The FAA's Center of Excellence for UAS Research

ASSURE

Alliance for System Safety of UAS through Research Excellence

2019 ANNUAL REPORT

OVERVIEW

FOREWORD:

As ASSURE (the Alliance for System Safety of UAS through Research Excellence) approaches the end of its first 5-year phase we look to the next 5-years serving as the Federal Aviation Administration's (FAA) Center of Excellence (COE) for Unmanned Aircraft Systems (UAS). We take this opportunity to review and reflect upon our accomplishments and look to our future endeavors.

Throughout this first phase we have built a highly-effective team of 25 research institutions consisting of 15 Core Universities, 8 Affiliate Universities, including 3 international schools, and 2 University Business Partners. This coalition features expertise across a broad spectrum of research including: air traffic integration, UAS airport ground operations, control and communications, detect and avoid (DAA), human factors, UAS collision severity, UAS pilot training and certification, low altitude operations safety, spectrum management, and UAS traffic management. ASSURE, working with our many industry partners, have generated innovative research in support of the FAA and the Department of Transportation.

The FAA uses ASSURE findings and recommendations to help guide the establishment of the standards and regulations in areas to include: UAS certification, ground collision studies to enable operations over people, air collision, and DAA for beyond-visual-line-of-sight (BVLOS). These standards and regulations are necessary to safely and efficiently integrate unmanned operations with manned operations and to increase private, public, and commercial UAS operations in the National Airspace System (NAS).

As we move into our next 5-years, you can expect ASSURE to continue its work many of these difficult regulatory and standards issues. Additionally, ASSURE research is trending into applications to support various concepts of operations like: disaster preparation and recovery, air mobility operations, the UAS delivery operations, and UAS operations on and around airfields.

I continue to be amazed at the quality work of our ASSURE researchers and their partners. This Annual Report provides highlights of the work conducted in FY 2019. We are prepared and excited for all the interesting opportunities that lay ahead in our next 5 years. Please take a moment to review our work and contact us with any ideas, suggestions, or comments.

STEPHEN P. LUXION (Colonel, USAF-Retired)
Executive Director, ASSURE

MISSISSIPPI STATE UNIVERSITY

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MISSION:

Our mission is to provide the Federal Aviation Administration the research they need to quickly, safely, and efficiently integrate unmanned aerial systems into our National Airspace System with minimal changes to our current system.

VISION:

Our vision is to help the unmanned aerial system market grow into its multibillion dollar market potential by conducting research that quickly, safely, and effectively get UAS flying alongside manned aircraft around the world.

ASSURE TAG LINE:

Informing UAS policy through research

WEBSITE:

http://www.assureuas.org/

ACKNOWLEDGMENTS

ASSURE would like to thank our FAA sponsors for all they do in helping us run such a large and diverse program. This year, the FAA and ASSURE had the additional challenge of meeting new reporting and approval processes for our research. This required 'All Hands on Deck' to develop, organize and manage an entirely new process. Through persistence, patience, and a strong team effort ASSURE and the FAA were able to overcome the many obstacles we faced. Ms. Karen Davis, National Program Director of FAA Center's of Excellence; Mr. Nick Lento, FAA Program Manager - ASSURE UAS Center of Excellence; and Ms. Sabrina Saunders-Hodge, Director FAA UAS Research Division and their teams continue to be key to the success of ASSURE. Through this challenge and our day-to-day activities, Ms. Davis, Mr. Lento, and Ms. Saunders-Hodge made themselves available to the ASSURE team to answer our questions and strategically work through issues to capture opportunities over this past year.

Dr. Julie Jordan, our new Interim Vice President for Research and Economic Development at Mississippi State University, stepped into her new role and has provided ASSURE a fresh look at how we do business. She has offered her support and recommendations to increase our exposure, international collaboration, and coordination of UAS research.

I would also like to acknowledge the amazing team that ensures that ASSURE runs so smoothly. Billy Klauser, Deputy Director; Dallas Brooks, Associate Director; and Sheila Ashley, Program Coordinator. We said goodbye to Brandy Akers, Financial Manager as she moved to bigger things within the university, and welcomed Whitley Alford to fill her role as well as Hannah Thach, our new Technical Director of Research. They help manage an extremely large team of universities and their many different offices and interests. This is not an easy task; I am grateful for their many long hours that make the team function so well.

The research that we do could not be done without the many core, affiliate, government, academic, and industry partners. To acknowledge every member of the many teams involved in the management and execution of the ASSURE mission is not be possible in this short space. Support from these partners comes from great people who are experts in aviation, aerospace, human factors, training, maintenance, logistics, operations, finance and administration, and many others who freely give their time every day to ensure the success of this center. Thank you!

FINANCIALS

ASSURE FUNDING SUMMARY

Total Funding $21,493,500.19

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Office- Mississippi State University	**$4,478,509.78**	**$3,660,763.15**	**$817,746.63**	**$4,477,983.68**	**122%**
Core Schools	**$17,014,990.41**	**$11,287,642.08**	**$5,727,348.33**	**$13,646,375.97**	**121%**
Drexel University	$739,343.94	$559,343.94	$180,000.00	$601,406.63	108%
Embry-Riddle Aeronautical University	$998,331.13	$584,316.65	$414,014.48	$741,763.64	127%
Kansas State University	$1,397,544.00	$837,439.90	$560,104.10	$863,837.83	103%
Mississippi State University	$1,155,956.81	$1,046,274.43	$109,682.38	$1,019,708.65	97%
Montana State University	$709,062.28	$478,870.83	$230,191.45	$622,427.38	130%
New Mexico State University	$1,420,153.89	$1,005,767.45	$414,386.44	$1,003,310.37	100%
North Carolina State University	$229,876.39	$229,876.39	$0.00	$229,876.39	100%
Ohio State University	$2,429,114.21	$1,531,117.45	$897,996.76	$3,170,692.38	207%
Oregon State University	$75,000.00	$75,000.00	$0.00	$75,000.00	100%
University of Alabama-Huntsville	$2,325,880.43	$1,550,758.94	$775,121.49	$1,583,143.99	102%
University of Alaska-Fairbanks	$338,994.40	$174,116.82	$164,877.58	$232,593.68	134%
University of California-Davis	$144,730.00	$45,000.00	$99,730.00	$45,197.00	100%
University of Kansas	$91,967.86	$91,967.86	$0.00	$92,000.01	100%
University of North Dakota	$2,097,671.07	$1,139,615.42	$958,055.65	$1,427,242.02	125%
Wichita State University	$2,861,364.00	$1,938,176.00	$923,188.00	$1,938,176.00	100%
Totals	**$21,493,500.19**	**$14,948,405.23**	**$6,545,094.96**	**$18,124,359.65**	**121%**

SUMMARY BY PROJECT

Total Funding $21,493,500.19

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Management Funding	**$4,796,031.97**	**$3,975,654.30**	**$820,377.67**	**$4,791,646.29**	**121%**
Projects	**$16,697,468.22**	**$10,972,750.93**	**$5,724,717.29**	**$13,332,713.36**	**122%**
A1: Unmanned Aircraft Integration: Certification Test to Validate sUAS Industry Consensus Standards	$299,996.00	$299,996.00	$0.00	$300,280.00	100%
A2: Small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight (BVLOS) Operations	$799,658.63	$799,658.63	$0.00	$799,944.34	100%
A3: UAS Airborne Collision Severity Evaluation	$1,000,000.00	$1,000,000.00	$0.00	$1,023,424.27	102%
A4: UAS Ground Collision Severity	$382,387.89	$382,387.89	$0.00	$409,098.69	107%
A5: UAS Maintenance, Modification, Repair, Inspection, Training, and Certification	$799,980.23	$799,980.23	$0.00	$829,733.21	104%
A6: Surveillance Criticality for SAA	$779,040.15	$779,040.15	$0.00	$779,040.15	100%
A7: UAS Human Factors Considerations	$746,917.33	$717,601.08	$29,316.25	$724,046.38	101%
A8: UAS Noise Certification	$50,000.00	$50,000.00	$0.00	$50,000.00	100%
A9: Secure Command and Control Link with Interference Mitigation	$329,996.24	$329,996.24	$0.00	$646,943.35	196%
A10: Human Factors Consideration of UAS Procedures & Control Stations	$798,182.05	$798,182.05	$0.00	$884,648.96	111%
A11: Low Altitude Operations Safety: Part 107 Waiver Request Case Study	$151,274.50	$151,274.50	$0.00	$184,588.38	122%
A12: Performance Analysis of UAS Detection Technologies Operating in Airport Environment	$298,427.20	$284,186.01	$14,241.19	$284,186.42	100%
A13: UAS Airborne Collision Severity Peer Review	$7,026.00	$7,026.00	$0.00	$7,026.00	100%
A14: UAS Ground Collision Severity Studies	$2,042,581.00	$2,039,161.32	$3,419.68	$2,274,960.59	112%
A15: Stem II	$149,982.00	$146,771.26	$3,210.74	$155,509.61	106%

(CONTINUED ON NEXT PAGE)

SUMMARY BY PROJECT (CONTINUED)

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Management Funding	**$4,796,031.97**	**$3,975,654.30**	**$820,377.67**	**$4,791,646.29**	**121%**
Projects	**$16,697,468.22**	**$10,972,750.93**	**$5,724,717.29**	**$13,332,713.36**	**122%**
A16: Airborne Collision Severity Evaluation - Structural Impact	$2,202,886.00	$890,252.95	$1,312,633.05	$739,162.13	83%
A17: Airborne Collision Severity Evaluation - Engine Ingestion	$1,532,252.00	$698,766.95	$833,485.05	$411,321.55	59%
A18: Small UAS Detect and Avoid Requirements Necessary for Limited BVLOS Operations: Separation Requirements and Training	$1,071,598.00	$525,603.54	$545,994.46	$2,375,141.78	452%
A19: UAS Test Data Collection and Analysis	$400,000.00	$142,355.34	$257,644.66	$231,421.18	163%
A20: UAS Parameters, Exceedances, Recording Rates for ASIAS	$399,716.00	$110,074.59	$289,641.41	$216,730.61	197%
A21: Integrating Expanded and Non-Segregated UAS Operations into the NAS: Impact on Traffic	$1,496,515.00	$20,436.20	$1,476,078.80	$0.00	0%
A27: Establish risk-based thresholds for approvals needed to certify UAS for safe operation	$500,037.00	$0.00	$500,037.00	$5,505.76	1%
A29: STEM Outreach- UAS as a STEM Outreach Learning Platform for K-12 Students and Educators (STEM III)	$459,015.00	$0.00	$459,015.00	$0.00	0%
Totals	$21,493,500.19	$14,948,405.23	$6,545,094.96	$18,124,359.65	121%

COST SHARE SUMMARY

Adaptive Aerospace Group, Inc.	$5,897.34
AgentFly Software	$50,000.00
Arlin's Aircraft	$3,000.00
Boeing	$46,235.64
Consortium on Electromagnetics and Radio Frequencies	$2,675.00
DJI	$61,509.84
DJI Research, LLC	$48,522.80
Drexel University	$362,396.63
Embry-Riddle Aeronautical University	$555,369.52
General Electric	$145,930.48
GoPro	$29,925.60
GreenSight Agronomics, Inc.	$13,357.00
Honeywell	$30,275.78
Intel	$26,669.60
K.I.M. Inc.	$51,200.00
Kansas Department of Commerce	$159,317.38
Kansas State University	$715,048.84
Keysight Technologies	$566,690.00
Keystone Aerial Surveys	$1,750.00
Kongberg Geospatial	$40,000.00
Mike Toscano	$147,500.00
Misc. External Match - Industry Funds	$50,835.78
Mississippi State University	$2,005,994.03
Montana Aircraft	$6,000.00
Montana State University	$543,856.74
New Mexico State University	$1,003,310.37
North Carolina State University	$914,370.49
North Dakota Department of Commerce	$796,657.08
NUAIR	$20,923.02
Ohio State University	$456,537.55
Ohio/Indiana UAS Center (ODOT)	$1,941,687.60
R Cubed Engineering	$6,970.09
Rockwell Collins	$4,015.80
Sandia	$2,257.00
SenseFly	$471,131.36
Simlat Software	$147,260.00
Sinclair Community College	$929,819.40
State of Kansas	$91,604.83
Technion Inc	$1,729,958.74
The Cirlot Agency	$116,824.90
University of Alabama in Huntsville	$876,986.79
University of Alaska Fairbanks	$232,593.68
University of California Davis	$45,197.00
University of Kansas Center for Research, Inc.	$92,000.01
University of North Dakota	$451,463.91
Virginia Polytechnic Institute and State Unviversity	$69,121.03
Wichita State University	$2,053,711.00
Total	**$18,124,359.65**

SUMMARY BY SOURCE

Universities	$11,307,776.99
State Contributions	$2,989,266.89
3rd Party Contributions	$3,827,315.77
Total	**$18,124,359.65**

RESEARCH STUDIES

UAS GROUND COLLISION SEVERITY EVALUATION II

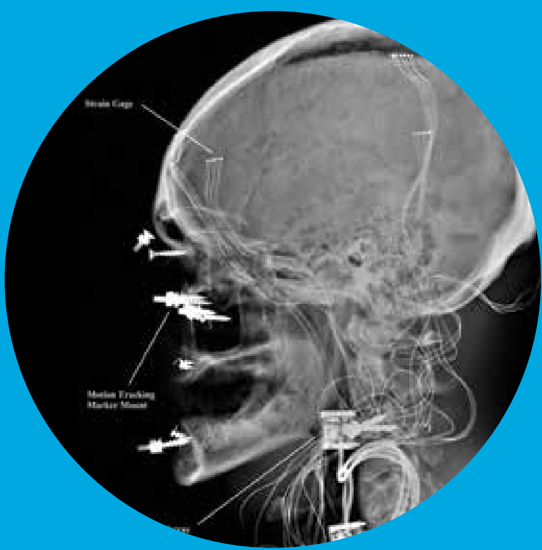
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE · WICHITA STATE UNIVERSITY · MISSISSIPPI STATE UNIVERSITY · THE OHIO STATE UNIVERSITY · VIRGINIA TECH

Lead University – University of Alabama – Huntsville

Background

The ASSURE research team conducted follow-on analysis and testing which built on the established framework for quantifying the injury potential of small unmanned aircraft systems (sUAS) resulting from collisions with non-participating public on the ground. The metrics developed in this research are critically important to defining standards and metrics necessary for rulemaking for flight over people.

The team developed a simplified process and refined the previous testing method for testing injury potential of sUAS. This provided a clear path for applicants to apply for a flight over people waiver under §107 and a safety case that are consistent with future flight over people rulemaking.



The ASSURE research team was led by University of Alabama – Huntsville (UAH) in collaboration with Wichita State University's National Institute of Aviation Research (NIAR), Mississippi State University (MSU), The Ohio State University (OSU), and Virginia Polytechnical Institute and State University (VT).

Approach

The goal over the 18-month period of performance was to assess injury potential of various sUAS of different material properties and construction. The team conducted fixed wing and multirotor sUAS failure flight testing and aerodynamic modeling, full anthropomorphic test device (ATD) impact testing, simplified head and neck only ATD impact testing, ATD and human-body model impact simulations, post mortem human surrogates (PMHS) impact testing, and high-fidelity head and neck only impact simulations. Over the course of the project, researchers collected data on over 41 flight test points, 155 simplified impact tests, 133 ATD impact tests, 41 PMHS impact tests, over 100 full-ATD and human-body model impact simulations, and 15 high-fidelity head and neck simulations. Tests were conducted with 16 different multi-rotor and fixed-wing sUAS and objects (payloads, wood blocks and batteries) with weights ranging from 0.75 – 13.2 lbs.

Key Findings

The ATD and PMHS testing provided insight into the applicability of automotive injury criteria in sUAS impact scenarios. In addition, experimental testing provided calibration data for ATD and human-body models, and correlation of ATD responses to PMHS injury data. The PMHS testing also enabled assessment of assumed injury thresholds from the previous ASSURE studies. Only one out of 33 high-speed drone impacts during PMHS testing resulted in an observable skeletal injury. The PMHS testing and analysis of the

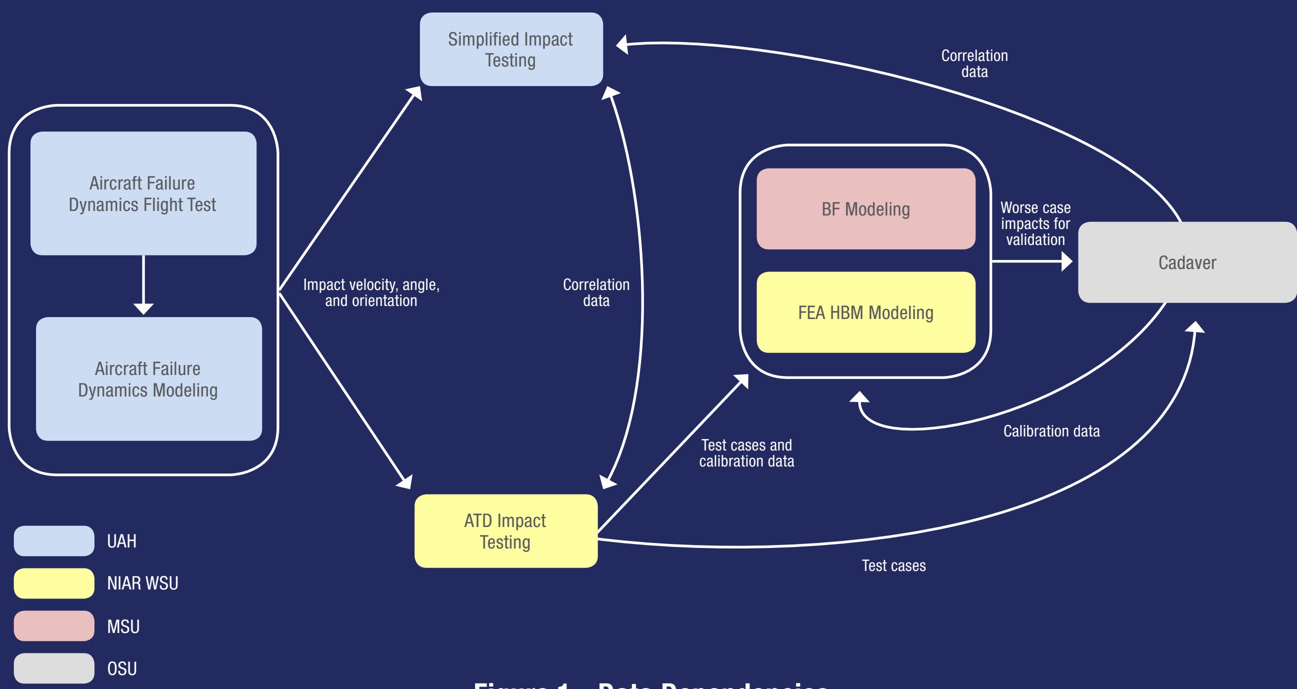
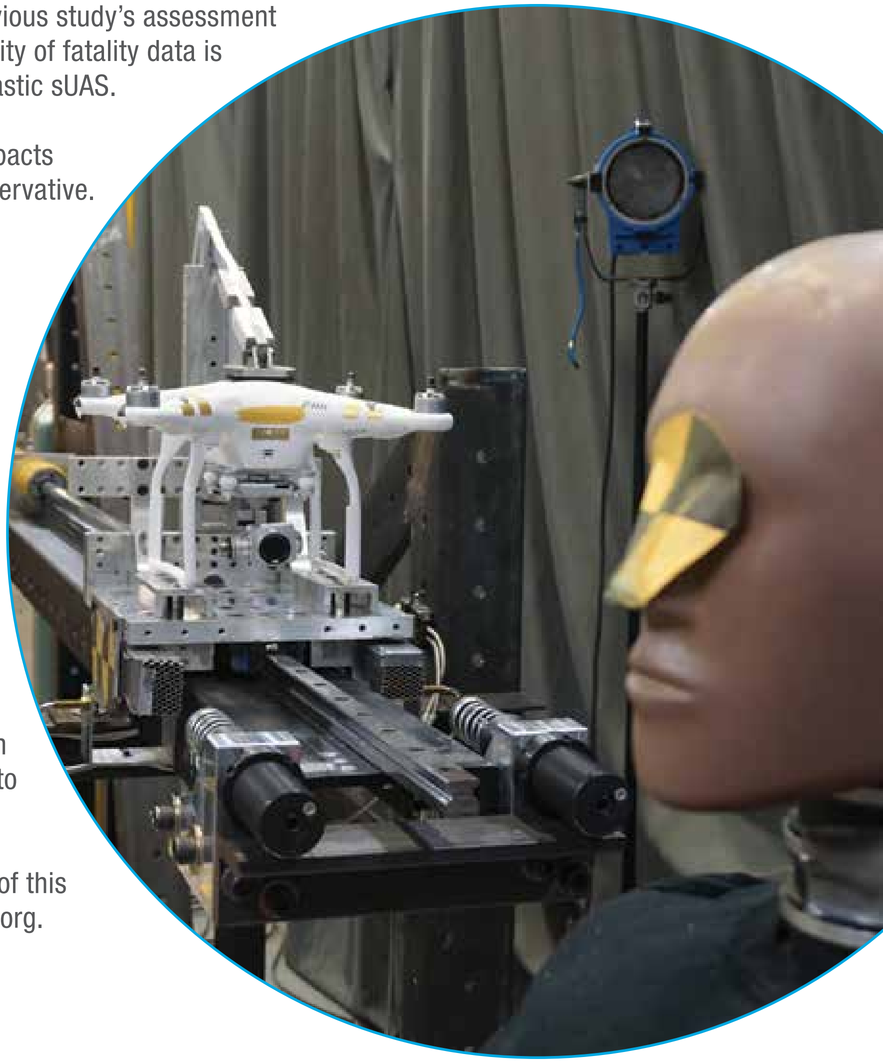


Figure 1 - Data Dependencies

injury data strongly support the ASSURE teams previous study's assessment that the Range Commanders Council (RCC) probability of fatality data is overly conservative and largely not applicable to elastic sUAS.

The preliminary injury thresholds for sUAS head impacts developed in the earlier work were also overly conservative. This research suggests that concussion may be a common injury outcome in higher energy drone collisions. However, this research did not validate concussion injury risk criteria in sUAS impact scenarios and, therefore, should not be used in establishing regulatory guidelines.



Additional PMHS testing is needed to develop more accurate probability-based injury risk curves, like those used by the automotive industry, but more relevant to the impact characteristics of sUAS. Until they are, the ASSURE research team recommend that the FAA use the automotive-based injury criteria called out in the final report and the risk thresholds that were further developed in this study to assess when additional operational risk mitigations are required to reduce the probability of serious injury.

For more information and to review the final report of this project, please visit our website at www.assureuas.org.

Name & Origin of All Research Personnel

Name	Origin
David Arterburn – UAH	United States
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Chris Sallis – UAH	United States
Mark Gauldin – UAH	United States
Doug Huie – UAH	United States
Nick Balch – UAH	United States
Josh Schofield – UAH	United States
Patrick Hambloch – UAH	Germany
Hunter Bray – UAH	United States
Casey Calamaio – UAH	United States
Kendall White – UAH	United States
Stefan Duma – VT	United States
Steven Rowson – VT	United States
Mark Blanks – VT	United States
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Andrew Mackey – NIAR	United States
Jonathan Conklin – NIAR	United States
Luis Gomez – NIAR	Spain
Tom Aldag – NIAR	United States
Gerardo Olivares – NIAR	United States
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John Bolte IV – OSU	United States
Jim Gregory – OSU	United States

Name & Origin of All Research Personnel

Name	Origin
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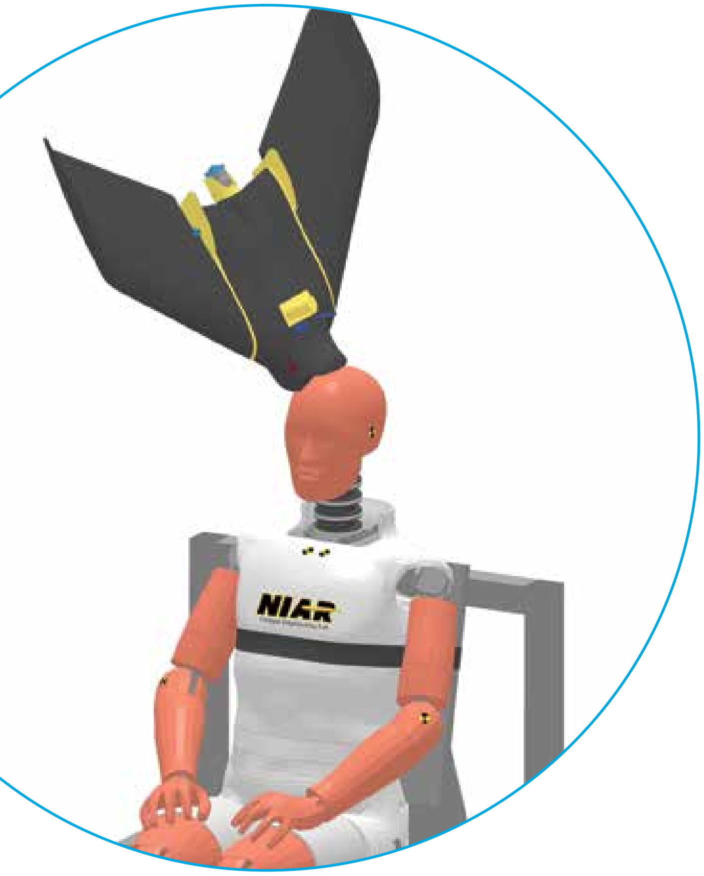
Matthew McCrink – OSU	United States
Ariana Willis – OSU	United States
David Stark – OSU	United States

Graduation Dates of Students:

Name	Graduation Date
N/A	N/A



AIRBORNE COLLISION SEVERITY EVALUATION – STRUCTURAL IMPACT

Lead University – Wichita State University's National Institute of Aviation Research

Background

Wichita State University's National Institute of Aviation Research (NIAR), University of Alabama, Huntsville (UAH), Montana State University (MtSU) and Embry-Riddle Aeronautical University (ERAU) make up the ASSURE COE research team. This follow-on study builds on our previous work aimed to understand the physical effects of an air-to-air collision between a small UAS (sUAS) and both a Narrow Body Commercial Aircraft and Business Jets operating under FAR 25 requirements. For this next progression of Airborne Collision Severity Evaluation work, the FAA has asked ASSURE to focus on three major research areas:

- Identify the probability of impact deflection due to the sUAS' interaction with the target aircraft's boundary layer prior to impact;
- Evaluate the severity of sUAS collisions with Rotorcraft; and
- Evaluate the severity of sUAS collisions with General Aviation.

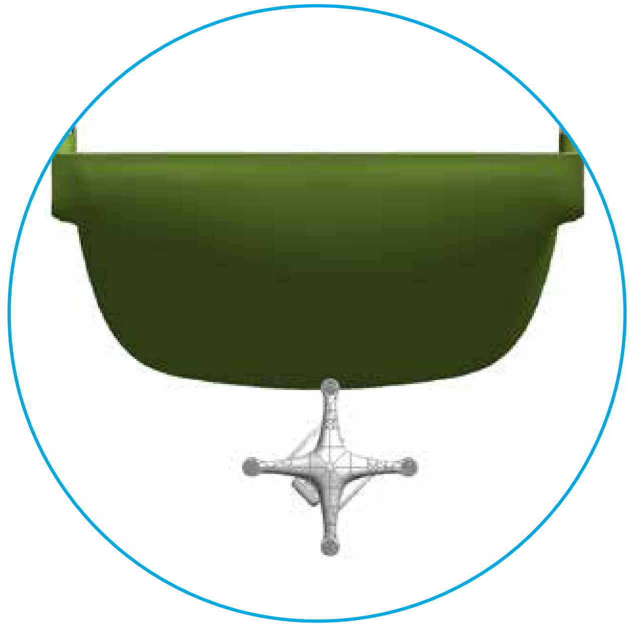
Approach

The research team's plan is for the study to take 24 months to complete. The study will include a peer review of the research task plan within the first 30 days of the award and another review of the final report at the conclusion of the project.

Task 1 – Identify the probability of impact deflection due to boundary layer interactions.

The research in Task 1 addresses the question of whether a sUAS could be deflected by the airflow of the boundary layer prior to impacting the aircraft. NIAR is conducting near-field fluid mechanics analysis of air-to-air impact events using computational fluid dynamics (CFD). These CFD analyses utilize computer aided design (CAD) models for both a representative quadcopter sUAS and the narrow body aircraft developed during the previous ASSURE project.

Researchers will analyze several sUAS orientations and speeds to create a response surface. ERAU will be using Proper Orthogonal Decomposition (POD) of the filed variables involved in the impact mechanics (stagnation pressure, deflection force, etc.) to analyze the results from the CFD runs. NIAR and ERAU then built a POD-trained Radial-basis function (RBF) interpolation network as a response surface for establishing a real-time physical correlation between the operating conditions and the field response. Finally, this POD-RBF response surface serves as the framework for establishing a probability distribution for the impact energy transfer mechanisms and the collision deflection (i.e. what is the likelihood and magnitude the sUAS will be deflected from a direct strike).

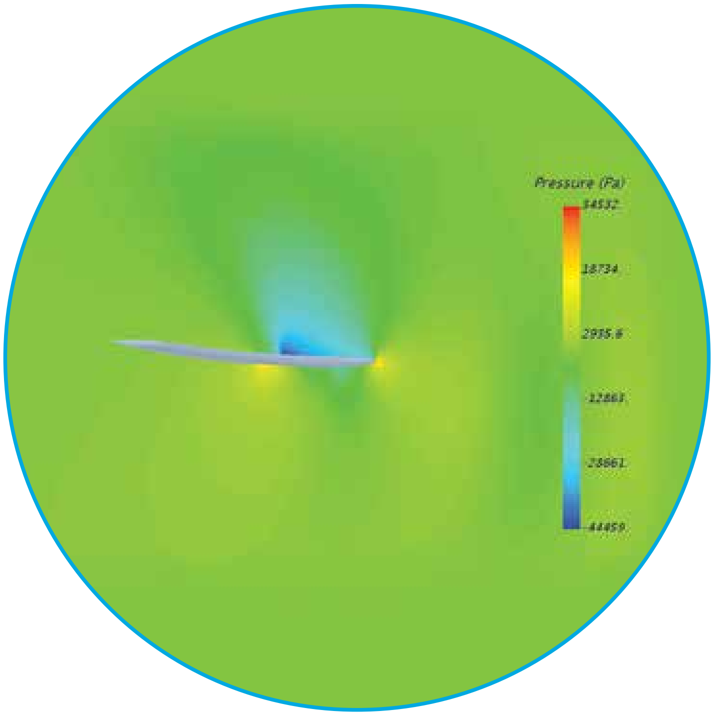


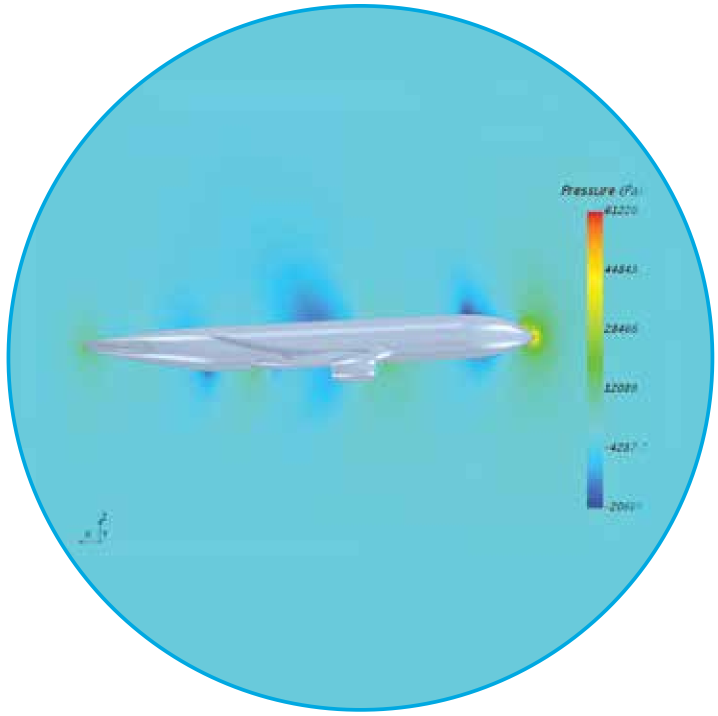
Task 2 – Evaluate the severity of sUAS collisions with Rotorcraft.

Previous ASSURE work and Task 1 of this project address large, high-altitude collisions. However, sUAS generally operate at lower altitudes, often sharing airspace with law enforcement, emergency medical, and other rotorcraft. In Task 2, NIAR and UAH will study sUAS collisions with rotorcraft airframes; specifically, rotors, blades, windshields, and tail structures. This research will help identify the damage severity for this type of sUAS airborne collision. NIAR has previously developed rotorcraft Finite Element (FEA) Models during the earlier ASSURE project. To validate these models, UAH is conducting component level testing.w Once validated, the team will conduct crashworthiness structural FEA simulations and damage evaluation for mid-air collision of sUAS and rotorcraft.

Task 3 – Evaluate the severity of small sUAS collisions with General Aviation.

General Aviation (GA) aircraft also operate at lower altitudes where sUAS may be present. In Task 3, the research team will study sUAS collisions with GA airframes, specifically looking at propellers, windshields, and tail structures. This research will help identify the damage severity of sUAS-GA airborne collisions. NIAR will update the FEA models used in the previous ASSURE project for the proper dynamic conditions. The data generated by the low-velocity component level testing from Task 2 will





be used to validate the models. MtSU is conducting the full-scale structural safety evaluations for mid-air collision with a GA airframe windshield. The team is conducting the crashworthiness structural FEA simulations, and damage evaluations.

Key Findings

The final report detailing this work is expected to be peer reviewed near the end of CY 2020 with a public release later that winter.

Name & Origin of All Research Personnel

Name	Origin
Gerardo Olivares – NIAR	United States
Luis Gomez – NIAR	Spain
Chandresh Zinzuwandia – NIAR	United States
Rodrigo Marco – NIAR	Spain
Nathaniel Baum – NIAR	United States
Harsh Shah – NIAR	India
Ramya Bhavana – NIAR	India
Russel Baldridge – NIAR	United States
Dave Arterburn – UAH	United States
Chris Duling – UAH	United States
Mark Zweiner – UAH	United States
Doug Cairne – MtSU	United States
Robb Larson – MtSU	United States
Eduardo Divo – ERAU	United States
Ray Prather – ERAU	United States

Graduation Dates of Students:

Name	Graduation Date
Nidhi Sathyanarayana	August 2019
Gerardo Alboreda	August 2020
Jefferson Vieria	May 2020

UAS AIRBORNE COLLISION SEVERITY EVALUATION – ENGINE INGESTION

The Ohio State University
Wichita State University
The University of Alabama in Huntsville

Lead University – The Ohio State University

Background

As the number of UAVs sold continues to increase, the integration of UAS into the airspace is a major safety concern due to the potential for a UAS-airplane collision. Recreational UAS tend to be relatively small and have the potential to be ingested into an engine. Although the effects of a bird ingest into an engine has been readily studied, the current tests and regulations cannot be transferred from birds to UASs. UAS key components: motor, battery, and camera, contain materials that are much denser and stiffer than ice and birds, which are typically modeled as a fluid since they are over 70% water. Preliminary work on this topic showed that UAS can cause significantly more damage than birds.

The goals of this study are to:

- Understand what the interaction of a UAS with a representative high-bypass ratio fan (typically used in large commercial transport) will look like; and
- Define best practices and fan models for use in further studies.

The Ohio State University (OSU) is leading this effort working with Wichita State University – National Institute for Aviation Research (NIAR) and University of Alabama at Huntsville (UAH).

Approach

The research is being carried out in close collaboration with engine industry manufacturers to create finite element (FE) models that will capture critical features of a fan UAV impact. The ingestion simulations will be carried out in LS-DYNA, a finite element analysis software that specializes in highly nonlinear transient dynamic analysis, for a variety of impact scenarios.

Task 1 – Representative High-Bypass Ratio Fan

The objective of this research task is to create a fan model that has representative structural and vibratory features of a modern high-bypass ratio fan. This task will be carried out in close collaboration with engine industry manufacturers to maximize its utility.

The fan is a representative of certain features (structural and vibratory) of a modern high-bypass ratio fan but does not match a specific fan currently in the fleet. It is 62 inches in diameter and has solid titanium blades. The blade geometry will be defined with industry to ensure the blade geometry, thickness of blade, angle of blade from root to tip, etc., are representative of current industrial fans of this size. The blade material model was developed from extensive testing and validation in a previous ASSURE research program. The full fan model will also be analyzed to ensure it captures the critical structural and vibratory features of a representative high-bypass ratio fan during foreign object ingestion.

The fan containment ring and nose cone are additional components included in this project to understand how they interact with the fan and UAS during the collision. These models will provide reasonable geometries for the representative fan but will model linear elasticity models and no failure. During the simulations these components give appropriate boundary conditions during the ingestion and enable the computation of the expected loads on these parts. This allows for the determination of cases where the greatest energy and/or strain is imparted to these components and enables industry to focus on these cases when using their actual proprietary designs.

Task 2 – Experimental Validation of Component and Full Quadcopter Model

The objective of this task is to conduct component level tests on the key quadcopter components: the battery, motor, and camera, as well as the full and complete quadcopter at conditions that would occur in an engine ingestion. The quadcopter is chosen because of its popularity, and the availability of a partially validated (FE) model developed in a previous ASSURE project. The quadcopter component models need to be validated for the higher impact speeds that would occur in an engine ingestion. The impact velocities are between 300-720 knots, and would be a slicing impact as opposed to a blunt force impact.

The validation tests are designed to be representative of a variety of component and full-quadcopter impacts during an engine ingestion. The testing team will launch the three UAV components and full quadcopter at two speeds in the range of 300-720 knots. Instead of blunt flat plate impacts, the components will impact angled titanium plates of fan-blade thickness to validate the deformation at the expected conditions during an ingestion. The batteries will be launched in a fully charged state to assess the likelihood of a fire in a slicing impact. The experiments will be filmed with a high-speed camera to ensure the kinematics and overall deformation match the computational simulations. Furthermore, additional load information will be measured on the titanium plates (e.g., strain gages), so that the loading in the model can also be matched with the loading in the computational simulations.

The data from the experiments will be collected and analyzed to update the key UAS component-level models and the integrated full-UAS model. The experiments could also indicate the possibility of a fire from the UAS battery during an ingestion. Additionally, the mesh sizing of the titanium plate will also be investigated during these component impacts. This investigation will inform the choice for the fan model's mesh sizing of the blades in the region of the impact to maximize fidelity while minimizing computational cost.

Task 3 – Sensitivity Analysis of Parameters to the Ingestion

The objective of this task is to conduct a series of ingestion simulations to understand the effect of various parameters on the ingestion event. The ingestion simulations will be conducted in LS-DYNA using the updated validated UAS model in Task 2. The ingestion simulation will consist of the fan model that is fixed with the fan rotating at a prescribed speed, which will not slow down during this relatively short ingestion simulation. For the ingestion simulations, the ASSURE research team will capture failure of elements in the fan and obtain expected strain and impact energies for the nose cone and the casing.

The research team will initially investigate various parameters of the ingestion including the rotational speed of the fan, the relative velocity of the UAS to the airplane, the orientation of the UAS during the impact, and the radial location of the UAS impact along the fan. Researchers will focus on the data from the ingestions concerning the failure in the elements of the fan model, the imbalance in the fan after the impact and the fan's plastic deformation as well as the strains and energy imparted to the casing and nose cone during the ingestion.

The results from these simulations will help determine a parameter space where one can determine which ingestion parameters lead to the worst outcome for the fan blades, fan disk, nose cone, or containment. The data points for the blade out and bird ingestion simulations for this specific fan model will provide additional data points of events that have been extensively researched.

Key Findings

This highly-complex and collaborative effort is expected to be completed by summer of 2021. The final report and findings will be peer reviewed and public release is slated for later that summer.

Name & Origin of All Research Personnel

Name	Origin
Kiran D'Souza – OSU	United States
Jim Gregory – OSU	United States
Jim Lawson – OSU	United States
Dushyanth Sirivolu – OSU	India
Troy Lyons – OSU	United States
Gerardo Olivares – NIAR	United States
Luis Gomez – NIAR	Spain
Hoa Ly – NIAR	Vietnam
Luis Castillo – NIAR	Mexico
Jerry Hendrix – UAH	United States
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Graduation Dates of Students:

Name	Graduation Date
Troy Lyons	Summer 2021
Nicholas Balch	December 2020
Zach Perrin	Spring 2020
Kelby Starchman	December 2019
Daniel Aiken	December 2019
Alex Blythe	December 2019

SMALL UAS DETECT AND AVOID REQUIREMENTS FOR LIMITED BEYOND VISUAL LINE OF SIGHT (BVLOS) OPERATIONS – SEPARATION REQUIREMENTS AND TESTING

Lead University – University of North Dakota

Background

The rules of manned aviation are very concise; see and avoid. Unmanned Aircraft Systems (UAS) do not have the luxury of a pilot in the cockpit to see and safely avoid nearby traffic. The current solution is to place visual observers on the ground or use chase planes. This limits the potential of Small UAS (sUAS) in commercial operations and for public benefit in areas such as precision agriculture, crop and wildlife monitoring, search and rescue, and linear infrastructure inspection due to safety concerns and access constraints for the visual observers.

Beyond Visual Line of Sight (BVLOS) operations with the use of Detect and Avoid (DAA) technology resolves this issue. Currently, standards and rules for DAA that allow UAS to conduct BLVOS operations do not exist. This follow-on work builds on our previous efforts to help inform FAA regulations and industry standards addressing DAA and BVLOS operations. This ASSURE team will:

- Develop an operational framework for sUAS BVLOS operations;
- Develop separation framework; and
- Test the recommended DAA testing plan and candidate DAA systems.

The ASSURE research team includes the University of North Dakota (UND), New Mexico State University (NMSU), University of Alaska Fairbanks (UAF), Kansas State University Polytechnic (KSU), and Mississippi State University (MSU).

Approach

The research focuses upon four primary tasks. In addition, the researchers have updated previous data, developed a test plan and will submit a comprehensive final report.

Task 1 – Development of an Operational Framework for sUAS BVLOS Operations—New Use Cases, Industry Focus, and Framework Expansion

This task builds on our previous development of an Operational Framework (OF) used for the eventual establishment of proposed operating rules, limitations, and guidelines for sUAS DAA. The researchers collected additional use case data, explored framework expansion and reviewed and revised the radio line-of-sight (RLOS) distance limitations.

Task 2 – Coordination with Standards Agency to Establish Framework

In collaboration with the American Society for Testing and Materials (ASTM), the ASSURE team is supporting a standards framework/body. ASTM Special Committee F38 provides the overarching standards body and subgroups are developing industry consensus standards for the following topics:

- Definition of a separation framework/standards, which focuses on DAA system requirements.
- Definition of testing methodologies for DAA systems to ensure safe separation, which includes consideration of the various approaches to DAA (e.g., on-board, off-board, radar, acoustic, etc.).

Task 3 – Development of Separation Framework

This task is focused on how characteristics of DAA systems and UAS impact maintenance of well clear status.

The team will develop the minimum set of characteristics to maximize the resultant safety and efficiency of DAA system testing.

The previous work the ASSURE team conducted indicates the characteristics of the Ground Control Station (GCS) and flight characteristics of UAS impacted the ability to maintain well clear during simulated tests. Through additional simulation and actual flight tests the researchers will conduct a rigorous exploration of impactful characteristics, including maneuverability in both the horizontal and vertical directions, the amount of time required to initiate a maneuver, and ownship positional uncertainty.

Task 4 – Testing of the recommended DAA testing plan and candidate DAA systems

Two fundamental items that require flight testing are the separation framework and the proposed testing plan. These are the foci of the flight tests. The flight tests also enable updates to the previous Safety Management System (SMS)/Safety Risk Management (SRM) analysis that the ASSURE team conducted. In addition, it provides an opportunity to compare different approaches to sUAS DAA.

The NMSU Flight Test Site (NMSU FTS), the Northern Plains UAS Test Site (NP UAS TS), and the Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) are conducting the flight tests.

The tests encompass the breadth of critical elements such as sensor uncertainty, UAS performance characteristics, different types of sensors, and elements of the testing plan.

Key Findings

Some testing and data analysis have been completed. The remaining effort is expected to be completed by fall of 2020. The final report and findings will be peer reviewed and public release is slated for later that summer.

Name & Origin of All Research Personnel

Name	Origin
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Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

ECOMMERCE – EMERGING UAS NETWORK AND IMPLICATIONS ON NAS INTEGRATION

MISSISSIPPI STATE UNIVERSITY

Lead University – Mississippi State University

Background
Logistics and information technology companies like Amazon, UPS, FedEx, and Google are looking for ways to increase the volume, speed, and delivery of commercial packages to retail customers with the use of unmanned aircraft systems (UAS). These UAS must be safely and efficiently integrated into the existing delivery networks and into the National Airspace System (NAS).

The ASSURE Research team will conduct surveys, assessments, analyses and simulation to support the creation of a notional nationwide commercial UAS delivery network framework. The researchers will consider the following key factors:

- Geography and structure of the existing package delivery network;
- Demographics of likely delivery customers;
- Effective radius of service from network hubs; and
- Costs of service provision to arrive at candidate network design.

Through analyses and simulations, the team will determine the potential impacts of the network upon the affected classes of airspace, interaction with other air traffic, overall ground/aviation safety and the environment, as well as potential integration with NASA's proposed unmanned traffic management (UTM) system. The resultant conclusions are intended to support an FAA risk and hazard analysis to identify where and how UAS-related safety risks are most likely to appear, so that the FAA can effectively target its resources based upon estimated safety risk.

Approach

Task 1 – Data Examination and Evaluation
The ASSURE team is examining the scope of commercial UAS delivery network entry into the NAS through a review of existing infrastructure data, a quantitative economic analysis of the market demand and choice modeling, and development of a methodology to analyze the economics of the potential network.

Task 2 – Network and Safety Analysis
In Task 2 the researchers are conducting a data and literature review of UAS delivery network design and network mobility studies. Upon completion, the team will determine the fundamental concept of operations (CONOPS) for a commercial UAS delivery network. Utilizing the rules established within the CONOPS, the team will develop a 3D Highway network route model and the software for the network route analysis. The researchers will identify UAS safety factors and a probability table using the Bayesian network

safety analysis. The team will also conduct a network performance analysis and format the network framework into geo-spatial maps for FAA use.

Task 3 – Emerging Network and NASA's UTM
After a data and literature review related to UAS navigation and traffic conflict resolution strategies, the team will design the UAS traffic and network segment routes. These segments will connect the route highways and delivery hubs and destinations. The ASSURE team will construct an air traffic simulation focusing on a representative delivery hub. Based on this and the software developed in Task 2, the team will analyze the simulation to provide capacity, mobility, and safety network performance recommendations. In addition, they will provide regional and national operation and policy implications.

Task 4 – Emerging Network and Environment Footprints
The ASSURE research team will examine the potential environmental impacts of a commercial UAS delivery network, with an emphasis on noise, visual, and air pollution. The team will conduct literature reviews and surveys to review environmental concerns for NAS aviation operations. The team will quantify the environmental impacts of a UAS delivery network and identify viable noise reduction technologies. The researchers will also measure the economic impact of various environmental affects and controls upon a potential UAS network.

Task 5 – Emerging Network and Regulatory Framework.
Task 5 focuses on the broad regulatory implications of an emergent retail delivery network. Using data from Tasks 1-4, the ASSURE team will explore regulatory options and present options and a timeline for evolving current regulatory guidance, processes, restrictions and definitions to better support the emergence of a commercial UAS delivery network—particularly within the projected economic and capability timeframes identified in Tasks 1-4.

Key Findings

The research team has received some data and completed the literature reviews. Research is ongoing for the next two years, and the final report is expected to be delivered to the FAA the fall of 2021.

Name & Origin of All Research Personnel

Name	Origin
Dallas Brooks – MSU	United States
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Adrian Sescu – MSU	United States

Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

UAS TEST DATA COLLECTION AND ANALYSIS

Lead University – University of North Dakota

Background

The FAA is mandated to establish a UAS research and development roadmap, including estimates, schedules, and benchmarks for UAS integration. The FAA must update the UAS Integration Research Plan on an annual basis to determine the most up to date research needs, research projects underway, and research planned to reach FAA UAS integration milestones.

This research provides an enhanced UAS data collection system that serves FAA needs to establish safety cases, evaluate needs for research, and align information with FAA research domains and the UAS Integration Research Plan.

The ASSURE team conducting this research includes, University of North Dakota (UND), New Mexico State University (NMSU), University of Alaska Fairbanks (UAF), Mississippi State University (MSU), and Virginia Tech (VT). This work relates to the development of the technical data requirements, test methods, risk assessments, safety risk management processes, data collection, and administrative processes/reporting used to inform safety cases in support of the UAS integration regulatory framework. The research will:

- Develop a system to capture test objectives and categorize them consistent with the FAA's UAS Integration Research Plan functional areas and research domains;
- Inform the development of regulatory products (i.e., rules, standards, policy, etc.) needed to reach UAS integration milestones; and
- Facilitate the query and reporting of data in a consistent format across the Test Sites.

Approach

In addition to the following task focuses, the FAA reviewed the framework twice and the ASSURE team revised the framework based on their feedback. The ASSURE team will submit a final report at the end of the project detailing the next steps to implement the system.

Task 1 – Initial Draft Safety Case Framework for Data Collection

The ASSURE team has developed an initial draft safety case framework for leveraging the FAA's test programs to collect test data that directly supports UAS integration safety cases while considering the constraints on these programs.

Task 2 – Develop Data Schema

This task defined and established a base set of data elements needed to support integration safety cases that should be collected. The schema aligned data elements within the safety case framework and to the FAA's research domains and functional areas.

Task 3 – Develop Demonstration Reporting System
In this task, the ASSURE team is developing a demonstration reporting system for evaluation of concepts. This reporting system will emulate critical elements of the proposed system to enable evaluation of concepts.

Task 4 – Develop Training Materials
The ASSURE team will develop an initial training system that outlines the system philosophy, design, user interface, and features, based upon the demonstration system and FAA feedback.

Key Findings
The final report detailing this work is expected to be peer reviewed the summer of 2020 with a public release later that summer.

Name & Origin of All Research Personnel

Name	Origin
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Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

UAS PARAMETERS, EXCEEDANCES, RECORDING RATES FOR ASIAS

Lead University – University of North Dakota

Background

This research builds upon existing aviation database and data-sharing efforts to enable safe integration of unmanned aircraft systems (UAS) in the National Airspace System (NAS). The ASSURE research team is developing a data architecture for UASs and operations which aligns with the FAA's Aviation Safety Information and Sharing (ASIAS) program.

The ASSURE team will:

- Design and evaluate Flight Data Monitoring (FDM), also known as Flight Operations Quality Assurance (FOQA), for unmanned operations and integrate that data into the ASIAS system; and
- Identify:
  - Current UAS FDM capabilities and practices, including refresh/recording rate and robustness, and developing guidance for a UAS FDM standard;
  - The best governance practices regarding the use and research involved with UAS flight data; and
  - UAS FDM events, including event definitions and exceedances, using the normal ASIAS techniques.

The ASSURE research team includes University of North Dakota (UND), Embry-Riddle Aeronautics University (ERAU), and Mississippi State University (MSU). This effort will help develop system requirements for data collection and analytical capabilities needed for processing UAS safety data within ASIAS in order to conduct aggregate safety risk analysis.

Approach

The ASSURE team has conducted a literature review and analysis and begun work on the following phases. At the end of the project the researchers will deliver a final report which will include findings and guidance.

Task 1 – Identify UAS flight data types and data sources and create a draft UAS data standard

The researchers worked with stakeholders to identify FDM formats, including telemetry streams and low-cost stand-alone recorders, most suitable for inclusion in a national ASIAS database. The team analyzed several telemetry data streams and assessed suitability for FDM utilization. Combining the above elements, the researchers created a draft UAS data standard that is robust enough to satisfy an FDM standard.

Task 2 – Design a basic set of UAS exceedances and test the capabilities

Using Subject Matter Expertise (SME) methodology like §121 Airline and National General Aviation Flight Information Database (NGAFID) operations, the ASSURE team is analyzing data and operations to determine suitability for comparison with current metrics across manned aircraft sectors. Upon completion of the analysis, the researchers are developing and testing the capability to upload UAS flight data into the ASIAS system using actual flight data conducted as part of UAS flights.

Task 3 – Validate and assess data robustness and viability

The ASSURE team will demonstrate developed technology to stakeholders and subject matter experts for feedback and final revision. Using the data, they will validate its capability to contribute to safety risk, mitigation, and hazard identification capabilities.

Key Findings

The final report detailing this work is expected to be peer reviewed the summer of 2020 with a public release later that summer.

Name & Origin of All Research Personnel

Name	Origin
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Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

ESTABLISH RISK-BASED THRESHOLDS FOR APPROVALS NEEDED TO CERTIFY UAS FOR SAFE OPERATION

Kansas State University · University of North Dakota · The Ohio State University · National UAS Training and Certification Center

Lead University - Kansas State University

Background

At present, FAA has taken steps toward the full integration of unmanned aircraft systems (UAS) into the National Airspace System (NAS) by considering waivers for expanded and non-segregated operations. Expanded and non-segregated operations will afford UAS operations in the same airspace as manned aircraft. Such operations will most likely involve interaction between UAS pilots, manned pilots, and air traffic controllers in a similar manner as aircraft operations are conducted today under instrument flight rules (IFR).

The ASSURE research team will focus on two elements of safety assurance. The first pertains to pilot training standards; the second focusses on recommending a framework related to aircraft performance-based certification considerations across a range of operational approvals. The research will inform the development of modified and new guidance towards regulations and certification standards regarding UAS crewmember training, certification, and aircraft type certification. In order to achieve full-scale integration and interoperability of manned and unmanned aircraft to fly routinely in domestic and international airspace, future work will require efforts to ensure:

- UAS and associated systems are certified as airworthy to achieve type certification;
- UAS are operated by a qualified pilot/operator in the appropriate class(es) of airspace; and
- UAS will operate in compliance with applicable regulatory guidance and equipage standards.

The theoretical and practical underpinnings established through this research will aid to:

- Identify limitations associated with the current evaluation paradigm associated with sUAS pilot certification (14 CFR §107) and report on the potential gaps towards expanded and non-segregated operations;
- Develop a framework to capture the knowledge, skills and abilities (KSAs) required of UAS pilots by classification and category of UAS towards industry consensus standards development; and
- Establish a framework to adopt, adapt and exercise current regulatory requirements, i.e. §23, 25, 27, 29, 31, 33, and 35, towards performance-based type certification for sUAS and a waiver to operate over people within visual line of sight as prescribed in 14 CFR §107.31.

Kansas State University (KSU) will lead the project in collaboration with University of North Dakota (UND), The Ohio State University (OSU), and Sinclair College (SC).

Approach
The research focuses upon four primary tasks. In addition, the researchers will create an RTP, conduct peer reviews throughout the project, and will submit a comprehensive final report.

Task 1 – Literature Review
The ASSURE team will conduct a literature review to determine use cases and identify any established or in development industry consensus standards. The team will also evaluate the current manned pilot training and certification program under §141 Pilot Schools. This effort will explore options to develop a framework for future trends in UAS pilot training, qualification, and standards requirements to operate in expanded and non-segregated airspace.

Task 2 – Development of UAS Pilot Certification Strategies
Based on findings from Task 1, the team will establish the methodology to identify UAS ratings based on the identified knowledge, skills and abilities (KSAs). The researchers will develop a strategy for UAS pilot training, certification, and ratings and will establish the criteria and level of rigor consistent with manned aviation pilot training. The team will then identify both the pilot certification, avionics, and procedure requirements necessary to facilitate expanded and non-segregated operations.

Task 3 – Development of UAS Airworthiness/Type Certification Framework and Use Case
The team will examine current regulatory guidelines, identify gaps in the certification process related to UAS, and establish a framework to adopt, adapt and exercise current regulatory requirements. The team will focus on three certification test cases:

- A §107 waiver using a sUAS like the Ebee X;
- An exemption under 14 USC Section 44807 using a more complex system like the Penguin C or FVR-90.

Task 4 – Conduct Assessment of Proposed Pilot Training and Certification Strategies
In this final task, the team will design a methodology to evaluate the UAS and classification training strategies to ensure validity and reliability towards industry consensus standards. Attaining insight from accredited bodies that operate degree programs specific to aviation pilot training will also shed valuable insight for the future expansion of UAS pilot training and certification.

Key Findings
This project has just begun. Deliverables and reports will be delivered throughout the next 24 months, and the final report will be delivered to the FAA for peer review the Fall of 2021.

Name & Origin of All Research Personnel

Name	Origin
Tom Haritos – KSU	United States
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Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

UAS AS A STEM OUTREACH LEARNING PLATFORM FOR K-12 STUDENTS AND EDUCATORS (STEM III)

Lead University - New Mexico State University

Background

This Science Technology, Engineering, and Math (STEM) outreach program is a continuation of previous ASSURE work. It focuses on the future unmanned aircraft system (UAS) workforce and the use of real-world research results from other ASSURE efforts. The outreach conducted in this program is an effective way to educate and disseminate research results. Some of the efforts are focused specifically on students and some on “teaching the teachers”.

New Mexico State University (NMSU) is leading the ASSURE team in cooperation with University of Alabama in Huntsville (UAH), University of Alaska Fairbanks (UAF), University of California at Davis (UCD), The Ohio State University (OSU), and Sinclair College (SC). The team will work with a diverse demographic to include urban areas, Alaskan Native, Native American, tribal communities, rural districts, intercity, farming communities, and more.

The ASSURE research team will focus on five basic categories:

- Educator-based STEM outreach program;
- Rural community education and outreach;
- UAS centered summer camps;
- After school programs; and
- In school immersion programs.

Approach

Each university has their own approach based on their local demographic and the specific categories they plan to focus on.

New Mexico State University – FAA STEM Program Management, Sinclair Sponsorship, and Various STEM Activities

As in previous years, NMSU will continue to lead the teams STEM activities. Additional efforts will focus on their existing outreach activities like the UAS Roadshows and UAS Summer Camps. Their focus is on middle school students who are primarily Hispanic and Native American.

University of Alabama in Huntsville (UAH) – Alabama Unmanned Systems Operations Mastery for Educators (AUSOME)

UAH will create an educator-based STEM outreach program focusing on UAS for minority and technology centric STEM programs in Alabama. The goal of the AUSOME project is to augment existing STEM programs. They will develop the segments where UAS are used as the central learning platform in the engineering, robotics, environmental science, math, and computer science curricula. UAH will cater to educators and STEM engagement staff to facilitate the addition of UAS topics into the programs. In addition, they will co-develop interdisciplinary learning material into their programs and providing training, educational material, and program maintenance support. A series of UAS Educator’s Workshops and educational outreach events will comprise of airspace education, UAS components, safe operations, regulation knowledge learning, policy development, science and engineering use cases.

UAH will collaborate with the Alabama Agricultural and Mechanical University (AAMU) STEM Knowledge Center, a Historic Black College and Land Grant School, the NASA Marshall Space Flight Center (MSFC) Minority University Research and Education Project (MUREP), and the U.S. Space and Rocket Center Space Camp for Educators program to host at least three UAS Educator’s Workshops per year. Educational material and activities developed for these roadshows is transferrable to STEM magnet schools and minority programs at STEM institutes to educate the educators on UAS, thereby expanding the knowledge base of the community.

University of Alaska Fairbanks (UAF) – The Alaskan UAS Airshow

Due to the remote nature of the state of Alaska, the Airshow will provide UAF an opportunity to fly experts from the University of Alaska Fairbanks's Alaska Center for UAS Integration (ACUASI) to schools across the state. These experts will teach students about UAS safety, rules, regulations, aerodynamics, and potential careers using UAS. The ACUASI team will take flight simulators and small first-person-view UAS for the students to use during the event.

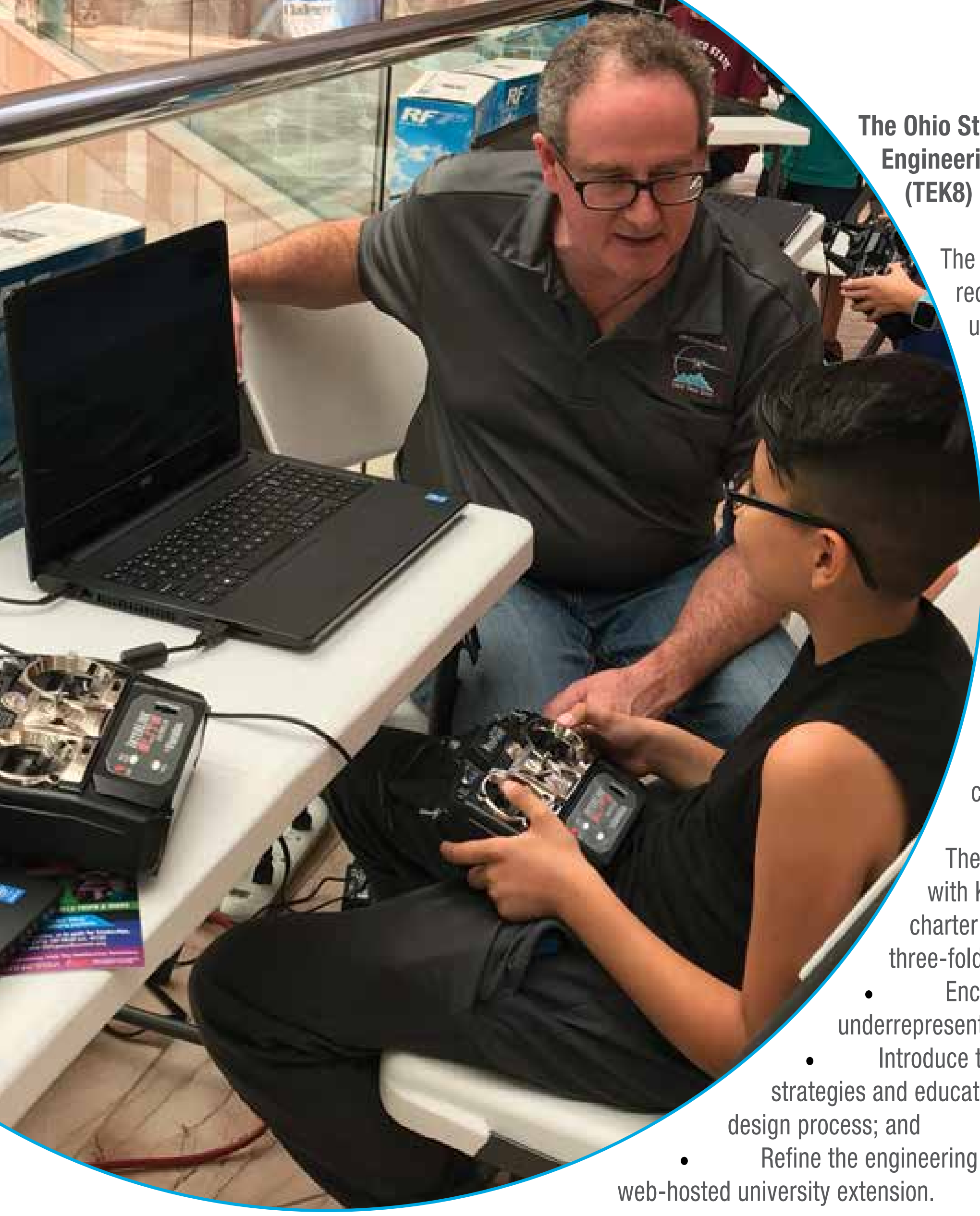
In addition to interacting with Alaska Native middle school students, the experts will work with law enforcement, school officials, and the community as a whole because of the small size of these towns and villages. The Airshow is a follow-on from the successful Roadshows conducted under the previous ASSURE STEM projects and will use the materials developed, acquired, and used during that effort.

University of California at Davis (UCD) – STEM Summer Drone Academy

UCD will build upon and enhance the highly successful 2018 Summer Drone Academy. They will add hands-on instruction and activities with Virtual Reality (VR) technologies, including real-world applications in Archaeology, Education, Medicine, and other relevant societal applications. UCD will select 10th and 11th grade high school students from ten Sacramento area high schools for the program based on their application credentials, personal essay, and grade point average (GPA).

The Drone Academy learning objectives will incorporate an intro to VR applications within the following STEM disciplines:

- Aviation overview and introduction to principles of flight;
- Industry overview emergence of drones for recreational and commercial use;
- Introduction to emerging robotics technology, with hands on applications using remote control ground bots and mini-drones;
- Team competitions using ground bots and mini-drones completing obstacle course for prizes;
- Overview of drone technology for socially beneficial applications;
- Teamwork, communication, creative design, and problem-solving skills using STEM themes; and
- Indoor and outdoor activities including overview of college programs at UCD.



The Ohio State University (OSU) – Translating Engineering to Kindergarten Through 8th graders (TEK8) with a Focus on UAS Research

The OSU TEK8 program will continue to recruit and mentor academically talented undergraduate engineering students in the Primary Investigator's (PI) research labs. The students in the PI's labs will support research focused on UAS development and integration into the National Airspace System (NAS). The students will take a course in the fall with in-service teachers pursuing graduate coursework. The undergraduate researchers will team with the teachers to transform their research experience into several engineering design challenges appropriate for grades K-8, and then take the project into underserved K-8 classrooms.

The TEK8 program has an existing relationship with KIPP Journey Academy, a diverse urban charter school. The goal of this program is three-fold:

- Encourage undergraduate research and underrepresented minority participation in engineering;
- Introduce teachers to project-based learning strategies and educate them in engineering practice and the design process; and
- Refine the engineering design challenges and document them in a web-hosted university extension.

Sinclair College National UAS Training and Certification Center – Interactive Middle School UAS Introduction and Simulation Experience

The Sinclair National UAS Training and Certification Center will extend a successful UAS STEM outreach model deployed initially in the 2016-17 school year in Greene County, Ohio. Many of these middle school aged students are in disadvantaged, underserved, and minority urban or rural districts ranging from intercity districts to rural farming communities and to those in western Appalachia.

This project introduces UAS technologies, applications and careers, and an initial UAS simulation session leveraging RealFlight and Simlat software in either the Sinclair Mobile-Ground Control Station (M-GCS) or Tactical-Ground Control Station (T-GCS). SC is targeting four weeks each academic year from 2019 through 2021.

Key Findings

This project has just begun. Reports and press releases will be delivered throughout the next 24 months, and the final report will be delivered to the FAA for peer review the Fall of 2021.

Name & Origin of All Research Personnel

Name	Origin
Henry Cathey – NMSU	United States
Jerry Hendrix – UAH	United States
Catherine Cahill – UAF	United States
Susan Ustin – UCD	United States
Kiran D'Souza – OSU	United States
Jeffery Miller – SCC	United States

Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

INTEGRATING EXPANDED AND NON-SEGREGATED UAS OPERATIONS INTO THE NAS – IMPACT ON TRAFFIC TRENDS AND SAFETY

The Ohio State University | Kansas State University | Embry-Riddle Aeronautical University | Drexel University | The University of Alabama in Huntsville | UAF University of Alaska Fairbanks | NM State University | University of North Dakota | Virginia Tech

Lead University – The Ohio State University & Kansas State University

Background

This research will provide further insight into the safe integration of small unmanned aircraft systems (sUAS) through forecasting of expanded and non-segregated sUAS operations. The ASSURE research team will collect data to inform the Federal Aviation Administration (FAA) on risk-based methodologies to safety rules, regulations and revised Safety Management System (SMS) protocols based on forecasted UAS operational needs and performance characteristics.

The research supports two critical components of the UAS Integration Research Plan:

- Expanded Operations – Operations Over People (OOP)
- Non-Segregated Operations – Beyond Visual Line of Sight (BVLOS)

These two components are anticipated to enable future UAS operations in controlled airspace with manned aircraft at varying altitudes and utilizing instrument flight rules within the National Airspace System (NAS). The ASSURE team will develop a quantitative framework for risk-based decision making and waiver approvals to meet the growing operational needs and technological evolution of UAS.

Ohio State University (OSU) and Kansas State University (KSU) are the leads for this project, with help from Embry-Riddle Aeronautical University (ERAU), Drexel University (DU), University of Alabama-Huntsville (UAH), University of Alaska Fairbanks (UAF), New Mexico State University (NMSU), University of North Dakota (UND), and Virginia Tech (VT).

Approach

This research is broken down into three phases. Each Phase is broken down further into tasks. The ASSURE team will develop a Research Task Plan (RTP). The RTP will be peer reviewed prior to the start of Phase 1.

Phase 1 – Evaluation of data and establishment of quantitative impact of expanded operations

The researchers will collect the data from the Integrated Pilot Program (IPP), non-hobbyists survey, waivers issued under §107, COA and Section 333 operations, and other data available for expanded and non-segregated commercial and (mixed) public use operations in controlled airspace with manned aircraft.

The ASSURE team will analyze this data to identify trends and develop recommendations for a quantitative framework to provide a complete and accurate picture of expanded operations.

The Phase 1 outcome report will provide summaries of all available data, establish quantitative relationships between existing trends, and explain shifts due to different aspects of integration activities such as waivers, IPP, and other regulatory relaxations.

Phase 2 – Establish scope of non-segregated operations
Building upon results from Phase 1, the researchers will project UAS traffic trends for the integration of expanded and non-segregated UAS operations into the NAS. The results will provide predictions on demand and what pace changes in demand will occur. Phase 2 will also identify both the avionics equipage and procedure requirements necessary to facilitate expanded and non-segregated operations in the NAS.

The Phase 2 outcome report will include the forecasted demand for expanded and non-segregated UAS operations, the distribution of UAS within the domain (including type, configuration, mission profiles, and equipage), the corresponding environments where the demand will occur, and a timeline which captures the pacing of and trends within the forecast.

Phase 3 – 'de minimis' risk likelihood and comparable framework
The final phase will establish quantitative relationships between the increased pace of automation and the impact on sightings/incidents and accidents.

The ASSURE team will use the comparisons to propose a predictable, repeatable, quantitative, and risk-based process or framework for inclusion in the SMS process, including the use of sensitivity analyses to help decision makers consider the range of uncertainty associated with available data. The researchers will develop a framework for SMS that defines a process for making risk-based decisions that applies across the varying levels of risk associated with the operation of different sUAS and considers performance-based requirements to mitigate risk.

The Phase 3 report will include a comprehensive risk framework and the data necessary to support analyses. This risk framework will address safety hazards and impacts associated with forecasts of expanded and non-segregated UAS operations and a summary of recommended revisions of the SMS process to manage associated risks based on the results of Phases 1-3.

Key Findings

This project has just begun. Deliverables and reports will be delivered throughout the next 24 months, and the final report will be delivered to the FAA for peer review the Fall of 2021.

Name & Origin of All Research Personnel

Name	Origin
Philip Smith – OSU	United States
Matt McCrink – OSU	United States
Jim Gregory – OSU	United States
Gary Allread – OSU	United States
Ellen Bass – DU	United States
Richard Stansbury – ERAU	United States
Kurt Carraway – KSU	United States
Henry Cathey – NMSU	United States
Jerry Hendrix – UAH	United States
Catherine Cahill – UAF	United States
Mark Askelson – UND	United States

Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

PUBLICATIONS, PROCEEDINGS, & FUTURE RESEARCH

2020 RESEARCH

Our previous research projects tied with FAA UAS regulating experience has identified knowledge gaps and needs for additional research. Below are the areas of research that the FAA has funded or has expressed interest in funding, with its limited resources. This is ASSURE's best guess; the priorities for future research supporting the mission to safely integrate UAS into the national airspace system NAS may change.

- Risk-Based Training & Standards for Waiver Review & Issuance
- Airborne Collision – Follow-on ATO for Heavier UAS
- A19 Range Data Follow-On, UAS Safety Case Development, Process Improvement & Data Collect
- Multi-UAS Control
- Risk-Based Thresholds for UAS Cert (Test Cases)
- Safety Research Center
- Disaster Preparation & Recovery
- Operations Over Moving Vehicles
- SARP Collision Avoidance and Well Clear Volumes
- Operations Over People NPRM Alternate Means of Compliance Waiver
- Safety Risks and Mitigations for UAS Operations on and Around Airports
- Implications of UAS Delivery Operations on NAS Integration
- Counter UAS Research
- Identify Wake Turbulence Requirements for UAS
- Identify Certification Considerations & Operation Integration Strategies for Air Mobility Ops
- Identify Cybersecurity Requirements for UAS Operations
- Identify UAS Noise & Emissions Requirements

SIGNIFICANT EVENTS

Significant Events	Date
UAS Center of Excellence (COE) Selection announced by FAA Administrator Huerta	May 2015
UAS COE Kick-Off Meeting	June 2015
Initial research grants awarded	September 2015
ASSURE IDIQ Kickoff Meeting, Washington, DC	October 2018
ASSURE Senior Advisory Group Meeting, Albuquerque, NM	December 2018
ASSURE Engine Ingest Scoping - Peer Review, Washington, DC	February 2019
ASSURE Structural Impact Scoping - Peer Review, Washington, DC	February 2019
ASSURE FAA Program Management Review, Washington, DC	February 2019
ASSURE Domestic Drone Security & Safety Summit, Washington, DC	April 2019
ASSURE sUAS Ground Collision Phase II - Final Report Peer Review, Washington, DC	April 2019
ASSURE XPONENTIAL 2019 & Presentations, Chicago, IL	April/May 2019
ASSURE FAA UAS Symposium, Baltimore, MD	June 2019
ASSURE FAA Program Management Review, Washington, DC	September 2019
ASSURE International UAS Regulator & Research Roundtable, Washington, DC	September 2019
ASSURE U-Space CONOPS & Research Dissemination Meetings, Brussels, Belgium	September 2019

JOURNAL ARTICLES

- Wallace, Ryan J.; Kiernan, Kristy M.; Haritos, Tom; Robbins, John; and Loffi, Jon M. (2019) "Evaluating Small UAS Operations and National Airspace System Interference Using AeroScope," Journal of Aviation Technology and Engineering: Vol. 8: Iss. 2, Article 3.
  Available at: https://doi.org/10.7771/2159-6670.1189

CONFERENCE PROCEEDINGS

- UAS Test Data Collection and Analysis: Is Your UAS Safety Case Ready for Flight – Leveraging Research and Operations to Get to YES Panel (Participant), 2019 FAA UAS Symposium, Baltimore, MD, June 2019.

The ASSURE University Coalition

Assure has the knowledge of a 23 Member University Coalition

MISSISSIPPI STATE UNIVERSITY

UAF UNIVERSITY OF ALASKA FAIRBANKS

THE OHIO STATE UNIVERSITY

UC DAVIS UNIVERSITY OF CALIFORNIA

KU

UAH THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

EMBRY-RIDDLE Aeronautical University

NM STATE UNIVERSITY

KANSAS STATE UNIVERSITY

WSU WICHITA STATE UNIVERSITY

OSU Oregon State University

MONTANA STATE UNIVERSITY

NC STATE UNIVERSITY

AUBURN UNIVERSITY

UND UNIVERSITY OF NORTH DAKOTA

Drexel UNIVERSITY

Université Concordia University

TUSKEGEE UNIVERSITY

National UAS Training and Certification Center

Indiana State University

LOUISIANA TECH UNIVERSITY

TECHNION Israel Institute of Technology

UNIVERSITY OF Southampton

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