Integrating Unmanned Aircraft Systems into the National Airspace System

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Operational Challenges of Unmanned Aircraft Systems: Research and Education

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

Sensefly Ebee

Latitude Engineering HQ-40

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

Monitor a pipeline from 400 ft.

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/ha14_02.php
Other Applications

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

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

http://www.uasblog.net/make-real-estate-more-yummily-throw-some-drone-sauce-on-it/
The Path to Full Integration

UAS Operations Today
- Part 107
- UAS Waivers to Part 107
  - Limited Operations Over People
  - Limited Night Operations
  - Limited BVLOS Operations
- Exemptions
- UAS COAs
- Experimental Category

Operations Over People
- Research Needs
- Operational Capabilities

Expanded Operations
- Beyond Visual Line of Sight

Small UAS Package Delivery Operations

Non-Segregated Operations

Routine/Scheduled Operations

Large Carrier Cargo Operations

Passenger Transport Operations

Identification & Tracking Capability

DAA & BVLOS Performance Requirements

UAS Operational Requirements & Repeatable Approval Process

UAS Low Altitude Authorization & Notification Capability (LAANC)

UAS Traffic Management

Command and Control Performance Requirements

Infrastructure/Equipment Investment Analysis

Cost Benefit Analysis

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 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!
Certified Industry Partners
Working with ASSURE

- Collaborate with **ASSURE partners**
  - Join ASSURE Certified Partners team
  - Annual Membership Fee (based on size of organization)
  - Waived 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
<table>
<thead>
<tr>
<th>Project Title</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1: Certification Test Case to Validate sUAS Industry Consensus Standards</td>
<td>KSU</td>
</tr>
<tr>
<td>A2: Small UAS Detect-and-Avoid (DAA) Requirements for Beyond-Visual-Line-of-Sight Operations (BVLOS)</td>
<td>NMSU</td>
</tr>
<tr>
<td>A3: UAS Airborne Collision Severity Evaluation</td>
<td>WSU</td>
</tr>
<tr>
<td>A4: UAS Ground Collision Severity Evaluation *</td>
<td>UAH</td>
</tr>
<tr>
<td>A5: UAS Maintenance, Modification, Repair, Inspection, Training, and Certification *</td>
<td>KSU</td>
</tr>
<tr>
<td>A6: Surveillance Criticality Study *</td>
<td>NCSU</td>
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<tr>
<td>A7: Human Factors Station Design Standards</td>
<td>DU</td>
</tr>
<tr>
<td>A8: UAS Noise Certification</td>
<td>MSState</td>
</tr>
<tr>
<td>A9: Secure C2 &amp; Spectrum Management</td>
<td>OSU</td>
</tr>
<tr>
<td>A10: Human Factors UAS Control Station Certification and Procedures *</td>
<td>ERAU</td>
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<tr>
<td>A11 Low Altitude Safety: Part 107 Waiver Request Study</td>
<td>UAH</td>
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<tr>
<td>A12 Detection of sUAS near Airports</td>
<td>MSU</td>
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<tr>
<td>UAS for STEM</td>
<td>NMSU</td>
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</tbody>
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* Indicates ERAU participation
ERAU Technical Areas under ASSURE

• ASSURE Executive Board **Lead in Air Traffic Integration**
  – Airport Ground Operations
  – ATC Interoperability
  – UAS Traffic Management

• Technical **Co-Lead**
  – 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
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

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

<table>
<thead>
<tr>
<th>UAS</th>
<th>Wood</th>
<th>Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Weight: 2.69 lbs.</td>
<td>Test Weight: 2.69 lbs.</td>
<td>Test Weight: 2.7 lbs.</td>
</tr>
</tbody>
</table>

**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%

**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%

**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!

Final reports at ASSUREUAS.org
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
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