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
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Pilot Action</th>
<th>Buffered Well Clear Criteria</th>
<th>Alerting Time Threshold</th>
<th>Aural Alert Verbiage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAA Warning Alert</td>
<td>• <strong>Immediate action required</strong></td>
<td>DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft modTau = 35 sec</td>
<td>25 sec (TCPA approximate: 60 sec)</td>
<td>“Traffic, Maneuver Now”</td>
</tr>
<tr>
<td></td>
<td>DAA Corrective Alert</td>
<td>• On current course, <strong>corrective action required</strong></td>
<td>DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft modTau = 35 sec</td>
<td>55 sec (TCPA approximate: 90 sec)</td>
<td>“Traffic, Avoid”</td>
</tr>
<tr>
<td></td>
<td>DAA Preventive Alert</td>
<td>• On current course, corrective action <strong>should not be required</strong></td>
<td>DMOD = 1.0 nmi HMD = 1.0 nmi ZTHR = 700 ft modTau = 35 sec</td>
<td>55 sec (TCPA approximate: 90 sec)</td>
<td>“Traffic, Monitor”</td>
</tr>
<tr>
<td></td>
<td>Remaining Traffic</td>
<td>• No action expected</td>
<td>Within surveillance field of regard</td>
<td>X</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**DMOD** = Decision Making Omission Distance

**HMD** = Human Memory Distance

**ZTHR** = Zone Threshold

**modTau** = Modified Traffic Approximation Time

**TCPA** = Time to Closest Point of Approach
Simulation Environment: LVC Architecture

**SaaProc Input:**
- Traffic
- Ownship

**SaaProc Output:**
- Intruders
- Saa Threat Alerts and Resolutions

**SaaProc/JADEM (sensor model):**
- Traffic
- Ownship

**Stratway Input:**
- Intruders
- Ownship

**Stratway Output:**
- Stratway Bands Msg

**VSCS Input:**
- Intruders
- SAA Threat Alerts

**VSCS Output:**
- Ownship

**LVC Gateway:**
- Traffic
- Ownship

**Intruders:**
- Traffic

**Ownship:**
- Traffic

**ADRS (LaRC):**
- Traffic
- Ownship

**ATC & Pseudo Pilot System (MACS):**
- Traffic

**ATC & PPIlots Input:**
- Ownship

**ATC & PPIlots Output:**
- Traffic
- **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

- PT4
  - Basic Standalone
  - Basic Integrated
  - Advanced Standalone
  - Advanced Integrated
  - Info Only
  - Info + Vector
  - Info + AR
  - Info + Vector + AR
  - Info Only
  - No-Fly Bands
  - Omni Bands
  - Vector Planner

- iHITL

- PT5
Self-Separation Timeline

Approximate detection range = 8 nm
Detect Intruders
Pilots Determine Resolution
Negotiate Clearance with ATC and uplink
maneuver to aircraft
# DAA-TCAS Alerting Structure

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</table>
| ![Symbol] | 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” |
| ![Symbol] | 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” |
| ![Symbol] | 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” |
| ![Symbol] | 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” |
| ![Symbol] | 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