Integrated Test and Evaluation (IT&E)
FT6

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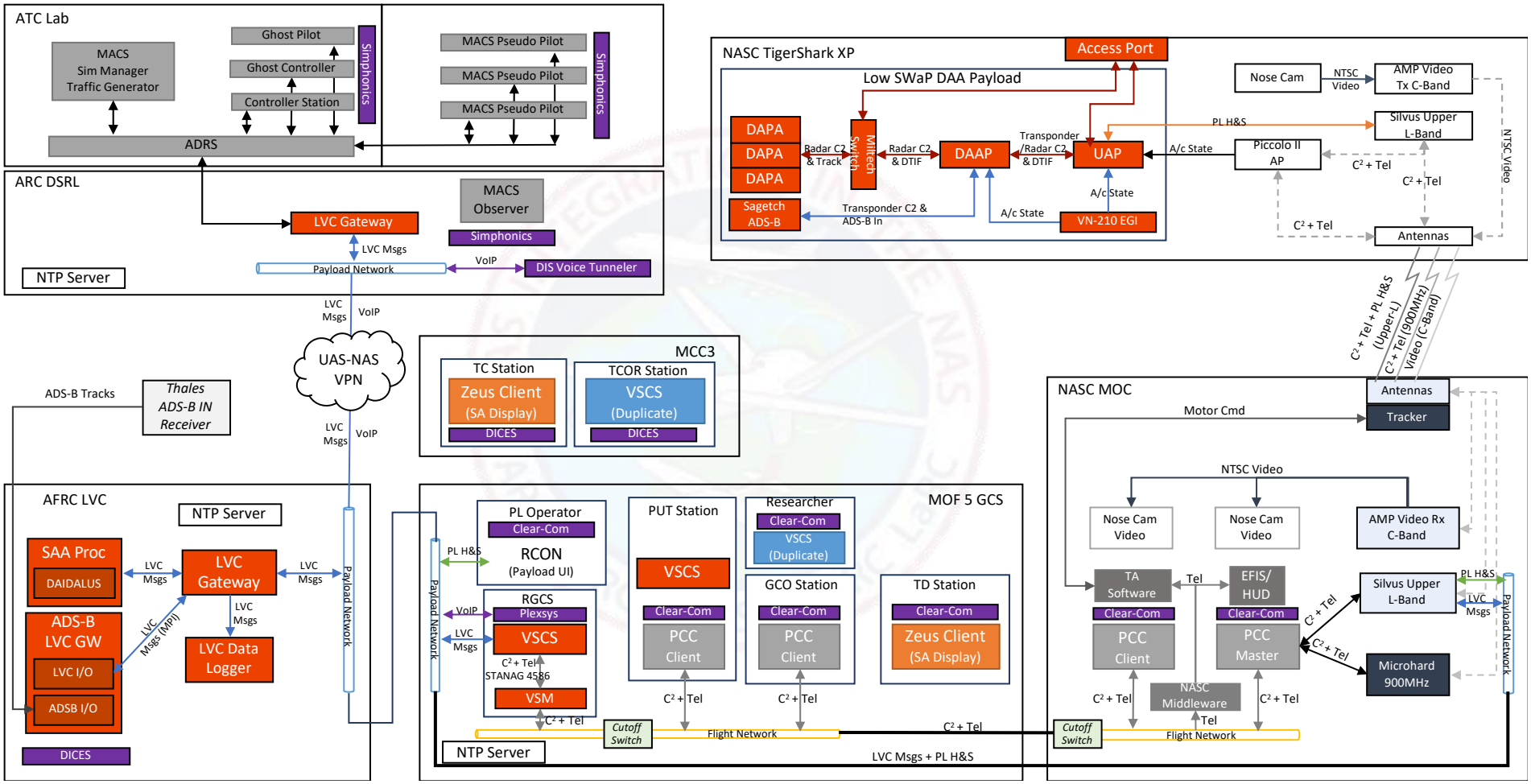
FT6 Full Mission Objectives

- **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**

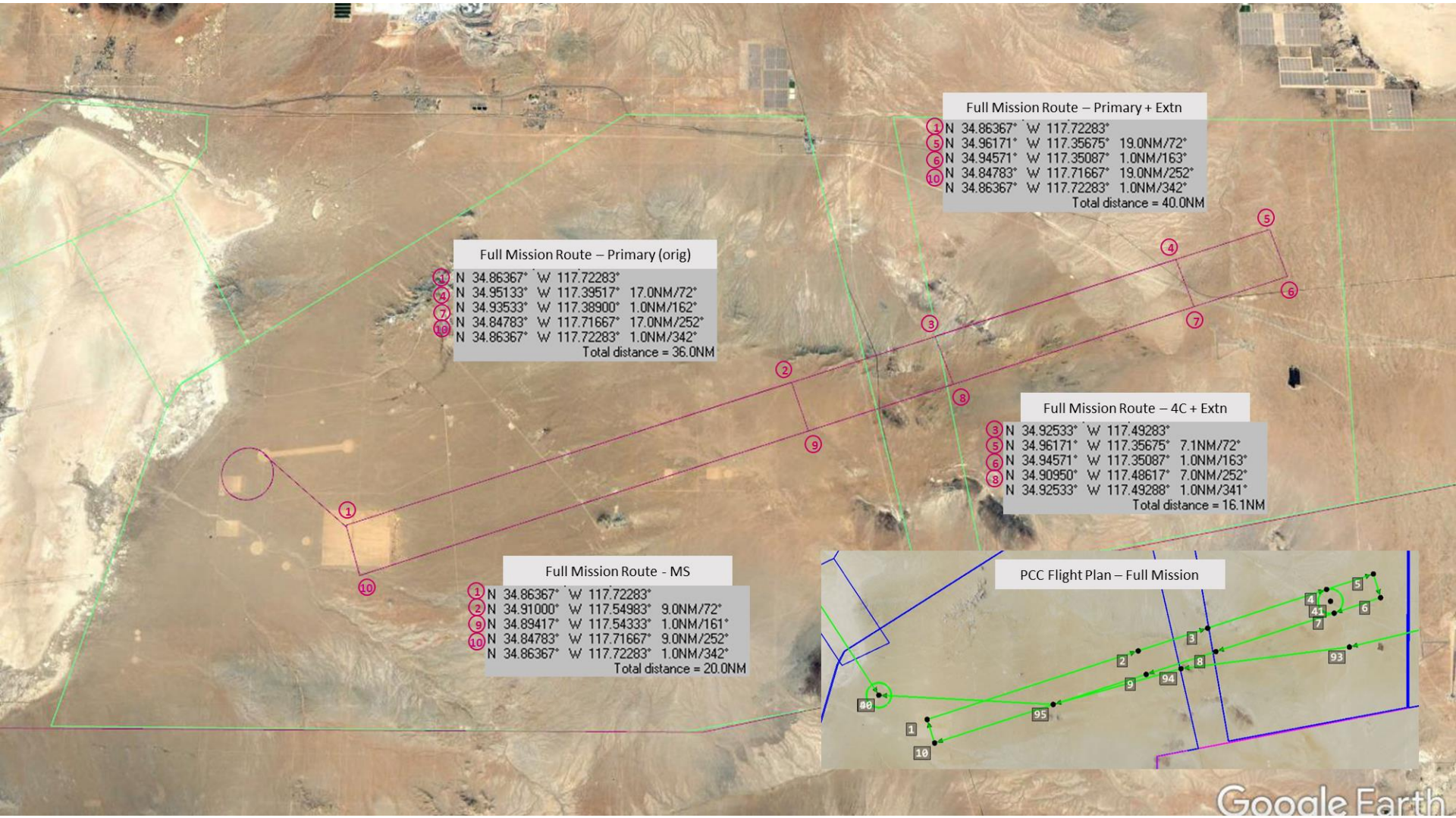
Partnership

Partner	Roles & Responsibility
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 System Architecture



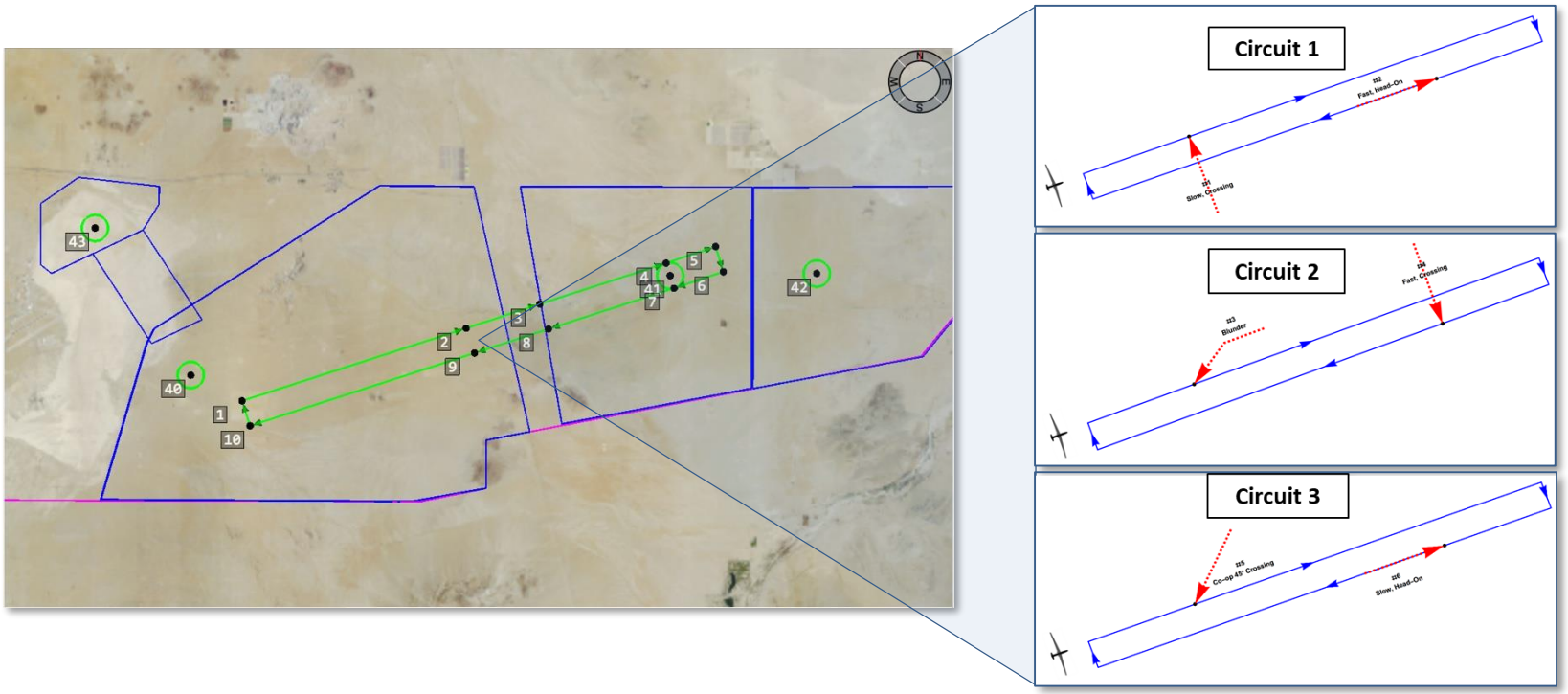
FT6 Full Mission Flight Plan - Overview



FT6 Full Mission Route – Encounters by Circuit

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

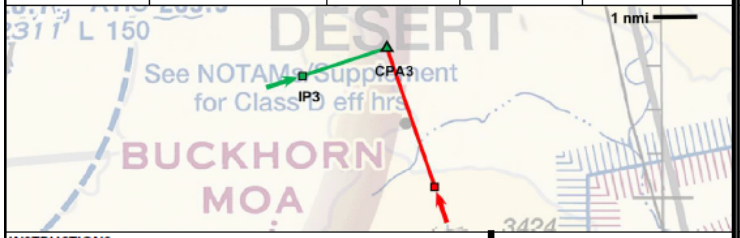


Full Mission Test Card (Example)

Full Mission	N1750X	Slow, crossing

Card #	FULL-01	OWNSHIP

INITIAL ALT	INITIAL SPEED	INITIAL WPT	RESPONSE	VID
8000 FT	60 KGS	IP3	Yes	NO



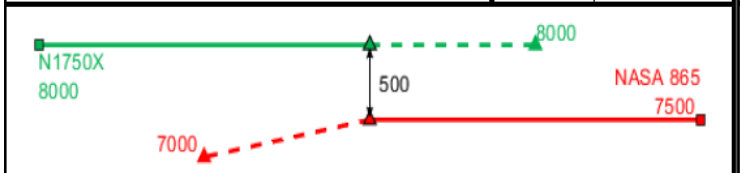
INSTRUCTIONS:
- Manuever at subject pilot discretion based on DAA alerting

LOST LINK WAYPOINT: LL - 1

DECONFLICTION ALT: 8000

ABORT PROCEDURE: 8000 — Continue on Mission Plan

SENSOR:	Radar Only	ADS-B Only	Radar + ADS-B
SAAPROC:	NASA856	NASA865	NASA801



COMEX TIME:

IP WIND:

WPT	LATITUDE	LONGITUDE	ALT V/V	DIST MC	KGS	LEG TIME (TOTAL REM.)
IP3	N34° 52.78'	W117° 39.78'	8000	2.0	60	2+00 (2+00)
	N34° 52' 46.9"	W117° 39' 47.1"	0	060		
CPA3	N34° 53.40'	W117° 37.47'	8000	0.0	60	End
	N34° 53' 23.9"	W117° 37' 27.9"	0	060		

NOTES: • Test subject pilot response

Maneuver:	Yes	No	
Guidance:	DAA	WCR	
Direction:	Lateral		
Limit:	NO DESCENT		

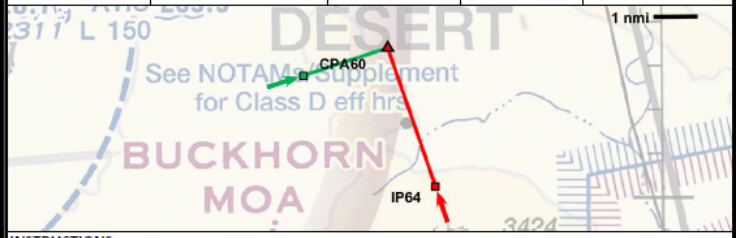
TOLERANCE:

Version 1.0, Created 10/22/2019 | Priority 1

Full Mission	NASA 865	Slow, crossing

Card #	FULL-01	INTRUDER 1

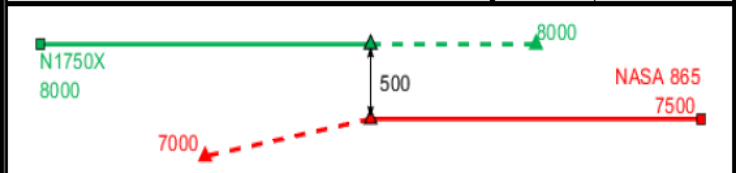
INITIAL ALT	INITIAL SPEED	INITIAL WPT	RESPONSE	VID
7500 FT	100 KGS	IP64	None	NO



INSTRUCTIONS:
- Report at IP:
- Altitude
- Time delta relative to comex

DECONFLICTION ALT: 7000

ABORT PROCEDURE: 7000 — RIGHT



COMEX TIME:

IP WIND:

WPT	LATITUDE	LONGITUDE	ALT V/V	DIST MC	KGS	LEG TIME (TOTAL REM.)
IP64	N34° 50.24'	W117° 36.18'	7500	3.3	100	2+00 (2+00)
	N34° 50' 14.2"	W117° 36' 11.1"	0	330		
CPA60	N34° 53.40'	W117° 37.47'	7500	0.0	100	End
	N34° 53' 23.9"	W117° 37' 27.9"	0	330		

NOTES:

TOLERANCE: ±8 sec

Version 1.0, Created 10/22/2019 | Priority 1

Flight Test 6 Summary

Flight Test 6 System Checkouts (SCOs)

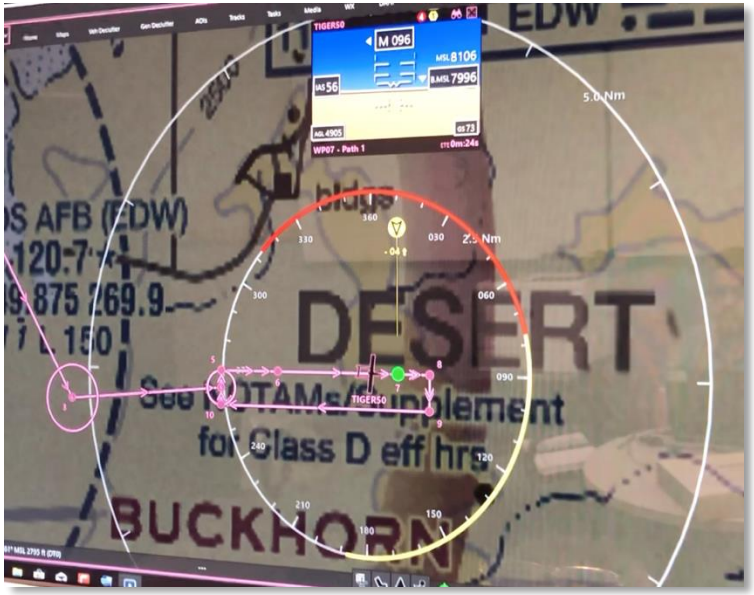
- **SCO #1 (7/9/19)**
  - 2.1 hrs
  - FT6 airspace link margin assessment
    - Encountered Lost Link condition with Silvus C2/Payload ~23nm east of GCS
    - Reestablished C2 link and RTB
- **SCO #2 (7/11/19)**
  - 2.9 hrs
  - FT6 operational procedures (join-ups, encounters at 500 ft altitude separation, 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

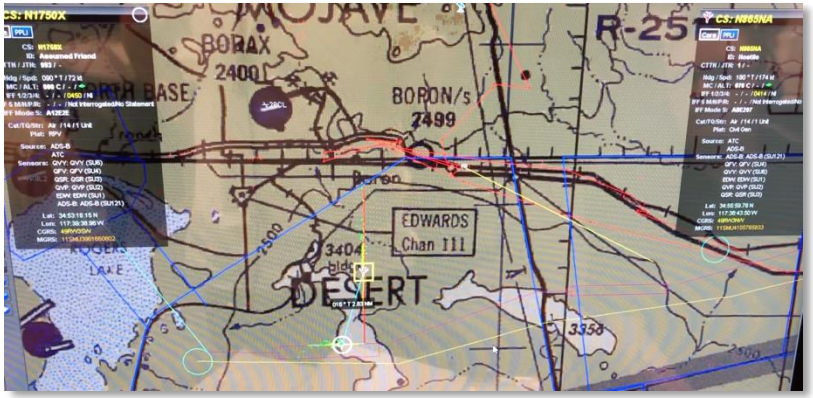
TigerShark XP-002 Chased by TG-14 (NASA 856) on SCO #1

Flight Test 6 Summary

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 MOF5 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

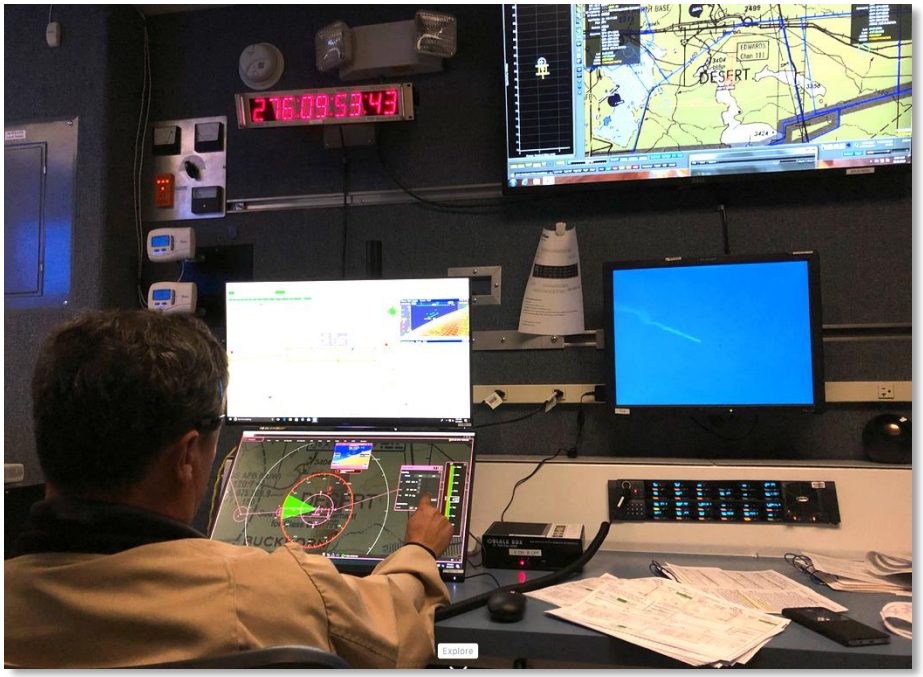


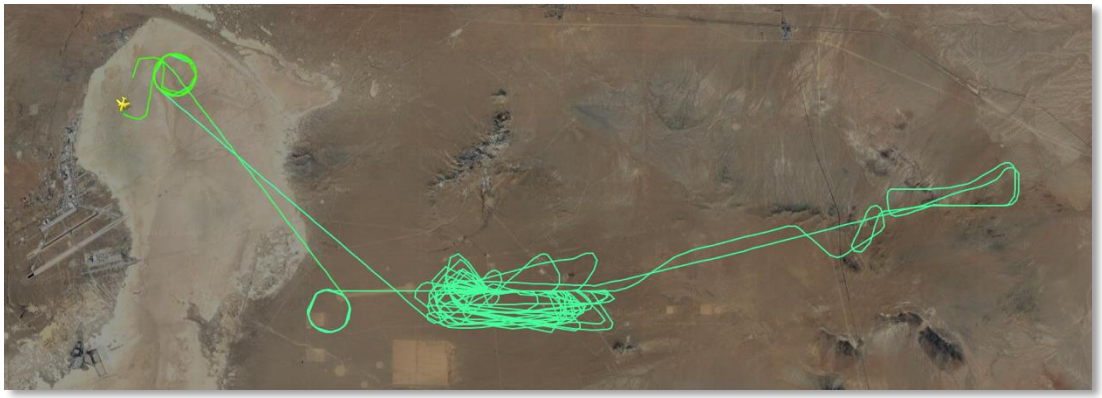


Flight Test 6 Summary

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

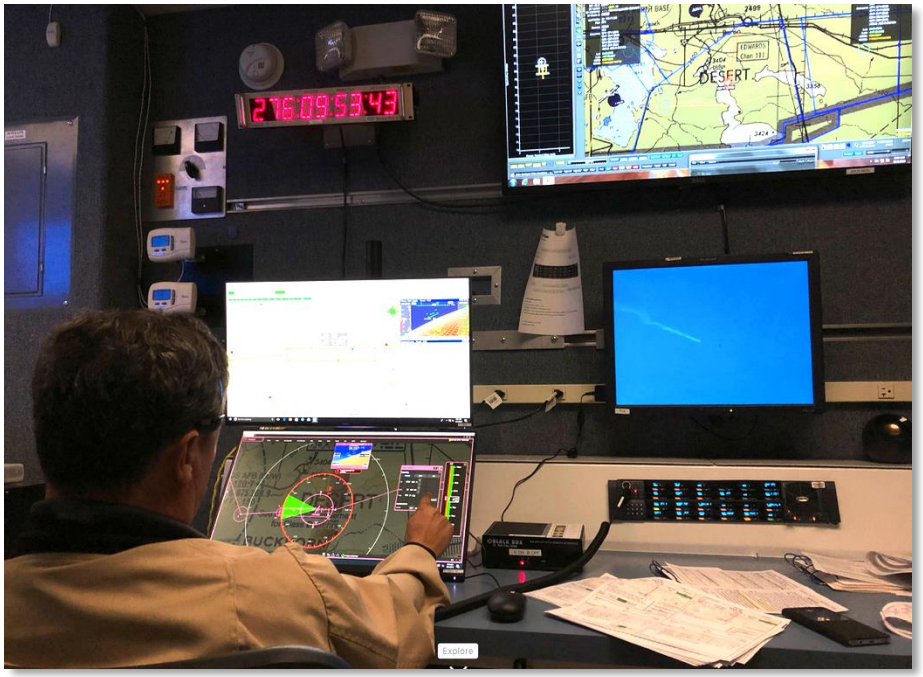


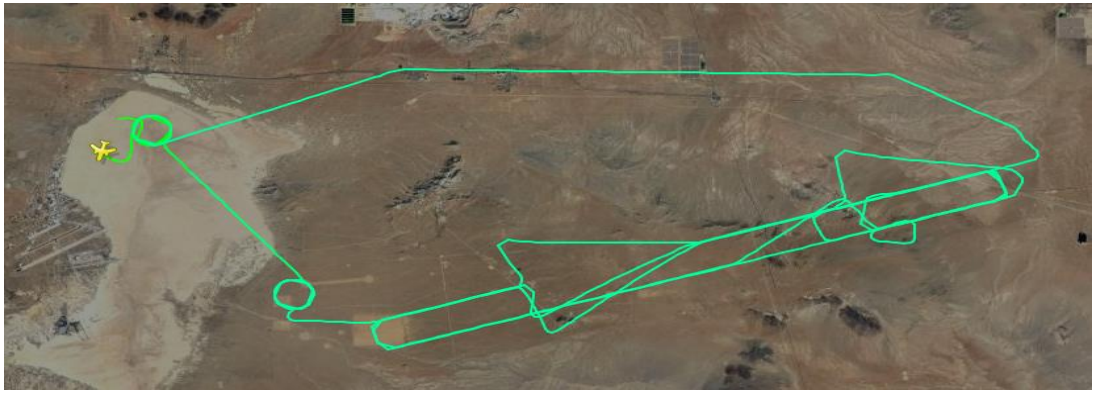


Flight Test 6 Summary

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