

DLR/ NASA Discussion

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UAS in the NAS, DAA Sub-Project Manager (SPM)

Detect and Avoid (DAA)

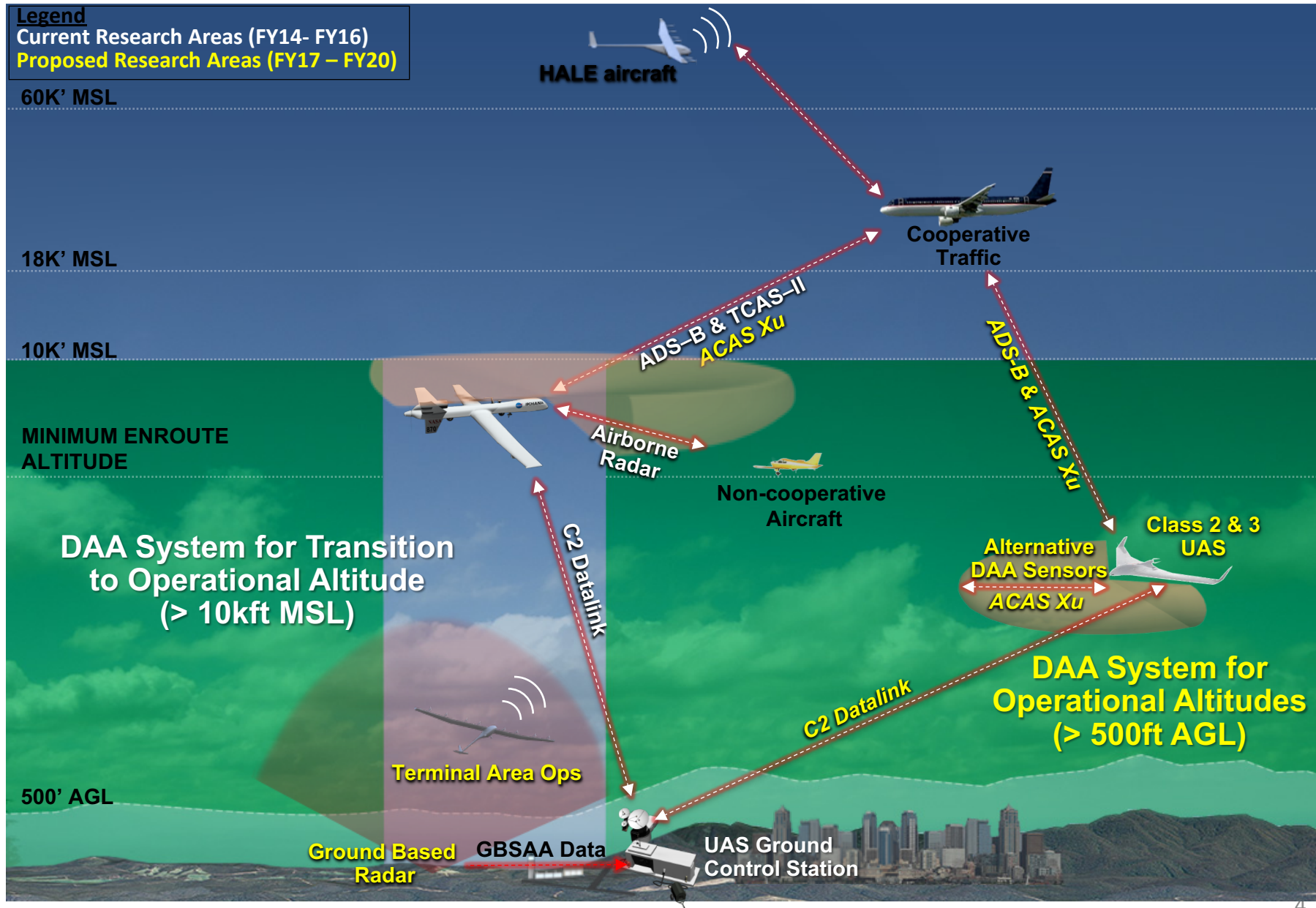
Technical Areas

- Guidance and Control (LaRC)
 - Tod Lewis
- Human Systems Integration (ARC)
 - Conrad Rorie
- Modeling and Simulation (ARC)
 - Gilbert Wu

Agenda

- DAA
- GCS
 - M:N
- RCO/SPO
- FT6
- ACAS

DAA Operational Environments



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

Horz Miss Distance = 4000ft; Vert Miss Distance = 450ft;
modTau = 35sec

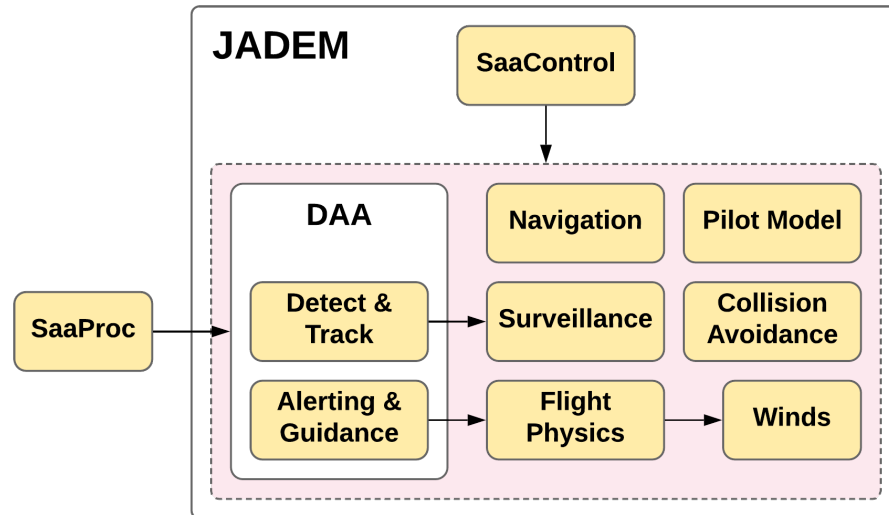
Ground Control Station (GCS)

- The Vigilant Spirit Control Station (VSCS) developed by the Air Force Research Laboratory (AFRL)
- Main Features:
 - Robust, flexible interface
 - Realistic control and navigation displays
 - System status and health monitoring
 - STANAG 4586 Compliant
 - Multi-UAS control with VSCS has been tested in simulation and flight by AFRL
- Current UAS in the NAS version modifications/additions:
 - Single pilot – single UAS control
 - NAS-compliant database (low- and high- altitude charts with navigational aids/"fixes")
 - Integrated traffic display
 - Integrated ACAS Xu (*coming June 2019*)



Simulation Environment: DAA System

- The Java Architecture for DAA Modeling and Extensibility (JADEM) was developed by the UAS in the NAS project at NASA Ames Research Center
- Main Functions:
 - Emulate surveillance parameters for various sensor types
 - e.g., ADS-B, active radar, TCAS, etc.
 - Receive state information from simulated traffic and ownship
 - Assign intruder alert levels based on given thresholds
 - Provide maneuver guidance

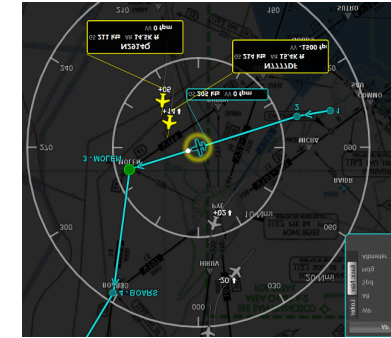


- DAA Module can be driven by
- Real time aircraft states
 - Recorded world VFR and IFR data
 - Encounter models
 - Test scenarios

DAA Guidance Concepts

- Guidance Types:

- Informative: Provides essential information of a hazard that the remote pilot may use to develop and execute an avoidance maneuver. **No maneuver guidance or decision aiding is provided to the pilot.**



- Suggestive: Provides a range of potential resolution maneuvers to avoid a hazard with manual execution. **An algorithm provides the pilot with maneuver decision aiding regarding advantageous or disadvantageous maneuvers.**

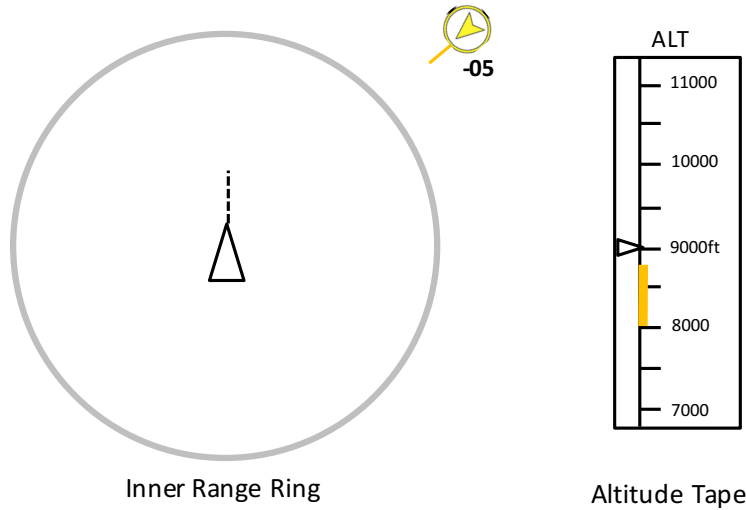


- Directive: Provides specific recommended resolution guidance to avoid a hazard with manual or automated execution. **An algorithm provides the pilot with specific maneuver guidance on when and how to perform the maneuver.**

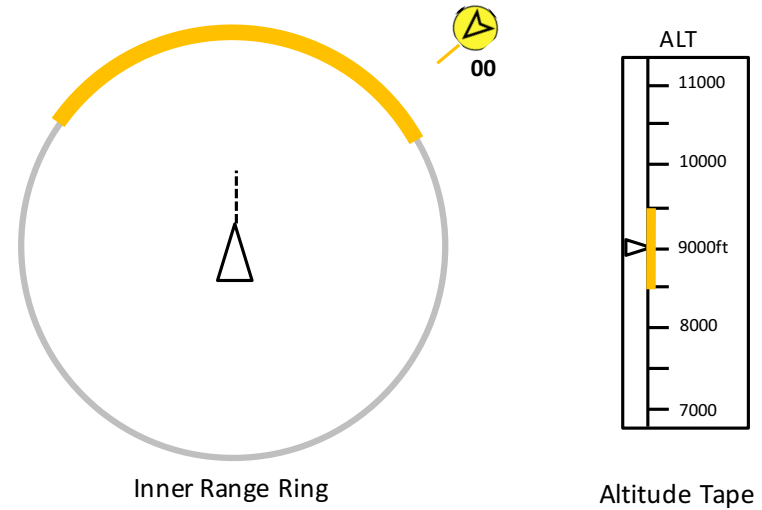


Phase 1 DAA Suggestive Maneuver Guidance

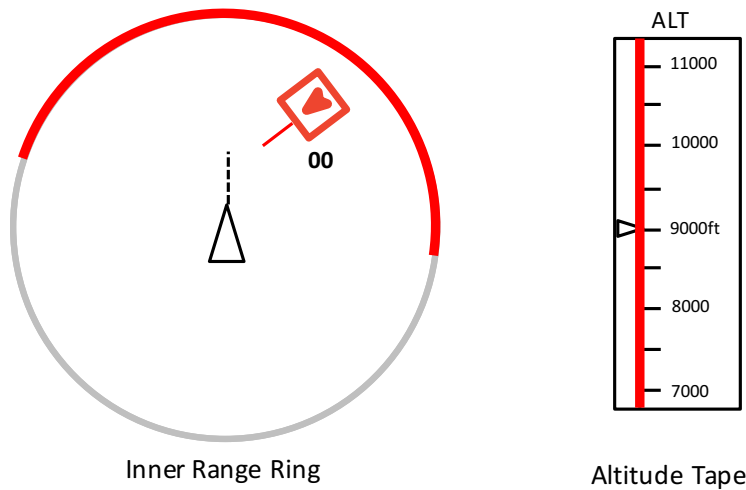
Remain DAA Well Clear Preventive Guidance



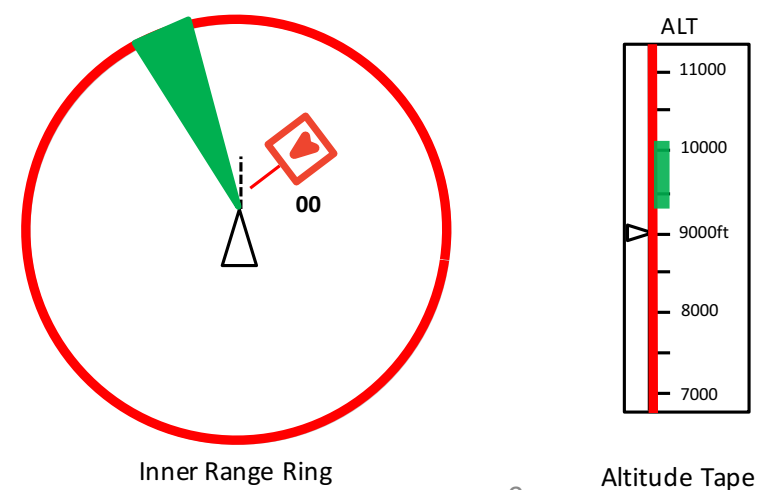
Remain DAA Well Clear Corrective Guidance




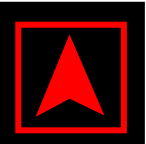



Remain DAA Well Clear Warning Guidance



Regain DAA Well Clear Guidance



DAA & RA Alerting Structure

Symbol	Name	Pilot Action	Well Clear Criteria	Time to Loss of DAA Well Clear	Aural Alert Verbiage
	TCAS/ACAS RA	<ul style="list-style-type: none"> • Immediate action required • Comply with RA sense and vertical rate • Notify ATC as soon as practicable after taking action 	(Driven by TCAS-II)	x	"Climb/Descend"
	DAA Warning Alert	<ul style="list-style-type: none"> • Immediate action required • Notify ATC as soon as practicable after taking action 	DMOD = 0.66 nmi HMD = 0.66 nmi ZTHR = 450 ft modTau = 35 sec	25 sec (TCPA approximate: 60 sec)	"Traffic, Maneuver Now" x2
	DAA Corrective Alert	<ul style="list-style-type: none"> • On current course, corrective action required • Coordinate with ATC to determine an appropriate maneuver 	DMOD = 0.66 nmi HMD = 0.66 nmi ZTHR = 450 ft modTau = 35 sec	55 sec (TCPA approximate: 90 sec)	"Traffic, Avoid"
	DAA Preventive Alert	<ul style="list-style-type: none"> • On current course, corrective action should not be required • Monitor for intruder course changes • Talk with ATC if desired 	DMOD = 0.66 nmi HMD = 0.66 nmi ZTHR = 700 ft modTau = 35 sec	55 sec (TCPA approximate: 90 sec)	"Traffic, Monitor"
	Basic Traffic	<ul style="list-style-type: none"> • No action expected 	Within surveillance field of regard	x	N/A

Phase 1 Accomplishments

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

DAA Relationships (FAA, RTCA, ICAO)

- FAA Research Transition Team (RTT)
 - DAA leads
 - Paul Campbell, FAA. Jay Shively, NASA.
- RTCA
 - SC 228 (DAA)
 - SC 147 (TCAS)
- ICAO
 - RPAS Panel – Advisor to US member and chairman; Randy Willis, FAA
 - Human In The Systems (HITS) rapporteur
 - Human Factors in RPAS Chapter

Flight Test 6

- Low Space, Weight and Power (SWaP) RADAR
- Low SWaP Well Clear Definition
- Tiger Shark Aircraft, Vigilant Spirit Ground Control Station



M:N

- Enable a single operator (or group of operators) to control multiple vehicles through human autonomy teaming (HAT) principles.

f (Nt, St, dist)

- *Neglect time f (automation, working agreements)*
- *Service time f (playbook)*
- *Distro f(predictive timeline displays)*

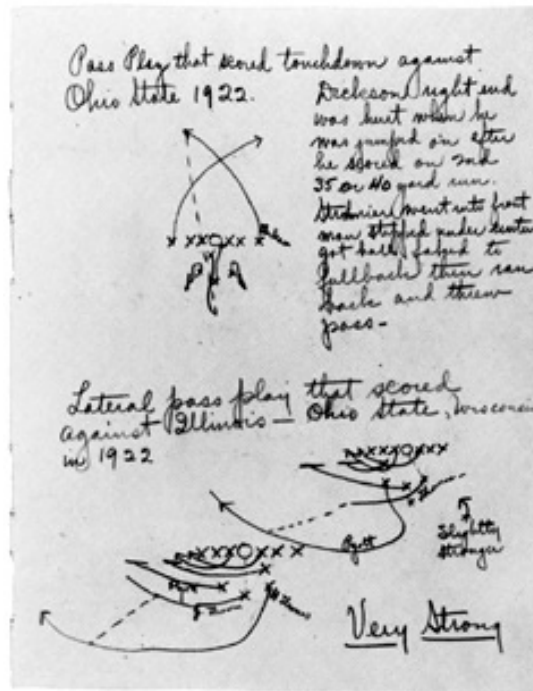
[Potential collaboration with Jack Dwyer, Boeing, under Space Act]

- Air taxi – 1:5
- Air freighter – 2:10
- Delivery – 1:100

Baseline TASKS – FY 20

- *CONOPS*
- *Roles and responsibilities*
- *Technology Forecast*
- *Simulation build-up*
- *HITL*

Delegation Control: Playbook[®]



A page from Alonzo Stagg's 1927 Playbook

- Delegation: one way humans manage supervisory control with heterogeneous, intelligent assets
- Playbook[®]: one's means of delegation
- Plays: analogous to football
 - Quick commands – complex actions
- A Play provides a framework
 - References an acceptable range of plan/behavior alternatives
 - Requires shared knowledge of domain Goals, Tasks and Actions
 - Supervisor can further constrain/stipulate
- Potentially facilitates intuitive cooperative control of Unmanned Systems

Example: Troops in Contact Tango

Predator Provides Overwatch and looks for egress routes

TANGO

Shadow provides situation awareness

Firescout Does Quick Med Drop



© 2009 Tele Atlas

Map data: Google, DigitalGlobe

Flight Demonstration 2011

Ft. Hunter-Liggett CA, 19 May 2011

Purpose:

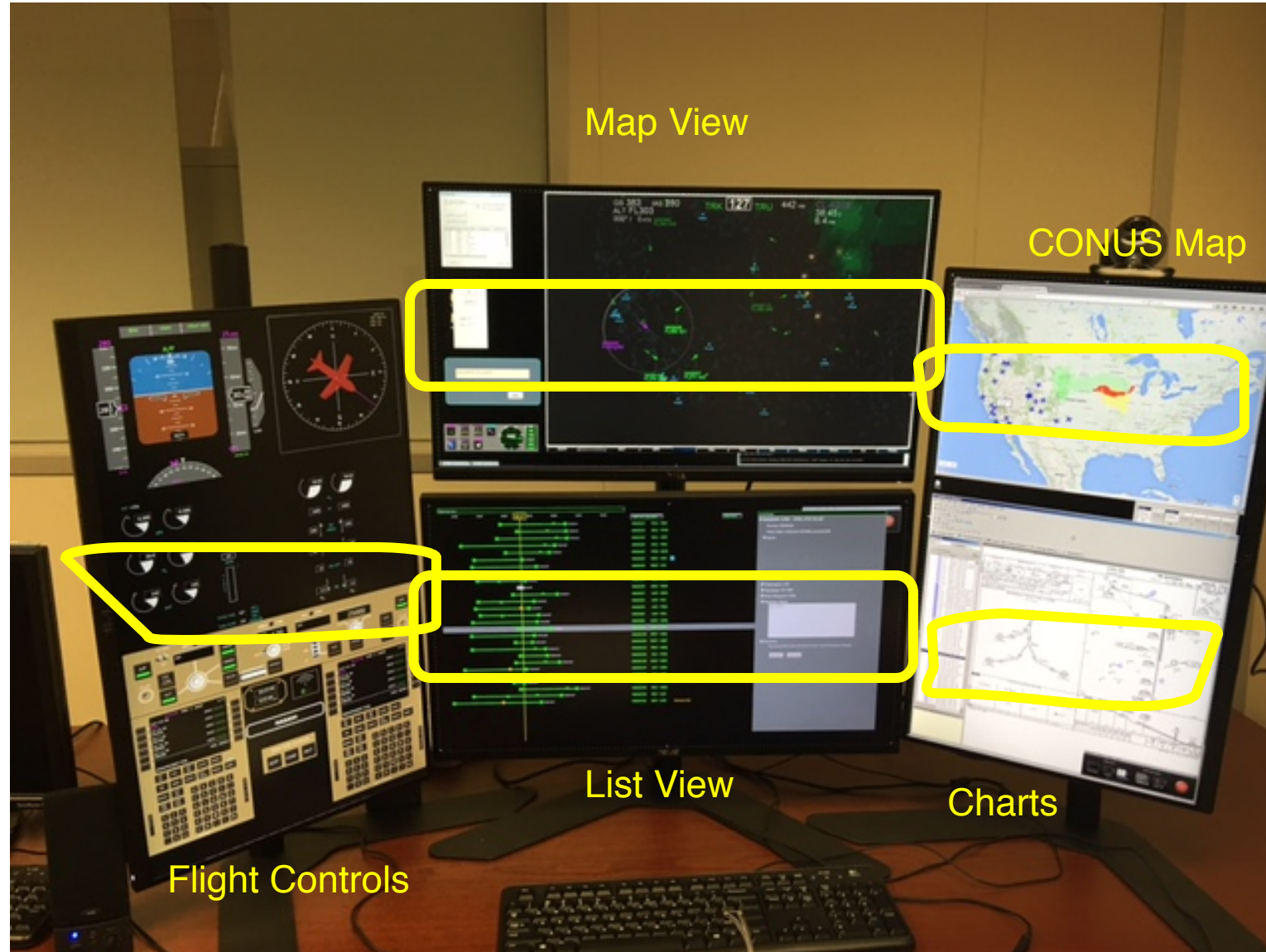
- Build on previous simulations and flight test examining single operator control of multiple heterogeneous ground/air unmanned systems through delegation control employment
 - Operator performance data collection/workload assessments
 - Heterogeneous flight assets: **Boeing Scan Eagle** and **Yamaha RMAX**; two virtual UAS
 - Testing in operationally relevant mission scenarios
 - Multi-sensor cross-cue in support of both targeting and convoy support
- Army AFDD/Boeing CRADA

Key Objective:

- Develop and test DelCon **Top Priority Plays**; route recon, convoy support, troops in contact



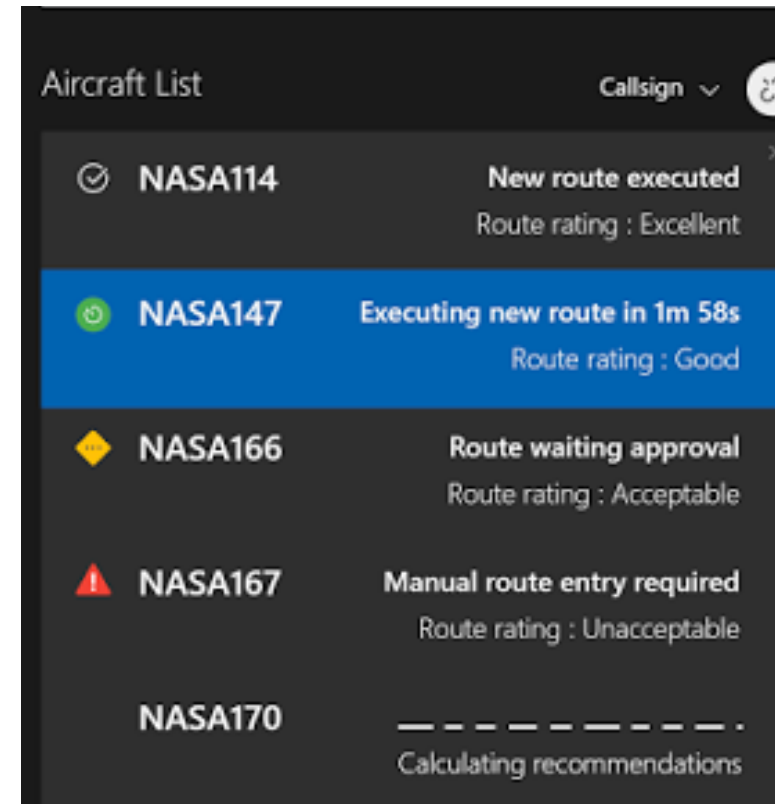
Ground Station Layout: Reduced Crew Operations



ALTA Action Phase

Based on working agreements, the Agent will do one of the following:

- [Auto] autonomously executes and informs operator
- [Veto] presents a solution which will be autonomously executed unless the operator intervenes
- [Select] presents multiple options for operator selection



The screenshot displays an 'Aircraft List' interface with a dark background. At the top right, there is a 'Callsign' dropdown menu and a help icon. The list contains five entries, each with a status icon, a callsign, and a description of the current state or action. The entry for NASA147 is highlighted in blue.

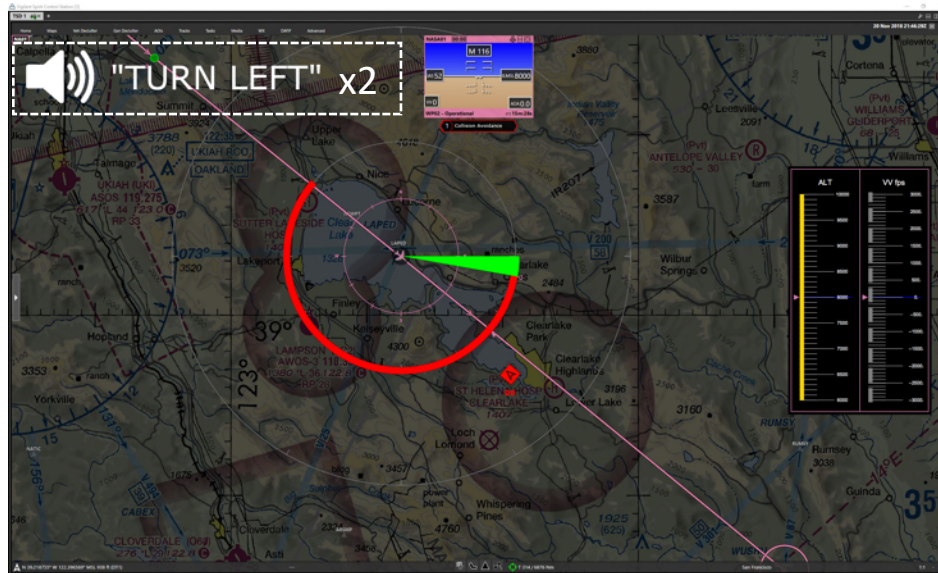
Icon	Callsign	Status / Action	Route Rating
✔	NASA114	New route executed	Excellent
🔄	NASA147	Executing new route in 1m 58s	Good
⚠	NASA166	Route waiting approval	Acceptable
🚨	NASA167	Manual route entry required	Unacceptable
	NASA170	Calculating recommendations	

Working Agreements: A Path to Full Autonomy

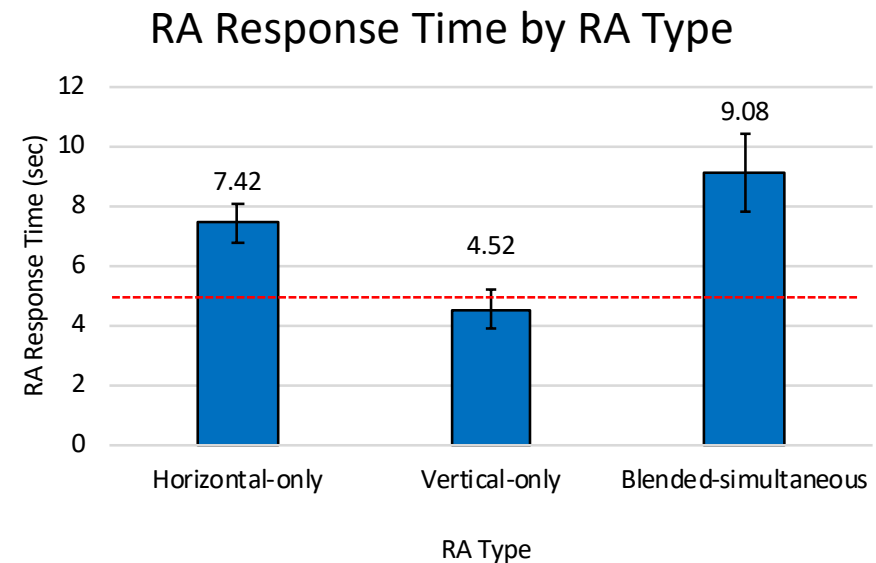
- Working agreements allow the task structure to remain the same while the involvement of human operators decreases due to improvements in the automation and increases in trust

ACAS Xu Engineering Analysis

- Examined how to present ACAS Xu Resolution Advisories (RAs) and how to automate them
 - ACAS X is unique in that it can issue *horizontal* RAs and *blended* RAs (simultaneous vertical & horizontal RA guidance)
- Findings heavily implied that increased automation is necessary to meet response time requirement (5 sec)



Screenshot of active Horizontal RA



ACAS Xu Engineering Analysis

- Investigated how best to annunciate auto-RA and auto-Return-to-Course (RTC) responses
 - E.g., do pilots need a dedicated aural alert 'Executing' or 'Returning'
- Also examined how to implement 'disengaging' the automation

