

## **Bird strikes with turbofan engines: is there a light-induced bias to left or right position?**

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Previous studies have indicated that navigation towers with red lights have more bird collisions than when lights are of shorter wave lengths, which is likely related to vision in birds being generally less sensitive than in humans to the red end of spectrum ( $>680$  nm). Thus, we hypothesized that aircraft navigation lights (red on left wing tip, green on right wing tip) would result in a bias in bird strikes to the left side of aircraft. To test this hypothesis, we examined the distribution of reported strikes to engine #1 (left side) or to engine #2 (right side) for transport aircraft with 2 underwing or fuselage-mounted turbofan-powered engines in the FAA National Wildlife Strike Database, 1990-2013. We conducted chi-square tests to determine the probability that the distribution of strikes between the left and right engine positions was not random, assuming a null hypothesis of 50% of the strikes to each engine position. We examined these distributions for strikes reported during dusk/dawn, day only, night only, and all times (including records in which time of day was not indicated).

For both underwing and fuselage-mounted engines, there was a highly significant ( $P \leq 0.0003$ ) bias toward strikes to engine #1 (left) compared to engine #2 (right): 3,094 vs 2,768 for underwing-mounted engines and 431 vs. 330 for fuselage-mounted engines. Night was the only time-of-day category that was not statistically significant ( $P = 0.0691$ ). B-737 and DC-9/MD-80 aircraft series had the largest bias for strikes to the #1 engine.

This analysis provides evidence that there is a slight, but statistically significant bias toward birds striking the left side of aircraft where a red navigation light is located compared to the right side where a green light is located. It was surprising that the bias was least prevalent at night when aircraft lighting would be expected to have the biggest influence. Since most strikes occur during landing and take-off, this difference for night strikes compared to day strikes may be explained by the brightness of landing lights overwhelming the navigation lights under these conditions. Our results may be useful in guiding the development of aircraft lighting systems and paint schemes to enhance visibility of aircraft to birds and reduce bird strikes. These findings may also lead to improved lighting schemes to reduce bird mortality with windows and communication towers.



# **Bird Strike Risk Reduction Project “Bird Avoidance by Design”**

**Lumen International – Joe Barnes**



# Lumen Corporate Information

- Florida Corporation specializing in consulting, project management, and specialized training. (1998 - Present)
- 12 years experience in aircraft lighting design and flight testing as F-16 NVG operational test pilot, and Director of the Air Combat Command Night Vision Center.
- Sole source to US State Dept. Air Wing to flight test and train pilots for hazardous night missions.
- Sole source to design, test, and train USDA contract pilots to perform aerosol employment missions using NVGs.
- Sole source to US Southern Command for Senior Special Projects Engineer.
- 5 years experience as B-737 Captain with Air Florida.





U.S. Department  
Of Transportation  
Federal Aviation  
Administration

# Wildlife Strikes to Civil Aircraft in the United States 1990–2013



U.S. Department of  
Agriculture  
Animal and Plant  
Health Inspection  
Service  
Wildlife Services

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FEDERAL AVIATION ADMINISTRATION  
NATIONAL WILDLIFE STRIKE DATABASE  
SERIAL REPORT NUMBER 20

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REPORT OF THE ASSOCIATE ADMINISTRATOR OF AIRPORTS  
OFFICE OF AIRPORT SAFETY AND STANDARDS  
AIRPORT SAFETY & CERTIFICATION  
WASHINGTON, DC

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JULY 2014

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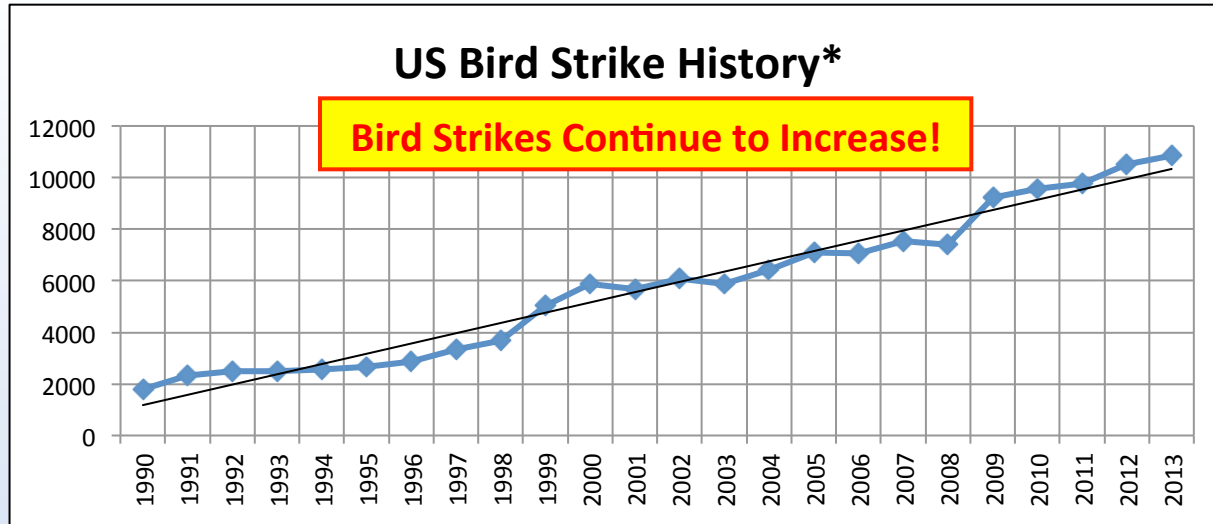
Sandra E. Wright, Wildlife Strike Database Manager, Airport Wildlife Hazards Program, U.S. Department of Agriculture, APHIS, Wildlife Services, 6100 Columbus Ave., Sandusky, OH 44870

John R. Weller, National Wildlife Biologist, Office of Airport Safety and Standards, Federal Aviation Administration, 800 Independence Ave., SE, Washington, DC 20591

Michael J. Begier, National Coordinator, Airport Wildlife Hazards Program, U.S. Department of Agriculture, APHIS, Wildlife Services, 1400 Independence Ave., SW, Washington, DC 20250



# The Problem

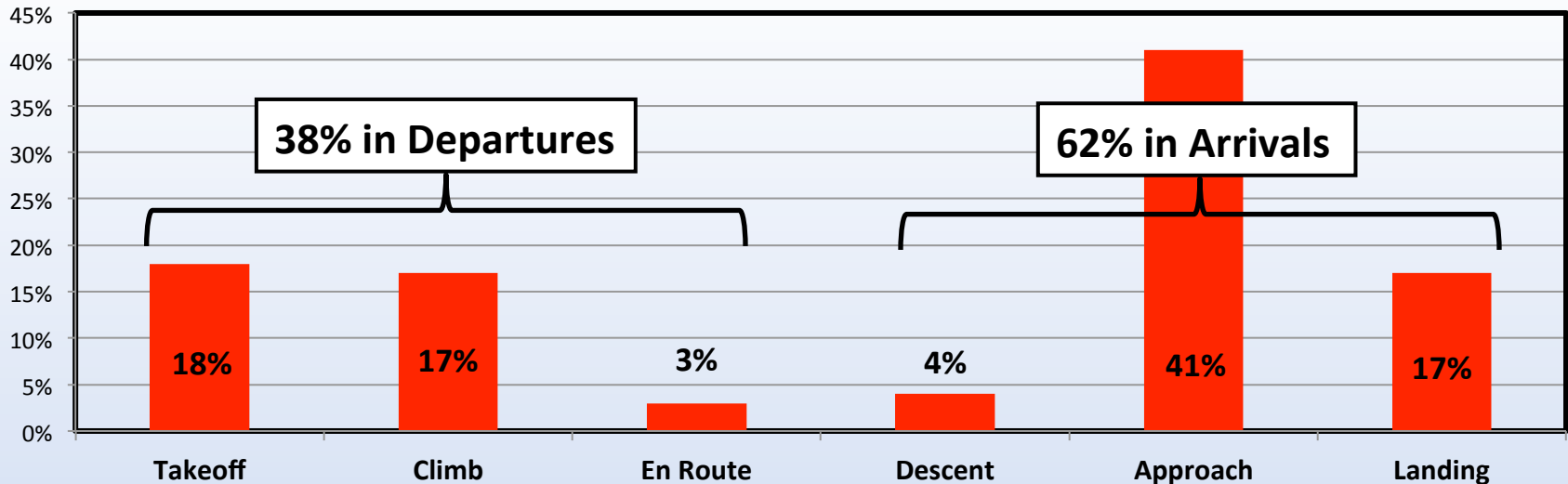


- **86% Commercial Aircraft; 14% General Aviation.**
- **62% daytime; 38% night, dusk, or dawn.**
- **92% of current Commercial Aircraft have two engines, thereby increasing engine ingestion risks.**
- **A 2015 cost estimate is **\$1 Mil+** per major event.**



# The Problem

Phase of Flight Bird Strike Percentage\*



- 92% of all bird strike events happened **below 3,500 Ft AGL**.
- 71% were **surface to 500 Ft AGL**.
- Typically, commercial jet **leading edge devices are extended**.
- Bird strikes on departure have a greater aircraft damage due to speed and **high engine power setting**.





# FAA Mitigation Activities

- The 2014 FAA/USDA “Bird Strike Report” cites the following FAA research efforts.
- Since 71% of all events occur from the surface to 500 Ft AGL, initial mitigation is an airport issue:
  - Strategies to reduce bird attraction to **airports**.
  - Technologies for harassing and deterring birds from **airports**.
  - Ground-based bird detection radar systems at **airports**.
  - **Aircraft** lighting systems to enhance a bird’s detection and avoidance of an aircraft.
    - Phase 1: How do birds see? (2014-15)
    - Phase 2: Which species are most dangerous? (2015-16)
    - Phase 3: What technologies are most effective? (2016-17)



# Follow-Up Question to NWRC

5 October 2014

**Bird strikes with underwing mounted engines: is there a bias related to left or right position?**

**Richard A. Dolbeer**, *Science Adviser, Airport Wildlife Hazards Program, United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, 1228 Laguna Drive, Huron, OH 44839, USA; phone: (419) 433-3105, email: dolbeer@bex.net*



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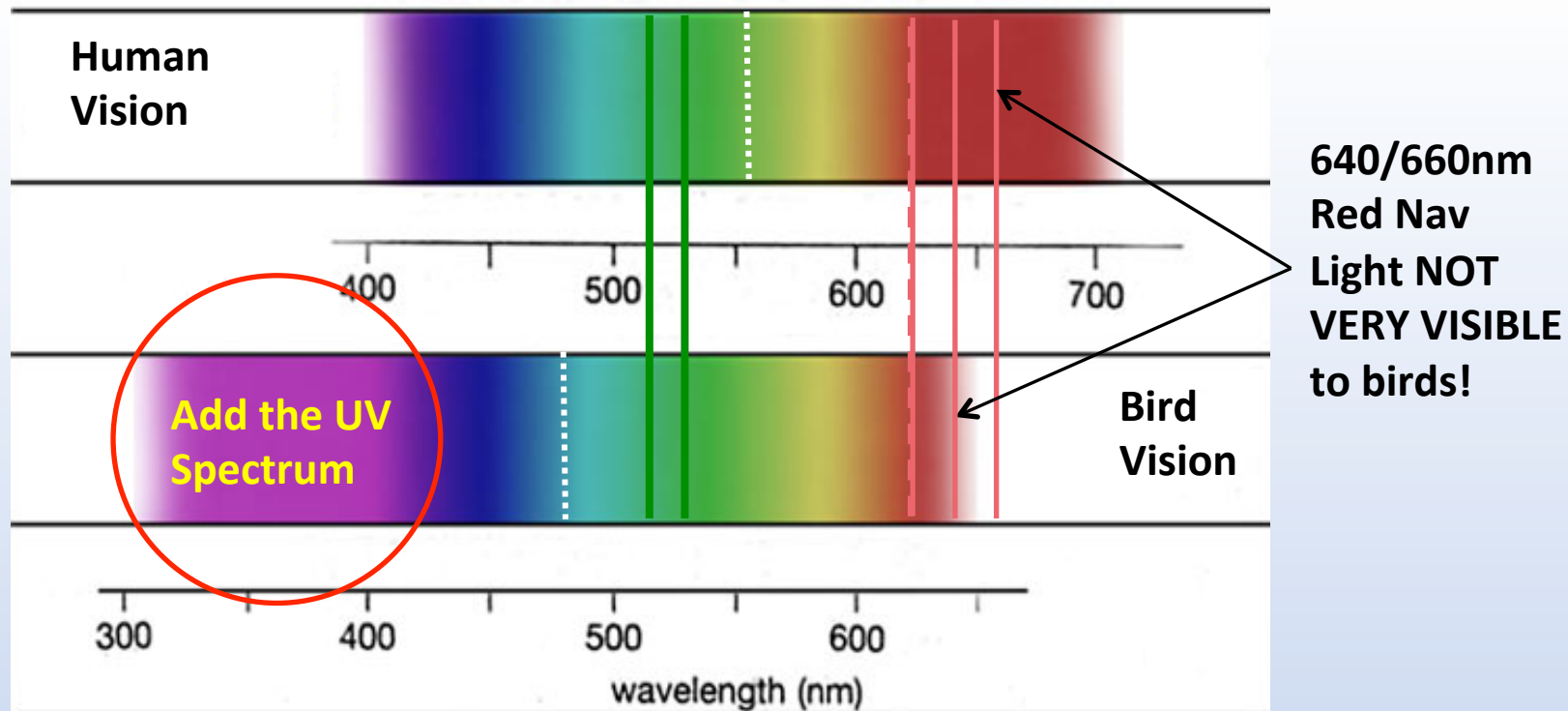
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- Overall, for all times of day, there was a statistically significant difference with **MORE bird strikes on the left side** of aircraft.
- There was a 5.6% overall difference with less than a 1/10,000 chance of that count being random. ( $P < 0.0001$ )
- Three “times of day” categories:
  - Day                                      53.2%/46.8%                      6.4% Difference
  - Dusk/Dawn                                55.9%/44.1%                      11.8% Difference
  - Night                                        51.5%/48.5%                      3.0% Difference
- Some factor is causing FEWER bird strikes on the right!



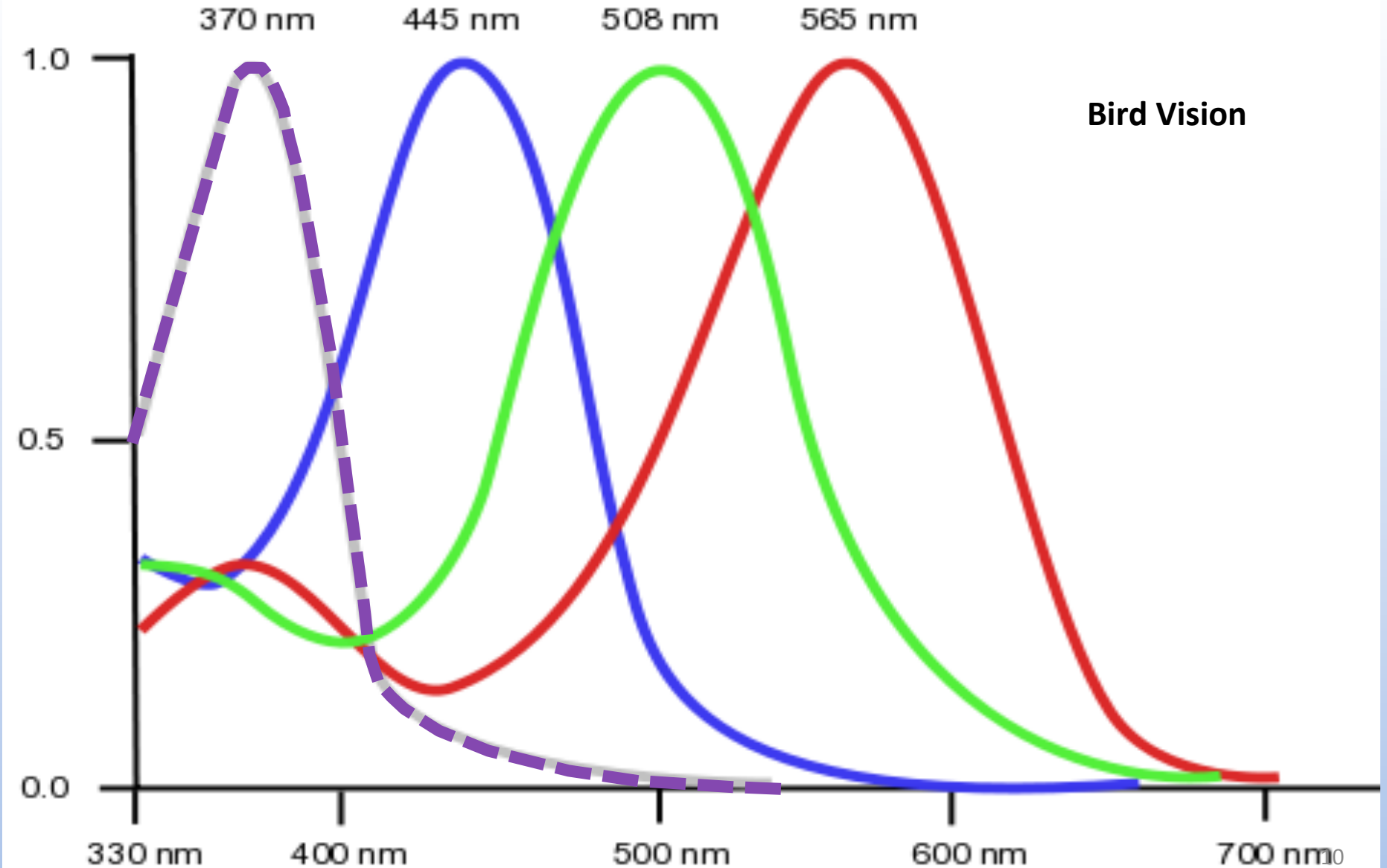
# Human vs Bird Visual Spectrum



- Logical Hypothesis: Since there are **FEWER BIRD STRIKES ON THE RIGHT SIDE** at dusk/dawn, the difference must be in external lighting.
- Birds avoid the green light because they can see it, resulting in fewer bird strikes on the right.
- Initial Plan of Action: Make the red navigation light just as visible to birds as the green navigation light and you will reduce the strikes on the left.
- Follow-on Plan of Action: Equip the entire aircraft with modifications that birds **CAN SEE** to significantly reduce bird strike events!



# Bird Visual Spectrum

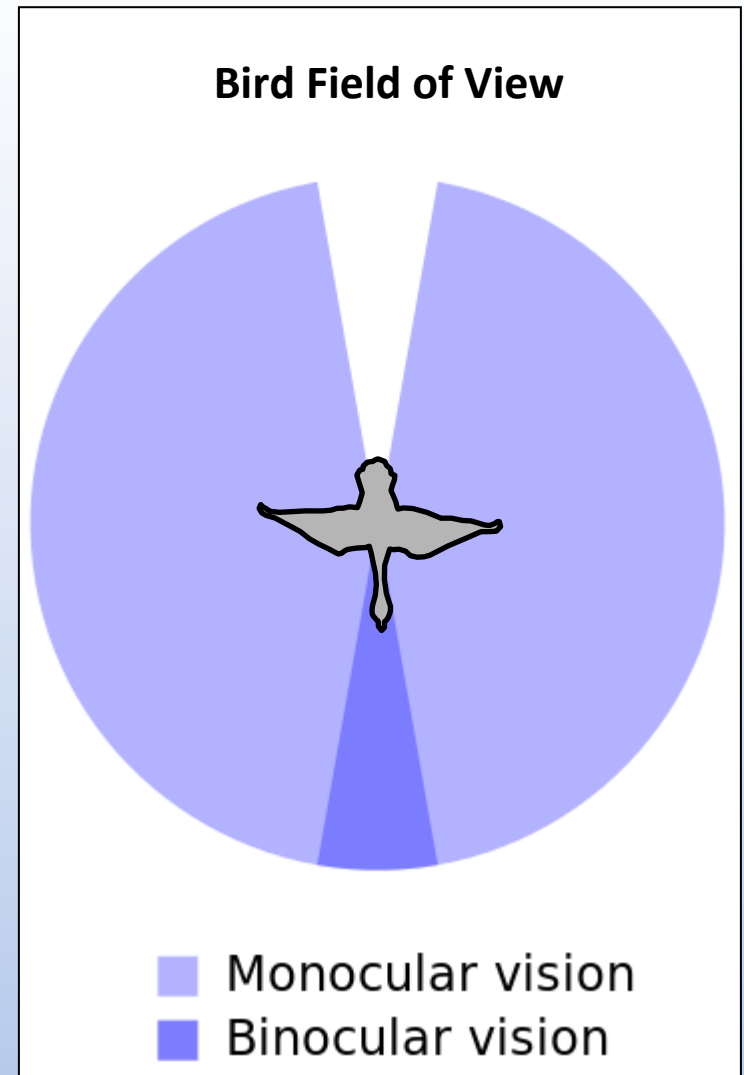


Bird Vision



# Bird Vision - Coverage

- A bird's visual coverage also varies with species, but most have almost 360 degree coverage.
- Birds have double-cone assemblies that aid in monocular vision for flight between close objects.
  - These double cones are very **sensitive to flicker** at certain frequencies.



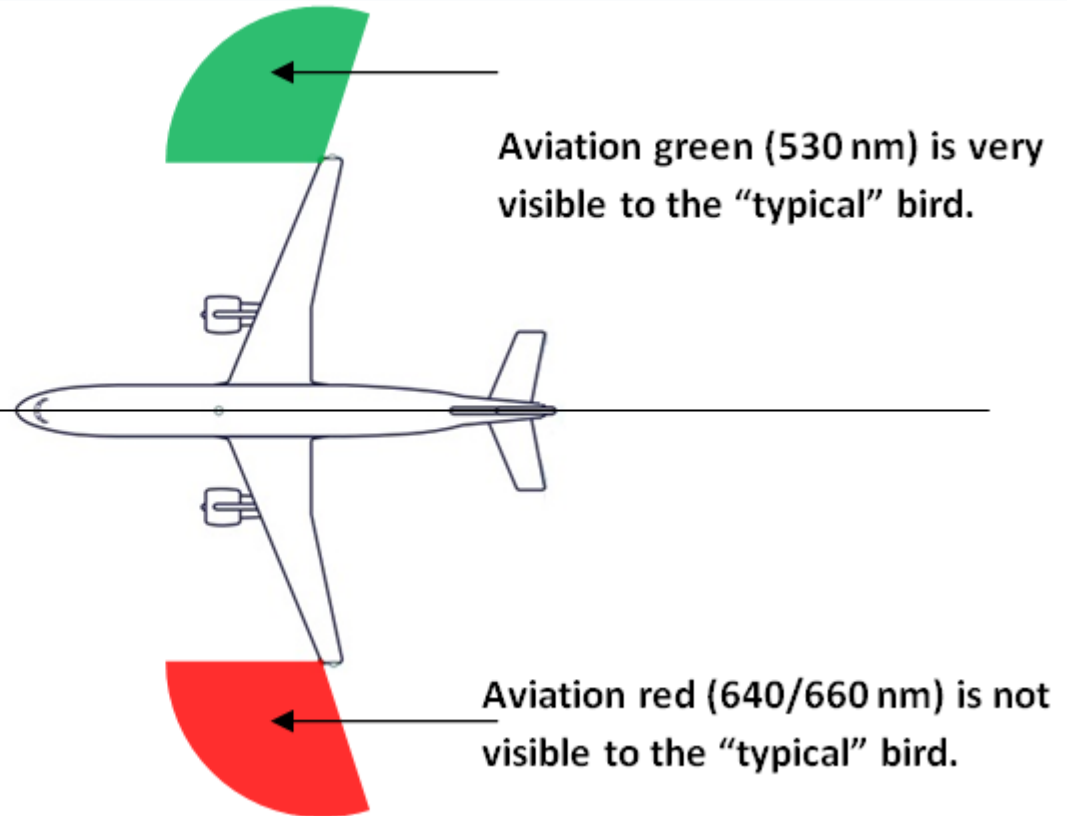


# Short-Term Goal

11.8 % FEWER bird strikes  
on the right side of the  
aircraft at dusk/dawn!

46.8% Overall    44.1% Dusk/Dawn

53.2% Overall    55.9% Dusk/Dawn



- Enhance the “detectability” of the red light by employing UV light and proprietary flicker patterns.



# Supporting Research

- ***Exploiting Avian Vision with Aircraft Lighting to Reduce Bird Strikes*, Blackwell et al, 2012**
  - “Based on spectral sensitivity in Canada geese, **aircraft-mounted lights that peak in the ultraviolet/violet range (380-400 nm) are likely to produce the maximum behavioral effect.**”
- ***Lasers as Non-Lethal Avian Repellants*, Blackwell et al, 2002**
  - “Notably, 6 groups of geese (4 birds/group) exhibited **marked avoidance of the beam...**”



# Supporting Research

- ***Cowbird Responses to Aircraft with Lights Tuned to Their Eyes: Implications for Bird-Aircraft Collisions, Doppler, Blackwell, DeVault, Esteban Fernandez-Jurcic, 2012 & 2015***
  - “... commercial aircraft themselves do not have any specific means of minimizing chances of bird strikes.”
  - The overall implication is that lights visually conspicuous to humans may not necessarily be so to birds.”
  - “... explore specific parts of the spectrum that are hidden to the human eye (e.g., ultra-violet)...”
  - “We suggest that some types of **lighting** may enhance the birds’ detection of high speed aircraft and, thus, **holds some potential as a means of reducing the frequency of bird strikes.**”



# UV Aircraft Lighting is Low Risk

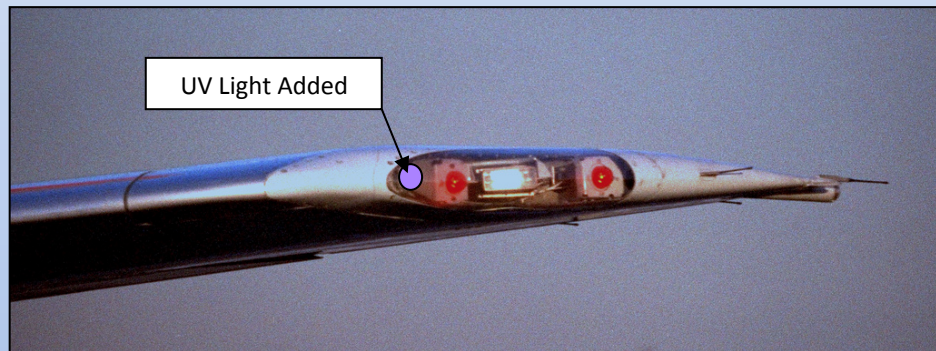
- Addition of UV lighting components could make the aircraft 25% more visible to birds in some conditions.
- Low technical risk to add UV LEDs and laser diodes.
- Proprietary “flicker” techniques will greatly enhance detection of aircraft by most birds.





# UV Lighting on Commercial Aircraft

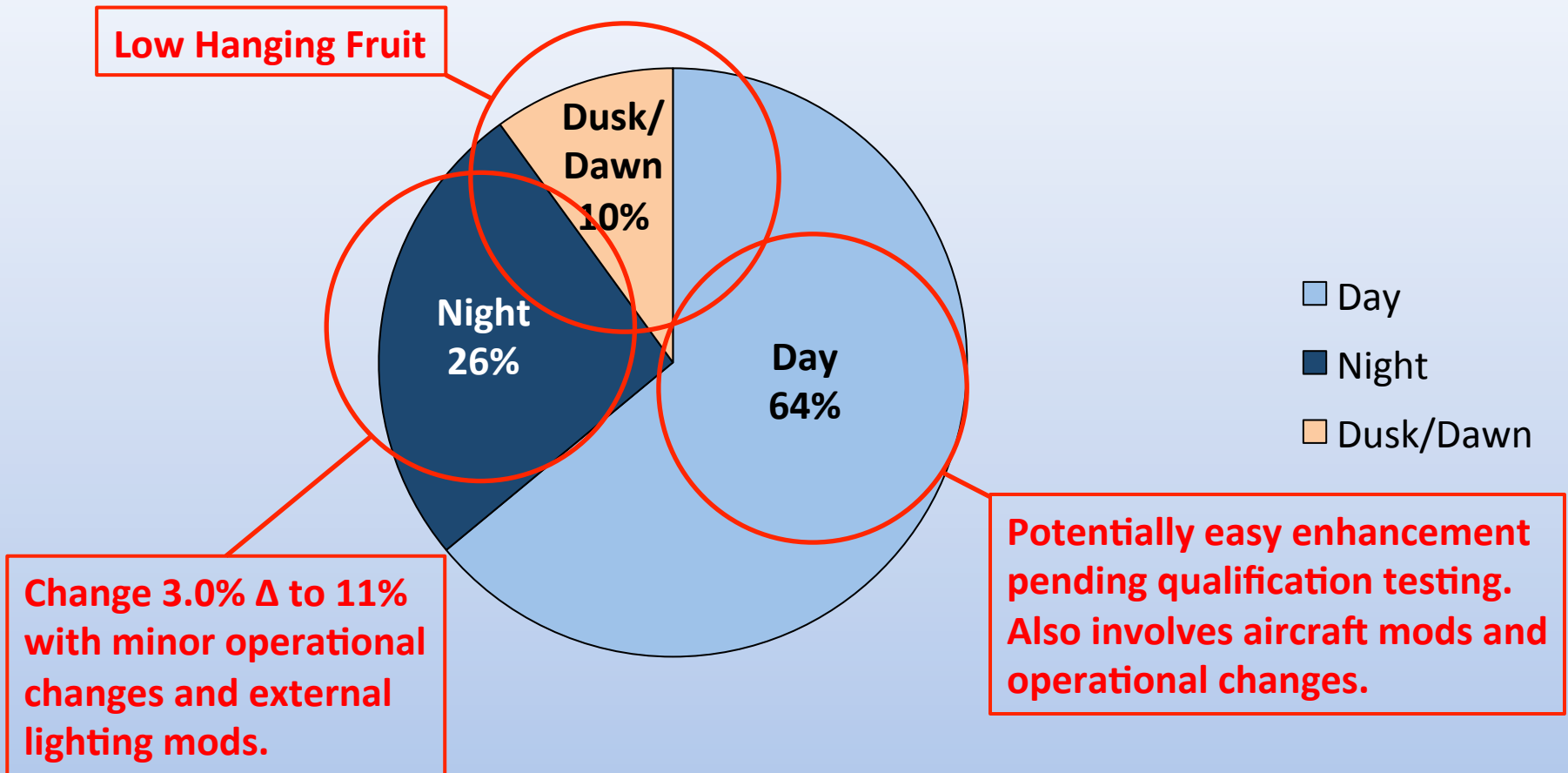
- The addition of UV lighting on commercial aircraft is low risk and low cost.
- Form – Fit – Function lighting hardware can be easily manufactured and installed.
- The prevention of just one major bird strike event could cover the costs of several aircraft modifications.





# Best Courses of Action

## Bird Strikes in “Time of Day”

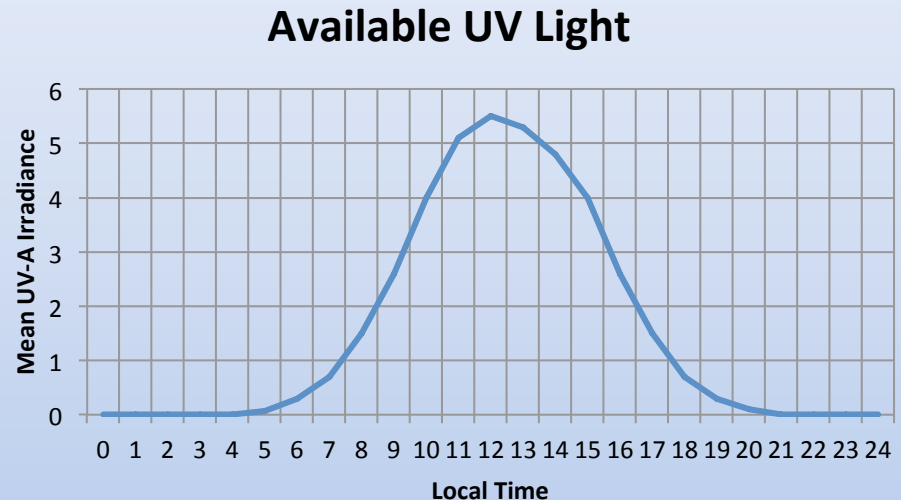


\* Data in this chart includes bird strike data from 2014 and early 2015



# Exploit Solar UV

- Enhance the ability of a bird to “see” an aircraft in clear sunlit conditions.
- Solution:
  - Employ modified paint to use the sun to enhance UV visibility for birds.





# Supporting Research

- ***Bird Strikes and Aircraft Fuselage Color: A Correlational Study***, Fernandez-Juricic et al, 2011
  - *“Recent research suggests that aircraft visibility could be enhanced to increase detection and avoidance by birds.”*
  - *“...we found that **brighter aircraft** were associated with **lower bird strike rates.**”*
- ***Testing the Hypothesis: Canada Geese See Their World Laterally and Obliquely***, Fernandez-Juricic et al, 2011
  - *“Overall, the visual system of geese combines features related to the **detection of predators...**”*



# UV Reflective Paint

- This technology is most effective in daylight when  $2/3$  of the bird strike events occur.
- It does not require direct sunlight.

As Seen By Birds



As Seen By Birds





# UV Absorbing Paint

- Techniques are available that will make birds tend to avoid or flee from aircraft they see.



Using ZnO paint derivatives, this “hawk face” is visible to birds, but not to people.



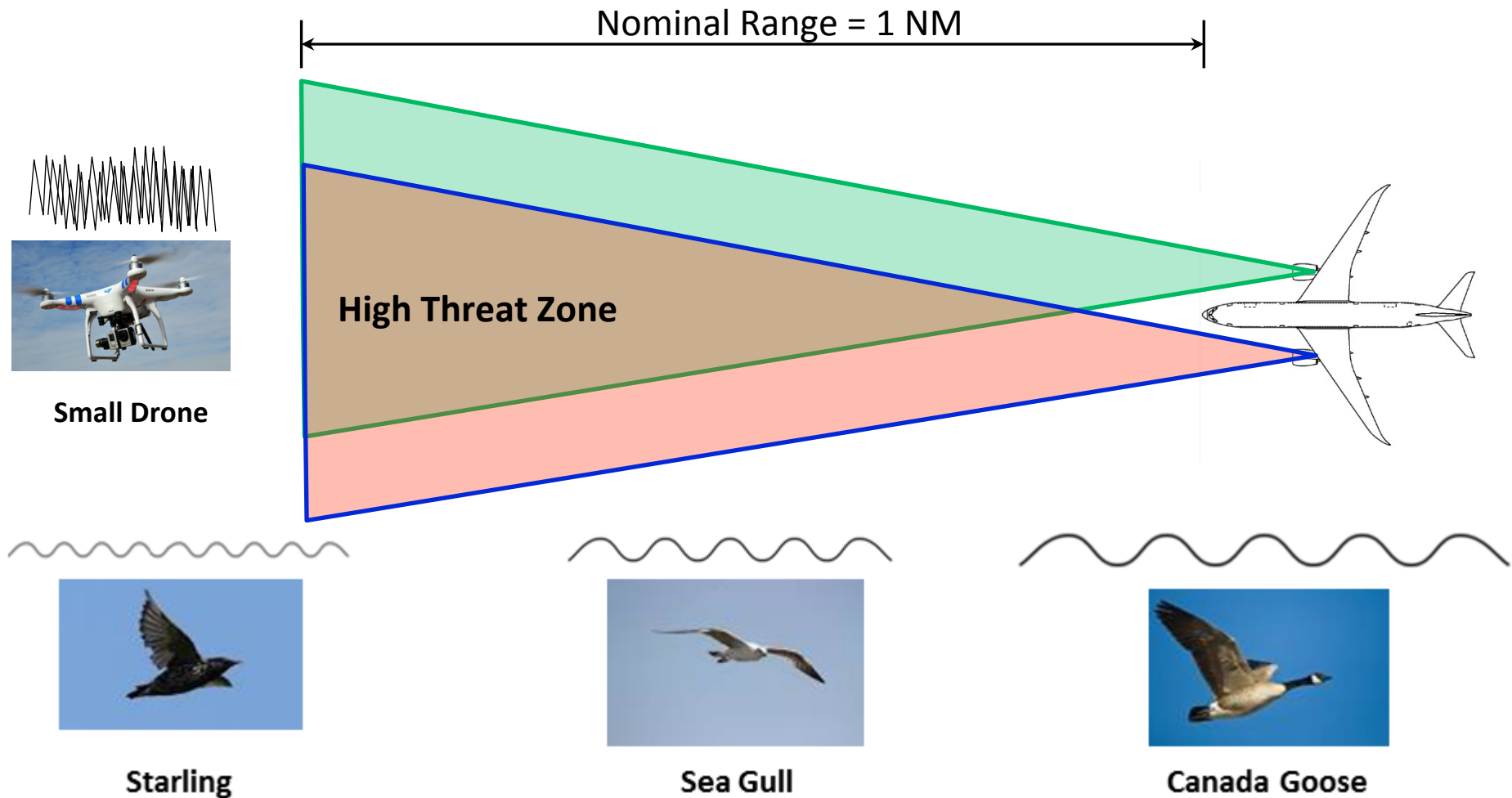
# Our Technical Approach

- **Goal 1: Increase the visibility of aircraft to BIRDS in dusk, dawn, and night time (1/3 of bird strike events).**
  - **Lighting Solutions: UV Coherent Light, LEDs, Flood Lights**
- **Goal 2: Increase the visibility of aircraft to BIRDS in daylight (2/3 of bird strike events).**
  - **Paint Solutions: UV Reflectivity, Absorption, Fluorescence**
- **Goal 3: Increase the detection of birds (& Drones) for PILOTS.**
  - **Very short range Doppler detection and warning of birds and drones.**
- **Goal 4: Reduce engine damage from bird strike events.**
  - **Patents in work and pending.**
- **Result: Modifying operational procedures and aircraft hardware will reduce bird strike events.**



# Bird Detection Doppler Radar

**Goal 3: Increase the detection of birds for PILOTS.**



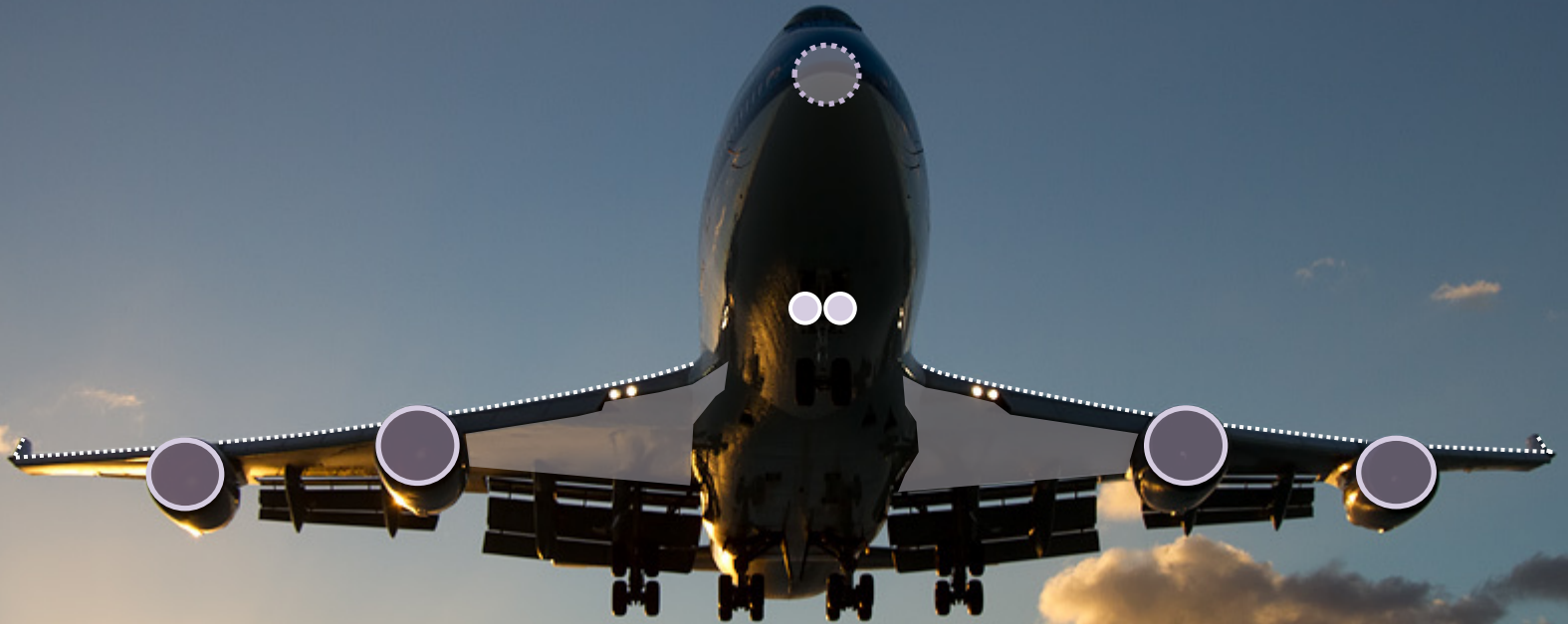


# 747 On Final As You See It





# 747 On Final As A Bird Sees It





# 747 On Final As the Public Sees It



- **The UV lighting “Kabuki Dance” is NOT VISIBLE to people on the ground or in the air.**



# Technology Summary

- “Bird Avoidance by Design” provides a huge marketing advantage over competitors who ignore the problem.
- Could be discriminator in choosing your company over others.
- Any company that actively attempts to reduce bird strike events will save \$ Millions as a result.





# The Train is Leaving the Station!



- Viable “bird strike reduction” technologies are being developed and patented now for commercial and military aircraft.
- We are still soliciting partners and investors.
- For additional information:
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  - Joe Barnes Cell: 561-779-5906



