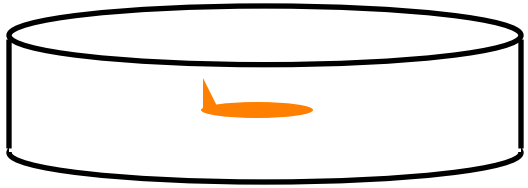
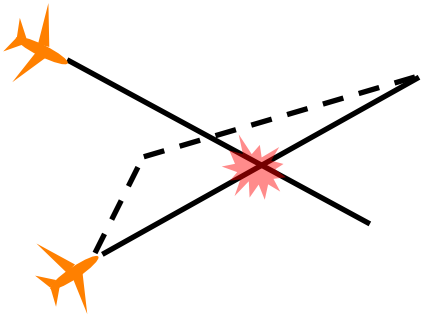


Separation Assurance and Collision Avoidance



Presented by: Todd Lauderdale

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
August 5, 2010

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

Tactical SA Objective

- **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

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

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

FY	Deliverable	To	Used For
FY12	Concept of operations for off-nominal procedures defined	Internal	Determine accepted risk mitigation procedures for automation
FY13	Performance of off-nominal procedures in fast-time simulations	FAA	Assess automation for off-nominal risk mitigation
FY14	Data supporting controller and operator acceptability of from HITL assessment	FAA	Determine acceptability of off-nominal procedures for UAS operators and controllers
FY15	Off-nominal automation performance in integrated environment from flight test	FAA	Study integrated system performance of off-nominal SA under real flight conditions

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

System Effects Objective

- **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

FY	Deliverable	To	Used For
FY11	Data quantifying impact of UAS and missions on current NAS	FAA	Assess the impact unique aspects of UAS and missions on NAS safety and efficiency to help determine required technologies
FY13	Data from analysis of safety and risk for specific UAS	FAA	Help determine the safety risks in terms of aircraft and infrastructure of a UAS mission
FY15	Mission planning tool to minimize UAS risk and enable contingency management	FAA, UAS operators	Allows for UAS mission planning to minimize NAS impact while maintaining mission goals

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

CA Objective

- **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

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

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