The FAA's Center of Excellence for UAS Research

ASSURE

Alliance for System Safety of UAS through Research Excellence

A6 Surveillance Criticality

Research Task Plan

North Carolina State University
The Ohio State University
Embry-Riddle Aeronautical University
University of North Dakota
Oregon State University
Mississippi State University

PROJECT A6: SURVEILLANCE CRITICALITY

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1 Scope

1.1 SCOPE

The research task plan will be conducted in accordance with the A6 Surveillance Criticality Statement of Work (SOW) approved by the FAA for each respective university. The research task plan incorporates comments received at the A6 Kickoff Meeting October 28, 2015 and the January 29, 2016 TIM calls with the FAA.

1.2 PURPOSE

The research plan describes the A6 team approach to answering the original research questions.

1) For a cooperative DAA solution based on ADS-B and/or transponders, how should the current operational or technical performance requirements for ADS-B Out and/or transponders be changed (if at all) for UAS Sense and Avoid functions?
2) Can UAS Sense and Avoid functions be carried out by equipage standards using current surveillance equipment?
3) What are the criteria for evaluating "equivalent level of safety" of UAS against piloted-aircraft for SAA functions?

1.3 APPLICABILITY

The research plan will be executed by the Alliance for System Safety of UAS through Research Excellence (ASSURE) team consisting of North Carolina State University, The Ohio State University, Embry-Riddle Aeronautical University, University of North Dakota, Oregon State University, and Mississippi State University.

2 Applicable Documents

2.1 GENERAL

The following documents are identified as valuable for this research effort.

2.2 GOVERNMENT DOCUMENTS

FAAO Order 8900.1	Flight Standards Information Management System
FAA DOCUMENT NO.: SBS-SRMD-111308-1	Safety Risk Management Document Surveillance and Broadcast Services Program Essential Services
FAA	Safety Management System Manual Version 4.0 (ATO 2014)
FAA	Design Assurance Working Group (DAWG) Recommendations for: Acquisition Executive Board (AEB) Steering Group on Software Design Assurance Policy in the AMS (Acquisition Management System)
AC20-151A	Airworthiness Approval of Traffic Alert And Collision Avoidance Systems (TCAS II), Versions 7.0 & 7.1 and Associated Mode S Transponders
AC20-172	Airworthiness Approval for ADS-B In Systems and Applications
AC23.1309	System Safety Analysis and Assessment for Part23 Airplanes
AC25.23	Airworthiness Criteria for the Installation Approval of a Terrain Awareness and Warning System (TAWS) for Part 25 Airplanes
TSO-C119d	Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II with Hybrid Surveillance
TSO-C195b	Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)

2.3 NON-GOVERNMENT DOCUMENTS

ARP4754A	Guidelines for Development of Civil Aircraft and Systems (SAE)
RTCA	Minimum Operational Performance Standards (MOPS) for Unmanned Aircraft Systems (UAS) Detect and Avoid (DAA) Systems

APPLICABLE DOCUMENTS

	Appendix A Detect and Avoid Operational Services and Environment Description (OSED) – DRAFT
RTCA Paper No. 261-15/PMC-1400	DRAFT Detect and Avoid (DAA) Minimum Operational Performance Standards (MOPS) for Verification and Validation
RTCA DO-181E	Minimum Operational Performance Standards for Air Trafffic Control Radar Beacon System / Mode Select (ARCRBS / Mode S) Airborne Equipment
RTCA DO-260B	Minimum Operational Performance Standards (MOPS) for 1090 MHz Extended Squitter Automatic Dependent Surveillance- Broadcast (ADS-B) and Traffic Information Services Broadcast (TIS-B)
RTCA DO-338	Minimum Aviation System Performance Standards (MASPS) for ADS-B Traffic Surveillance Systems and Applications (ATSSA)
RTCA DO-358	Minimum Operational Performance Standards (MOPS) for Flight Information Services Broadcast (FIS-B) with Universal Access Transceiver (UAT)
UND	LD-CAP Report from AUVSI. “Evaluating Prototype Sense and Avoid Alternatives in Simulation and Flight”

3 Definitions and Acronyms

AC	Advisory Circular
ADS-B	Automatic Dependent Surveillance-Broadcast
ASSURE	Alliance for System Safety of UAS through Research Excellence
ATC	Air Traffic Control
AUVSI	Association of Unmanned Vehicle Systems International
C2	Command and Control
CFR	Code of Federal Regulations
CoE	Center of Excellence
DAA	Detect and Avoid
ERAU	Embry Riddle Aeronautical University
FAAO	FAA Order
FHA	Functional Hazards Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
KSN	Knowledge Services Network
LD-CAP	Limited Deployment- Cooperative Airspace Project
MSU	Mississippi State University
MOPS	Minimum Operational Performance Standards
NASA	National Aeronautics and Space Administration
NCSU	North Carolina State University
NPRM	Notice of Proposed Rule Making
OHSt	The Ohio State University
ORSt	Oregon State University
RTCA	Radio Technical Commission for Aeronautics
SAA	Sense and Avoid
SC	Special Committee
SOW	Statement(s) of Work
sUAS	Small Unmanned Aircraft System
TCAS	Traffic Collision Avoidance System
TIM	Technical Interchange Meeting
UAS	Unmanned Aircraft System

DEFINITIONS AND ACRONYMS

UND	University of North Dakota
UTM	UAS Traffic Management

4 Overview

4.1 INTRODUCTION

There is no known research to examine the impact of existing airborne surveillance equipment predicated on the pilot-in-the aircraft-operational concept in context of UAS in the NAS operational safety. Research must determine the sufficiency of existing airborne surveillance equipment for manned aircraft (e.g. transponders and/or ADS-B) for providing separation provision and collision avoidance functions for UAS operating in the NAS across a wide range of scenarios and operating conditions. This research must answer the primary three questions:

1- For a cooperative Detect-and-Avoid (DAA) solution based on ADS-B and/or transponders, how should the current operational or technical performance requirements for ADS-B Out and/or transponders be changed (if at all) for UAS Sense and Avoid functions?
2- Do current surveillance equipment technologies meet the design assurance criteria to provide UAS DAA functions?
3- What are the criteria for evaluating "equivalent level of safety" of UAS against piloted-aircraft for DAA functions?

The research team will develop a methodology and toolset for evaluating Sense-and-Avoid (SAA) technologies using available analysis processes, simulation environments, and equipment characterizations. The team will utilize industry partner knowledge and resources, recognized UAS Integration ConOps (from RTCA) scenarios, and a team of researchers to conduct a 3 phase iterative analysis and testing plan.

4.2 RESEARCH OBJECTIVES

In addition to answering the primary research questions, the research will accomplish the following objectives:

- Assess the pilot-controller interaction to isolate failures and faults in surveillance equipment and its contribution to safety of flight in maintaining separation and preventing collisions between aircraft.
- Identify how the pilot's role in an aircraft and ATC contributes to the safety of separation and collision avoidance and determine if procedural (e.g. separation standards) or design changes (e.g. performance or safety requirements) of existing procedures and/or equipment may fail to provide sufficient safety with respect to separation and collision avoidance for UAS.

- Conduct a safety evaluation of separation and collision avoidance functions supported by airborne surveillance systems and equipment to identify operational (e.g. separation standards) or design standards shortcomings to meeting NAS safety objectives, including analysis of “all clear” definitions.
- Propose mitigation strategies to compensate for the lack of a pilot in the aircraft. Those strategies include surveillance technology performance requirements, flight scenarios to avoid, and further research opportunities.

4.3 RELATED WORK

The research will include a complete review of previous and concurrent research related to design assurance standards and performance reviews for ADS-B and TCAS, including work done on RTCA SC-228. University of North Dakota research on the Limited Deployment – Cooperative Airspace Project (LD-CAP) will be reviewed and applied when appropriate. ASSURE A6 Industry Partners will also provide research results and sample data sets from work supporting ADS-B network integration, DOD related SAA functional testing, and manned aircraft SAA performance evaluations.

5 Research Tasks

5.1 GENERAL

The A6 Surveillance Criticality project is divided into four phases. Phase 1 is the communication phase that spans the entire period of performance of the project to support data exchange between team members and the FAA. Phase 2, Phase 3, and Phase 4 are the iterative technical activities for the project that will produce the desired outcomes and deliverables. Each of these phases builds on the foundation established in Phase 2. Task descriptions and expected deliverables for each Phase are defined below.

5.2 PHASE 1: DATA EXCHANGE

To maintain communications between team members and the FAA, the project will utilize multiple communication methods for sharing data, providing project status updates, and working with team members. The following methods will be used during this project:

Technical Interchange Meetings (TIMs). TIMs will be regularly scheduled to review the results of research with the FAA. In general, these meetings will occur on the last Thursday of each month from 3:30-4:30 PM Eastern Standard Time (EST) and will be scheduled by the FAA and conducted via WebEx. The FAA may choose to cancel these meetings as necessary due to conflicts. TIMs may be conducted in conjunction with FAA UAS Center of Excellence (CoE) Quarterly Meetings if needed.

Quarterly Meetings. Each individual research teams shall report financial status through the FAA's Knowledge Services Network (KSN) on a quarterly basis in accordance with ASSURE requirements. The research team shall also report the status of the research desired products, schedule, budget and risks through the FAA UAS CoE quarterly Project Management Review (PMR) meetings scheduled by the FAA and the ASSURE Management Team.

Tasks

T1.1- Develop comprehensive project Research Task Plan with detailed descriptions for each technical task on the work plan during each Phase of the project.

T1.2- Conduct Technical Interchange Meetings (TIMS) with FAA, other university teammates, and industry partners on specific topics throughout the period of performance. 12 TIMs are anticipated in the initial project scope.

T1.3- Preparation of the Final Report for review and distribution.

Deliverables

D1.1- Comprehensive Research Task Plan with current schedule
D1.2- TIM Summaries
D1.3- Final Report

Participants in Phase 1: All

5.3 PHASE 2: INITIAL SYSTEM DESIGN AND TESTING

Phase 2 provides the foundation for the entire research agenda. Beginning with a literature search and background review of prior, related work, the team will develop the methodology for constructing the surveillance system characterizations that will be modeled in the simulation environment for evaluating system performance in a select set of scenarios. This phase will conclude with a stakeholders workshop to review the system characterization, failure analysis, and simulation capabilities that the team will use for detailed analysis and expanded scenarios.

Tasks

T2.1- Conduct a Literature Review
T2.2- Identify Operational Assumptions
T2.3- Characterization of Equipment Performance and Reliability
T2.4- FHA/Bow-Tie Analysis
T2.5- Performance Baseline Results
T2.6- Operational Workshop #1

Deliverables

D2.1- Literature Review
D2.2- ConOps description with assumptions for framing the analysis and evaluation scenarios
D2.3- Interim Report to include results from initial analysis and feedback from the first Operational Workshop

Participants in Phase 2: NCSU, ERAU, UND, OhSt, MSU (workshop only), OrSt (workshop only)

5.4 PHASE 3: REVISED SYSTEM DESIGN AND TESTING

Phase 3 will build on the results from Phase 2 simulation analysis, feedback from Workshop #1, and alternative scenarios and surveillance system evaluation criteria from the original research to repeat

the characterization, analysis, and simulation process. Updates to the system characterizations and simulations will be performed and reviewed. After simulations are complete, a second stakeholders workshop will be hosted by the team for demonstrating the performance of the A6 surveillance system criticality evaluation tool.

Tasks

T3.1- Identification of Mitigations and Associated Equipment Performance Updates
T3.2- Revised FHA/Bow-Tie Analysis
T3.3- Revised Performance Baseline Analysis
T3.4- Operational Workshop #2

Deliverables

D3.1- Phase 3 Summary Report

Participants in Phase 3: NCSU, ERAU, UND, OhSt, MSU, OrSt

5.5 PHASE 4: FINAL REVISIONS AND ANALYSIS

The team will again combine the results of the analysis from Phase 3 and feedback from Workshop #2 to modify the system characterizations and failure analyzes, modify scenarios, model alternative surveillance technologies, or update simulation design. Results from a final set of simulation runs will be included in the Final Report. A third workshop may be hosted if funding and time permit, but that is not anticipated.

Tasks

T4.1- Alternatives Analysis- additional characterizations, FHA, simulations

Deliverables: None, the Final Report is a product of Phase 1: Data Exchange.

RESEARCH TASKS

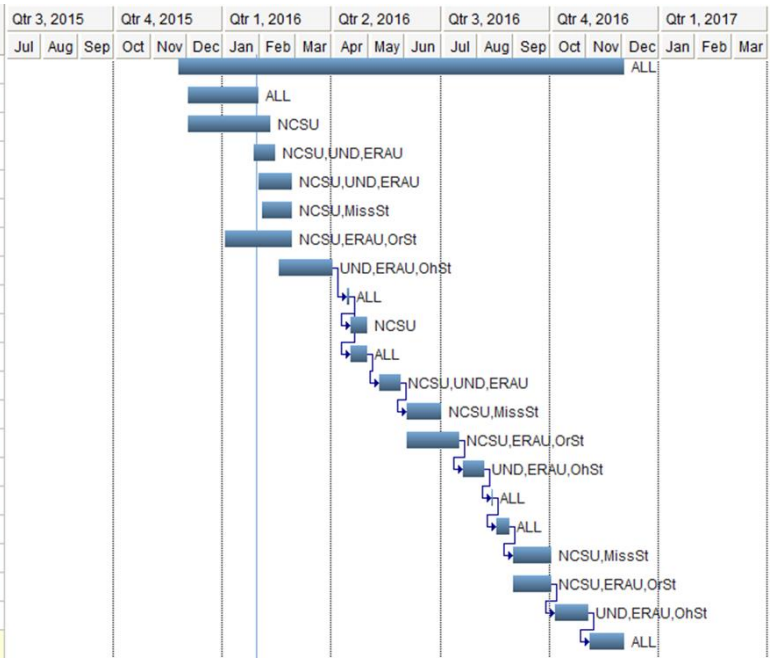
5.6 EXPECTED OUTCOMES

Phase	Expected Outcomes (Deliverables)	Original Date Due	Updated Date Due	Detailed Tasks
Phase 1: Data Exchange	Research Task Plan (D1.1)	1/30/16	3/31/16	1.1, 1.2, 1.3
	Meeting notes capturing the discussions and action items from each TIM. (D1.2)	monthly	monthly	
	Final Report (D1.3)	11/30/16	11/30/16	
Phase 2: Initial System Design and Testing	ConOps, test scenario descriptions with integrated system characterization descriptions (D2.2)	2/26/16	5/20/16	2.1, 2.2, 2.3, 2.4, 2.5, 2.6
	Initial system modeling and simulation analysis	3/31/16	6/17/16	
	Literature Review (D2.1)	2/8/16	4/15/16	
	Operational Workshop #1	4/14/16	6/22/16	
	Interim Report (D2.3)	4/29/16	7/7/16	
Phase 3: Revised System Design and Testing	Revise system characterization descriptions for mitigation and including Workshop #1 feedback	6/30/16	8/29/16	3.1, 3.2, 3.3, 3.4
	Revised system modeling and simulation analysis	8/5/16	9/8/16	
	Operational Workshop #2 (D3.1)	8/12/16	9/12/16	
Phase 4: Final Revisions and Analysis	Revise system characterization descriptions for mitigation and including Workshop #2 feedback	9/30/16	10/31/16	4.1
	Revised system modeling and simulation analysis	10/31/16	11/18/16	
	Operational Workshop #3 (if necessary)	TBD	Dropped	

6 A6 Project Schedule

Original Schedule From 1/29/2016

	Name	Start	Finish
1	Meeting notes for each TIM/PMR	11/23/2015	11/30/2016
2	Research Task Plan	12/01/2015	01/29/2016
3	Literature Review	12/01/2015	02/08/2016
4	ConOps Review	01/25/2016	02/12/2016
5	Test Scenario Descriptions	01/29/2016	02/26/2016
6	Characterization Descriptions	02/01/2016	02/26/2016
7	System Modeling	01/01/2016	02/26/2016
8	Simulation Analysis (round 1)	02/15/2016	03/31/2016
9	Operational Workshop #1	04/12/2016	04/14/2016
10	Interim Report	04/15/2016	04/29/2016
11	Workshop #1 Review	04/15/2016	04/29/2016
12	ConOps modifications	05/09/2016	05/27/2016
13	Revised System Characterization	06/01/2016	06/30/2016
14	Update System Model	06/01/2016	07/15/2016
15	Updated Simulation Analysis (round 2)	07/18/2016	08/05/2016
16	Operational Workshop #2	08/11/2016	08/12/2016
17	Workshop #2 Review	08/15/2016	08/26/2016
18	Revised System Characterization	08/29/2016	09/30/2016
19	Update System Model	08/29/2016	09/30/2016
20	Updated Simulation Analysis (round 3)	10/03/2016	10/31/2016
21	Final report	11/01/2016	11/30/2016



A6 PROJECT SCHEDULE

6.1 UPDATED SCHEDULE 3/31/2016

Name	Duration	Start	Finish
Meeting notes for each TIM/PMR	268d?	11/23/2015	11/30/2016
Research Task Plan	44d?	12/01/2015	01/29/2016
Literature Review	50d?	12/01/2015	02/08/2016
ConOps Review	42d?	01/25/2016	03/22/2016
Test Scenario Descriptions	58d?	01/25/2016	04/13/2016
Characterization Descriptions	80d?	02/01/2016	05/20/2016
System Modeling	107d?	01/04/2016	05/31/2016
Simulation Analysis (round 1)	50d?	04/11/2016	06/17/2016
Operational Workshop #1	3d?	06/20/2016	06/22/2016
Interim Report	11d?	06/23/2016	07/07/2016
Workshop #1 Review	11d?	06/23/2016	07/07/2016
ConOps modifications	15d?	07/08/2016	07/28/2016
Revised System Characterization	22d?	07/29/2016	08/29/2016
Update System Model	33d?	07/05/2016	08/18/2016
Updated Simulation Analysis (round 2)	15d?	08/19/2016	09/08/2016
Operational Workshop #2	2d?	09/09/2016	09/12/2016
Workshop #2 Review	10d?	09/13/2016	09/26/2016
Revised System Characterization	25d?	09/27/2016	10/31/2016
Update System Model	25d?	09/27/2016	10/31/2016
Updated Simulation Analysis (round 3)	14d?	11/01/2016	11/18/2016
Final report	43d?	10/03/2016	11/30/2016