Forecasting wildlife strike risk for low-altitude aircraft operations

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Aviation Revolutions

First Revolution

Lighter Than Air (LTA) flight

Montgolfier Bros.
France
1780s

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Aviation Revolutions

Second Revolution
Powered Flight
Wright Bros.
USA
1900s

Third Revolution
Jet Age
Sir Frank Whittle
UK
1930s
First Airliner
DHC Comet 1951

Next Revolution
Advanced Air Mobility (AAM)
Many Protagonists
Soon

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First Principles – Dolbeer, Miller, & Schank

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.

Aircraft-Wildlife Conflict Index

Aircraft Movement Rate (ACMR)

*

Animal Movement Rate (AMR)

Case Study - Oakey Army Aviation Centre Helicopters

- High mass, flocking species
- Fly slow
- Don’t fly at dusk or at night
- Fly high
- Don’t change vectors quickly

- High speed, explosive flock
- Fly fast
- Fly undetected
- Fly low
- Change vectors quickly

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Aircraft Types

Adapted from: Panchal et al. 2022.

Type	Multicopter	Lift + Cruise	Tilt Rotor	Fixed wing	Helicopter
Example	VoloCity VoloRegion	Embraer X (Eve)	Joby	Cessna 172	Eurocopter EC135
Frontal Area (ft^2)	300-1,075	550-1,650	530-800	322	56-880
Cruise Speed (knots)	60-100	130	174	124	137
Cruise Altitude (ft) AMSL	2,500	2,600-3,300	8,000	3,000-9,000	1,000-3,000
MTOW (lbs)	1984	2204	4001	2449	6393
Rotors/propellers	18	10	6	1	1
Airworthiness Standard for wildlife	?	?	Part 29 and 35	Part 23	Part 27

Aircraft Types

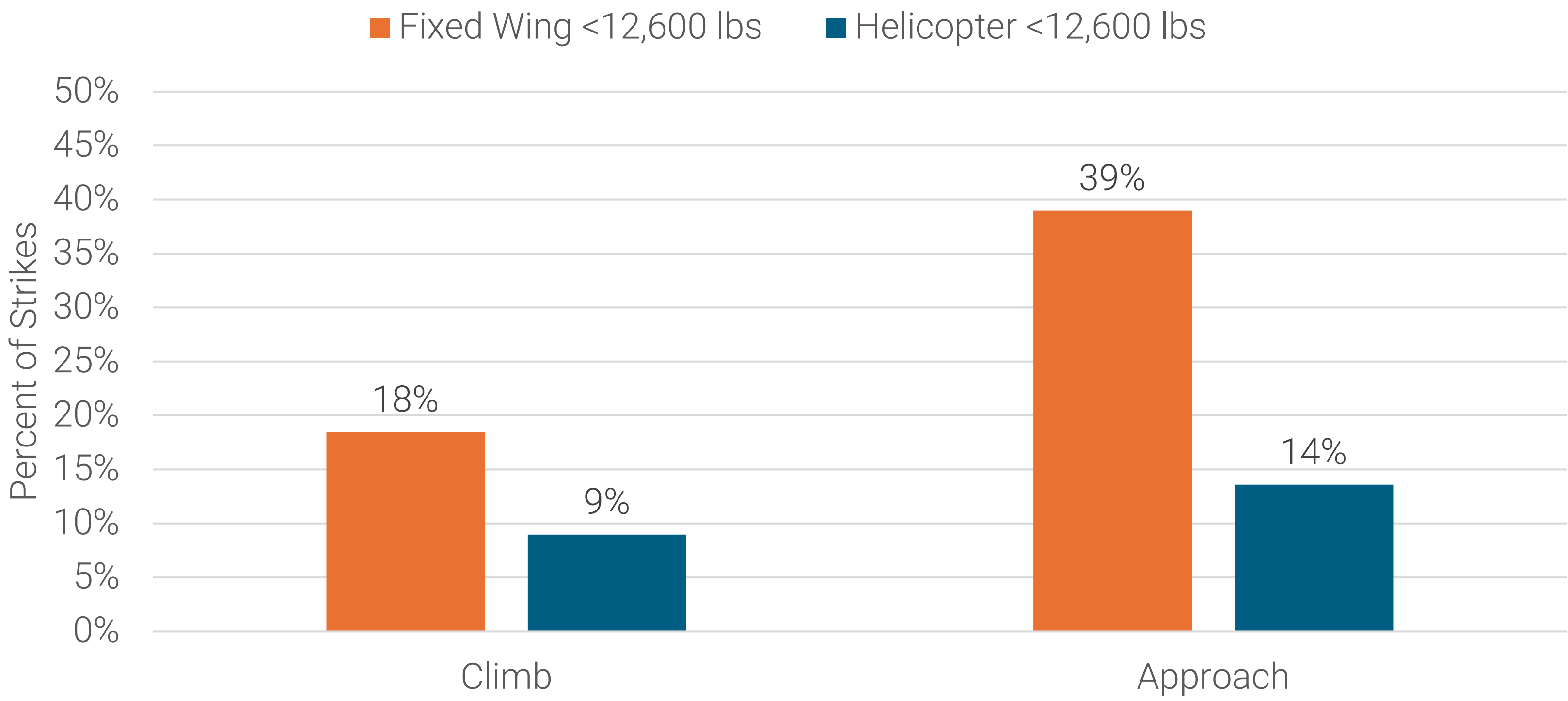
What's In and What's Out?

For this analysis, we used the following criteria:

- Flight at or below 10,000'
- MTOW less than 12,500 lbs
- Cruise speeds 60 – 175 knots
- Fixed wing and rotary-wing

Phase of Flight

Difference in climb and approach due to time in bird-rich zone holds for aircraft <12,600 lbs



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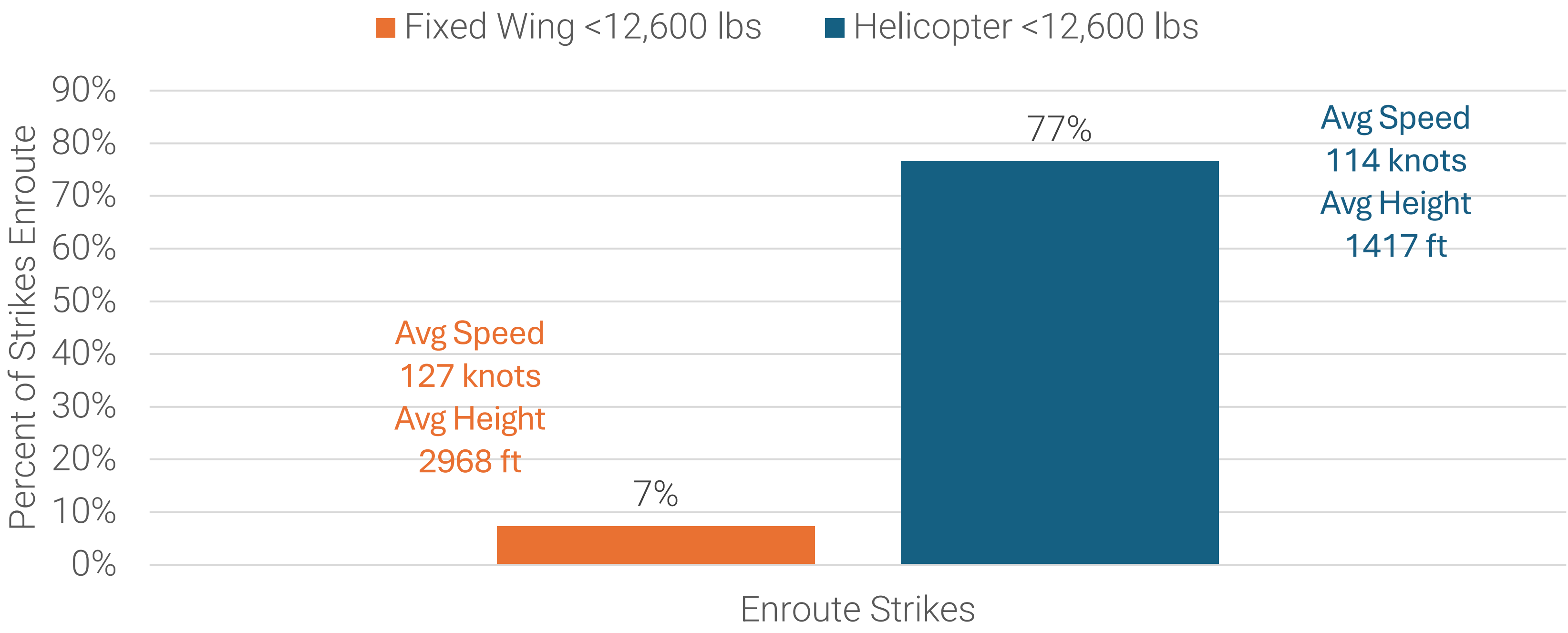
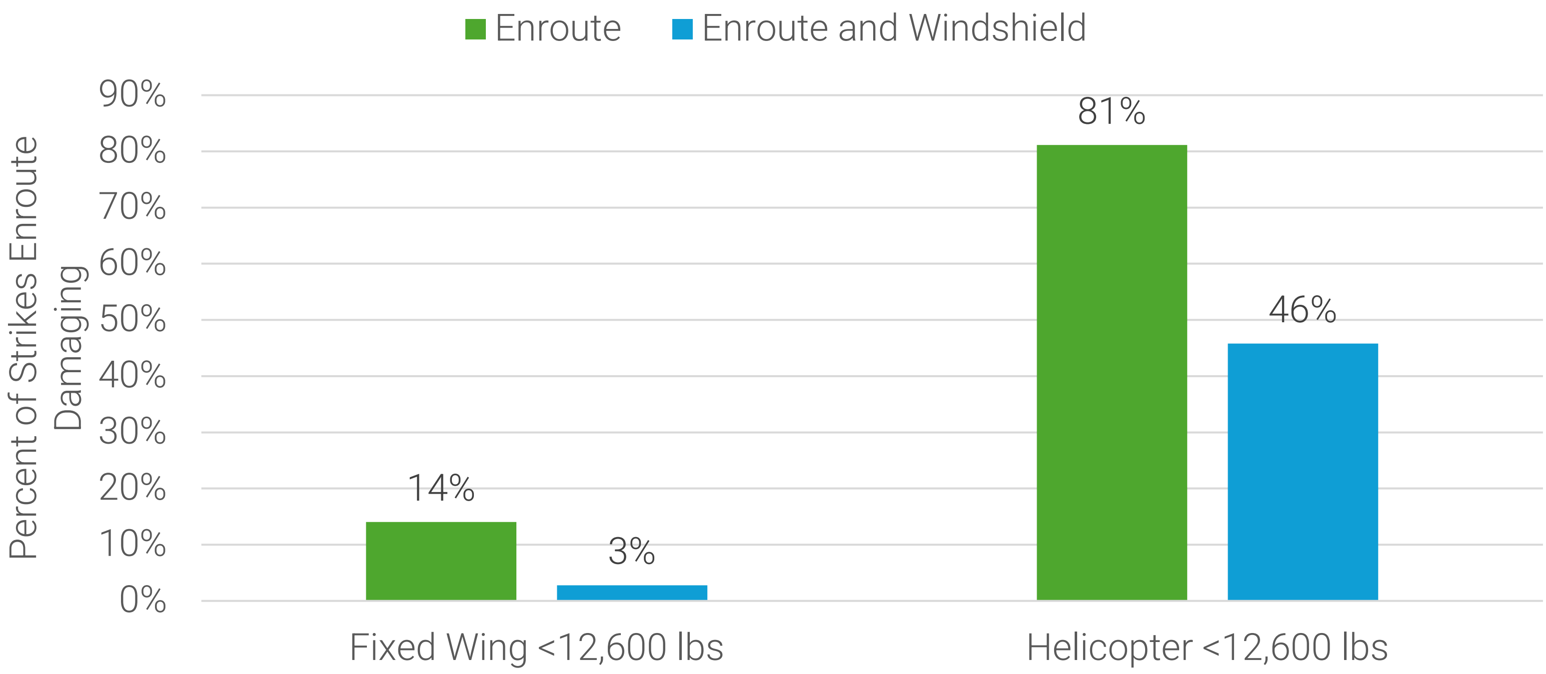
Phase of Flight

Enroute helicopter strikes at lower altitude – more time in bird rich zone



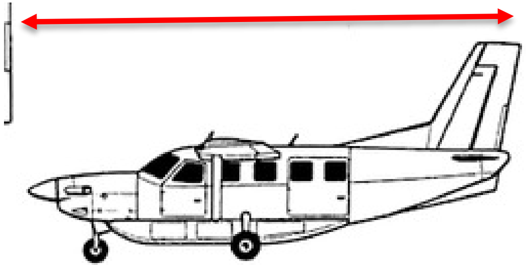
Phase of Flight

3% of FW damaging strikes involved windshield vs 46% for helicopters



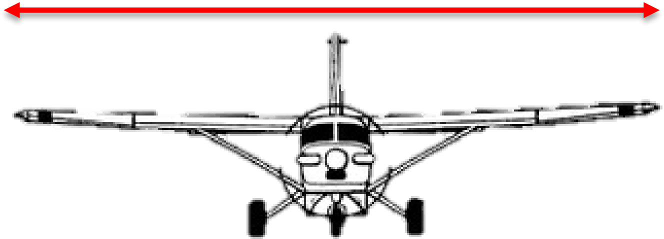
Q Zodiac 100 vs EC135

10 m

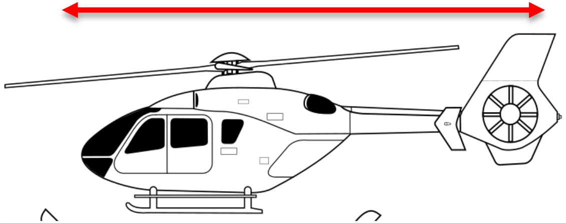


MTOW 3200kg

13.7 m



10 m

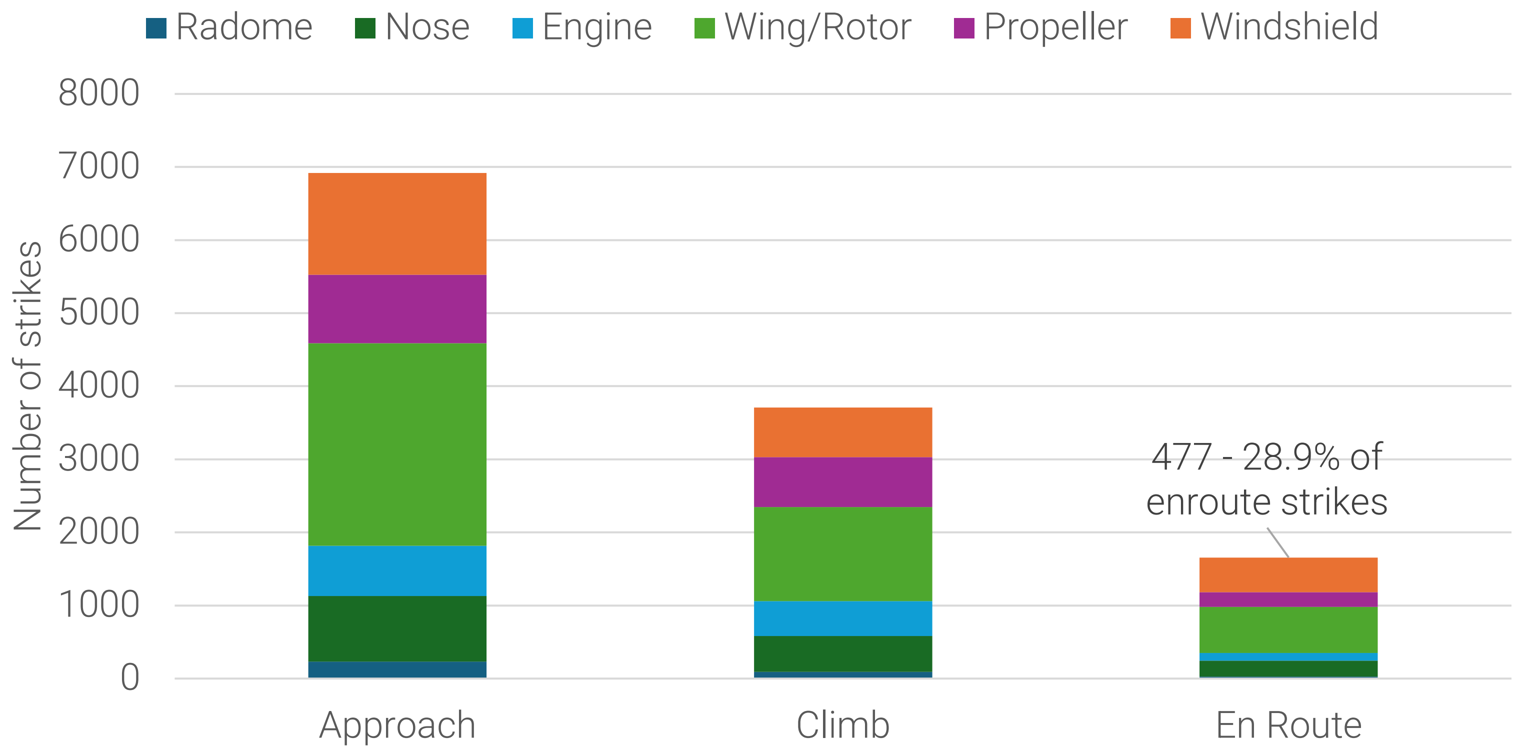


MTOW 2900kg

10.2. m

Phase of Flight

Strike location by flight phase – FW <12,600 lbs



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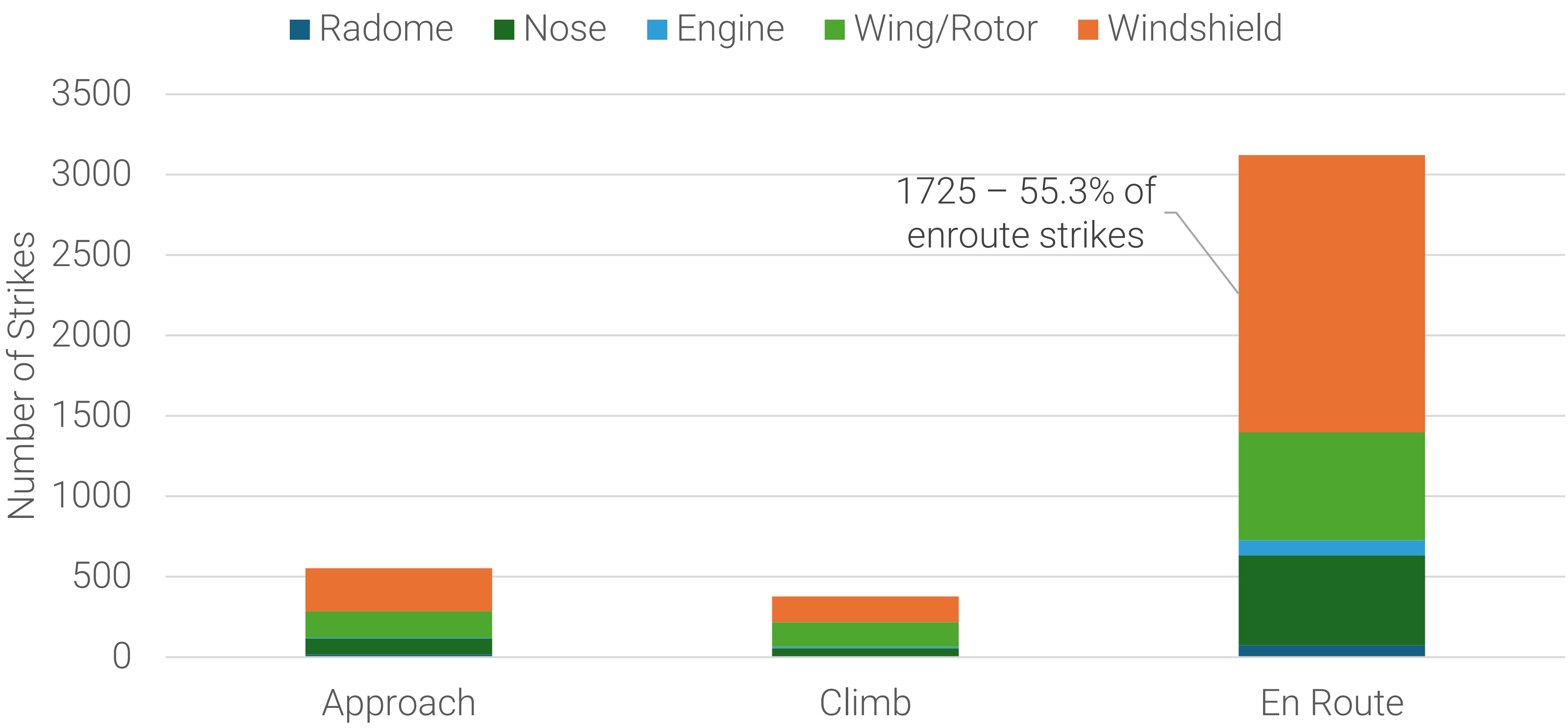
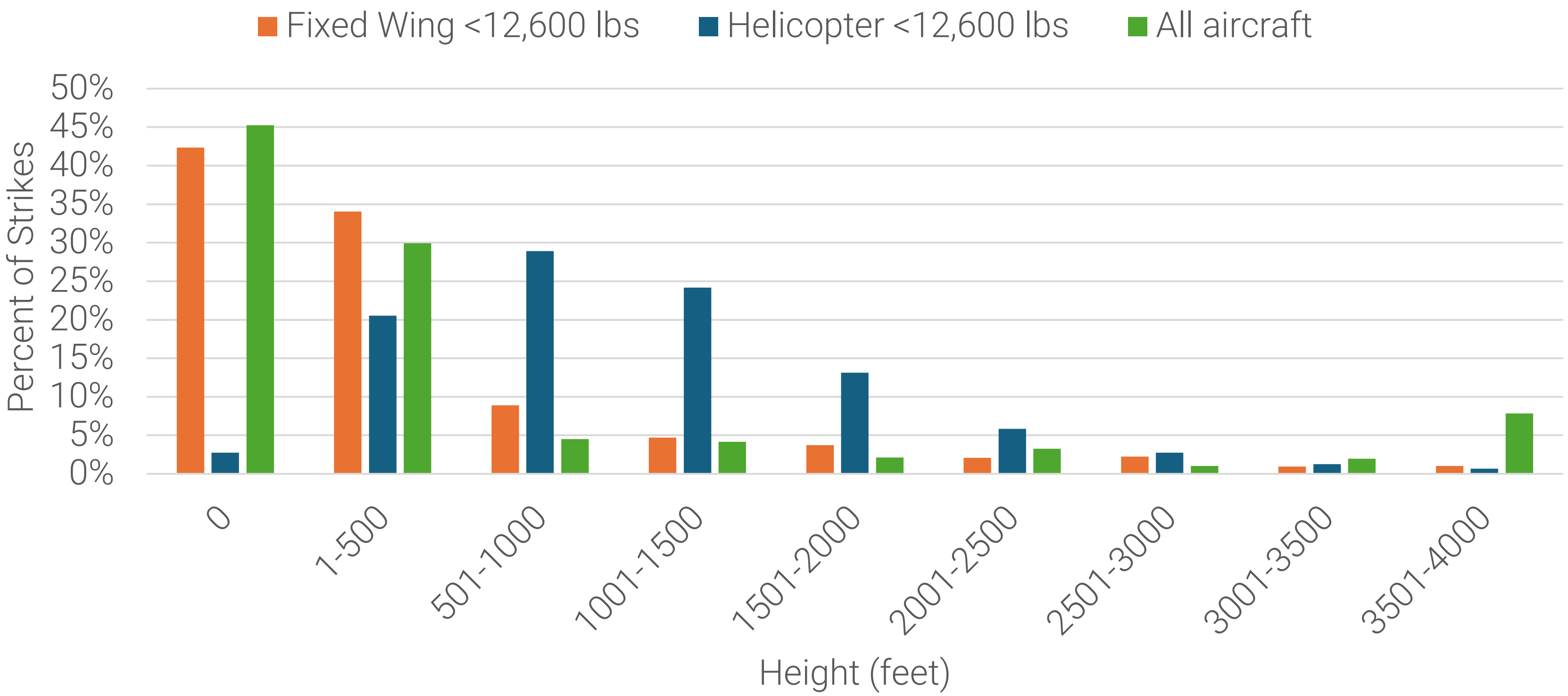
Phase of Flight

Strike location by flight phase – Helicopter <12,600 lbs



Height

Height distribution of strikes differs between FW and helicopter for aircraft less than 12,600 lbs



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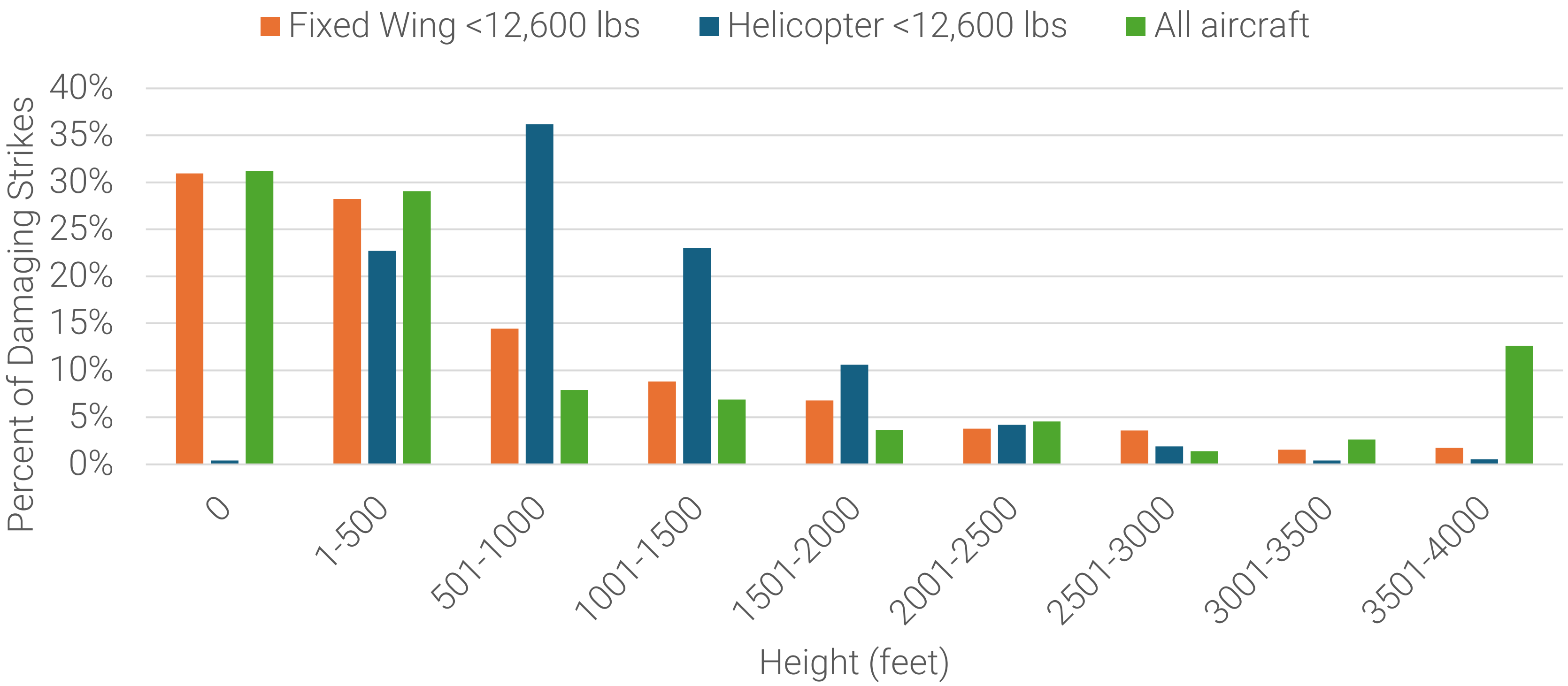
Height

Data for damaging strikes similar to strikes in general and helicopter peak in 501-1,000 ft



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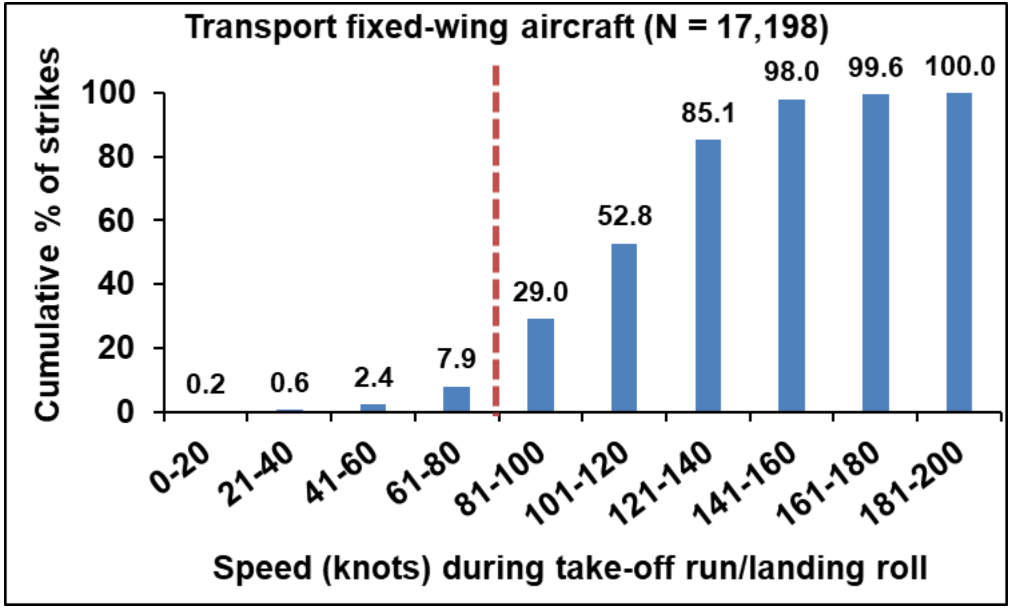
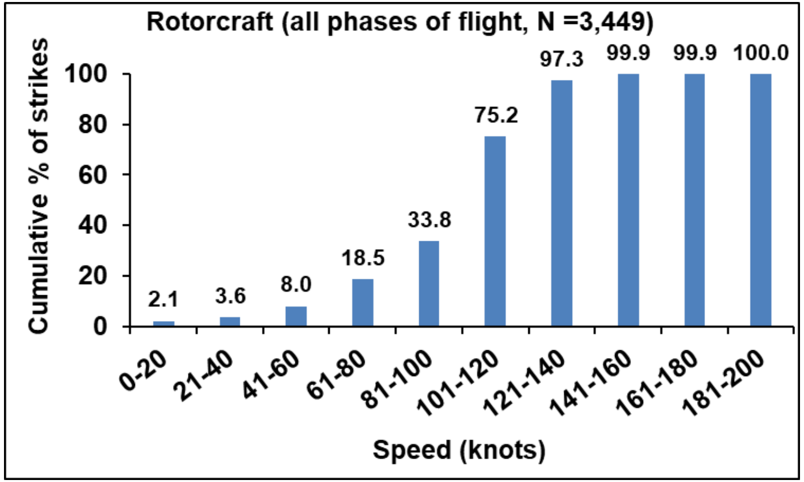
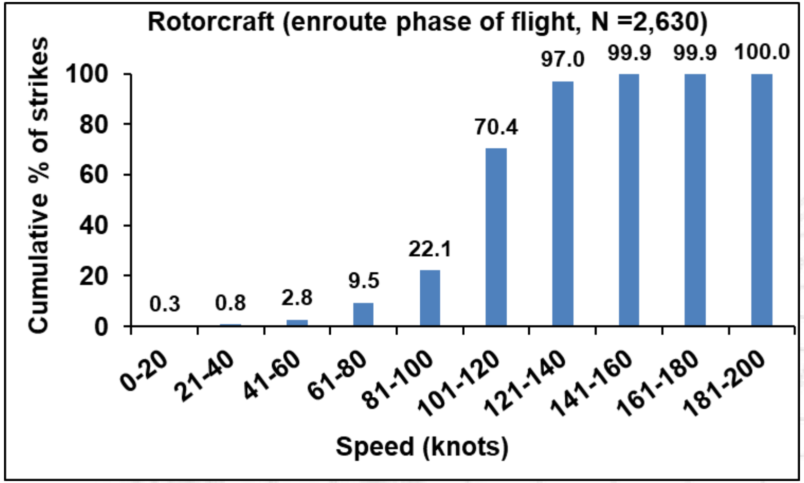
Speed







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

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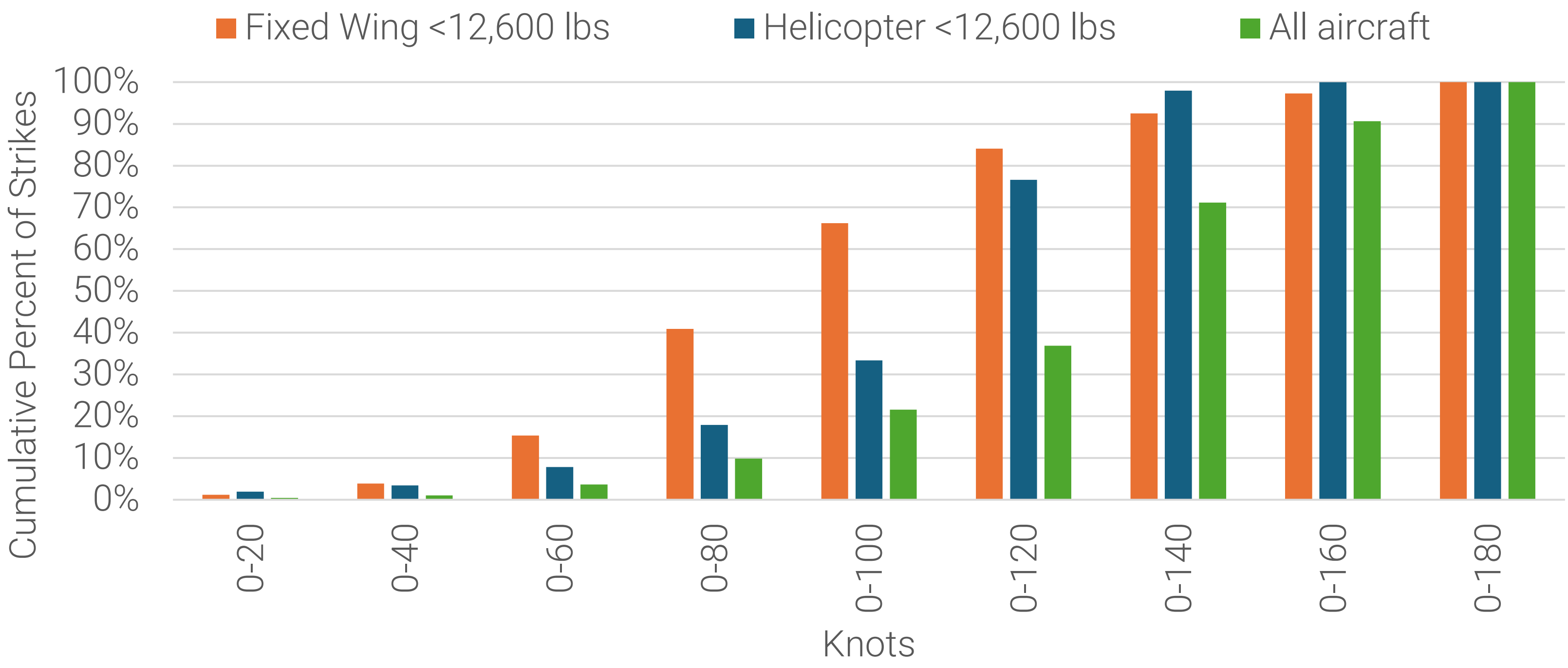
Speed

Approx. same % for FW and Helicopter <=40 knots
but substantial difference at >40 to <120 knots



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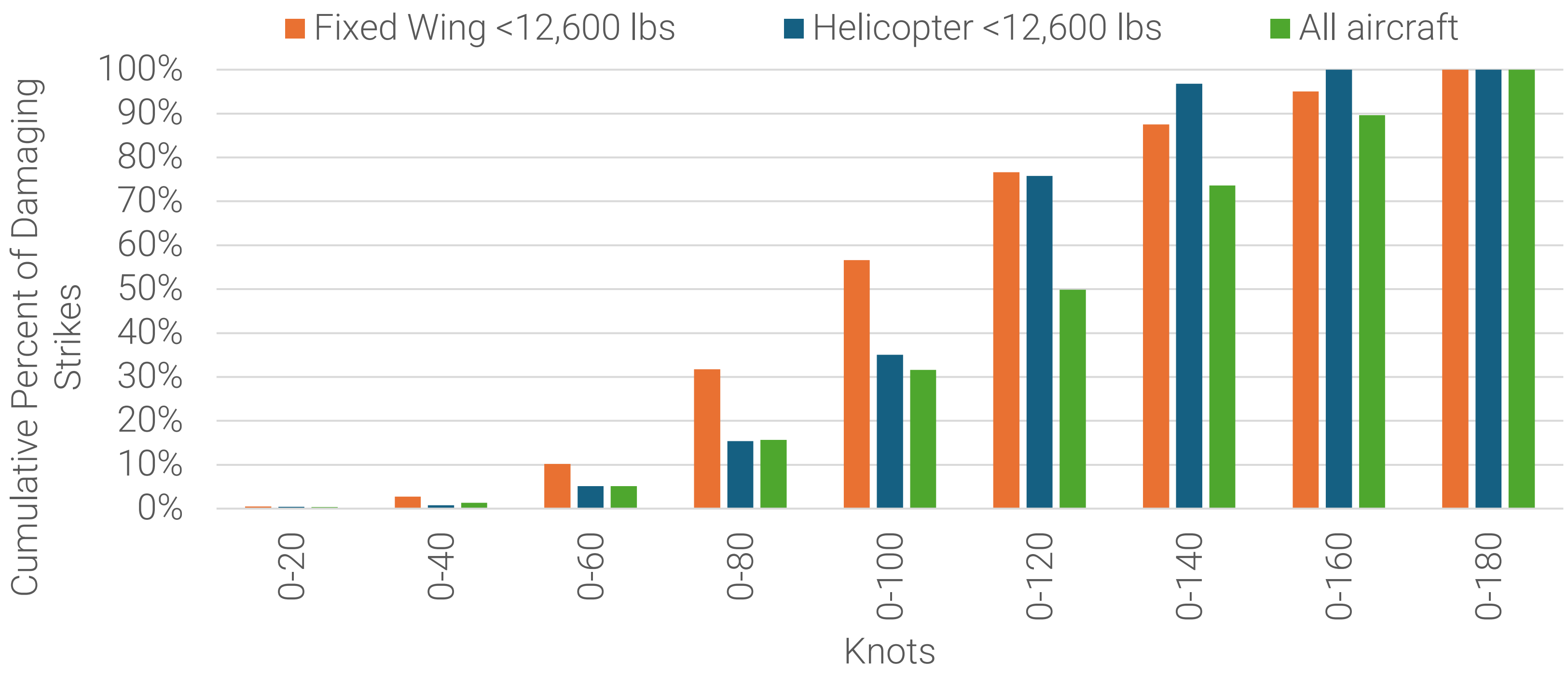
Speed

32% of FW aircraft and 15% of helicopters have damage at <=80 knots



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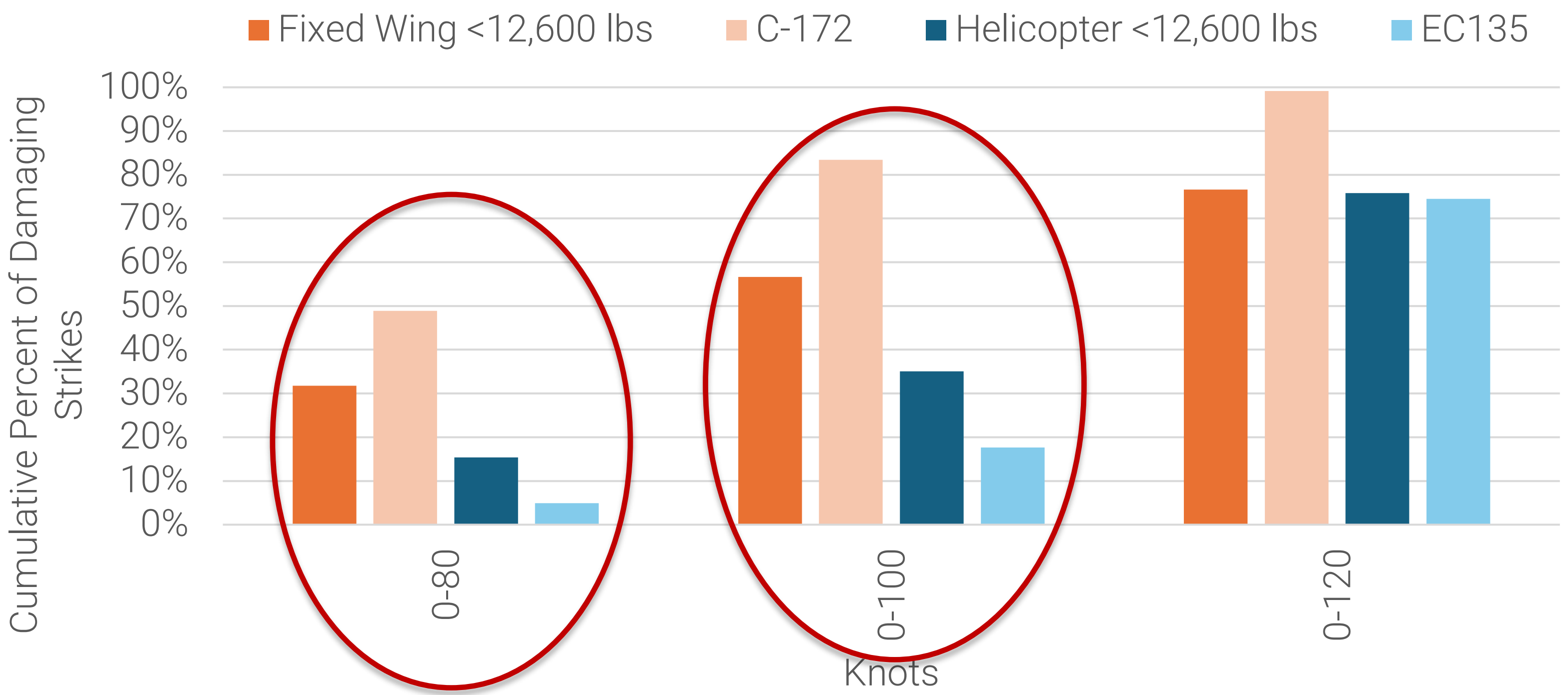
Speed

Caution in just looking at numbers across whole categories – FW and helicopter <12,600 lbs



Note differences in all aircraft and representative aircraft

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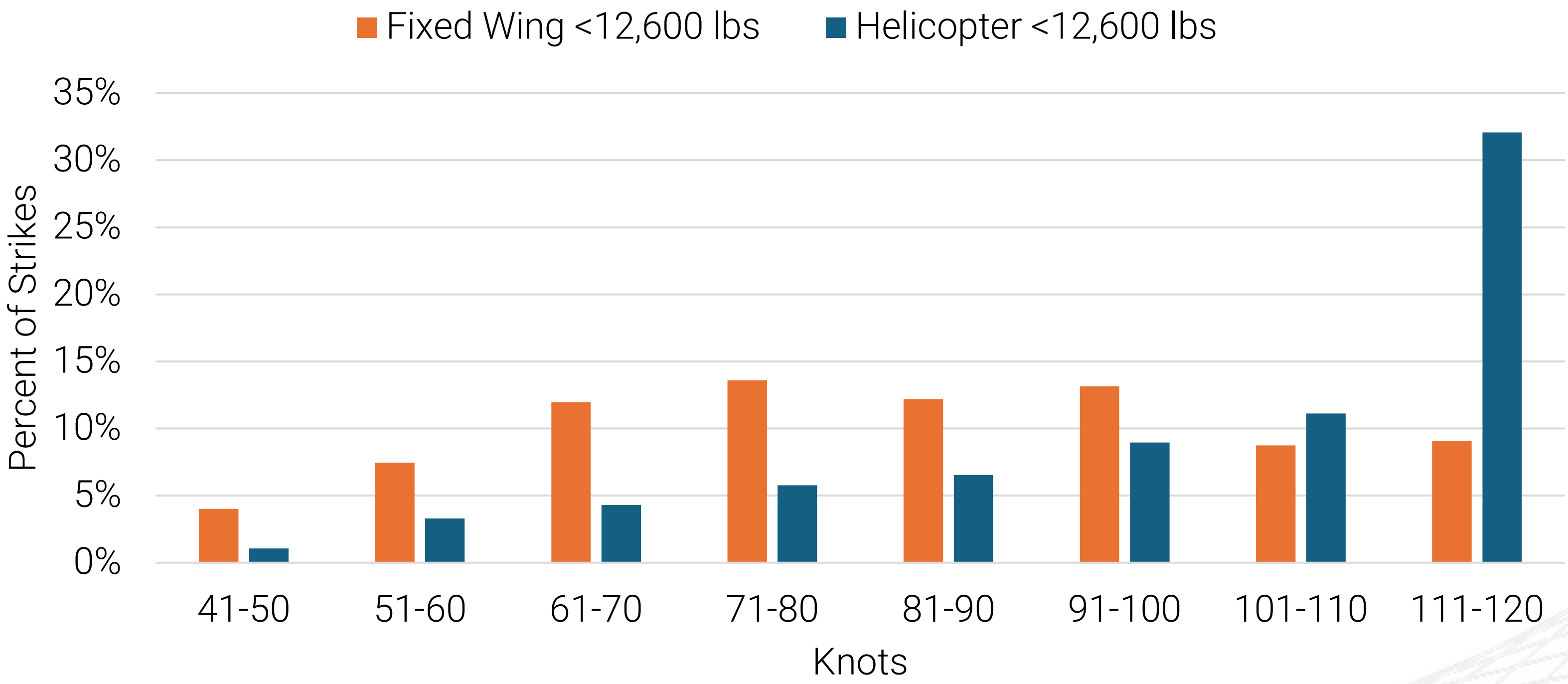
Speed

Detail of strikes for 80 knots ± 40 knots - Increasing strikes at increasing speeds, but not limited to >80 knots



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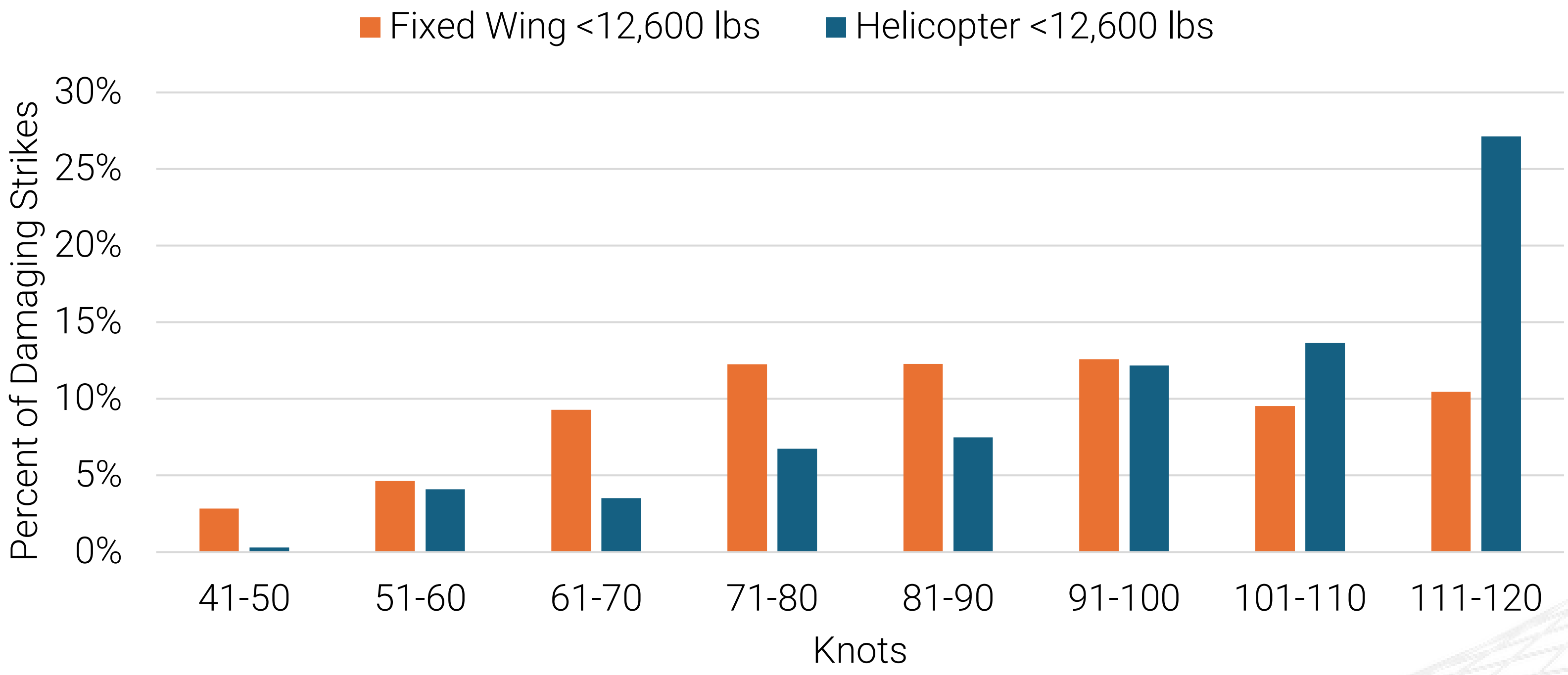
Speed

Detail of damaging strikes for 80 knots ± 40 knots
- Increasing strikes at increasing speeds, but not limited to >80 knots



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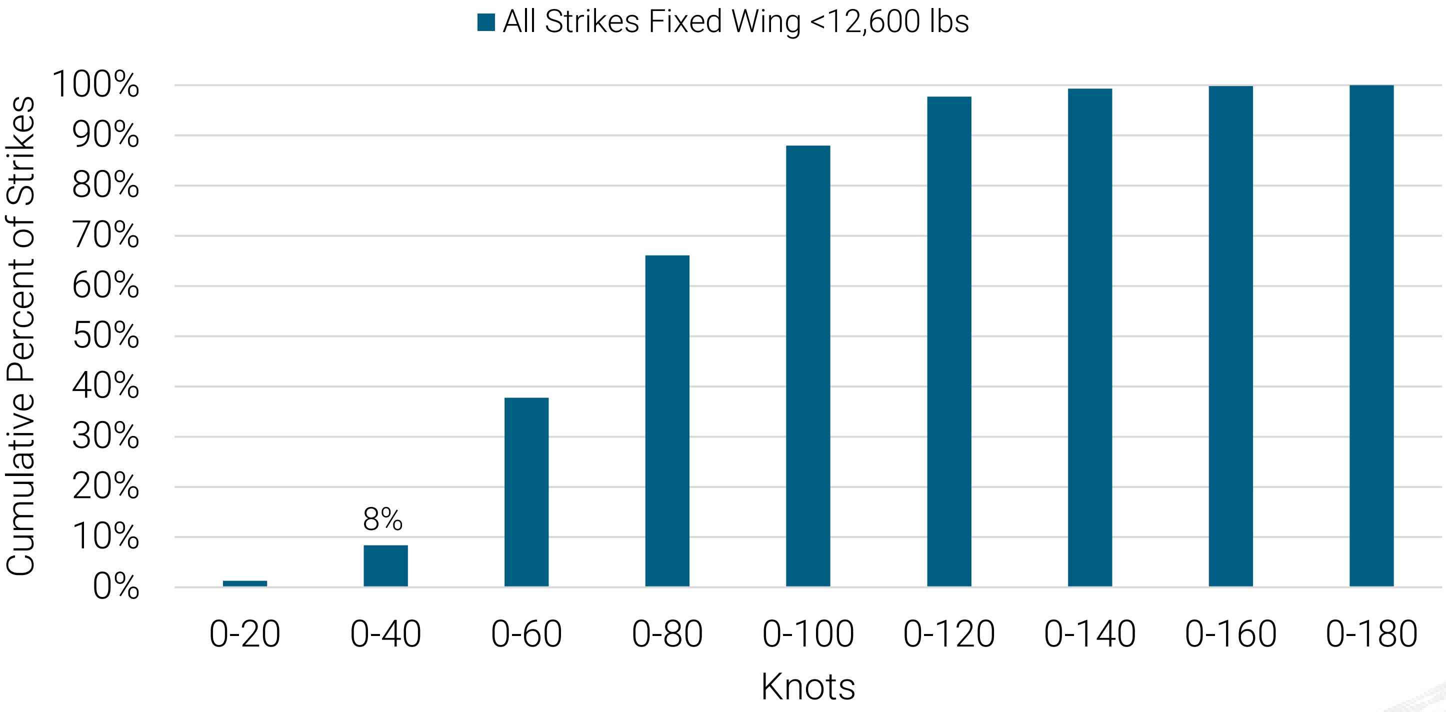
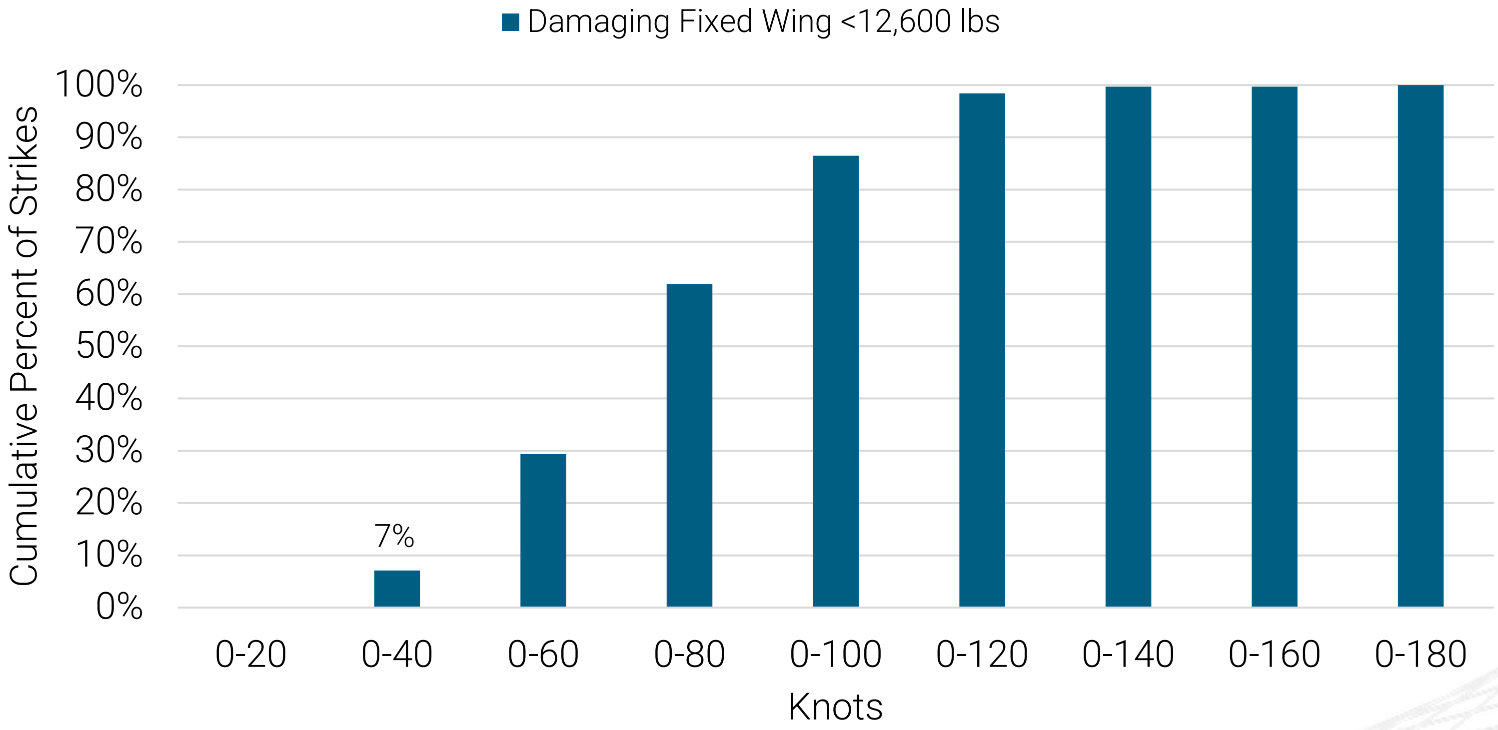
Speed

FW takeoff strikes – 92% of strikes occur at >40 knots



Speed

FW takeoff damaging strikes – 93% of strikes occur at >40 knots



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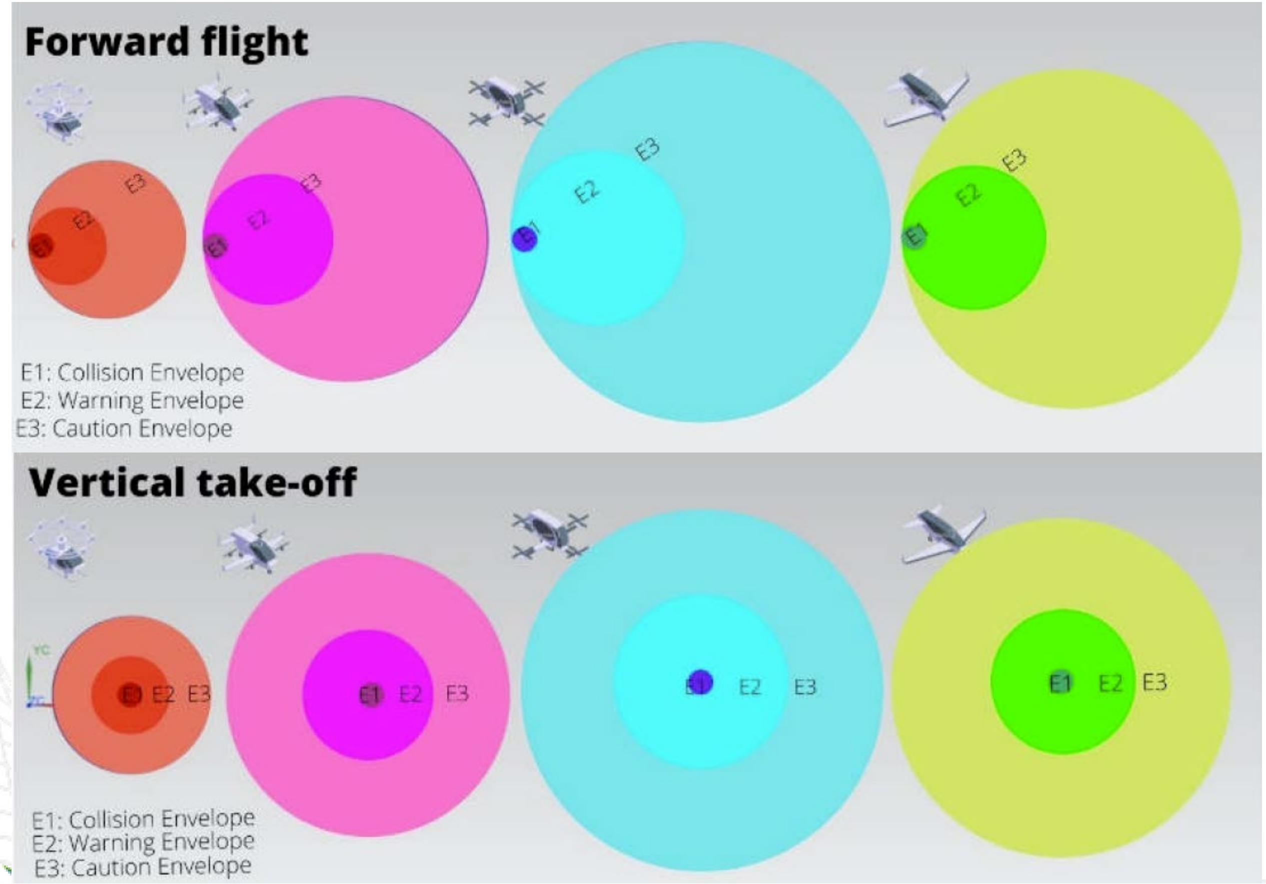
Frontal Area and Flight Angle



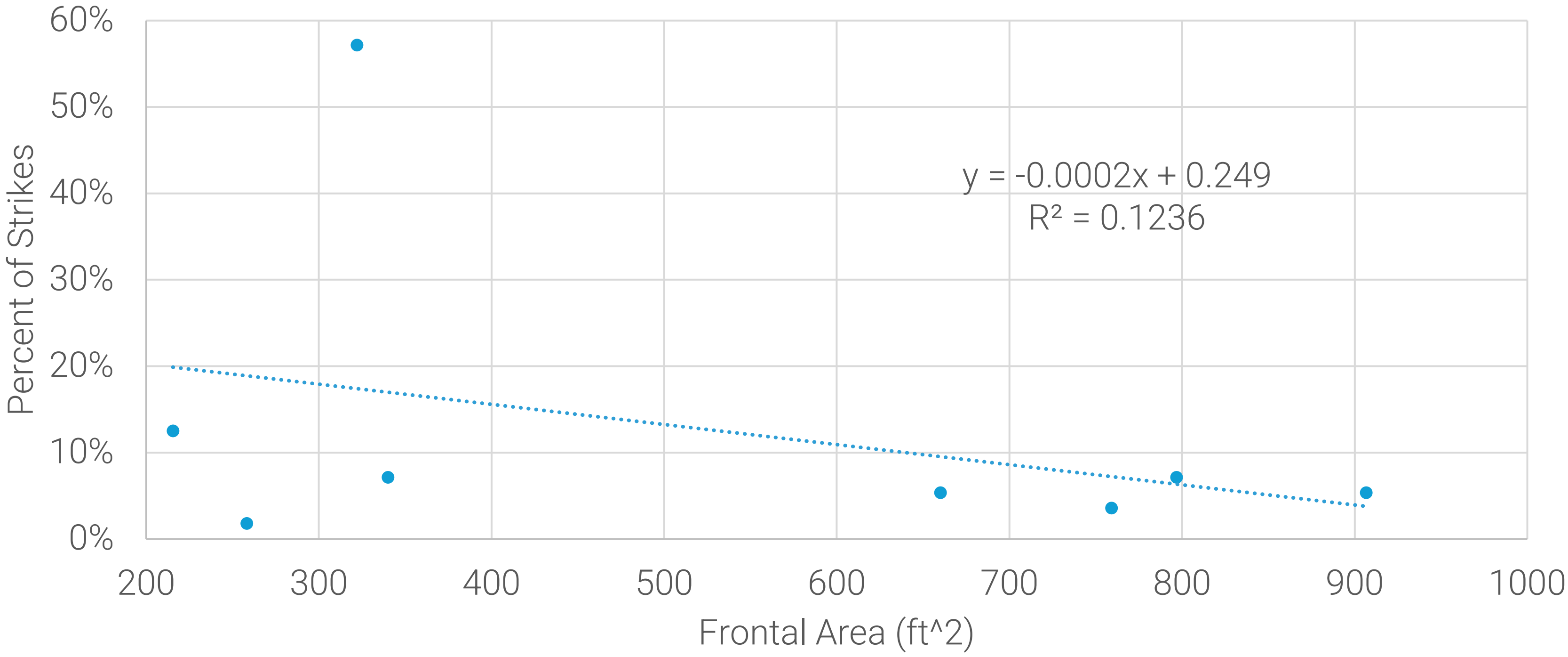
Safety envelopes. Top – forward flight, bottom – vertical flight. Source Panchal et al. 2022.

Safety envelopes as a function of horizontal/vertical speed, aircraft size, and frontal surface of aircraft

Frontal surface depends on direction for AAM aircraft

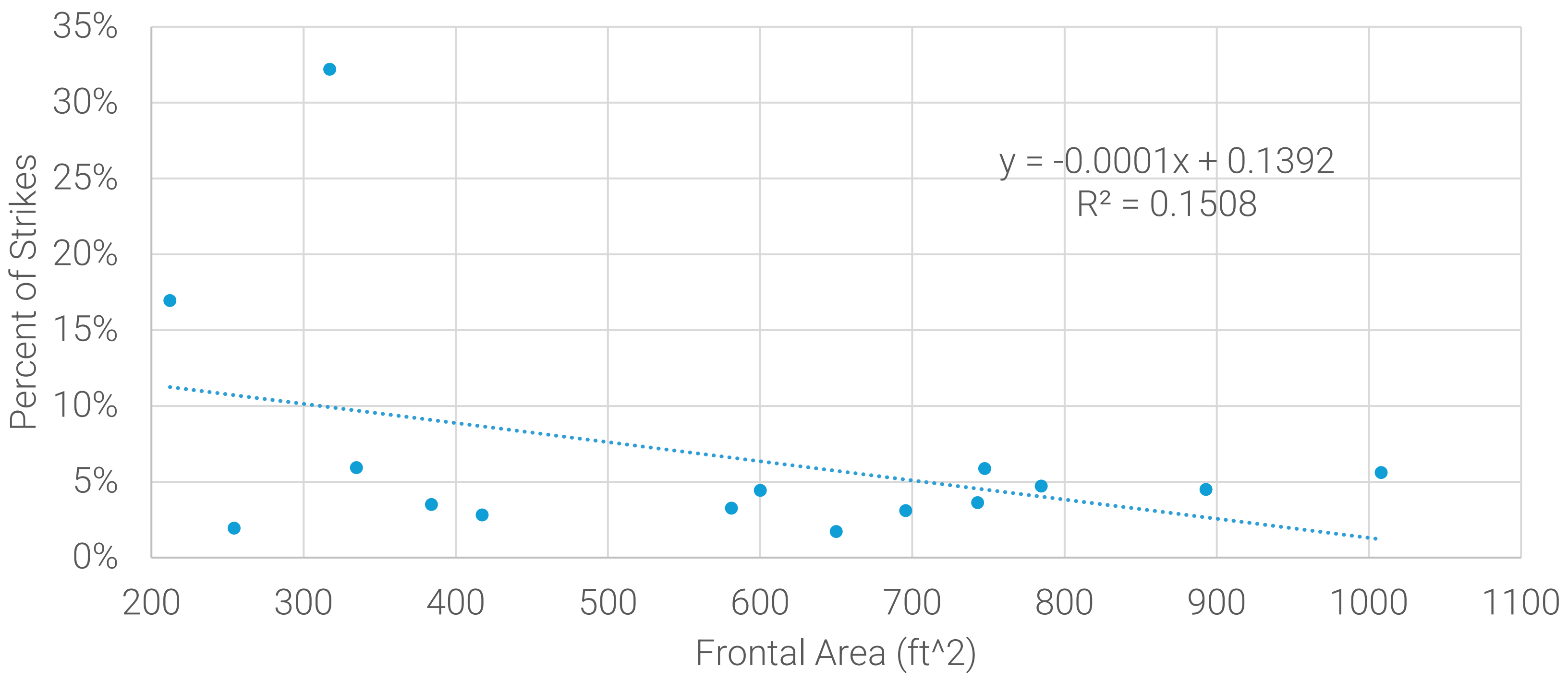
Frontal Area

% of strikes for top 20 struck FW <12,600 lbs by frontal area – horizontal flight phases – 1-500 ft AGL



Frontal Area

% of strikes for top 20 struck FW <12,600 lbs by frontal area – vertical flight phases - 1-500 ft AGL



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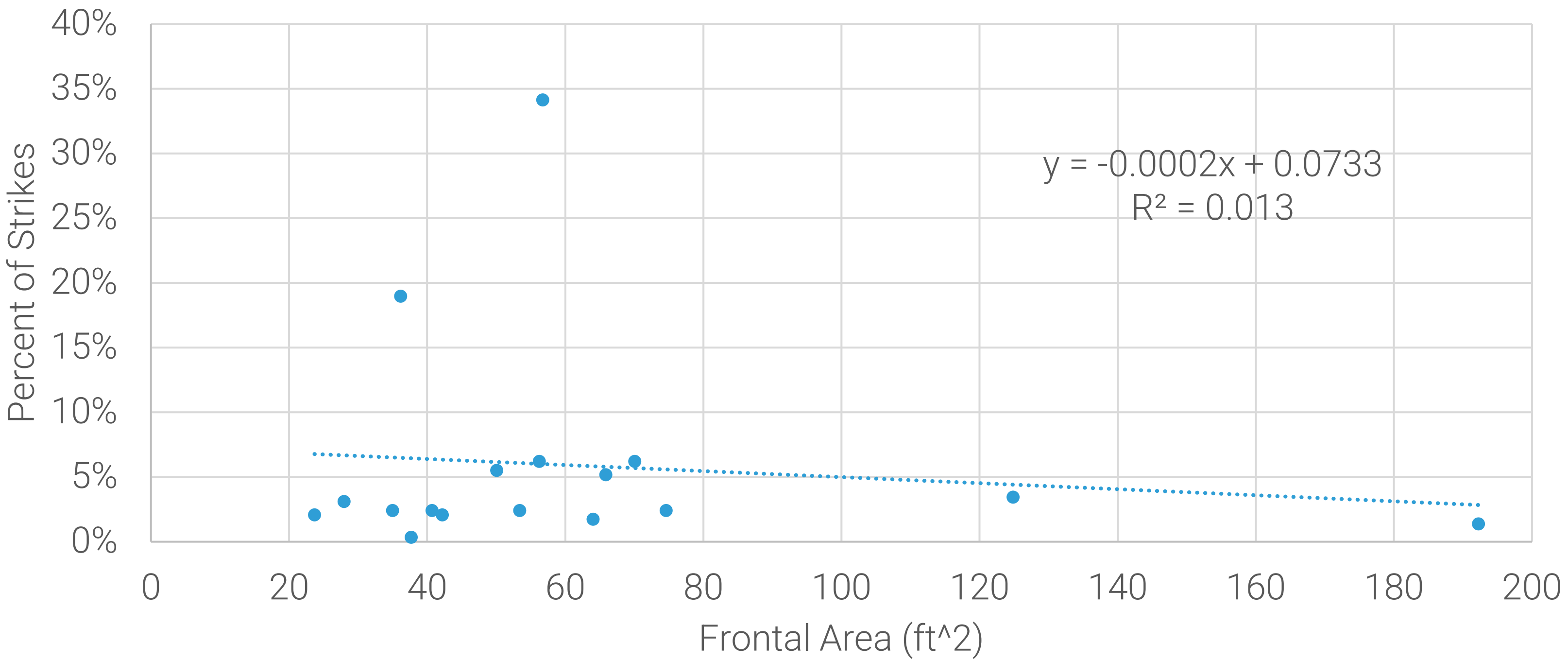
Frontal Area

% of strikes for top 20 struck helicopter <12,600 lbs by frontal area – horizontal flight phases – 1-500 ft AGL



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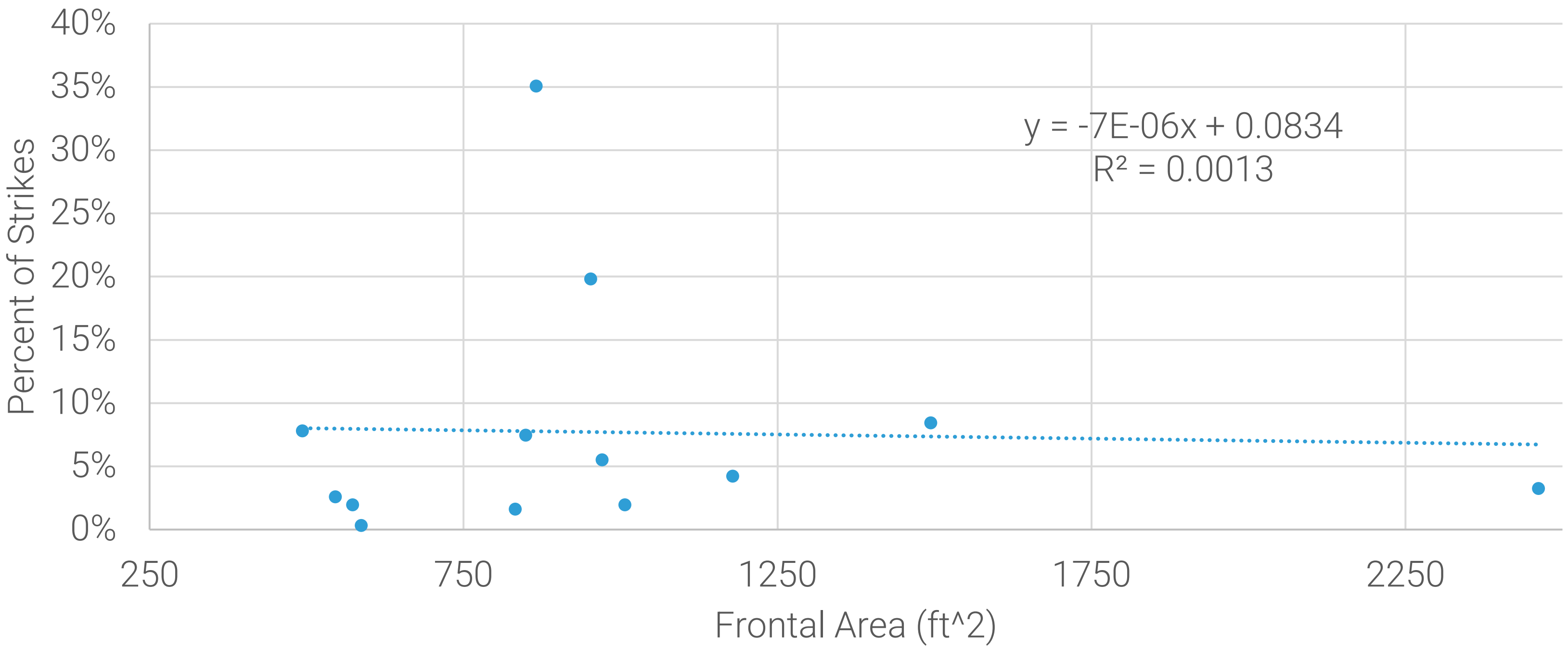
Frontal Area

% of strikes for top 20 struck helicopter <12,600 lbs by frontal area – vertical flight phases – 1-500 ft AGL



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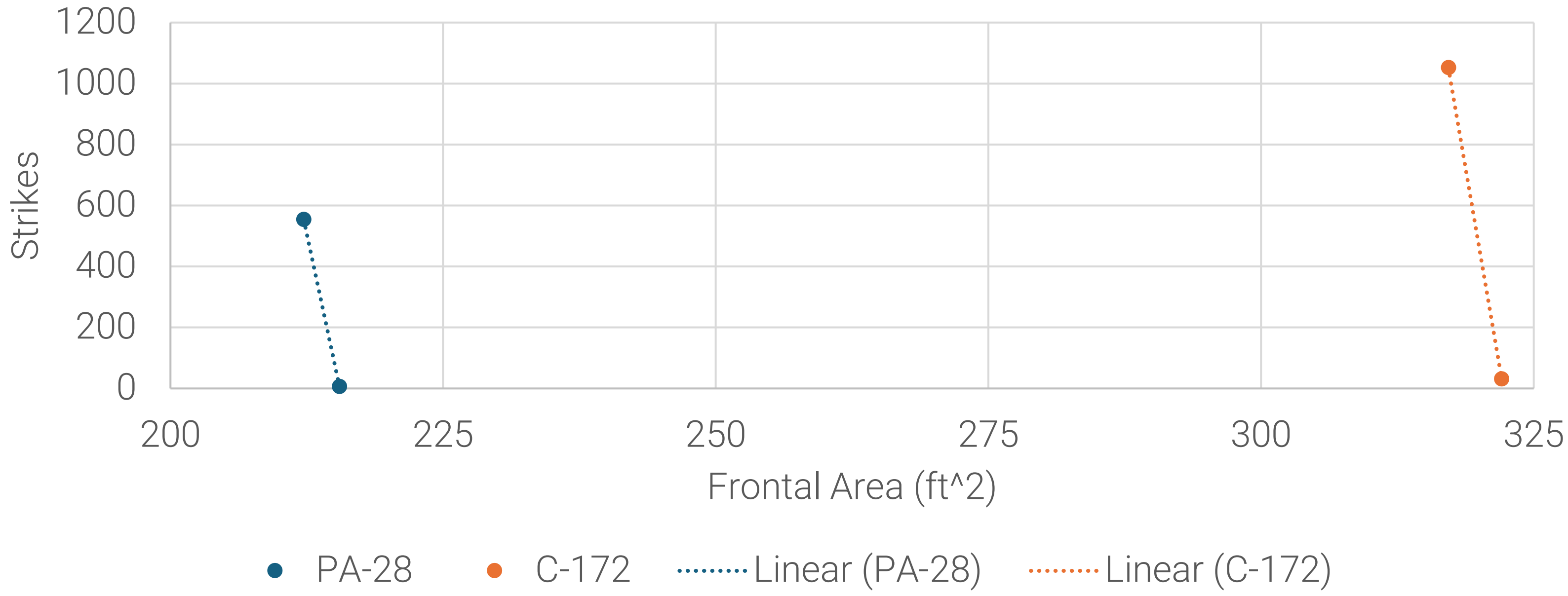
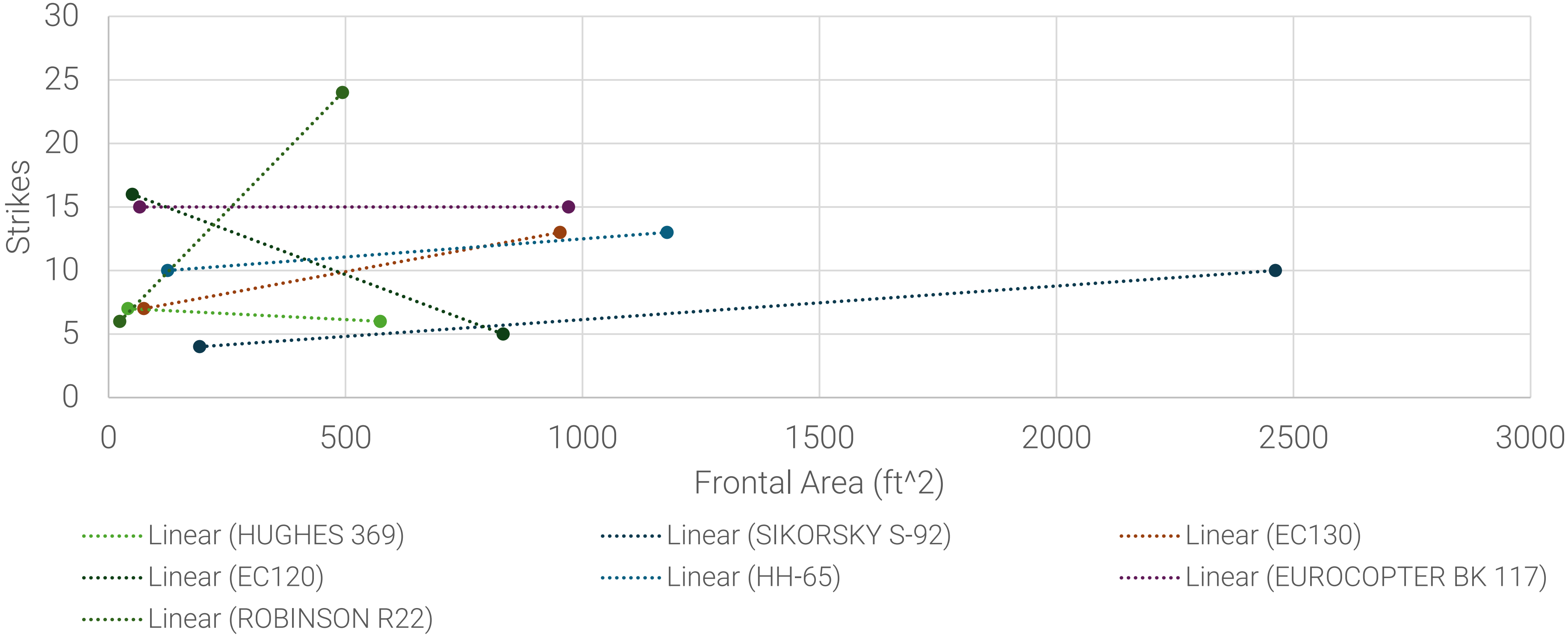
Frontal Area

Representative FW aircraft strike comparison in horizontal and vertical flight phases – More strikes in vertical phases despite smaller estimated frontal area



Frontal Area

Representative helicopters strike comparison in horizontal and vertical flight phases – mixed bag results associated with frontal surface area



Aircraft-Wildlife Conflict Index

Aircraft Movement Rate (ACMR)	x	Animal Movement Rate (AMR)

- # aircraft per unit time
- Aircraft type
  - Frontal area?
  - Material?
- Aircraft operations
  - Phase of flight
  - Height
  - Speed

x

- # of birds per unit time
- Wildlife type (species)
  - Mass
  - Flock size
- Species operations
  - Ability to avoid strikes
  - Height
  - Speed/Direction

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Support for Aircraft-Wildlife Conflict Index

Dolbeer (various publications)
“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.”

Groll et al. (2025)
“Pilots and air traffic controllers conduct operations with consideration of numerous objectives, such as operational efficiency, mission accomplishment, and safety (including wildlife strike mitigation). **It is likely unacceptable, therefore, to prohibit flight operations due to wildlife activity except in exceptional circumstances**.

Aircraft-Wildlife Conflict Index Applications

FlySafe

- Near-real time and forecast wildlife risk data for Belgium, the Netherlands, and Germany
- Time-based plots of wildlife intensity by altitude
- Limitations – coarse resolution

German Aerospace Center Simulations

- Take-off delays are feasible if:
  - imposed for high-risk strikes only
  - bird movement can be predicted reliably

Refining First Principles

- What data inputs do we need?
  - Electric, quiet flight
  - Within urban area movements – wildlife presence
- Do AAM aircraft require differing temporal and spatial scales?
  - Enroute – landscape scale monitoring
  - Flights of <15 minutes and low altitude
- How do we collect that data, collate store and analyze it?
  - Strike reporting in a completely decentralized system
- How to fuse and integrate cross disciplinary data sets to better predict those areas most likely to have aircraft-wildlife conflict?

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Aircraft-Wildlife Conflict Index

Aircraft Movement Rate (ACMR) x Animal Movement Rate (AMR)

Success is operationalizing the information to better predict and adapt prior to accidents

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Additional Literature

- Dolbeer, R.A. (2025). Wildlife strikes involving civil rotorcraft: implications for Advanced Air Mobility Operations. FAA Airports Technical Center publication [in press].
- Groll, M., Stepanian, P., & Metz, I. (2025). Wildlife Strike Mitigation in AAM: Key Technology Gaps and Proposed Solutions. 1-17. 10.4050/F-0081-2025-107.
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- Panchal, Isha & Metz, Isabel & Ribeiro, Marta & Armanini, Sophie. (2022). Urban Air Traffic Management for Collision Avoidance with Non-cooperative Airspace Users.