The FAA's Center of Excellence for UAS Research

ASSURE

Alliance for System Safety of UAS through Research Excellence

2020 ANNUAL REPORT

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ASSURE-UAS

OVERVIEW

FOREWORD:

What an extraordinary year; a year that brought the COVID-19 virus; a pandemic that caused, at the time of this writing, nearly 40 million cases and over 1 million deaths worldwide, shutdowns (to include many of our universities), lockdowns, social distancing, and concern for the health and well-being of family and friends. Despite all this and even more, I was so in awe and proud of how the ASSURE (the Alliance for System Safety of UAS through Research Excellence) universities, researchers, students, and business partners made appropriate adjustments for safety and managed through all the challenges to provide the Federal Aviation Administration's (FAA) research critical to inform national policy, regulations and guidelines on how to safely integrate unmanned aircraft systems (UAS) into the nation's airspace. Because of this work, it is my hope that autonomous systems will serve the public in emergencies like this and day-to-day emergency response in the future.

Through all this craziness, ASSURE successfully passed a milestone, the first five-year phase as the FAA's Center of Excellence (COE) for Unmanned Aircraft Systems (UAS) and will continue to serve in that role going forward. As part of this landmark accomplishment, ASSURE management took the opportunity to brief all the 15 Core University Vice-Presidents (or equivalent) on this first phase and ASSURE's path forward. While the alliance has faced its share of challenges (such as cost-match, a long grant approval process and a pandemic), I was happy to report that the alliance is strong and growing. ASSURE has built a highly effective team of 26 research institutions consisting of 15 Core Universities, 9 Affiliate Universities (including 4 international schools), and 2 Universities that have joined us as business partners. We added Affiliate University Nanyang Technological University-Singapore (NTU) as part of our strategic effort to collaborate on and coordinate regulatory research worldwide. While COVID-19 has slowed this evolution, ASSURE is actively engaged with Civil Aviation Authorities and Universities around the globe and hopefully by next year's annual report the pandemic will have eased and we will be able to report more progress on the international front.

ASSURE is not only expanding geographically, our universities are conducting more research over a wider variety of topics. At the time of this writing, ASSURE researchers are engaged in nearly 40 different projects at various levels of completion from proposal to final reports and peer review; this is up from 10-12 studies in the past. FAA-ASSURE level of effort in funding and projects is over three times what it was at the beginning of the program.

The FAA has shifted our research from completing collision severity studies to more encompassing risk assessment of different types of operations, airspace, mid-air collisions and waiver frameworks. ASSURE is also studying operation enablers like multi aircraft control, cyber security, and an alternative means of compliance for operations over people. The FAA has tasked ASSURE to conduct certification research for operations like UAS cargo transportation, air carrier operations, and air mobility. ASSURE and the FAA continue their projects focused on the public good through our continued Science, Technology, Engineering, and Math (STEM) projects for under-represented minorities, and a new, very large, multiyear, interagency effort to better integrate UAS quickly, efficiently, and safely into disaster preparation and relief operations. These are just a few of the studies ASSURE is conducting to inform FAA and other agencies' regulations, guidelines and standards related to unmanned aircraft operations.

This Annual Report provides highlights of the work conducted in FY 2020. Please take a moment to review our work and contact us with any ideas, suggestions, or comments.

THANK YOU for your time and efforts in supporting ASSURE and the FAA through this difficult year,

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

MISSISSIPPI STATE UNIVERSITY

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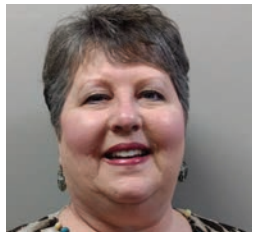

Sheila Ashley

Administrative Assistant
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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:

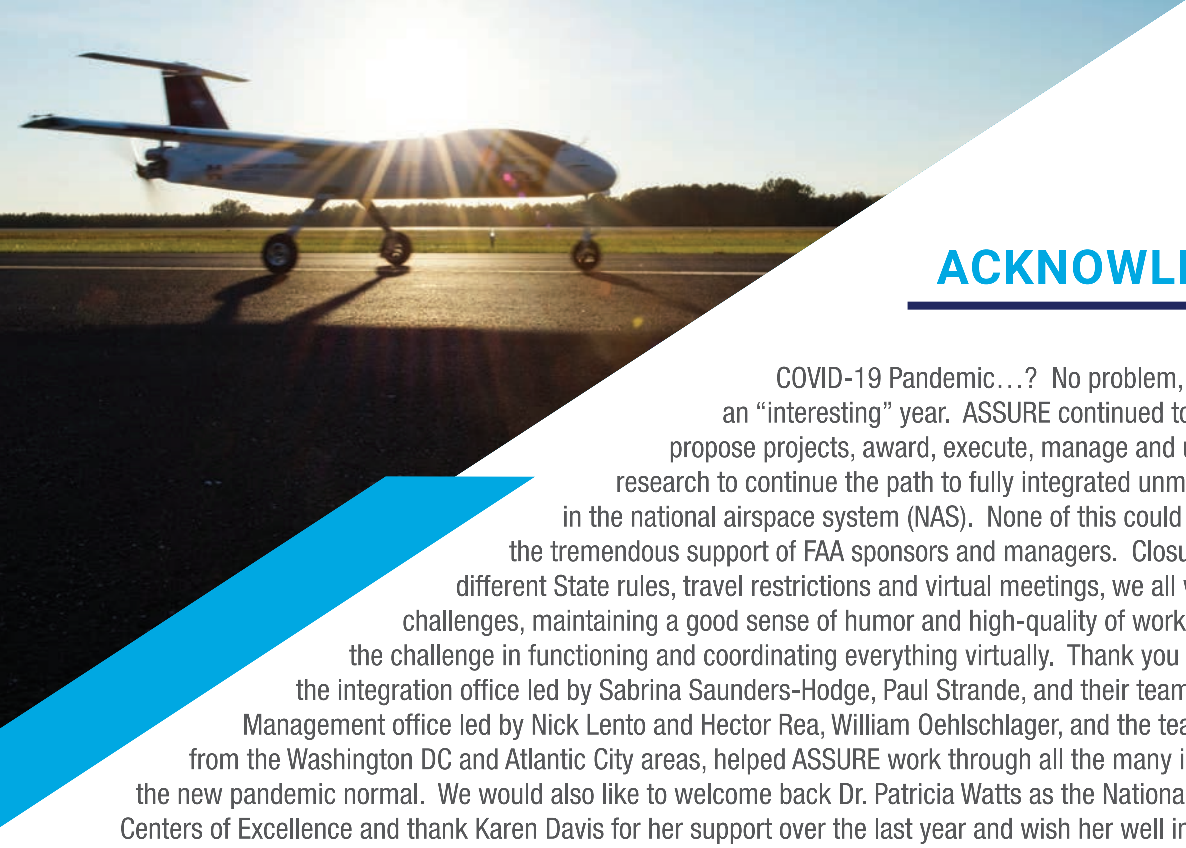
Our vision is to help the unmanned aerial system market grow into its multibillion-dollar market potential by conducting research that quickly, safely, and effectively get UAS flying alongside manned aircraft around the world.

ASSURE TAG LINE:

Informing UAS policy through research

WEBSITE:

http://www.assureuas.org/



ACKNOWLEDGMENTS

COVID-19 Pandemic…? No problem, we got this. Wow, what an "interesting" year. ASSURE continued to build requirements, propose projects, award, execute, manage and ultimately use the research to continue the path to fully integrated unmanned operations in the national airspace system (NAS). None of this could be possible without the tremendous support of FAA sponsors and managers. Closures, shut-downs, different State rules, travel restrictions and virtual meetings, we all worked though the challenges, maintaining a good sense of humor and high-quality of work. The FAA has taken on the challenge in functioning and coordinating everything virtually. Thank you to our sponsors from the integration office led by Sabrina Saunders-Hodge, Paul Strande, and their team. Our FAA Program Management office led by Nick Lento and Hector Rea, William Oehlschlager, and the team of project managers from the Washington DC and Atlantic City areas, helped ASSURE work through all the many issues associated with the new pandemic normal. We would also like to welcome back Dr. Patricia Watts as the National Program Director of FAA Centers of Excellence and thank Karen Davis for her support over the last year and wish her well in her new opportunities within the FAA.

Dr. Julie Jordan, our Vice President for Research and Economic Development at Mississippi State University and her Associate VP, Maj Gen (USAF-Retired) Jim Martin have provided invaluable support and guidance through this COVID crisis, closing out its first five-year term, and development of a path forward in support of the FAA and expansion of ASSURE research.

I would also like to acknowledge the amazing team that ensures that ASSURE runs so smoothly. Billy Klauser, Deputy Director; Whitley Alford, Financial Manager, and Sheila Ashley, Administrative Assistant. Hannah Thach has done a tremendous job in her first year as Technical Director of Research. She has done a great job of working with the FAA PM Office and our universities to codify the procedures that enable our researchers to provide studies that inform national policy. Our Mississippi State team manages an extremely large team of universities and their many different offices and interests. This is not an easy task; I am gratefully 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 $34,857,137.83

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Office- Mississippi State University	**$5,768,919.78**	**$4,675,581.63**	**$1,093,338.15**	**$4,675,581.63**	**100%**
Core Schools	**$29,088,218.05**	**$14,020,590.96**	**$15,067,627.09**	**$19,050,170.07**	**136%**
Drexel University	$931,343.94	$700,825.06	$230,518.88	$776,592.65	111%
Embry-Riddle Aeronautical University	$1,513,154.13	$785,778.78	$727,375.35	$1,089,005.45	139%
Kansas State University	$2,075,705.00	$1,174,341.00	$901,364.00	$2,067,490.82	176%
Mississippi State University	$4,000,956.81	$1,164,814.46	$2,836,142.35	$1,150,034.21	99%
Montana State University	$709,062.28	$571,589.50	$137,472.78	$796,244.37	139%
New Mexico State University	$2,274,152.53	$1,122,245.73	$1,151,906.80	$1,122,245.73	100%
North Carolina State University	$539,854.39	$229,876.39	$309,978.00	$229,876.39	100%
Ohio State University	$3,302,993.21	$1,850,323.62	$1,452,669.59	$4,334,550.62	234%
Oregon State University	$688,000.00	$96,248.28	$591,751.72	$75,000.00	78%
University of Alabama-Huntsville	$3,717,078.43	$2,240,757.00	$1,476,321.43	$2,548,163.64	114%
University of Alaska-Fairbanks	$1,420,993.40	$205,943.51	$1,215,049.89	$290,528.61	141%
University of California-Davis	$144,730.00	$71,628.30	$73,101.70	$114,087.60	159%
University of Kansas	$891,967.86	$91,967.86	$800,000.00	$92,000.01	100%
University of North Dakota	$3,566,862.07	$1,694,427.47	$1,872,434.60	$2,344,525.97	138%
Wichita State University	$3,311,364.00	$2,019,824.00	$1,291,540.00	$2,019,824.00	100%
Totals	**$34,857,137.83**	**$18,696,172.59**	**$16,160,965.24**	**$23,725,751.70**	**127%**

SUMMARY BY PROJECT

Total Funding $34,857,137.83

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Management	**$6,086,441.97**	**$4,991,189.00**	**$1,095,252.97**	**$4,991,189.00**	**100%**
Projects	**$28,770,695.86**	**$13,704,983.59**	**$14,942,271.47**	**$18,734,562.70**	**137%**
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	$284,186.03	$284,186.01	$0.02	$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	$2,042,089.21	$2,039,161.32	$2,927.89	$2,274,960.61	112%
A15: Stem II	$149,982.00	$149,982.00	$0.00	$158,642.77	106%

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SUMMARY BY PROJECT (CONTINUED)

Total Funding $34,857,137.83

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Management	**$6,086,441.97**	**$4,991,189.00**	**$1,095,252.97**	**$4,991,189.00**	**100%**
Projects	**$28,770,695.86**	**$13,704,983.59**	**$14,942,271.47**	**$18,734,562.70**	**137%**
A16: Airborne Collision Severity Evaluation - Structural Impact	$2,203,377.79	$1,315,854.73	$887,523.06	$1,277,515.99	97%
A17: Airborne Collision Severity Evaluation - Engine Ingestion	$1,532,252.00	$1,087,081.70	$445,170.30	$1,100,049.76	101%
A18: Small UAS Detect and Avoid Requirements Necessary for Limited BVLOS Operations: Separation Requirements and Training	$1,108,574.53	$855,640.22	$252,934.31	$4,600,607.91	538%
A19: UAS Test Data Collection and Analysis	$462,976.47	$331,724.74	$131,251.73	$427,523.40	129%
A20: UAS Parameters, Exceedances, Recording Rates for ASIAS	$413,957.17	$283,842.10	$130,115.07	$396,319.22	140%
A21: Integrating Expanded and Non-Segregated UAS Operations into the NAS: Impact on Traffic	$1,496,515.00	$658,262.16	$714,812.04	$742,709.75	113%
A23: Validation of Low-Altitude Detect and Avoid Standards- Safety Research Center	$1,500,000.00	$0.00	$1,500,000.00	$0.00	0%
A24: UAS Safety Case Development, Process Improvement, and Data Collection	$1,479,956.87	$37,349.20	$1,442,607.67	$117,591.96	315%
A25: Develop Risk-Based Training and Standard for Operational Approval and Issuance	$498,161.00	$91,476.58	$406,684.42	$61,865.48	68%
A26: Establish UAS Pilot Proficiency Requirements	$500,000.00	$74,160.32	$425,839.68	$80,317.74	108%
A27: Establish risk-based thresholds for approvals needed to certify UAS for safe operation	$500,037.00	$181,660.28	$318,376.72	$492,251.26	271%
A28: Disaster Preparedness and Response	$1,999,978.77	$45,014.14	$1,954,964.63	$352.74	0%

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SUMMARY BY PROJECT (CONTINUED)

Total Funding $34,857,137.83

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Management	**$6,086,441.97**	**$4,991,189.00**	**$1,095,252.97**	**$4,991,189.00**	**100%**
Projects	**$28,770,695.86**	**$13,704,983.59**	**$14,942,271.47**	**$18,734,562.70**	**137%**
A29: STEM Outreach-UAS as a STEM Outreach Learning Platform for K-12 Students and Educators (STEM III)	$459,015.00	$154,445.32	$304,569.68	$80,893.96	52%
A31: Safety Risk and Mitigations for UAS Operations On and Around Airports	$1,481,814.00	$0.00	$1,481,814.00	$0.00	0%
A33: Science and Research Panel (SARP) Support	$70,383.00	$0.00	$70,383.00	$0.00	0%
A35: Identify Wake Turbulence and Flutter Testing Requirements for UAS	$1,498,921.00	$0.00	$1,498,921.00	$0.00	0%
A36: Urban Air Mobility (UAM): Safety Standards, Aircraft Certification and Impact on Market Feasibility and Growth Potentials	$1,199,922.00	$0.00	$1,199,922.00	$0.00	0%
A37: UAS Standards Tracking, Mapping, and Analysis	$499,900.00	$0.00	$499,900.00	$0.00	0%
A38: CyberSecurity and Safety Literature Review	$494,238.00	$0.00	$494,238.00	$0.00	0%
A40: Validation of American Society for Testing Materials (ASTM) Remote ID Standards-Safety Research Center	$750,000.00	$0.00	$750,000.00	$0.00	0%
Totals	**$34,857,137.83**	**$18,696,172.59**	**$16,037,524.44**	**$23,725,751.70**	**127%**

COST SHARE SUMMARY BY CONTRIBUTORS

Adaptive Aerospace Group, Inc.	$5,897.34
AgentFly Software	$50,000.00
ARC	$41,355.58
Arlin's Aircraft	$3,000.00
AUVSI	$15,873.00
Boeing	$46,235.64
Consortium on Electromagnetics and Radio Frequencies	$2,675.00
DJI	$63,285.84
DJI Research, LLC	$48,522.80
Drexel University	$537,582.65
Embry-Riddle Aeronautical University	$902,611.33
General Electric	$145,930.48
GoPro	$29,925.60
GreenSight Agronomics, Inc.	$37,777.00
Honeywell	$30,275.78
Indemnis	$251,685.84
Intel	$113,101.60
K.I.M. Inc.	$51,200.00
Kansas Department of Commerce	$286,554.47
Kansas State University	$1,767,196.82
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	$2,136,319.59
Montana Aircraft	$6,000.00
Montana State University	$717,673.73
New Mexico State University	$1,122,245.73
North Carolina State University	$914,370.49
North Dakota Department of Commerce	$1,409,779.34
NUAIR	$20,923.02
Ohio State University	$509,315.65
Ohio/Indiana UAS Center (ODOT)	$3,052,767.74
R Cubed Engineering	$6,970.09
RFAL	$21,343.30
Rockwell Collins	$4,015.80
Sandia	$2,257.00
SenseFly	$471,131.36
Simlat Software	$147,260.00
Sinclair Community College	$954,087.32
State of Kansas	$91,604.83
Technion Inc	$1,927,556.69
The Cirlot Agency	$116,824.90
University of Alabama in Huntsville	$1,343,239.54
University of Alaska Fairbanks	$290,528.61
University of California Davis	$114,087.60
University of Kansas Center for Research, Inc.	$92,000.01
University of North Dakota	$625,025.37
Virginia Polytechnic Institute and State University	$255,602.44
Wichita State University	$2,135,359.00
Total	**$23,725,751.70**

SUMMARY BY YEAR

FY16 Cost Share	$4,197,084.44
FY17 Cost Share	$4,274,690.28
FY18 Cost Share	$1,789,332.05
FY19 Cost Share	$7,863,252.88
FY20 Cost Share	$5,601,392.05
Cumulative Cost Share	**$23,725,751.70**

SUMMARY BY SOURCE

Universities	$14,417,245.88
State Contributions	$4,840,706.38
3rd Party Contributions	$4,467,799.44
Total	**$23,725,751.70**

RESEARCH STUDIES

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 projects needed, planned, and underway 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.

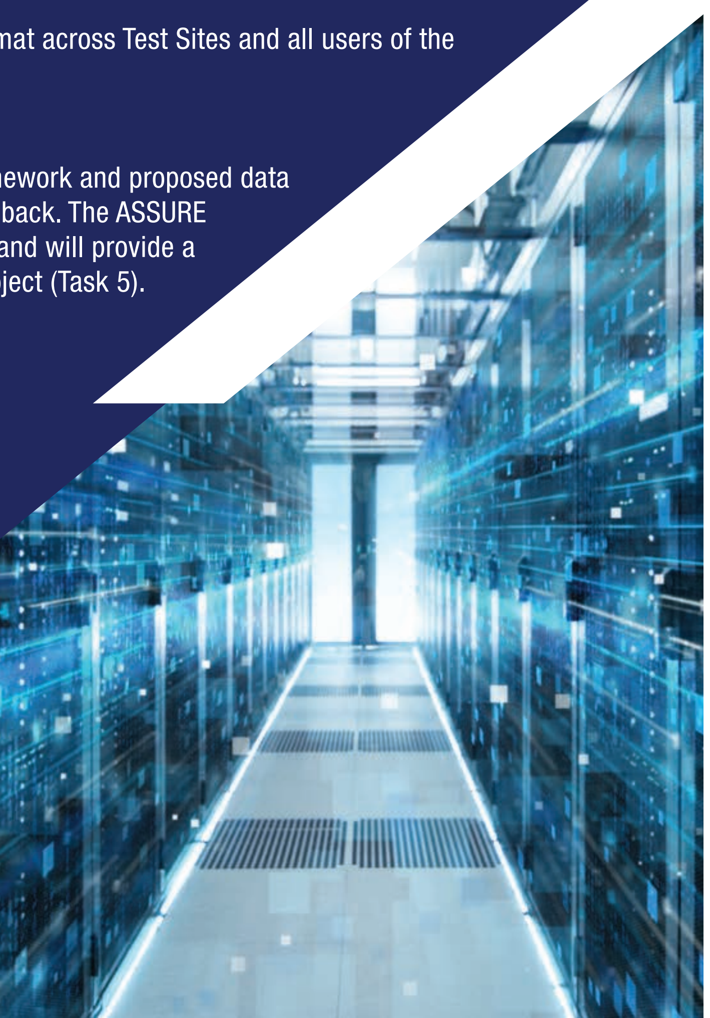
The ASSURE team conducting this research includes the University of North Dakota (UND), New Mexico State University (NMSU), University of Alaska Fairbanks (UAF), Mississippi State University (MSU), and Virginia Tech (VT). This work relates to the development of the technical data requirements, test methods, 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:

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

Approach
In addition to the following tasks, the FAA reviewed the safety case framework and proposed data schema twice and the ASSURE team revised these based upon FAA feedback. The ASSURE team has submitted a final report for Phase I of this project (Tasks 1-4) and will provide a prototype data collection system at the conclusion of Phase II of this project (Task 5).

Task 1 – Initial Draft Safety Case Framework for Data Collection
The ASSURE team has developed a safety case framework for collecting 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. 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
The ASSURE team developed a demonstration reporting system for evaluation of concepts. This reporting system emulates critical elements of the proposed system to enable concept evaluation.

Task 4 – Develop Training Materials
The ASSURE team developed training materials that outline system philosophy, design, user interface, and features. These are based upon the demonstration system and FAA feedback.

Task 5 – Implementation of a Prototype Data Collection System
The team is currently developing a prototype data collection system based upon Phase I outcomes. Beyond the demonstration system, this prototype system incorporates data storage and retrieval capabilities, thus setting the stage for analysis of data collected using this system.

Key Findings
Upon completion of this research the ASSURE team found:

- The need for a system such as the one designed herein is significant. This need is twofold, many applicants do not understand how to build a safety case, and the FAA needs a test data collection system to support their UAS research and development roadmap.
- A framework for developing safety cases can be organized into four primary steps:
  - Operational Context Definition
  - Data Collection
  - Safety Case
  - FAA Approval

This proven approach provides a framework for developing a safety case regardless of the specific operational context, mitigation methods, etc.

- A review of existing data systems and team discussions underscored the challenges associated with data integrity. As this system is further developed, significant care will be required to ensure that data are entered in a consistent manner to ensure maximum utility for the FAA.
- One of the most challenging aspects to developing this system is definition of the data schema. The challenges associated with this include:
  - An incredibly large number of data elements could be included, as different information is relevant to different CONOPS, mitigations, etc.
  - Design of a system that provides the information needed to evaluate a safety case while also being as streamlined as possible for the user.
- The hardware and software requirements for a demonstration system are modest, as the volumes of test data are much smaller than that for operational data.

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
Mark Askelson – UND	United States
Gary Ulrich – UND	United States
Paul Snyder – UND	United States
Matthew Hillestad – UND	United States
John Wold – UND	United States
Mounir Chrit – UND	Morocco
Chris Theisen – NPUASTS	United States
Matt Henry – NPUASTS	United States
Evan Bollinger – NPUASTS	United States
Erin Roessler – NPUASTS	United States
Mark Blanks – VT	United States
John Coggin – VT	United States
Matt Burton – VT	United States
Tom Jones – VT	United States
Robert Briggs – VT	United States
Chris Tysor – VT	United States
Henry Cathey – NMSU	United States
Joseph Millette – NMSU	United States
Tim Lower – NMSU	United States
Andrew Denney – NMSU	United States
Ross Palmer – NMSU	United States
Gay Lenzo – NMSU	United States
Robert McCoy – NMSU	United States
Catherine Cahill – UAF	United States
Nick Adkins – UAF	United States
Thomas Elmer – UAF	United States
Robert Parcell – UAF	United States
Ronald Winningham – UAF	United States
Matthew Westhoff – UAF	United States
Jason Williams – UAF	United States
Alan Martinez – MSU	United States
Jr Jamora – MSU	United States
David Simpson – MSU	United States

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 developed a data architecture for UASs and operations which aligns with the FAA's Aviation Safety Information and Sharing (ASIAS) program.

The ASSURE team:

- Designed and evaluated Flight Data Monitoring (FDM), also known as Flight Operations Quality Assurance (FOQA), for unmanned operations and integrated that data into the ASIAS system; and
- Identified:
  - o Current UAS FDM capabilities and practices, including refresh/recording rate and robustness, and developing guidance for a UAS FDM standard;
  - o The best governance practices regarding the use and research involved with UAS flight data; and
  - o 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 Aeronautical University (ERAU), and Mississippi State University (MSU). This effort helped 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
Over the course of 24 months, the ASSURE team completed the following tasks. The results highlighted in the Key Findings can be found in the full report at assureuas.org.

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 Part 121 Airlines and National General Aviation Flight Information Database (NGAFID) operations, the ASSURE team analyzed data and operations to determine suitability for comparison with current metrics across manned aircraft sectors. Upon completion of the analysis, the researchers developed and tested 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 demonstrated developed technology to stakeholders and subject matter experts for feedback and final revision. Using the data, they validated its capability to contribute to safety risk, mitigation, and hazard identification capabilities.


Key Findings

The ASSURE team delivered the final findings of this report to the FAA the Summer of 2020. The findings concluded that most UAS platforms have at least some basic capabilities to produce and record flight data. This data is useful for an ASIAS-FDM initiative, and will most likely follow a similar path as General Aviation did with the NGAFID. Although only a small number of data parameters are necessary, most UAS platforms, even small airframes, produce robust data. The NGAFID, or the like will work well for a nationwide UFDM rollout and the next steps intend to focus on just that.

As this ASSURE study continues into Phase II, the focus will turn directly onto the flight data. The team will evaluate data availability, standardization, and usefulness in terms of usability within a CAST/GAJSC safety paradigm. Although the data is relatively easy to recover, there is little uniformity within the different formats. This is one of the challenges in creating a nationwide UFDM program. Fortunately, this Phase I effort created the basic building blocks to move Phase II forward. In addition to the evaluation tasks, the Phase II effort includes building a data repository and establishing governances. This work is expected to kickoff in early 2021.

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AIRBORNE COLLISION SEVERITY EVALUATION - STRUCTURAL IMPACT

Wichita State University · The University of Alabama in Huntsville · Montana State University · Embry-Riddle Aeronautical University

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:

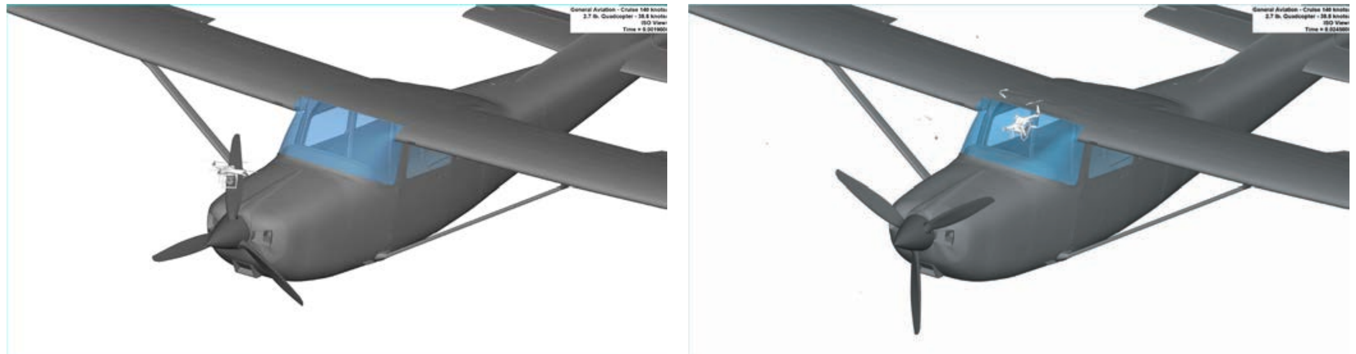
- Identify the probability of impact deflection due to the sUAS' interaction with the target aircraft's boundary layer prior to impact;
- Evaluate the severity of sUAS collisions with Rotorcraft; and
- Evaluate the severity of sUAS collisions with General Aviation.

Approach

The team is approximately two years into the research and plans complete the project in the summer of 2021. The study includes a peer review of the research task plan conducted just after the award and a 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 conducted 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 used 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 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 served 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).



Quadcopter 2.6 lbs vs. General Aviation Aircraft at 180 knots Combine Speed (Propeller and Windshield Impact)

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 are studying 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. 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 is studying 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 research team will use the data generated by the low-velocity component level testing from Task 2 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
Numerical models of the main rotorcraft components and a full general aviation aircraft have been developed. In addition, high speed component level testing has been completed for several sUAS components (battery, motor, and camera). Results from these tests are being used to update and validate the sUAS components numerical models. Once this work is completed, the validated sUAS models will be used to evaluate the impact severity with rotorcraft and general aviation aircraft. Additional work has been conducted to evaluate the effects of the airflow around the aircraft on the trajectory of sUAS prior to impact. Preliminary results indicate that the deflection of sUAS due to aircraft aerodynamic forces is minimal and will not affect the impact locations selected for the airborne severity studies.

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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 UAS 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.

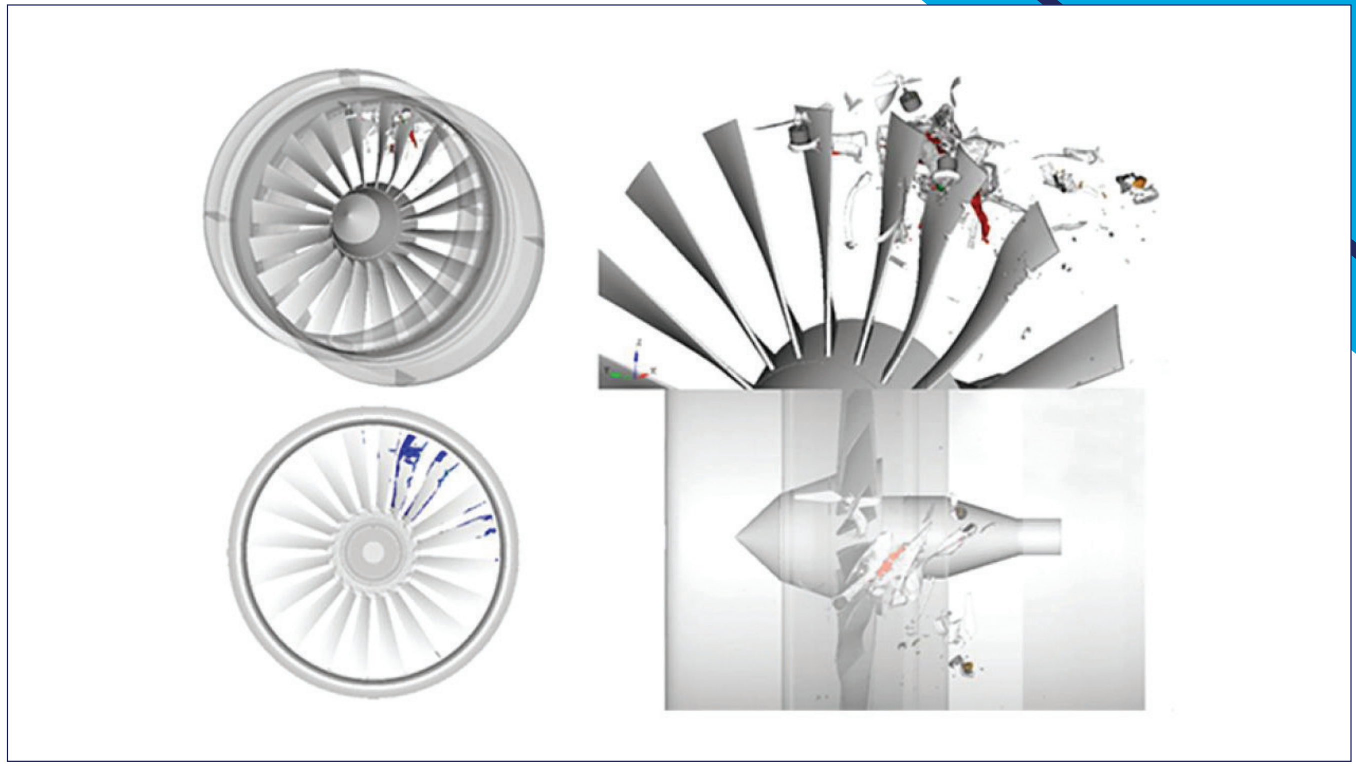
Approach:

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). 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. 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 was 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 FAA 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 provide reasonable geometries for the representative fan but 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 quadcopter, with legs and camera removed, 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 response information will be measured on the titanium plates (e.g., strain gages), so that the response in the model can also be matched with the response in the computational simulations. Two Digital Image Correlation Systems will be used to record strain data on both sides of the titanium blades. Load cells are also installed within the blade fixture setup as an additional means to match computational simulations with the experiments.

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 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, 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
The research team is now halfway through their four-year effort. Through their partnership with engine manufacturers the research team developed an open representative fan model for foreign object ingestion studies that meets the manufacturer's structural requirements. In addition, the team created a nose cone, casing, and shaft, and integrated it with the fan model to obtain the boundary conditions necessary for this research. Finally, the team developed a way to precisely deliver key UAV components at high velocity into the airfoil shaped test specimens, and the component level tests are currently underway.

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

Lead University – The University of North Dakota

Background

A core rule of manned aviation is 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 solutions are to either place visual observers on the ground or use a chase plane. This limits the potential of Small UAS (sUAS) 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 visual observers and chase planes.

Beyond Visual Line of Sight (BVLOS) operations with the use of Detect and Avoid (DAA) technology resolves this issue. Groups are currently developing standards and rules for DAA that allow BLVOS operations. This follow-on work builds on our previous efforts to inform FAA regulations and industry standards addressing DAA and BVLOS operations. This ASSURE team:

- Has developed an operational framework for sUAS BVLOS operations;
- Has developed a separation framework; and
- Is developing and testing methods for evaluating 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), Mississippi State University (MSU), and The Ohio State University (OSU).

Approach

The research focuses upon four primary tasks. In addition, the researchers have updated previous results, 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 research to develop 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 supported establishment of

a standards framework. ASTM Special Committee F38 provides the overarching standards body, and:

- One subgroup developed proposed separation framework/standards, which includes the definition of well clear and proposed acceptable DAA performance for maintaining well clear status.
- A second subgroup is developing 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, acoustics, etc.).

Task 3 – Development of Separation Framework
This task is focused on how characteristics of the DAA system and the UAS impact maintenance of well clear status. The team developed a fast-time simulation system. By varying across parameters of interest, including DAA system parameters and UAS parameters, the team executed > 700,000 simulations.

Simulations showed that the most impactful DAA-system parameters for maintenance of well clear are detection range and field of view. UAS characteristics that had the greatest impact include pilot response time and airspeed. In these simulations, maintenance of well clear required detection ranges of 7000-8000 ft, even with very enabling assumptions regarding pilot response time and UAS airspeed. For acoustic sensors, this range increased to ~10,000 ft owing to the reduced speed of sound (relative to the speed of light).

Task 4 – Testing of the recommended DAA testing plan and candidate DAA systems
Flight testing is needed to validate separation framework simulations, evaluate DAA system capabilities, and evaluate 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. The NMSU Flight Test Site (NMSU FTS), the Northern Plains UAS Test Site (NPUASTS), and the Alaska Center for Unmanned Aircraft Systems Integration (ACUASI) are conducting the flight tests. To date, four rounds of flight testing have been conducted including two rounds by ACUASI and one round each by the NMSU FTS and NPUASTS.

Flight tests have informed the team of DAA system capabilities. They have also provided validation of the separation framework simulations and an opportunity to evaluate testing methodologies. The team has developed and evaluated a safe means for testing horizontal encounters, and is currently developing an approach for testing climb- and descend-into encounters.

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 provide reasonable geometries for the representative fan but 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

Key Findings

Key findings include:

- Low-altitude sUAS use cases can be divided into 11 general use case classes, which can be organized into 47 subclasses. Key use cases include survey/mapping, imaging, environmental monitoring, patrol/security, disaster response, precision agriculture, and reconnaissance/surveillance/intelligence.
- The most impactful DAA-system parameters for maintenance of well clear are detection range and field of view, while the most impactful sUAS parameters are pilot response time and airspeed.
- Even with very enabling assumptions regarding pilot response time and UAS airspeed, simulations show that maintenance of well clear with sUAS requires detection ranges of 7000-8000 ft. For acoustic sensors, this range increases to ~10,000 ft owing to the reduced speed of sound (relative to the speed of light).
- Testing DAA system performance using encounters of sUAS and manned aircraft is challenging, as poor test design can compromise safety. Use of a modest vertical offset during testing of horizontal encounters enables maintenance of safety and collection of required data.
- Operational variations, vehicle performance variations, assumed position accuracies, and additional safety elements must be considered when establishing vertical separation distances used during testing to ensure maintenance of set separation limits. The A18 team determined that to meet the required 250 ft vertical separation, testing would be conducted with 350 ft of separation to account for variabilities and inaccuracies to avoid violating well clear.

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

Lead University – The Ohio State University and Kansas State University

Background

This research will provide further insight into the safe integration of sUAS through forecasting of expanded and non-segregated sUAS operations. The ASSURE research team will collect data to inform the FAA on risk-based methodologies to develop and apply 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 leading 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. To direct this research, the ASSURE team developed a Research Task Plan (RTP) which was peer reviewed prior to the start of Phase 1.

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

The Phase 1 outcome report characterizes findings in four areas, providing summaries of the data sets used, establishing quantitative relationships among existing trends, and explaining shifts due to different aspects of integration efforts such as waiver approvals and other regulatory changes. This includes development of a data catalog characterizing the data sets that were used in the analyses (including UAS registration, MLS, pilot certification, sightings report and aeroscope data as well as waiver approval letters and NPRMs), a taxonomy indicating the range of operational concepts that sUAS operators want to pursue, a presentation of analysis results, and an evaluation of the validity of sightings reports.

Phase 2 – Establish scope of non-segregated operations

Building upon results from Phase 1, in Year 2 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 regarding demand and an assessment of changes in demand likely to occur. Phase 2 will also identify 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 expected pacing of and trends within the forecast.

Phase 3 – 'de minimis' risk likelihood and comparable framework

In Phase 3, the ASSURE team will define a predictable, repeatable, quantitative, risk-based 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. This framework will provide a process for making risk-based decisions that applies across the varying levels of risk associated with the operation of different sUAS and that considers performance-based requirements to mitigate risk.

Key Findings

Phase 1. The team submitted Part 1 of the Phase 1 report to the FAA. In this report, the researchers identify the range of current and future sUAS Concepts of Operations (CONOPS) and relevant data sets to characterize current sUAS activity.

In the Phase 1 report, the team further provides an analysis of Part 107 waiver approval letters. This analysis underscores the barrier that risk assessments associated with the use of DAA (Detect and Avoid) technologies still present to BVLOS operations. Despite the high demand for BVLOS capability, there were very few approved waivers that utilized DAA systems. In contrast, the analysis identified successful approval of waivers for Operations Over People that have been enabled by the use of parachutes. Interviews with FAA staff further indicated that rejections of Part 107 waivers are due primarily to a lack of supporting documentation critical to the development of a safety case in the areas of: operational context, system performance, and safety mitigations.

The ASSURE researchers also submitted a draft report for Part 2 of the Phase 1 report. The analysis identified areas where current data collection practices indicate a need for future rulemaking in order to specify safety risk management data collection requirements clearly and more comprehensively.

Part 3 of this draft report presents the analysis of UAS detection data that was collected in the vicinity of the Dallas-Fort Worth International Airport over an 18-month period (August 2018 – January 2020) including 12,500 unique DJI sUAS across more than 162,000 separate operations. These detection data were used to evaluate the validity of the data available in the FAA Sightings database. An initial assessment is presented in the draft report for Phase 1. A complete analysis of such validity is being completed and will be documented in Part 3 of the final report for Phase 1.

Phase 2. ASSURE researchers are developing a Predictive Analytical Simulation for Advanced Unmanned Technology (PASAUT) to provide a structured method for identifying how upcoming advances in technologies are likely to impact future sUAS waiver requests and activity levels. Phase 2 is one of the major focus areas for Year 2 of the project.

Phase 3. The final phase focuses on the development of a clear and consistent process and quantitative risk-assessment framework to guide the development of applications for sUAS operations, and to provide a well-defined and consistent methodology for the FAA evaluation of these applications, incorporating consideration of both the safety risks and societal benefits. The research team developed a framework that embeds the use of Probabilistic Risk Assessments (PRAs) into a five-step process consistent with the FAA's definition of its SMS and documented this framework in a report delivered to the FAA.

This framework defines a process for focusing analysis on critical (high-risk) scenarios, using thresholding to categorize quantitative risk assessments in a manner consistent with current FAA definitions of "Hazard Outcomes" and "Likelihood Definitions." This framework then maps the results of such assessments of risk into the structure of the risk matrix as defined in FAA Order 8040.6, providing a rubric that structures decision making in a manner that is consistent with long-standing FAA practice.

Overall Summary. As indicated above, two reports have been delivered to the FAA thus far, one focusing on the results of the initial tasks associated with Phase 1, and one documenting the results of the initial task required for Phase 3. In addition, a draft report was submitted covering all of the tasks associated with Phase 1. The final version of this draft report will be delivered to the FAA in January of 2021. Reports on the results of Phase 2 and the remaining tasks for Phase 3 will also be delivered in 2021, culminating on an overall final report covering the findings of the full 24 month period of performance, which 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
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DEVELOP RISK-BASED TRAINING AND STANDARDS FOR WAIVER REVIEW AND ISSUANCE

Lead University – Kansas State University

Background

Under the FAA Modernization and Reform Act of 2012, Congress tasked the FAA with integrating UASs into the National Airspace System (NAS). In order to comply with the Congressional mandate, the FAA established an sUAS rule, allowing sUAS to operate in the NAS. With the passage of 14 CFR part 107 came the capability of operators to waive specific provisions for increased operational flexibility. The FAA must closely review all waiver requests and evaluate each safety case to ensure that the safety of the NAS is not compromised by the proposed UAS flight operation. This presents challenges, as the FAA's standard risk assessment practices do not directly translate to UAS operations. In order for the FAA to process part 107 waiver requests effectively while maintaining safety in the NAS, a new scalable compliance framework for mapping risk in UAS operations is required.

This research is intended to:

- Provide recommendations to the FAA on modification to 8040.4B and/or 8040.6 to incorporate a range of UAS operations.
- Taking existing standards – e.g. ASTM and JARUS SORA into consideration and develop a scalable compliance framework to assess various risk components that could "feed into" revised UAS-specific tables in 8040.4B and/or 8040.6.
- Validate the proposed scalable compliance risk assessment framework by submitting a range of waivers using the proposed system.

The ASSURE research team led by Kansas State University Polytechnic (KSU) includes the University of North Dakota (UND), and University of Alaska Fairbanks (UAF).

Approach

In addition to the tasks discussed here, the study includes a peer review of the research task plan and a review of the final report at the conclusion of the project. The study is broken down into two parts running in parallel.

- Task 1 – Literature Review and Framework Development
- Task 2 – Framework Validation Case Studies

These tasks are further broken down into subtasks.

Task 1.1 - Literature Review
This task consisted of a review of relevant literature, to include FAA Order 8040.4B, FAA Order 8040.6, ASTM 3178-16, JARUS SORA, and other sources. As part of this process, the research team identified gaps and similarities between risk-assessment methodologies for developing a set of guidelines towards the development of a scalable compliance risk-assessment framework.

Task 1.2 – Framework Development
The research team is using the information gathered from the literature review to develop a compliance-based risk framework for submitting and reviewing part 107 waivers. This framework will serve as a utility to establish a robust safety case and for the FAA to review part 107 waivers in a repeatable and consistent manner. As validation, the research team will submit two waivers for expanded operation established as case studies in Task 2. The framework will include suggested revisions to 8040.4B and/or 8040.6 that aid to identify and establish risk criteria for specific sUAS Concepts of Operations (CONOPs), such as Beyond Visual Line of Sight (BVLOS) and operations over people. The framework will also provide guidance for translation between alternative risk assessment methods – e.g. ASTM and JARUS SORA.

Task 1.3 – Develop a Low-Altitude Risk Assessment Roadmap
As an added task, the research team developed a roadmap that outlined key data categories required for a low-altitude risk assessment, focusing specifically on UAS operations at or below 400 ft AGL. The intent of this roadmap was to (1) identify data categories required for the FAA to complete a low-altitude risk assessment, (2) provide insight into what data exists and where these data reside, (3) determine the research applicable to this analysis as has been conducted through previous, current or upcoming FAA or industry standards efforts, and (4) identify gaps in required data and articulate research requirements to fill the gaps as able.

Task 2.1 – Develop a part 107 Waiver for BVLOS with a Visual Observer (VO)
The ASSURE team focused on validating the scalable compliance framework in the context of BVLOS with a VO. This represents the least complex validation case, and it assesses the application of the framework to what could be considered a "baseline" use case for flight operations beyond 14 CFR Part 107.

Task 2.2 – Develop a part 107 Waiver for BVLOS without a Visual Observer (VO)
This task addresses a waiver application with an increased risk threshold as defined in the risk-based framework. Thus, this waiver application enables researchers to evaluate the risk-based framework with a waiver application that is both more complex and requires more scrutiny on the part of FAA reviewers.

Key Findings
The literature review brought to light several gaps in the evaluation of part 107 waivers, and a need for standardization in the following areas:

- Definitions for common Safety Risk Assessment (SRA) terminology and concepts.
- SRA framework for stakeholders seeking part 107 waivers that meet FAA order 8040.4B and ensure a more uniform approach to assessing and accepting risk.
- Risk matrix chart developed for use across the FAA. The risk matrix must be transparent for all stakeholders, and should clearly define safety terms such as likelihood and severity consistent with the UAS operating environment.

The roadmap is currently in review by the FAA. This and other reports will be delivered throughout the 24 months period of performance, and the final report will be delivered to the FAA for peer review early 2022.

Name & Origin of All Research Personnel

Name	Origin
Tom Haritos (PI) – KSU	United States
Kurt Carraway (Co-PI) – KSU	United States
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Graduation of Students

Name	Graduation Date (estimated)
Jacob Kimerer	November, 2020

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

Lead University – Kansas State University

Background
At present, FAA has taken steps toward the full integration of `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 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 part 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) is serving as the lead University driving this project in collaboration with University of North Dakota (UND), The Ohio State University (OSU), and Sinclair College (SC).

Approach
To date, the research team has generated an RTP which currently serves as a living document to transcribe the Durability and Reliability (D&R) process. Coordination with the Los Angeles Aircraft Certification Office (LA ACO) serves as a component of the peer review. Upon completion, the research team will submit a comprehensive final report detailing the findings and products as a component of this research

Task 1 – Literature Review
The ASSURE Team conducted a literature



review to identify existing pilot training and airworthiness certification paradigms while exploring their applicability to UAS. The team reviewed existing manned pilot certification standards in 14 CFR §61, regulations for sUAS, applicable airworthiness standards, and literature relating to industry consensus standards for UAS. As a result, the research team identified important differences in manned/unmanned regulatory structures, guidance for UAS pilot and certification standards, and additional considerations for risk assessment and airworthiness certification. These concepts will: (1) inform UAS pilot certification requirements and (2) exercise the airworthiness certification process for UAS via use case scenarios. The resulting outputs of this research will provide feedback to the FAA regarding UAS operational approvals, and identify key considerations for pilot and UAS certification to mitigate risks associated with expanded flight operations beyond 14 CFR §107.

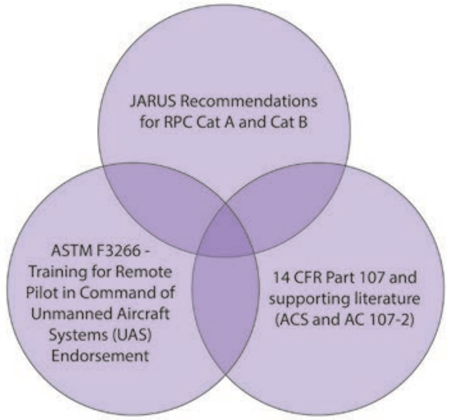
Task 2 – Development of UAS Airworthiness/Type Certification Framework and Use Case
For this task, the research team has collaborated with the FAA's Aircraft Certification Service (AIR-694), the LA ACO, and an original equipment manufacturer (OEM) to pursue a type certification for an EbeeX using a D&R means of compliance. The research team continues to work with the OEM (senseFly) to navigate the Type Certification (TC) process and document key processes, procedures, and methods of compliance (MOCs) required for the OEM to prepare and execute the D&R process. As part of this task, KSU also participated in the ASTM D&R Working Group. The output from this task will be a report that outlines required processes, procedures, and documentation for OEMs to navigate the TC process using D&R for primary MOCs. In addition, the report will highlight the advantages and shortcomings associated with this process.

Task 3 – Development of UAS Pilot Certification Strategies
The UAS pilot training and requirements specified by 14 CFR part 107 are relatively modest. The research team anticipates that more robust UAS pilot training and knowledge requirements will be needed to meet the more rigorous safety thresholds associated with expanded, non-segregated UAS flight operations. Below are two examples of common provisions included in a subset of waivers for 14 CFR §107.29 – Daylight Operation. These provisions highlight a combination of technical and training requirements often associated with UAS flight operations that reach beyond the part 107 baseline: specifically, for operations at night. These provisions ascertain the need for a combination of both (1) basic technical/airworthiness requirements, and (2) pilot knowledge and skills to address enhanced levels of risk associated with more complex flight operations.

> *Training:*
> *"Prior to conducting operations that are the subject of this Waiver, the remote PIC and VO must be trained, as described in the Waiver application, to recognize and overcome visual illusions caused by darkness, and understand physiological conditions which may degrade night vision. This training must be documented and must be presented for inspection upon request from the Administrator or an authorized representative."*
>
> *Technical:*
> *"The sUA[S] must be equipped with lighted anti-collision lighting visible from a distance of no less than 3 statute miles. The intensity of the anti-collision lighting may be reduced if, because of operating conditions, it would be in the interest of safety to do so…."*

To date, the A27 research team has accomplished the following regarding this task:

- Analyzed existing literature relating to UAS pilot qualifications and training.
- Constructed a framework of "go-to" knowledge, skills, and abilities (KSA's).
- Formulated links KSA's to build operational training requirements that are suited to UAS operations beyond the scope of Part 107.
- Constructed a matrix for comparisons across 14 CFR part 107, ASTM F3266, JARUS RPC recommendations and 14 CFR part 61 Private Pilot training elements.
- The methodology follows a "risk-based" approach, establishes a baseline, and affords the opportunity to allow flexibility for certain skillsets to be added on – e.g. endorsements.
- The process includes classifying applicable requirements relating to their relevance of topical categories framed in JARUS RPC recommendations in addition to identifying parallels and gaps that may exist across differing training paradigms to identify commonalities and gaps.



Key Findings

Task 2 – Durability and Reliability Type Certification

For non-aviation applicants, additional "up-front" engagement may be necessary to ensure a complete understanding of the processes, procedures, and required documentation to both initiate and navigate the TC process. Overall, the applicants seem to follow the process. The applicant's initial questions focused on providing adequate information to start the TC process.

Task 3 – UAS Pilot Operational Training Requirements

The team found a connection between Task 2 and 3; training is an important element of the initial CONOPs, which is an important element of the type certification application package. Baseline training requirements generated through Task 3 will likely require further refinement. Unique CONOPs will dictate what kind of training is applicable and under what specific circumstances said training applies.

Name & Origin of All Research Personnel

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Graduation of Students

Name	Graduation Date (estimated)
Jacob Kimerer	November, 2020

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 student instruction 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 works with a diverse demographics including urban areas, Alaskan Native, Native American, tribal communities, rural districts, intercity, farming communities, and more.

The ASSURE research team focus is in 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. The efforts started in late 2019 and the outreach activities followed the overall plan until early in 2020. Unfortunately, due to COVID-19 the STEM Outreach events were effectively put on pause. It was impossible to conduct the in-person outreach activities, camps, and instruction when schools closed, and states restricted student interaction. Each school has readjusted and is working to create new plans for continued STEM Outreach.

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

As in previous years, NMSU continued to lead the teams STEM activities and programmatic support. Additional efforts focused on plans to offer their existing outreach activities like the UAS Roadshows and UAS Summer Camps. Restrictions related to COVID-19 halted the camp and roadshow due to state gathering guidelines. Their focus continues to be on middle school students who are primarily Hispanic and Native American. Key highlights before the shutdown included supporting the El Paso Space Festival with hundreds sitting down to practice flying drones on flight simulators, a "fly in" at the Las Cruces International airport, and supporting various online panel discussion related to UAS and STEM. Adjustments were made to plans for future activities with concentrations on events to take it on the road again, teach the teachers, and camps.

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

During the Spring and Summer of 2020, the Alabama Unmanned Systems Operations Mastery for Educators (AUSOME) Program has supported the development of new robotics-based lesson plans with the U.S. Space and Rocket Center

(USSRC) Education Department and provided demonstrations of UAS in STEM for USSRC Camp Programs. The AUSOME team from the University of Alabama in Huntsville (UAH) conducted four demonstrations in total, reaching educators from across the state of Alabama and high school aged students attending camp programs. The UAH/AUSOME team was also invited to participate in the National Robotics Day symposiums in February 2020 to showcase the use of UAS in STEM at the USSRC. These demonstrations followed state and organizational COVID-19 mitigation measures. The UAH/AUSOME team has also been coordinating with the Alabama State Department of Education's STEM division known as the Alabama Math, Science, and Technology Initiative (AMSTI) on providing inputs for the state Digital Literacy Curriculum program and educator professional development training. The AUSOME and AMSTI partnership have a goal to jointly develop UAS STEM kits for eleven locations across Alabama where educators can be instructed on how to use UAS in the classroom. These STEM kits will include a collection of lesson plans, UAS, and example code for introducing high school level to UAS a tool for data collection, introductory computer science, and aerospace education. The UAH/AUSOME team is currently suspending most activities until Spring/Summer 2021 with the exception of three or four demonstrations with USSRC including the U.S. State Teachers of the Year award recipients from 2019 and 2020. AUSOME will also continue coordinating with AMSTI on state approved UAS STEM development.

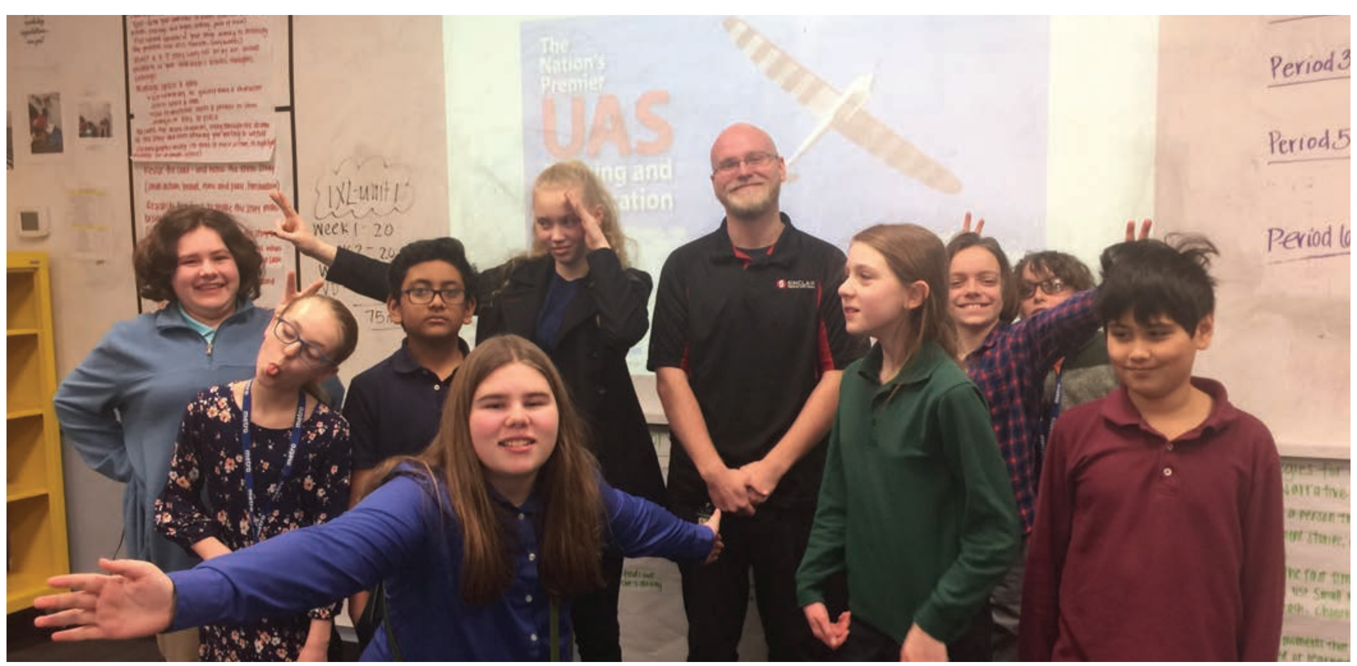
University of Alaska Fairbanks (UAF) – The Alaska UAS Airshow

Due to the remote nature of the state of Alaska, the Airshow provides UAF an opportunity to fly experts from the University of Alaska Fairbanks's Alaska Center for UAS Integration (ACUASI) to schools across the state. COVID-19 has severely disrupted ACUASI's ability to conduct its planned outreach to remote, fly-in, predominantly Alaska Native communities in Alaska as a part of the 'The Alaska UAS Airshow'. The remoteness of those communities and their lack of health infrastructure has resulted in travel to the communities by outsiders being prohibited, and the lack of bandwidth in these villages has limited the team's ability to conduct real-time distance delivery of content to the schools. As soon as they are able, 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 targets schools with student populations from rural and inner city, minority, low income, non-English first



language, and no university experience in family. UCD is partnering with CITRIS and the Banatao Institute at UCD to lead the classes for their STEM program. Building on the highly successful 2018 Summer Drone Academy UCD held an in-person weekend High School Drone Build Camp Feb. 8-9, 2020. They had 20 9-12 grade registered students from the UCD Early Academic Opportunity Program (EAOP) and 3 flight instructors and 3 student mentors. Students participated in hands-on drone construction and flights, Virtual Reality (VR) technologies and learned about real-world drone applications. Because UCD can't hold in-person activities due to COVID-19 they worked with EAOP and have recruited 40 students and 4 UCD student mentors. In addition, they have scheduled a series of zoom classes, starting Dec. 4 with 9-10th grades and 11-12th grades (4 students/1-hr virtual zoom class) 20 students total for each group, to fly indoor drones. UCD will evaluate the effectiveness of the zoom classes and initiate more classes that incorporate a broader range of skills in future classes if it is successful. They hope to offer their regularly scheduled weeklong summer camp again in July 2021.

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 work 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 works with Metro Middle School (a diverse semi-public, non-charter, privately funded 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 original purpose of Sinclair's effort was to provide presentations highlighting UAS applications, careers, and technologies, and ASSURE projects, coupled with interactive hands-on simulation leveraging RealFlight simulators operated in the Sinclair Tactical Ground Control Station (T-GCS) or Mobile Ground Control Station (M-GCS) deployed to 6th grade classes around the State of Ohio. Early success was achieved from January to early March 2020 with 19 outreach days at 18 schools reaching 2,508 students in 6th grade classes in the greater Dayton, Cincinnati, Columbus, and Cleveland regions. The project was on track to reach the goal of 40 outreach days in the first grant year and the overall goal of 120 outreach days over the grant period of performance.

However, because of the school closures caused by COVID-19 beginning in March 2020 and continuing into the 2020-21 academic year, Sinclair sought and received approval for an alternative approach to continue the outreach goals of the project while following best practices for social distancing, wearing masks, and cleaning equipment. This included continued pursuit of middle school classroom outreach when possible, but added support of UAS focused camps, engagement at remote control and traditional aviation flying events, and deployments to aviation and history related museums. For each outreach day, the T-GCS or M-GCS were still deployed outside of the facilities, but desktop simulators were employed with social distancing and sanitation protocols. This modified approach has allowed Sinclair to continue outreach until conditions permit middle school programs again.

Key Findings

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

- Currently, there are no UAS-specific STEM training programs in the State of Alabama.
- AMSTI and the State Digital Literacy Curriculum Program is very interested in providing a UAS professional development programs to Alabama Educators.
- With the support of AUSOME, the USSRC Camp and Education Programs will introduce UAS in their robotics and space camp activities.

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

- The UAF team is working to develop new materials and methods for delivering the content to the villages without video-streaming material
- In addition, UAF is working with Alaska Superintendents Association, the Alaska Gateway School District, and others to find ways to interact with students across Alaska without visiting schools in person.
- All UAF outreach events, from STEM nights, to telephone interactions with homeschool students, and career presentations, have been well received by participants of all ages.

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

- The STEM Summer Drone Academy has achieved near equal numbers of female: male students; multiracial, rural/urban students.
- Students from different schools, who didn't even know each other, were able collaborate very well in group settings to learn and build relationships.
- Feedback on the program was very positive, and students had fun while learning.

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

- OSU developed two design challenges based on research on UAV ingestion into engines and physics-based UAV models for design optimization.
- The team delivered the design challenges to Metro middle school students, and will be documented on a web-hosted university extension.

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

- From the start of program outreach on January 6, 2020 through September 30, 2020, the following metrics were achieved:
    - o 37 outreach days at 21 locations in Ohio including the Dayton, Cincinnati, Columbus, and Cleveland regions
    - o Engaged 3,115 individuals in sixth grade middle school classrooms and the broader public at approved alternate camp and museum outreach events
    - o Established agreements with alternate venues to conduct outreach including:
        - – WACO Learning Center – Troy, Ohio
        - – National Park Service Dayton Aviation Heritage National Historical Park – Dayton, Ohio
        - – Dayton History Carillon Historical Park – Dayton, Ohio
        - – Mound Cold War Discovery Center – Miamisburg, Ohio

Name & Origin of All Research Personnel

Name	Origin
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Catherine Cahill – UAF	United States
Nicholas Adkins – UAF	United States
Susan Ustin – UCD	United States
Nathan Metzler – UCD	Unavailable
Kiran D'Souza (PI) – OSU	United States
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ESTABLISH PILOT PROFICIENCY REQUIREMENTS - MULTI-UAS COMPONENTS

Lead University –
Oregon State University

Background
Several organizations have identified human factors issues unique to UAS, including the US Air Force Accident Investigation Board, the National Transportation Safety Board, the US Department of Transportation, National Aeronautics and Space Administration, RTCA Special Committee (SC)-228, and others. This research will address gaps in knowledge that are currently a barrier to the safe, efficient, and timely integration of systems composed of multiple UAS into the NAS, namely operation of multiple aircraft by a single pilot.

This research will help inform FAA regulations and industry standards addressing single pilot and multiple UAS operations. This research intends to:

- Identify human factors differences, limitations and use cases for operating multiple UAS.
- Identify available control systems, capabilities, limitations, and maturity levels.
- Determine and model predicted limitations.
- Conduct human-in-the-loop evaluation of a single use case.

The ASSURE research team led by Oregon State University (OrSU), includes Drexel University (Drexel), and Kansas State University Polytechnic (KSU).

Approach
The study includes a peer review of the research task plan and a review of the final report at the conclusion of the project.

Task 1 & 2 – Literature Review and Gap analysis
Through the course of these tasks the research team will:

- Identify the relevant literature,
- Develop a taxonomy to use to categorize the literature,
- Identify methods to support organizing the literature and executing the categorization,
- Categorize the literature findings, and
- Identify research gaps requiring additional research.

Task 3 – Assess Human Factors Limitations
This task identifies the human factors limitations to monitoring multiple UAS, including potential hazards, mitigations, and controls for the mitigations, generates potential operational scenarios (use cases) and a task analysis, and metrics. It also generates a taxonomy of open problems and a report that captures the human factors limitations when monitoring multiple UAS. The researchers will:

- Identify potential human factors limitations, including potential hazards, mitigations, and controls.
- Develop operation scenarios and a task analysis that will consider prior aircraft procedures.
- Review the existing aptitude measurements and developing a taxonomy that informs gaps for single pilot multiple UAS deployments.

Task 4 – Assess Required Aptitude
This task focuses on developing computational user models that provide a predictive analysis of the human-in-the-loop human factors considerations for pilots controlling multiple UAS and for supervisors (i.e., technicians) responsible for monitoring multiple UAS systems. The results from Tasks 1 and 3 will be used, specifically, the task analysis and use cases will directly inform the development of the user models. The models will focus on the predominant human factors and training results developed during Tasks 1 and 3, but may also vary environmental conditions, levels of autonomy on the sUAS, mission duration and number of vehicles. The researchers will:

- Identify the modeling tool, IMPRINT Pro (Archer et. al, 2005) will be used for developing the computation models.
- Develop the computational models, including their ability to provide a predictive analysis of human factors limitations that can be used for developing the human-in-the-loop evaluation protocol.

Task 5 – Human-in-the-loop Simulation
Human-in-the-loop evaluations will be used to collect empirical results focused on validating a subset of the Task 1 and 3 results, taxonomy, and use cases and the Task 4 models. The Task 4 model predictions will inform the experimental design and can be used as a direct comparison to the results collected from humans interacting with either simulated or real multiple UAS systems. For example, measures of cognitive workload gathered during experimental trials can be compared to the modeled cognitive workload.

The designed experiments will involve ten to fifteen pilots that represent a mix of those who have recently completed the part 107 examination with no formal aviation training and pilots that have completed a rigorous aeronautical focused UAV training program, such as the one offered at KSU. The pilot pools will incorporate regional part 107 certified pilots, pilots from the associated universities, and those associated with Oregon's three UAS test sites. Further, Oregon and Washington have a number of UAS related companies (i.e., FLIR systems, Insitu, AeroDrone) that can be approached to identify potential pilots. This mix of pilots will provide data to inform the specification of pilot qualifications. The researchers will:

- Design the experimental protocol and obtaining human subjects IRB approvals.
- Obtain an FAA waiver for multiple UAS flights.
- Recruit participants with the necessary backgrounds and experience.
- Conduct the evaluation trials with representative participants and collecting necessary results.
- Analyze the evaluation results and completing the findings report.

Key Findings

The literature review is in progress at this time. Reports will be delivered throughout the 24-month period of performance, and the final report will be delivered to the FAA for peer review early 2022.

Name & Origin of All Research Personnel

Name	Origin
Julie A. Adams – OrSU	USA
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Tyler Read – OrSU	USA
Patrick Uriarte – OrSU	USA
Ellen Bass – Drexel	USA
Allison Sands – Drexel	USA
Tom Haritos – KSU	USA
Christina Harry – KSU	USA

Graduation of Students

Name	Graduation Date (estimated)
Tyler Read	June 2023
Patrick Uriarte	June 2022
Christina Harry	Undergraduate student

DISASTER PREPAREDNESS AND RESPONSE USING UAS

Lead University – University of Alabama – Huntsville

Background

This research is in direct response to the FAA Reform Act of 2018 directing research into disaster use of UAS. The FAA has identified a need to better integrate UAS into the fabric of disaster response/relief aviation operations, and prevent unwanted incursion of UAS during such operations. Existing government research, sponsored by the Department of the Interior (DOI), is examining UAS use in disaster response, and this research recommends improvements to coordination and operations procedures and practices.

The FAA, as the regulator and ultimate authority of the NAS, needs to understand:

1) Any challenges and/or shortfalls in the current process for UAS integration into disaster efforts?
2) What changes may be made to better support the use of UAS by disaster relief agencies and support personnel?
3) What impact of such changes would have on UAS and NAS safety?

With DOI conducting their own research for responding to natural disasters, the FAA needs to understand their role in initiating procedures and how the coordination might change to ensure safety in the NAS. Coordination between these two research projects will avoid duplicative efforts across the government.

The ASSURE research will look at how UAS can aid in disaster preparedness and response to different natural and human-made disasters along with emergency operations per Section 359 of the FAA Reform Act of 2018. It will focus on procedures to coordinate with the DOI, the Department of Homeland Security (DHS) including the Federal Emergency Management Agency (FEMA) and other federal, local, and state governments to ensure proper coordination during those emergencies. The research results will develop requirements, technical standards, policies, procedures, guidelines, and regulations needed to enable emergency response operations for UAS. Effective and efficient use of UAS in a disaster are the two primary goals of this project. This will offer an effective tool to assist first responders to save lives faster and accelerate personnel and infrastructure recovery.

The University of Alabama – Huntsville (UAH) will direct the overall project and work closely with University of Alaska-Fairbanks (UAF), New Mexico State University (NMSU), University of Vermont (UVM), Oregon State University (OrSU), Mississippi State University (MSU), and North Carolina State University (NCSU).

Approach
This research is broken into phases each with clear research questions and objectives. The ASSURE team is currently in Phase I and is broken down into six tasks described below. Phase II will give the research team the opportunity to exercise the findings found in Phase I and will happen in the coming years. Successful completion of this research is likely to shed important insights into interactions between human factors, technology and procedures, and will further improve regulatory processes and practices that govern UAS integration into the National Airspace System (NAS).

Task 1. Survey of Experts for Disaster Preparedness and Response Use Case Development
The research team will survey government experts to find the use cases for emergency preparedness and response. They will include interaction with the National Incident Management System (NIMS) and the Incident Command Structure (ICS) or similar constructs or organizations that will include but not be limited to disaster response to wildfires, hurricanes, tornados, flooding, and human-made disasters. This task also considers both historical events and training/preparedness for disasters.

Task 2. Survey of Experts for Disaster Response using Manned Aircraft
In task 2 ASSURE will survey the government to see how coordination for disaster response is done today with manned aircraft. Through FEMA/DOI/DHS and state government survey, the team will determine how local and state governments use manned aircraft to respond to disasters.

Task 3. Development of the CONOPS and ORA by Disaster
The researchers will develop Concepts of Operations (CONOPS) and Operations Risk Assessment (ORA) for some of the use cases that were reported on in Task 1. These CONOPS will include wildfire, hurricane, tornado, flooding, earthquake, and volcanic eruptions along with oil spill, nuclear dispersion, terrorist attack, train derailment, and COVID use cases.

Task 4. Common Risks and Waivers/Exemptions for Disaster Support
ASSURE will take the CONOPS and ORA's from Task 3 to determine common risks, what mitigations can be put in place for those risks amongst the different ORAs, and what waivers/exemptions would need to be in place for those operations.

Task 5. Coordination Levels amongst Federal Agencies
In Task 5, the research team will determine the coordination level needed amongst federal agencies to conduct the disaster response missions with UAS instead of manned aircraft. In addition, they will determine the local and state government interactions needed for each mission chosen.

Task 6. Study on the Fire Department and Emergency Service Agency Use of UAS (Section 359 of the FAA Reform Act of 2018)
The ASSURE team will study the use of UAS by fire departments and emergency series to provide the FAA with information on the current use, obstacles to adoption, outreach approaches, regulation recommendations, training and certification matters, airspace issues, and other items that may emerge.

Key Findings
This project has just begun, and the team has already completed the first Peer Review with comments from FAA, NASA, NOAA, FEMA, Forestry and NIST representatives. Reports will be delivered throughout the 24-month period of performance, and the final report will be delivered to the FAA for peer review in the summer of 2022.

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PUBLICATIONS, PROCEEDINGS & FUTURE RESEARCH

UPCOMING RESEARCH

Below are the areas of research the FAA has funded or has expressed interest in funding, considering its limited resources. The 2020 upcoming work was awarded at the end of the fiscal year and is in the early planning stages. The 2021 upcoming work is ASSURE's best guess for future research based on FAA priorities for supporting the mission to safely integrate UAS into the National Airspace System and are subject to change.

2020 Research

- Verification & Validation of Low Altitude Detect & Avoid Standards
- UAS Safety Case Development, Process Improvement, & Data Collection
- Safety Risk Mitigation for UAS on & Around Airports
- Wake Turbulence Encounters
- Urban Air Mobility Studies
- Standard Tracking, Mapping, & Analysis
- Cybersecurity Requirements for UAS Operations
- Verification & Validation of Remote ID Standards

2021 Research

- Air Carrier Operations
- UAS Cargo Operations
- High-Bypass UAS Engine Ingestion Test
- GPS & ADS-B Risks for UAS
- Shielded UAS Operations
- Visual Operations Standards for UAS
- sUAS Mid-Air Collision Likelihood
- ASIAS Phase II
- sUAS Traffic Analysis
- Guidance for Autonomous Systems
- Disaster Preparedness & Recovery for UAS Phase II

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
SESAR-JU U-Space Concept of Operations, EUROCONTROL, Brussels, Belgium	October 2019
Canada's National Unmanned Systems Industry Conference, Ottawa, Canada	October 2019
Air Mobility Conference & Amsterdam Drone Week, Amsterdam, Netherlands	December 2019
UAS Technical Analysis & Applications Center Conference, Las Cruces, NM	December 2019
Integrating Expanded & Non-Segregated Ops Peer Review, Washington, DC	January 2020
ARC Industry Forum: Driving Digital Transformation in Industry & Cities, Orlando, FL	February 2020
UAS West for DOD & Government Presentation, San Diego, CA	February 2020
ASSURE Present @ Montana Aviation Conference, Great Falls, MT	February 2020
ASSURE FAA Program Management Review, Oregon State University, OR	March 2020
ASSURE Present @ Unmanned Systems & Robotics Summit, Washington DC	March 2020
Agility Prime Virtual Web Event	April 2020
FAA UAS Symposium Session 1 Virtual Web Event	July 2020
FAA UAS Symposium Session 2 Virtual Web Event	August 2020
FAA International Roundtable Meeting, Virtual Web Event	September 2020
sUAS Detect-and-Avoid Flight Testing, University of North Dakota	September 2020

The ASSURE University Coalition

Assure has the knowledge of a 24 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

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

LED BY MISSISSIPPI STATE UNIVERSITY

The FAA's Center of Excellence for UAS Research

ASSURE

Alliance for System Safety of UAS through Research Excellence

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