The Space Congress® Proceedings | 2018 (45th) The Next Great Steps

Feb 28th, 7:30 AM - 8:30 AM

Integrating Unmanned Aircraft Systems into the National Airspace System

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Operational Challenges of Unmanned Aircraft Systems: Research and Education

EMBRY-RIDDLE Aeronautical University
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John M. Robbins, Ph.D. and Richard S. Stansbury, PhD

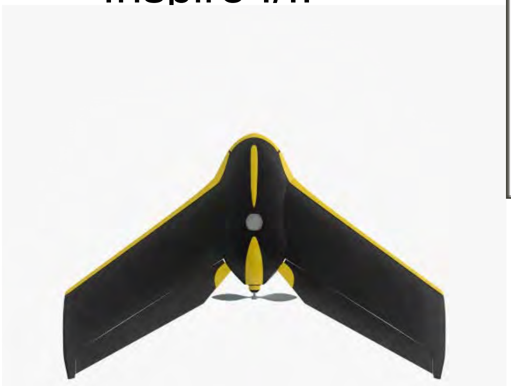
Overview

- Industry Overview
- Systems Overview
- FAR Part 107
- Recent News
- UAS Applications
- UAS Research toward Integration
- Questions

Flight Line and Lab Facilities

Inspire I/II

Latitude Engineering HQ-40



Sensefly Ebee

Advanced Unmanned Systems Laboratory

Martin UAV Superbat

UAS Technology

- **What is it?**
  - UAS, UAVs, RPAs
  - Drones
  - RC aircraft models
  - System of systems

- **Where did it come from and how has it changed?**
  - Tactical ISR
  - Miniaturization of Technology
  - Availability
  - Application
  - Increased educational opportunities

UAS Classification

UAS Design

Vertical Takeoff or Landing

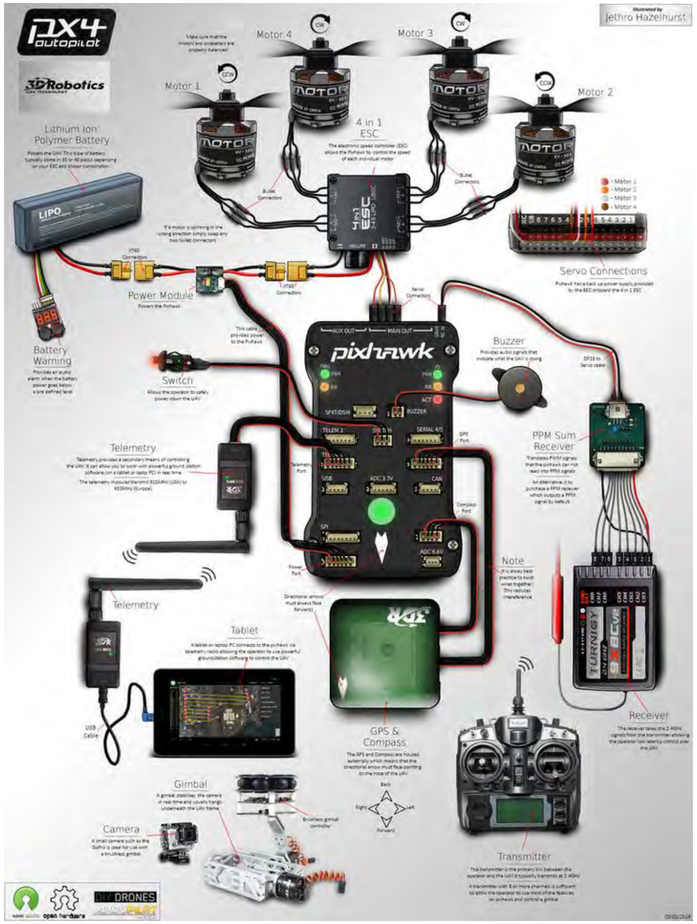
Fixed-Wing

Hybrid

Lighter than Air

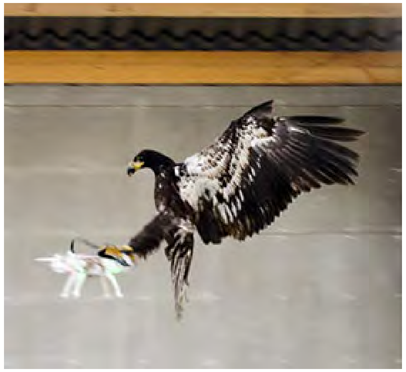
UAS Design

Systems Architecture



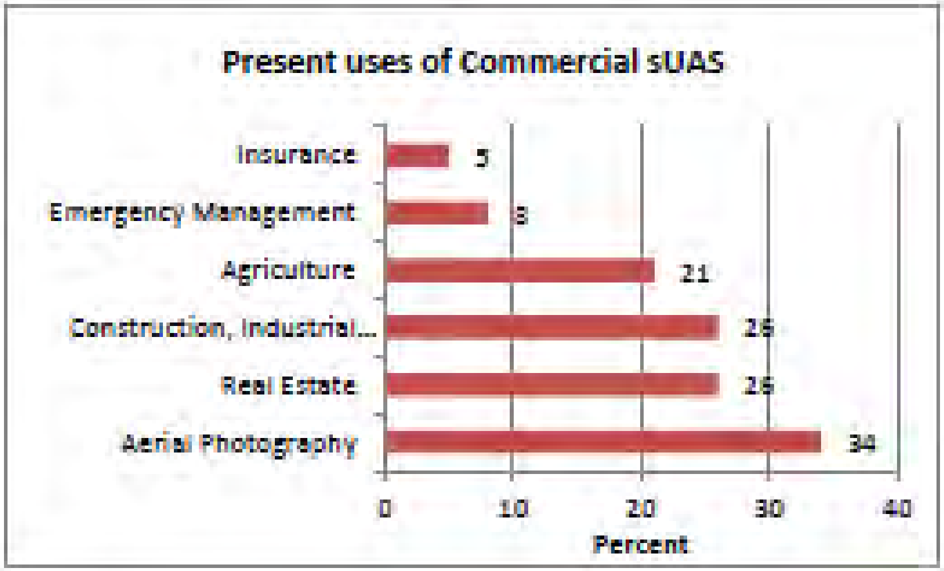
UAS Integration

- What are the issues with integration?



State of Industry

- Steady demand for government, commercial, and hobbyist use of UAS into the NAS
- 2012 – FAA Reauthorization and Modernization Act called for the integration of UAS into the NAS by 2015
- 2015
  - NPRM Small UAS Rules
  - ASSURE FAA Center of Excellence for UAS launched
- 2016
  - Part 107 - Small UAS Rules released
  - microUAS Aviation Rulemaking Committee launched
  - FAA's Drone Advisory Committee formed
- No certification or airworthiness standards for UAS

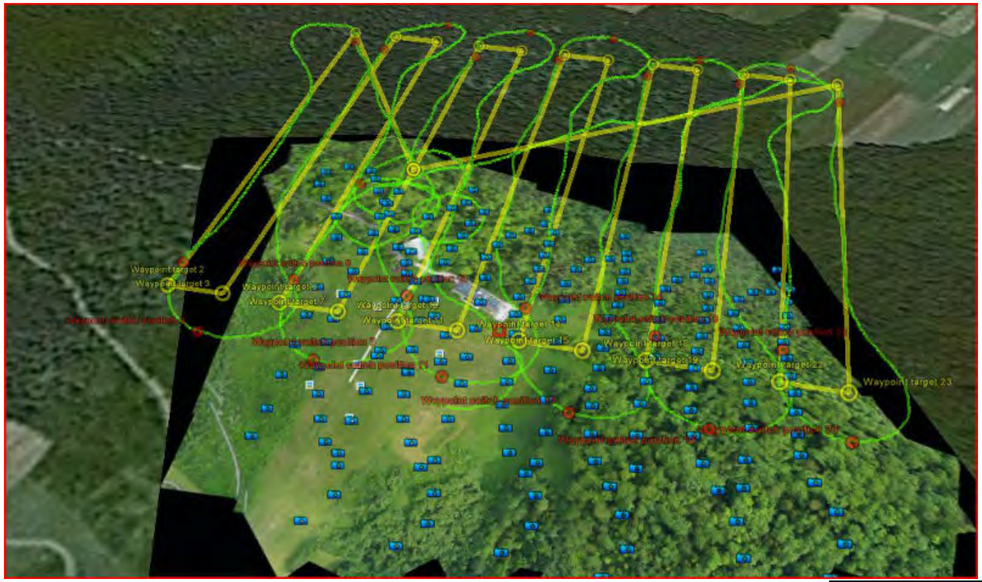


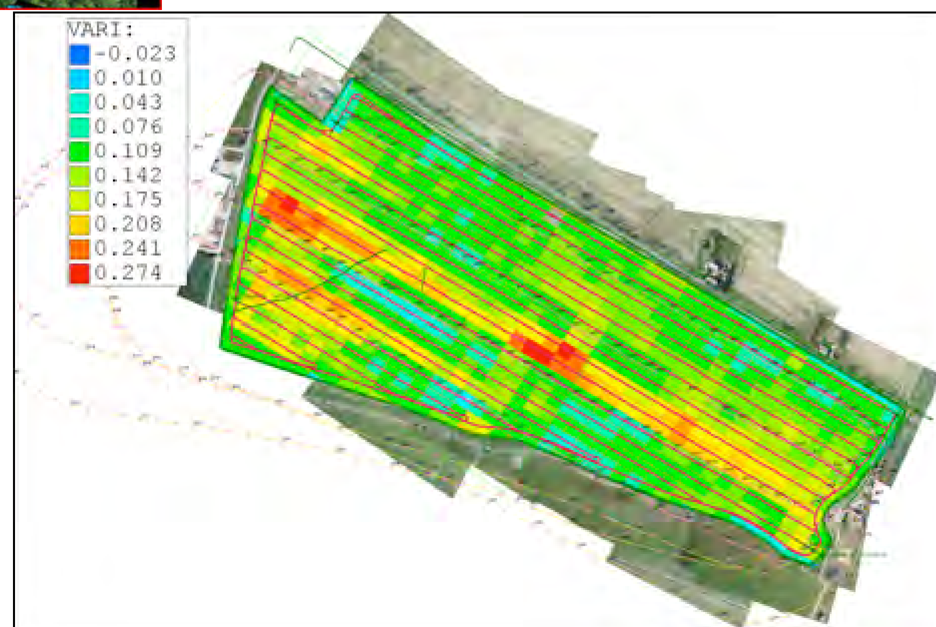
UAS Integration

Part 107 Overview

- RPC required for those operating commercially; Hobby aircraft under Section 336 of Public Law 112-95; AC-91-57 a
- Governing those aircraft weighing less than 55 lbs. operating less than 100 mph
  - No FAA classification scale for those larger than 55 lbs.
- Restricted to 400 ft. AGL within 400 ft. of a structure
- Restricted to Visual Line of Sight Operations (VLOS)
  - Many aircraft have the capability to fly Beyond Visual Line of Sight (BLOS)
  - Expected rulemaking considering BLOS operations expected soon
- May not operate over any persons not directly participating in the operation, not under a covered structure, and not inside a covered stationary vehicle
- Daylight operations only
  - 333 exemptions issued for night operations
- Must always yield right of way to manned aircraft
- Minimum visibility 3 miles from control station
- Ops. in B, C, D, and E airspace allowed with ATC permission
  - https://www.faa.gov/uas/request_waiver/
- Ops. in Class G allowed with no ATC permissions
- Must be registered in accordance with FAR Part 91.203 (a)(2)

Applications: Precision Agriculture





Application: Law Enforcement and Public Safety

Post Hurricane Irma Damage Assessment

Application:
Infrastructure Monitoring

https://www.avinc.com/public-safety/applications/oilandgas

http://www.suasnews.com/2015/06/36480/why-bnsf-railway-is-using-drones-to-inspect-thousands-of-miles-of-rail-lines/

Railroads
Pipelines
Bridges
Roads
Powerlines
Powerplants
Refineries
Etc.

Application: Science / Environment

https://www.cresis.ku.edu/content/news/newsletter/1240

Gale UAS

http://www.pifsc.noaa.gov/cruise/ha1402.php

Other Applications

https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011

Delivery
Filmmaking
News photography
Real-estate
Construction survey
Insurance assessment
Private detectives / spying
Paparazzi
Humanitarian aid

http://www.uasblog.net/make-real-estate-more-yummily-throw-some-drone-sauce-on-it/

Research Planning

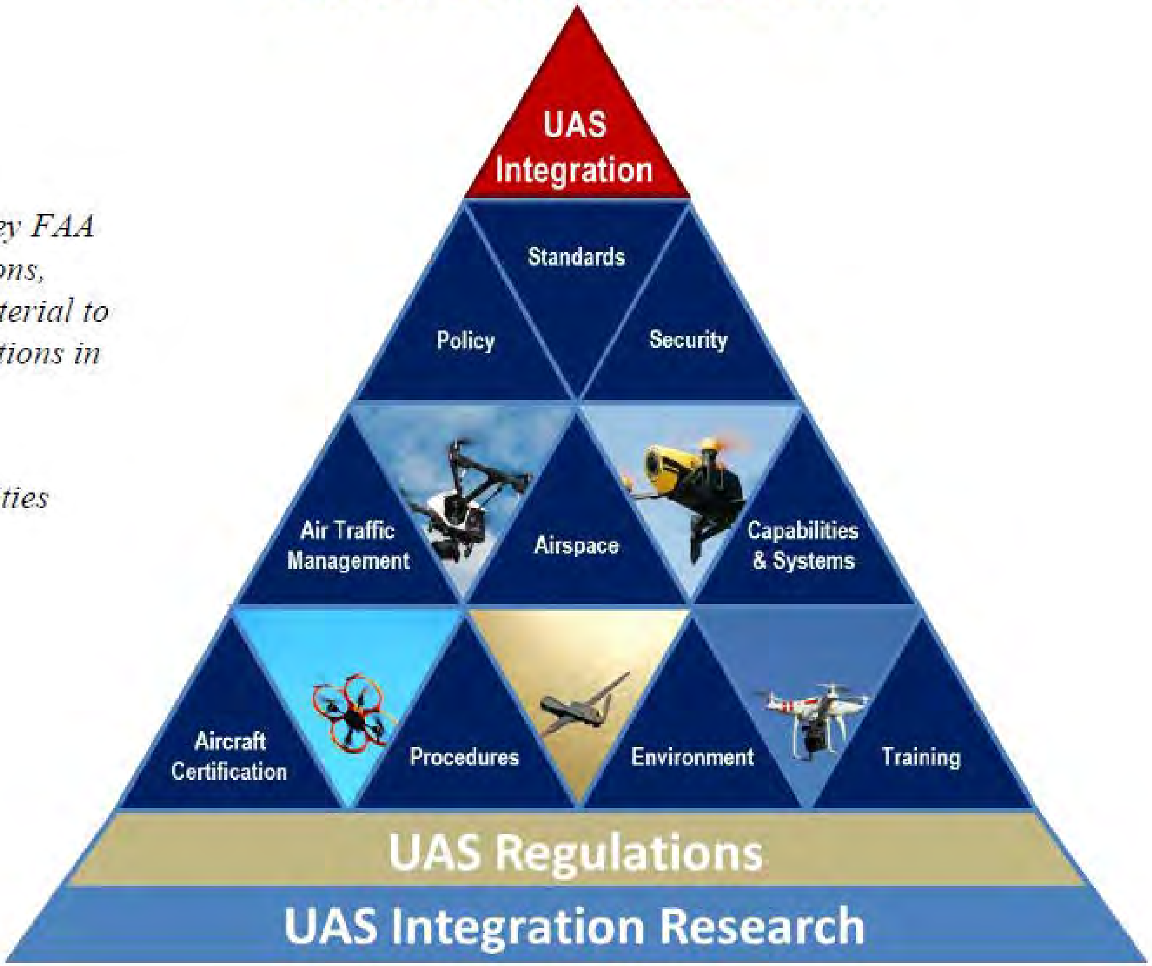
The Path to Full Integration

Source: Sabrina Saunders-Hodge, Director UAS Research at FAA UAS Integration Office Briefing at ERAU Symposium for Unmanned and Autonomous Systems, November 30, 2017

UAS Integration Research Functional Framework

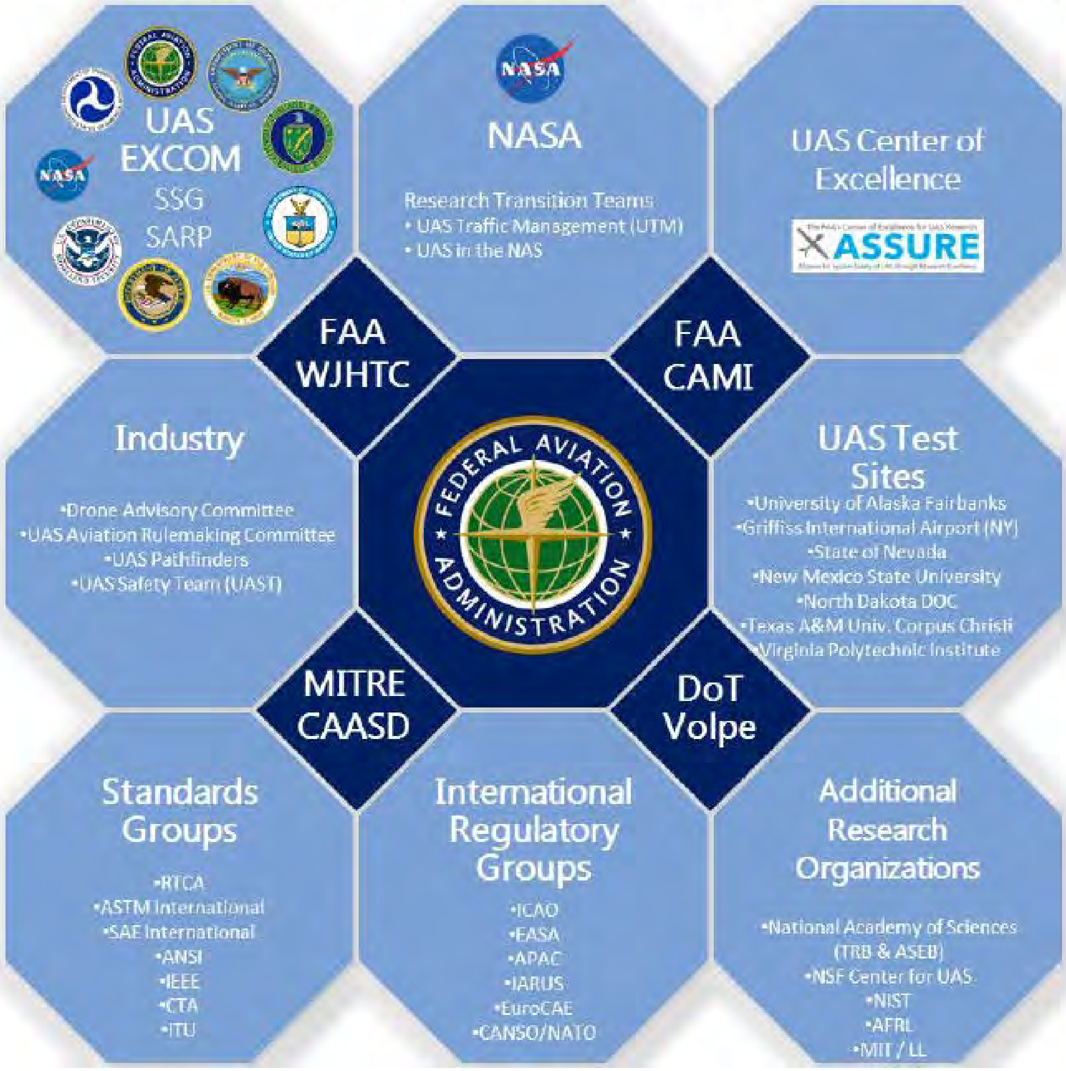
UAS integration research supports key FAA mission functions to publish regulations, policy, procedures, and guidance material to support safe and efficient UAS operations in the NAS.

Ongoing and planned research activities inform these functional areas.



Source: Sabrina Saunders-Hodge, Director UAS Research at FAA UAS Integration Office Briefing at ERAU Symposium for Unmanned and Autonomous Systems, November 30, 2017

UAS Research Collaboration & Partnerships



Source: Sabrina Saunders-Hodge, Director UAS Research at FAA UAS Integration Office Briefing at ERAU Symposium for Unmanned and Autonomous Systems, November 30, 2017

What is ASSURE?

- Long title: The Alliance for System Safety of UAS Through Research Excellence - The Federal Aviation Administration's Center of Excellence for Unmanned Aerial Systems
- Short title: The FAA's Drone Research Center
- COEs are "entities with substantive ties to universities which advance the state of transportation knowledge within a particular aviation area
- FAA William J. Hughes Tech Center manages COEs
- COE's get two funding vehicles
  - Grants (mandatory 1-to-1 cost share)
  - IDIQ Contracts (cost share negotiable)
- 23 Schools, 100+ companies – big team for a big job!

CORE TEAM

Alabama
UNIVERSITY of ALABAMA in HUNTSVILLE
Alaska
UNIVERSITY of ALASKA in FAIRBANKS
Arizona
EMBRY AERONAUTICAL UNIVERSITY-PRESCOTT
California
UNIVERSITY of CALIFORNIA DAVIS
Florida
EMBRY RIDDLE AERONAUTICAL UNIVERSITY
Kansas
KANSAS STATE UNIVERSITY
UNIVERSITY of KANSAS
WICHITA STATE UNIVERSITY
Montana
MONTANA STATE UNIVERSITY
New Mexico
NEW MEXICO STATE UNIVERSITY
North Carolina
NORTH CAROLINA STATE UNIVERSITY
North Dakota
UNIVERSITY OF NORTH DAKOTA
Oregon
OREGON STATE UNIVERSITY
Ohio
THE OHIO STATE UNIVERSITY
Pennsylvania
DREXEL UNIVERSITY

AFFILIATE TEAM

Alabama
AUBURN UNIVERSITY
TUSKEGEE UNIVERSITY
Indiana
INDIANA STATE UNIVERSITY
Israel
TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY
Louisiana
LA TECH UNIVERSITY
Ohio
SINCLAIR COMMUNITY COLLEGE
Canada
CONCORDIA UNIVERSITY
United Kingdom
UNIVERSITY of SOUTHAMPTON

Certified Industry Partners

EMBRY-RIDDLE Aeronautical University
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Working with ASSURE

- Collaborate with **ASSURE partners**
  - Join ASSURE Certified Partners team
    - Annual Membership Fee (based on size of organization)
    - Waivered for in-kind contributions to research reaching 10 times annual fee
  - Participate & influence research
  - Public reports released by the FAA
  - Non-certified partners are invited to public events

- **ASSURE Research & Development Corporation (ARDC)**
  - 501(c)3 Non-Profit – Solve problems / seek opportunities outside work for the FAA
  - Leverages
    - ASSURE Alliance and its relationships
    - Knowledge and experience gained from FAA research

ASSURE Research Projects

Project Title	Lead
A1: Certification Test Case to Validate sUAS Industry Consensus Standards	KSU
A2: Small UAS Detect-and-Avoid (DAA) Requirements for Beyond-Visual-Line-of-Sight Operations (BVLOS)	NMSU
A3: UAS Airborne Collision Severity Evaluation	WSU
A4: UAS Ground Collision Severity Evaluation *	UAH
A5: UAS Maintenance, Modification, Repair, Inspection, Training, and Certification *	KSU
A6: Surveillance Criticality Study *	NCSU
A7: Human Factors Station Design Standards	DU
A8: UAS Noise Certification	MSState
A9: Secure C2 & Spectrum Management	OSU
A10: Human Factors UAS Control Station Certification and Procedures *	ERAU
A11 Low Altitude Safety: Part 107 Waiver Request Study	UAH
A12 Detection of sUAS near Airports	MSU
UAS for STEM	NMSU

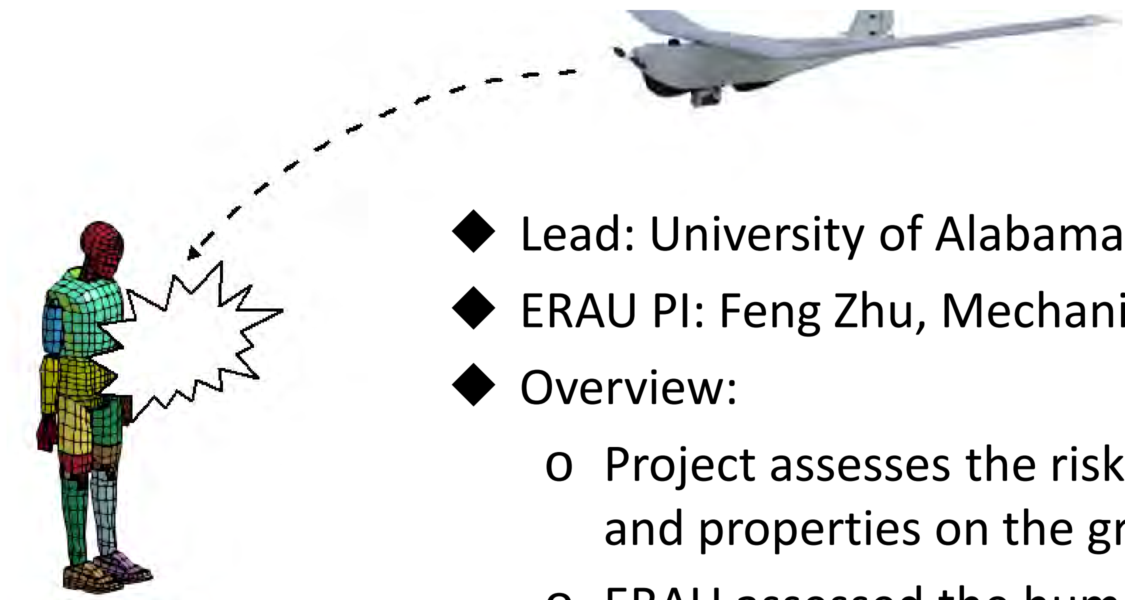
** Indicates ERAU participation*

ERAU Technical Areas under ASSURE

- ASSURE Executive Board **<u>Lead in Air Traffic Integration</u>**
  - Airport Ground Operations
  - ATC Interoperability
  - UAS Traffic Management
- Technical **<u>Co-Lead</u>**
  - UA Pilot Training, Certification, and other UA Crew Training with KSU-Salinas
  - Control and Communication (C2) with NCSU
- Supporting Research Areas
  - Detect and Avoid (DAA)
  - Human Factors
  - Airworthiness
  - Applications
  - Low-altitude operations
  - Noise Reduction and Wake mitigation
  - Spectrum Management
  - Economic Impact
  - Outreach

A4 – UAS Ground Collision Severity Evaluation

Final reports at ASSUREUAS.org



- Lead: University of Alabama – Huntsville
- ERAU PI: Feng Zhu, Mechanical Engineering
- Overview:
  - Project assesses the risk of UAS operations to persons and properties on the ground
  - ERAU assessed the human injury associated with a UAS strike
    - Examine versus various UAS attributes including size, weight, shape, etc.
    - Modeling and simulation used to determine potential injury types and severities

A4 - Key Findings from the Ground Collision Severity Report

Final reports at ASSUREUAS.org

- 300 publications reviewed to evaluate existing injury metrics, battery standards, toy standards, and casualty models to determine applicability to small UAS
- Three dominant injury metrics applicable to sUAS
  - Blunt force trauma injury – Most significant contributor to fatalities
  - Lacerations – Blade guards required for flight over people
  - Penetration injury – Hard to apply consistently as a standard
- Collision Dynamics of sUAS is not the same as being hit by a rock
  - Multi-rotor UAS fall slower than metal debris of the same mass due to higher drag on the drone
  - UAS are flexible during collision and retain significant energy during impact
  - Wood and metal debris do not deform and transfer most of their energy
- Payloads can be more hazardous due to reduced drag and stiffer materials
- Blade guards are critical to safe flight over people
- Lithium Polymer Batteries need a unique standard suitable for sUAS to ensure safety

Comparison of Steel and Wood with Phantom 3

UAS

Test Weight: 2.69 lbs.
Impact Velocity: 49-50 fps
Impact Energy: 100-103 ft-lbs.

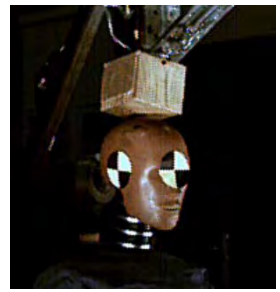
Motor Vehicle Standards

- Prob. of neck injury: 11-13%
- Prob. of head injury: 0.01-0.03%

Range Commanders Council Standards

- Probability of fatality from…
  - Head impact: 98-99%
  - Chest impact: 98-99%
  - Body/limb impact: 54-57%

Wood



Test Weight: 2.69 lbs.
Impact Velocity: 52-54 fps
Impact Energy: 116-120 ft-lbs.

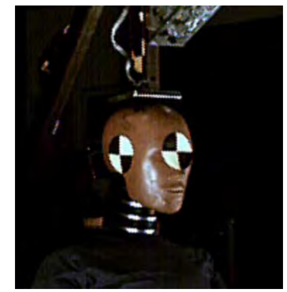
Motor Vehicle Standards

- Prob. of neck injury: 63-69%
- Prob. of head injury: 99-100%

Range Commanders Council Standards

- Probability of fatality from…
  - Head impact: 99-100%
  - Chest impact: 99-100%
  - Body/limb impact: 67-70%

Steel



Test Weight: 2.7 lbs.
Impact Velocity: 52-53 fps
Impact Energy: 114-121 ft-lbs.

Motor Vehicle Standards

- Prob. of neck injury: 61-72%
- Prob. of head injury: 99-100%

Range Commanders Council Standards

- Probability of fatality from…
  - Head impact: 99-100%
  - Chest impact: 99-100%
  - Body/limb impact: 65-71%

Final reports at ASSUREUAS.org

A5 – UAS Maintenance, Modification, Repair, Inspection, Training, and Certification Considerations

- Lead: Kansas State University – Salina
- ERAU PI: John Robbins, College of Aviation
- Overview:
  - In-depth analysis of maintenance operations and considerations that different from manned aircraft
  - Requirements for a maintenance program to ensure UAS remain airworthy
  - Requirements for training of maintenance personnel
  - Exploration of maintenance induced failures on the NAS

Final reports at ASSUREUAS.org

A6 – Surveillance Criticality for SAA

- Lead: North Carolina State University
- ERAU PI: Mohammad Moallemi
  - NEAR Lab
- Overview:
  - Examination of surveillance technologies for UAS detect-and-avoid,
    - Airborne RADAR, ADS-B, Ground-based RADAR, TCAS, etc.
  - Determine the criticality of sensor(s) in ensure adequate separation of air traffic
  - ERAU is supporting modeling and simulation
  - Match 100% covered by Industry!

A10 – Human Factors Considerations of UAS Procedures, & Control Stations

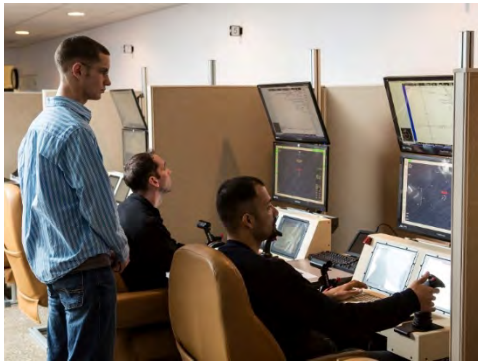
- Lead: ERAU
- Richard S. Stansbury (PI) and Joe Cerreta (technical lead)
- Overview:
  - Addresses all phases of flight for larger than small fixed-wing UAS
  - Address pilot and crew roles for: aviate, navigate, communicate, and contingency operations
  - Three major components:
    - Development of functional allocation and minimum control station requirements
    - Develop minimum environmental and ergonomic requirements for UAS control stations
    - Develop minimum pilot and crewmember procedures.

Final reports at ASSUREUAS.org

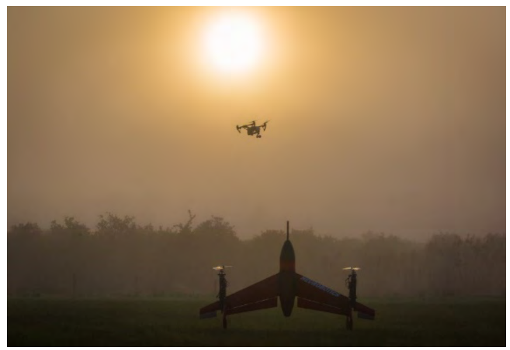
Non-ASSURE UAS Research toward Integration at ERAU

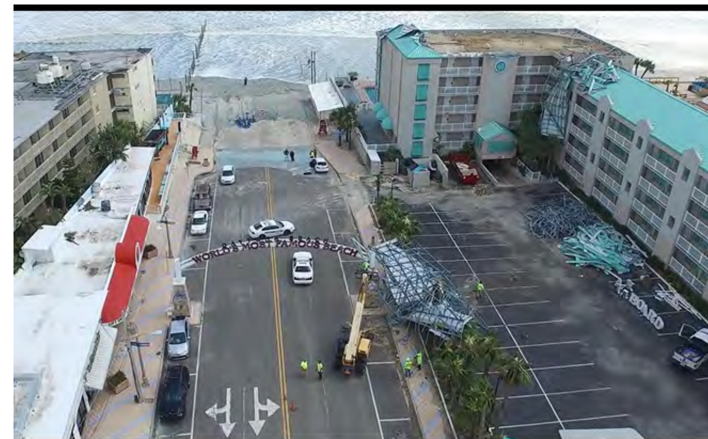
- Partnership with Booz Allen Hamilton on ACRP 03-42 “UAS at Airports”
  - Development of guidance materials for stakeholders involved in operation at airports
  - Stakeholders: UAS operators, airports, airport businesses, ATC, government (local, state, and federal), public, etc.
  - Kicked off March 2017, 18 month research project
- Deep learning-based terrain classification for emergency landing site detection
  - ERAU Internal Project
- Other Research Topics under Investigation:
  - UAS cybersecurity
  - Assured autonomy
  - Airport environment integration
  - UAS Air Traffic Management under FAA NextGen
  - Multi-sensor UAS detection, identification, and tracking
  - Vehicle health and recovery systems
  - UAS as a service architecture
  - Integrated modeling and simulation environments
  - Numerous others…

UAS Integration is dependent upon education addressing operations, engineering, maintenance, and planning/logistics.

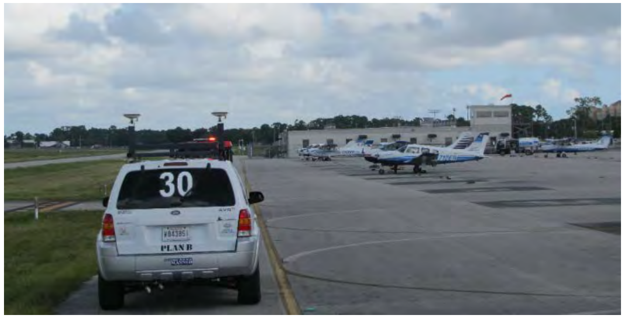


UAS Integration is driven by applications.





UAS Integration is enabled by innovation.



Questions