Integrated Test and Evaluation (IT&E)
FT6
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FT6 Full Mission Objectives

• IT&E FT6 Project Objectives
  – Perform Full Mission Data Flights for the following:
    • Inform Phase 2 MOPS development of requirements for Low Size, Weight, and Power (SWaP) airborne non-cooperative surveillance system.
    • Inform Phase 2 MOPS development of DAA Well-Clear (DWC) alerting and guidance requirements.
    • Characterize Subject Pilot Under Test (SPUT) response data (full-mission operational environment) to validate Low SWaP Human in the Loop (HITL) simulation findings.
  – NASA Level 1 Milestone due on 12/20/19
    • [SP D.5.30] [SP T.8.40] End of Data Collection for FT6
## Partnership

<table>
<thead>
<tr>
<th>Partner</th>
<th>Roles &amp; Responsibility</th>
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| **NASA ARC** | • Responsible for providing the technical research content for Flight Test 6  
• Provide the Principal Investigators, along with a flight simulation team who support the preparatory integrated human in-the-loop simulations required to develop the low SWaP DAA algorithm  
• Provide the virtual environment and staff needed to accomplish the Full Mission phase of the test  
• Provide VSCS display via partnership with Air Force Research Laboratory |
| **NASA AFRC**| • Responsible test organization  
• Responsible for planning, coordinating, executing and reporting on the flight test  
• Led flight safety analysis  
• Provide facility and logistical support for the TigerShark UAS  
• Responsible for design, test, and assist with integration of the low SWaP surveillance system payload onto the TigerShark |
| **NASC LaRC**| • Responsible for providing the test objectives and technical research content for Flight Test 6  
• Provide the Principal Investigator, along with a flight simulation team  
• Develop the low SWaP DAA algorithm |
| **Honeywell**| • Provide DAPA Lite low SWaP radar  
• Responsible for providing hardware, software and technical support for the DAPA Lite radar, DAA processor, and sensor fusion and target tracking algorithm |
| **NASC**    | • Responsible for providing a TigerShark XP integrated with the NASA provided low SWaP system  
• Provide TigerShark UAS, flight operations staff and TMOC GCS  
• Provide technical support and operations resources to support flight test activities |
FT6 Full Mission Flight Plan - Overview

FT6 Full Mission Route - Primary (orig):
N 34.86367' W 117.72283'
N 34.95133' W 117.72283' 17.0NM/72'
N 34.84783' W 117.71667' 17.0NM/252'
N 34.86367' W 117.72283' 1.0NM/342'

Total distance = 36.0NM

FT6 Full Mission Route - Primary + Extn:
N 34.86367' W 117.72283'
N 34.96171' W 117.35675' 19.0NM/72'
N 34.94571' W 117.35087' 1.0NM/163'
N 34.86367' W 117.72283' 1.0NM/342'

Total distance = 40.0NM

FT6 Full Mission Route - MS:
N 34.86367' W 117.72283'
N 34.91000' W 117.54983' 9.0NM/72'
N 34.89417' W 117.54333' 9.0NM/161'
N 34.86367' W 117.72283' 1.0NM/342'

Total distance = 30.0NM

FT6 Full Mission Route - 4C + Extn:
N 34.96171' W 117.35675' 7.1NM/72'
N 34.94571' W 117.35087' 1.0NM/163'
N 34.92533' W 117.49288' 7.0NM/252'
N 34.92533' W 117.49288' 1.0NM/341'

Total distance = 16.1NM

PCC Flight Plan – Full Mission
HITL Validation – 6-10 Human Test Subjects (Subject Pilot Under Test)

- Minimum of 6 live encounters per test subject
- 3 circuits planned; 2 live encounters per circuit
- 4 non-cooperative intruder encounters, 2 cooperative (ADS-B) intruder encounters
- All encounters are 500ft vertical separation (no visual required)
- Backup cards developed for airspace contingencies
Full Mission Test Card (Example)

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Flight Test 6 System Checkouts (SCOs)

• SCO #1 (7/9/19)
  – 2.1 hrs
  – FT6 airspace link margin assessment
    • Encountered Lost Link condition with Silvus C2/Payload ~23nm east of GCS
    • Reestablished C2 link and RTB

• SCO #2 (7/11/19)
  – 2.9 hrs
  – FT6 operational procedures (join-ups, encounters at 500 ft altitude separation, smoke system VID augmentation checks)
  – Payload system checkout
    • ADS-B IN track of intruder was not functional
    • Ames LVC in shadow (subscribe only) mode

• SCO #3 (7/16/19)
  – 2.7 hrs
  – Silvus C2 Link Spectrum Scans
  – Full Mission encounter setups for practice
  – DAA and HSI researchers onsite

• SCO #4 (7/18/19)
  – 2.0 hrs
  – FT6 airspace link margin assessment with updated C2 frequencies
  – Payload system checkout
    • ADS-B IN track of intruder was still not functional after replacing MXS ADS-B unit
    • Unable to evaluate DAA alerting and guidance and Full Mission test points
  – DAA and HSI researchers onsite
Flight Test 6 System Checkouts (SCOs)

- **SCO #5 (8/13/19, 3.6 hrs)**
  - ADS-B only scripted encounters [no Sensor Uncertainty Mitigation (SUM)]
  - 17 encounters completed
  - Early DAA band saturation due to large state error estimates

- **SCO #6 (8/22/19, 2.1 hrs)**
  - DAPA-Lite Radar checkout encounters
  - Radar range not sufficient for detect and avoid

- **SCO #7 (8/28/19, 2.0 hrs)**
  - ADS-B only scripted encounters [no Sensor Uncertainty Mitigation (SUM)]
  - Only 2 encounters completed due to range/airspace conflicts

- **SCO #8 (8/29/19, 3.5 hrs)**
  - ADS-B only scripted encounters (no SUM)
  - 15 encounters completed
  - DAA alerting and guidance more stable
  - Lost connection between DAAP/Fusion Tracker and UAP near end of flight, required full payload pallet power cycle to recover
  - Data latency with MOFS PCCs and VSCS traced to a bad mux/demux card in the MOC

- **SCO #9 (9/24/19, 4.0 hrs)**
  - DAPA-Lite Radar checkout encounters
  - ADS-B only scripted encounters (no SUM)
  - 18 encounters completed
  - Radar range not sufficient for detect and avoid; Honeywell reviewing data
  - DAA alerting and guidance very stable
Flight Test 6 Scripted Encounters (SEs)

• SE #1 (10/01/19, 4.4 hrs)
  – ADS-B scripted encounters and Radar characterization
  – 26 encounters completed
  – DAA alerting and guidance very stable

• SE #2 (10/03/19, 3.9 hrs)
  – ADS-B scripted encounters
  – 23 encounters completed
  – DAA alerting and guidance very stable

• SE #3 (10/08/19, 3.7 hrs)
  - 17 scripted encounters completed with non-coop FOR/range set to 2.0 and 2.5 nmi
  - Early data reviews looks good with non-coop range of 2.5 nmi selected for Full Mission

• SCO #10 (10/16/19, 3.5 hrs)
  – 12 encounters completed
  – Updated radar calibration data collected
  – Radar range not sufficient for detect and avoid

• Full Mission Shakedown (10/17/19, 3.3 hrs)
  – 11 encounters completed
  – Full integration checks with Ames and virtual ATC
  – Close call at landing

• Full Mission Rehearsal #1 (10/24/19, 2.8 hrs)
  – 9 encounters completed
  – New takeoff and land plan exercised to increase operational flexibility
  – Multiple lessons learned to refine test procedures and improve data collection capability
Flight Test 6 Summary

Flight Test 6 Full Mission Encounters (FMEs)

- **Full Mission Rehearsal #2 (10/29/19, 2.8 hrs)**
  - 6 encounters completed
  - DAA alerting and guidance very stable

- **Full Mission #1 (10/31/19, 2.8 hrs)**
  - 6 encounters completed
  - 1st SPUT in seat
  - DAA alerting and guidance very stable

- **Full Mission #2 (11/5/19, 2.9 hrs)**
  - 7 encounters completed (includes repeat)
  - 2nd SPUT in seat
  - DAA alerting and guidance very stable

- **Full Mission #3 (11/7/19, 3.0 hrs)**
  - 7 encounters completed (includes repeat)
  - 3rd SPUT in seat
  - DAA alerting and guidance very stable
Flight Test 6 Summary

• **FT6 Accomplishments** (as of 11/7/2019)
  - 19 flight tests
  - 58.0 flight hours
  - 215 air-to-air encounters

• **Upcoming Milestones**
  - Full Mission Rehearsal #4 11/13/19
  - Full Mission Data Collection Schedule 10/31/19 – 12/10/19
  - FT6 VIP Day 11/13/19
  - Level 1 Milestone due 12/20/19