Development of a Safety Management System Framework (SMS) to Mitigate Bird Strikes in Urban Air Mobility

Presented By:
Bill Deng Pan
panb@my.erau.edu
Ph.D. in Aviation Student, Graduate Research Assistant,
School of Graduate Studies, College of Aviation

Research Advisor:
Flavio A.C. Mendonca, Ph.D., MBA, M.Sc.
coimbraf@erau.edu
Associate Professor, Aeronautical Science Department,
College of Aviation

EMBRY-RIDDLE
Aeronautical University

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  - Operational Hazards and Risks
- Wildlife/Bird Strike Hazard Management
- Proposed Operational Framework
- Proposed SMS Framework
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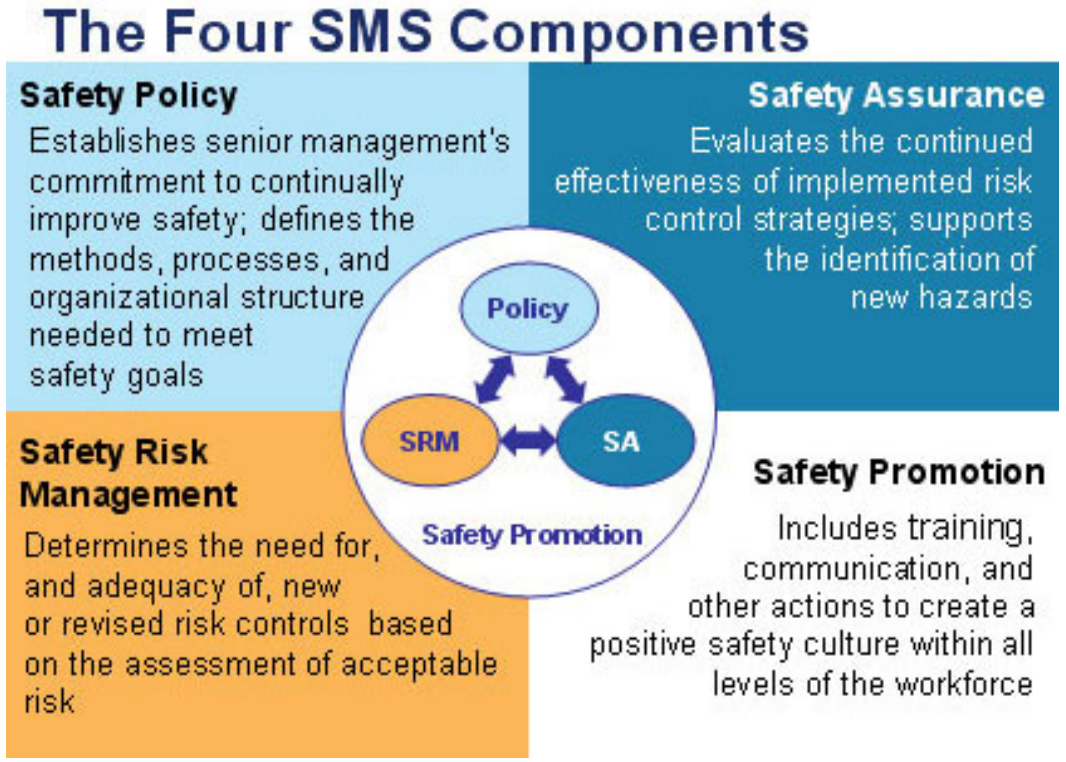
  - Safety Promotion
- Conclusion/Projected Impacts

Source: Lilian, G. (2019) *NASA and Uber Test System for Future Urban Air Transport*. NASA. https://www.nasa.gov/centers-and-facilities/ames/nasa-and-uber-test-system-for-future-urban-air-transport/

Introduction/Background

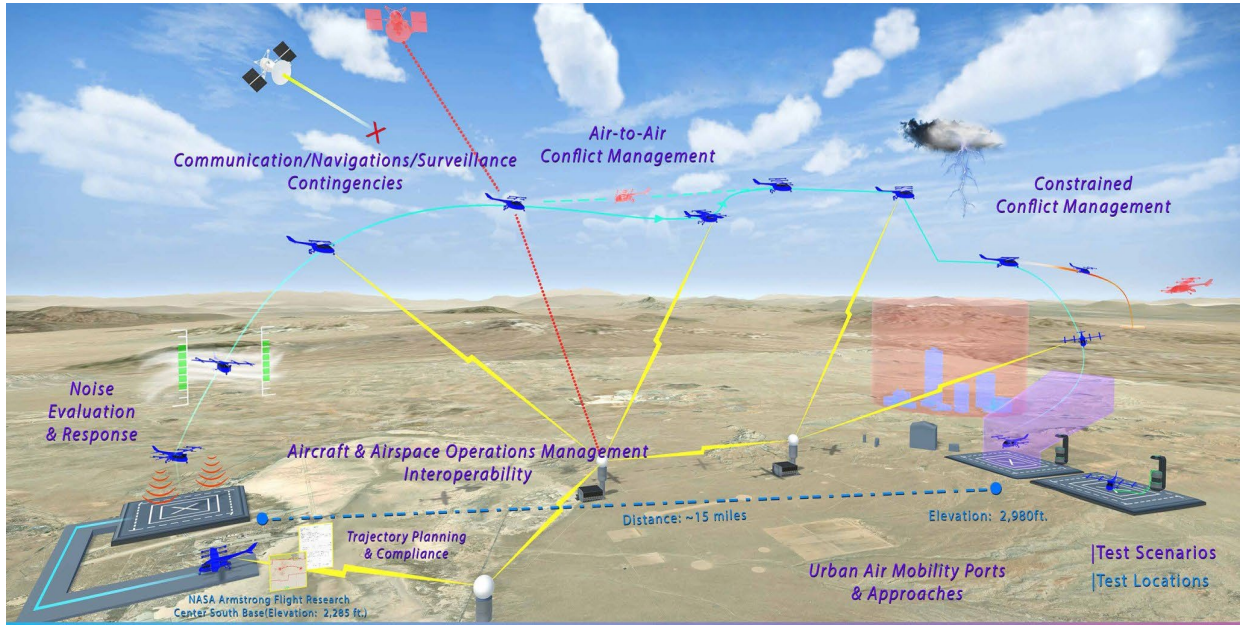
- Urban Air Mobility (UAM) is an emerging aviation technology utilizing electric vertical take-off and landing (eVTOL) aircraft to move people and cargo
- UAM implementation requires significant new infrastructure, both *physical* and *non-physical.*
    - Low-altitude operations in densely populated areas increase exposure to wildlife attractants, increasing the risk of bird strikes.
- This study aimed to develop a Safety Management System (SMS) framework tailored to UAM operations to address and mitigate bird strike risks, supporting the safe integration of UAM into the national airspace system



Source: Federal Aviation Administration (2024) *Safety Management System*. U.S. Department of Transportation. https://www.faa.gov/about/initiatives/sms/explained/components

Hazards and Risks

- UAM's low-altitude operations increase sustained exposure to wildlife threats, especially birds.
- **Vehicles frequently take off and land near:**
  - Parks, wetlands, waterfronts, and rooftops: areas that attract birds
  - Dense urban environments, where bird populations thrive due to food, shelter, and nesting sites
- **Risks are increased by:**
  - Lack of established wildlife hazard programs along UAM routes and at takeoff/landing sites
  - Aircraft vulnerabilities: exposed rotors, lightweight materials, and reliance on external sensors
  - Autonomous systems, which can be compromised by impacts to navigation or vision-based sensors



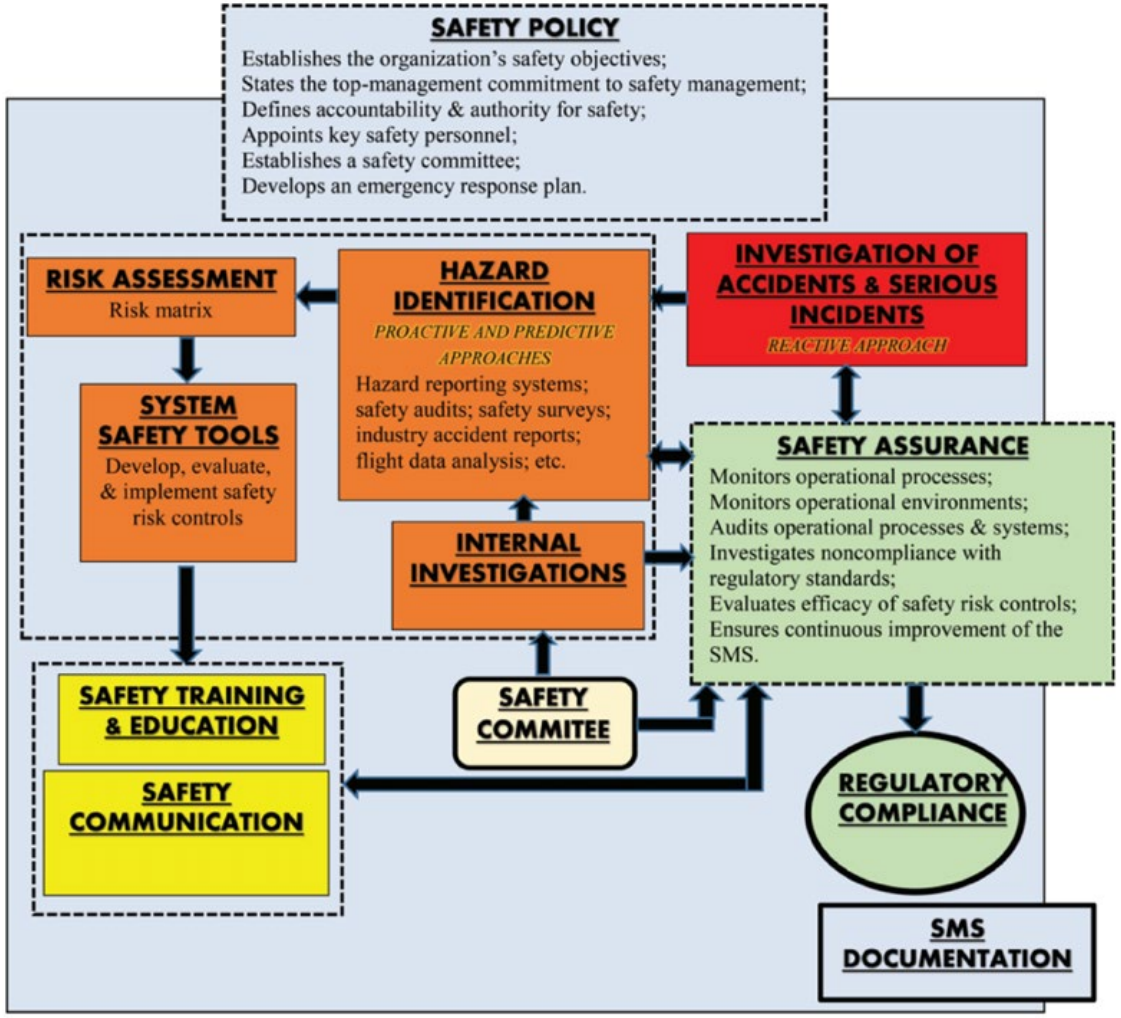
Source: National Aeronautics and Space Administration. (2020) *NASA's Urban Air Mobility Grand Challenge Advances* with *Agreement Signings*. NASA. https://www.nasa.gov/news-release/nasas-urban-air-mobility-grand-challenge-advances-with-agreement-signings/

Risk Mitigation Strategies for UAM Bird Strike Hazards

- **Technological Approaches:**
  - Use of radar and optical sensors for real-time wildlife detection
  - Predictive analytics leveraging migration, environmental, and historical strike data
- **Operational Measures:**
  - Locating vertiports away from known wildlife attractants and flyways
  - Coordinating flight schedules to avoid peak bird activity
  - Urban design strategies to deter bird activity
- **Training & Emergency Preparedness:**
  - Protocols for UAM operators to prevent and respond to strikes
  - Public awareness campaigns and onboard systems to improve passenger safety
- **Existing Tools Adaptable for UAM:**
  - WHAM-RAT: Risk assessment tool combining likelihood and consequence of strikes
  - Wildlife Hazard Assessments (WHAs) and Management Plans (WHMPs) can be adapted for UAM/vertiport environments

Proposed Operational Framework/SMS Principles

- The proposed SMS framework is designed for use by a UAM operator conducting short eVTOL flights (~35 minutes) to address general UAM safety risks and hazards specific to low-altitude operations.
- Designed to be scalable and adaptable for broader use by UAM and vertiport operators.
- Wildlife hazard mitigation is essential for safe, credible UAM integration.
- **Safety Management System (SMS) Framework:**
  - Structured approach to risk identification and mitigation
  - Data-driven and adaptive safety planning
  - Enhances public trust and operational resilience



Source. Adapted from "A Safety Management Model for FAR 141 Approved Flight Schools", by Mendonca, F. A. C. & Carney, T. Q. 2017, Journal of Aviation Technology and Engineering, 6(2), Article 3. Copyright 2017 Purdue University Press.

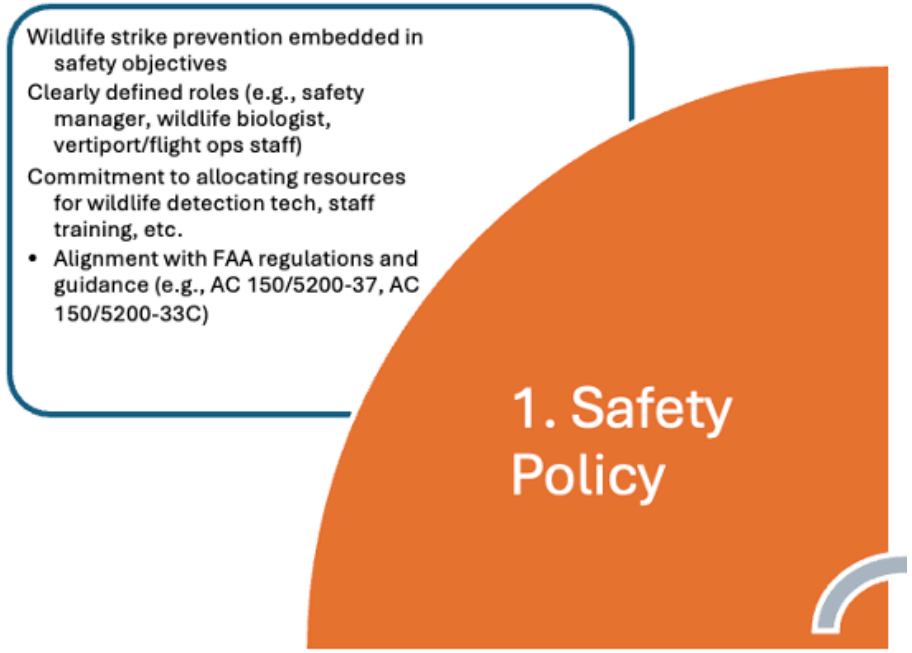
Proposed SMS Framework

Safety Policy

- Establishes organizational commitment to bird and wildlife hazard mitigation.

Key Aspects:

- **Clearly Defined Organizational Structure:** Defines key roles (e.g., Safety Manager, QAWB, crew) to ensure coordinated hazard mitigation.
- **Established Procedures:** Establishes clear, adaptive protocols for identifying, preventing, and responding to wildlife strikes.
- **Policy Regulatory Alignment:** Aligns with existing FAA airport wildlife guidance while addressing UAM-specific needs.



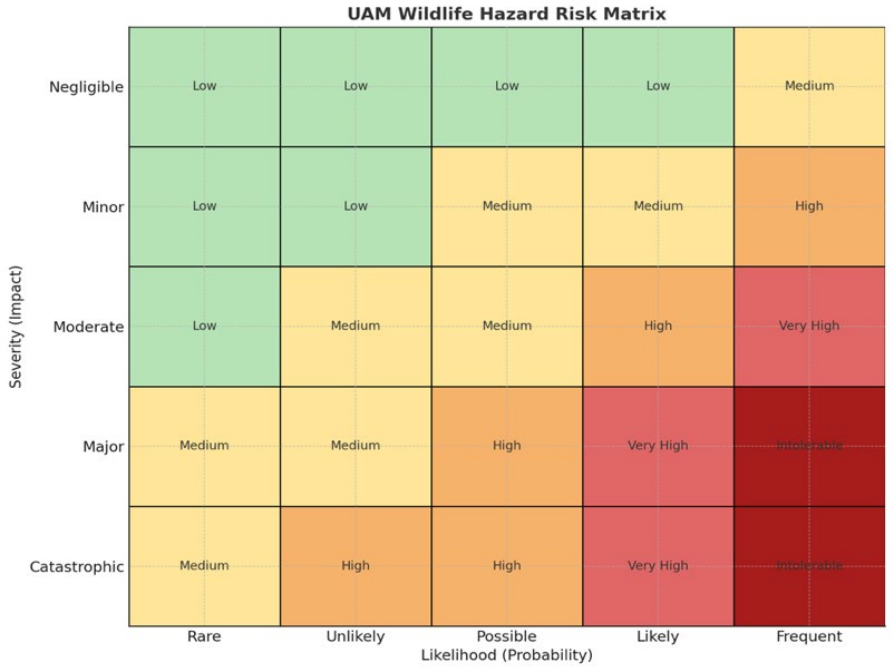
Role	Responsibilities
Senior Leadership /Executives	- Allocate resources for wildlife hazard mitigation - Endorse and enforce organizational safety priorities - Ensure SMS accountability across departments
Safety Manager	- Oversees SMS implementation and continuous improvement - Monitors wildlife hazard reports and data - Coordinates post-strike inspections and investigations - Communicates safety performance to senior leadership
QAWB	- Conducts wildlife hazard assessments and monitoring - Advises on bird activity, habitat patterns, and mitigation strategies - Collaborates with local wildlife agencies and planners - Support data analysis and risk assessments
Flight Crew / UAM Operators	- Report all wildlife sightings and strike events - Follow protocols for in-flight wildlife encounters - Participate in wildlife safety briefings and training
Vertiport Manager / Supervisor	- Implements wildlife mitigation procedures at vertiports - Trains staff on reporting protocols and emergency response - Monitors local wildlife conditions and coordinate with Safety Manager
Maintenance Personnel	- Conduct aircraft inspections following reported wildlife strikes - Document and report findings to the Safety Manager - Assist in post-incident analyses
Administrative / Data Staff	- Enter wildlife strike data into national databases - Maintain internal wildlife hazard records and documentation

Safety Risk Management

- Focused on identifying hazards, assessing risk, and implementing controls to reduce safety threats to acceptable levels.

Key Aspects:

- **Hazard Identification:**
  Identify bird species, habitats, and attractants near flight paths and vertiports; use WHAs and wildlife strike data to assess risks.
- **Establish Monitoring & Reporting Procedures:**
  Collect and log strike/near-miss data; inspect vertiports daily for wildlife activity; centralize reporting for trend analysis.
- **Operational Risk Assessment:**
  Use a formal risk matrix to evaluate strike likelihood and severity; consider operational phases, aircraft vulnerability, and secondary impacts.
- **Risk Mitigation of Operations:**
  Implement controls based on risk level—e.g., flight path adjustments, habitat management, bird deterrents, real-time detection, and staff training.
- **Tracking & Review of Risk Mitigation Effectiveness:**
  Document actions in a WHMP; review regularly; update procedures as conditions and data evolve to maintain safety performance.

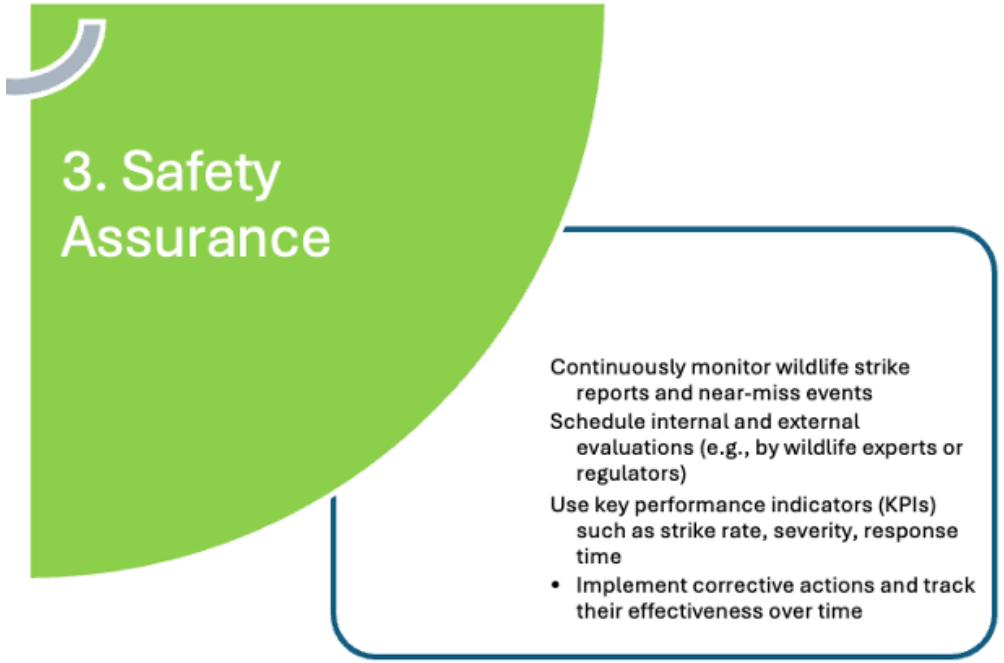


Safety Assurance

- Ensures risk controls are effective and supports continuous safety improvement.

Key Aspects:

- **Develop Key Performance Indicators (KPIs):**
  Track strike rate, severity, near-misses, response time, compliance, and high-risk species involvement.
- **Internal Audits:**
  Verify adherence to wildlife mitigation procedures (e.g., fencing, patrols, reporting).
- **External Audits:**
  Independent reviews by regulators or QAWBs assess effectiveness and SMS compliance.
- **Corrective Actions:**
  Address deficiencies with retraining, route changes, or WHMP updates; formalize and track actions.
- **Continuous Improvement Programs:**
  Use audit findings, KPI trends, and strike data to refine strategies and support industry-wide learning.



Key Performance Indicators for UAM Wildlife Strike Risk Management

KPI	Description	Measurement Unit	Benchmark / Target	Purpose / Use
Wildlife Strike Rate	Number of confirmed wildlife strikes per operational metric	Strikes per 10,000 departures	<1 per 10,000 flights	Monitor overall strike frequency
Strike Severity Rate	Percentage of wildlife strikes resulting in aircraft damage	% of damaging strikes	0% (zero damaging strikes annually)	Identify severity trends and risk exposure
Near-Miss Event Frequency	Number of reported wildlife near-miss events	Events per 1,000 flights	Decreasing trend over time	Assess potential strike risks not resulting in contact
Corrective Action Follow-Up Rate	Percentage of wildlife incidents followed by documented root cause analysis and mitigation	% of incidents with follow-up	100%	Ensure all incidents are properly addressed and improvements are implemented
Strike Hotspot Identification Frequency	Number of new high-risk wildlife areas identified and mapped	Locations per quarter	≤1 if warranted by data	Enhance targeted mitigation and resource allocation
Benchmark Comparison Score	Comparison of UAM wildlife strike metrics to helicopter or general aviation benchmarks	% difference or qualitative rating	Equal to or better than helicopter ops	Evaluate relative safety performance
High-Risk Species Strike Rate	*Percentage of Wildlife Strikes Involving the 50 Most Hazardous Wildlife Species in North America*	% of strikes involving the 50 most hazardous wildlife species in North America (FAA, 2018a)	0% (zero strikes annually or decreasing trend over time)	Tracks the frequency of high-risk species involved in strike events to evaluate the effectiveness of targeted mitigation strategies and prioritize species-specific hazard management.

Safety Promotion

- Builds a strong safety culture through training, communication, and shared responsibility.

Key Aspects:

- **Foster a Strong Safety Culture:**
  Foster a proactive, non-punitive reporting environment where all staff actively contribute to wildlife hazard awareness and mitigation.
- **Develop Effective Training:**
  Provide role-specific wildlife hazard training for pilots, vertiport staff, and maintenance crews, including strike prevention, response, and seasonal refreshers.
- **Establish Communication Channels:**
  Ensure consistent, two-way communication of wildlife risks through briefings, dashboards, and bulletins; engage external partners for coordinated mitigation and community reporting.

Conclusions/Projected Impacts

Effectiveness/Implementation Considerations

- **Comprehensive SMS Integration:**
  All four SMS pillars must work together and be embedded into daily operations.
- **Industry Gaps:**
  Many wildlife specialists lack SMS training; WHAs often aren't linked to broader safety systems due to resource and guidance gaps.
- **Regulatory Uncertainty:**
  UAM falls between existing aviation rules. A flexible SMS can bridge current gaps and adapt as standards evolve.
- **Operational Relevance:**
  Framework applies to both urban and regional UAM and supports onboarding of personnel new to aviation.

Projected Impacts

- **Benefits to UAM Operators:**
  - Fewer bird strikes = less damage, fewer delays
  - Improved risk assessment, real-time monitoring, and mitigation
  - Long-term cost savings, legal protection, and enhanced customer trust
- **Benefits to Vertiport Operators:**
  - Site-specific hazard controls improve safety and reduce disruptions
  - Supports compliance and readiness for evolving regulations
- **Regulatory Value:**
  - Aligns with FAA and ICAO safety frameworks
  - Informs future oversight strategies and improves wildlife strike reporting data
- **Public Impact:**
  - Boosts safety and public trust in eVTOL integration
  - Encourages safer, community-aligned infrastructure development

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Questions?

Thank You!

Bill Deng Pan

School of Graduate Studies | College of Aviation

panb@my.erau.edu

EMBRY-RIDDLE
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