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Utilizing UAS to Support Wildlife Hazard Management Efforts by Airport Operators

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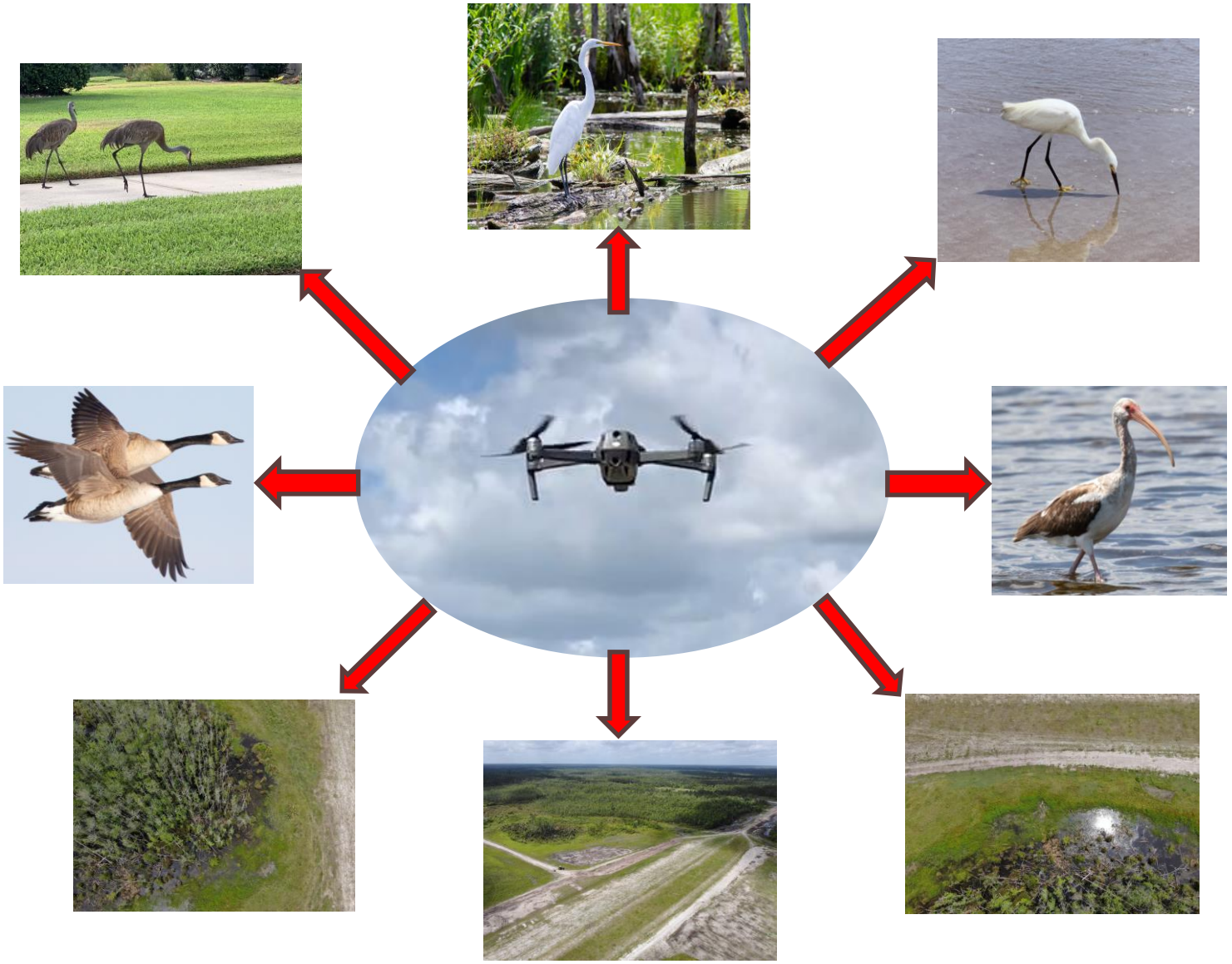

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- Flavio A. C. Mendonca, Ph.D., MBA - Assistant Professor (ERAU)
- Ryan Wallace, Ed.D. - Associate Professor (ERAU)
- Anthony Chimino – Student (BS Aeronautical Science) (ERAU)
- Jose Cabrera - Student (BS Unmanned Aircraft Systems) (ERAU)
- Robert Sliwinski, - Qualified Airport Wildlife Biologist (**Christopher B. Burke Engineering, Ltd**.)

Utilizing UAS to Support Wildlife Hazard Management Efforts by Airport Operators

- Purpose of our Study
  - To investigate how UAS technologies could be safely and effectively applied to identify hazardous wildlife species to aviation operations as well as potential wildlife hazard attractants within the airport jurisdiction.






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- Concept of Operations (ConOps)
  - ConOps → "*a description of the nature of UAS operations and the resulting impacts on relevant stakeholders and the environment*" (Hamilton et al., 2020)
    - ConOps include methods of operation, flight pattern, and safety risk management
      - Airborne and processing sensors
        - DJI Mavic 2 Enterprise
          - Visual and thermal cameras
  - Our team utilized a trailer with different pieces of equipment, which included an ADS-B flight box and two television (TV) sets

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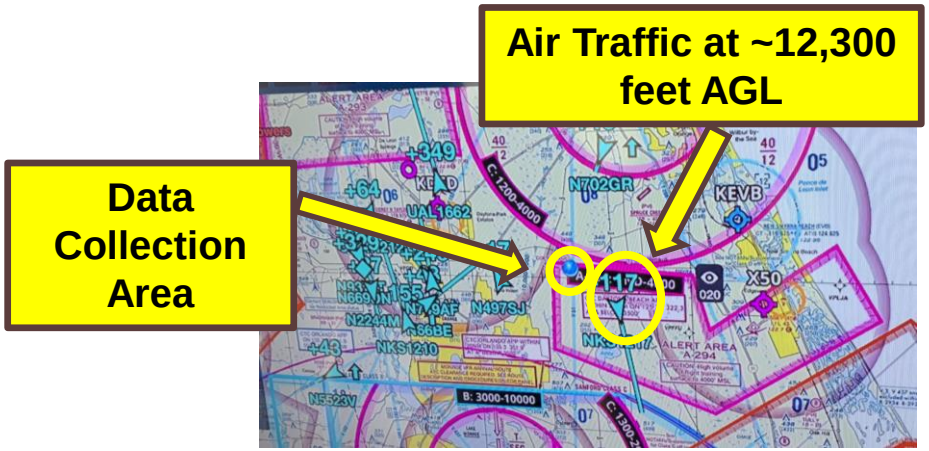
- Concept of Operations (ConOps)
  - Risk Mitigation
    - Crew Resource Management
    - Site surveys
    - Flight risk assessment tool (FRAT)
    - Automatic Dependent Surveillance – Broadcast (ADS-B) flight box
    - A visual observer



		0	1	2	3	4	Rating
Operational Factors	Type of Operation	Proficiency	Demo	Recurrency / Subsequent	Training	Initial Experimental or Service Learning Flight	
	Duration of Operation	< 1 hour	1 - < 2 hours	2 - < 4 hours	4-6 hours	> 6 hours	
	Simultaneous Operations	1 UA		2 UAs	3 UAs		
Crew Factors (any member)	Hours of Rest in Last 24 Hours (from prior duty)	> 14	> 12 - 14	> 10- 12	> 8 - 10	8 or less	
	# of Flights in UAS category (multi-rotor vs. fixed-wing)	> 50	50 - 41	40 - 31	30 - 20	< 20	
	# of Flights in Last 90 Days	> 12	> 7 - 12	> 5 - 7	> 3 - 5	3 or less	
	Student Crew	VO		PMC		RPIC	
	Total UAS Hours	> 50	40 - 50	30 - 40	20 - 30	< 20	
Environmental Factors	Surface wind (% of OEM UAS max; if not OEM prescribed)	50% or < 8 kts	60% or 9 - 12 kts	70% or 13 - 15 kts	80% or 16 - 19 kts	90% or > 20 kts	
	Weather Forecast for Operation	14 CFR 107 Minimums					
	Surrounding Area	Flat, no obstacles	Flat, with obstacles	Hilly or mountainous	Urban	Confined	
						Total Risk Score →	
No unusual hazards. Use normal flight planning and operational procedures. Requires PIC signoff.							< 21
Elevated risk. Conduct flight planning with extra care. Review personal minimums and operating procedures to ensure that all standards are being met. Consider alternatives to reduce risk. Requires UAS-S Program Coordinator signoff or, for operations outside of the local area, their designee.							21-35
Conditions present much higher than normal risk. Conduct flight planning with extra care and review all elements to identify those that could be modified to reduce risk. If available, consult with a more experienced pilot or instructor for guidance before flight. Develop contingency plans before flight to deal with high risk items. Decide beforehand on alternates and brief crewmembers on special precautions to be taken during the flight. Consider delaying flight until conditions improve and risk is reduced. Requires Department Chair signoff.							> 35

FRAT

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- Exploratory Field Campaign
  - Data collected at Coe Field airport

Source: Skyvector.com

Source: Google Earth

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- Airborne Data Collection
  - UAS was flown automatically in a basic grid pattern and manually
  - Flights were completed using the “DJI’s Go 4 software” through the smart controller
  - Estimated flight time was 22 to 28 minutes
  - The UAS controller was hooked up via an HDMI cable to a TV set that was placed inside the trailer
  - At least one member of the team was inside the trailer monitoring the TV and writing down any necessary observations on a data collection sheet

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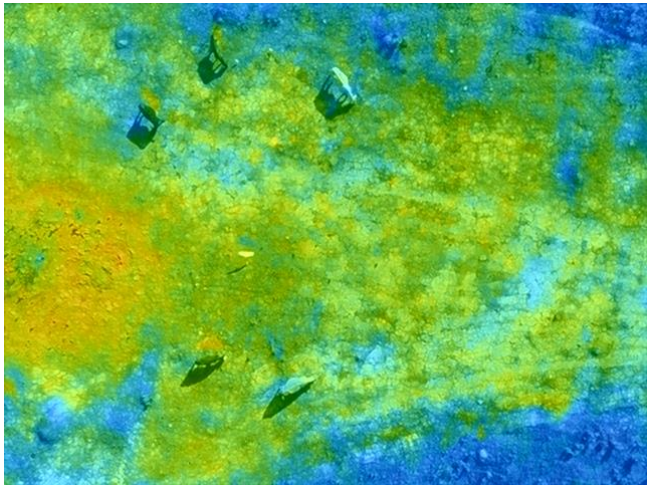
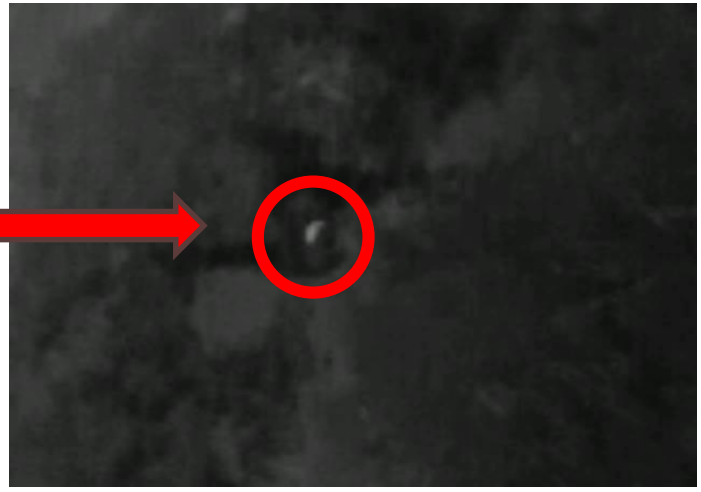
- Airborne Data Collection
  - Our team could identify the presence of cattle at Coe Field airport





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- Airborne Data Collection
  - Cattle Egrets → listed as the 14th most hazardous wildlife species to aviation operations in the U.S.

Utilizing UAS to Support Wildlife Hazard Management Efforts by Airport Operators

- Airborne Data Collection
  - White Ibises ⟹ this highly sociable bird species forage in groups in areas of standing water

Utilizing UAS to Support Wildlife Hazard Management Efforts by Airport Operators

- Airborne Data Collection
  - Sandhill Cranes ➡ fifth most hazardous wildlife species to aviation operations

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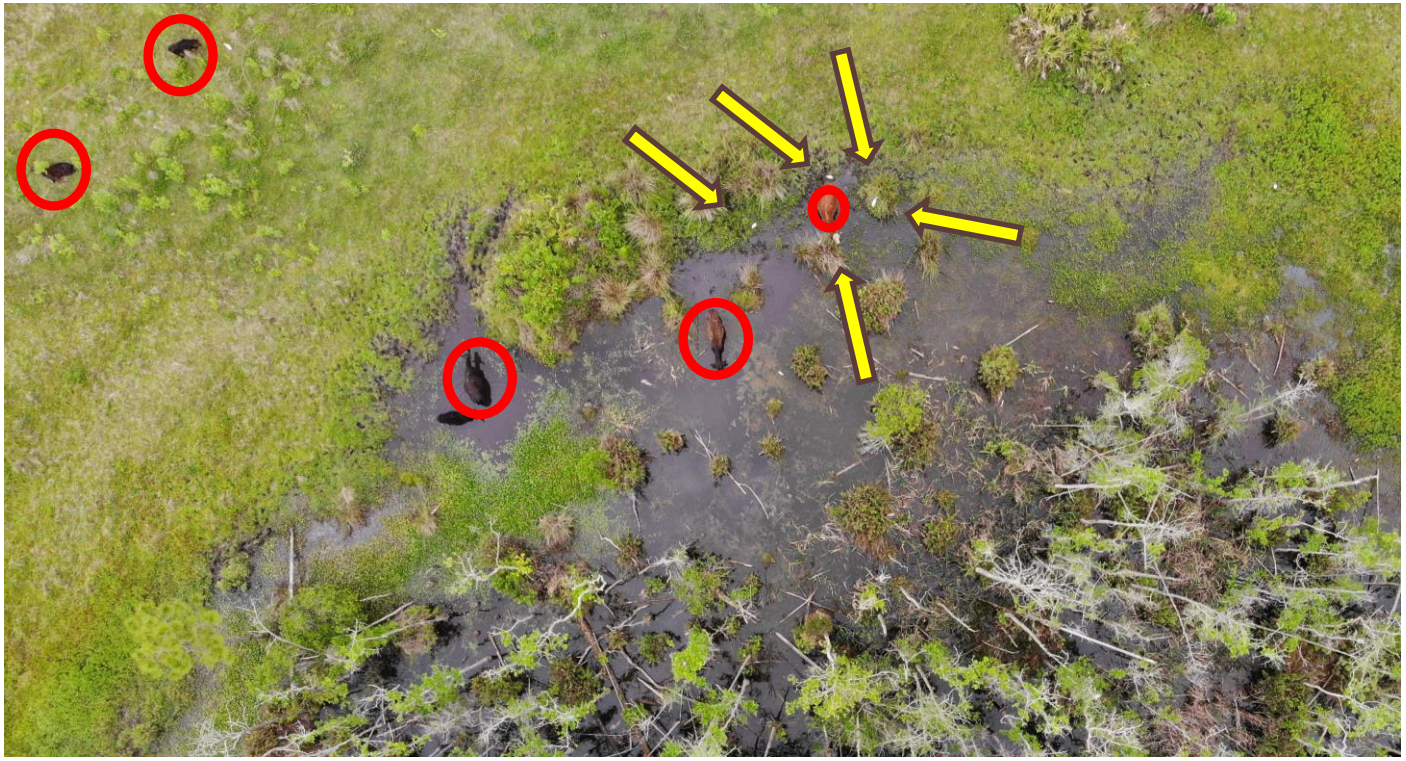
- Airborne Data Collection
  - "*Land-use practices and habitats are the key factors determining the wildlife species and the size of wildlife populations that are attracted to airport environments*" (Cleary & Dolbeer, 2005)



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Utilizing UAS to Support Wildlife Hazard Management Efforts by Airport Operators

- Aircraft Operations at Coe Field Airport
  - There was no aircraft operations at Coe Field airport during data collection
    - Our team had to mitigate risks associated with radio-controlled aircraft at the airport

Utilizing UAS to Support Wildlife Hazard Management Efforts by Airport Operators

- Conclusion and Key Findings
  - A bird's eye view can help a QAWB overcome several issues during a WHA
    - Obtain information in areas that are difficult to access by ground-based means
    - Identify habitats and land uses and their influence on wildlife behaviors
    - Observe wildlife species that do not congregate in groups
    - Observe different wildlife species and habitats simultaneously
    - Facilitate the identification of wildlife species
    - Obtain images that can be further analyzed and incorporated into the WHA report
  - The safety risk management strategies implemented certainly helped mitigate risks during data collection

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- Limitations
  - Reduced effectiveness during data collection using the thermal camera
  - Reduced opportunities for data collection
  - The support of a QAWB during data collection is needed

    - Full report ➡ https://faachallenge.nianet.org/wp-content/uploads/FAA_2021_TechnicalPaper_EmbryRiddleAeronauticalUniversity.pdf

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Reference List

Adkins, K., Wambolt, P., Sescu, A., Swinford, C., & Macchiarella, N. D. (2020). Observational practices for urban microclimates using meteorologically instrumented unmanned aircraft systems. *Atmosphere, 11*(1008), 2-17. https://doi.org/10.3390/atmos11091008

Airbus (2007). *Flight operations briefing notes - human performance: Enhancing situational awareness*. Smartcockpit. https://www.smartcockpit.com/docs/Enhancing_Situation_Awareness.pdf

Anderson, A., Carpenter, D. S., Begier, M. J., Blackwell., B. F., DeVault, T. L., & Shwiff, S. A. (2015). Modeling the cost of bird strikes to US civil aircraft. *Journal of Transportation Research, 38*, 49-58. https://doi.org/10.1016/j.trd.2015.04.027

Audubon (2021). *White Ibis: Eudocimus albus.* Guide to North American birds: White Ibis. https://www.audubon.org/field-guide/bird/white-ibis

Aviation Accreditation Board International (AABI) (2019). *AABInternational: Accreditation criteria manual*. AABI. http://www.aabi.aero/wp-content/uploads/2019/08/AABI-201-Accreditation-Criteria-Manual-Rev.-7-19-19.pdf

Barnas, A. F., Chabot, D., Hodgson, A. J., Johnston, D. W., Bird, D. M., & Ellis-Felege, S. N. (2020). A standardized protocol for reporting methods when using drones for wildlife research. *Journal of Unmanned Vehicle Systems*, 8, 89-98. https://cdnsciencepub.com/doi/10.1139/juvs-2019-0011

Belant, J. L., & Ayers, C. R. (2014). *Habitat management to deter wildlife at airports* (ACRP Synthesis No. 52). Transportation Research Board on the National Academies. http://www.trb.org/Publications/Blurbs/170766.aspx

Blackwell, B., & Wright, S. E. (2006). Collisions of Red-tailed hawks (Buteo jamaicensis), Turkey Vultures (Cathartes aura), and Black Vultures (Coragyps atratus) with aircraft: Implications for bird strike reduction with aircraft. Journal of Raptor Research, 40(1), 76-80. https://doi.org/10.3356/0892-1016(2006)40[76:CORHBJ]2.0.CO;2

DeFusco, R. P., & Unangst, E. T. (2013). Airport wildlife population management: A synthesis of airport practice (ACRP Synthesis 39). Transportation Research Board on the National Academies. http://www.trb.org/main/blurbs/169414.aspx

Cleary, E. C., & Dickey, A. (2010). Guidebook for addressing aircraft/wildlife hazards at general aviation airports (ACRP Report No. 32). Transportation Research Board on the National Academies. http://www.trb.org/Publications/Blurbs/163690.aspx

Cornell Lab of Ornithology (2021a). Bird guide: Browse by taxonomy. The Cornell Lab. https://www.allaboutbirds.org/guide/browse/taxonomy/Cathartidae#

Cornell Lab of Ornithology (2021b). All about birds: Cattle Egret identification. The Cornell Lab. https://www.allaboutbirds.org/guide/Cattle_Egret/id

Cornell Lab of Ornithology (2021c). All about birds: White Ibis identification. The Cornell Lab. https://www.allaboutbirds.org/guide/White_Ibis/id

Cornell Lab of Ornithology (2021d). All about birds: Sandhill Crane identification. The Cornell Lab. https://www.allaboutbirds.org/guide/Sandhill_Crane/id

Cornell Lab of Ornithology (2021e). All about birds: Black Vulture identification. The Cornell Lab. https://www.allaboutbirds.org/guide/Black_Vulture/id

Cornell Lab of Ornithology (2021f). All about birds: Mottled Duck identification. The Cornell Lab. https://www.allaboutbirds.org/guide/Mottled_Duck/id

Cornell Lab of Ornithology (2021g). All about birds: Mallard identification. The Cornell Lab. https://www.allaboutbirds.org/guide/Mallard/id

DeFusco, R. P., & Unangst, E. T. (2013). Airport wildlife population management: A synthesis of airport practice (ACRP Synthesis 39). Retrieved from the Transportation Research Board on the National Academies website: http://www.trb.org/main/blurbs/169414.aspx

DeFusco, R. P., Unangst, E. T. J., Cooley, T. R., & Landry, J. M. (2015). Applying an SMS Approach to Wildlife Hazard Management (ACRP Report No. 145). Transportation Research Board on the National Academies. http://www.trb.org/Publications/Blurbs/ 173318.aspx

DeVault, T. L., Blackwell, B. F., & Belant, J. L. (Ed.) (2013). Wildlife in airport environments. Baltimore, Maryland: The John Hopkins University Press.

DeVault, T. L., Blackwell, B. F., Seamans, T. W., Begier, M. J., Kougher, J. D., Washburn, J. E., Miller, P. R., & Dolbeer, R. A. (2018). Estimating interspecific economic risk of bird strikes with aircraft. Wildlife Society Bulletin, 42(1), 94-101. https://doi.org/10.1002/wsb.859

DJI (2021). Specs: Mavic 2 enterprise advanced. DJI. https://www.dji.com/mavic-2-enterprise-advanced/specs

Dolbeer, R. A., Begier, M. J., Miller, P. R., Weller, J. R., & Anderson, A. L. (2021). Wildlife strikes to civil aircraft in the United States: 1990–2019 (Serial Report Number 26). FAA. https://www.faa.gov/airports/airport_safety/wildlife/media/Wildlife-Strike-Report-1990-2019.pdf

Dolbeer, R. A. (2020). Population increases of large birds in North America pose challenges for aviation safety. Human-Wildlife Interactions, 14(3), 345-357. https://doi.org/10.26077/53f9-edc3

Electronic Code of Federal Regulations, Title 14, Chapter I, Subchapter C, Part 33. (2021). e-CFR. https://www.ecfr.gov/cgi-bin/text-idx?node=pt14.1.33&rgn=div5#se14.1.33_176

Erbe, C., Parsons, M., Duncan, A., Osterrieder, K. S., & Allen, K. (2017). Aerial and underwater sound of unmanned aerial vehicles (UAV). Unmanned Vehicle Systems, 5, 92-101. https://doi.org/10.1139/juvs-2016-0018

Hamilton, B. A. (2020a). Airports and unmanned aircraft systems Volume 1: Managing and engaging stakeholders on UAS in the vicinity of airports (ACRP Research Report No. 212, volume 1). Transportation Research Board on the National Academies. https://www.nap.edu/ catalog/25607/airports-and-unmanned-aircraft-systems-volume-3-potential-use-of-uas-by-airport-operators

Martin, J. A., Belant, J. L., DeVault, T. L., Blackwell, B. F., Junior, L. W. B., Riffel., S. K., & Wang, G. (2011). Wildlife risk to aviation: A multi-scale issue requires a multi-scale solution. Human-Wildlife Interactions, 5(2), 198-203. https://digitalcommons.unl.edu/icwdm _usdanwrc/1311/

McEvoy, J. F., Hall, G. P., & McDonald, P. G. (2016). Evaluation of unmanned aerial vehicle shape, flight path and camera type for waterfowl surveys: Disturbance effects and species recognition. PeerJ (4), 1-21. https://peerj.com/articles/1831/

Mendonca, F., Keller, J. C., Wang, Y. (2017). Managing the risk: An analysis of bird strike reporting at Part 139 airports in Indiana (2001-2014). Journal of Airline and Airport Management, 7(1), 43-64. https://doi.org/10.3926/jairm.82

Mlambo, R., Woodhouse, I. H., Gerard, F., & Anderson, K. (2017). Structure from Motion (SfM) photogrammetry with drone data: A low cost method for monitoring greenhouse gas emissions from forests in developing countries. Forests, 8(3), 1-20. https://doi.org/10.3390/f8030068

National Transportation Safety Board (NTSB). (2010). Loss of thrust in both engines, US airways flight 1549 and Subsequent Ditching on the Hudson River: US Airways Flight 1549 Airbus A320-214, N106US Airbus Industry A320-214, N106US (NTSB/AAR-10/03). NTSB. http://www.ntsb.gov/investigations/AccidentReports/ Reports/AAR1003.pdf

Neubauer, K., Fleet, D., Grosoli, F., & Verstynen, H. (2015). Unmanned aircraft systems (UAS) at airports: A primer (ACRP Report 144). Transportation Research Board on the National Academies. https://www.nap.edu/catalog/21907/unmanned-aircraft-systems-uas-at-airports-a-primer

Paranjape, A. A., Chung, S. J. & Shim, D. H. (2018). Robotic herding of a flock of birds using an unmanned aerial vehicle. IEEE. https://ieeexplore.ieee.org/document/8424544

Prather, C. D. (2019). Current landscape of unmanned aircraft systems at airports (ACRP Synthesis 104). Transportation Research Board on the National Academies. http://www.trb.org/Main/Blurbs/180032.aspx

Rahman, D. A., Setiawan, Y., Wijayanto, A. K., Rahman, A. A. A. F., & Martiyani, T. R. (2020, September, 28). An experimental approach to exploring the feasibility of unmanned aerial vehicle and thermal imaging in terrestrial and arboreal mammals research. The 1st JESSD Symposium: International Symposium of Earth, Energy, Environmental Science and Sustainable Development 2020. Jakarta, Indonesia.

Rillstone, D. J., & Dineen, C. M. (2013). Airport responsibility for wildlife management (ACRP Legal Research Digest No. 20). Transportation Research Board on the National Academies. http://www.trb.org/Publications/Blurbs/169414.aspx

Valavanis, K., & Vachtsevanos, G. J., (2015). Handbook of unmanned aircraft vehicles. Springer Reference.

Wallace, L., Lucieer, A., Malenovsky, Z., Turner, D., & Vopenka, P. (2016). Assessment of forest structure using two UAV techniques: A comparison of airborne laser scanning and structure from motion (SfM) point clouds. Forests, 7(62), 2-16. https://doi.org/10.3390/f7030062

Federal Aviation Administration (FAA). (2004). Crew resource management training (AC 120-51E). FAA. https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.inform ation/documentID/22878

Federal Aviation Administration (FAA). (2016). Pilot's handbook of aeronautical knowledge. FAA. https://www.faa.gov/regulations_policies/handbooks_ manuals/aviation/phak/

Federal Aviation Administration (FAA). (2018). Protocol for the conduct and review of wildlife hazard site visits, wildlife hazard assessments, and wildlife hazard management plans (AC 150/5200-38). FAA. https://www.faa.gov/documentLibrary/media/Advisory_ Circular/150-5200-38.pdf

Federal Aviation Administration (FAA). (2019a). Qualifications for wildlife biologist conducting wildlife hazard assessments and training curriculums for airport personnel involved in controlling wildlife hazards on airports (AC 150/5200-36B). FAA. https://www.faa.gov/airports/resources /advisory_circulars/index.cfm/go/document.current/documentNumber/150_5200-36

Federal Aviation Administration (FAA). (2019b). FAA strategic plan: FY 2019-2022. (AC 150/5200-36B). FAA. https://www.faa.gov/about/plans_reports/media/FAA_Strategic_Plan_Final_FY2019-2022.pdf

Federal Aviation Administration (FAA). (2020). Hazardous wildlife attractants on or near airports (AC 150/5200-33C). FAA. https://www.faa.gov/documentLibrary/media/Advisory_Circular/ 150-5200-33C.pdf

Federal Aviation Administration (FAA). (2021a). FAA wildlife strike database. FAA. https://wildlife.faa.gov/home

Federal Aviation Administration (FAA). (2021b). Some significant wildlife strikes to civil aircraft in the United States, January 1990 – January 2021). FAA. https://www.faa.gov/airports/ airport_safety/wildlife/media/significant-wildlife-strikes-1990-jan-2021.pdf

Federal Aviation Administration (FAA). (2021c). UAS data exchange (LAANC). FAA. https://www.faa.gov/uas/programs_partnerships/data_exchange/

Federal Aviation Administration (FAA). (2021d). Equip ADS-B. FAA. https://www.faa.gov/nextgen/equipadsb/

Federal Aviation Administration (FAA). (2021e). FAA challenge: Smart airport student competition. FAA. http://faachallenge.nianet.org/2021-challenge-guidelines/

ForeFlight (2021). Internet traffic. ForeFlight: A Boeing company. https://foreflight.com/products/ foreflight-mobile/internet-traffic/

Florida Fish and Wildlife Conservation Commission (2021). Sandhill Crane. MYFWC. https://myfwc.com/wildlifehabitats/profiles/birds/cranes/sandhill-crane/

Fraser, B. T., & Congalton, R. G. (2018). Issues in unmanned aerial systems (UAS) data collection of complex forest environments. Remote Sensing, 10(908), 1-21. https://doi.org/10.3390/rs10060908

Franklin, K. (2012, December 18). Large bird collides with police helicopter, strikes pilot in the face: Cops. 6 South Florida. https://www.nbcmiami.com/news/local/large-bird-collides-with-police-helicopter-strikes-pilot-in-the-face-cops/1914972/

Gade, S., Paranjape, A. A., & Chung, S. J. (2015). Herding a flock of birds approaching an airport using an unmanned aerial vehicle. Aerospace Research Central. https://arc.aiaa.org/doi/10.2514/6.2015-1540

Hamilton, B. A. (2020a). Airports and unmanned aircraft systems Volume 1: Managing and engaging stakeholders on UAS in the vicinity of airports (ACRP Research Report No. 212, volume 1). Transportation Research Board on the National Academies. https://www.nap.edu/ catalog/25607/airports-and-unmanned-aircraft-systems-volume-3-potential-use-of-uas-by-airport-operators

Hamilton, B. A. (2020b). Airports and unmanned aircraft systems Volume 3: Potential use of UAS by airport operators (ACRP Research Report No. 212, volume 3). Transportation Research Board on the National Academies. https://www.nap.edu/ catalog/25607/airports-and-unmanned-aircraft-systems-volume-3-potential-use-of-uas-by-airport-operators

Hamilton, B. A. (2020c). Airports and unmanned aircraft systems Volume 2: Incorporating UAS into airport infrastructure planning guidebook (ACRP Research Report No. 212, volume 2). Transportation Research Board on the National Academies. https://www.nap.edu/ catalog/25607/airports-and-unmanned-aircraft-systems-volume-3-potential-use-of-uas-by-airport-operators

Johnson, S. A., & Main, M. B. (2020, Febraury). Recognizing Florida's venomous snakes. University of Florida. https://edis.ifas.ufl.edu/publication/uw229

Jordan, B. R. (2019). Collecting field data in volcanic landscapes using small UAS (sUAS)/drones. Journal of Volcanology and Geothermal Research, 385, 231-241. https://doi.org/10.1016/j.jvolgeores. 2019.07.006

Kanki, B., Helmreich, R. L., & Anca, J. (2019). Crew resource management. San Diego, CA: Elsevier.

Lyons, M. B., Brandis, K. J., Murray, N. J., Wilshire, J. H., McCann, J. A., Kingsford, R. T., & Callaghan, C. T. (2019). Monitoring large and complex wildlife aggregations with drones. *Methods in Ecology and Evolution*, 10, 1024-1035. https://doi.org/10.1111/2041-210X.13194

Maddalon, J. M., Hayhurst, K. J., Koppen, D. M., Upcurch, J. M., Morris, A. T., & Verstynen, H. A. (2013). *Perspectives on unmanned aircraft classification for civil airworthiness standards*. NASA. https://shemesh.larc.nasa.gov/people/jmm/NASA-TM-2013-217969.pdf.

Marra, P. P., Dove, C. J., Dolbeer, R. A., Dahlan, N. F., Heacker, M., Whaton, J. F., Diggs, N. E., France, C. & Henkes, G. A. (2009). Migratory Canada geese cause crash of US airways flight 1549. *Frontiers in Ecology and the Environment, 7*(6), 297-301. https://doi.org/10.1890/090066

Martin, J. A., Belant, J. L., DeVault, T. L., Blackwell, B. F., Junior, L. W. B., Riffel., S. K., & Wang, G. (2011). Wildlife risk to aviation: A multi-scale issue requires a multi-scale solution. *Human-Wildlife Interactions, 5*(2), 198-203. https://digitalcommons.unl.edu/icwdm _usdanwrc/1311/

McEvoy, J. F., Hall, G. P., & McDonald, P. G. (2016). Evaluation of unmanned aerial vehicle shape, flight path and camera type for waterfowl surveys: Disturbance effects and species recognition. PeerJ (4), 1-21. https://peerj.com/articles/1831/

Mendonca, F., Keller, J. C., Wang, Y. (2017). Managing the risk: An analysis of bird strike reporting at Part 139 airports in Indiana (2001-2014). *Journal of Airline and Airport Management, 7*(1), 43-64. https://doi.org/10.3926/jairm.82

Mlambo, R., Woodhouse, I. H., Gerard, F., & Anderson, K. (2017). Structure from Motion (SfM) photogrammetry with drone data: A low cost method for monitoring greenhouse gas emissions from forests in developing countries. *Forests, 8*(3), 1-20. https://doi.org/10.3390/f8030068

National Transportation Safety Board (NTSB). (2010). *Loss of thrust in both engines, US airways flight 1549 and Subsequent Ditching on the Hudson River: US Airways Flight 1549 Airbus A320-214, N106US Airbus Industry A320-214, N106US* (NTSB/AAR-10/03). NTSB. http://www.ntsb.gov/investigations/AccidentReports/ Reports/AAR1003.pdf

Neubauer, K., Fleet, D., Grosoli, F., & Verstynen, H. (2015). *Unmanned aircraft systems (UAS) at airports: A primer* (ACRP Report 144). Transportation Research Board on the National Academies. https://www.nap.edu/catalog/21907/unmanned-aircraft-systems-uas-at-airports-a-primer

Paranjape, A. A., Chung, S. J. & Shim, D. H. (2018). *Robotic herding of a flock of birds using an unmanned aerial vehicle*. IEEE. https://ieeexplore.ieee.org/document/8424544

Prather, C. D. (2019). *Current landscape of unmanned aircraft systems at airports* (ACRP Synthesis 104). Transportation Research Board on the National Academies. http://www.trb.org/Main/Blurbs/180032.aspx

Rahman, D. A., Setiawan, Y., Wijayanto, A. K., Rahman, A. A. A. F., & Martiyani, T. R. (2020, September, 28). *An experimental approach to exploring the feasibility of unmanned aerial vehicle and thermal imaging in terrestrial and arboreal mammals research*. The 1st JESSD Symposium: International Symposium of Earth, Energy, Environmental Science and Sustainable Development 2020. Jakarta, Indonesia.

Rillstone, D. J., & Dineen, C. M. (2013). *Airport responsibility for wildlife management* (ACRP Legal Research Digest No. 20). Transportation Research Board on the National Academies. http://www.trb.org/Publications/Blurbs/169414.aspx

Valavanis, K., & Vachtsevanos, G. J., (2015). *Handbook of unmanned aircraft vehicles*. Springer Reference.

Wallace, L., Lucieer, A., Malenovsky, Z., Turner, D., & Vopenka, P. (2016). Assessment of forest structure using two UAV techniques: A comparison of airborne laser scanning and structure from motion (SfM) point clouds. *Forests, 7*(62), 2-16. https://doi.org/10.3390/f7030062