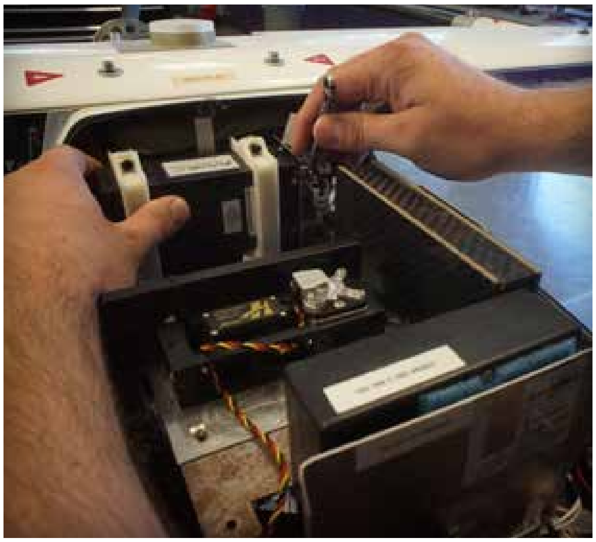
The FAA's Center of Excellence for UAS Research

ASSURE

Alliance for System Safety of UAS through Research Excellence

2018 ANNUAL REPORT

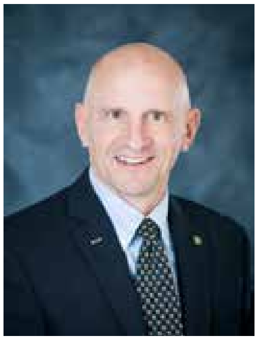






OVERVIEW

FOREWORD:



The Alliance for System Safety of UAS through Research Excellence (ASSURE), consists of twenty-three world leading research institutions along with industry and government partners. ASSURE serves as the Federal Aviation Administration's (FAA) academic research Center of Excellence (COE) for Unmanned Aircraft Systems (UAS). This coalition features expertise across a broad spectrum of research including: air traffic integration, UAS airport ground operations, control and communications, detect and avoid, human factors, UAS collision severity, UAS pilot training and certification, low altitude operations safety, spectrum management, and UAS traffic management.

Over the past three years, team ASSURE has become a highly-effective team generating quality research in support of the FAA and the Secretary of Transportation. The FAA uses ASSURE findings and recommendations to help guide the establishment of the standards and regulations necessary to increase private, public and commercial UAS operations in the nation's airspace. ASSURE aligns its research activities with the FAA's priorities as described in its UAS Strategic Roadmap. Our ultimate goal is the safe and efficient integration of unmanned operations with manned operations in the National Airspace System.

To achieve this goal, ASSURE influences UAS Policy through leading-edge research across a broad spectrum of subjects. Studies include: UAS certification, ground collision studies to enable operations over people, air collision studies, and detect and avoid for beyond-visual-line-of-sight operations (BVLOS), noise studies, communications research, control station standards recommendations, and detection of small UAS in the vicinity of airfields to name just a few.

As we move into our fourth year, ASSURE will continue its work on air and ground collision, detect-and-avoid, as well as our Science, Technology, Engineering and Math (STEM) outreach to underserved minorities. We will branch into studies that will better define flight test data structures and reporting to provide the FAA a better understanding of the safety of various systems and operations. With a new contract vehicle in place with the FAA, the ASSURE team will look to support not only the FAA, but also other branches of government as they look to leverage UAS in the activities for which they are responsible. Also, ASSURE and the FAA have started efforts to extend ASSURE as the UAS Center of Excellence to the year 2027.

As the new Executive Director of ASSURE, I am proud to share with you this Annual Report which highlights the work the ASSURE team has provided the FAA and the nation in Fiscal Year 2018. Please take a moment to review our work and contact us with any ideas, suggestions, or comments.

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

ASSURE LEADERSHIP:

Dr. David Shaw
MSU Vice President for
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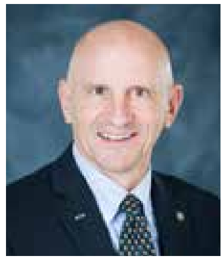

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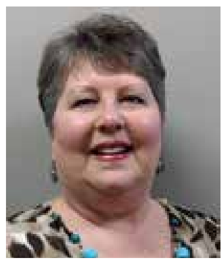

Sheila Ashley
Program Coordinator
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MISSION:

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 gets UAS flying alongside manned aircraft around the world.

ASSURE TAG LINE:

Informing UAS Policy Through Research.

ACKNOWLEDGMENTS

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

Dr. David Shaw, Vice President for the Office of Research and Economic Development at Mississippi State University, continues to provide leadership to the program he envisioned and nurtured into existence. In 2018, he led the team through a transition of leadership and has worked diligently to increase international collaboration and coordination on UAS research.

I would also like to acknowledge the amazing team that ensures that ASSURE runs so smoothly. Dallas Brooks, Associate Director; Brandy Akers, Financial Manager; and Sheila Ashley, Program Coordinator have kept our large team of 23 universities and their many offices and interests coordinated and all moving toward our common goals. This is not an easy task; I am grateful for their many long hours that make the team function so well.

The ASSURE team encompasses many core, affiliate, government, academic, and industry partners. To acknowledge every member of the several organizations involved in the management and execution of the ASSURE mission would not be possible. Support from these partners comes from great people who are experts in aviation, aerospace, human factors, training, maintenance, logistics, operations, finance, administration, and many who freely give their time every day to ensure the success of this center.

Thank you!

FINANCIALS

ASSURE FUNDING SUMMARY

Total Funding $18,085,667.59

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Office Funding	**$3,400,867.52**	**$2,797,304.94**	**$603,562.58**	**$1,039,295.26**	**37%**
Core Schools	**$14,684,800.07**	**$8,508,047.83**	**$6,176,752.24**	**$9,221,811.51**	**108%**
Drexel University	$559,350.00	$559,343.94	$6.06	$601,406.63	108%
Embry-Riddle Aeronautical Univeristy	$807,887.00	$503,931.13	$303,955.87	$525,528.90	104%
Kansas State University	$842,491.00	$817,491.00	$25,000.00	$848,117.56	104%
Mississippi State University	$1,431,531.07	$810,329.44	$621,201.63	$745,003.04	92%
Montana State University	$719,726.00	$380,772.28	$338,953.72	$402,791.43	106%
New Mexico State University	$1,310,000.00	$840,202.17	$469,797.83	$837,687.21	100%
North Carolina State University	$229,916.00	$229,876.39	$39.61	$229,876.39	100%
Ohio State University	$2,056,792.00	$1,005,649.79	$1,051,142.21	$1,148,967.23	114%
Oregon State University	$75,000.00	$75,000.00	$0.00	$75,000.00	100%
University of Alabama-Huntsville	$1,996,464.00	$916,445.65	$1,080,018.35	$1,174,377.60	128%
University of Alaska-Fairbanks	$235,982.00	$24,693.18	$211,288.82	$47,594.40	193%
University of California-Davis	$45,000.00	$34,841.95	$10,158.05	$34,841.95	100%
University of Kansas	$92,000.00	$91,967.86	$32.14	$92,000.01	100%
University of North Dakota	$1,696,164.00	$883,735.05	$812,428.95	$1,124,851.16	127%
Wichita State University	$2,586,497.00	$1,333,768.00	$1,252,729.00	$1,333,768.00	100%
Totals	**$18,085,667.59**	**$11,305,352.77**	**$6,780,314.82**	**$10,261,106.77**	**91%**

SUMMARY BY PROJECT

Total Funding $18,085,667.59

	Award Amount	Expenditures	Remaining	Cost Share	
Program Management Funding	**$3,733,867.52**	**$3,114,827.13**	**$619,040.39**	**$1,312,159.28**	**42%**
Projects	**$14,351,800.07**	**$8,190,525.64**	**$6,161,274.43**	**$8,948,947.49**	**109%**
A1: Unmanned Aircraft Integration: Certification Test to Validate sUAS Industry Consensus Standards	$300,001.00	$299,996.00	$5.00	$300,280.00	100%
A2: Small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight (BVLOS) Operations	$799,992.00	$799,658.63	$333.37	$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	$382,500.00	$382,387.89	$112.11	$409,098.69	107%
A5: UAS Maintenance, Modification, Repair, Inspection, Training, and Certification	$800,000.00	$799,980.23	$19.77	$829,733.21	104%
A6: Surveillance Criticality for SAA	$781,533.07	$779,040.15	$2,492.92	$779,040.15	100%
A7: UAS Human Factors Considerations	$750,000.00	$717,601.08	$32,398.92	$766,189.59	107%
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	$330,000.00	$329,996.24	$3.76	$646,943.35	196%
A10: Human Factors Consideration of UAS Procedures & Control Stations	$900,000.00	$798,182.05	$101,817.95	$882,092.12	111%
A11: Low Altitude Operations Safety: Part 107 Waiver Request Case Study	$151,733.00	$151,274.50	$458.50	$184,588.38	122%
A12: Performance Analysis of UAS Detection Technologies Operating in Airport Environment	$300,000.00	$284,186.01	$15,813.99	$269,029.64	95%
A13: UAS Airborne Collision Severity Peer Review	$7,026.00	$7,026.00	$0.00	$7,026.00	100%
A14: UAS Ground Collision Severity Studies	$2,042,581.00	$1,682,025.60	$360,555.40	$1,643,204.13	98%
A15: Stem II	$149,982.00	$109,171.26	$40,810.74	$118,250.11	108%

(CONTINUED ON NEXT PAGE)

SUMMARY BY PROJECT (CONTINUED)

Total Funding $18,085,667.59

	Award Amount	Expenditures	Remaining	Cost Share	Cost Share %
Program Management Funding	**$3,733,867.52**	**$3,114,827.13**	**$619,040.39**	**$1,312,159.28**	**42%**
Projects	**$14,351,800.07**	**$8,190,525.64**	**$6,161,274.43**	**$8,948,947.49**	**109%**
A16: Airborne Collision Severity Evaluation - Structural Impact	$2,202,886.00	$0.00	$2,202,886.00	$0.00	0%
A17: Airborne Collision Severity Evaluation - Engine Ingestion	$1,532,252.00	$0.00	$1,532,252.00	$0.00	0%
A18: Small UAS Detect and Avoid Requirements Necessary for Limited BVLOS Operations: Separation Requirements and Training	$1,071,598.00	$0.00	$1,071,598.00	$240,103.51	100%
A19: UAS Test Data Collection and Analysis	$400,000.00	$0.00	$400,000.00	$0.00	0%
A20: UAS Parameters, Exceedances, Recording Rates for ASIAS	$399,716.00	$0.00	$399,716.00	$0.00	0%
Totals	**$18,085,667.59**	**$11,305,352.77**	**$6,780,314.82**	**$10,261,106.77**	**91%**

COST SHARE SUMMARY

Adaptive Aerospace Group, Inc.	$5,897.34
AgentFly Software	$50,000.00
Arlin's Aircraft	$3,000.00
Boeing	$46,235.64
DJI	$8,070.00
DJI Research, LLC	$48,522.80
Drexel University	$362,396.63
Embry-Riddle Aeronautical University	$339,134.78
General Electric	$145,930.48
GoPro	$29,925.60
GreenSight Agronomics, Inc.	$13,357.00
Honeywell	$30,275.78
Intel	$26,669.60
K.I.M. Inc.	$43,200.00
Kansas Department of Commerce	$152,969.00
Kansas State University	$705,676.95
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	$1,128,850.74
Montana Aircraft	$6,000.00
Montana State University	$324,220.79
New Mexico State University	$837,687.21
North Carolina State University	$914,370.49
North Dakota Department of Commerce	$688,546.07
NUAIR	$20,923.02
Ohio State University	$146,175.00
Ohio/Indiana UAS Center (ODOT)	$233,000.00
R Cubed Engineering	$6,970.09
Rockwell Collins	$4,015.80
Sandia	$2,257.00
SenseFly	$432,574.40
Simlat Software	$147,260.00
Sinclair Community College	$15,842.40
State of Kansas	$91,604.83
The Cirlot Agency	$116,824.90
University of Alabama in Huntsville	$560,217.20
University of Alaska Fairbanks	$47,594.40
University of California Davis	$34,841.95
University of Kansas Center for Research, Inc.	$92,000.01
University of North Dakota	$326,305.09
Wichita State University	$1,264,988.00
Total	**$10,261,106.77**

SUMMARY BY SOURCE

Universities	$7,100,301.64
State Contributions	$1,166,119.90
3rd Party Contributions	$1,994,685.23
Total	**$10,261,106.77**

RESEARCH STUDIES

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

UAS Ground Collision Severity Evaluation II

Research Focus Lead: University of Alabama, Huntsville

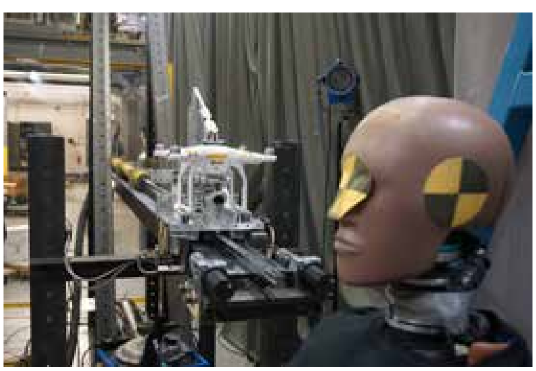
The ASSURE research team of Wichita State University’s National Institute of Aviation Research (NIAR), Mississippi State University (MSU), The Ohio State University (OSU), Virginia Tech University (VT), and led by The University of Alabama in Huntsville (UAH), is conducting a follow-on study building on the findings of previous projects that established a framework for quantifying the injury potential of small unmanned aircraft (UA) resulting from collisions with non-participating public on the ground. The purpose of this study is to:

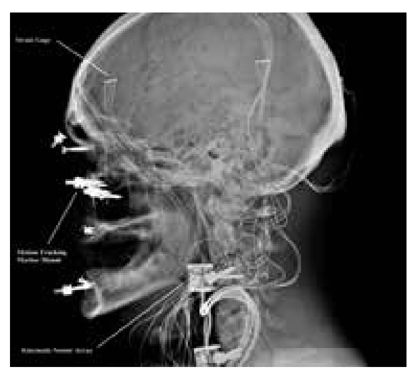
- expand the number and types of unmanned aircraft
- refine and validate methodology/framework for determining injury potential to the non-participating public
- establish a clear and easily repeatable test method to determine the injury potential from the amount of kinetic energy (KE) transferred to a person impacted by a UA in various conditions and scenarios;
- recommend an acceptable level of safety using this test method; and
- study the difference in energy transfer that would cause a concussion as compared to previous work on skull fractures.

Approach

The research is being conducted over an 18-month period that included a “scope” peer review of the research plan at the beginning of the research task and will include an additional peer review of the final reports occurring at the end of the program. The research is broken down into six fundamental tasks:

1. Develop a Simple and Repeatable Test Method
2. Build a Human Body Model
3. Build High Biofidelity Human Head and Neck
4. Conduct Post-Mortem Human Studies (PMHS) to Validate the Models Above
5. Provide a means of active collaboration with an FAA Test Site and ASSURE certified partner to develop insight into injury risk analysis including concussions as well as injury risk testing methodologies.
6. Provide Technical and Administrative Oversight of this Multi-Disciplinary and Inter-university Research.





Research Tasks 1-4 are mutually supporting tasks to gain a greater understanding of the human injury potential of sUAS. The role that each test and simulation effort plays in defining human injury potential for a specific aircraft is depicted in Figure 1. The effort leverages the ASSURE's previous collision projects including the evaluation of the linear relationship between maximum resultant acceleration as a function of impact KE and determining whether this relationship is consistent with human injury potential as defined by PMHS testing. The DJI Phantom 3 and Sensefly eBee+ are common to all testing and modeling efforts to provide continuity between datasets and representation of common multi-rotor and fixed wing configurations. Additional flight testing and impact testing using both the simplified testing and ATD testing are being conducted to broaden the understanding of injury potential of a wider range of vehicles, constructions and material properties.

The relationships between the various elements of the research shown in Figure 1. Flight Testing determines operational impact velocities as a function of failure modes, impact KE, impact angles and orientations for Simplified, Anthropomorphic Test Dummy (ATD) and PMHS testing, as well as modeling efforts. The flight testing activity also provides validation data for the Aircraft Failure Dynamics Modeling, which is depicted by the linkage between the Aircraft Failure Dynamics Flight Test and Aircraft Failure Dynamics Modeling. Monte Carlo simulations of post-failure dynamics allow a comprehensive analysis of impact conditions to determine if additional impact tests and simulation cases in Tasks 1-3 should be completed. Simplified Testing develops lower-velocity impact data points, estimates the slope of the curve-fit, and refines higher-velocity impact test points. ATD Testing as part of Tasks 1 and 2 develops higher-velocity impact data points, provides calibration data for modeling efforts in Tasks 2 and 3, and correlation data for Simplified Test data. NIAR and MSU are conducting impact simulations with the Human Body Model and Biofedelic Head/Neck, respectively. NIAR and MSU developed calibrated aircraft Fine Element Models (FEMs) for use in comprehensive simulation of impact testing of specific aircraft to establish the worst-case impact test points for The Ohio State University (OSU) PMHS Testing. The ATD and Simplified Testing from Task 1 in conjunction with the modeling efforts in Tasks 2 and 3 established impact angles and impact KE parameters for the PMHS testing in Task 4. PMHS test results from Task 4 validate the models in Task 2 and 3 and form the basis for determining the levels of safety necessary for both the simplified and ATD test methods performed in Task 1. While no one test or modeling effort will be exhaustive for any one vehicle (except the Phantom 3), the research approach further refines three specific test methods; modeling, simplified tests, and extensive tests for evaluating vehicles in terms of human injury potential. The tests are intended to increase the body of knowledge for the FAA in terms of rulemaking for flight over people operations by evaluating the various injury potential test methods and comparing them with actual PMHS injuries. The modeling efforts provide the FAA with validated tools that can be used for evaluating a broader number of sUAS impact scenarios.

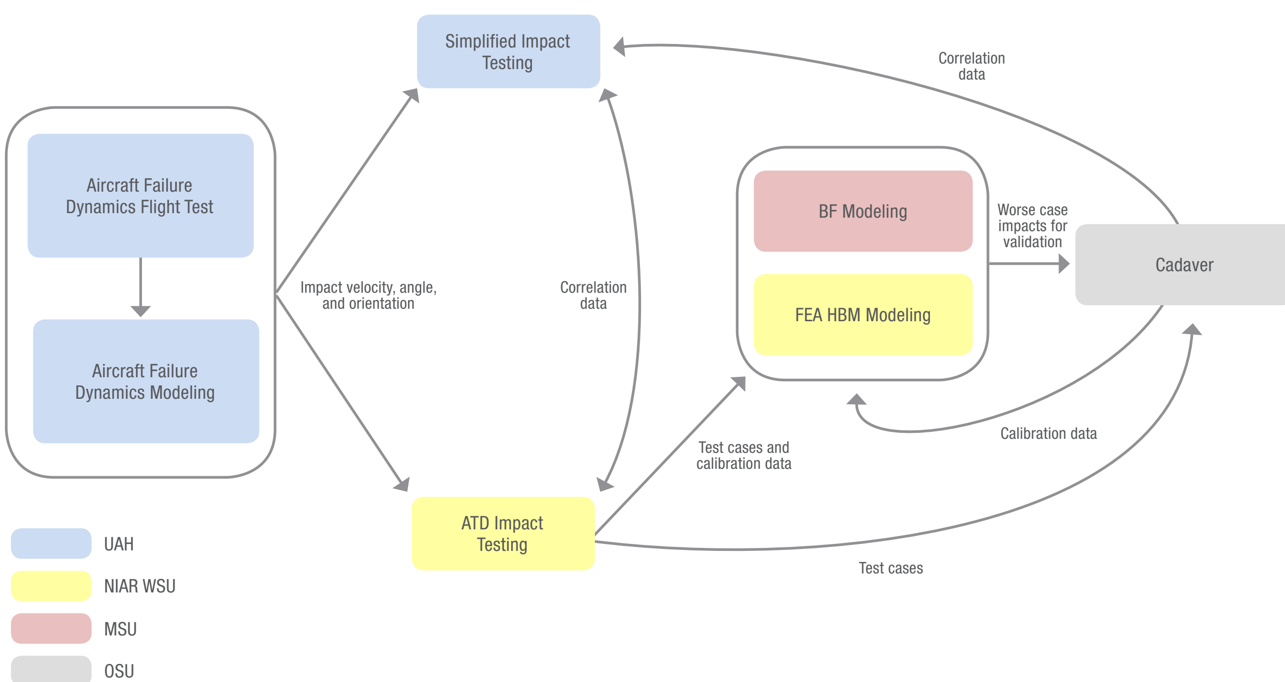


Figure 1 - Data Dependencies

The Flight Testing effort and Aircraft Failure Dynamic simulations will provide aerodynamic information and dynamic response data for a group of sixteen vehicles. Flight testing was conducted under no or low-wind conditions and test a range of propulsion and control surface failures designed to determine aircraft terminal velocity (multi-rotor vehicles), flat plate drag area estimates (multi-rotor vehicles), glide ratio and airspeed (fixed wing vehicles), and aircraft dynamics. The aircraft failure dynamics simulation provide larger datasets to encompass more combinations of failure types and environmental conditions, which, in turn, provide insight into credible, worst case failure situations and impact parameters. The dynamic simulation outputs also identify the hazard area under each vehicle based on flight condition at failure and a range of failure modes. These hazard area estimates are critical to support separate efforts, outside of this research, to calculate the probability of an aircraft strike to a person. Simplified testing will produce low-velocity impact for human injury estimates for a set of sixteen vehicles, a wooden block, and a battery or camera payload under impact conditions specified during flight-testing and dynamic simulation. The ATD testing will replicate credible high-velocity impacts based on the outputs from flight-testing and dynamic simulation. The ATD testing will include eight different vehicles, wooden and foam blocks, Phantom 3 Battery and an SLR Camera. NIAR FEA Calibration impact tests will replicate low-velocity impact conditions to complete the NIAR dataset of calibrated FEMs that were started with high-velocity impacts during our previous research. The eBee+ aircraft will be added the NIAR FEA calibration and modeling efforts to add foam type aircraft to the analysis. The OSU PMHS Impact tests will span low and high-velocity impacts to provide correlation data for both the Simplified and ATD impact testing, as well as validation data for the NIAR and MSU FEA impact simulation efforts. PMHS tests include 40 impacts using five aircraft as well as wooden and foam blocks. NIAR and MSU impact simulations will span low to high-velocity impacts with the MSU impact simulations being more narrowly focused on impact velocities and KE levels that correlate to head injury thresholds (skull fracture and concussion) and neck injury thresholds for each aircraft model (Phantom 3 and eBee+).

Key Findings

At the time of this writing, testing is nearing completion. The team has discovered many interesting results, however months of data anaylsis, correlation, and report writing are ahead. The team expects to complete its reports and peer reviews before spring 2019. Their findings will be revised following peer review as appropriate, prior to presenting final findings to Congress, stakeholders and the public.

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Name & Origin of All Research Personnel during Original Ground Collision Severity Research

Name	Origin
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Chris Duling, UAH	USA
Nishanth Goli, UAH	India
Emily McGuire, UAH	USA
Mack Wood, UAH	USA
Jasleen Kaur, UAH	India
Eduardo Divo, ERAU	USA
Feng Zhu, ERAU	China
Victor Huayamave, ERAU	USA
Alexander Dori, ERAU	USA
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Mark Ewing, KU	USA
George Blake, KU	USA
John Pritchard, KU	USA
Eric Bodlak, KU	USA
Ratneshwar Jha, MSU	USA
Thomas Lacy, MSU	USA
Calvin Walker, MSU	USA
Raj Prabhu, MSU	India
Lakeisha Williams, MSU	USA
June Liao, MSU	USA
Prateek Jolly, MSU	China
David Francis, MSU	India
Hannah Stealey, MSU	USA
Anna Dulaney, MSU	USA
Parker Bertheslon, MSU	USA
Ashma Sharma, MSU	Nepal
Robert Huculak, WSU	USA
Marcus Pyles, WSU	USA
Andrew Mackey, WSU	USA
Jonathan Conklin, WSU	USA
Luis Gomez, WSU	Spain
Tom Aldag, WSU	USA
Gerardo Olivares, WSU	USA

Name & Origin of Research Personnel Working Follow-On Research

Name	Origin
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Chris Duling, UAH	USA
Nishanth Goli, UAH	India
Emily McGuire, UAH	USA
Chris Sallis, UAH	USA
Mark Gauldin, UAH	USA
Doug Huie, UAH	USA
Nick Balch, UAH	USA
Josh Schofield, UAH	USA
Patrick Hambloch, UAH	Germany
Hunter Bray, UAH	USA
Casey Calamaio, UAH	USA
Kendall White, UAH	USA
Stefan Duma, VT	USA
Steven Rowson, VT	USA
Mark Blanks, VT	USA
Raj Prabhu, MSU	India
Lakeisha Williams, MSU	USA
Jonathan Pote, MSU	USA
Wilburn Whittington, MSU	USA
Anna Marie Dulaney, MSU	USA
Alex Smith, MSU	USA
Ky Phong Pham, MSU	Vietnam
Ashma Sharma, MSU	Nepal
Robert Huculak, WSU	USA
Marcus, Pyles, WSU	USA
Andrew Mackey, WSU	USA
Jonathan Conklin, WSU	USA
Luis Gomez, WSU	Spain
Tom Aldag, WSU	USA
Gerardo Olivares, WSU	USA
Jaime Espinosa de los Monteros, WSU	Spain
Russell Baldridge, WSU	USA
John Bolte IV, OSU	USA

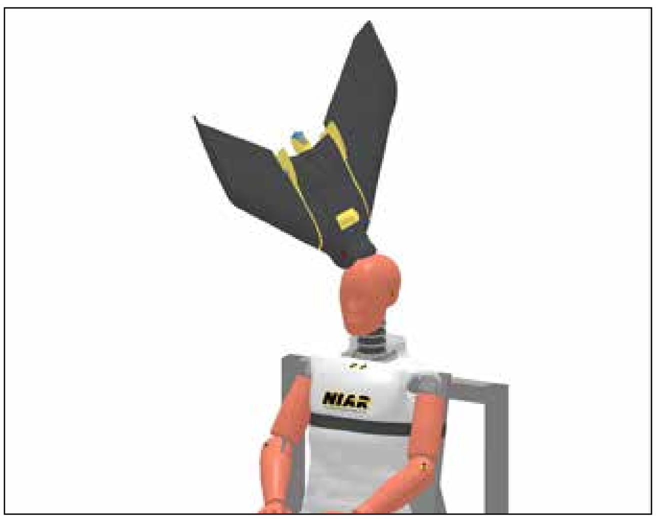
Jim Gregory, OSU	USA
Yun Seok Kang, OSU	South Korea
Matthew McCrink, OSU	USA
Ariana Willis, OSU	USA
David Stark, OSU	USA

Graduation Dates of Students:

Name	Graduation Date
N/A	N/A

Placement of Previous Research Students:

Name	Placement
Prateek Jolly, MSU	Unknown



Performance Analysis of UAS Detection Technologies Operating in Airport Environments

Mississippi State University: Research Focus Lead

The steep increase in reports of small-unmanned aircraft (UA) close to airports and manned air traffic is presenting a new challenge for the FAA. The safety of the NAS is the Agency's responsibility, including the identification of possible gaps in safety and addressing them before a significant incident occurs.

The ASSURE COE team, Mississippi State University, the University of North Dakota and New Mexico State University, analyzed data following airport demonstrations of selected UAS detection and tracking systems at three major airport locations. The goal of the project was to identify the capabilities, performance characteristics, and limitations of specific instances of UAS detection technologies to assess which technologies demonstrate the applicability and/or promise for use in and around the airport environment.

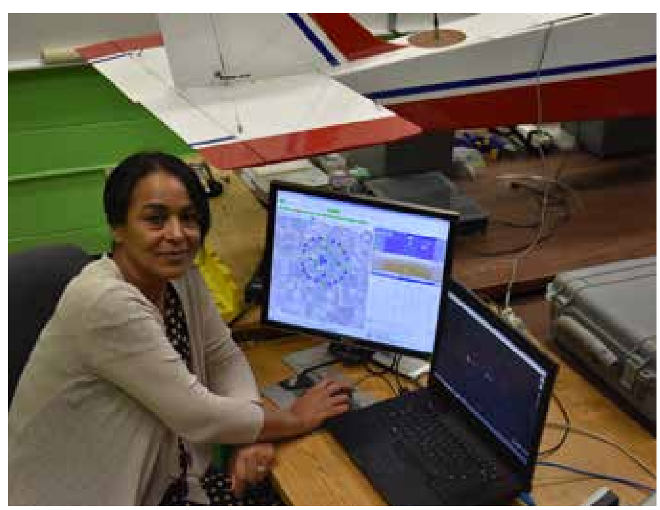
The FAA entered Cooperative Research and Development Agreements (CRADA) with selected detection system original equipment manufacturers (OEMs) to assess their technologies in real-world airport environments. Technology demonstrations were conducted at four locations: Atlantic City International Airport (ACY), John F. Kennedy International Airport (JFK), Denver International Airport (DEN), and the Dallas-Fort Worth International Airport (DFW). The final evaluation (DFW) was conducted with the full ASSURE team on-site and generated substantial performance data collected and validated by the ASSURE research team. The ASSURE team also analyzed data provided to the FAA by the respective OEMs from the ACY, JFK and DEN demonstrations. The final report provides sensor-performance analysis results for the DFW, ACY, and DEN flight tests. JFK results are not presented since data from the JFK flights tests were not shared with the research team.

In preparation for the final demonstration event, ASSURE researchers defined and developed a data collection construct which identified key system performance data elements, defined their format, and enabled them to normalize their application across disparate systems. This custom-developed data construct allows real-time analysis of UAS detection system performance, ensuring data integrity throughout the data collection and analysis process. It also supports effective system-to-system comparisons using key performance measures.

While the researchers were limited by the amount, reliability and consistency of information provided by vendors from the ACY, JFK and DEN demonstrations, the team was able to draw substantial and detailed performance results from ASSURE-collected data during the DFW event. Our research found that different configurations and combinations of sensors (radar, optical, acoustic, etc.) substantially affected results. In addition, environmental attributes (existing structures, RF interference/congestion, available lighting) also had a significant effect on system performance—certain sensor types performed better in some conditions and worse in others. Overall, our research found that detection systems that fuse different sensors, and/or utilize layering of sensors, increased probabilities of detection and provide operators with more context regarding targets.

While the systems demonstrated during these events were capable of operating with only one person, the task load for detection, alerting, tracking and coordinating an appropriate and effective response will likely require the teamed approach. Training for the use of each system generally required a couple of days. The amount of time required to install a system was dependent on the complexities of the site, and whether the site had previously been surveyed. More detailed discussions of the various sensors, a failure-mode analysis (provides insight regarding scenarios that would cause detection failures for different types of technologies), and an evaluation of using a layered approach are provided in the final report.

A complementary effort on this research was the production of an airport protection report that was a review of selected literature on technologies for detection, identification and tracking that have been identified by the FAA as showing relevance or promise to this project. The FAA provided a listing of the limited number of documents requested to be reviewed. Some of these documents were unclassified and some had varying levels of classification. The literature review provided a brief background on different potential airport protection concepts including the threats to airports and concepts of operations. Descriptions of the various potential systems approached toward detecting and identifying UAS were demonstrated and documented. A summary of the unclassified sections of the documents were presented. Much of the information that is unclassified was treated as For Official Use Only. The actual performance data for each system is classified. An unclassified report was prepared and the classified information was provided in a classified Annex to the final report. Information on some related DAA research was also presented because many of the technologies being developed for DAA can/may have applications for detection, identification, and tracking.



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Graduation Dates of Students:

Name	Graduation Date
Alex Butland	May 2017
Taylor Trask	Spring 2019

Placement of Previous Research Students:

Name	Placement
Alex Butland	Graduate Student

MINORITY OUTREACH

UAS as a STEM Minority Outreach Learning Platform

New Mexico State University: Research Focus Lead

The University of Alaska-Fairbanks, University of California-Davis, and Montana State University under the leadership of New Mexico State University are incorporating Science, Technology, Engineering, and Math (STEM) Outreach to students from groups who are under-represented in STEM fields. No one single approach addresses STEM outreach for students of different ages, backgrounds or who have different cultural and regional influences. There are common technical ideas and instructional approaches that can be used as building blocks, which can then be tailored to the various under-represented target groups.

The objective of this project is to expand the potential STEM Outreach approaches to the FAA that use UAS's as the central learning platform. Each university focuses their outreach to different under-represented groups leveraging their unique UAS resources and established connections and relationships within their local communities.

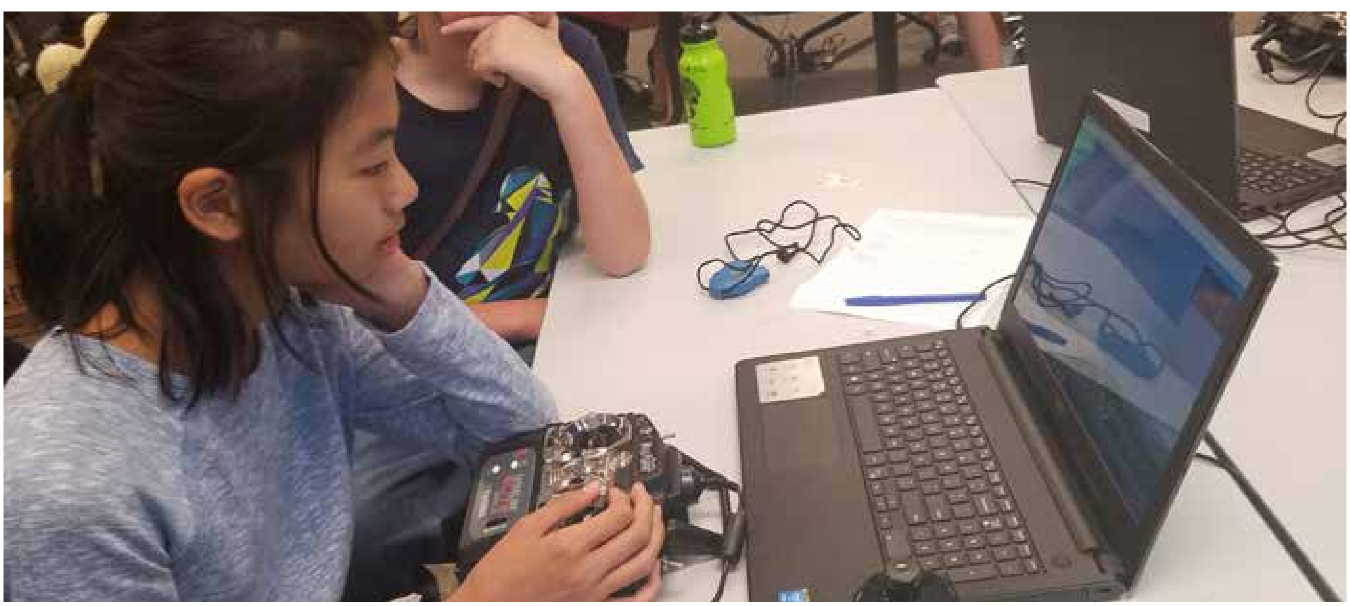
New Mexico State University

The New Mexico State University Physical Science Laboratory manages one of the FAA's approved UAS Test Sites that has an 18-year history of UAS operations and research and has a number of in-place appropriate resources to support this work. The NMSU UAS team has joined with the NMSU's College of Education STEM Outreach Center. The synergy of these two groups has brought together the best of UAS technical knowledge and educational approaches to inspire the next generations to study technical fields. NMSU's primary role for this effort is coordinating the program with the other University team members, and preparing concise reporting to the FAA on progress. NMSU has capitalized on the UAS educational materials prepared under previous FAA UAS STEM efforts to offer hands-on UAS outreach to broad groups of students. This has included offering summer camps, cloning of our UAS summer camp, demonstrations, and other outreach events. The focus has been to give students an opportunity to explore aspects of STEM with an emphasis on aerospace science. Most of these opportunities are for minority, marginalized and underrepresented students including Hispanic, English Language Learners, and many who receive free and reduced lunches. Educational outreach in non-traditional opportunities, such as after-school and summer camps ensure students receive hands-on STEM instruction that relates real-world learning experiences to current events in science.

Summer Camp
NMSU supported another round of UAS summer camps in June of this year. These camps were based on the UAS summer camps provided in 2017 which were a great hit last year. The "Drones for Beginners" camp June 18-22, 2018, had a total of ~60 students and was a one-week version of previously offered camp. The "Drones for Advanced Flyers" camp June 25-29, 2018, had a total ~60 students, and was for students who took the class last summer. The students built their drones, flew them and were able to take them home after the camp. NMSU completed a "clone" of the successful UAS summer camps with a local group Insight El Paso. The existing materials were put on loan to support the camp. NMSU's UAS instructor facilitated the program with Insight El Paso providing support staff and paying his salary. This was a win-win situation. The camp was held from July 30 - August 3 and had 16 participants for 7 hours a day.

STEM Outreach Activities

The Dona Ana Community College (DACC) offered an ACT prep class again this year again. The goal of this effort was to instruct in key areas and to take multiple practice tests to help students increase their scores on the ACT exam. This is a very successful local program. The NMSU UAS flight team performed two different flight demonstrations during the 5-week class. Talks on UAS and STEM careers accompanied the flight demos. For the final graduation ceremony for the 125+ students and their families, the NMSU PI, Mr. Henry Cathey was asked to be the main speaker for the evening on STEM careers and opportunities. A presentation was made to over 350 people on STEM careers.



University of Alaska-Fairbanks

The location of the University of Alaska-Fairbanks (UAF) provides natural access to predominantly Alaska native communities.UAF has a tradition of engaging students and communities across the State in research-focused STEM activities. The primary target for these STEM outreach programs is Alaskan Natives. The University of Alaska Fairbanks conducted numerous STEM outreach activities throughout the past year.

Summer Camp

The key event for the University of Alaska STEM effort was the UAF UAS STEM Summer Camp, June 11-15, 2018. Twenty-one students participated in the camp through a week of very structured activities. Students had flight simulator time, construction time including troubleshooting issues, and flight time on the drone racing course inside the Patty Ice Area. All students took home a full first-person video and racing drone system that they built. A survey of attending students showed the positive impact of the camp.

Roadshows

UAF also conducted two UAS roadshows: one at Delta Junction Middle School on August 24, 2018 (~20 middle school students), and a second one at the Nenana School (~20 high school level students) on September 20, 2018. The sessions included lectures on aviation safety, UAS careers, STEM training, and time on flight simulators and with first person view UAS. UAF's first community outreach event under this effort focused on drone racing at the UAF Patty Ice Arena on December 3, 2017. There were over 200 participants. Additionally, throughout the year UAF conducted ongoing outreach to tour groups including students from Delta Junction, the Kenai Peninsula, Bering Strait School District, and others.





University of California-Davis

The University of California, Davis has a wide range of programs related to STEM, outreach, minority education at the campus level in the College of Engineering, College of Agriculture and Environmental Sciences (CAES), and College of Letters and Science that target K-14 students from socioeconomically disadvantaged backgrounds. UC Davis is 1st in the nation for women in STEM disciplines and 9th among institutions granting undergraduate degrees to students of color.

Summer Camp

UC Davis team in partnership with the Early Academic Outreach Program (EAOP) and the UC multicampus Center for Information Technology in the Interest of Society (CITRIS) hosted a one-week summer camp to 15 high school students (10th, 11th grade) from eight high schools, both urban and rural, in the region. The Early Academic Outreach Program (EAOP) program, which works with 2,500 middle and high school students from 12 high schools in the area that have large targeted student populations. EAOP helped with logistics in accessing students and handling applications, and in recruiting UCD student mentors to work with the high school students. Moreover, CITRIS provided supplies, programming and other extensive support for the program. The goals were to encourage students to academically prepare to enroll in STEM disciplines in university after college. Students learned simple programming, how to be an FAA-certified UAS pilot, careers using UAS technologies, working in groups to solve problems, and other experiences to show students that they can succeed in this environment and have fun doing it. Several students provided feedback that they wished the program was two weeks long!

Outreach

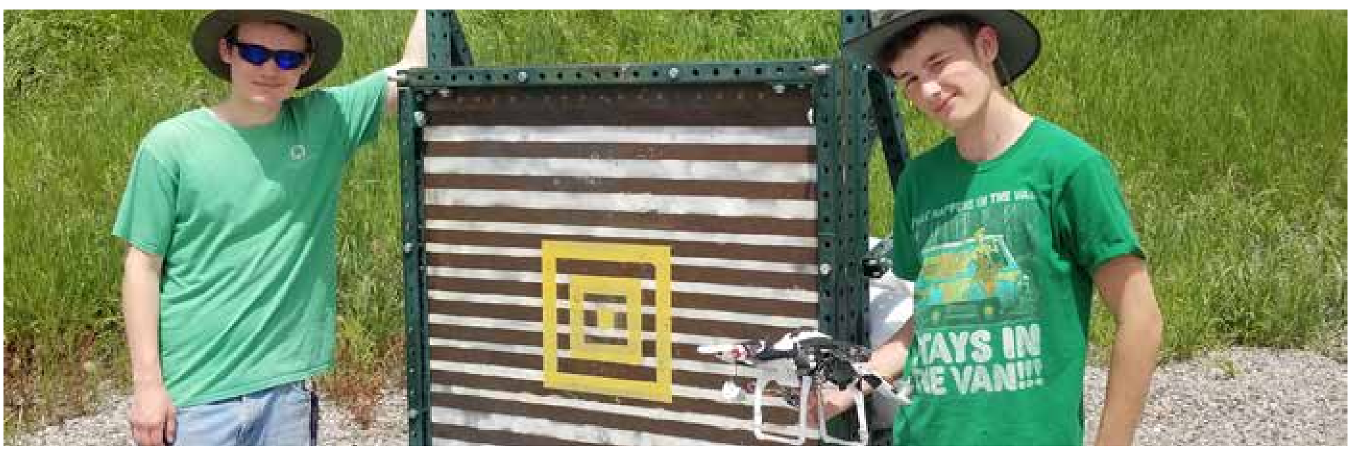
The UCD team displayed a booth at the UC Davis Picnic Day and at the three-day Sacramento Capitol Air Show, both of which hosted thousands of people. The goal was to show the public some of the many ways that UC Davis uses this technology to benefit the state, particularly in agricultural applications and natural resource management. We displayed difference sizes of UAS. Students also explained how UAS are used in research, and described how students can participate in that research, as well as provided an overview of the FAA rules for flying and answered questions.

Montana State University

Montana State University integrated UAS STEM education into the Montana State University Montana Apprenticeship Program (MAP). MAP aims to increase Native American and other underrepresented and "first-generation" high school students' enrollment in higher education. A pull-through is provided at the university level to provide a continuum of STEM engagement of minorities and underrepresented students from middle school through higher education. This is intended to provide a seamless path to university education for students who have been stimulated at the grade school, middle school and high school levels. MAP students have an extraordinary track record, with a 100 percent success rate for finishing High School. The MAP students started June 24, 2018, and went through July 21, 2018. Students attended structured STEM activities in the morning including math workshops, writing workshops and other college prep-activities. Students came to MtSU research group in the afternoons. Their UAS efforts worked with the UAS Air-to-Air Collision research and the MtSU UAS Launcher. They participated first hand in UAS impact studies and were treated just like university student researchers. FAA management personnel visited the site on July 17, 2018. As a follow-on, these two students were offered an open invitation to join the UAS research group at Montana State when they graduate from high school in Spring 2019. (The students involved indicated that they plan to attend MtSU this summer, which should be good timing for further work on the FAA-Sponsored Phase II Air-to-Air Collision research).

Outreach

The Montana State team co-sponsored and organized the Montana Antique Aircraft Association's (MAAA) "Drone Zone" program on August 3-4, 2018 (The FAA STEM II paid for half and the MAAA paid for half). For the FAA STEM Outreach, a drone net including interactive activities and registered sUAS pilots and supervisors provided oversight and instruction. This is a regional draw of unique and historical planes. FAA Certified UAS Pilots supported the participants on a, "First come, first served," basis. There was continuous activity during the sessions. Participants were individually instructed on the "Four Forces of Flight," given a tutorial on flight control, and then flew UAS with the pilots.



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PUBLICATIONS, PROCEEDINGS, & FUTURE RESEARCH

2019 RESEARCH

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

- Commerce: Emerging UAS Network and Implications on NAS Integration
- Airborne Collision Severity Evaluation - Structural Impact (General Aviation and Rotorcraft, with a study of boundary layer effects on collisions)
- Airborne Collision Severity Evaluation – Engine Ingestion
- Small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight (BVLOS) Operations
- Separation Requirements and Testing
- UAS Test Data Collection and Analysis
- UAS Parameters, Exceedances, Recording Rates for the FAA's Aviation Safety Information and Sharing (ASIAS) program
- Stand-up UAS Safety Research Center

SIGNIFICANT EVENTS

Significant Events	Date
UAS Center of Excellence (COE) Selection announced by FAA Administrator Huerta	May 2015
UAS COE Kick-Off Meeting	June 2015
Initial research grants awarded	September 2015
ASSURE sUAS Ground Collision Study Phase II Research Approach Peer Review, Washington, D.C.	October 2017
ASSURE sUAS Airborne Collision Public Release, Washington, D.C.	November 2017
ASSURE Senior Advisory Group Meeting, Albuquerque, New Mexico	December 2017
ASSURE Academic STEM Workshop, Daytona Beach, Florida	January 2018
ASSUE Engine Collision Workshop, Columbus, Ohio	January 2018
ASSURE Meetings with Department of Homeland Security and NASA, Washington, D.C.	February 2018
ASSURE Meetings with Spanish Government Regulators and Universities, Madrid, Spain	February 2018
ASSURE Attend and Support FAA UAS Symposium, Baltimore, Maryland	March 2018
ASSURE FAA Program Management Review, Baltimore, Maryland	March 2018
ASSURE Engine Ingest Meeting, Wichita, Kansas	April 2018
ASSURE XPONENTIAL 2018 & Presentations, Denver, Colorado	May 2018
ASSURE Meeting of its Industry Partners, Denver, Colorado	May 2018
ASSURE International Regulators Meeting, Denver, Colorado	May 2018
ASSURE Visit & Meetings with Israel MOT & CAAI, Tel Aviv, Israel	July 2018
ASSURE Visit & Meeting with Spain AESA, Madrid, Spain	July 2018
ASSURE FAA Program Management Review, Columbus, Ohio	September 2018

JOURNAL ARTICLES

- Arterburn, D., Duling, C., and Goli, N., "Ground Collision Severity Standards for UAS Operating in the National Airspace System (NAS)," 17th AIAA Aviation Technology, Integration, and Operations Conference, AIAA AVIATION Forum, (AIAA 2017-3778)

CONFERENCE PROCEEDINGS

- Performance Analysis of UAS Detection Technologies Operating in Airport Environments, Askelson, Brooks, Cathey and Hottman, TAAC Conference, Dec. 2017
- Presentation on Collision Severity to the National Academy of Science Committee conducting a study to evaluate the potential of probabilistic assessments of risks and other risk assessment methods for streamlining the process of integrating unmanned aircraft systems (UAS) into the national airspace system (NAS)
- Presented paper at American Society of Engineering Education Annual Conference "Impact of Programming Robots and Drones on STEM Attitudes," July 2018
- UAS STEM Minority Outreach Panel Discussion, TAAC Conference, Dec. 2017

The ASSURE University Coalition

Assure has the knowledge of a 23 Member University Coalition

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The FAA's Center of Excellence for UAS Research

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Alliance for System Safety of UAS through Research Excellence

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