UAS Integration into the NAS: iHITL: DAA Display Evaluation
Preliminary Results

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Overview

• Goals:

1. Leverage the lessons learned from PT4 to continue the evaluation of candidate Sense and Avoid (SAA) with respect to pilot performance of the self-separation function
   • What are the individual contributions of the various PT4 advanced display features to pilots’ response times and ability to maintain well clear?
2. Introduce non-cooperative intruders to examine effect of different sensor ranges on pilots’ ability to maintain well clear

• Rationale

  – PT4 compared a ‘Basic’ display configuration to a suite of ‘Advanced’ features
    • iHitL design will allow us to measure any differences between specific display features and determine the implications of their presence or absence in the GCS
  – Non-cooperative traffic are a major consideration in the development of SAA systems
    • The presence of non-cooperative aircraft provides a more realistic environment
    • Limited surveillance range and field of regard may have significant impact on pilot performance and behavior
Experimental Design

• One-Way Repeated Measures Factorial: Display Information Level (4 Level; Within Subjects)
  – D1: Advanced Display with Information Only
  – D2: Advanced Display with Information + Vector Planner
  – D3: Advanced Display with Information + Auto Resolutions
  – D4: Advanced Display with Information + Vector Planner + Auto Resolutions
    • Roughly same as ‘Advanced’ suite in PT4

• Embedded Variable
  – Track Type (manipulated within each scenario; not counterbalanced)
    1. Cooperative Traffic (ADS-B-equipped)
      – Range = 80nm & +/- 5000ft
    2. Non-Cooperative Traffic
      – Range = 6nm
      – Azimuth = +/- 110deg (from nose)
      – Elevation = +/- 20deg (from horizontal)
Alerting Criteria

Vertical Separation
- Well-clear: 400 feet
- Self Separation: 900 feet
- Preventive: 900 feet

Time until CPA:
- 110 s

“Well Clear” Threshold: 40 s

“Self Separation” Threshold: 400 feet

“Preventive Alert” Threshold: 900 feet
Display Conditions
D1 Encounter
D2 Encounter
D3 Encounter
D4 Encounter
Participants

• Participants:
  – 4 MQ-1 Predator/MQ-9 Reaper Pilots (avg. 46 years old)
    • All received Undergraduate Pilot Training
  – 5 RQ-4 Global Hawk Pilots (avg. 33 years old)
    • 3 received Undergraduate Pilot Training
    • 1 received RQ-4 Basic Training (AF Specialty Code 18X)
    • 1 received cross training
  – All 9 pilots had military UAS experience
    • Military Combat & Non-Combat Experience = avg. 1182 hours
    • Civilian Airspace = avg. 153 hours
      – 5 pilots had less than 50 hours of experience flying in civilian airspace
  – 1 retired Air Traffic Controller with experience in Oakland Center airspace (confederate)
Procedure

• UAS Scenario (38min)
  – UAS: Predator B
  – Airspace: ZOA 40/41
    • Class A & E with mixed IFR/VFR traffic
    • Manned traffic modeled using real traffic data

• Primary Tasks:
  1. Fly HAWK21 along pre-filed path (Fire Line)
     • Only responsible for navigating the aircraft
     • Requires interaction with the GCS and coordination ATC
  2. Comply with ATC clearances and traffic display alerts to maintain safety of flight

• Secondary tasks:
  – ‘Chat’ directed
    • “Mission” Radio Frequency changes
    • Radial and Distance check
    • Nominal information requests (e.g., fuel level remaining)
  – System Alerts
    • Generator Failure (checklist)
    • Tanker Header Overpressure (checklist)
    • Annunciator checks
Research Ground Control Station
Simulation Architecture

ARC CVSRF – ATC Lab
- Voice Comm
- MACS Sim Manager Traffic Generator
- Ghost Pilot
- Ghost Controller
- Controller Station
- ADRS

ARC CVSRF – Pilot Lab
- Voice Comm
- MACS Pseudo Pilot
- MACS Pseudo Pilot
- MACS Pseudo Pilot

ARC DSRL
- HLA - High Level Architecture
- ADRS Toolbox
- MACS Observer
- RUMS Server
- LVC GW Toolbox

DFRC RGCS LAB
- Pilot Control Station
- Eye Tracker
- Pilot Cms
- Vigilant Spirit Control Station (VSCS SIM)
- VSCS Traffic Display

DFRC LVC LAB
- LVC Gateway
- Gateway Data Logger
- Voice Comm
- SAA Proc
- AutoResolver/CA
- Voice Comm

IT&E Components
- RUMS Server
- Internet Browser
- CSD Observer
- Observer
- Internet
- Brouser
- Observer
- MACS Observer

LVC Participants & Displays
- DIS Voice Tunneler
- Internet
Initial Research Question

- What was the effect of the DAA guidance tools on pilots’ performance in response to self separation alerts?
  - Same measured response metrics as those captured in PT4

- Measured Response data were analyzed utilizing 5 separate One-Way Analyses of Variance (ANOVAs)

I. Independent Variable: Display
   1) D1: Advanced Display with Information Only
   2) D2: Advanced Display with Information + Vector Planner
   3) D3: Advanced Display with Information + Auto Resolutions
   4) D4: Advanced Display with Information + Vector Planner + Auto Resolutions

II. Analyses for: Alert Type and Intruder Type
   1) All self separation (SS) alerts
   2) Predictive SS alerts (yellow with red outline; collapsed across Intruder Type)
   3) Non-Predictive SS alerts (yellow; collapsed across Intruder Type)
   4) Cooperative SS alerts (collapsed across Alert Type)
   5) Non-Cooperative SS alerts (collapsed across Alert Type)
Stages of Pilot DAA Task

T<sub>0</sub>: Traffic Display Alert (SS or CA)
T<sub>1</sub>: Pilot Notifies ATC
T<sub>2</sub>: ATC Approval
T<sub>3</sub>: Pilot Initiates Edit
T<sub>4a</sub>: Pilot Uploads First Edit
T<sub>4b</sub>: Pilot Uploads Final Edit
T<sub>5</sub>: Traffic Alert Removed
T<sub>6</sub>: UAS Completes Maneuver

Compliance Time

Alert Duration Time

Total Response Time

Aircraft Response Time

Initial Response Time

Clearance Approval Time

Initial Edit Time (First Upload)

Total Edit Time (Final Upload)

Time

Notification Time

Initial Response Time

Clearance Approval Time

Initial Edit Time (First Upload)

Total Edit Time (Final Upload)

Approval vs Upload Time

Notify vs Upload Time

Approval vs Upload Time

Approval vs Upload Time
Self-Separation Timeline

TOTAL RESPONSE TIME:
Detect Intruders
Pilots Determine Resolution
Negotiate Clearance with ATC and uplink maneuver to aircraft

Time until CPA

110 sec  ? sec  35 sec

Aircraft Maneuver Time
Well Clear Threshold
Encounter Statistics

- **Total Number of Encounters:**
  - **Alert Type:**
    - 134 Predictive SS Alerts
    - 115 Non-Predictive SS Alerts
  - **Intruder Type:**
    - 92 Cooperative
    - 157 Non-Cooperative

- **Pilots responded to a total of 196 Self Separation Alerts**
  - **Alert Type:**
    - 122 Predictive SS Alerts (91% of total)
    - 74 Non-Predictive SS Alerts (64% of total)
  - **Intruder Type:**
    - 61 Cooperative (66% of total)
    - 135 Non-Cooperative (86% of total)
  - **Alert Type X Intruder Type:**
    - 25 Cooperative/Predictive
    - 36 Cooperative/Non-Predictive
    - 97 Non-Cooperative/Predictive
    - 38 Non-Cooperative/Non-Predictive
Data Slides Organization

- Slides organized by metric
  - Analysis of Variance (ANOVA) results for All SS Alerts
    - Was there an effect of Display on the dependent variable?
  - ANOVA by Alert Type
  - ANOVA by Intruder Type
  - Means of the Alert/Intruder Type by Display
  - Means of Display by Alert/Intruder Type
  - Comparison of display means for PT4 and iHITL
# iHITL Results

## Summary of Results

<table>
<thead>
<tr>
<th></th>
<th>PT4 Grand Mean</th>
<th>iHITL Grand Mean</th>
<th>All SS</th>
<th>Predictive</th>
<th>Non-Predictive</th>
<th>Cooperative</th>
<th>Non-Cooperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notification Time</td>
<td>29.07s</td>
<td>14.03s</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Clearance Approval Time</td>
<td>5.08s</td>
<td>5.54s</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
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<td>ATC Notification vs Upload Time</td>
<td>3.51s</td>
<td>0.18s</td>
<td>p = .075</td>
<td>X</td>
<td>p &lt; .05</td>
<td>p = -.55</td>
<td>X</td>
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<tr>
<td>ATC Approval vs Upload Time</td>
<td>-1.52s</td>
<td>-6.46s</td>
<td>p = .092</td>
<td>X</td>
<td>p &lt; .05</td>
<td>p = .070</td>
<td>X</td>
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<tr>
<td>Initial Response Time</td>
<td>19.32s</td>
<td>8.52s</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Initial Edit Time</td>
<td>11.77s</td>
<td>6.29s</td>
<td>p &lt; .01</td>
<td>p &lt; .05</td>
<td>p &lt; .05</td>
<td>p &lt; .01</td>
<td>p = .056</td>
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<td>Total Edit Time</td>
<td>17.65s</td>
<td>9.83s</td>
<td>X</td>
<td>p &lt; .05</td>
<td>X</td>
<td>X</td>
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<td>Aircraft Response Time</td>
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<td>14.54s</td>
<td>p = .069</td>
<td>p = .059</td>
<td>p &lt; .05</td>
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<td>Total Response Time</td>
<td>37.87s</td>
<td>18.08s</td>
<td>X</td>
<td>p = .056</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Alert Duration Time</td>
<td>48.61s</td>
<td>33.58s</td>
<td>X</td>
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<td>X</td>
<td>X</td>
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<td>Compliance Time</td>
<td>71.43s</td>
<td>37.53s</td>
<td>p &lt; .05</td>
<td>p &lt; .05</td>
<td>X</td>
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<td>X</td>
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</tbody>
</table>

Only 6 significant differences between display conditions
Some Results:

Total Edit Time

Total Response Time
Stages of Pilot DAA Task

- \( T_0 \): Traffic Display Alert (SS or CA)
- \( T_1 \): Pilot Notifies ATC
- \( T_2 \): ATC Approval
- \( T_3 \): Pilot Initiates Edit
- \( T_{4a} \): Pilot Uploads First Edit
- \( T_{4b} \): Pilot Uploads Final Edit
- \( T_5 \): Traffic Alert Removed
- \( T_6 \): UAS Completes Maneuver

**Compliance Time**

- Alert Duration Time
- Total Response Time
- Aircraft Response Time
- Initial Response Time
- Initial Edit Time (First Upload)
- Total Edit Time (Final Upload)

**Other Times**

- Notification Time
- Clearance Approval Time
- Initial Edit Time
- Total Response Time
- Upload Time
- Approval Time
- Total Upload Time
There was a not significant effect of Display on Total Edit Time for all SS alerts, \( p > .05 \)

Pilots took an average of **9.83 seconds** to complete their final edit in response to SS alerts
• There was a significant effect of Display on Total Edit Time for Predictive alerts, p < .05
  - D3 was significantly faster than D2, but no different than the other two displays
• Pilots took an average of 8.83 seconds to complete their final edit in response to Predictive SS alerts

• There was no significant main effect of Display on Total Edit Time for Non-Predictive alerts, p > .05
• Pilots took an average of 12.862 seconds to complete their final edit in response to Non-Predictive SS alerts
There was no significant effect of Display on Total Edit Time for Cooperative SS alerts, $p > .05$

Pilots took an average of 12.08 seconds to complete their final edit in response to Cooperative SS alerts

There was a near significant effect of Display on Total Edit Time for Non-Cooperative SS alerts, $p = .064$

Pilots took an average of 8.31 seconds to complete their final edit in response to Non-Cooperative alerts
## Total Edit Time

<table>
<thead>
<tr>
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<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
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<td><strong>Non-Cooperative/Non-Predictive</strong></td>
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Total Edit Time

<table>
<thead>
<tr>
<th></th>
<th>Cooperative/Predictive</th>
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<th>Non-Cooperative/Predictive</th>
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</thead>
<tbody>
<tr>
<td>D1</td>
<td>16.33</td>
<td>16.40</td>
<td>13.26</td>
<td>8.21</td>
</tr>
<tr>
<td>D2</td>
<td>12.64</td>
<td>12.63</td>
<td>10.50</td>
<td>10.86</td>
</tr>
<tr>
<td>D3</td>
<td>14.00</td>
<td>2.50</td>
<td>2.64</td>
<td>13.17</td>
</tr>
<tr>
<td>D4</td>
<td>12.17</td>
<td>13.64</td>
<td>4.54</td>
<td>9.40</td>
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</tbody>
</table>
Stages of Pilot DAA Task

- Traffic Display Alert (SS or CA)
- Pilot Notifies ATC
- ATC Approval
- Pilot Initiates Edit
- Pilot Uploads First Edit
- Pilot Uploads Final Edit
- Traffic Alert Removed
- UAS Completes Maneuver

Time Points:
- $T_0$: Traffic Display Alert
- $T_1$: Pilot Notifies ATC
- $T_2$: ATC Approval
- $T_3$: Pilot Initiates Edit
- $T_{4a}$: Pilot Uploads Final Edit
- $T_{4b}$: Traffic Alert Removed
- $T_5$: UAS Completes Maneuver
- $T_6$: 

Key Times:
- Initial Response Time
- Initial Edit Time (First Upload)
- Total Edit Time (Final Upload)
- Aircraft Response Time
- Compliance Time
- Alert Duration Time
- Total Response Time
- Notification Time
- Clearance Approval Time
- Initial Response Time

Comparisons:
- Notify vs Upload Time
- Approval vs Upload Time

Process:
- Pilot Notifies ATC
- ATC Approves
- Pilot Initiates Edit
- Pilot Uploads First Edit
- Pilot Uploads Final Edit
- Traffic Alert Removed
- UAS Completes Maneuver
• There was not a significant effect of Information on Total Response Time for all SS alerts, $p > .05$

• Pilots took an average of **18.08 seconds** to complete their final edit in response to SS alerts (from first alert appearance)
There was a near significant effect of Display on Total Response Time for Predictive SS alerts, $p = .056$

Pilots took an average of 16.22 seconds to complete their final edit in response to Predictive SS alerts (from first alert appearance)
• There was no significant effect of Information on Aircraft Response Time for Cooperative SS alerts, p > .05
• Pilots took an average of 23.92 seconds to complete their final edit in response to Cooperative SS alerts (from first alert appearance)

• There was no significant effect of Display on Aircraft Response Time for Non-Cooperative SS alerts, p > .05
• Pilots took an average of 15.15 seconds to complete their final edit in response to Non-Cooperative SS alerts (from first alert appearance)
Total Response Time

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
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<tr>
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<td>15.48</td>
<td>10.52</td>
<td>11.23</td>
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<td>21.64</td>
<td>16.67</td>
<td>22.90</td>
<td>16.10</td>
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</table>
Total Response Time

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
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<tr>
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<td>21.64</td>
<td>16.67</td>
<td>22.90</td>
<td>16.10</td>
</tr>
</tbody>
</table>
iHITL Results Summary

• Few Meaningful Significant Results
  – Except for one, all for edit times where D3, and sometimes D4, are significantly faster
  – Does not translate to significant difference in total response time
    • No more than 8.5s difference between fastest and slowest times from Non-Cooperative/Predictive

• Some overall Trends:
  – Predictive alerts tended to have faster response times than Non-Predictive alerts
  – Non-Cooperative alerts tended to have faster response times than Cooperative alerts
  – Except for Edit Times, appears to be less variability across Intruder/Alert (especially Non-Cooperative/Predictive) type than Display type
iHITL Results Summary

• Initial Response Time:
  – Non-Cooperative on average 5 seconds faster than Cooperative
  – Intruder/alert type appears more predictive of response time with low variability between D1 – D4
  – Non-Cooperative/Predictive fastest overall

• Initial Edit Time:
  – D3 consistently significantly fastest
  – D1 consistently significantly slowest
  – Lower variability for D3 and D2, higher variability for D1 and D4 across Intruder type

• Total Edit Time:
  – D3 significantly faster than D2 for Predictive SS alerts only (about 8 seconds faster)
  – Non-Cooperative on average 4 seconds faster than Cooperative
  – Least variability in D2 across Intruder/Alert Type

• Aircraft Response Time
  – D4 significantly faster than D1 and D2 (10-20 seconds)
  – Lowest and least variability in response times for Non-Cooperative/Predictive
  – Least variability in D4

• Total Response Time
  – No significant results
  – Predictive on average 5.5 seconds faster than Non-Predictive
  – Non-Cooperative on average 9 seconds faster than cooperative
iHITL and PT4 Results

• iHITL Response Times faster than PT4 Response Times
• Closest comparisons:
  – PT4 Basic_Integrated (Basic) vs. iHITL D1
    • D1 added information: predictive alert level, well clear ring, intruder CPA location
  – PT4 Advanced_Integrated (Advanced) vs. iHITL D4
    • D4 removed information: vertical situation display, ownship CPA, time to CPA
• Initial Response Time, about 11 seconds faster overall (19.32s vs. 8.52s)
• Total Edit Time, about 8 seconds faster overall (17.65s vs. 9.82s)
• Total Response Time, about 8 seconds faster overall (37.87s vs. 18.08s)

<table>
<thead>
<tr>
<th>Measure</th>
<th>PT4 Basic</th>
<th>iHITL D1</th>
<th>PT4 Advanced</th>
<th>iHITL D4</th>
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<tr>
<td>Initial Response Time</td>
<td>22</td>
<td>8</td>
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<td>7</td>
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<td>Total Edit Time</td>
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<td>Total Response Time</td>
<td>45</td>
<td>21</td>
<td>32</td>
<td>16</td>
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</table>
Total Edit Time

IHITL and PT4 Display Comparison

- D1: 12.65
- D2: 11.43
- D3: 6.74
- D4: 8.51
- Int_Basic: 22.65
- Int_Advanced: 10.08
- SA_Basic: 21.60
- SA_Advanced: 16.28
Total Response Time

IHITL and PT4 Display Comparison

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>Int_Basic</th>
<th>Int_Advanced</th>
<th>SA_Basic</th>
<th>SA_Advanced</th>
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<tbody>
<tr>
<td></td>
<td>20.54</td>
<td>19.71</td>
<td>16.34</td>
<td>15.74</td>
<td>44.86</td>
<td>32.35</td>
<td>38.68</td>
<td>35.60</td>
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</table>
Self-Separation Timeline

TOTAL RESPONSE TIME:
Detect Intruders
Pilots Determine Resolution
Negotiate Clearance with ATC and uplink maneuver to aircraft

110 sec

Time until CPA

35 sec

Aircraft Maneuver Time

Well Clear Threshold

110 sec

? sec

35 sec
Self-Separation Timeline

Time until CPA

100 sec

94 sec
Basic Integrated (45s)

91 sec
Basic Standalone (39s)

87 sec
Advanced Standalone (36s)

Well Clear Threshold

Latest SS alerting time that allows pilot to upload final maneuver by display
Self-Separation Timeline

- Basic Integrated (45s) - 30 sec
- Basic Standalone (39s) - 36 sec
- Advanced Standalone (36s) - 39 sec
- Advanced Integrated (32s) - 43 sec
Self-Separation Timeline

Time until CPA

110 sec ? sec 35 sec

Aircraft Maneuver Time

Well Clear Threshold

D1 (21s) 54 sec
D2 (20s) 55 sec
D3 (16s) 59 sec
D4 (16s) 59 sec
DAA Task

• What does the DAA Task add to pilot response times?
  – A number of subtasks:
    • Detect
    • Determine
    • Execute

• Can compare to pilot response times when responding to ATC clearances in same navigation mode (AutoPilot; full mission simulation)
  – Assumption that ATC response is near immediate
  – Auto resolution conditions (D3 and D4) actually reduce edit times

<table>
<thead>
<tr>
<th>Measure</th>
<th>FM AP Mean</th>
<th>iHITL Grand Mean</th>
<th>Difference</th>
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<tbody>
<tr>
<td>Initial RT</td>
<td>1.23s</td>
<td>8.25s</td>
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<tr>
<td>Initial Edit Time</td>
<td>9.11s</td>
<td>6.29s</td>
<td>-2.82s</td>
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<tr>
<td>Total Edit Time</td>
<td>9.25s</td>
<td>9.83s</td>
<td>+0.58s</td>
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<tr>
<td>Aircraft RT</td>
<td>10.43s</td>
<td>14.54s</td>
<td>+4.11s</td>
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</table>
Part Task Simulation 5

- Goal: Continue examining DAA display concepts
  - Revisit a minimum information display condition – PT4 Basic with predictive alert level
  - Evaluate suggestive and informative displays
  - Evaluate effect of nominal uncertainty on displays and pilot performance

- Data Collection March 2014
All Results Slides
Stages of Pilot DAA Task

1. 
   - **T0**: Traffic Display Alert (SS or CA)
2. 
   - **T1**: Pilot Notifies ATC
3. 
   - **T2**: ATC Approval
4. 
   - **T3**: Pilot Initiates Edit
5. 
   - **T4a**: Pilot Uploads First Edit
6. 
   - **T4b**: Pilot Uploads Final Edit
7. 
   - **T5**: Traffic Alert Removed
8. 
   - **T6**: UAS Completes Maneuver

**Compliance Time**

- Alert Duration Time
- Total Response Time
- Aircraft Response Time
- Initial Response Time
- Initial Edit Time (First Upload)
- Total Edit Time (Final Upload)

**Notification Time**

- Initial Approval Time

**Clearance Approval Time**

- Notify vs Upload Time
- Approval vs Upload Time

**Response Time**

- Costs of Approval vs Upload Time

**Post-Event Times**

- Clearance Approval Time
- No-fy Time

**Event Timings**

- Total Event Time
- Total Response Time
- Total Compliance Time

**Miscellaneous**

- Edit Time
- Upload Time
- Approval Time
- No-fy Time
• There was a not a significant main effect of Display on ATC Notification Time for all SS alerts, $p > .05$

• Pilots took an average of **14.03 seconds** to notify ATC of a maneuver in response to a SS alert
ATC Notification Time

**Predictive SS Alerts**

- There was no significant effect of Display on ATC Notification Time for Predictive SS alerts, $p > .05$
- Pilots took an average of **14.05 seconds** to notify ATC of a maneuver in response to a Predictive SS alert

**Non-Predictive SS Alerts**

- There was no significant effect of Display on ATC Notification Time for Non-Predictive SS alerts, $p > .05$
- Pilots took an average of **14.52** to notify ATC of a maneuver in response to a Non-Predictive SS alert
• There was no significant effect of Display on ATC Notification Time for Cooperative SS alerts, p > .05
• Pilots took an average of 16.40 seconds to notify ATC of a maneuver in response to a Cooperative SS alert

• There was no significant effect of Display on ATC Notification Time for Non-Cooperative SS alerts, p > .05
• Pilots took an average of 13.15 seconds to notify ATC of a maneuver in response to a Non-Cooperative SS alert
ATC Notification Time

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<td>14.08</td>
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</table>
# ATC Notification Time

## Bar Chart

The bar chart shows the ATC notification times for different scenarios:
- **Cooperative/Predictive**
- **Cooperative/Non-Predictive**
- **Non-Cooperative/Predictive**
- **Non-Cooperative/Non-Predictive**

### Table

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ATC Notification Time

IHITL and PT4 Display Comparison

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<th>D4</th>
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Stages of Pilot DAA Task

- **T₀**: Traffic Display Alert (SS or CA)
- **T₁**: Pilot Notifies ATC
- **T₂**: ATC Approval
- **T₃**: Pilot Initiates Edit
- **T₄a**: Pilot Uploads First Edit
- **T₄b**: Pilot Uploads Final Edit
- **T₅**: Traffic Alert Removed
- **T₆**: UAS Completes Maneuver

Compliance Time

- Alert Duration Time
- Total Response Time
- Aircraft Response Time
- Initial Response Time
- Initial Edit Time (First Upload)
- Total Edit Time (Final Upload)

Time Measurement:

- Notification Time
- Clearance Approval Time
- Initial Edit Time
- Total Edit Time
- Approval vs Upload Time
- Notify vs Upload Time
• There was no significant main effect of Information on Clearance Approval Time, p > .05

• It took an average of **5.54 seconds** for pilots to receive and an ATC approval for a maneuver in response to a SS alert
There was no significant main effect of Information on Clearance Approval Time, p > .05

It took an average of **5.50 seconds** for pilots to receive and an ATC approval for a maneuver in response to a Predictive SS alert

There was no significant main effect of Display on Clearance Approval Time, p > .05

It took an average of **5.96 seconds** for pilots to receive and an ATC approval for a maneuver in response to a Non-Predictive SS alert
Clearance Approval Time

Cooperative SS Alerts

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<tr>
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Non-Cooperative SS Alerts

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<th>D4</th>
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<td>5.54</td>
<td>5.42</td>
<td>5.72</td>
<td>5.21</td>
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</tbody>
</table>

- There was not a significant effect of Display on Clearance Approval Time for Cooperative SS alerts, p > .05
- It took an average of **5.72 seconds** for pilots to receive and an ATC a Cooperative SS alert

- There was no significant effect of Display on Clearance Approval Time for Non-Cooperative SS alerts, p > .05
- It took an average of **5.47 seconds** for pilots to receive and an ATC approval for a maneuver in response to a Non-Cooperative SS alert
Clearance Approval Time

<table>
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Clearance Approval Time

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<td><strong>Approval</strong></td>
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<tr>
<td><strong>Time</strong></td>
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<tr>
<td><strong>Cooperative/Predictive</strong></td>
<td>4.50</td>
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<td><strong>Cooperative/Non-Predictive</strong></td>
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<td><strong>Non-Cooperative/Predictive</strong></td>
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<td><strong>Non-Cooperative/Non-Predictive</strong></td>
<td>4.58</td>
<td>6.86</td>
<td>5.21</td>
<td>6.25</td>
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Clearance Approval Time

IHITL and PT4 Display Comparison

<table>
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<th></th>
<th>D1</th>
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<th>D3</th>
<th>D4</th>
<th>Int_Basic</th>
<th>Int_Advanced</th>
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Stages of Pilot DAA Task

- Traffic Display Alert (SS or CA)
- Pilot Notifies ATC
- ATC Approval
- Pilot Initiates Edit
- Pilot Uploads First Edit
- Pilot Uploads Final Edit
- Traffic Alert Removed
- UAS Completes Maneuver

Compliance Time
- Alert Duration Time
- Total Response Time

Aircraft Response Time
- Initial Response Time
- Initial Edit Time (First Upload)
- Total Edit Time (Final Upload)

Notification Time
- Clearance Approval Time
- Total Response Time

Notify vs Upload Time
- Approval vs Upload Time
- Notify vs Upload Time
Across all maneuvers, pilots requested a clearance **93.4%** of the time

On average, pilots who *requested* an ATC clearance did so prior to maneuvering in response to SS alerts **57.2%** of the time (65.1% overall)

- D1 = 71.3%
- D2 = 56.0%
- D3 = 49.8%
- D4 = 51.8%
• There was a near significant effect of Display on ATC Notification vs Upload Time for all SS alerts, \( p = .075 \)

• On average, pilots requested an ATC clearance 0.18 seconds prior to uploading a maneuver in response to a Predictive SS alert
There was no significant effect of Display on ATC Notification vs Upload Time for Predictive SS alerts, \( p > .05 \)

On average, pilots \textit{requested} an ATC clearance \textbf{1.01 sec after} uploading a maneuver in response to a Predictive SS alert

There was a significant effect of Display on ATC Notification vs Upload Time for Non-Predictive SS alerts, \( p < .05 \)

- No differences between displays were significant

On average, pilots \textit{requested} an ATC clearance \textbf{2.24 seconds prior} to uploading a maneuver in response to a Non-Predictive SS alert
• There was a near significant effect of Information on ATC Notification vs Upload Time for Cooperative SS alerts, $p = .055$
• On average, pilots requested an ATC clearance 2.40 seconds prior to uploading a maneuver in response to a Cooperative SS alert

• There was no significant effect of Display on ATC Notification vs Upload Time for Non-Cooperative SS alerts, $p > .05$
• On average, pilots requested an ATC clearance 0.76 seconds after uploading a maneuver in response to a Non-Cooperative alert
<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
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<tr>
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ATC Notification vs Upload Time

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<th>Cooperative/Non-Predictive</th>
<th>Non-Cooperative/Predictive</th>
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<tbody>
<tr>
<td>D1</td>
<td>2.50</td>
<td>8.13</td>
<td>0.69</td>
<td>6.92</td>
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<td>D2</td>
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<td>-1.66</td>
<td>2.58</td>
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<td>D3</td>
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<td>2.10</td>
<td>-3.43</td>
<td>-0.21</td>
</tr>
<tr>
<td>D4</td>
<td>4.08</td>
<td>-7.29</td>
<td>-4.79</td>
<td>-4.38</td>
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</tbody>
</table>
ATC Notification vs Upload Time

IHITL and PT4 Display Comparison

Stages of Pilot DAA Task

- **T₀**: Traffic Display Alert (SS or CA)
- **T₁**: Pilot Notifies ATC
- **T₂**: ATC Approval
- **T₃**: Pilot Initiates Edit
- **T₄a**: Pilot Uploads First Edit
- **T₄b**: Pilot Uploads Final Edit
- **T₅**: Traffic Alert Removed
- **T₆**: UAS Completes Maneuver

**Key Times**

- **Initial Response Time**
- **Clearance Approval Time**
- **Initial Edit Time (First Upload)**
- **Total Edit Time (Final Upload)**
- **Total Response Time**
- **Compliance Time**
- **Alert Duration Time**
- **Aircraft Response Time**
- **Notification Time**
- **Total Edit Time**
- **Approval vs Upload Time**
- **Notify vs Upload Time**

**Notation**

- **T₀**: Initial Time
- **T₁**: Action Time
- **T₂**: Approval Time
- **T₃**: Edit Time
- **T₄a**: Edit Time
- **T₄b**: Edit Time
- **T₅**: Removal Time
- **T₆**: Completion Time
Across all maneuvers, pilots received a clearance **92.9%** of the time.

On average, pilots who *received* an ATC clearance, did so prior to maneuvering in response to SS alerts **56.2%** of the time (62.8% overall)

- D1 = 49.8%
- D2 = 48.3%
- D3 = 43.5%
- D4 = 33.6%
• There was a near significant effect of Display on ATC Approval vs Upload Time for all SS alerts, $p = 0.092$

• On average, pilots *received* an ATC clearance **6.46 seconds after** uploading a maneuver in response to a Predictive SS alert
• There was no significant effect of Display on ATC Approval vs Upload Time for Predictive SS alerts, p > .05

• On average, pilots received an ATC clearance **6.46 seconds** after uploading a maneuver in response to a Predictive SS alert

• There was a significant effect of Display on ATC Approval vs Upload Time for Non-Predictive SS alerts, p < .05

  – No differences between displays were significant

• On average, pilots received an ATC clearance **3.71 seconds** after uploading a maneuver in response to a Non-Predictive SS alert
• There was a near significant effect of Display on ATC Approval vs Upload Time for Cooperative SS alerts, $p = .070$
• On average, pilots received an ATC clearance **3.33 seconds after** uploading a maneuver in response to a Cooperative SS alert

• There was no significant effect of Display on ATC Approval vs Upload Time for Non-Cooperative SS alerts, $p > .05$
• On average, pilots received an ATC clearance **6.20 seconds after** uploading a maneuver in response to a Non-Cooperative SS alert
### ATC Approval vs Upload Time

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<td>Cooperative/Non-Predictive</td>
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<td>-1.71</td>
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<td>Non-Cooperative/Predictive</td>
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<td>Non-Cooperative/Non-Predictive</td>
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ATC Approval vs Upload Time

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<td>-10.00</td>
<td>-10.63</td>
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ATC Approval vs Upload Time

IHITL and PT4 Display Comparison

-2.57  -3.21  -6.14  -9.43  1.70  -4.97  -2.79  SA_Advanced
Stages of Pilot DAA Task

- **T₀** Traffic Display Alert (SS or CA)
- **T₁** Pilot Notifies ATC
- **T₂** ATC Approval
- **T₃** Pilot Initiates Edit
- **T₄a** Pilot Uploads First Edit
- **T₄b** Pilot Uploads Final Edit
- **T₅** Traffic Alert Removed
- **T₆** UAS Completes Maneuver

**Compliance Time**
- Initial Response Time
- Aircraft Response Time
- Alert Duration Time
- Total Response Time
- Total Edit Time (First Upload)
- Total Edit Time (Final Upload)

**Notification Time**
- Clearance Approval Time
- Initial Edit Time (First Upload)

**Time**
- Initial Response Time
- Total Response Time
- Compliance Time

**Uploads**
- Final Edit
- First Edit
- Initial Edit (First Upload)
- Total Edit Time (Final Upload)

**Approval Time**
- Approval vs Upload Time
- Notify vs Upload Time

**Clearance**
- Clearance Approval Time
- Approval vs Upload Time
- Approval vs Upload Time

**UAS Completes Maneuver**
- Time

**Notations**
- T₀: Traffic Display Alert (SS or CA)
- T₁: Pilot Notifies ATC
- T₂: ATC Approval
- T₃: Pilot Initiates Edit
- T₄a: Pilot Uploads First Edit
- T₄b: Pilot Uploads Final Edit
- T₅: Traffic Alert Removed
- T₆: UAS Completes Maneuver
• There was no significant effect of Display on Initial Response Time for all SS alerts, p > .05

• Pilots took an average of 8.25 seconds to initiate an edit in response to a Predictive SS alert
There was no significant effect of Display on Initial Response Time for Predictive SS alerts, $p > .05$

- Pilots took an average of **7.40 seconds** to initiate an edit in response to a Predictive SS alert

There was no significant effect of Display on Initial Response Time for Non-Predictive SS alerts, $p > .05$

- Pilots took an average of **10.00 seconds** to initiate an edit in response to a Non-Predictive SS alert
There was no significant effect of Display on Initial Response Time for Cooperative SS alerts, $p > .05$

Pilots took an average of **11.84 seconds** to initiate an edit in response to a Cooperative SS alert

There was no significant effect of Display on Initial Response Time for Non-Cooperative SS alerts, $p > .05$

Pilots took an average of **6.84 seconds** to initiate an edit in response to a Non-Cooperative SS alert
Initial Response Time

<table>
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<tr>
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<td>10.00</td>
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<td>17.17</td>
<td>6.83</td>
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<td>6.70</td>
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## Initial Response Time

![Bar chart showing response times for different scenarios.

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<th>Scenario</th>
<th>Cooperative/Predictive</th>
<th>Cooperative/Non-Predictive</th>
<th>Non-Cooperative/Predictive</th>
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<tr>
<td>D1</td>
<td>10.00</td>
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-5.00 0.00 5.00 10.00 15.00 20.00 25.00
Initial Response Time

IHITL and PT4 Display Comparison

- D1: 7.89
- D2: 8.28
- D3: 9.60
- D4: 7.24
- Int_Basic: 21.62
- Int_Advanced: 22.09
- SA_Basic: 15.26
- SA_Advanced: 18.30
Stages of Pilot DAA Task

- **T₀**: Traffic Display Alert (SS or CA)
- **T₁**: Pilot Notifies ATC
- **T₂**: ATC Approval
- **T₃**: Pilot Initiates Edit
- **T₄a**: Pilot Uploads First Edit
- **T₄b**: Pilot Uploads Final Edit
- **T₅**: Traffic Alert Removed
- **T₆**: UAS Completes Maneuver

**Timephases**:
- **Notification Time**
- **Clearance Approval Time**
- **Initial Response Time**
- **Aircraft Response Time**
- **Total Response Time**
- **Alert Duration Time**
- **Compliance Time**
- **Initial Edit Time (First Upload)**
- **Total Edit Time (Final Upload)**

**Times**:
- **Initial Response Time**
- **Initial Edit Time**
- **Total Edit Time**
- **Aircraft Response Time**
- **Clearance Approval Time**
- **Alert Duration Time**
- **Compliance Time**
- **Total Response Time**

**Comparison**:
- **Notify vs Upload Time**
- **Approval vs Upload Time**
• There was a significant effect of Display on Initial Edit Time for all SS alerts, p < .01
  – D3 was significantly faster than D1 and D2
• Pilots took an average of **6.29 seconds** to complete their first edit in response to SS alerts
• There was a significant effect of Display on Initial Edit Time for Predictive SS alerts, p < .05
  – D3 was significantly faster than D1
• Pilots took an average of **5.67 seconds** to complete their first edit in response to Predictive SS alerts

• There was a significant effect of Display on Initial Edit Time for Non-Predictive SS alerts, p < .05
  – D3 was significantly faster than D1 and D2
• Pilots took an average of **6.86 seconds** to complete their first edit in response to Non-Predictive SS alert
• There was a significant effect of Display on Initial Edit Time for Cooperative SS alerts, $p < .01$
  – D3 and D4 were both significantly faster than D1 and D2
  – No difference between D1 and D2
  – No difference between D3 and D4
• Pilots took an average of 7.04 seconds to complete their first edit in response to Cooperative SS alerts

• There was a near significant effect of Display on Initial Edit Time for Non-Cooperative SS alerts, $p = .056$
• Pilots took an average of 5.84 seconds to complete their first edit in response to Non-Cooperative Alerts
Initial Edit Time

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
</tr>
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<tbody>
<tr>
<td>Cooperative/Predictive</td>
<td>8.17</td>
<td>10.36</td>
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<td>1.30</td>
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<td>Non-Cooperative/Predictive</td>
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Initial Edit Time

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Initial Edit Time

IHITL and PT4 Display Comparison

- D1: 8.33
- D2: 8.93
- D3: 2.66
- D4: 5.24
- Basic_Int: 17.11
- Advanced_Int: 5.51
- Basic_SA: 13.02
- Advanced_SA: 11.43
Stages of Pilot DAA Task

- **T₀** Traffic Display Alert (SS or CA)
- **T₁** Pilot Notifies ATC
- **T₂** ATC Approval
- **T₃** Pilot Initiates Edit
- **T₄a** Pilot Uploads First Edit
- **T₄b** Pilot Uploads Final Edit
- **T₅** Traffic Alert Removed
- **T₆** UAS Completes Maneuver

**Times:**
- Initial Response Time
- Initial Edit Time (First Upload)
- Total Response Time
- Aircraft Response Time
- Compliance Time
- Alert Duration Time
- Total Time (Final Upload)
- Notification Time
- Clearance Approval Time
- Initial Edit Time
- Notify vs Upload Time
- Approval vs Upload Time
- Total Edit Time (Final Upload)
• There was a not significant effect of Display on Total Edit Time for all SS alerts, $p > .05$

• Pilots took an average of **9.83 seconds** to complete their final edit in response to SS alerts
There was a significant effect of Display on Total Edit Time for Predictive alerts, $p < .05$

- D3 was significantly faster than D2, but no different than the other two displays

Pilots took an average of **8.83 seconds** to complete their final edit in response to Predictive SS alerts

There was no significant main effect of Display on Total Edit Time for Non-Predictive alerts, $p > .05$

- Pilots took an average of **12.862 seconds** to complete their final edit in response to Non-Predictive SS alerts
• There was no significant effect of Display on Total Edit Time for Cooperative SS alerts, \( p > .05 \)
• Pilots took an average of \textbf{12.08 seconds} to complete their final edit in response to Cooperative SS alerts

• There was a near significant effect of Display on Total Edit Time for Non-Cooperative SS alerts, \( p = .064 \)
• Pilots took an average of \textbf{8.31 seconds} to complete their final edit in response to Non-Cooperative alerts
Total Edit Time

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Total Edit Time

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<td>D4</td>
<td>12.17</td>
<td>13.64</td>
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<td>9.40</td>
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</table>
Stages of Pilot DAA Task

- $T_0$: Traffic Display Alert (SS or CA)
- $T_1$: Pilot Notifies ATC
- $T_2$: ATC Approval
- $T_3$: Pilot Initiates Edit
- $T_{4a}$: Pilot Uploads First Edit
- $T_{4b}$: Pilot Uploads Final Edit
- $T_5$: Traffic Alert Removed
- $T_6$: UAS Completes Maneuver

Compliance Time
- Alert Duration Time
- Total Response Time
- Aircraft Response Time
- Initial Response Time
- Clearance Approval Time
- Initial Edit Time (First Upload)
- Total Edit Time (Final Upload)

Other Times:
- Notification Time
- Initial Edit Time
- Total Edit Time
- Approval Time
- Upload Time
- Notify vs Upload Time
- Approval vs Upload Time
There was a near significant effect of Display on Aircraft Response Time for all SS alerts, $p = .069$

Pilots took an average of 14.54 seconds to upload their first maneuver in response to SS alerts (from first alert appearance)
Aircraft Response Time

**Predictive SS Alerts**

- There was a near significant effect of Display on Aircraft Response Time for Predictive SS alerts, $p = .059$
- Pilots took an average of **13.06 seconds** to upload their first maneuver in response to Predictive SS alerts (from first alert appearance)

**Non-Predictive SS Alerts**

- There was a significant effect of Display on Aircraft Response Time for Non-Predictive SS alerts, $p < .05$
  - No differences between displays were significant
- Pilots took an average of **16.86 seconds** to upload their first maneuver in response to Non-Predictive SS alerts (from first alert appearance)
There was a significant effect of Display on Aircraft Response Time for Cooperative SS alerts, \( p < .01 \)
- D4 was significantly faster than D1 and D2
- Pilots took an average of **18.87 seconds** to upload their first maneuver in response to Cooperative SS alerts (from first alert appearance)

There was no significant effect of Display on Aircraft Response Time for Non-Cooperative SS alerts, \( p > .05 \)
- Pilots took an average of **12.68 seconds** to upload their first maneuver in response to Non-Cooperative SS alerts (from first alert appearance)
Aircraft Response Time

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Aircraft Response Time

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<td>D4</td>
<td>11.42</td>
<td>13.50</td>
<td>11.23</td>
<td>16.10</td>
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</table>
Aircraft Response Time

IHITL and PT4 Display Comparison

- D1: 16.22
- D2: 17.20
- D3: 12.26
- D4: 12.47
- Int_Basic: 38.66
- Int_Advanced: 27.50
- SA_Basic: 32.96
- SA_Advanced: 29.64
Stages of Pilot DAA Task

- **Notification Time**
- **Clearance Approval Time**
- **Initial Response Time**
- **Aircraft Response Time**
- **Initial Edit Time (First Upload)**
- **Total Edit Time (Final Upload)**
- **Total Response Time**
- **Compliance Time**
- **Alert Duration Time**

- **T₀**: Traffic Display Alert (SS or CA)
- **T₁**: Pilot Notifies ATC
- **T₂**: ATC Approval
- **T₃**: Pilot Initiates Edit
- **T₄a**: Pilot Uploads First Edit
- **T₄b**: Pilot Uploads Final Edit
- **T₅**: Traffic Alert Removed
- **T₆**: UAS Completes Maneuver
• There was not a significant effect of Information on Total Response Time for all SS alerts, $p > .05$
• Pilots took an average of **18.08 seconds** to complete their final edit in response to SS alerts (from first alert appearance)
• There was a near significant effect of Display on Total Response Time for Predictive SS alerts, $p = .056$
• Pilots took an average of **16.22 seconds** to complete their final edit in response to Predictive SS alerts (from first alert appearance)

• There was no significant effect of Display on Total Response Time, $p > .05$
• Pilots took an average of **22.86 seconds** to complete their final edit in response to Non-Predictive SS alerts (from first alert appearance)
There was no significant effect of Information on Aircraft Response Time for Cooperative SS alerts, p > .05

Pilots took an average of 23.92 seconds to complete their final edit in response to Cooperative SS alerts (from first alert appearance)

There was no significant effect of Display on Aircraft Response Time for Non-Cooperative SS alerts, p > .05

Pilots took an average of 15.15 seconds to complete their final edit in response to Non-Cooperative SS alerts (from first alert appearance)
## Total Response Time

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<td>16.67</td>
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<td>16.10</td>
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## Total Response Time

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<tbody>
<tr>
<td>D1</td>
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<td>D2</td>
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Total Response Time

IHITL and PT4 Display Comparison

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<th>D3</th>
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<td>32.35</td>
<td>38.68</td>
<td>35.60</td>
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</table>
Stages of Pilot DAA Task

- **T₀**: Traffic Display Alert (SS or CA)
- **T₁**: Pilot Notifies ATC
- **T₂**: ATC Approval
- **T₃**: Pilot Initiates Edit
- **T₄a**: Pilot Uploads First Edit
- **T₄b**: Pilot Uploads Final Edit
- **T₅**: Traffic Alert Removed
- **T₆**: UAS Completes Maneuver

**Key Times**
- **T₀**
- **T₁**
- **T₂**
- **T₃**
- **T₄a**
- **T₄b**
- **T₅**
- **T₆**

**Time Phases**
- **Initial Response Time**
- **Clearance Approval Time**
- **Notification Time**
- **Aircraft Response Time**
- **Initial Edit Time (First Upload)**
- **Total Edit Time (Final Upload)**
- **Total Response Time**
- **Compliance Time**
- **Alert Duration Time**

**Comparisons**
- **Notify vs. Upload Time**
- **Approval vs. Upload Time**

**Metrics**
- **Notification Time**
- **Clearance Approval Time**
- **Initial Response Time**
- **Initial Edit Time (First Upload)**
- **Total Edit Time (Final Upload)**
- **Total Response Time**
- **Compliance Time**
- **Alert Duration Time**

**Note:** The diagram shows the sequence of stages and the associated times, emphasizing the timeline and key events in the process.
• There was no significant effect of Display on Alert Duration Time for all SS alerts, p > .05
• Pilots had an average duration of **33.58 seconds** for all Predictive SS alerts
There was no significant effect of Display on Alert Duration Time for Predictive SS alerts, $p > .05$

Pilots had an average duration of **32.52 seconds** for all Predictive SS alerts

There was no significant effect of Display on Alert Duration Time for Non-Predictive SS alerts, $p > .05$

Pilots had an average duration of **30.56 seconds** for all Non-Predictive SS alerts
Alert Duration Time

**Cooperative SS Alerts**

- There was no significant effect of Display on Alert Duration Time for Cooperative SS alerts, p > .05
- Pilots had an average duration of **36.21 seconds** for all Cooperative SS alerts

**Non-Cooperative SS Alerts**

- There was no significant effect of Display on Alert Duration Time for Non-Cooperative SS alerts, p > .05
- Pilots had an average duration of **30.25 seconds** for all Non-Cooperative SS alerts
<table>
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# Alert Duration Time

![NASA Logo](image)

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Alert Duration Time

IHITL and PT4 Display Comparison

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Stages of Pilot DAA Task

Traffic Display Alert (SS or CA)
- \( T_0 \)

Pilot Notifies ATC
- \( T_1 \)

ATC Approval
- \( T_2 \)

Pilot Initiates Edit
- \( T_3 \)

Pilot Uploads First Edit
- \( T_{4a} \)

Pilot Uploads Final Edit
- \( T_{4b} \)

Traffic Alert Removed
- \( T_5 \)

UAS Completes Maneuver
- \( T_6 \)

**Compliance Time**

- Alert Duration Time
- Total Response Time
- Aircraft Response Time
- Initial Response Time
- Clearance Approval Time
- Initial Edit Time (First Upload)
- Total Edit Time (Final Upload)

**Time Measurement**

- Initial Edit Time vs First Upload
- Total Edit Time vs Final Upload
- Approval vs Upload Time
- Notify vs Upload Time
Compliance Time

- There was a significant effect of Display on Compliance Time for all SS alerts, $p < .05$
  - No differences between displays were significant
- Pilots took an average of **37.53 seconds** to fully complete a maneuver in response to SS alerts (alert to end of aircraft maneuver)
• There was a significant effect of Display on Compliance Time for all SS alerts, $p < .05$  
  – No differences between displays were significant  
• Pilots took an average of 37.60 seconds to fully complete a maneuver in response to Predictive SS alerts (alert to end of aircraft maneuver)  
• There was no significant effect of Display on Compliance Time for Non-Predictive SS alerts, $p > .05$  
• Pilots took an average of 41.03 seconds to fully complete a maneuver in response to Non-Predictive SS alerts (alert to end of aircraft maneuver)
Compliance Time

Cooperative SS Alerts

- There was no significant effect of Display on Compliance Time for Cooperative SS alerts, $p > .05$
- Pilots took an average of 39.27 seconds to fully complete a maneuver in response to Cooperative SS alerts (alert to end of aircraft maneuver)

Non-Cooperative SS Alerts

- There was no significant effect of Display on Compliance Times for Non-Cooperative SS alerts, $p > .05$
- Pilots took an average of 36.56 seconds to fully complete a maneuver in response to Non-Cooperative SS alerts (alert to end of aircraft maneuver)
## Compliance Time

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<th>D2</th>
<th>D3</th>
<th>D4</th>
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<tbody>
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<td>48.50</td>
<td>59.50</td>
<td>37.67</td>
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<tr>
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<td>40.13</td>
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Compliance Time

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Compliance Time

IHITL and PT4 Display Comparison

- D1: 39.63
- D2: 43.57
- D3: 33.24
- D4: 33.67
- Int_Basic: 84.79
- Int_Advanced: 59.18
- SA_Basic: 73.50
- SA_Advanced: 68.25