UAS-15-02 Sense and Avoid (SAA) System Certification Considerations Testing and Validation of Non-deterministic Data Processing

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| **Title of Research Requirement** | **Sense and Avoid (SAA) System - Certification Considerations for Requirements-based Testing and Validation of Non-deterministic Data Processing**  |
| TCRG | UAS  |
| Fiscal Year | 2015  |
| TCRG Tech Priority | 02  |
| Date | 7/23/2012  |
| TCRG Lead | Kerin Olson  |
| OPI Reference | AFS-400  |
| Sponsor/Point of Contact | Steve George, AFS-407  |
| Endorsement of Sponsoring Office's Manager | Yes  |
| Office Manager's Approval | Jim Williams, AFS-80, 08/03/12  |
| Description of the Requirement | Note - This research is intended to begin with a subsequent phase for research (same title) approved to start in FY 13. FY 13 requirement documentation and/or Execution Report will be amended to be consistent with FY 14 documentation. |
|  | **Problem / Need** - Certification of a SAA system that uses nondeterministic data processing presents unique challenges. Sense and avoid systems may use nondeterministic data processing to fuse sensor data, track targets and/or make decisions on avoidance maneuvers based on predicted trajectories of ownship and threat aircraft. Non-deterministic data processing can be more computationally efficient, but may allow multiple valid solutions for a given set of input data. Testing and validation of such nondeterministic data processing is challenging because this type of processing allows multiple outcomes and they may all be valid given the uncertainties in the past and present positions of the aircraft involved. . Development of SAA system certification requirements will require consideration of nondeterministic data processing to ensure validity of SAA data . |
|  | **Requirement -** This research will identify airworthiness approval testing and validation considerations in the context of the new and novel system requirements for this type of SAA system. The key research question to answer is:  |
|  | What are the certification considerations for SAA system requirements based testing and validation of non-deterministic surveillance processing, tracking, threat declaration and maneuvering logic? |
|  | **Outcome -** Consistent airworthiness testing and validation requirements that expedite the design and approval of SAA systems using nondeterministic data processing. |
| Sponsor Outcome & Implementation Plan |  |
|  | **Implementation Plan** - Incorporate tailored airworthiness testing and validation requirements into airworthiness approval guidance for this type of SAA system to be documented in advisory circular 90-SAA by 2017. |
| NextGen Connection | No  |
| NextGen Linkage Info. |   |
| Metrics, Milestones, and Project Phases | **Phase 1 -** Research and evaluate accepted testing and validation methods for nondeterministic data processing systems with special emphasis on airworthiness requirements for avionics with data processing characteristics and requirements common to SAA systems by December 2014 |
|  | **Phase 1 Milestones -**Development of generally accepted testing and validation methods to be included in the technical report that have a breadth and depth acceptable to the sponsor by May 2014. Development of specific applicable avionics testing and validation methods to be included in the technical report that have a breadth and depth acceptable to the sponsor by September 2014 |
|  | **Exit criteria -** Technical report, approved by the sponsor, detailing generally accepted testing and validation methods and specific avionics testing and validation methods (if any) for systems most similar to SAA systems using nondeterministic data processing by December 2014 |
|  | **Phase 2** - Using phase 1 documentation, evaluate unique SAA system requirements and recommend acceptable testing and validation methods for nondeterministic data processing systems used for SAA systems by August 2015  |
|  | **Phase 2 Milestones -** Development of acceptable testing and validation methods to be included in the technical report that have a breadth and depth acceptable to the sponsor by April 2015 |
|  | **Exit criteria -** Technical report, approved by the sponsor, detailing recommended testing and validation methods for SAA systems using nondeterministic data processing, completed by August 2015 |
| Background | The fundamental purpose of all UAS SAA systems is to satisfy the "see-and-avoid" requirements of 14 CFR Part 91.113. Other 14 CFR Part 91 regulations may also apply based on the flight rules (i.e., IFR versus VFR), route, or altitude the UAS pilot uses. Multiple sensors are likely needed for the UAS SAA system to sense and avoid other NAS users due to the different observability (e.g., radar cross-section, transponder equipage, physical size, atmospheric conditions, etc.) of other aircraft. Multiple sensors also may allow decreased acquisition time, greater acquisition range, and improved position accuracy of the SAA target. However, the avoidance logic for multiple sensors and the associated data processing provide the challenge of a nondeterministic solution (i.e., potential multiple valid solutions) to the positioning, predicted tracks, and avoidance maneuvers for a given threat geometry. Testing and validation of the nondeterministic data processing required for these systems must account for the potentially multiple valid solutions that this data processing method can produce. The key is to evaluate the acceptable range of valid behavior and separate invalid data processing outcomes from valid ones despite the potential variability that may occur. |
|  | Other Research - Research on requirements for SAA systems using nondeterministic data processing is also being conducted by NASA by their Langley Research Center. The NASA-Langley point of contact is Dr Paul Miner. Related NASA research in this area will be coordinated and leveraged to the maximum practical extent by SMEs from the FAA Tech Center and AFS-407. |
| Regulatory Link | 14 CFR 91.111 and 91.113 are principal regulatory compliance areas along with other Part 91 paragraphs depending on flight rules, route and atitude the UAS pilot uses. |
|  | 14 CFR Part 23 or a UAS-specific equivalent for rulemaking associated with UAS SAA requirements. Advisory Circular 90-SAA for future guidance on SAA system approval. |
| Output | Phase 1 Technical report, detailing generally accepted testing and validation methods and specific avionics testing and validation methods (if any) for systems most similar to SAA systems using nondeterministic data processing |
|  | Phase 2 Technical report, detailing recommended testing and validation methods for SAA systems using nondeterministic data processing |
| Notes |  |
| 1) Criteria-Potential to Prevent or Mitigate Safety Risks\* | 1=Essential  |
| Evidence Justification | **Evidence - High** |
|  | The acceptability of unmanned aircraft integration into the NAS is directly related to the ability of UAS to avoid near midair collisions with all other aircraft. |
|  | 2011 midair collision between a USAF C-130 and a US Army RQ-7 Shadow demonstrates how even small UAS can represent a significant hazard to manned aircraft since they are difficult to see and therefore avoid. |
|  | Video images taken in 2004 from a military UAV in Afghanistan show it flying head-on toward an Airbus A300, carrying 100 passengers, on its approach to the Kabul airport. Only a last-second avoidance maneuver by the Airbus pilot prevented a mid-air collision. SAA systems development must precede integration into civil airspace to preclude incidents like this one. |
|  | Midair collisions continue to be a problem for manned aviation as well as unmanned aircraft. 2003 FAA collision avoidance system rulemaking expanded the TCAS mandate based on airplane weight and performance rather than passenger capacity to reduce the risk of a mid-air collision involving those aircraft and to increase safety for others, including the public on the ground. The same public interest to reduce collision risk drives the need for SAA systems on UAS. |
|  | 2008 NTSB recommendation to remove the transponder exemption for gliders emphasizes the need for airspace users to equip with cooperative systems to avoid collisions. UAS have the same need and interoperability and reliability of non-deterministic SAA systems must be assured through appropriate airworthiness certification.  |
|  | <http://www.ntsb.gov/doclib/recletters/2008/A08_14_15.pdf> |
|  | **Impact - High** |
|  | Lack of UAS SAA capability poses a significant risk to other NAS users and public. If successful, this requirement would facilitate certification of systems that prevent midair and near midair collisions between unmanned aircraft and other aircraft. |
|  | Successful development of robust SAA systems reduces the risk of operations using airspace segregation or other expedient current mitigations that may not address new and novel hazards "discovered" during future operations with a higher density of UAS operating among higher density air traffic. |
| 1b) Feedback |  |
| 2) Criteria-Identify and Analyze Emerging Threats | 5=Important  |
| 2a) Rationale for Ranking | **Evidence - High** |
|  | There is evidence of a significant need to develop avionic systems design and airworthiness approval requirements for SAA systems using nondeterministic data processing because requirements for nondeterministic SAA systems are not available and these types of systems are well-suited to address the computational complexity and uncertainty in the processing of sensor/track data and collision avoidance algorithms used for SAA. |
|  | **Impact - Low**  |
|  | The outcome of this research will impact the guidance developed by the AFS-407 sponsor that is intended for use by SAA avionic systems designers and FAA airworthiness authorities in the design and approval of SAA systems using nondeterministic data processing. |
| 2b) Feedback |   |
| 3) Criteria-Enhance Existing Safety Regulations and Standards | 1=Essential  |
| 3a) Rationale for Ranking | **Evidence - High**  |
|  | 14 CFR 91.111 and 91.113 are two principal see and avoid regulatory compliance areas in Part 91 along with others such as 91.119, 91.123, and 91.181 that depend on flight rules, route and altitude the pilot uses. These existing see and avoid regulations address manned requirements and either the regulations or guidance on alternate means of compliance needs to be developed to address this deficiency. Examining methods to certify sense and avoid systems must include new and novel nondeterministic data processing of sensor and relative position data used by those systems.  |
|  | **Impact - High** |
|  | The outcome of this research will determine the UAS SAA system requirements for systems of this type and the applicable airworthiness standards used to certify SAA systems with nondeterministic data processing will be documented in guidance such as Advisory Circular 90-SAA |
| 3b) Feedback |  |
| 4) Criteria-Prepare for New Technologies, etc. | 1=Essential  |
| 4a) Rationale for Ranking | **Evidence - High** |
|  | Several aircraft and avionics manufacturers are developing SAA systems as either airborne, ground-based or combination systems. Nondeterministic data processing for some of these systems may be used to fuse sensor data, track targets or make decisions on avoidance maneuvers based on the predicted trajectories of the UAS and threat aircraft. This data processing is required to manage the complex data relationships and sensor/trajectory uncertainties and the FAA needs to be prepared to certify SAA systems that use this data processing methodology. |
| **Impact - High**  |  |
|  | This research will prepare the FAA for the certification of these new and novel SAA systems by providing a standard methodology to assure they perform their intended function.  |
| 4b) Feedback |  |
| 5) Criteria-Answer Internal and External Drivers | 2 |
| 5a) Rationale for Ranking | **Internal Drivers:** |
|  | The safe integration of UAS into the NAS is an important objective for the FAA, as evidenced in Destination 2025: |
|  | “Manned and unmanned flights will both achieve safe flight…” |
|  | <http://www.faa.gov/about/plans_reports/media/Destination2025.pdf> |
|  | UAS is also an important consideration in NextGen research, represented in the 2012 NextGen Implementation Plan: "With NextGen, we must continue to advance safety in the face of increasing traffic and the introduction of unmanned aircraft systems…” |
|  | <http://www.faa.gov/nextgen/implementation/media/NextGen_Implementation_Plan_2012.pdf> |
|  | **External Drivers:** |
|  | UAS integration is mandated in the FAA Modernization and Reform Act of 2012. Section 332 calls for "the safe integration of civil unmanned aircraft systems into the national airspace system a soon as practicable, but not later than September 30, 2015." This also addresses elements such as rulemaking, standards, requirements, technologies, and methods to ensure safe integration. |
|  | [http://www.faa.gov/regulations\_policies/reauthorization/media/PLAW-112publ95[1].pdf](http://www.faa.gov/regulations_policies/reauthorization/media/PLAW-112publ95%5B1%5D.pdf) |
|  | NTSB 2010 Notice in Federal Register. Requires public and civil UAS operators of unmanned aircraft heavier than 300 pounds to notify the NTSB of accidents involving such aircraft. The FAA is now required to respond to NTSB recommendations regarding unmanned aircraft in the same manner in does for other aircraft. |
|  | <http://www.ntsb.gov/doclib/legal/NTSB_830_revision_Aug2010.pdf> |
|  | As directed by the National Defense Authorization Act of 2010, the FAA and DoD developed a NAS Access Plan for public UAS. Per that plan, the FAA has committed to develop "validated airspace integration requirements and associated standards" in the Mid-term (2015 - 2020) and approve technical standards and performance specifications by the Far-Term (2020 - 2025). |
|  | <http://www.intelligence.senate.gov/pdfs/military_act_2009.pdf> |
|  | Increasing UAS use by DoD, NASA, CBP and other government agencies and increasing public perception of benefits (safety, security, economic, etc.) from increased use of UAS in the U.S. NAS. |
| **Impact - High** |  |
|  | The operational and airworthiness standards supported by this research will serve as the basis for the civil certification of UAS surveillance systems. These standards will satisfy the needs identified in the internal and external drivers above, including the need to accept the use of DoD surveillance systems which may be the first to be fielded for NAS operations. |
| 5b) Feedback |  |
| 6) Additional Justification (if none, add "None" to block. | None |
| Proposed Project Manager | Sabrina Saunders-Hodge, (202) 267-9993  |
| Total Prioritized Funding Level FY2012 ($K) |  |
| Total Prioritized Funding Level FY2013 ($K) |  |
| Total Prioritized Funding Level FY2014 ($K) | $1,000 |
| Previous FY | [Sense and Avoid (SAA) System - Certification Considerations for Requirements-based Testing and Validation of Non-deterministic Data Processing](https://avssp.faa.gov/avs/aviationsafetyresearch/_layouts/listform.aspx?PageType=4&ListId=%7bEA672CC6-BB7A-4B07-A2B7-62392F41D077%7d&ID=1044&RootFolder=*)  |
| Old Requirement Number | None |
| Attached List of Task(s) | Yes |
| BnYd | No |
| Attachments  | [FY15 Cost Estimates v1.0 12 DEC 12.xlsx](https://avssp.faa.gov/avs/aviationsafetyresearch/Lists/RED%20Requirements/Attachments/1245/FY15%20Cost%20Estimates%20v1.0%2012%20DEC%2012.xlsx) |
|  | [UAS-FY2014 cost estimates revised report costs V3 9-FEB 12.xls](https://avssp.faa.gov/avs/aviationsafetyresearch/Lists/RED%20Requirements/Attachments/1245/UAS-FY2014%20cost%20estimates%20revised%20report%20costs%20V3%209-FEB%2012.xls) |
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