



UAS Integration in the NAS

National Aeronautics and Space Administration

Flight Test 6 VIP Day: A little bit of how we got here

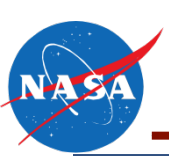
Jay Shively
DAA Sub-Project Manager





Only 1 sense?

- You can't hear the engine rpm fluctuating
- You can't feel vibrations, accelerations or motion
- You can't smell the fuel leak
- You can't taste the electrical fire smoke
- AND, you lose vision in one eye, only 30° FOV!
- WELCOME to UAS flying!



DAA Operational Environments

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

60K' MSL



HALE aircraft

18K' MSL



Cooperative Traffic

10K' MSL

ADS-B & TCAS-II
ACAS Xu

MINIMUM ENROUTE ALTITUDE



Airborne Radar



Non-cooperative Aircraft

ADS-B & ACAS Xu

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

Alternative DAA Sensors
ACAS Xu

Class 2 & 3 UAS

500' AGL

C2 Datalink

Terminal Area Ops

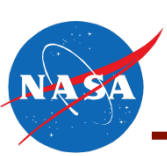
C2 Datalink

DAA System for Operational Altitudes (> 500ft AGL)

Ground Based Radar

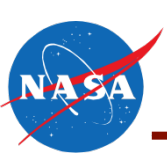
GBSAA Data

UAS Ground Control Station



Long Road (from memory and I'm old, so...)

- Planning Meetings
 - Armstrong – 2009?
 - Jeff Bauer/ John Cavolowsky
 - Still with US Army
- Meeting of Experts
 - John Hansman, Washington, DC
 - 2010
- Formulation Meeting
 - 2011
 - ARMD, Jaiwon Shin
- First Meeting with FAA
 - 2012
 - San Diego
- NAC
 - John Langford, Dave Voss, Rose Mooney...
- KDPs
- Annual Reviews



Many Contributors

PM

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Chuck Johnson

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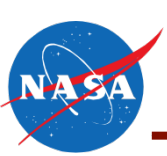
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See and Avoid: FAR Sec. 91.113

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”

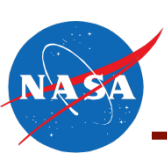
Pilots vision replaced by sensors (on- or off- board or both)

Pilot judgment of well clear = mathematical expression of well clear

Phase 2:

Non-coop horizontal = 2200, vertical = 450, no tau

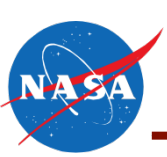
Terminal horizontal = 1500, vertical = 450, no tau



DAA (grossly over-simplified)

Three Technical Areas:

- Human Systems Integration
 - Displays
 - Guidance
 - Alerting
 - Human in the loop simulations
- Modeling and simulation
 - Fast time simulations (ACES)
 - Well clear definition(s) and analysis
- Guidance and Control
 - Avoidance algorithm (DAIDULUS)
 - Terminal area focus simulations



Phase 1

- Ikhana with large General Atomics RADAR
- TSO-C211 (DAA) and TSO-C212 (ATAR)
- No Chase COA

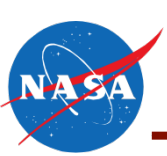


FOCI

- Low Space, Weight and Power (SWaP) Sensors
- Smaller UAS (class 2 & 3)
- Terminal Area Operations

Tiger Shark with Honeywell RADAR Panels





Contributions to the Community

Phase 1

DO-365

DO-366

Minimum Operating Performance Standards (MOPS) for Air-to Air Radar Detect and Avoid (DAA) Systems

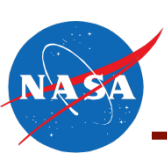
Technical Standard Orders

TSO-C211, Detect and Avoid

TSO-C212, ATAR for Traffic Surveillance

NASA DAA Team Contributions:

- Well clear definition
- Alerting
- Guidance
- Displays
- Reference algorithm
- Significant modeling and simulation



Future

- Lots of progress, but not complete..
- ACAS-sXu
- ACAS-Xr
- Obstacles
- Terrain
- UAM
- GC