National Aeronautics and Space Administration

NASA UAS Integration Into the NAS Project Detect and Avoid Display Evaluations

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Background

- Approach: Conduct a series of iterative human in the loop experiments, in a representative simulation environment, with different display configuration to objectively measure pilot performance on maintaining well clear
  - Key metrics: pilot response time, losses of well clear, severity of losses of well clear
  - Four simulations have been conducted: PT4, iHITL, PT5, PT6
    - Displays are modified/improved/changed based on data/observations
    - Displays are carried through to new HITLs to create anchors or linkages to previous data for comparison
    - New displays are developed for test
    - Test/simulation environment/protocols also updated and improved between HITLs
  - Two "mini-HITLs"
    - TCAS interoperability
    - Missing Information

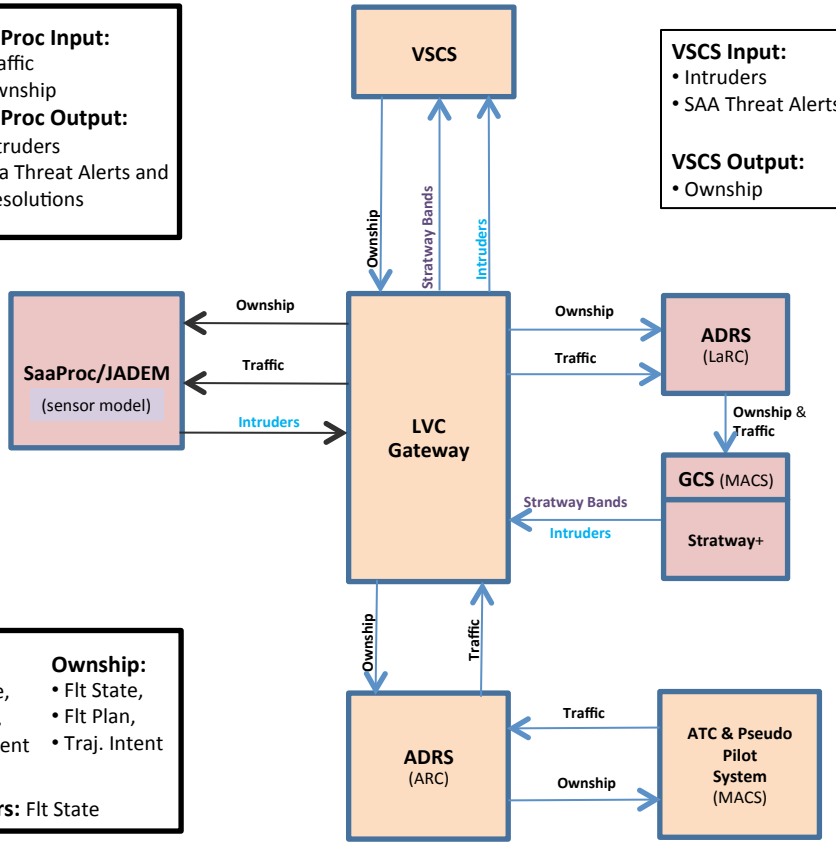
Simulation Environment: Draft MOPS Alerting Structure

Symbol	Name	Pilot Action	Buffered Well Clear Criteria	Alerting Time Threshold	Aural Alert Verbiage
	DAA Warning Alert	• ***Immediate action required*** • Notify ATC as soon as practicable after taking action	DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft modTau = 35 sec	25 sec (TCPA approximate: 60 sec)	"Traffic, Maneuver Now"
	DAA Corrective Alert	• On current course, ***corrective action required*** • Coordinate with ATC to determine an appropriate maneuver	DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft modTau = 35 sec	55 sec (TCPA approximate: 90 sec)	"Traffic, Avoid"
	DAA Preventive Alert	• On current course, corrective action ***should not be required*** • Monitor for intruder course changes • Talk with ATC if desired	DMOD = 1.0 nmi HMD = 1.0 nmi ZTHR = 700 ft modTau = 35 sec	55 sec (TCPA approximate: 90 sec)	"Traffic, Monitor"
	Remaining Traffic	• No action expected	Within surveillance field of regard	X	N/A

Simulation Environment: LVC Architecture

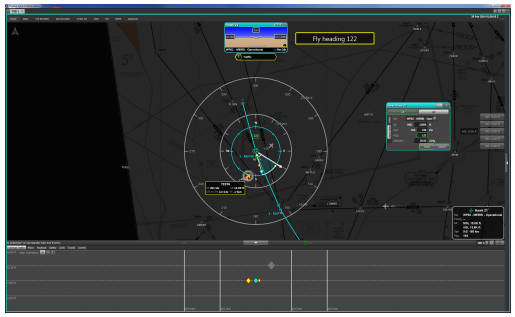
SaaProc Input:
- Traffic
- Ownship

SaaProc Output:
- Intruders
- Saa Threat Alerts and Resolutions



VSCS Input:
- Intruders
- SAA Threat Alerts

VSCS Output:
- Ownship



Stratway Input:
- Intruders
- Ownship

Stratway Output:
- Stratway Bands Msg

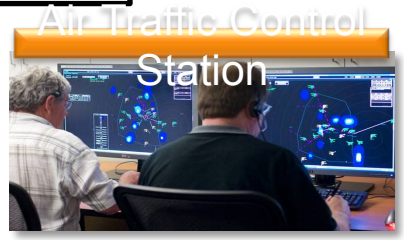
Traffic:
- Flt State,
- Flt Plan,
- Traj. Intent

Ownship:
- Flt State,
- Flt Plan,
- Traj. Intent

Intruders: Flt State

ATC & PPilots Input:
- Ownship

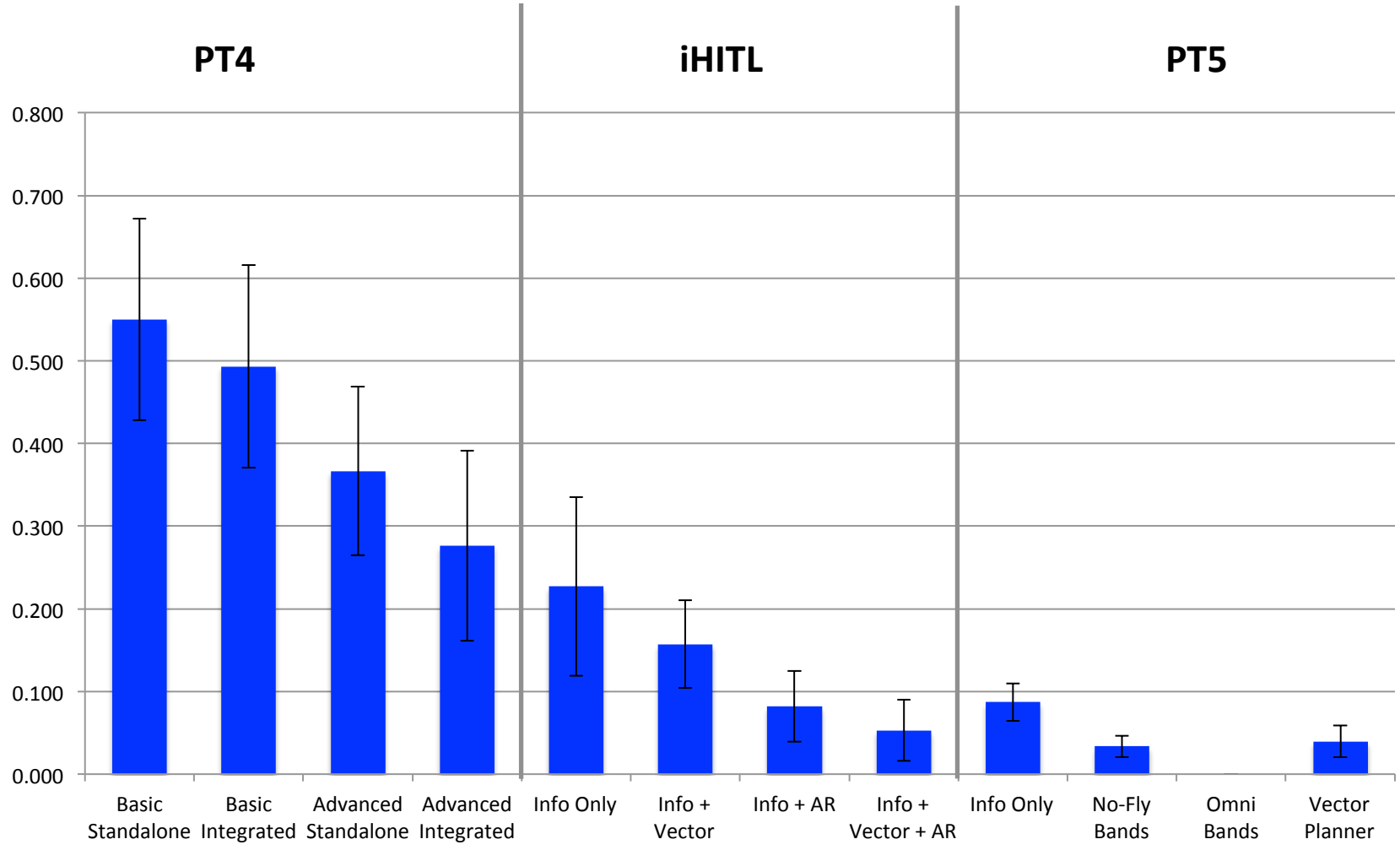
ATC & PPilots Output:
- Traffic



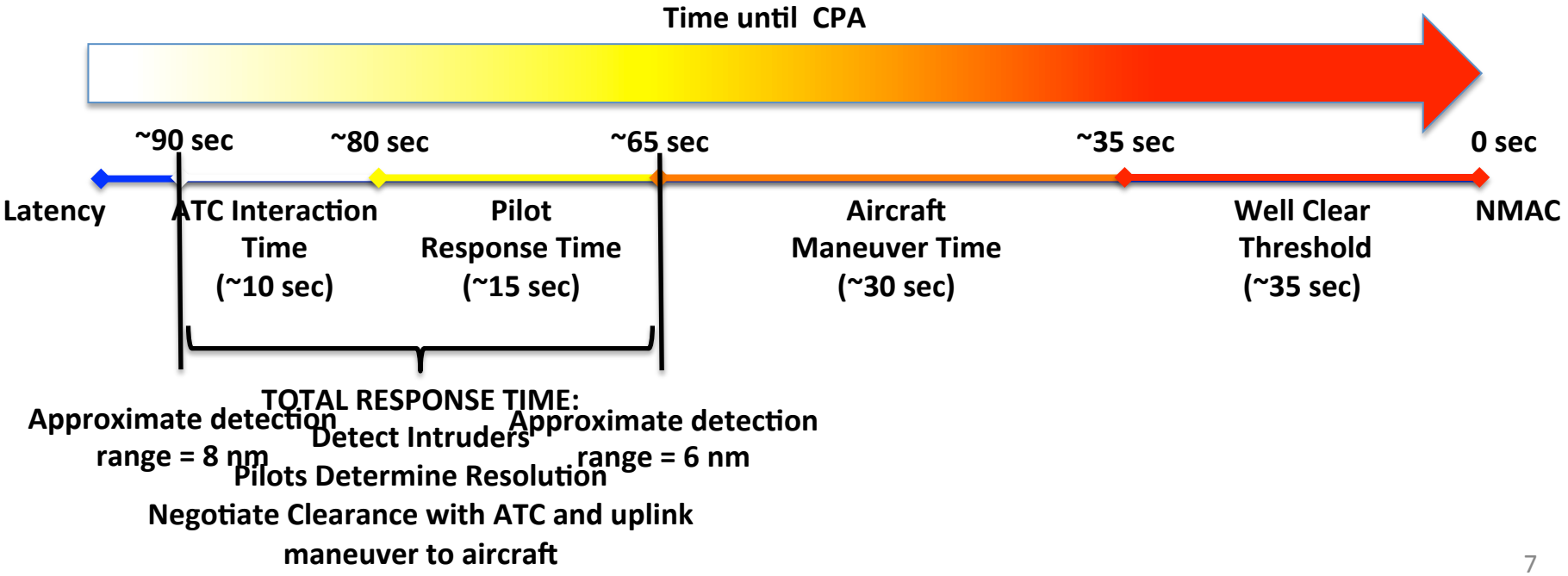
GCS Simulation

- **Vigilant Spirit Control Station (VSCS)** from Air Force Research Laboratory (AFRL)
- Modification and on-site support by AFRL
- New Space Act Agreement is in process to continue and extend this collaboration
- Provides experimental flexibility and also mature enough to use in flight test
  - AFRL has used in flight test with small UAS
  - NASA has used it as standalone traffic display & as a control station to send commands to surrogate UAS

Losses of Well Clear Proportions Across Simulations



Self-Separation Timeline



DAA-TCAS Alerting Structure

Symbol	Name	Pilot Action	Buffered Well Clear Criteria	Alerting Time Threshold	Aural Alert Verbiage
	TCAS RA	• **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	• ***Immediate action required*** • Notify ATC as soon as practicable after taking action	DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft modTau = 35 sec	25 sec (TCPA approximate: 60 sec)	"Traffic, Maneuver Now"
	DAA Corrective Alert	• On current course, ***corrective action required*** • Coordinate with ATC to determine an appropriate maneuver	DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft modTau = 35 sec	55 sec (TCPA approximate: 90 sec)	"Traffic, Avoid"
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	Remaining Traffic	• No action expected	Within surveillance field of regard	X	N/A

Summary
RTCA SC 228 Phase 1 MOPS

- Suggestive Displays
  - Guidance Bands
- Integrated or stand alone*
- Alerting Logic
- Minimum Information tags
- TCAS/DAA interop logic
- Well Clear Recovery logic/display
- Pilot response timeline
  - Derived RADAR Requirements

Support of RTCA MOPS Phase 2 (in planning)

Potential DAA Topics:

- Well Clear
- Terminal Operations
- Alternative Sensors
- GBSAA

VSCS:

- New well clear definitions
- New Sensor Models
- Smaller UAS Models
- Terminal Airspace