



# UAS Integration in the NAS

National Aeronautics and Space Administration

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

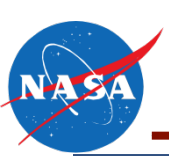
Jay Shively  
DAA Sub-Project Manager





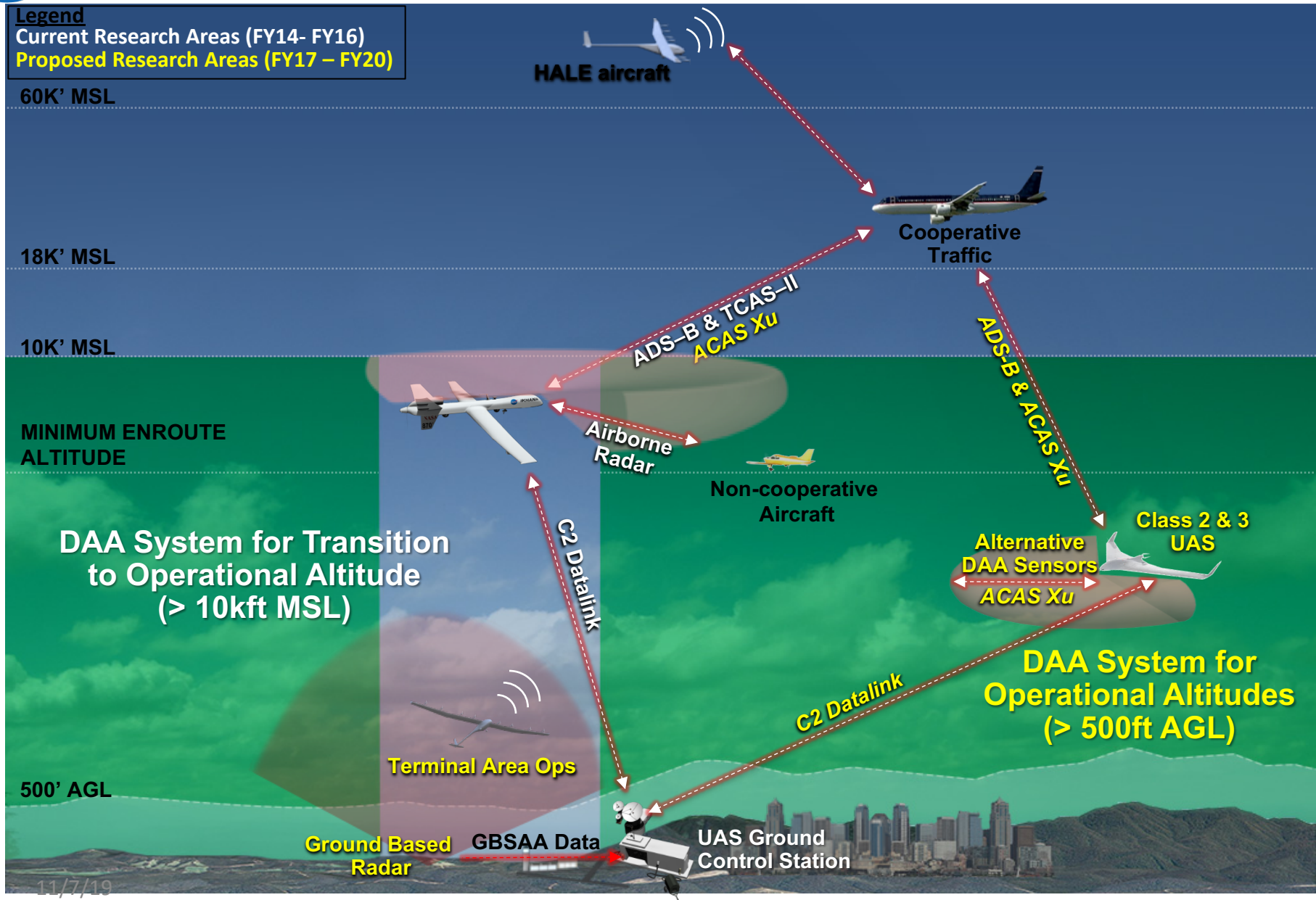
## Only 1 sense?

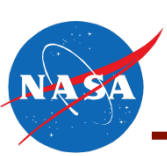
- You can't hear the engine rpm fluctuating
- You can't feel vibrations, accelerations or motion
- You can't smell the fuel leak
- You can't taste the electrical fire smoke
- AND, you lose vision in one eye, only 30° FOV!
- WELCOME to UAS flying!



# DAA Operational Environments

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

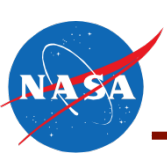




## Long Road (from memory and I'm old, so...)

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- 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

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## PM

Jeff Bauer

Chuck Johnson

Laurie Grindle

Robert Sakahara

Mauricio Rivas

## Lead Engineer

CJ Bixby

Debra Randall

Will Johnson

## DAA Tech Leads

Tod Lauderdale

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Keith Arthur

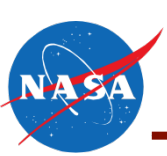
Tod Lewis

Mark Pestana

Jay Shively

Lisa Fern

Conrad Rorie



## See and Avoid: FAR Sec. 91.113

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*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”

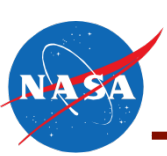
Pilots vision replaced by sensors (on- or off- board or both)

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

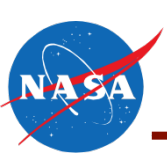


# DAA (grossly over-simplified)

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## 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



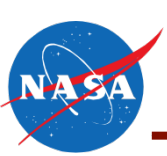


## FOCI

- 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

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## Phase 1

DO-365

DO-366

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

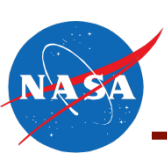
## **Technical Standard Orders**

**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

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