Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project

Detect and Avoid

Jay Shively
DAA Sub-Project Manager

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Manned and unmanned aircraft will be able to routinely operate through all phases of flight in the NAS, based on airspace requirements and system performance capabilities.
Future Civil UAS Airspace Environment

**IFR-LIKE**
UAS will be expected to meet certification standards and operate safely with traditional air traffic and ATM services. *(Example Use Case: Communication Relay / Cargo Transport)*

**VFR-LIKE**
These UAS will operate at altitudes below critical NAS infrastructure and will need to routinely integrate with both cooperative and non-cooperative aircraft. *(Example Use Case: Infrastructure Surveillance)*

**LOW ALTITUDE URBAN**
Must interface with dense controlled air traffic environments as well as operate safely in uncontrolled airspace. *(Example Use Case: Traffic Monitoring / Package Delivery)*

**LOW ALTITUDE RURAL**
Low risk BVLOS rural operations with or without aviation services. *(Example Use Case: Agriculture)*

**TOP OF CLASS G**
Agricultural Aircraft, Helicopters

**TIME (Notional)**
Restricted Access, Routine Access
DAA Operational Environments

Legend
Current Research Areas (FY14- FY16)
Proposed Research Areas (FY17 – FY20)

60K’ MSL

18K’ MSL

10K’ MSL

MINIMUM ENROUTE ALTITUDE

DAA System for Transition to Operational Altitude (> 10kft MSL)

500’ AGL

UTM

Terminal Area Ops

Ground Based Radar

GBSAA Data

Cooperative Traffic

Non-cooperative Aircraft

Airborne Radar

ADS-B & TCAS-II

ACAS Xu

DAA System for Operational Altitudes (> 500ft AGL)

“Tweener” UAS

Alternative DAA Sensors

ACAS Xu

C2 Datalink

C2 Datalink

DAA System for Operational Altitude

HALE aircraft

Cooperative Traffic

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Ground Based Radar

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UAS Ground Control Station

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Demand for UAS Integration

• Several civil/commercial markets are poised to take full advantage of the capabilities UAS offer

<table>
<thead>
<tr>
<th>Demand Scenario</th>
<th>Automation Assisted</th>
<th>Highly Automated</th>
<th>Autonomous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Altitude Rural</td>
<td>Aerial Photography</td>
<td>Wildlife Surveillance</td>
<td>Precision Agriculture</td>
</tr>
<tr>
<td>IFR-Like</td>
<td>Broad Area Surveillance</td>
<td>Cargo Transport</td>
<td>Communication Relay</td>
</tr>
<tr>
<td>Low Altitude Urban</td>
<td>Search and Rescue</td>
<td>Traffic Monitoring</td>
<td>Local Package Delivery</td>
</tr>
<tr>
<td>VFR-Like</td>
<td>Horizontal Infrastructure</td>
<td>Passenger Transport</td>
<td>Cargo Delivery</td>
</tr>
</tbody>
</table>

growth until the barriers and challenges, currently preventing full integration, are addressed

“For every year integration is delayed, the United States loses more than $10B in potential economic impact ($27.6M per day).” – AUVSI Economic Report 2013
UAS-NAS Phase 2
Project Organization Structure

**Project Leadership**
- Project Manager (PM): Laurie Grindle, AFRC
- Deputy PM: Robert Sakahara, AFRC
- Deputy PM, Integration: Davis Hackenberg, AFRC
- Chief Engineer: William Johnson, LaRC

**Project Support: Technical**
- Staff Engineer: Dan Roth, AFRC
- Systems Eng Lead: TBD, TBD

**Project Support: Project Planning & Control**
- Lead Resource Analyst: April Jungers, AFRC
- Resource Analysts: Winter Preciado, Warquel Frieson, ARC
- Scheduler: Irma Ruiz, AFRC
- Risk Manager: Jamie Turner, AFRC
- Change/Doc. Mgmt: Lexie Brown, AFRC
- Admin: Sarah Strahan, AFRC

**Command and Control (C2)**
- Subproject Manager: Mike Jarrell, GRC
- Subproject Technical Lead: Jim Griner, GRC

**Detect and Avoid (DAA)**
- Subproject Manager: Jay Shively, ARC
- Subproject Technical Leads:
  - Confesor Santiago, ARC; Lisa Fern, ARC; Tod Lewis, LaRC

**Integrated Test & Evaluation**
- Subproject Manager: Heather Maliska, AFRC
- Subproject Technical Leads:
  - Jim Murphy, ARC; Sam Kim, AFRC

**Technical Work Packages (TWP):**
- Terrestrial Extensions, Ka-band Satcom, Ku-band Satcom, C-band Satcom
- Alternative Surveillance, Well Clear, ACAS Xu, External Collaboration, Integrated Events
- Integration of Technologies into LVC-DE, Simulation Planning and Integration, Integrated Flight Test
General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear.

Piloted “see and avoid” = UAS “detect and avoid”

Pilots vision replace by sensors (on- or off- board or both)

Pilot judgment of well clear = mathematical expression of well clear

Horz Miss Distance = 4000ft; Vert Miss Distance = 450ft; modTau = 35sec; DMOD = 4000ft
Research Areas to support DAA:

Define operational environment (CONOPS)

Develop well clear definition

Develop algorithms for guidance

Develop sensor requirements

End to end timelines
  Human response
  A/C response
  Datalink latencies

Develop guidance displays, alerting logic and presentation

Ensure interoperability with TCAS/ACAS
## Alerting

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Pilot Action</th>
<th>Buffered Well Clear Criteria</th>
<th>Time to Loss of Well Clear</th>
<th>Aural Alert Verbiage</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="TCAS RA" /></td>
<td>TCAS RA</td>
<td>• <strong>Immediate action required</strong>&lt;br&gt;• Comply with RA sense and vertical rate&lt;br&gt;• Notify ATC as soon as practicable after taking action</td>
<td>*DMOD = 0.55 nmi&lt;br&gt;*ZTHR = 600 ft&lt;br&gt;*modTau = 25 sec</td>
<td>0 sec (+/- 5 sec) (TCPA approximate: 25 sec)</td>
<td>“Climb/Descend”</td>
</tr>
<tr>
<td><img src="image" alt="DAA Warning Alert" /></td>
<td>DAA Warning Alert</td>
<td>• <strong>Immediate action required</strong>&lt;br&gt;• Notify ATC as soon as practicable after taking action</td>
<td>DMOD = 0.75 nmi&lt;br&gt;HMD = 0.75 nmi&lt;br&gt;ZTHR = 450 ft&lt;br&gt;modTau = 35 sec</td>
<td>25 sec (TCPA approximate: 60 sec)</td>
<td>“Traffic, Maneuver Now” x2</td>
</tr>
<tr>
<td><img src="image" alt="Corrective DAA Alert" /></td>
<td>Corrective DAA Alert</td>
<td>• On current course, <strong>corrective action required</strong>&lt;br&gt;• Coordinate with ATC to determine an appropriate maneuver</td>
<td>DMOD = 0.75 nmi&lt;br&gt;HMD = 0.75 nmi&lt;br&gt;ZTHR = 450 ft&lt;br&gt;modTau = 35 sec</td>
<td>55 sec (TCPA approximate: 90 sec)</td>
<td>“Traffic, Avoid”</td>
</tr>
<tr>
<td><img src="image" alt="Preventive DAA Alert" /></td>
<td>Preventive DAA Alert</td>
<td>• On current course, corrective action <strong>should not be required</strong>&lt;br&gt;• Monitor for intruder course changes&lt;br&gt;• Talk with ATC if desired</td>
<td>DMOD = 0.75 nmi&lt;br&gt;HMD = 1.0 nmi&lt;br&gt;ZTHR = 700 ft&lt;br&gt;modTau = 35 sec</td>
<td>55 sec (TCPA approximate: 90 sec)</td>
<td>“Traffic, Monitor”</td>
</tr>
<tr>
<td><img src="image" alt="Guidance Traffic" /></td>
<td>Guidance Traffic</td>
<td>• <strong>No action required</strong>&lt;br&gt;• Traffic generating guidance bands outside of current course</td>
<td>Associated w/ bands outside current course</td>
<td>X</td>
<td>N/A</td>
</tr>
<tr>
<td><img src="image" alt="None (Target)" /></td>
<td>None (Target)</td>
<td>• <strong>No action required</strong>&lt;br&gt;• No coordination required</td>
<td>Within surveillance field of regard</td>
<td>X</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* These values show the Protection Volume (not well clear volume) at MSL 5000-10000 ft (TCAS Sensitivity Level 5)
Phase 1:

SC 228 DAA MOPS Phase 1

Class A, transitioning through E

Larger UAS capable for carrying an on-board DAA sensor and performing in an IFR environment

Users: DoD, DHS, NASA, public agencies

Phase 2:

SC 228 Phase 2 MOPS

Terminal Operations

Smaller, less payload A/C

Alternative Sensors

New Well Clear Definition

Airspace down to UTM

Users: Police, Fire, BLM, Forestry, Public Utilities, Fisheries, Agriculture
Customers

- SC 228
- SC 147
- DoD
- ICAO
- Industry
- FAA
Questions ?