

RESEARCH ABSTRACT

ASSURE UAS Research and Development Program
FAA Research Requirement: Certification Test Case to Validate sUAS Industry Consensus Standards
UAS Research Focus Area: Low Altitude Operations Safety
FAA Management Team: UAS COE PM: Sabrina Saunders-Hodge, ANG-C2 UAS COE Dep. PM: Paul Rumberger, ANG-C2 Research Sponsor: Chris Swider, AFS-88 Research Sponsor Subject Matter Expert/Task Monitor: Cyrus Roohi, AFS-88 Task Program Manager: David Buhrman, ANG-C21
ASSURE Principal Investigator (PI): Mark Blanks, UAS Program Manager, Kansas State University
Other ASSURE Performers PI's: Tom Aldag, Director of R&D, Wichita State University Emanuel Grant, Associate Professor, University of North Dakota
ASSURE External Advisory Board Principle Investigator (if applicable): N/A
Other ASSURE External Advisory Board (EAB) Performers: N/A
Classified or Security Related Work: No

EXECUTIVE SUMMARY

Kansas State University (KSU) is proposing to take a small Unmanned Aircraft System (sUAS) through a compliance checklist typical of an airworthiness certification process outlined in 14 CFR 21.17(b) using ASTM F38 standards as the airworthiness criteria. This is intended to validate the standards through direct application to a master compliance checklist with testing conducted as needed on complex requirements. This research project will identify gaps and issues with compliance that can be used to strengthen the standards and demonstrate their suitability as a basis for certification.

The tasks outlined in this proposal will be completed cooperatively utilizing the UAS operations research resources at KSU and the airworthiness test facilities at Wichita State University (WSU). The University of North Dakota (UND) will conduct software requirements validation efforts.

In the first year, a flight test program will be proposed based on the requirements of several of the ASTM F38 standards. Additionally, compliance findings for all ASTM F38 requirements shall be documented in the form of a compliance checklist as a continuation of work done in the previous year by KSU and WSU. Compliance findings will be shared with the ASTM F38 committee members in order to improve upon the standards. In the second year, compliance issues will be reported for additional beyond line-of-sight (BLOS), operations over people and software considerations following publication of new ASTM F38 standards related to these three areas.

1.0 Background

ASTM F38 is in the process of developing standards and guidance materials for UAS. The committee is specifically developing minimum safety, performance, and flight proficiency requirements. F38 is also quality assurance and production acceptance which includes weight and balance, performance specifications, control, stall speed, handling characteristics...etc. The standards developed by this committee, and technical subcommittees will define robust verification and validation framework with varied platforms in order to insure that the standards are acceptable for the safe integration of UAS in the NAS.

In order to validate the ASTM F38 standards, Kansas State University (KSU) is proposing to take a small Unmanned Aircraft System (sUAS) through a compliance checklist typical of an airworthiness certification process outlined in 14 CFR 21.17(b) using these standards as the airworthiness criteria. Analysis and testing according to the prescribed methods of compliance allow hands-on validation of the standards and identification of gaps, weaknesses, and overly-burdensome requirements.

Additional research topics are proposed for the validation of requirements pertaining to BLOS operations and unmanned aircraft (UA) software systems. It is expected that additional requirements will be defined for BLOS and operations over people through the creation of two new ASTM standards. Likewise, a new standard is currently in development for software requirements. Following the anticipated publication of a standard addressing software of unknown pedigree (SOUP) for unmanned systems, the University of North Dakota will validate ASTM requirements leveraging previous research demonstrating DO-178C compliant software specification techniques.

Previous research exercising ASTM F38 standards using a certification test case has been conducted since FY2014 through KSU Salina. Therefore, the research within this task will be a continuation of the prior research. Kansas State University, Wichita State University, and the University of North Dakota will leverage previous work done under this task to successfully complete the new requirements outlined below.

2.0 Scope

This project will support ASTM F38 standards development. Requirements will be theoretically and physically validated by considering certification strategies for a small UA (weighing less than 55 pounds) with visual-line-of-sight (VLOS) operations in the first year with BLOS operations and software requirements addressed in the second year. Goals of the project include identifying issues with demonstrating compliance and airworthiness gaps.

The main research questions being answered through this research are:

- 1) Are the ASTM F38 standards suitable for use as a certification basis for sUAS?
- 2) With which ASTM F38 standard requirements is compliance difficult or overly burdensome?
- 3) What are the gaps in the ASTM F38 standards with regards to assuring airworthiness and safe integration of sUAS into the NAS? Are safety-of-flight-critical hazards adequately addressed by the standard requirements?
- 4) Is a flight test program feasible using the ASTM requirements as a framework?

3.0 Research Framework

3.1 Research Requirement.

The following research will be executed in **FY16**:

1. Flight Test Program

A flight test program shall be established to show compliance with applicable sUAS ASTM standards and FAA regulations. Exemption from 14 CFR Part 36 will be pursued in order to develop precedence for future sUAS seeking Part 36 exemption. A test plan will be prepared and any issues complying with ASTM requirements will be documented in an Issues Paper.

Exit Criteria – Completion of a report documenting the flight test program and report of compliance issues.

2. Compliance Findings and Issues

Compliance findings shall be documented in the form of a compliance checklist. The checklist will list the requirement, method of compliance, and the compliance finding. Completion of the compliance checklist may entail performing compliance methodology (where feasible) in order to validate the choice of method of compliance and identify difficulties of showing compliance. This will be a continuation of prior research with KSU. A report shall be produced documenting issues arising from choice of method of compliance and difficulty of showing compliance.

Exit Criteria – Completion of compliance checklist and report of compliance issues.

3. Final Report

A final report for FY16 documenting the project shall be submitted including applicable data, analysis and findings from the project. The report should also contain findings, recommendations and lessons learned to support future sUAS certification projects. This report will be made available for public share as desired.

Exit Criteria – Completion of a final report incorporating comments from all involved parties.

4. Technical Interchange Meetings (TIMs)

The UAS COE performer and FAA will conduct Technical Interchange Meetings (TIMs) throughout the performance of this task as needed to review progress and evaluate scope. Status reports shall be submitted monthly describing schedule, risks, accomplishments, and upcoming activities. Two conferences with ASTM meetings will be attended in FY16. The budget for this task will cover these travel expenses as well as weekly trips between Wichita and Salina, as well as 2 trips to Salina for UND.

The following research will be executed in **FY17**:

5. BLOS and Operations over People

The ASTM F38 standards, in their current form, do not address BLOS flight operations or operations over people; however, the standards are expected to be revised in the near future to incorporate both of these types of operations. BLOS and operations over people are expected to require more robust standards to reduce risk. A more thorough exploration of issues associated with these types of operations, such as controlled descents, geo-fencing, and command and control (C2) performance, is required in order to evaluate the new standards. In anticipation of these upcoming revisions, the ASSURE performer shall provide a compliance issues report and gap analysis for additional BLOS considerations following publication of new BLOS and Operations over People requirements.

Exit Criteria – Completion of a report documenting the compliance checklist, gaps, and compliance issues.

6. Software Validation

The current ASTM F38 standards also do not include any requirements for software performance, quality, or testing with regards to sUAS airworthiness. It is also expected that a new standard will be drafted in the upcoming year to address this gap. The ASSURE performer will provide a compliance issues report and gap analysis for additional software considerations following publication of new software requirements.

Exit Criteria – Completion of a report documenting the compliance checklist, gaps, and compliance issues.

3.2. Research Mapping.

This research will support the following FAA initiatives:

- a. Work requested by the FAA via Statement of Work for FY15 UAS COE Requirements Review Package.
- b. Informs work being done by ASTM F38 Committee to establish a set of consensus standards for airworthiness, maintenance and operation in support of 14 CFR Part 107.

3.3 Research Review.

Previous research conducted by Kansas State University for the validation of ASTM F38 standards as a basis for certification identified gaps and issues with the standards and test methodologies used for validation. This past research focused primarily on environmental testing to determine compliance with specific paragraphs from F3002-14a. Formal testing focused on command and control (C2) link failure, autopilot failure, and engine failure which were identified as higher levels of risk by the operational risk assessment. Environmental effects such as electromagnetic interference (EMI), temperature, and vibration were considered to be the most significant detriment to these areas of potential fault or failure.

4.0 Research Approach and Outcomes

The research task plan, outcomes, and associated spending are proposed in the following table. Kansas State and Wichita State Universities will share task efforts equally and will accomplish them cooperatively utilizing the UAS operations research resources at Kansas State and the

airworthiness test facilities at Wichita State. The University of North Dakota will conduct software requirements validation research efforts.

Task	Proposed Outcomes	Date Due	ASSURE Performer
1. Flight Test Program Development	Flight Test Report documenting the proposed flight test program	T+3 months	KSU WSU
	Issues Paper documenting issues with difficulty of showing compliance		
2. Compliance Findings and Testing	Compliance Findings Report	T+9 months	KSU WSU
	Issues Paper documenting issues with difficulty of showing compliance		
3. Final Report	FY16 report documenting data, analysis, findings of the project, recommendations and lessons learned.	T+12 months	KSU WSU
4. Technical Interchange Meetings (TIMs)	Meeting notes capturing the discussions and action items from each TIM. The budget for this task also covers travel expenses.	Submit 3 days after the TIM	KSU WSU UND
5. BLOS and Ops over People Requirements Validation	Requirements Validation & Report	T+18 months	KSU WSU
6. Software Requirements Validation	Requirements Validation & Report	T+18 months	UND
	Test articles/Replacement hardware		KSU
	Monthly Status Reports	Monthly	KSU/WSU

T=Date of Award

5.0 Government Furnished Information

The government will furnish the following information to the performer:

1. Project sequencing
2. Partnership for Safety Plan (PSP)
3. Project Specific Certification Plan (PSCP)
4. Certification Documentation
5. Environmental Test Report

6. Documentation of initial Aircraft Flight Manual (AFM) detailing operation, aircraft characteristics and limitations.

6.0 Period of Performance/Projected Schedule

The following table outlines the proposed schedule for this project. The technical period of performance for this task order is 18 months.

Task	FY16				FY17	
	4Q CY15	1Q CY16	2Q CY16	3Q CY16	4Q CY16	1Q CY17
1. Flight Test Program Development						
2. Compliance Findings and Testing						
3. Final Report						
4. Technical Interchange Meetings						
5. BLOS and Ops over People Requirements Validation & Report						
6. Software Requirements Validation & Report						

7.0 List of Universities and Individuals Involved in the Project

Kansas State University

- Mark Blanks, UAS Program Manager, Applied Aviation Research Center
- Timothy Bruner, UAS Research Engineer, Applied Aviation Research Center

Wichita State University

- Tom Aldag, Director of R&D, National Institute for Aviation Research
- Andrea Meyer, Research Engineer, National Institute for Aviation Research

University of North Dakota

- Emanuel Grant, Associate Professor, Department of Computer Science

8.0 Estimated Level of Effort and Associated Costs

Performer: Kansas State University			
Year	Performance Period		
FY16	12 months	Tasks 1, 2, 3, 4	
FY17	6 months	Tasks 4, 5	
Total	18 months		

Performer: Wichita State University			
Year	Performance Period		
FY16	12 months	Tasks 1, 2, 3, 4	
FY17	6 months	Tasks 4, 5	
Total	18 months		

Performer: University of North Dakota			
Year	Performance Period		
FY17	6 months	Task 6	
Total	6 months		