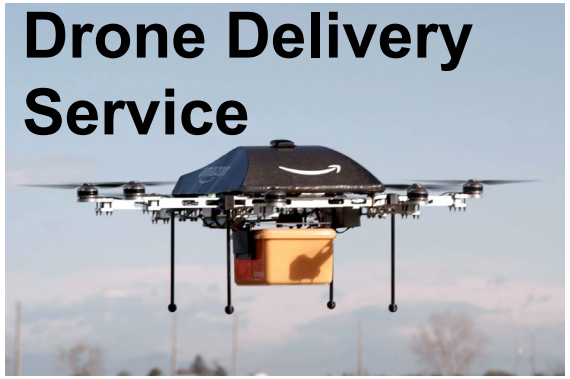
•Wildlife strikes involving civil rotorcraft: implications for Advanced Air Mobility operations



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Airport Wildlife Hazards Program

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Findings and recommendations expressed in this presentation do not necessarily represent the position of the U.S. Federal Aviation Administration

This presentation is based primarily on the following publication:

Dolbeer, R. A. 2025. Wildlife strikes involving civil rotorcraft: implications for Advanced Air Mobility Operations. FAA Airports Technical Center publication [in press].

"Miracle on the Hudson" and "Miracle in the Cornfield"

A study in similarities and contrasts

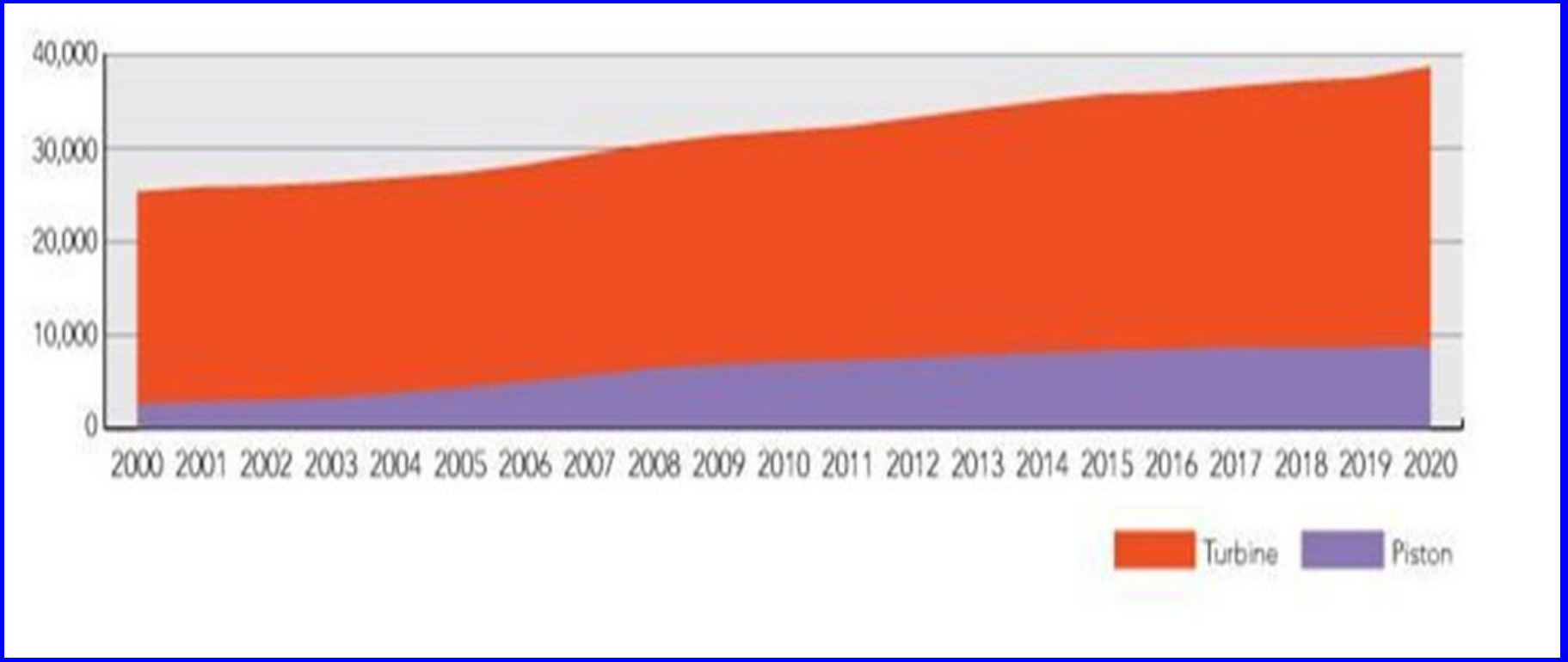
Characteristics of event	Miracle on Hudson	Miracle in Cornfield
1. Aircraft	A320 (2 engines)	A321 (2 engines)
2. Birds struck	Multiple Canada geese	Multiple herring gulls
3. Parts struck/damaged	Both engines	Both engines
4. Status of aircraft	Climb, 2900 ft AGL	Take-off run, 0 ft AGL
5. Status of birds	Migratory, 2900 ft	Local, on runway
6. Methods currently available to mitigate risk	None	Garbage control/ harassment/ lethal control

We are entering a new era of electric-powered aircraft (Advanced Air Mobility)

Large numbers of quiet aircraft sharing low-altitude zones with raptors, waterfowl, and other large birds.

As with “Miracle on the Hudson” type events, **we have no mitigation strategies in place!**

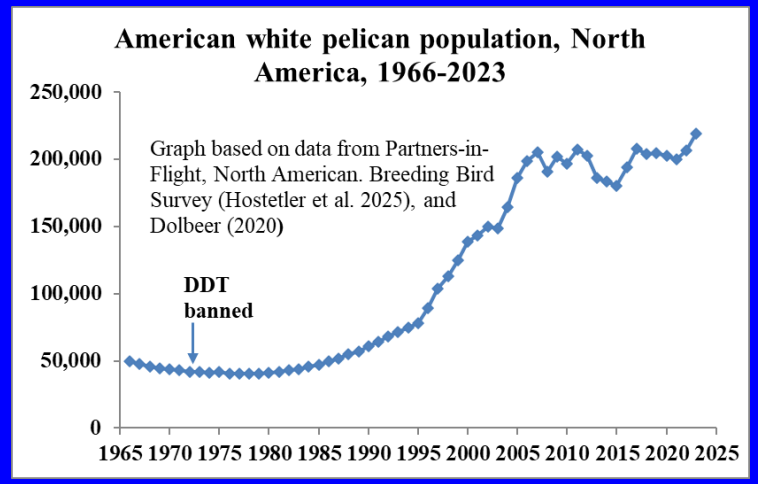
The helicopter industry is growing

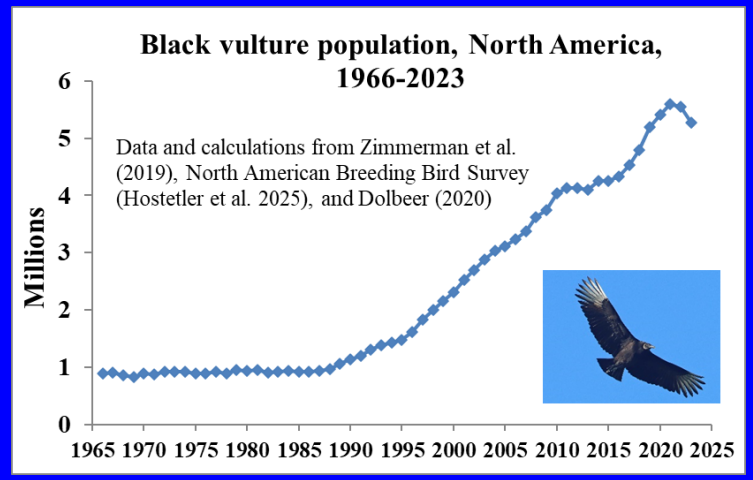


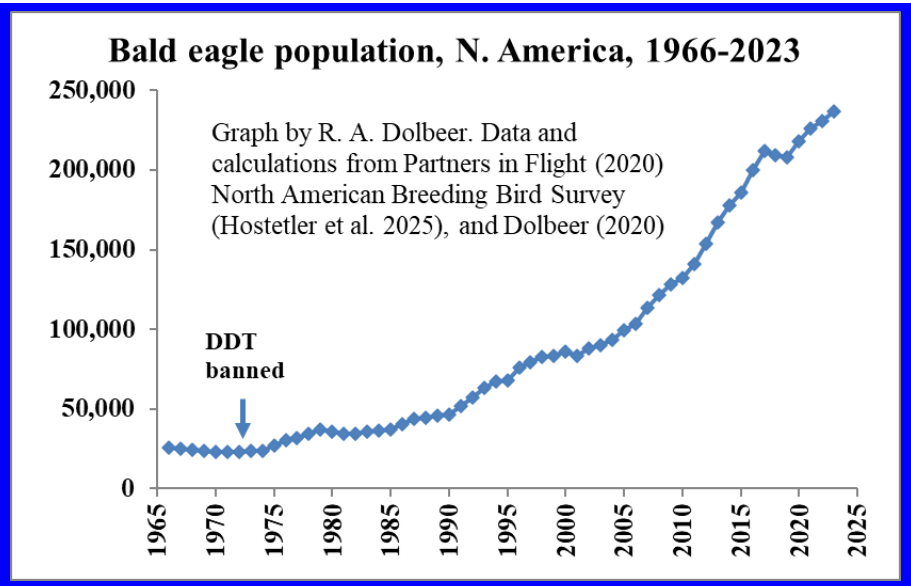
Number of civil helicopters in service increased 50% (26,000 to 39,000) from 2000 to 2020 (worldwide).

https://www.flightglobal.com/helicopters/the-global-helicopter-market-in-numbers/141414.article

Almost all large bird species in North America have significant population increases since 1990*



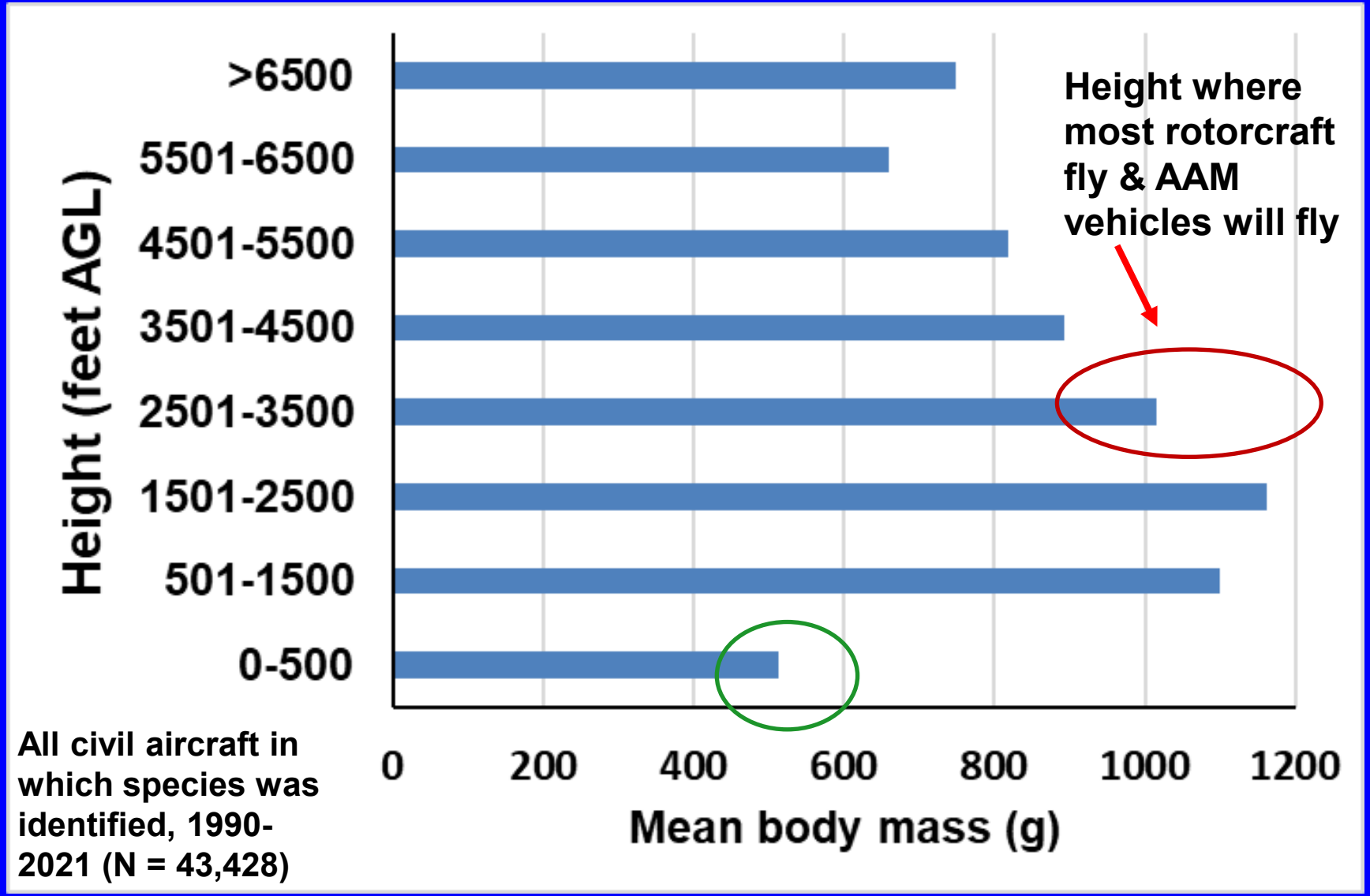


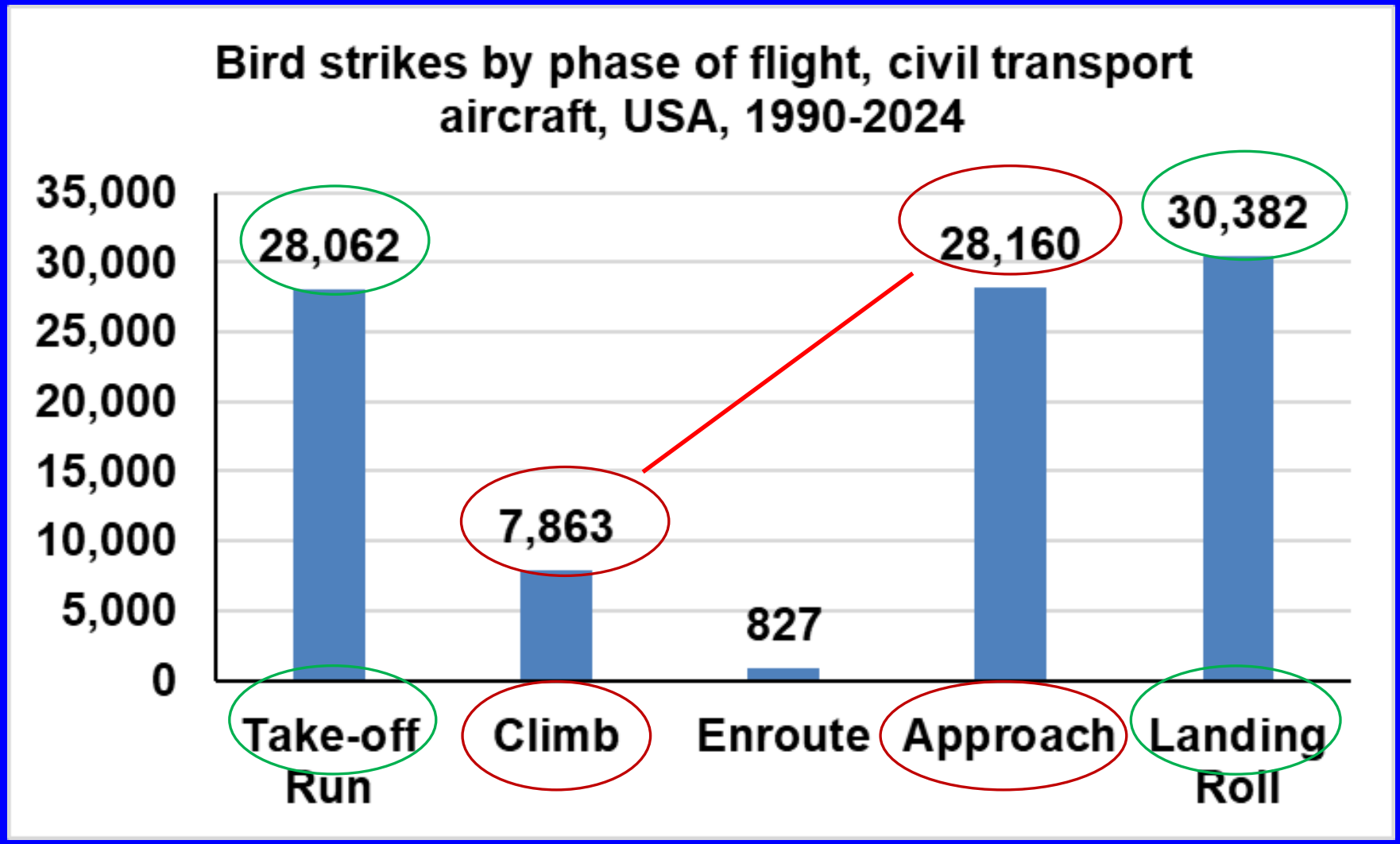


4- to 5-fold increases

Dolbeer, R. A. 2020. Population increases of large bird species in North America pose challenges for aviation safety. Human Wildlife Interactions 14 (3):345–357.

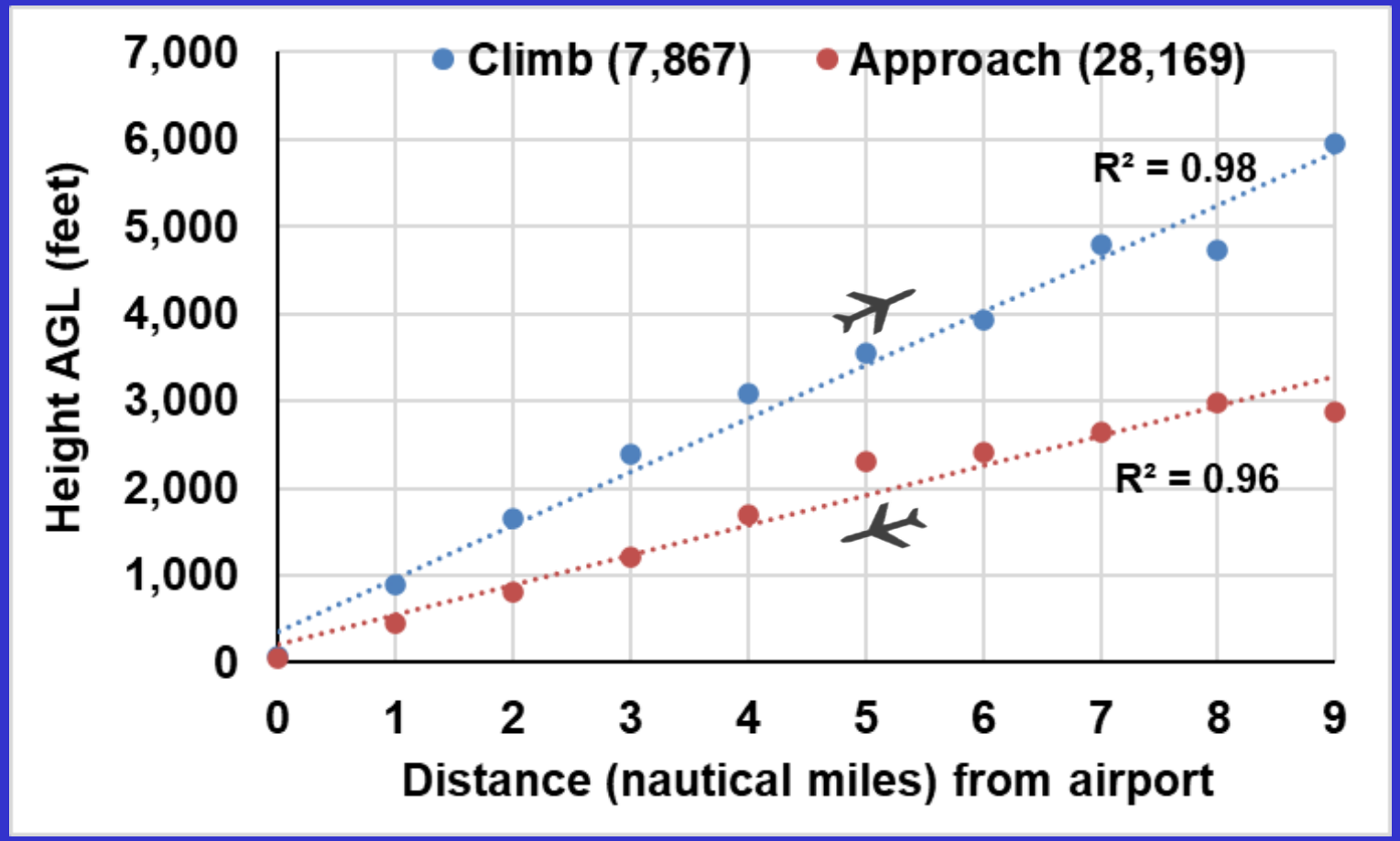
The mean body mass of birds struck at 501-3500 feet AGL is twice that of birds struck at ≤500 feet!





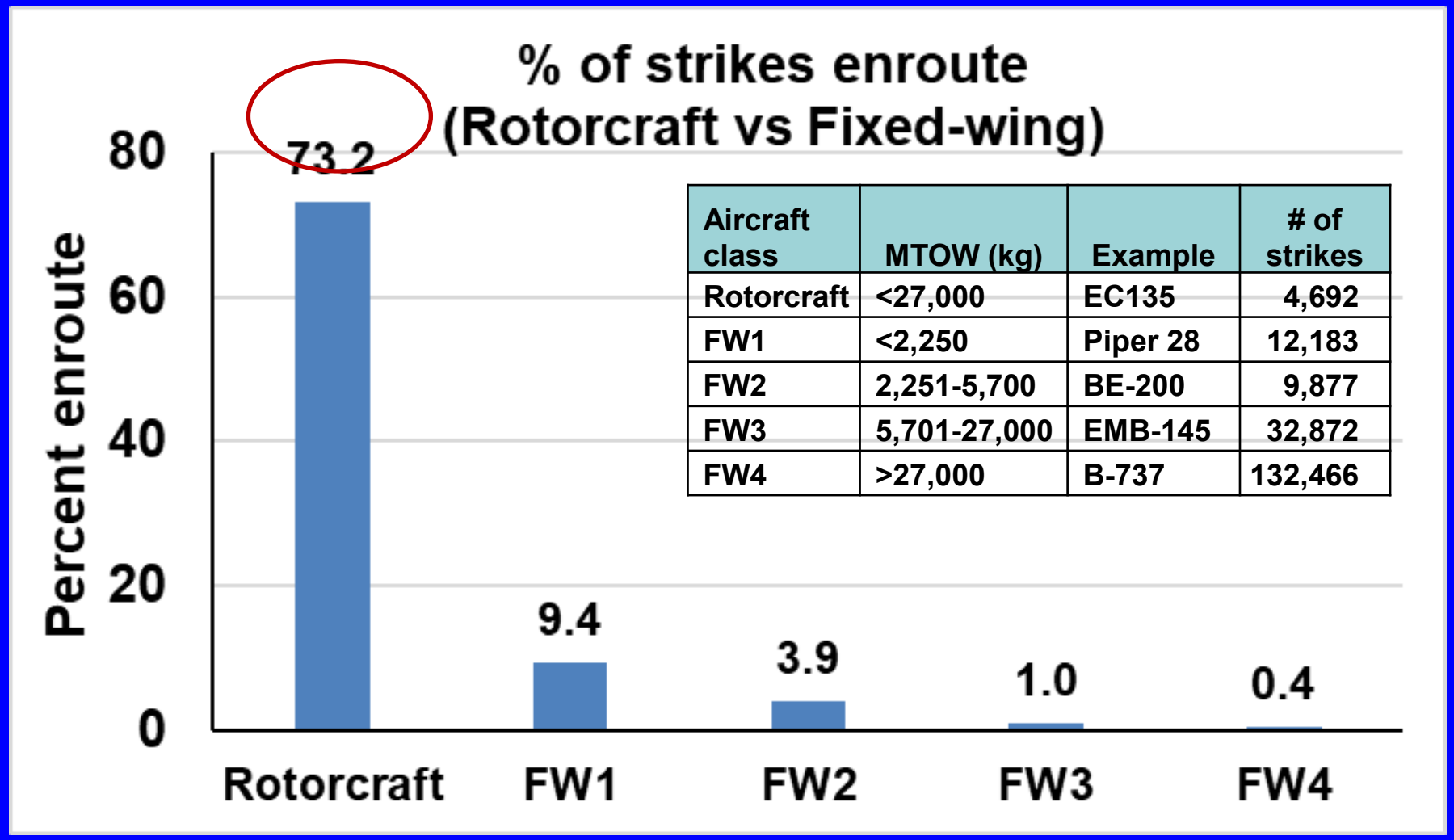
- **Similar number of strikes on T/O-off run and Landing roll!**
- **3.6x more strikes on Approach vs Climb. Why?**

Distance vs Height profiles of strikes during Climb and Approach, large transport aircraft (1990-2025)



Aircraft on Approach spend significantly more time in "bird-rich zone" below 3000 feet than aircraft during climb.

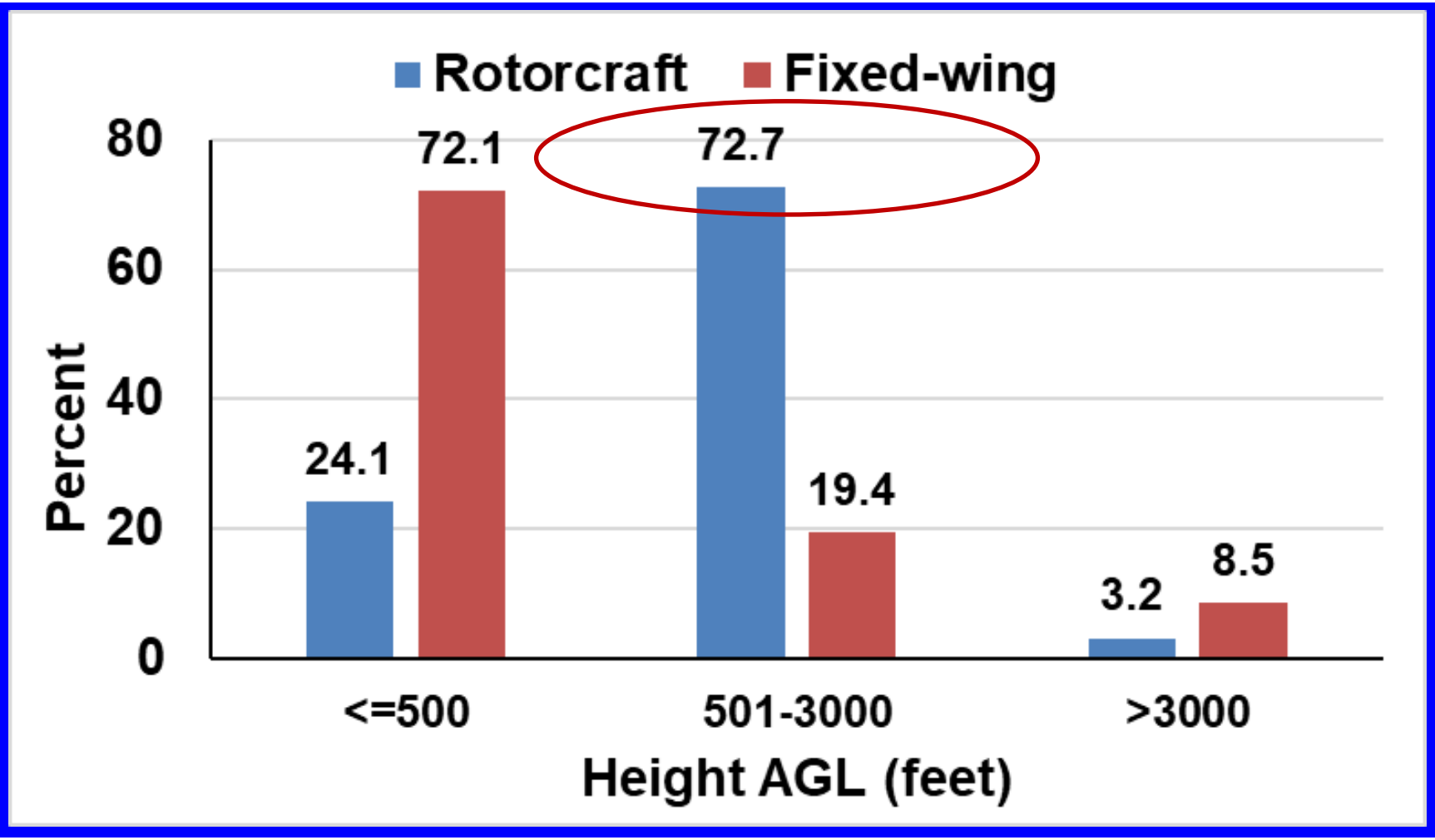
The % of strikes by phase of flight is dramatically different for civil rotorcraft and fixed-wing aircraft, USA, 1990-2024



Aircraft class	MTOW (kg)	Example	# of strikes
Rotorcraft	<27,000	EC135	4,692
FW1	<2,250	Piper 28	12,183
FW2	2,251-5,700	BE-200	9,877
FW3	5,701-27,000	EMB-145	32,872
FW4	>27,000	B-737	132,466

Piper 28 BE-200 EMB-145 B-737

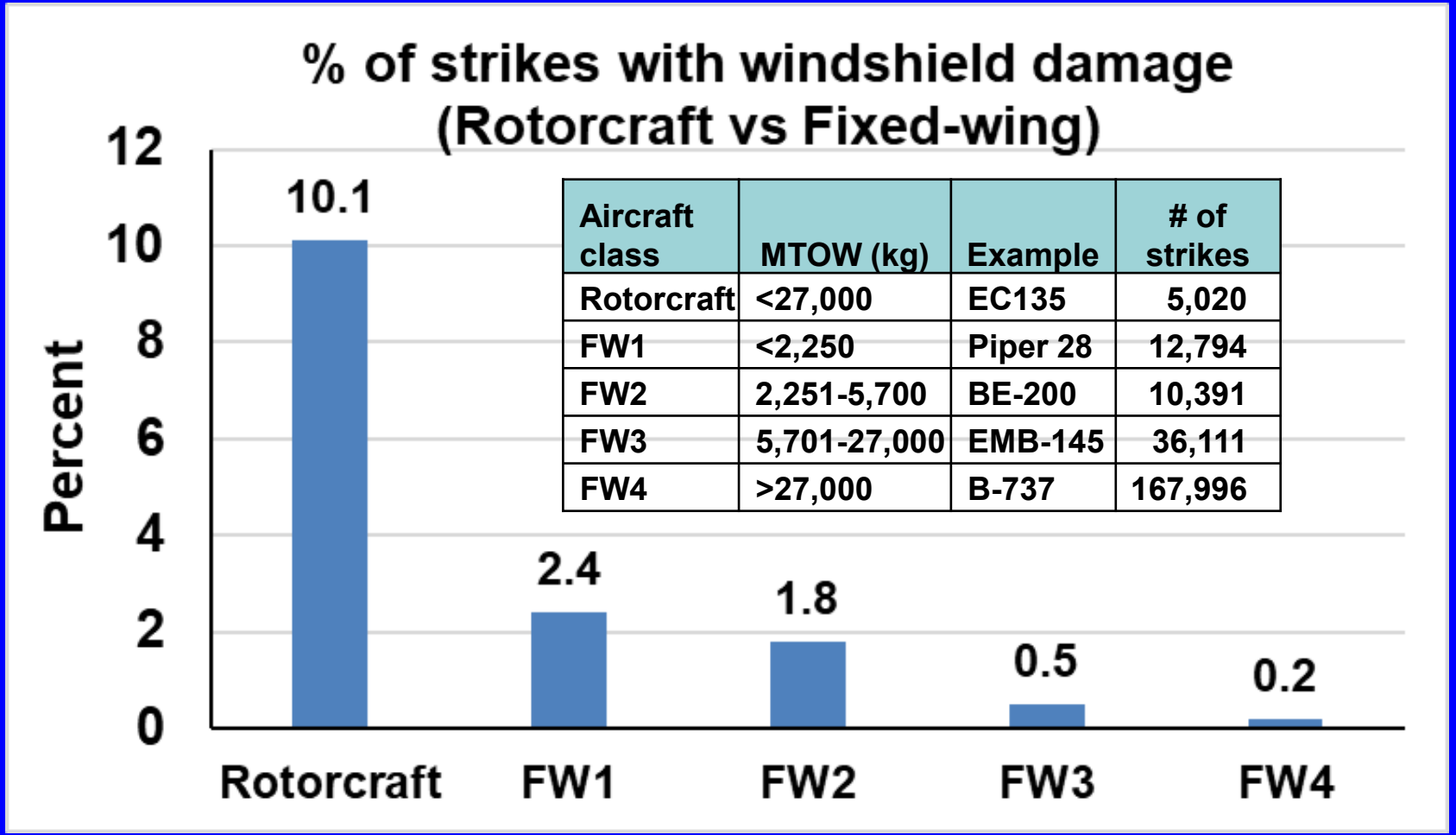
The percentage of rotorcraft strikes in the bird-rich zone from 501-3,000 feet AGL is 3.7 greater than for fixed-wing aircraft.



N = 157,622 fixed-wing aircraft; 4,138 rotorcraft

Civil aviation, 1990-2025, USA.

% of strikes with windshield damage is dramatically different for civil rotorcraft and fixed-wing aircraft, USA, 1990-2025



Aircraft class	MTOW (kg)	Example	# of strikes
Rotorcraft	<27,000	EC135	5,020
FW1	<2,250	Piper 28	12,794
FW2	2,251-5,700	BE-200	10,391
FW3	5,701-27,000	EMB-145	36,111
FW4	>27,000	B-737	167,996

Piper 28 BE-200 EMB-145 B-737

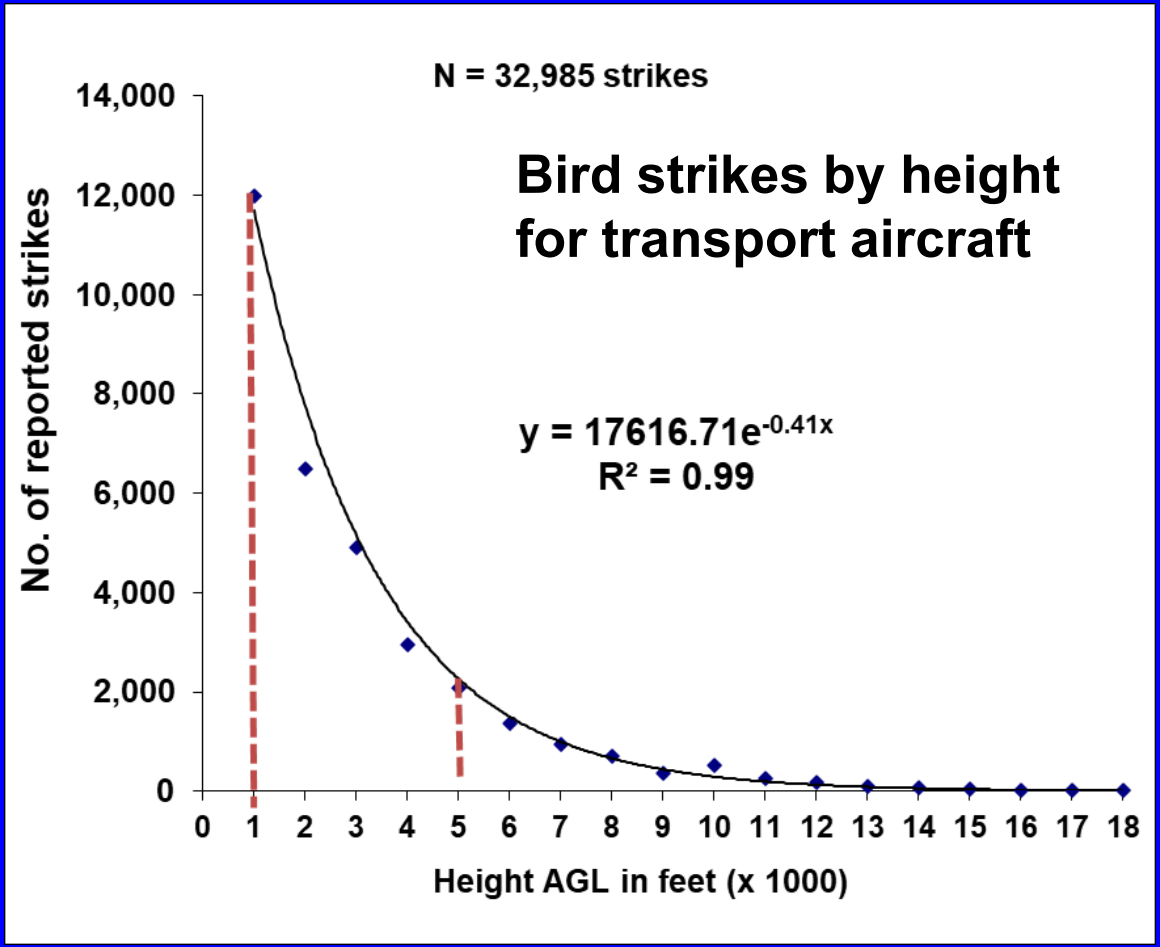
The characteristics of strikes is dramatically different for civil rotorcraft and civil fixed-wing aircraft, USA.

- **Most rotorcraft strikes occur enroute, whereas few fixed-wing strikes occur enroute.**
- **Rotorcraft strikes enroute primarily occur in the "bird rich" zone from 501 to 3,000 feet.**
- **Mean body mass of birds struck in this height band is 2 times that of birds struck at ≤500 feet.**
- **Windshields of rotorcraft are much more likely to be damaged than windshields of fixed-wing aircraft.**
- **None of these strikes can be mitigated by traditional wildlife management techniques used at airports!**

So, how can we mitigate damaging strikes with rotorcraft that will also translate to Advanced Air Mobility aircraft?

How can we mitigate the risk of bird strikes with rotorcraft and AAM aircraft?

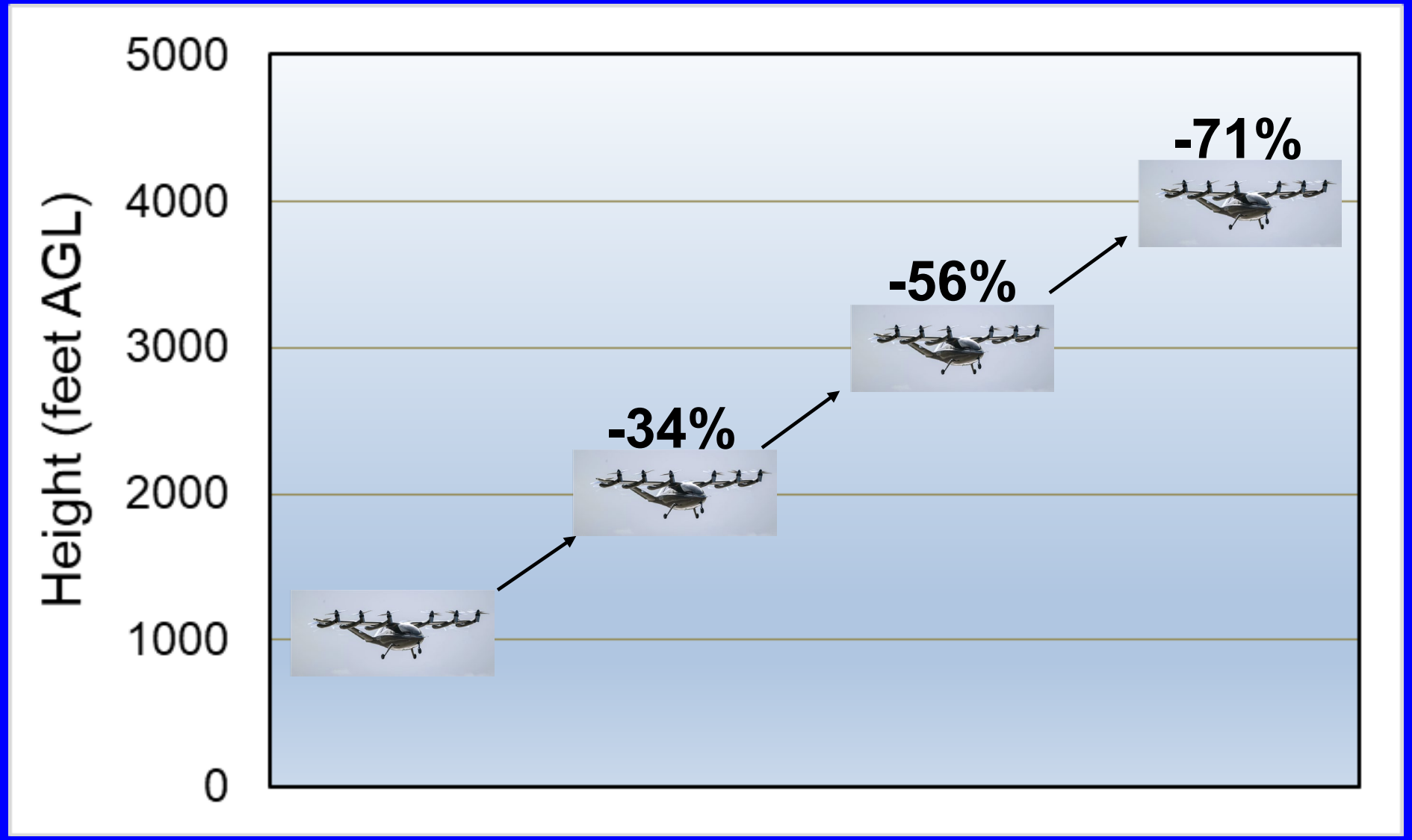
1. Adjust flight height above ground level (AGL)



Gain in height (ft AGL) from 500 to:	% reduction in probability of strike
1500	34
2500	56
3500	71
4500	81
5500	87

Dolbeer, R. A. et al. 2025. Wildlife strikes to civil aircraft in the United States, 1990-2024. U.S. Department of Transportation, Federal Aviation Administration, Office of Airport Safety and Standards, Serial Report No. 31, Washington, DC., USA.

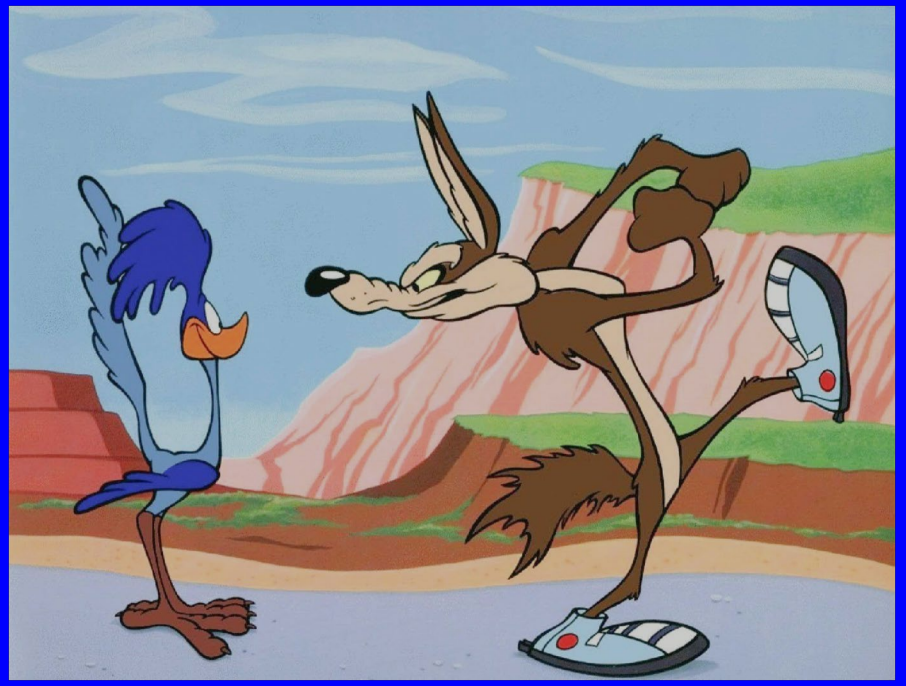
Dolbeer's rule: For every 1,000-foot increase in height, 34% reduction in probability of a strike



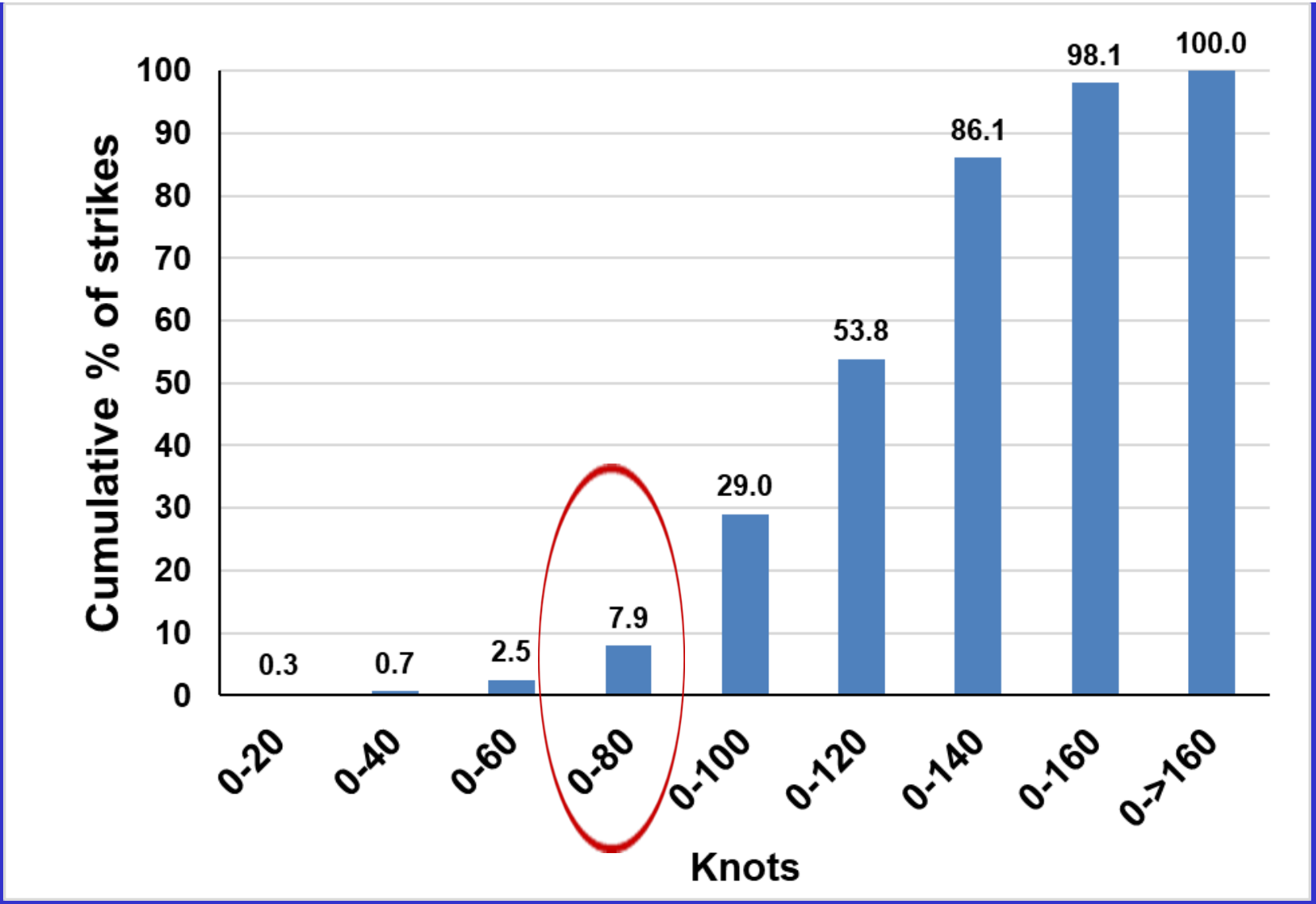
Helicopter Association International (HAI)

How can we mitigate the risk of bird strikes with rotorcraft and AAM aircraft?

2. Adjust speed of aircraft



92% of bird strikes occur at >80 knots for large civil aircraft (T/O mass >27,000 kg) during take-off run or landing roll, 1990-2021, USA (N = 14,726)



Bird avoidance in relation to speed of aircraft

- Birds do a decent job of avoiding aircraft below ~80 knots
- Above 80 knots, aircraft speed makes little difference
- Delivery Drones should maintain speeds below 80 knots
- Rotorcraft/Urban Air Taxis should reduce speeds to 80 knots when radar indicates high bird densities in the air

How can we mitigate the risk of bird strikes with rotorcraft and AAM aircraft?

3. Aircraft lighting

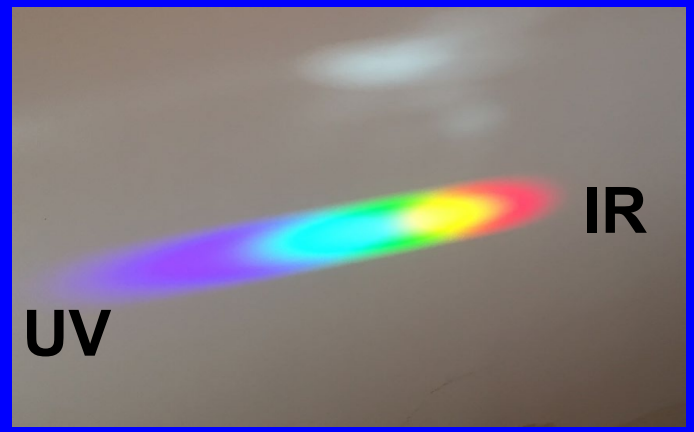
a) Wavelength

b) Pulse rate

How can we mitigate the risk of bird strikes with Urban Air Taxis and Delivery Drones?

3. Aircraft lighting

3a. Wavelength: Many bird species "see" in near UV



Blackwell, B. F., T. L. DeVault, T. W. Seamans, S. L. Lima, P. Baumhardt, and E. Fernández-Juricic. 2012. Exploiting avian vision with aircraft lighting to reduce bird strikes. J. Applied Ecology 49:758–766.

Birds do not see well in red end of spectrum

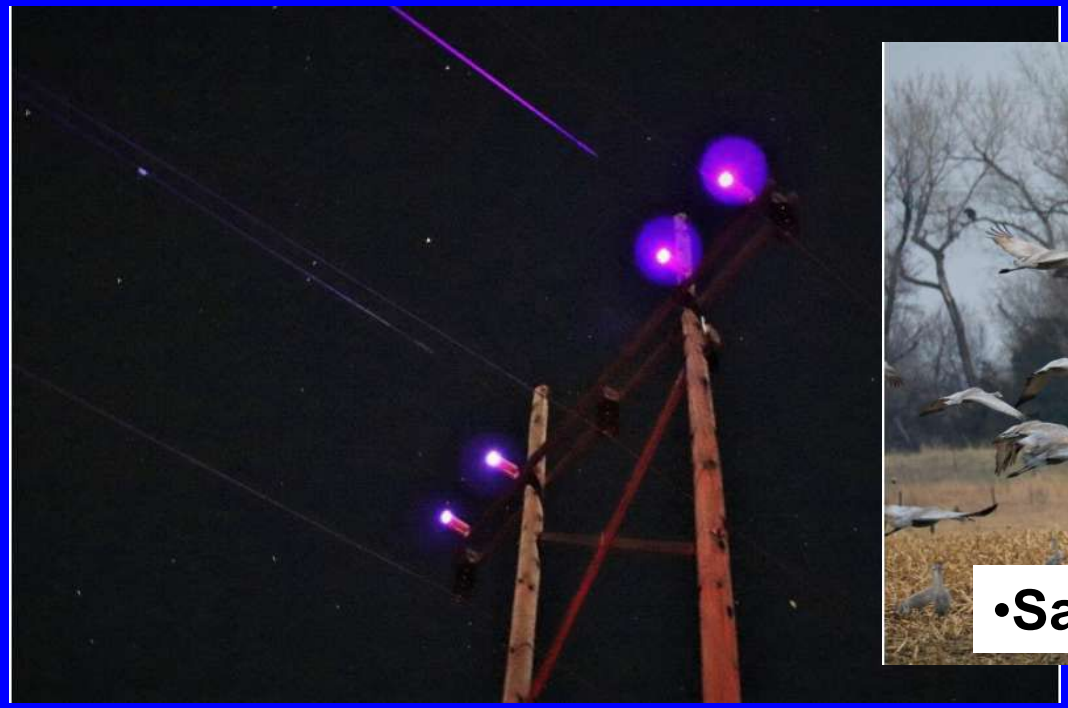
Dolbeer, R. A., and W. J. Barnes. 2017. Positive bias in bird strikes to engines on left side of aircraft. Human-Wildlife Interactions 11 (1): 71-76.

Based on avian research, the FAA changed obstruction lighting standards to reduce bird mortality, including the elimination of steady-burning red lights from several lighting configurations (Patterson 2012, Federal Aviation Administration 2015).

•Communication towers with red warning lights had more bird collisions than towers with lights of shorter wave lengths (Gehring et al. 2009, Sheppard 2011, Patterson 2012).

•More night migrants flew in circular flight patterns near a tower with a combination of blinking and non-blinking red lights than near a tower of similar height equipped only with white strobe lights (Gauthreaux and Belser 2006).

•Tasmanian silvereyes oriented in the appropriate migratory direction under white and green light (571 nm) but were disoriented under red (633 nm) light (Munro et al. 1997) .



•Sandhill cranes, Nebraska

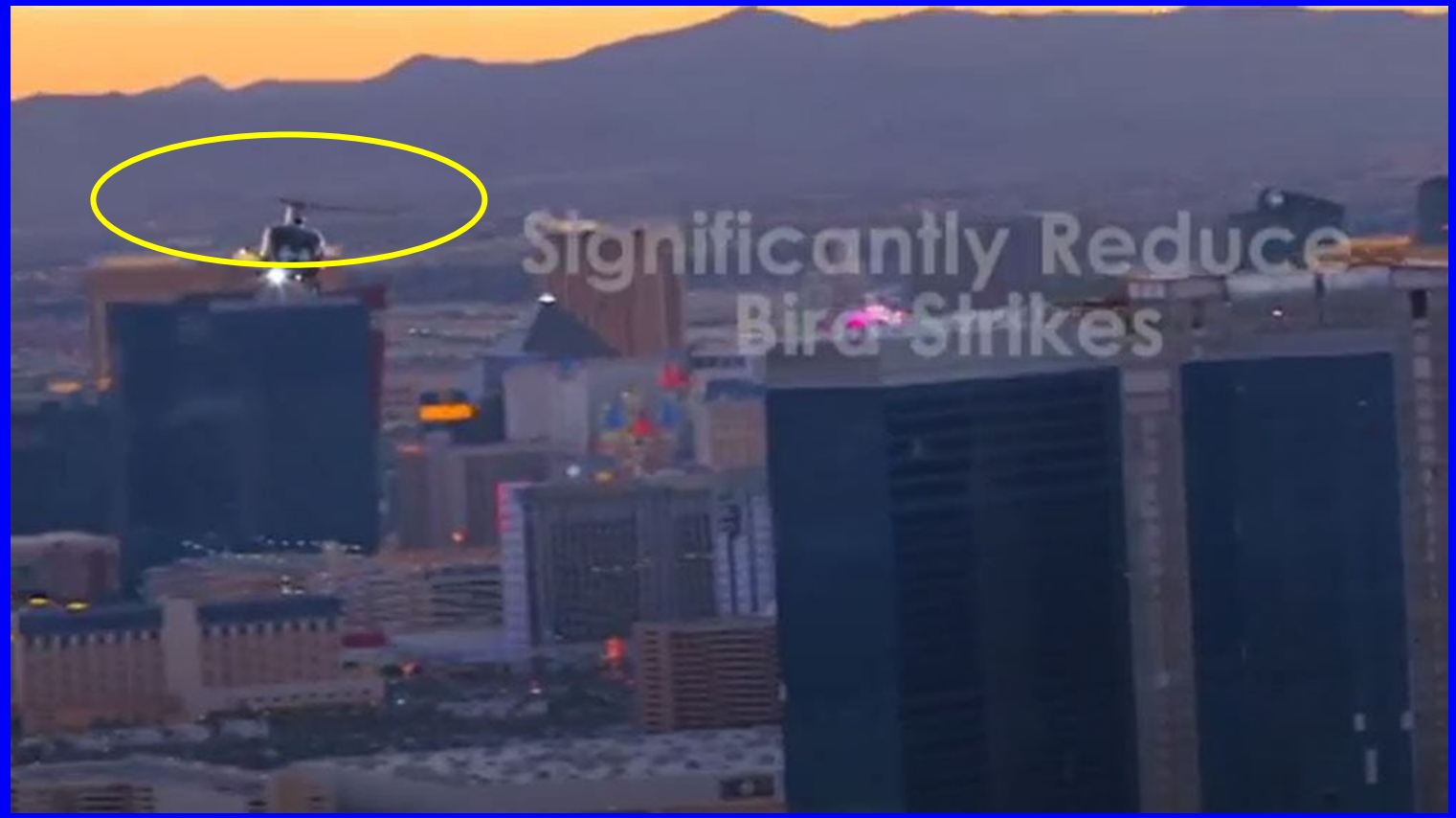
Ultraviolet illumination helps birds avoid power lines

“Over a 38-night period, sandhill crane collisions decreased 98% when the lights were on”

•Dwyer, J. F., A. K. Pandey, L. A. McHale, and R. E. Harness. 2019. Near-ultraviolet light reduced Sandhill Crane collisions with a power line by 98%. The Condor 121 (2).

3b. Pulsating lights.

Various studies have suggested Pulsating Lights reduce bird strikes.



Pulsed lighting

- Mandernach, J. 2018. Pulsating exterior lights save lives: mitigating bird strikes. Rotor. Winter 2018: 22-24.

Maverick Aviation statistics	Before pulsing lights	After pulsing lights
Flight hours	142,848	284,170
Near-fatal bird strikes	6	0

Pulsed lighting

- Fedy, D. 2018. Metro study finds Pulselites helps reduce bird strikes. Vertical magazine. June-July: 32.

- Study looked at 43 helicopters in Metro Aviation's fleet, 2016-2017.
- For the 2-year period, strike rate was 3x lower on aircraft with pulsing lights.
- During Sep-Oct (migration months), strike rate was 5x lower on aircraft with pulsing lights.

How can we mitigate the risk of bird strikes with rotorcraft and AAM aircraft?

3. Aircraft lighting (Summary)

- Equip rotorcraft and AAM aircraft with pulsed lighting with UV component (minimize lighting at red end of spectrum).
- Advanced, lightweight LED lighting gives many options.

How can we mitigate the risk of bird strikes with rotorcraft and AAM aircraft?

4. Bird-detecting Radar

- Birds have been detected by radar since initial deployment in WWII.
- Advances are being made in dedicated radars for detecting drones and birds in 3D.
- This information needs to be transmitted to flight crews in real time, such has been done for windshear for the past 30 years.

NexRad Weather Radar already provides remarkable data on bird movements

Conclusions

- Rotorcraft and AAM (quiet, electric-powered) aircraft share low-altitude zones with raptors, waterfowl, and other large birds.
- **This is not an airport/heliport problem!**
- This is an off-airport airspace management problem, and **we have few mitigation measures in place for bird strikes.**

Mitigation measures that can be implemented:

- Fly at maximum allowed heights.
- Strengthen aircraft components such as windshields/rotors.
- Keep speeds <80 knots under high bird densities.
- Aircraft lighting (pulsating lights with UV component).
- Bird-detecting radar for flight planning and real-time warnings.


Mitigating bird strikes with rotorcraft/ AAM aircraft requires a paradigm shift from traditional wildlife management!
Let’s do it!
•Safer skies for all who fly!
•Thank you.