NTSB National Transportation Safety Board

Office of Aviation Safety

Bird-Strike Certification Standards and Damage Mitigation

John O'Callaghan

Aircraft Performance

Topics

- Trajectory of accident flight
- Bird-strike airframe certification standards
- Variables affecting structural damage sustained during a bird-strike
- Precautionary strategy for minimizing damage in advance of a bird-strike

NTSB

Trajectory of Accident Flight

- No FDR or CVR data available
- Trajectory estimated using:
  - Radar data
  - Surveillance camera footage
  - Evidence at crash site
  - Simulation

NTSB

Trajectory of Accident Flight

Aircraft image not to scale

NTSB

Bird-Strike Certification: Part 25

- Several FARs specify bird-strike standards
- FARs 25.571 & 25.631 most relevant to this accident
- Both require continued safe flight and landing following bird-strike
- 25.571 (general structure): 4-lb bird at airplane cruise speed
- 25.631 (empennage): 8-lb bird at airplane cruise speed
- FAA: “a specific rule applying to the entire airplane would only add to the substantiation effort without providing any significant design changes”

NTSB

Bird-Strike Energy

- Speed and mass define the kinetic energy of the bird relative to the airplane ("bird-strike energy"):

$$E = \frac{1}{2} m V^2$$

Where:

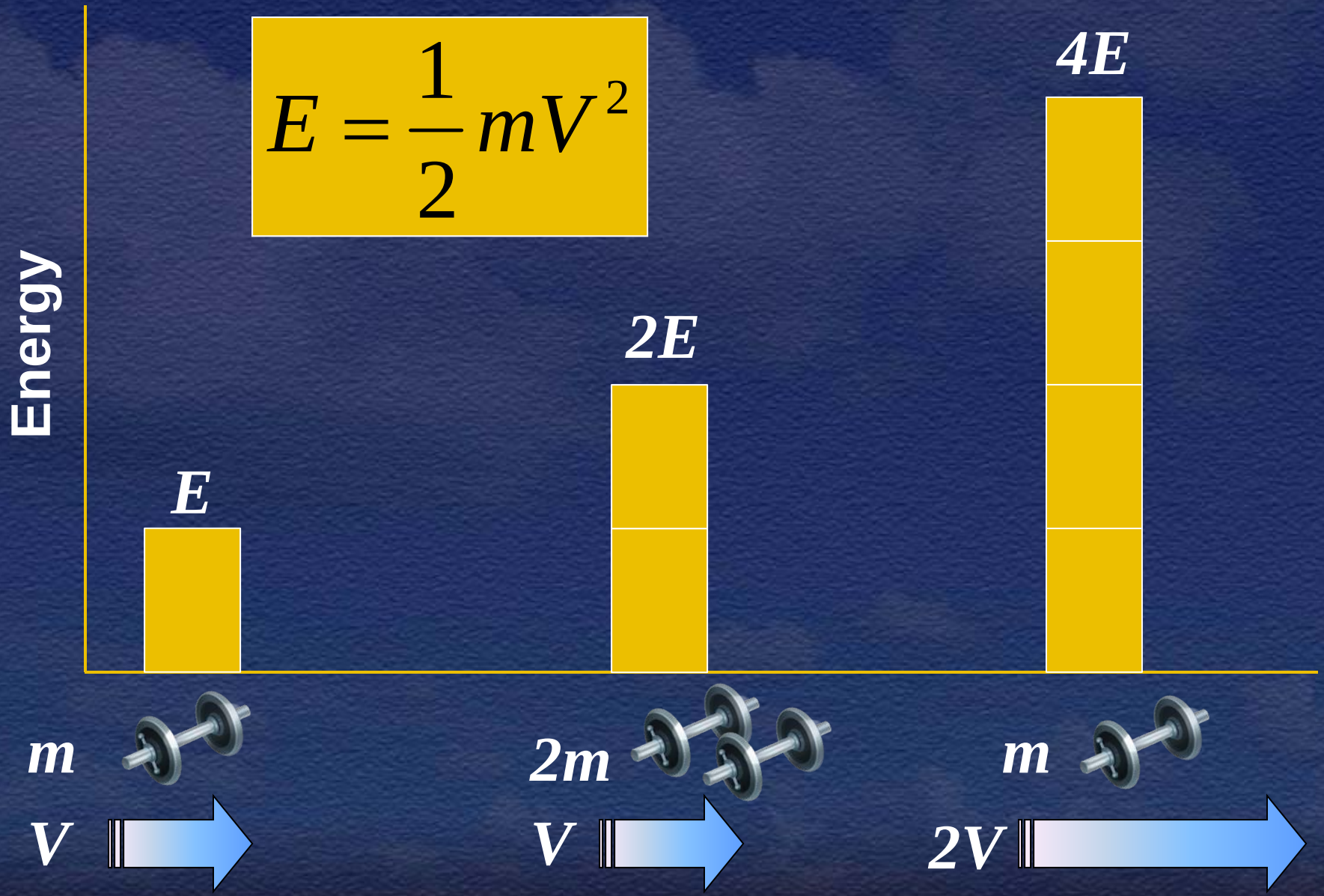
E = bird-strike energy
m = mass of bird
V = speed of bird relative to airplane

- Bird-strike damage increases with bird-strike energy

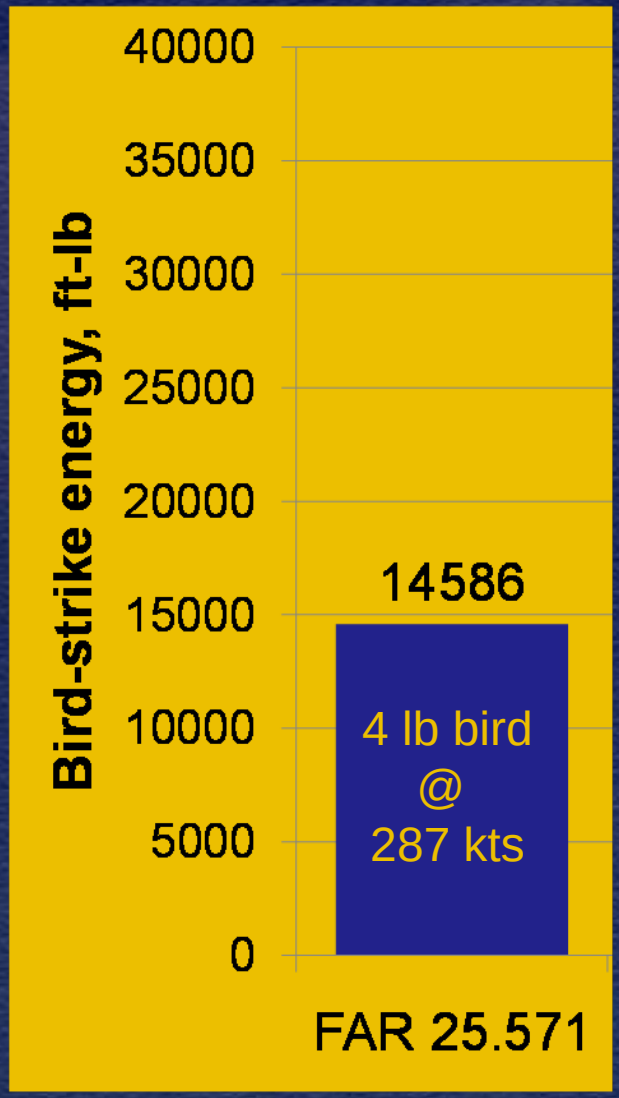
NTSB

Bird-Strike Energy

$$E = \frac{1}{2} m V^2$$

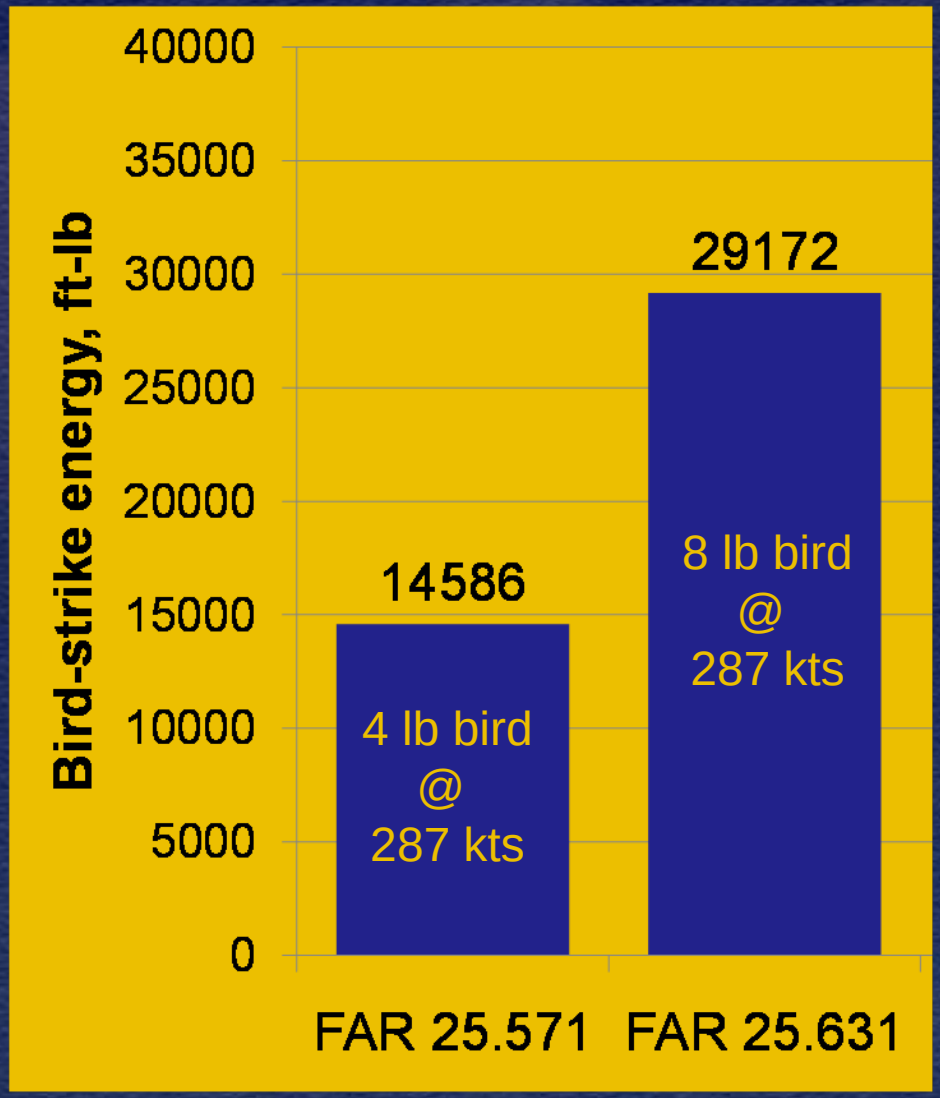


Bird-Strike Energy



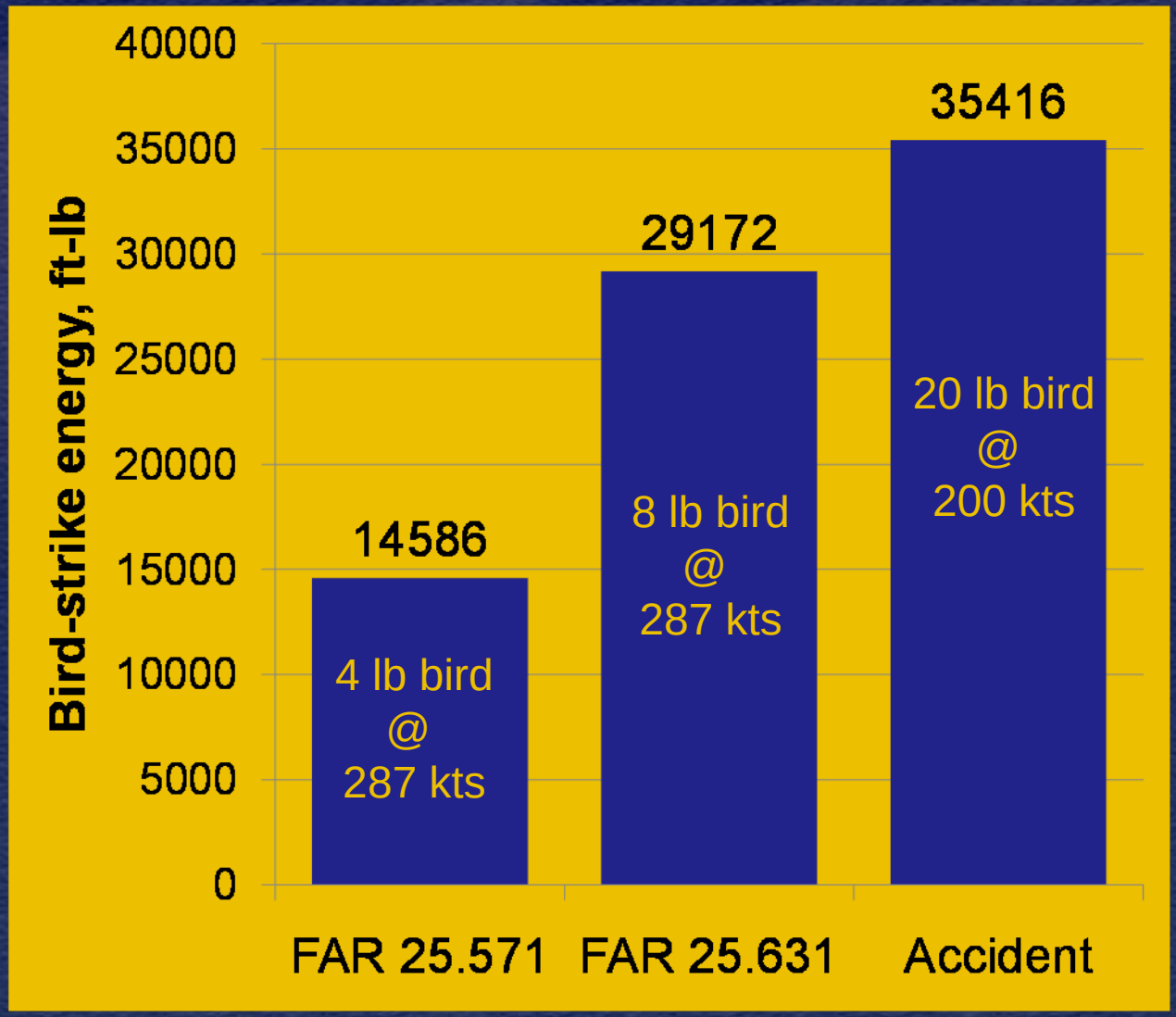
NTSB

Bird-Strike Energy



NTSB

Bird-Strike Energy



NTSB

Comparison of 4, 8, & 20 lb Birds

Weight

Cormorant
(4 lb)

Canada Goose
(8 lb)

American White Pelican
(20 lb)

Example of Bird-Strike Damage

Cessna Citation 500 wing leading-edge damage: 4 lb bird at 287 kts

Minimizing Bird-Strike Damage

- Damage should be survivable if energy is below demonstrated certification values
- To remain below demonstrated bird-strike energy, airplane speed must decrease as bird mass increases
- However, airplane must always remain at or above a safe maneuvering speed
- Other operational considerations may preclude flying at lower speeds

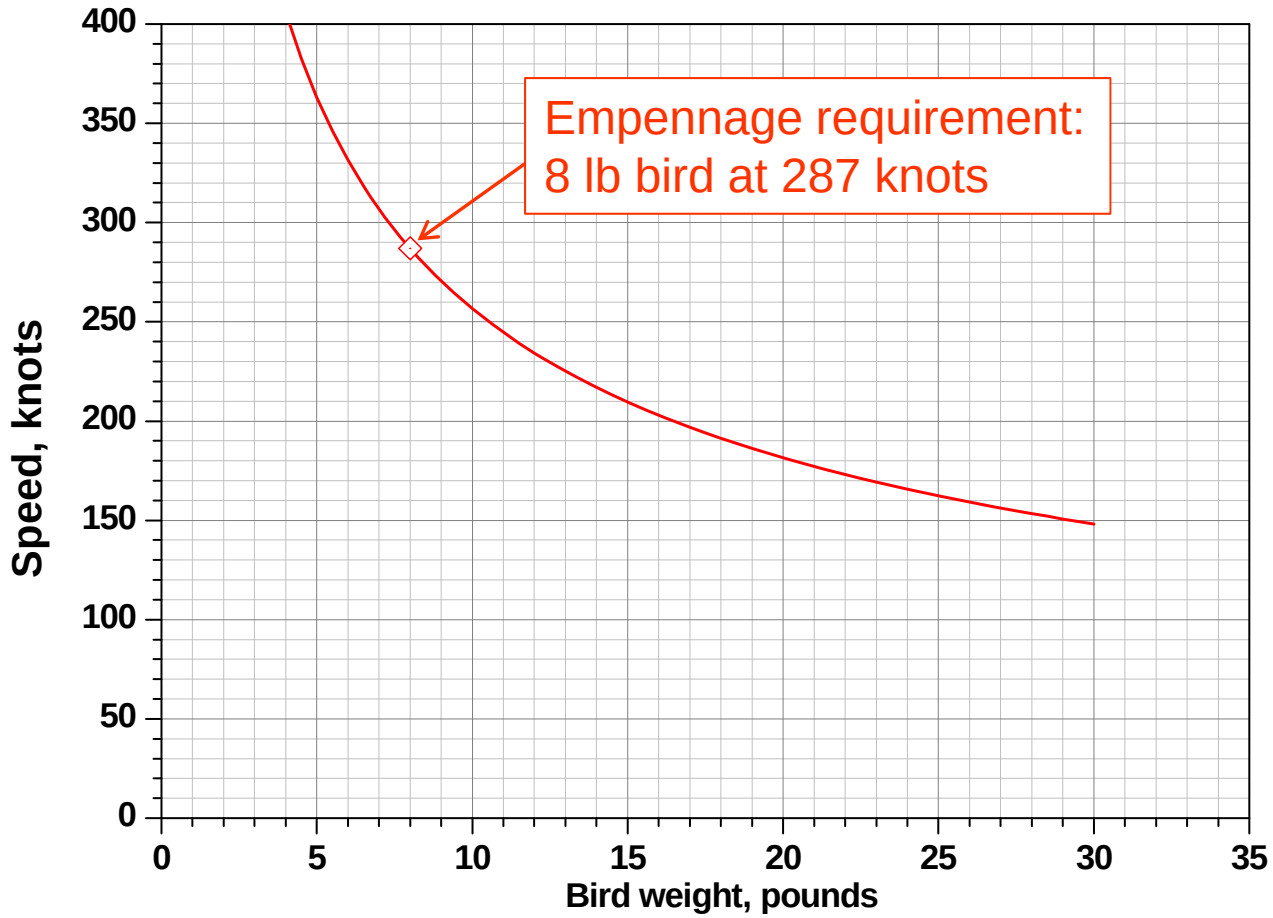
NTSB

Minimizing Bird-Strike Damage

Airplane speed and bird weight relationships for equivalent bird-strike energy

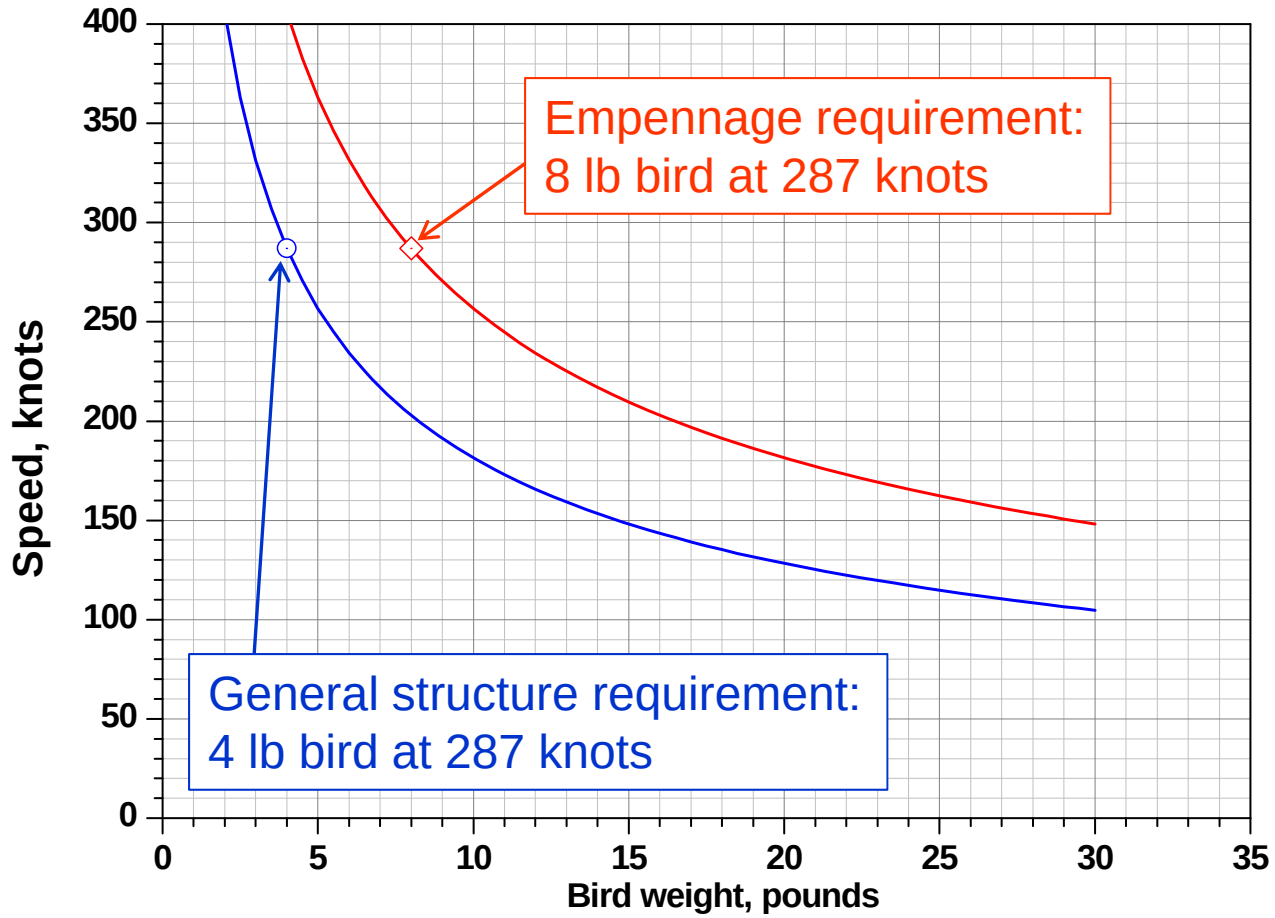
Minimizing Bird-Strike Damage

Airplane speed and bird weight relationships for equivalent bird-strike energy



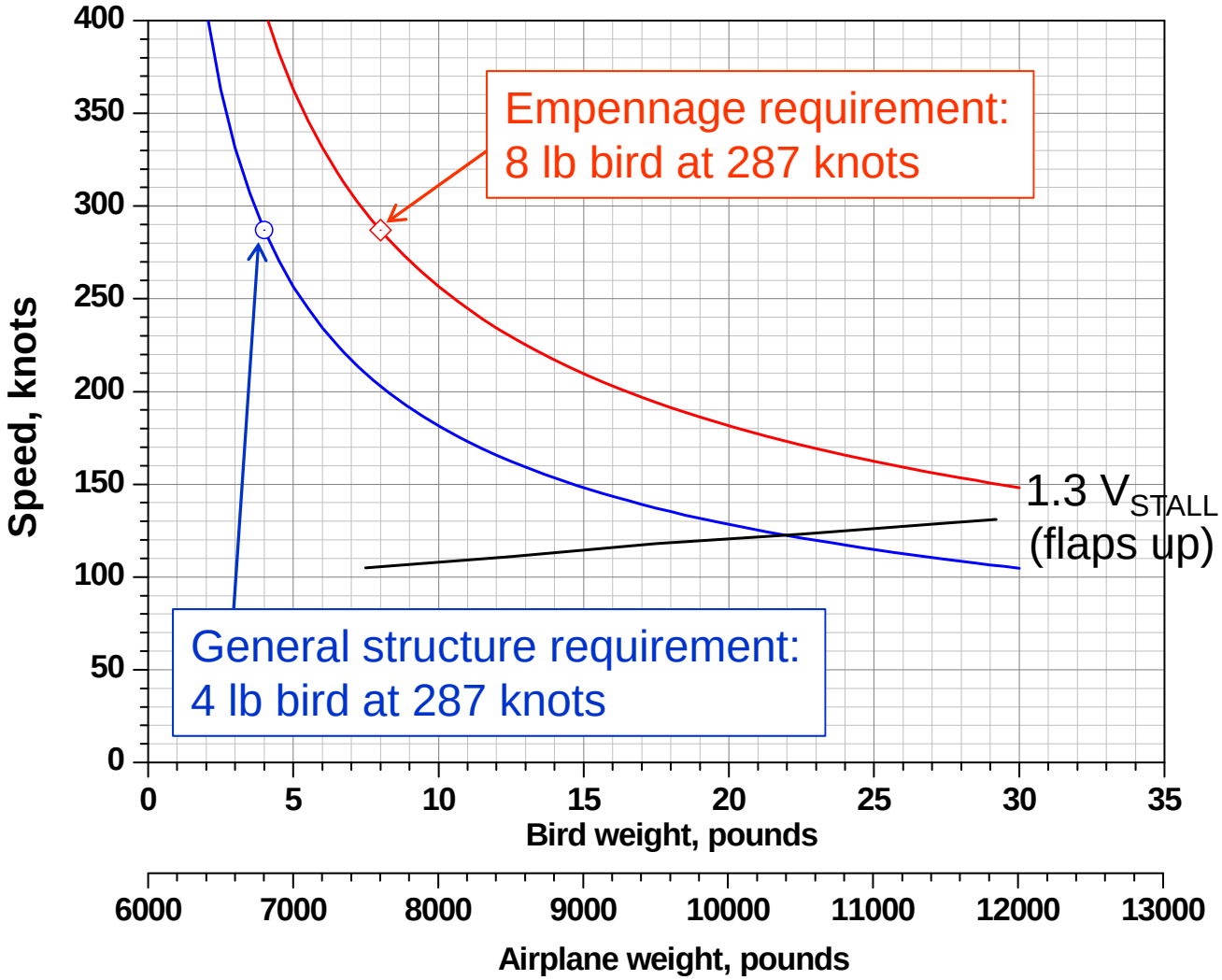
Minimizing Bird-Strike Damage

Airplane speed and bird weight relationships for equivalent bird-strike energy



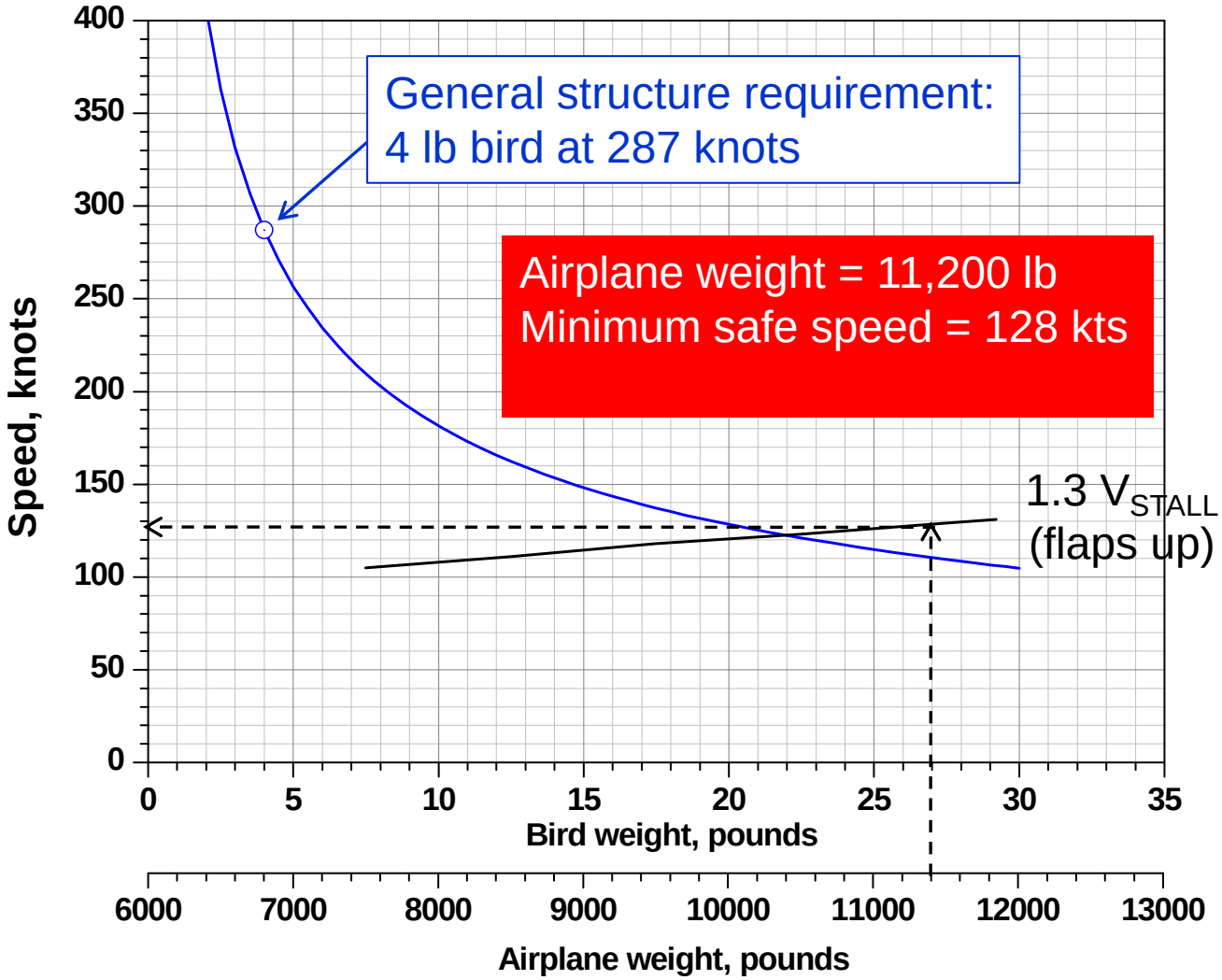
Minimizing Bird-Strike Damage

Airplane speed and bird weight relationships for equivalent bird-strike energy



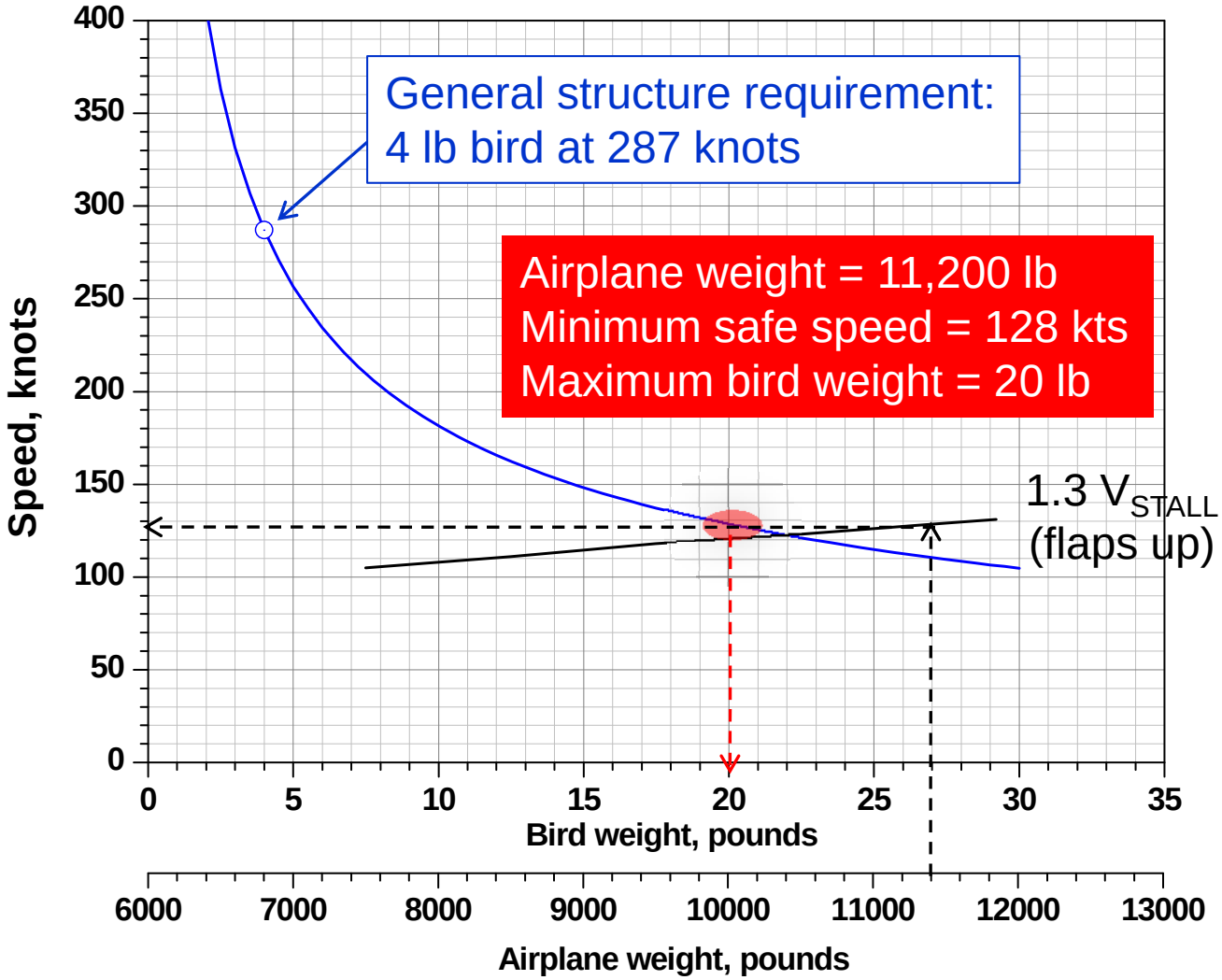
Minimizing Bird-Strike Damage

Airplane speed and bird weight relationships for equivalent bird-strike energy



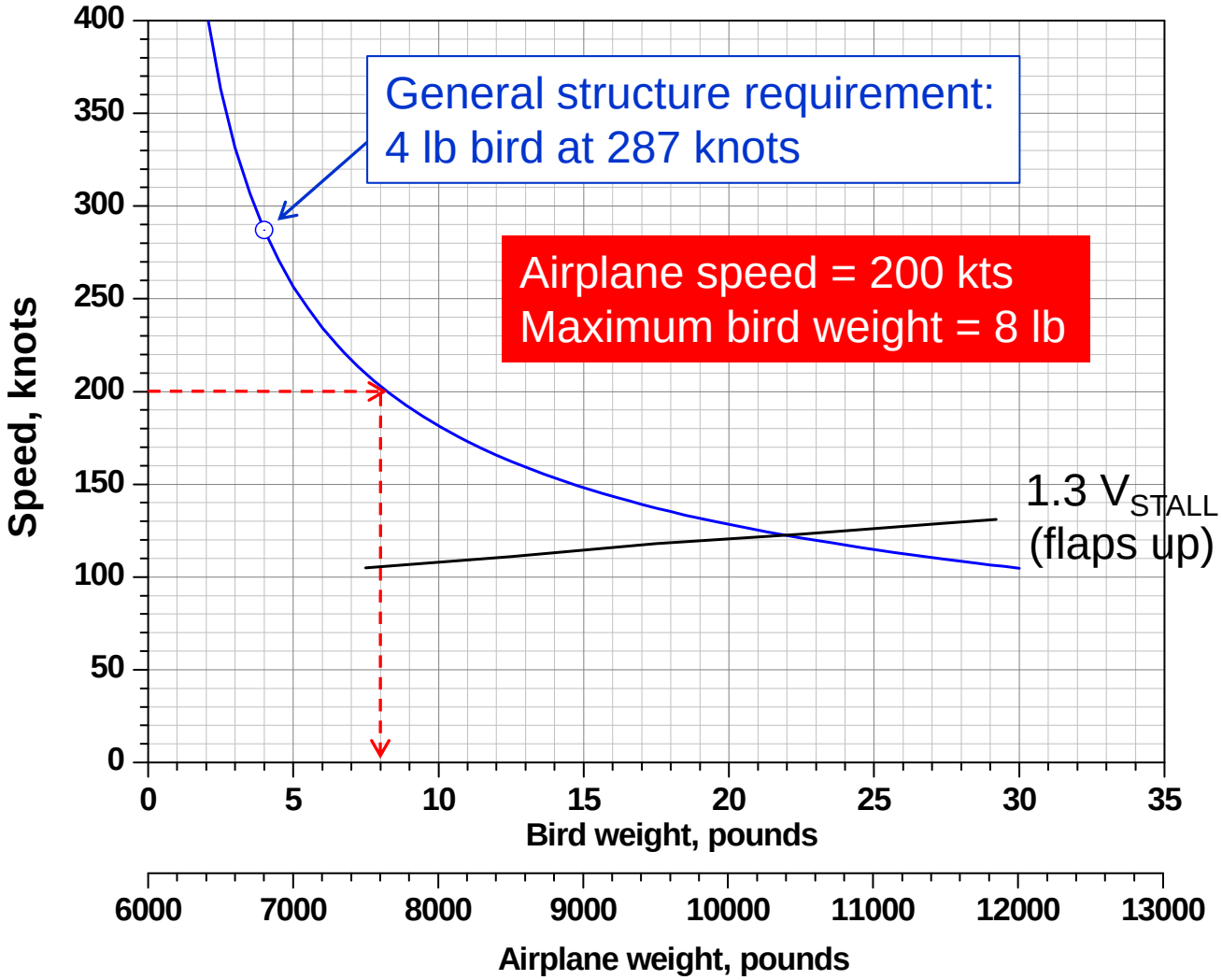
Minimizing Bird-Strike Damage

Airplane speed and bird weight relationships for equivalent bird-strike energy



Minimizing Bird-Strike Damage

Airplane speed and bird weight relationships for equivalent bird-strike energy



Summary

- Analysis of radar, video, crash site, and simulation data indicates loss of control and rolling dive following bird-strike
- Energy of bird-strike exceeded certification requirements of the Cessna 500
- FARs governing bird-strikes do not require uniform bird weights across all aircraft structures
- The risk of catastrophic damage from a bird-strike can be reduced by remaining within the demonstrated bird-strike energy envelope

NTSB

NTSB

Part 25 Bird-Strike Standards

FAR	Component(s)	Bird-strike parameters		Performance requirement
		Bird mass	Aircraft speed	
25.571(e)(1)	General structure	4 lb.	V_C @ sea level / .85 V_C @ 8000 ft	Successful completion of flight
25.631	Empennage	8 lb.	V_C @ sea level	Continued safe flight and landing
25.775(b)	Windshield	4 lb.	V_C @ sea level	Bird does not penetrate windshield
25.775(c)	Windshield	Not specified	Not specified	Minimize danger to pilots from flying windshield fragments
25.1323(j)	Duplicate pitot tubes	Not specified	Not specified	Bird does not damage both tubes

Part 23 Bird-Strike Standards

FAR	Component(s)	Bird-strike parameters		Performance requirement
		Bird mass	Aircraft speed	
23.775(h)(1)	Windshield	2 lb.	Maximum flap approach speed	Bird does not penetrate windshield
23.1323(f)	Duplicate pitot tubes	Not specified	Not specified	Bird does not damage both tubes

Part 29 Bird-Strike Standards

FAR	Component(s)	Bird-strike parameters		Performance requirement
		Bird mass	Aircraft speed	
29.631	General structure	2.2 lb.	Lesser of V_H or V_{NE} to 8000 ft.	Continued safe flight and landing (Category A); Safe landing (Category B)

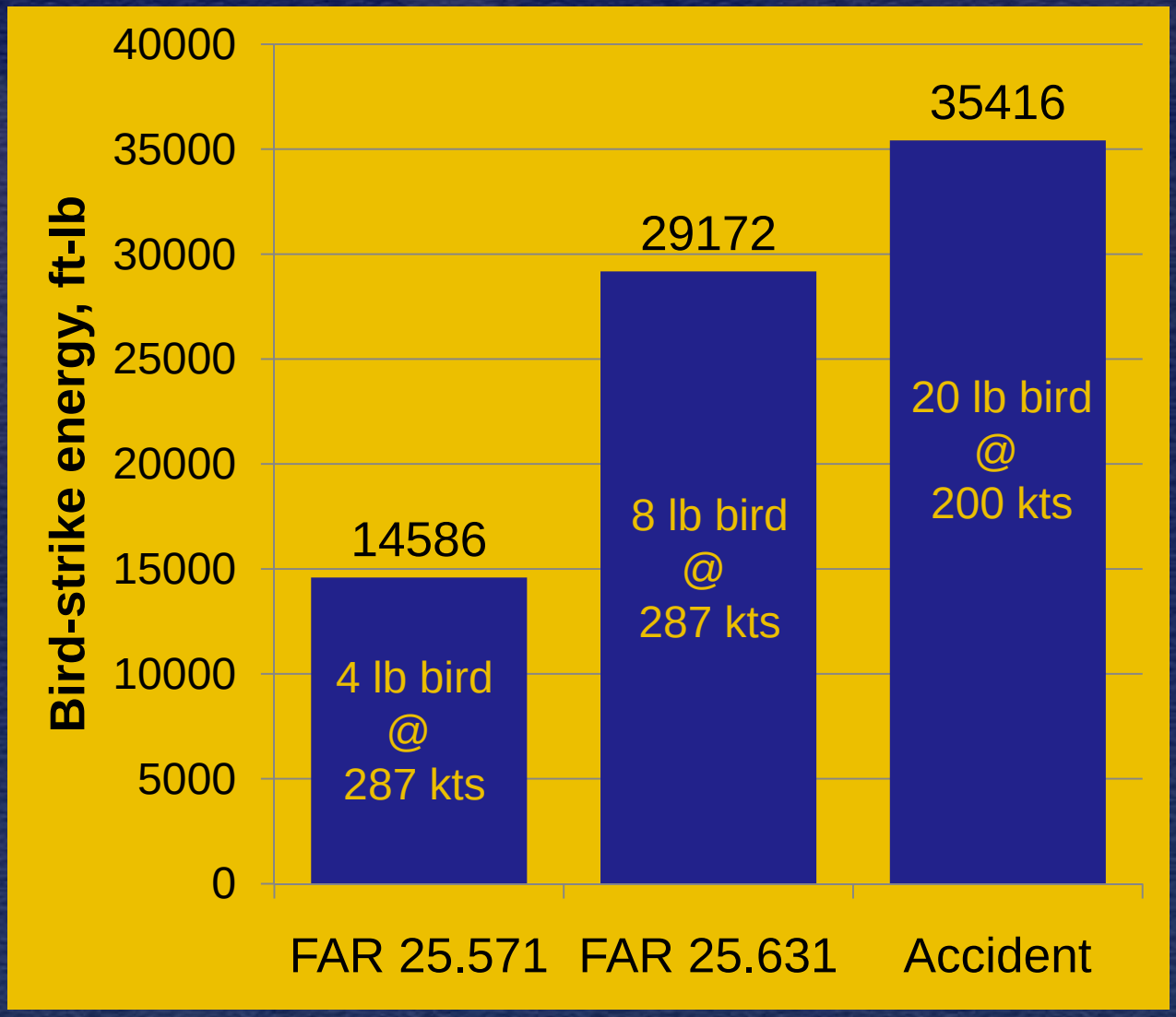
NTSB

Part 33 Bird-Strike Standards

- Bird ingestion standards for turbine engines are specified in FAR 33.76
- Standards consider multiple scenarios involving different sizes and numbers of birds, depending on engine inlet area
- Performance criteria include both safe-shutdown and run-on requirements
- This subject discussed at Public Hearing on US Airways Flight 1549

NTSB

Minimizing Bird-Strike Damage



NTSB