Separation Assurance and Collision Avoidance

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Meeting of Experts on NASA's Unmanned Aircraft System (UAS) Integration in the National Airspace Systems (NAS) Project

Aeronautics and Space Engineering Board
National Research Council
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In Scope

• Real-time trajectory safety and contingency monitoring
• Mission planning for safety and to minimize impact
• Collision avoidance system requirements

Not in Scope

• “Sense and Avoid” sensors and algorithms will be developed by external partners
SA/CA Issues

Four areas of research:

– Tactical Separation Assurance Safety Systems
– Off-Nominal Procedures and Automation
– System Effects of UAS Inclusion
– Required Collision Avoidance System Performance
Tactical SA Safety Systems

• Air traffic controllers retain their responsibility for Separation Assurance
• Provide additional layer of safety and monitoring for UAS in Tactical Separation Assurance timeframe
• Real-time analysis of mission safety
• Leverage NASA NextGen technologies
Objective SACA-1: Determine the level of safety provided by tactical separation assurance safety monitoring systems for UAS missions

- **Rationale**: Continuous mission-risk monitoring can provide equivalent levels of safety for UAS operations possibly reducing the burden on other safety systems
- **Approach**: Utilize and adapt algorithms and approaches developed for the NextGen Airspace Systems Program for UAS applications
## Tactical SA Deliverables

<table>
<thead>
<tr>
<th>FY</th>
<th>Deliverable</th>
<th>To</th>
<th>Used For</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY12</td>
<td>Safety data from fast-time simulation of UAS SA</td>
<td>FAA</td>
<td>Assess the viability and efficacy of Tactical SA safety systems</td>
</tr>
<tr>
<td>FY13</td>
<td>Algorithm effectiveness and controller/UAS operator acceptance from HITL study</td>
<td>FAA</td>
<td>Determine controller and operator acceptance of systems</td>
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<tr>
<td>FY14</td>
<td>Performance data of tactical separation assurance safety systems from flight test</td>
<td>FAA</td>
<td>Determine efficiency under uncertainty</td>
</tr>
<tr>
<td>FY15</td>
<td>Performance data of algorithm as part of integrated system from flight test</td>
<td>FAA</td>
<td>Determine integrated functionality under real conditions</td>
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</table>
Tactical SA Collaboration

• Partnerships: FAA - UAS models, controller expertise, scenario development

• Integrated Test and Evaluation:
  – Integrated Sim 1: Determine possible controller and UAS operator acceptance of UAS safety tools
  – Integrated Flight Test 2: Evaluate operation of safety tools with real latencies and trajectory uncertainties
  – Integrated Flight Test 3: Further evaluation of real world uncertainties and integration with off-nominal procedures
Off-Nominal Safety Assurance

• Defined by loss of communication and possibly other failures
• Since aircraft have no onboard pilot:
  – Aircraft may need to independently avoid other aircraft or regions of complex airspace
  – Also, may need to select overflight areas of low risk to ground infrastructure
• Provide automation alternative to some aspects of the flight authorization process
Off-Nominal SA Objective

**Objective SACA-2:** Study off-nominal procedures and automation to assure safety of other aircraft and infrastructure in the event of a UAS off-nominal event such as loss of communication

> **Rationale:** Off-nominal events are a barrier to UAS integration because there is no pilot for emergency decision making, so determining the appropriate procedures and automating those tasks will mitigate the risk of UAS operations

> **Approach:** Leverage the contingency management experience of NASA and the off-nominal procedures work of external partners to provide tools for UAS safety in off-nominal conditions
## Off-Nominal SA Deliverables

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<tbody>
<tr>
<td>FY12</td>
<td>Concept of operations for off-nominal procedures defined</td>
<td>Internal</td>
<td>Determine accepted risk mitigation procedures for automation</td>
</tr>
<tr>
<td>FY13</td>
<td>Performance of off-nominal procedures in fast-time simulations</td>
<td>FAA</td>
<td>Assess automation for off-nominal risk mitigation</td>
</tr>
<tr>
<td>FY14</td>
<td>Data supporting controller and operator acceptability of from HITL assessment</td>
<td>FAA</td>
<td>Determine acceptability of off-nominal procedures for UAS operators and controllers</td>
</tr>
<tr>
<td>FY15</td>
<td>Off-nominal automation performance in integrated environment from flight test</td>
<td>FAA</td>
<td>Study integrated system performance of off-nominal SA under real flight conditions</td>
</tr>
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</table>
Off-Nominal SA Collaboration

• Partnerships: DoD - off-nominal processes and procedures; FAA - flight authorization process
• ARRA: Contingency management ConOps
• Integrated Test and Evaluation:
  – Integrated Flight Test 3: Evaluate performance and acceptability of off-nominal procedures and automation with real latency and uncertainty
System Effects of UAS

- Often have different performance characteristics than manned aircraft
- Often fly different routes than manned aircraft
- Systems studies will provide:
  - Mission safety assessments and risk mitigation tools
  - Impacts of UAS operations on other NAS stakeholders
Objective SACA-3: Study the effects of inclusion of specific UAS and missions in the NAS to determine the probable impact of the UAS mission on safety and other NAS stakeholders

Rationale: The current risks and difficulties associated with mixed UAS operations can be studied to determine their impact and develop tools and procedures to mitigate this impact

Approach: Use NASA airspace modeling resources to evaluate UAS impact and to identify risk reduction strategies for specific UAS missions
# System Effects Deliverables

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<tr>
<td>FY11</td>
<td>Data quantifying impact of UAS and missions on current NAS</td>
<td>FAA</td>
<td>Assess the impact unique aspects of UAS and missions on NAS safety and efficiency to help determine required technologies</td>
</tr>
<tr>
<td>FY13</td>
<td>Data from analysis of safety and risk for specific UAS</td>
<td>FAA</td>
<td>Help determine the safety risks in terms of aircraft and infrastructure of a UAS mission</td>
</tr>
<tr>
<td>FY15</td>
<td>Mission planning tool to minimize UAS risk and enable contingency management</td>
<td>FAA, UAS operators</td>
<td>Allows for UAS mission planning to minimize NAS impact while maintaining mission goals</td>
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System Effects Collaboration

• Partnerships: FAA - Collaboration and sharing of fast-time modeling results and scenario development

• Scenario and model sharing with Communications simulation effort
Collision Avoidance Requirements

• Focus on system performance requirements instead of component design
• Generate data to determine the required performance of a CA system
• Different requirements may be necessary for different UAS classes and missions
Objective SACA-4: Provide data supporting possible requirements for the performance of collision avoidance systems for specific UAS and situations

—Rationale: There are many collision avoidance algorithms and sensors under development, but no functional requirements to verify system performance

—Approach: Generate data on collision avoidance performance requirements using simulation expertise
## CA Deliverables

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<tbody>
<tr>
<td>FY12</td>
<td>Survey of current systems CA systems and requirements used</td>
<td>Internal</td>
<td>Inform future research into CA requirements of current system performance</td>
</tr>
<tr>
<td>FY12</td>
<td>Assessment of previous CA requirement specification methodologies</td>
<td>Internal</td>
<td>Inform methodologies for determining required performance</td>
</tr>
<tr>
<td>FY14</td>
<td>Data from simulations to determine CA performance requirements</td>
<td>FAA</td>
<td>Large scale assessment of different UAS collision risks and performance characteristics</td>
</tr>
<tr>
<td>FY15</td>
<td>Candidate CA system requirements from compiled safety data from simulations</td>
<td>FAA</td>
<td>Provide a design standard for CA system performance</td>
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CA Collaboration

- Partnerships: FAA - Collaborate on desired data for analyses and requirement generation; DoD - Input on sense and avoid systems and performance

- ARRA: Survey of “Sense and Avoid” capabilities
Facilities

• Air Traffic Control Lab – Ames
• Air Traffic Operations Lab - Langley
• Airspace Operations Lab - Ames
• IDEAS Lab – Langley
• Small UAS aircraft and operations labs – Ames, Langley, Dryden
• Manned surrogate UAS – Langley
• Ikhana MQ-9 - Dryden