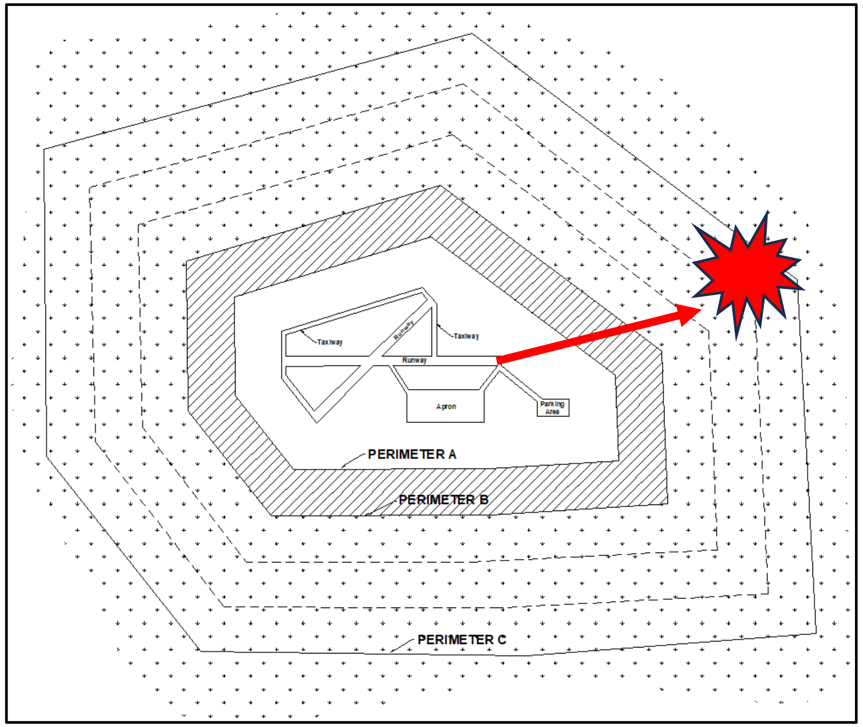
Case Study: US Airways Flight 1549

January 15, 2009, New York-LaGuardia (LGA/KLGA)

Image: Greg Ng

Departure
3.8 nautical miles
2,818' AGL
Canada Geese

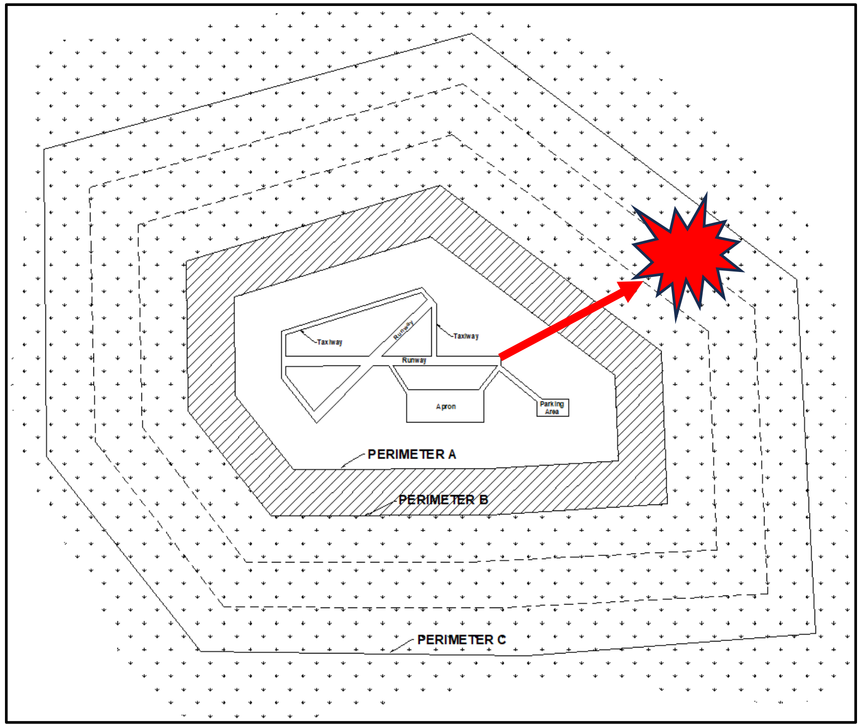


Case Study: Delta Flight 8944

March 30, 2021, Salt Lake City (SLC/KSLC)


Images: Ryan Miller

Departure
3.0 nautical miles
4,000′ AGL
American white pelicans



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Case Study: JeJu Air Flight 2216

December 29, 2024, Muan International Airport (MWX/RKJB)

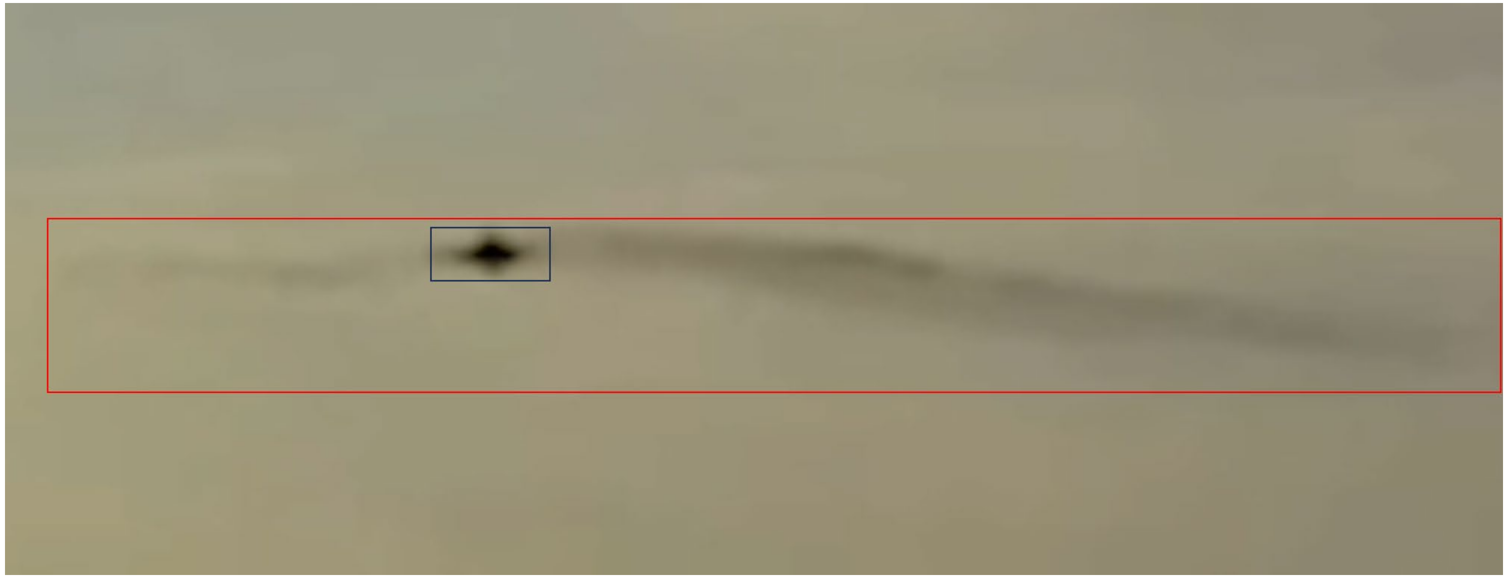
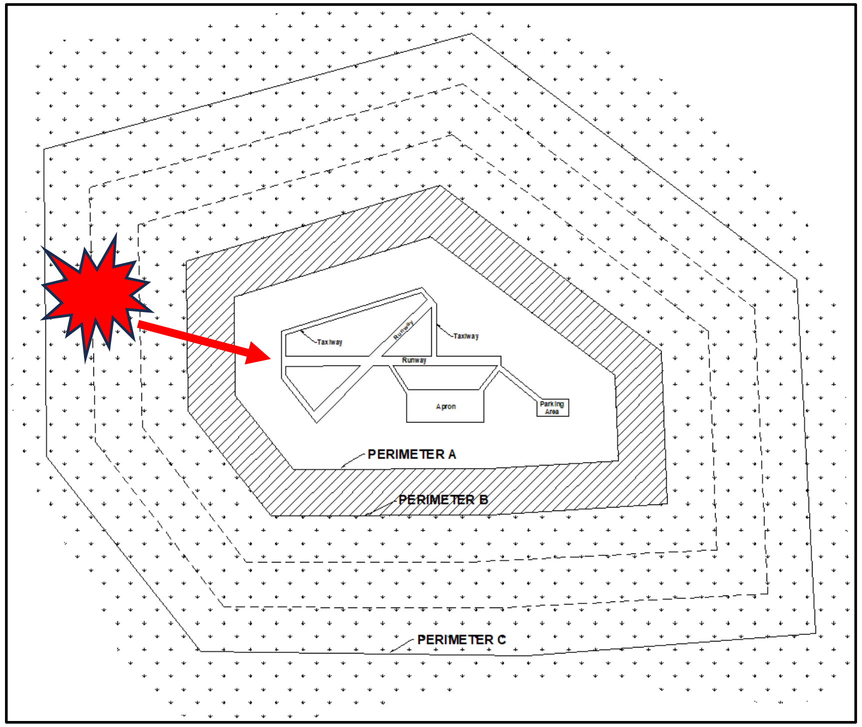


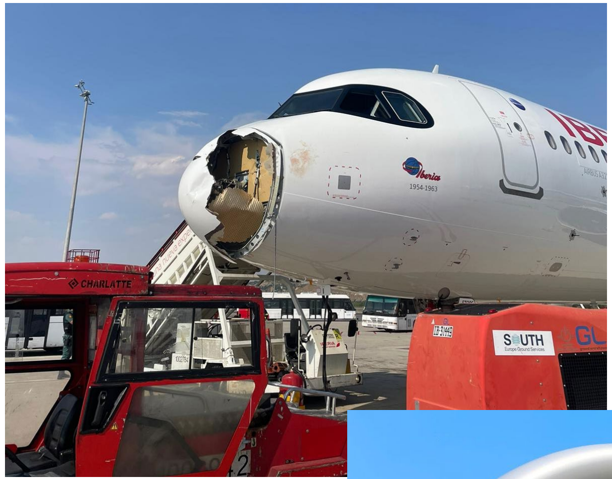
Image: KBS

Arrival
2.2 nautical miles
750′ AGL
Baikal teal ducks



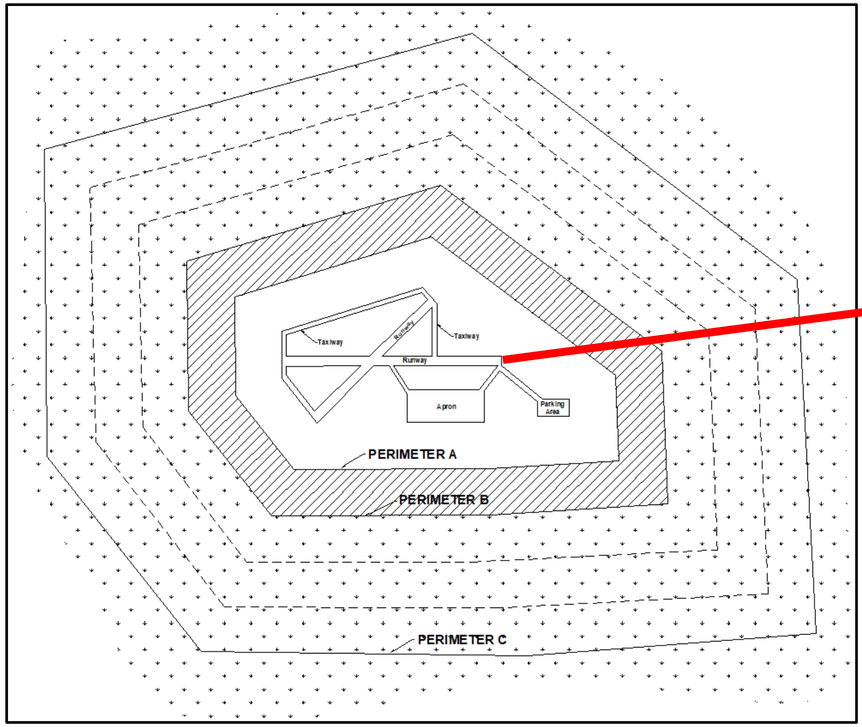
Case Study: Iberia Airways Flight 539

August 3, 2025, Madrid-Barajas Adolfo Suárez (MAD/LEMD)



Images: Ivan Palacios

Departure
9.1 nautical miles
4,275′ AGL
Vulture



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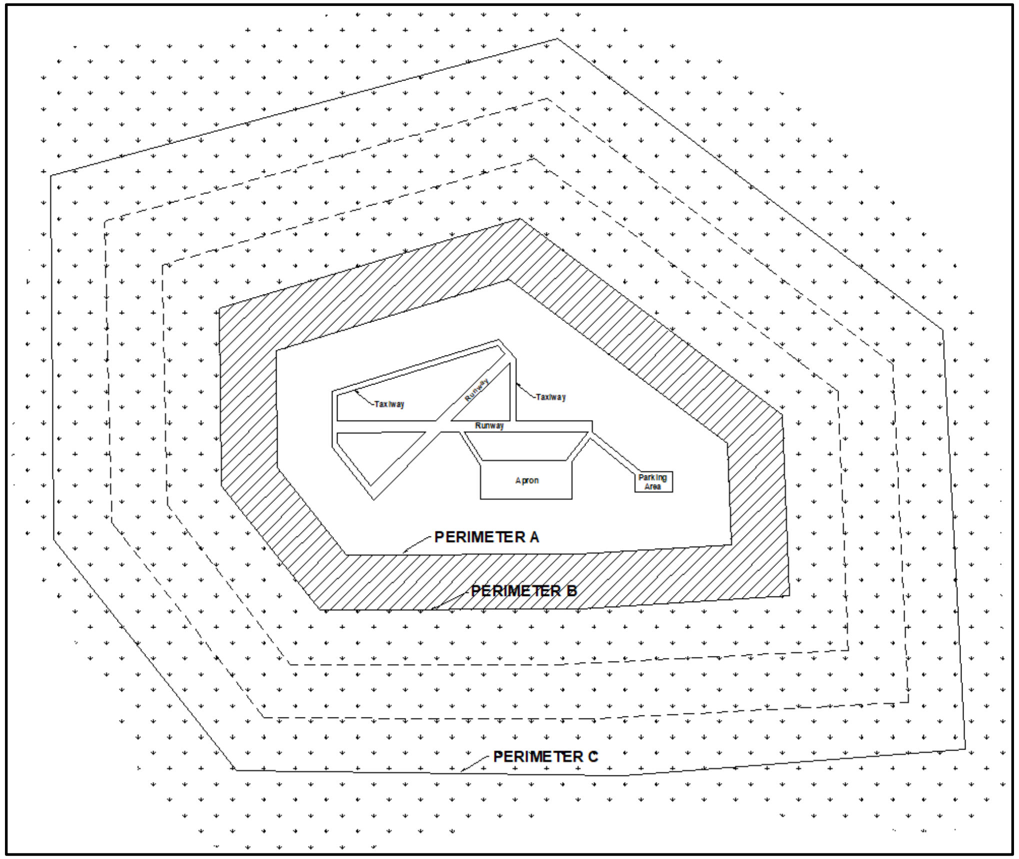
Current Airport Wildlife Hazard Management Model



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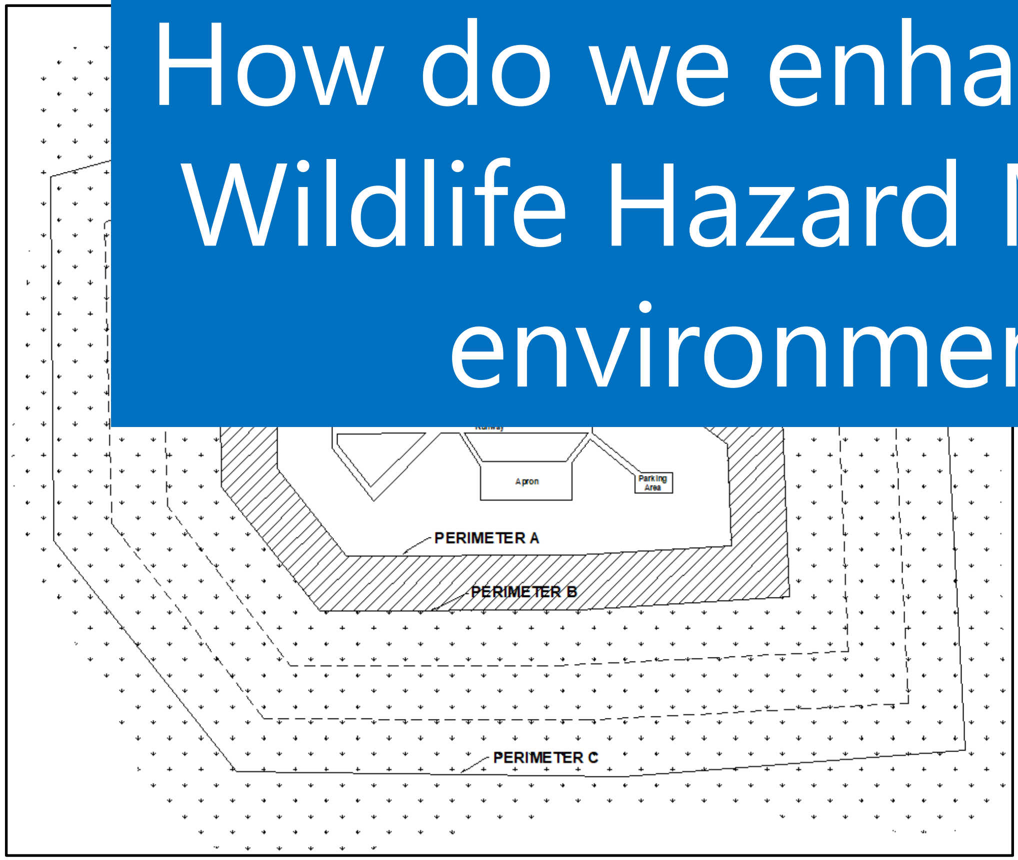

How do we enhance and expand Airport Wildlife Hazard Management to keep it environmentally sustainable?

ardous

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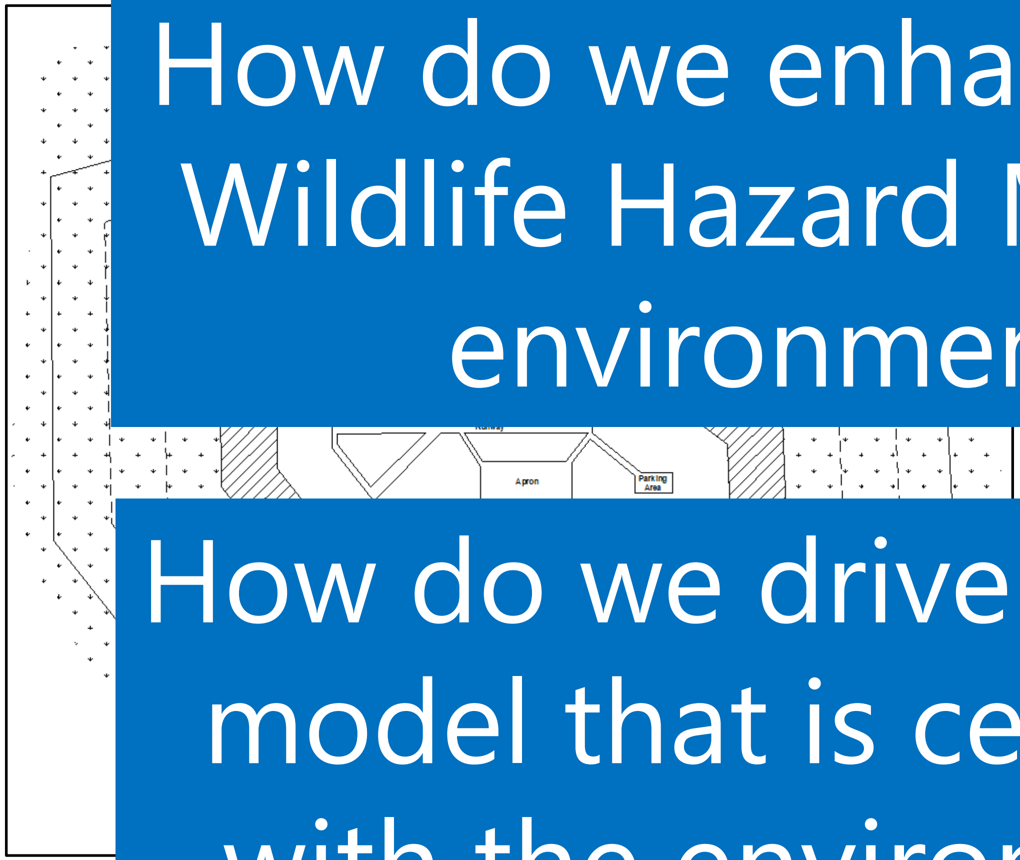

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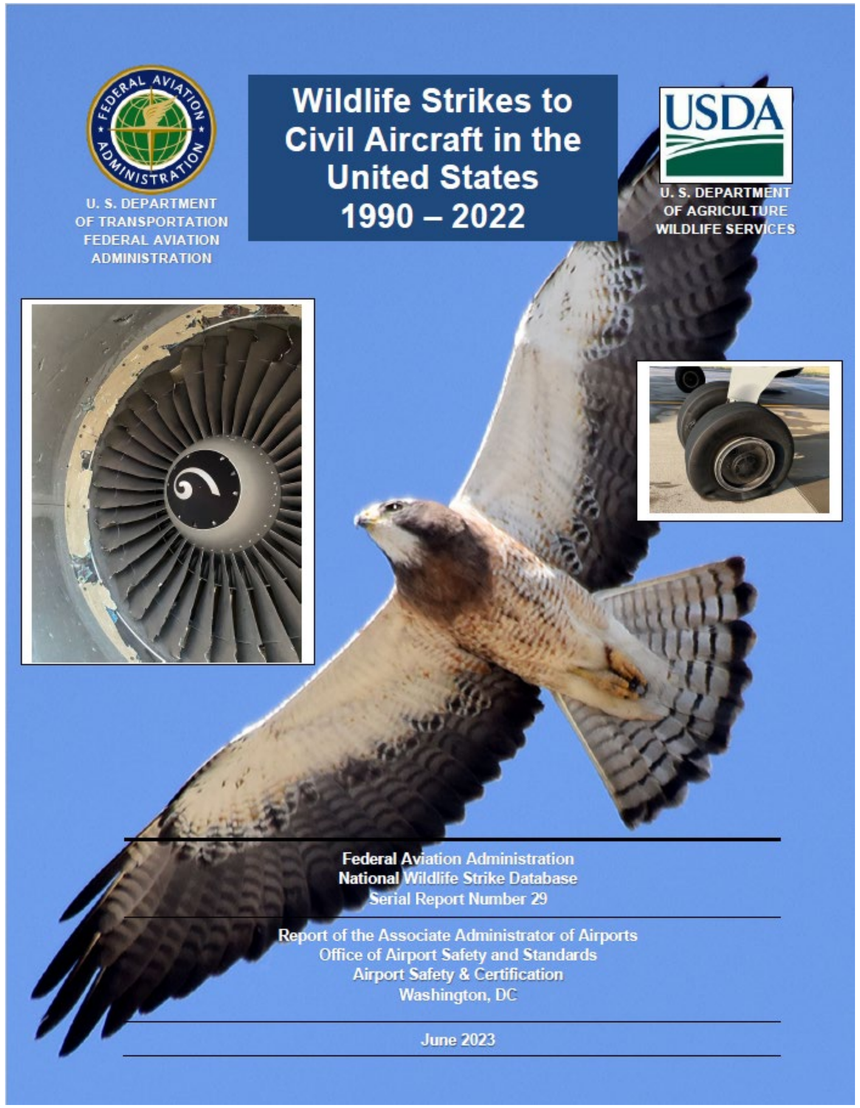
PERIMETER C: Recommended for all airports. 5-mile range to protect approach, departure and

How do we enhance and expand Airport Wildlife Hazard Management to keep it environmentally sustainable?

How do we drive a paradigm shift from a model that is centered around Conflict with the environment to one that also incorporates Compatibility?

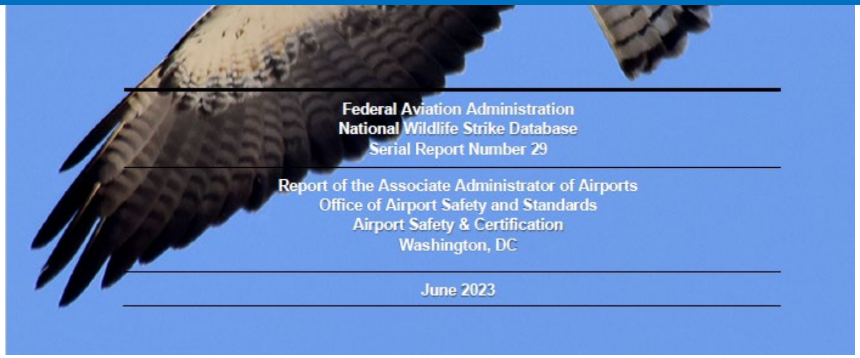
Federal
or Near
(https://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5200-33C.pdf)

Paradigm Shift



To address strikes outside the airport environment, municipalities and the aviation community must first widen their view of wildlife management to minimize hazardous wildlife attractants within 5 miles of airports. Second, the aviation community needs to broaden the view of wildlife strike risks from a ground-based wildlife management problem to an airspace management problem that also encompasses Air Traffic Control, flight crews, and aircraft manufacturers. Long-term goals include the integration of avian radar and bird migration forecasting into airspace management and the development of aircraft lighting systems to enhance detection and avoidance by birds.

Compatibility = Expanding our understanding of our Environment & Adapting Operations to Allow Simultaneous Use



include the integration of avian radar and bird migration forecasting into airspace management and the development of aircraft lighting systems to enhance detection and avoidance by birds.

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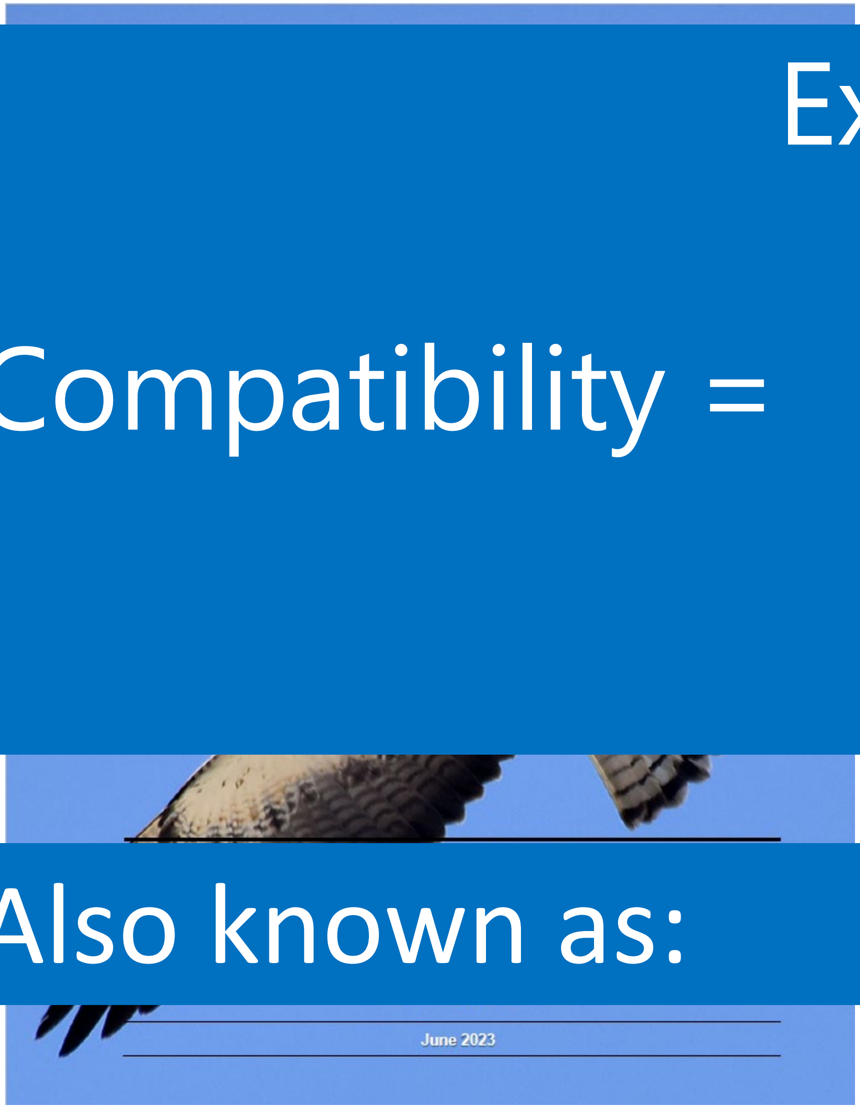

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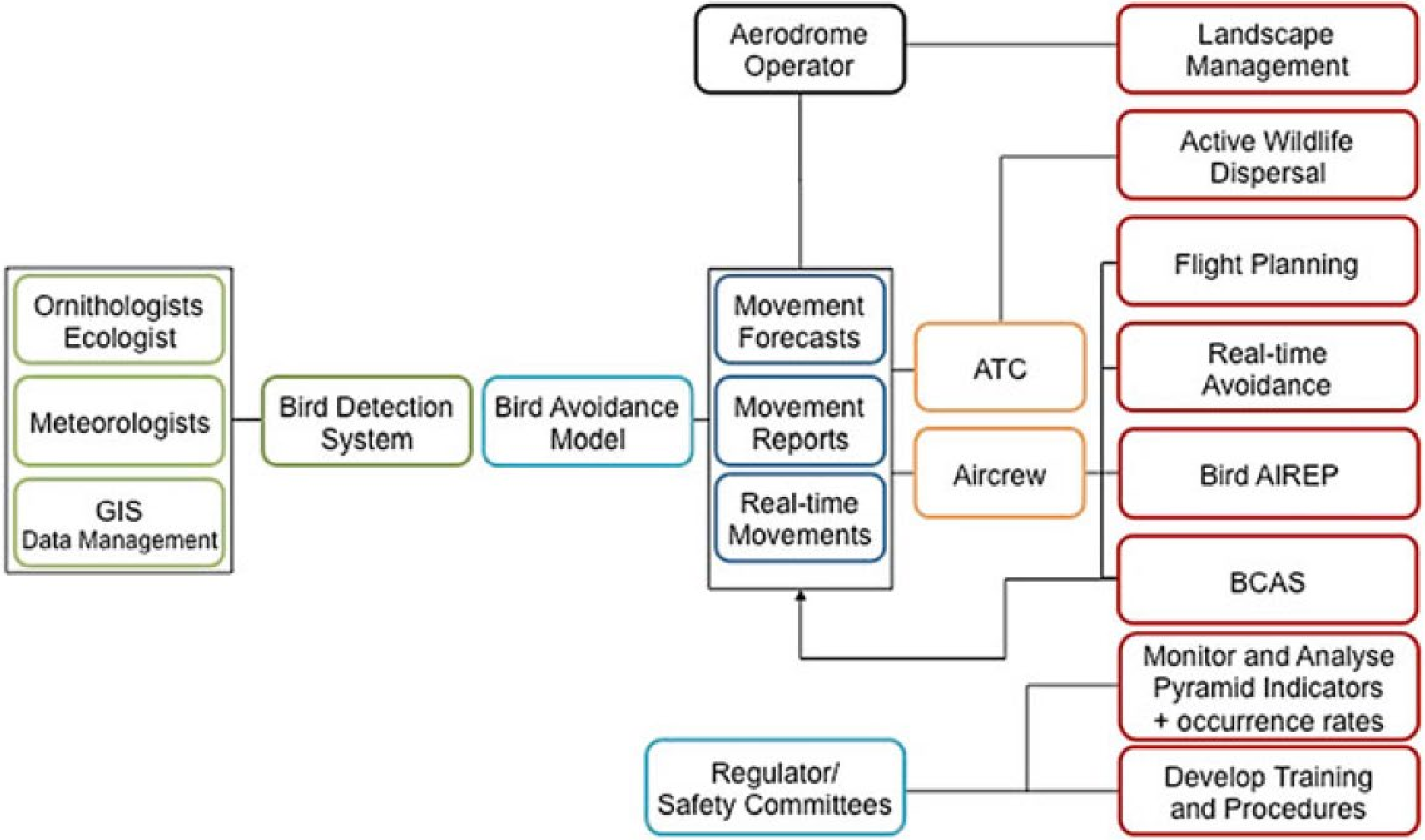
Compatibility = Expanding our understanding of our Environment & Adapting Operations to Allow Simultaneous Use

Also known as: Detect and Avoid

A New Model for Airport Wildlife Hazard Management



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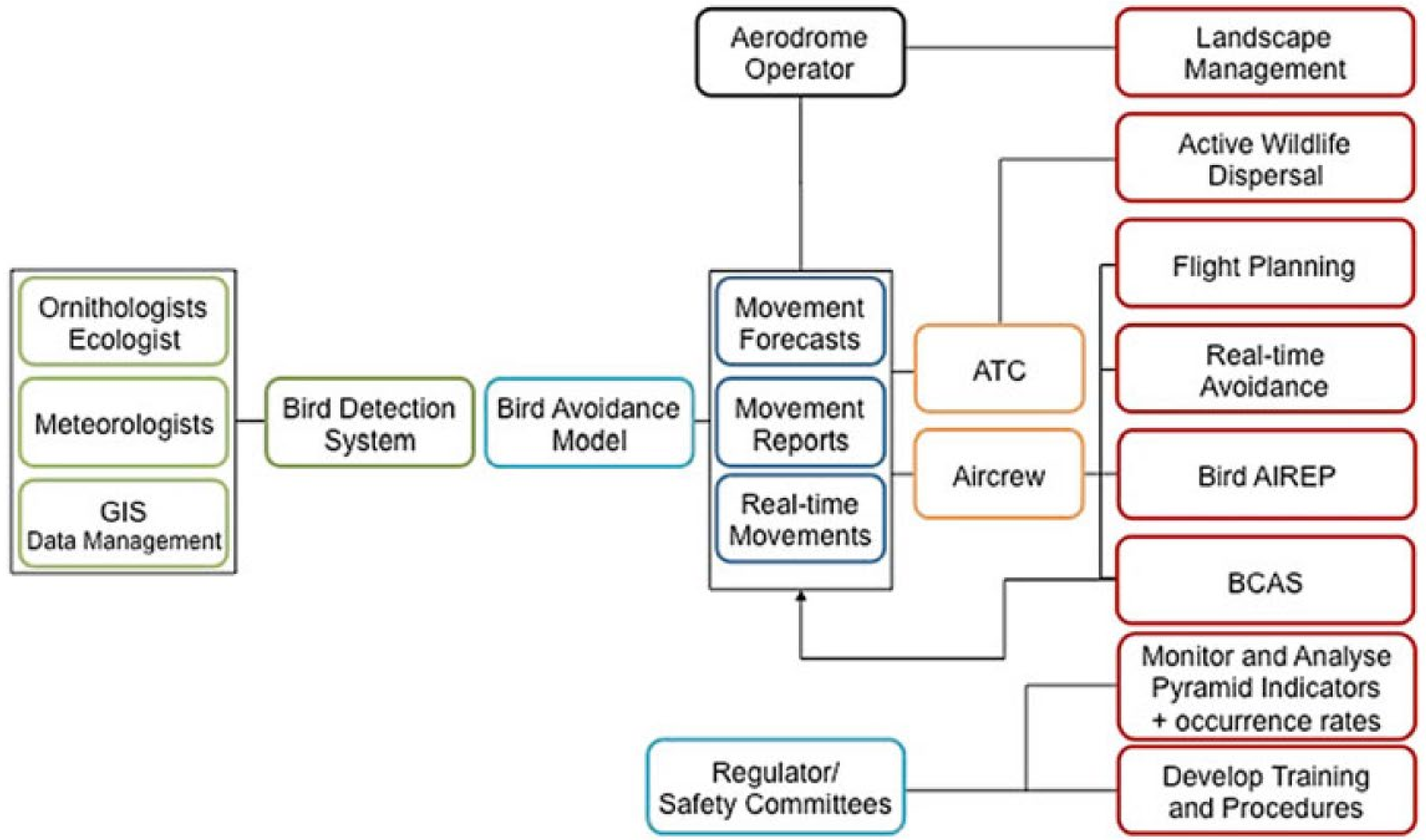

Continued USDA-WS Leadership

QAWBs driving change with Operations Managers

Airport WHMPs that are expanded to encompass Detection and Avoidance

Hazard Management focused not just on reducing exposure, but on Engineering and Administrative Controls

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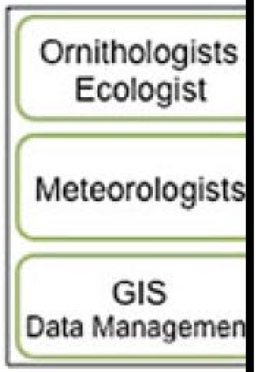

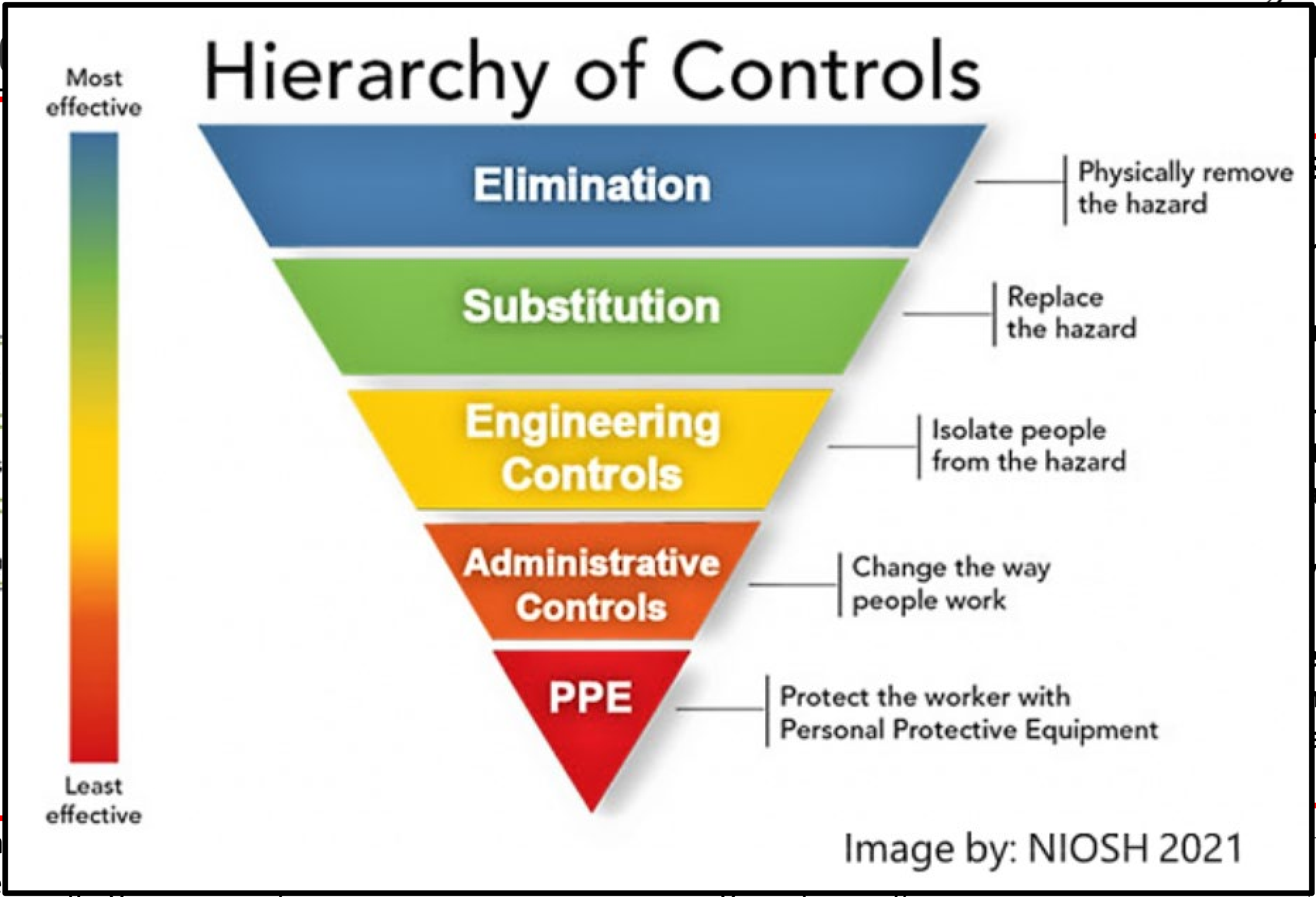

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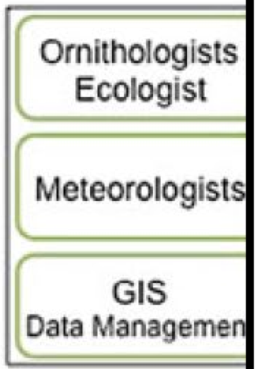

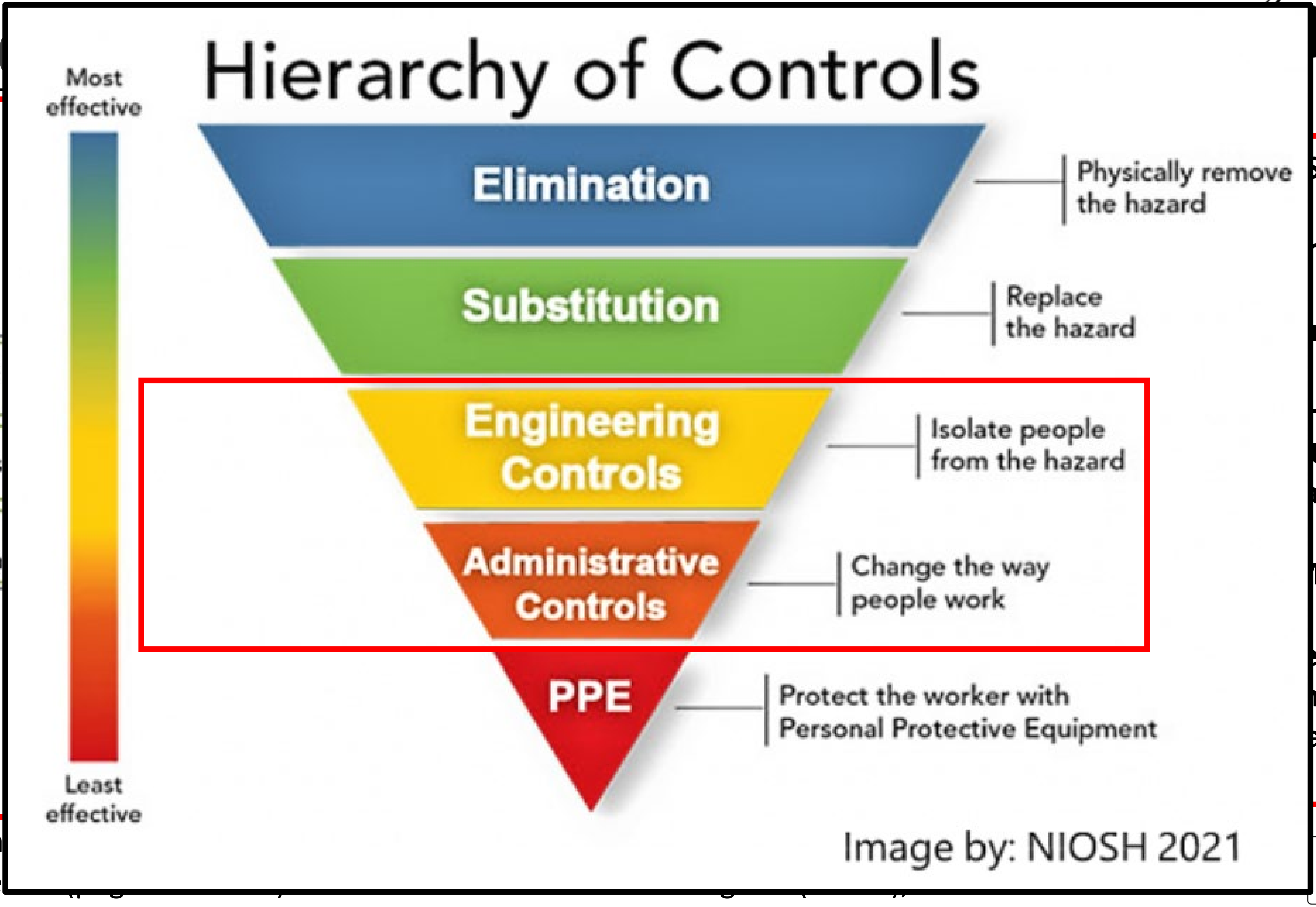

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Current Avian Detection Guidance

U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: Airport Avian Radar Systems	**Date:** 11/23/10 **Initiated by:** AAS-100	**AC No:** 150/5220-25 **Change:**

1. **PURPOSE.** This advisory circular (AC) provides guidance on the use of avian radar systems to supplement an airport's Wildlife Hazard Management Plan (WHMP) and reduce the potential avian threats to aircraft.

2. **SCOPE.** This AC describes how airports can select, procure, deploy, and manage an avian radar system. A chapter dedicated to each of the program areas is provided, as shown in the summaries below:

- Selection: Describes the factors that must be considered when choosing the proper system for a given set of airport conditions and requirements (Chapter 3).
- Procurement: The minimum performance standards for airport avian radar systems are provided (Chapter 4).
- Deployment: Discusses the process of installing a system in the location best suited to maximize system capabilities (Chapter 5).
- Management: Outlines the effective use of avian radar system data using the fundamental principles of risk management (Chapter 6).

The guidance in this AC is applicable to airport owners and operators. This AC is based on research conducted by the Federal Aviation Administration (FAA) Airport Technology Research and Development Program to examine the performance of several avian radar technologies.

3. **APPLICATION.** The Federal Aviation Administration (FAA) recommends the guidance and specifications in this Advisory Circular for deploying and managing an avian radar system at an airport. In general, use of this AC is not mandatory. However, use of this AC is mandatory for all projects funded with federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, Policies, Standards, and Specifications, and PFC Assurance No.9, Standards and Specifications.

- Airport-centric
  - Written for QAWBs and Operations Managers
  - No guidance for ATC, Carriers, or Aircrew
- Outlines Airport Coverage (Several miles) vs Local Coverage (5-20 miles)
  - But no detection standards beyond 3 nm and no coverage requirements beyond 5 nm
- No Concept of Operations
- No updates or revisions in 15 years
  - Significant technological and implementation progress in that period

Enhanced Detection Model

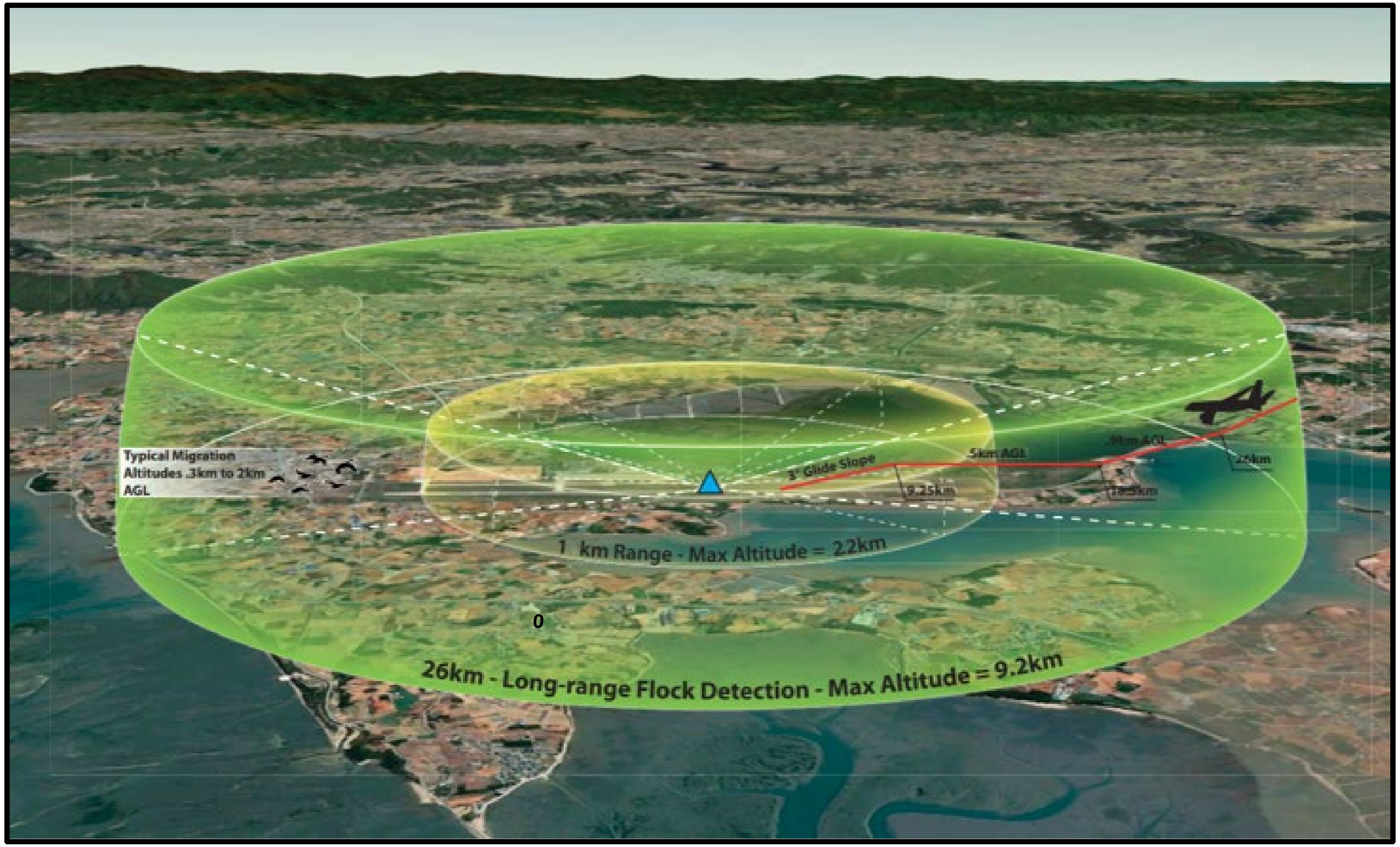
Dual-Focus:

➢ **Short-range Airport Coverage**

- High-fidelity 3D coverage for AOA and 5-mile Perimeter C
- Standards in accordance with Advisory Circular

➢ **Long-range Local Coverage**

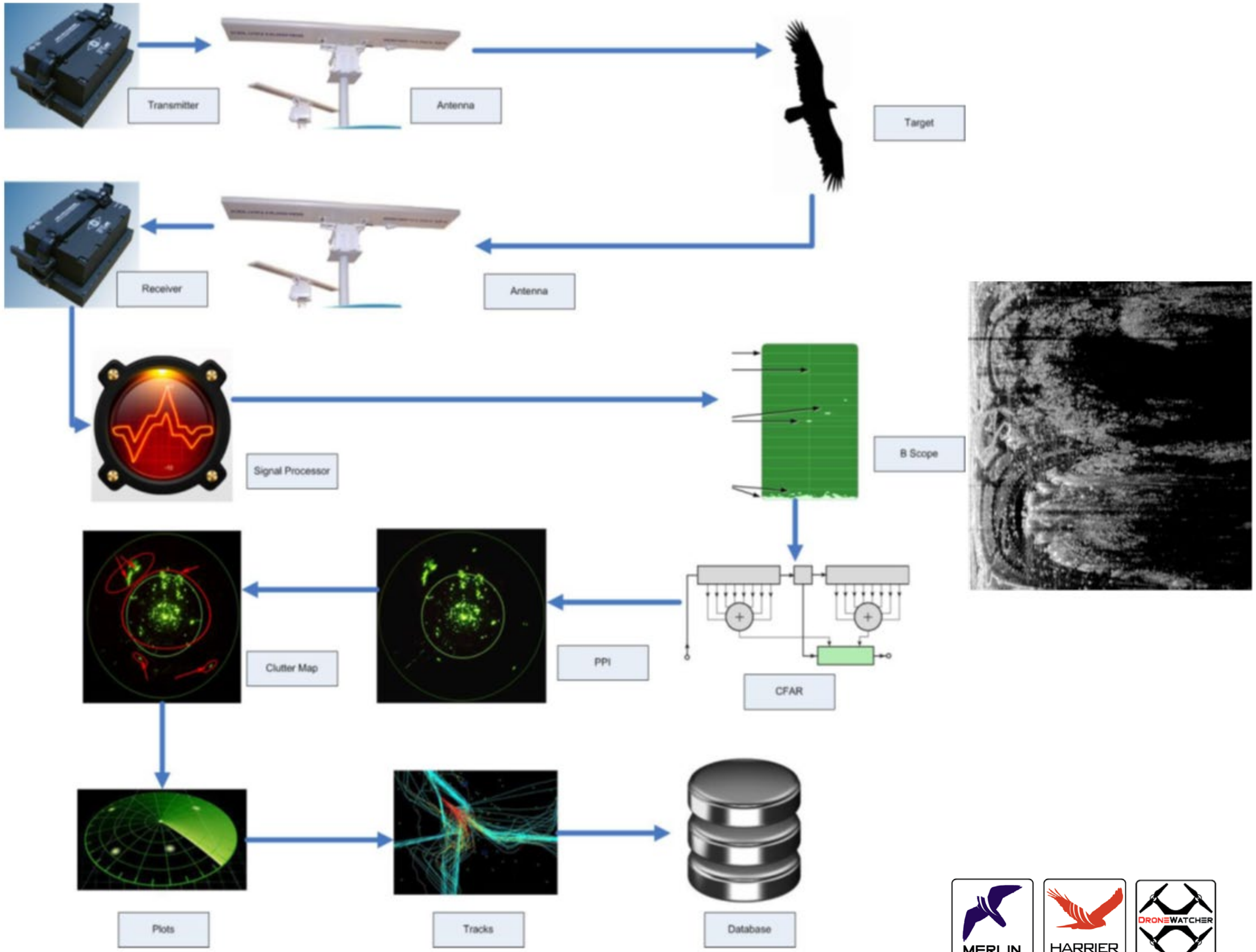
- Tuned/Optimized for large birds and flocks
- Covers aircraft through terminal environment (10+ nm) and migratory altitudes (500’ AGL - 7,000’+ AGL)



Long-Range Detection Model

- Modern radars utilize a variety of signal processing filters and techniques to enhance quality and resolution of target detection
  - Constant False Alarm Rate (CFAR)
  - Pulse Compression

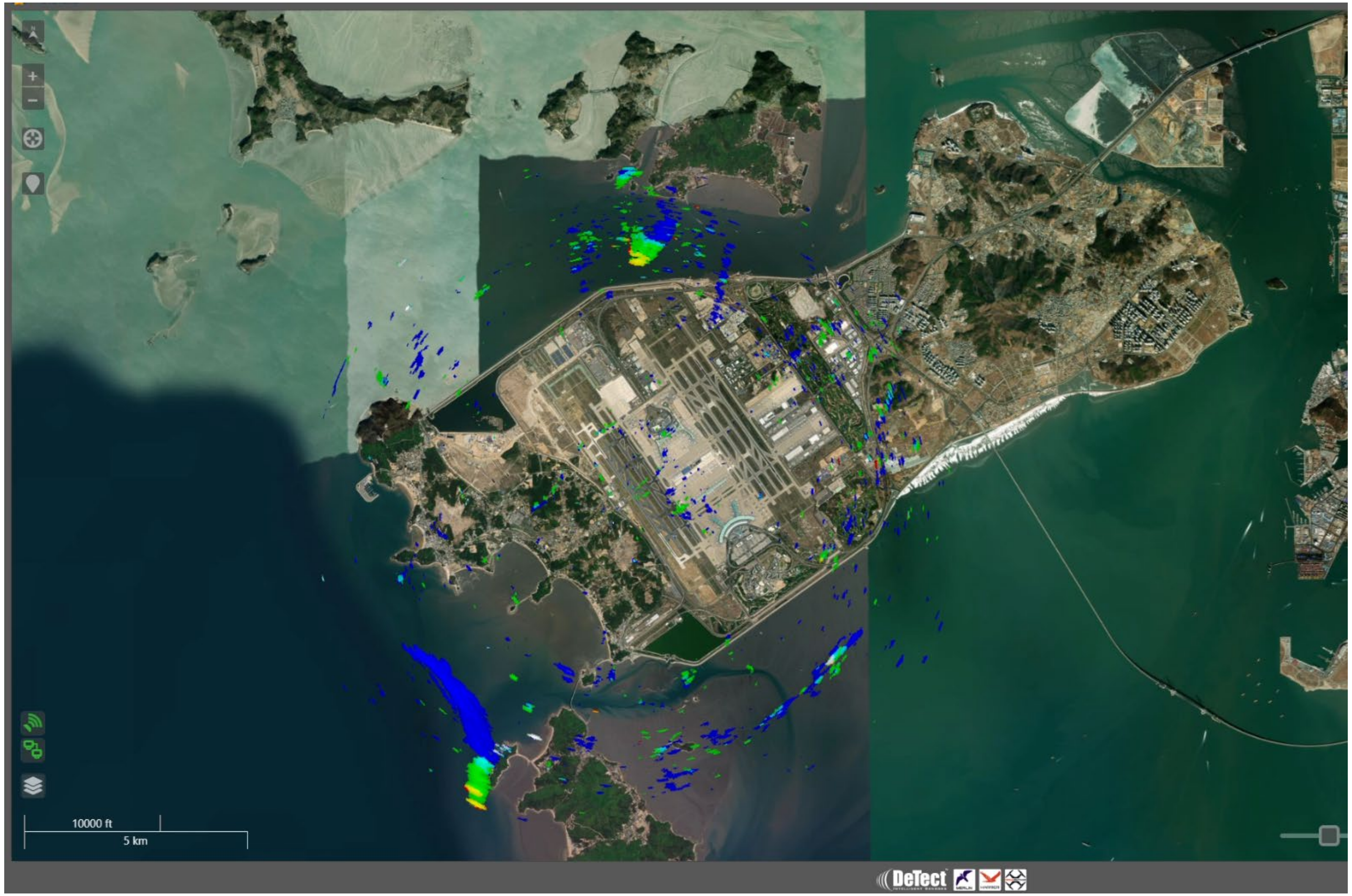
- These enhance the signal-to-noise ratio of desired targets and suppress unwanted signals, especially large and distant ones



Long-Range Detection Model

Radar Echo Trails:

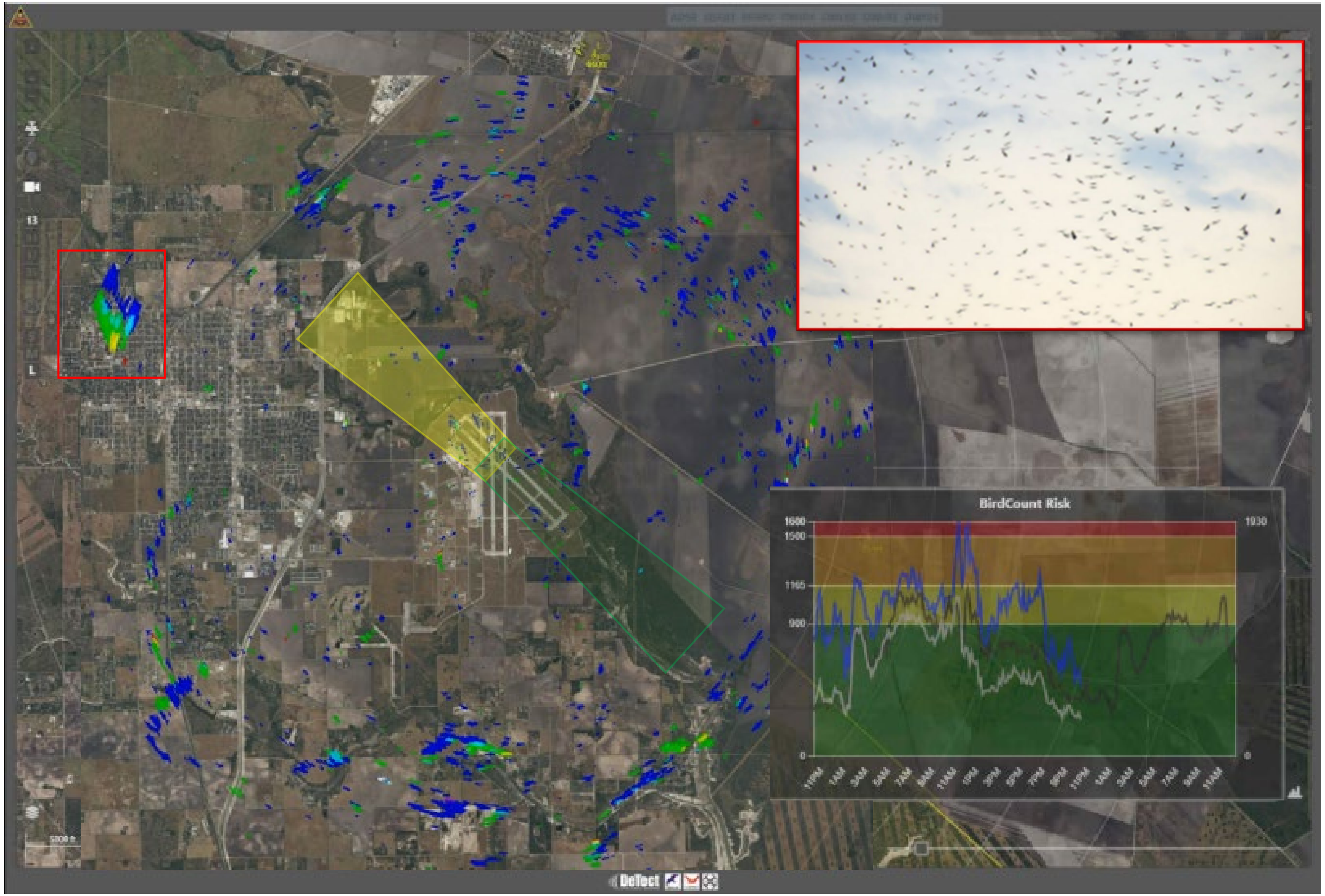
- ➢ The drawback to utilizing signal processing filters to enhance short- and medium-range detection for individual targets is that large distant targets are suppressed
- ➢ These large and distant targets are the exact types of targets desired when focusing on long-range flock detection
- ➢ Utilizing the more traditional radar technique of painting radar echo trails enables long-range detection optimized for flocks



Long-Range Detection Model

Radar Echo Trails:

- Presentation on display is analogous to a weather radar
- A flock's echo trail builds in relation to its size, speed, and direction of movement
- Hazardous flocks can then be auto-alerted or cross-cued to other sensors



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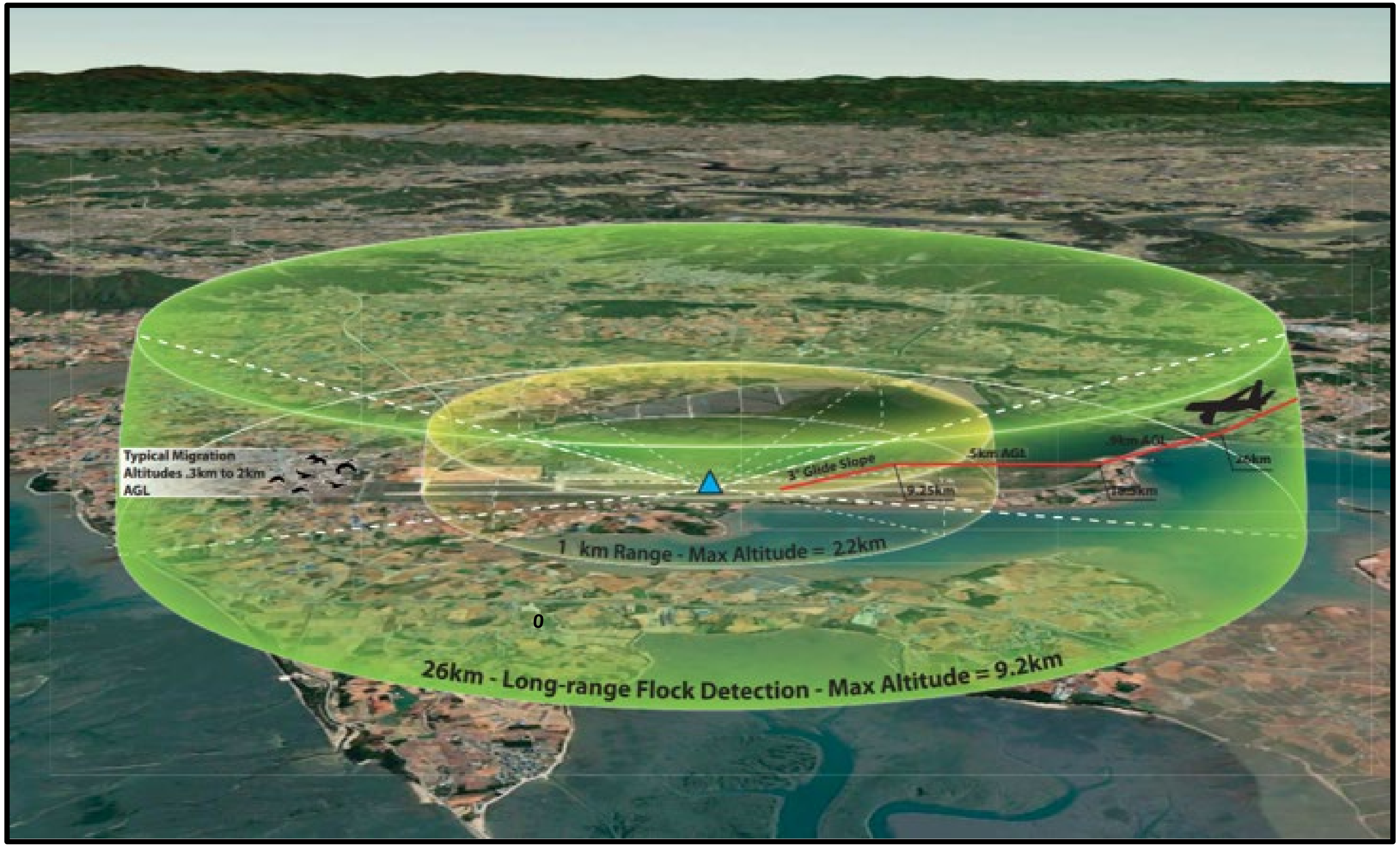
Operational Avoidance

- Enhanced detection is only as effective as the Engineering and Administrative controls that are applied to it

- Transitioning from an airport-centric ground-based wildlife management paradigm to an airspace-centric air traffic management-based paradigm is a seismic shift that will require a whole-of-industry approach

- The implementation of Terminal Doppler Weather Radars (TDWRs) for windshear avoidance can serve as our guide



Operational Avoidance

- **A dual-focus for detection drives a dual Concept of Operations (CONOPS) for Avoidance:**

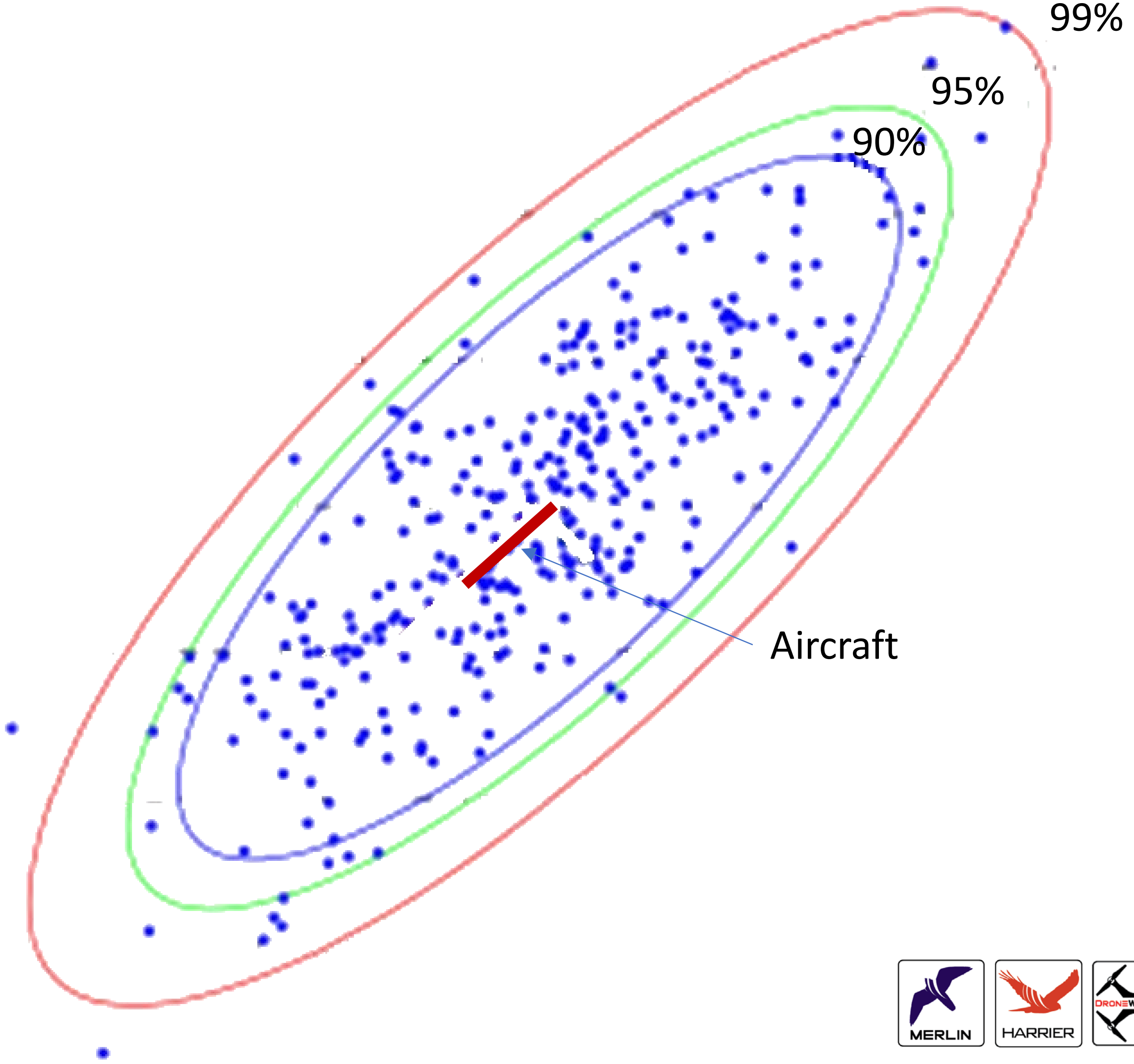
- **Short-range Airport CONOPS**
- Managed by Airport Air Traffic Control Tower (ATCT)
- Departure: Probability of Intercept sequencing
- Arrival: Automated, software-driven, real-time arrival altering zones

- **Long-range Local/Terminal CONOPS**
- Managed by Terminal Radar Approach Control (TRACON)
- Utilize “The Weather Model”

Image: usahas.com

Operational Avoidance – Short Range

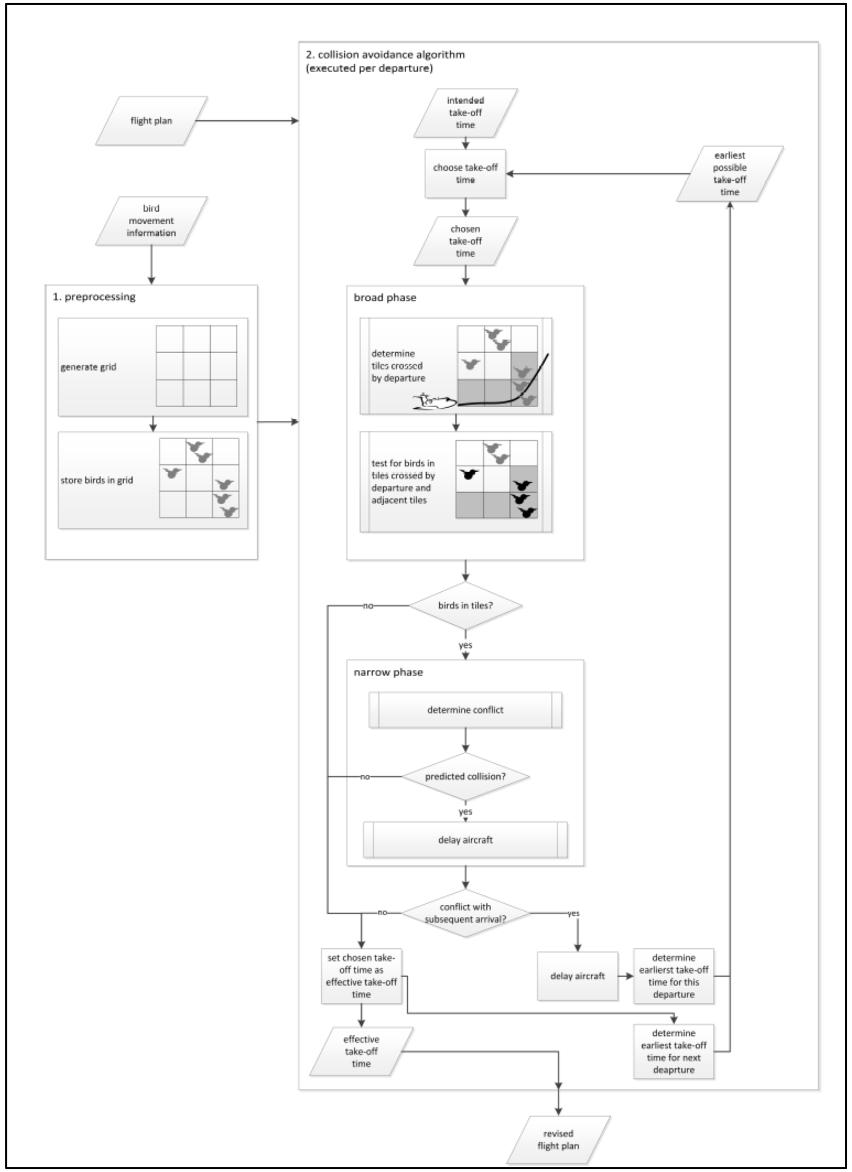
- **Short-range Airport CONOPS**
- **Departure:**
- Automated, software-driven, dynamic real-time altering and sequencing
- Departure clearance and sequencing utilizing probability of intercept algorithms and bird strike risk severity matrices



Operational Avoidance – Departure Probability of Intercept

- Departure probability of intercept and collision avoidance model developed by Dr. Isabel Metz and Delft University of Technology Aerospace engineering team

- Collision avoidance algorithm tested in fast-time Monte Carlo simulations involving various air traffic and bird densities



Metz, I.C.; Ellerbroek, J.; Mühlhausen, T.; Kügler, D.; Kern, S.; Hoekstra, J.M. The Efficacy of Operational Bird Strike Prevention. Aerospace 2021, 8, 17. https://doi.org/10.3390/aerospace8010017.

Operational Avoidance – Departure Probability of Intercept

Table 3. Overview of delays resulting from the intervention of the collision avoidance algorithm per individual scenario, averaged per air traffic intensity as well as averages weighted by number of flights over all scenarios.

Traffic Intensity	Bird Movement Intensity	Delayed Flights [%]	Delays per Prevented Strike [-]	Average Delay per Affected Aircraft [s]	Maximum Observed Delay [s]
high	*high*	15	14	192	2135
high	*medium*	3	7	70	704
high	*low*	<1	6	59	350
high	***average***	6	9	107	2135
medium	*high*	3	2	35	486
medium	*medium*	<1	2	29	320
medium	*low*	<1	2	23	295
medium	***average***	1	2	29	486
	weighted average	4	8	158	2135

Metz, I.C.; Ellerbroek, J.; Mühlhausen, T.; Kügler, D.; Kern, S.; Hoekstra, J.M. The Efficacy of Operational Bird Strike Prevention. Aerospace 2021, 8, 17. https://doi.org/10.3390/aerospace8010017.

Bird Strike Risk Severity Matrix

Likelihood of Collision

Almost Certain	**<10m**	Moderate	High	Extreme	Extreme	Extreme
Likely	**<50m**	Moderate	Moderate	High	Extreme	Extreme
Possible	**<100m**	Low	Moderate	Moderate	High	Extreme
Unlikely	**<200m**	Low	Low	Moderate	High	High
Rare	**<400m**	Low	Low	Low	Moderate	Moderate
	Kinetic Energy	**>13000J**	**>73333J**	**>133666J**	**>194000J**	**>390000J**
	Runway (155knots)	**0.401kg**	**2.352kg**	**4.287kg**	**6.223kg**	**12.509kg**
	Approach (155knots)	**0.401kg**	**2.352kg**	**4.287kg**	**6.223kg**	**12.509kg**
	Departure(200knots)	**0.241kg**	**1.413kg**	**2.575kg**	**3.737kg**	**7.513kg**
	Traffic Pattern (170knots)	**0.333kg**	**1.955kg**	**3.564kg**	**5.173kg**	**10.399kg**
	Example Bird	Sandwich Tern	Vulture	Golden Eagle	Whooping Crane	Trumpeter Swan

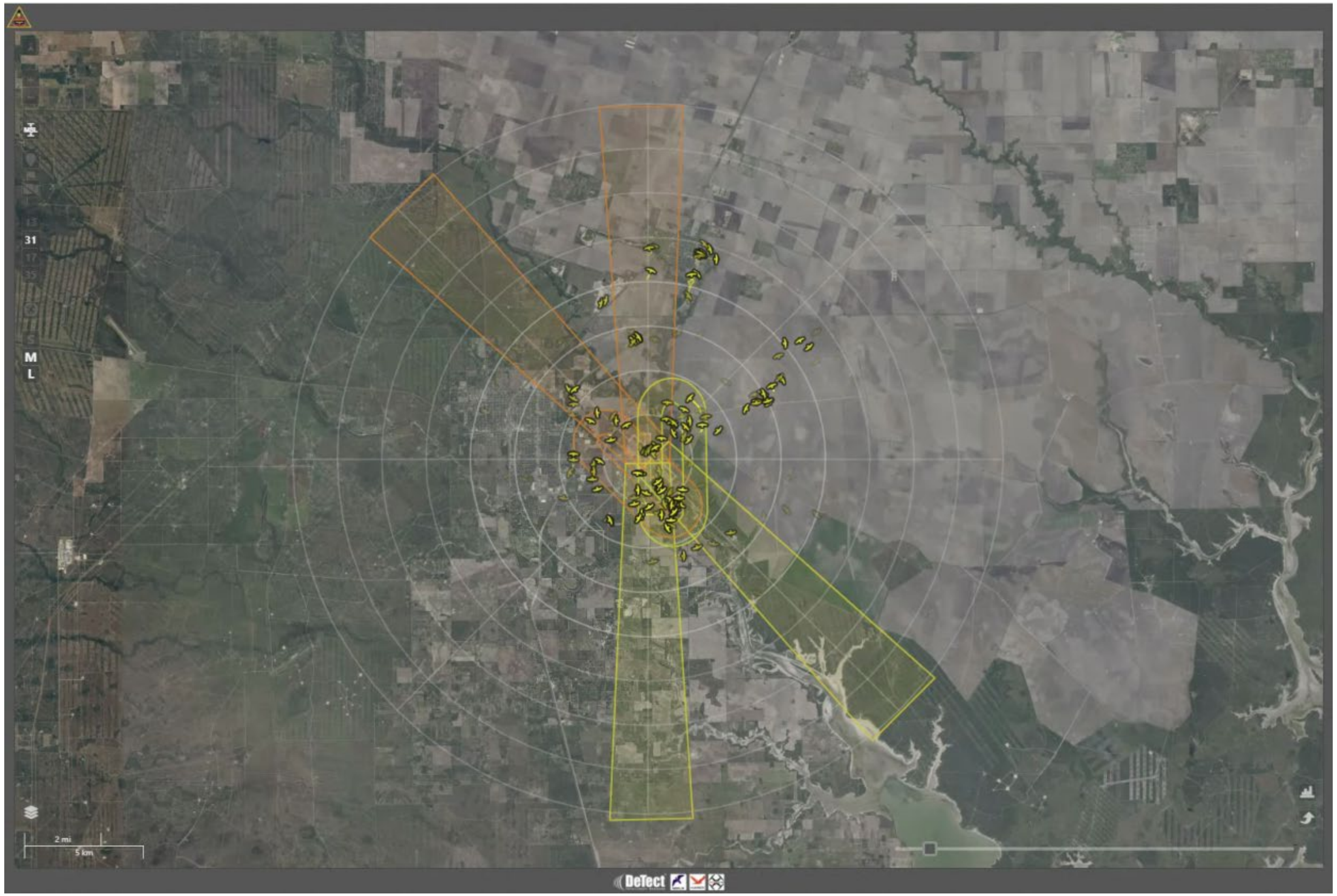
Consequence (Kinetic Energy)





Operational Avoidance – Short Range

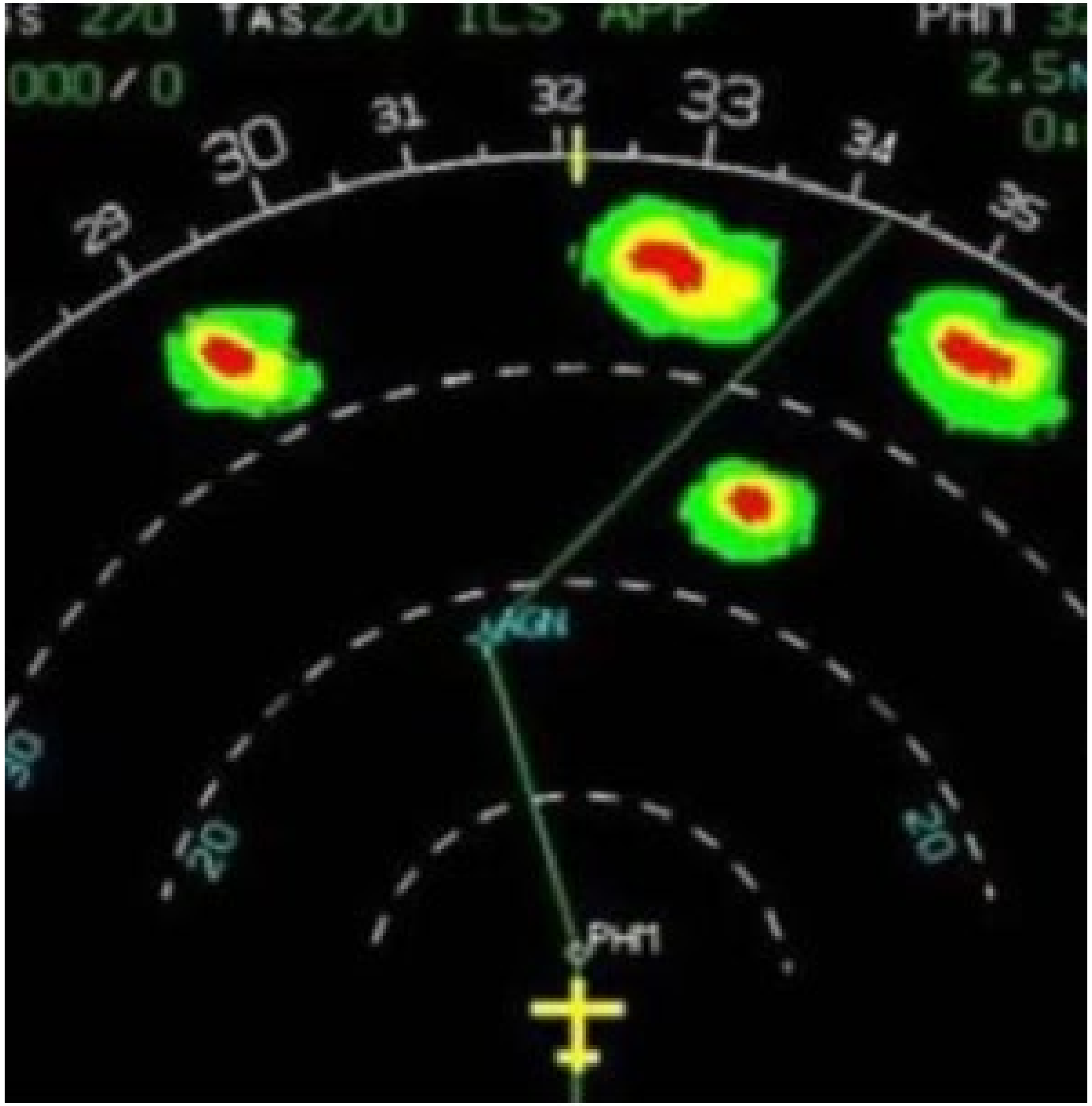
- **Short-range Airport CONOPS**
- **Arrival:**
- Automated, software-driven, real-time arrival altering zones for ATCT issuance of safety advisories in accordance with standard FAA JO 7110.65, Section 2-1-6 procedures



Operational Avoidance – Long Range

- **Long-range Local/Terminal CONOPS**
  - Managed by Terminal Radar Approach Control (TRACON)

- **“The Weather Model”**
  - For Departure and Arrival
  - TRACON provides flock position information to departing and arriving aircraft as they would for cumulonimbus / convective cells (aka Thunderstorms) in accordance with standard FAA JO 7110.65 2-6-4, and vectors aircraft around flocks when requested



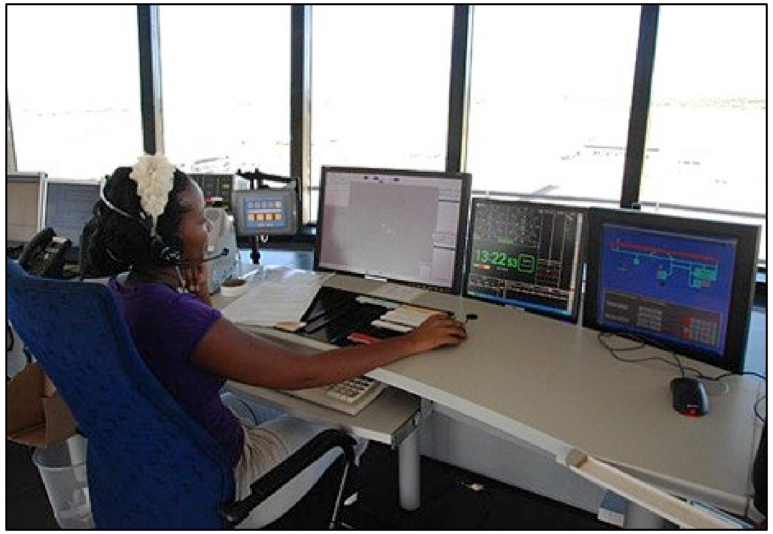
Agenda

Image: Ivan Palacios

- Airport Wildlife Hazard Management
  - Current Model
  - Mitigation Gaps
  - Case Studies
- **Paradigm Shift**
  - Enhanced Detection
  - Operational Avoidance
  - **Case Studies**

Case Study: Short-Range Detection and Avoidance

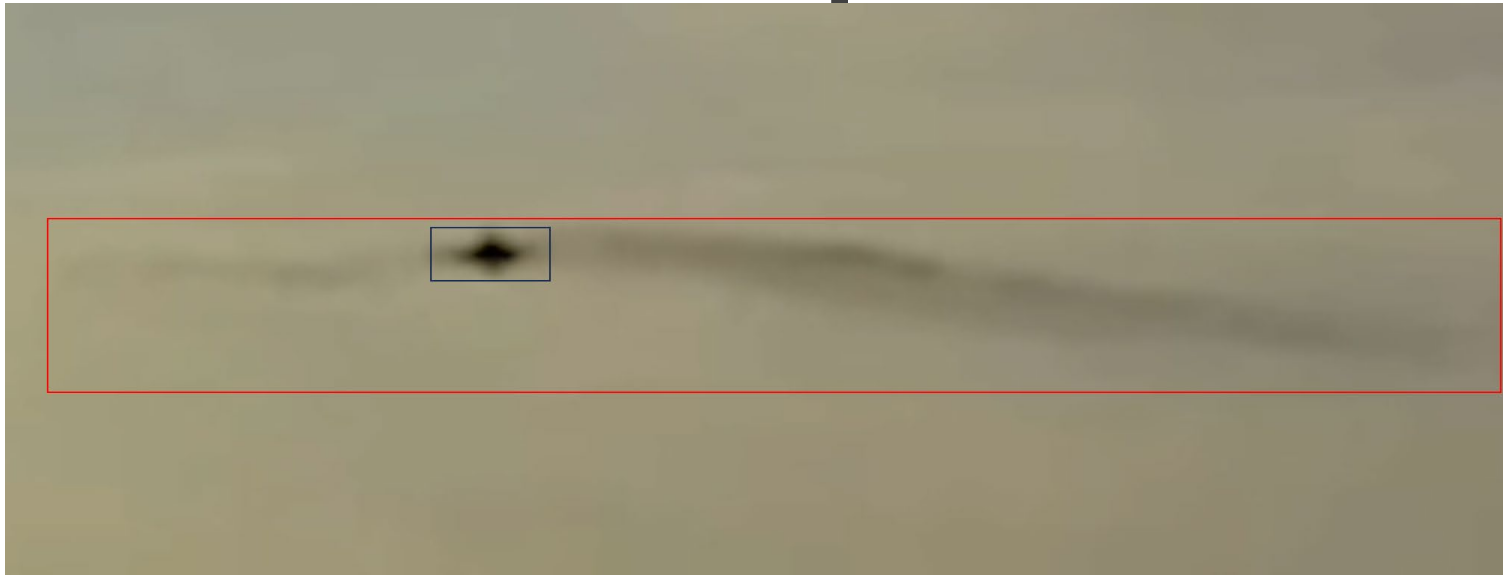
King Shaka Airport, South Africa (KSIA)



- Wildlife hazard: Swallows (Hirundo rustica) that egress a roost-site on the Runway 06 approach; resistant to habitat management/ dispersal/depredation
- The tower uses an automated, real-time output integrated into the airport COP Display: 'Go' (GREEN), 'No Go' (RED) audible & visual alerting display. Tower issues real-time alerts to pilots
- **Simple CONOPS:** 'Go' (OK to land/depart or 'No-Go (runway hold or holding pattern)

Case Study: Long-Range Detection and Avoidance

Muan International Airport (MWX/RKJB)



- Jeju Air Flight 2216, Boeing 737-800 wingspan: 35.8 meters
- Flock extends ~437m (1433 ft) in width. For a radar located at approximately midfield on the airport, the flock would extend over 4.52° in azimuth, or multiple radar antenna beamwidths
- Baikal teal length: ~40cm (16”)
- 1/5th of the red bounding rectangle is occupied by the flock -- estimate flock size at 6,555 individual teal
- Baikal teal average body mass: 507grams RCS X- band as 0.005 to 0.024 m^2 and in the S-band to be 0.006 to 0.031 m^2
- With a 1° x 20m range bin at 3nm it forms an area of ~100 x 20m or 2000m^2, which could contain ~1,333 Baikal teal, for a total RCS in the range bin of 6.665 to 31.992 m^2 in X-band or 7.998 to 41.323m^2 in S-band
- RCS in the range of 6.665 to 31.992 m^2 for a 1° beam width, the flock of Baikal teal in this case should be readily detectable on any radar capable of extracting a plot that covers 4.52° in azimuth or ~437m (1433 ft) in width
- Many tracking radars might ignore such a large plot from such an extended target. The radar display or collision warning algorithm would need to represent the flock as creating a danger over a 219m radius from the center point of the flock

Questions?


Image: Ivan Palacios

- Airport Wildlife Hazard Management
  - Current Model
  - Mitigation Gaps
  - Case Studies
- Paradigm Shift
  - Enhanced Detection
  - Operational Avoidance
  - Case Studies

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