Joint Detect and Avoid Flight Testing

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UAS-NAS Test Flow

Timeline Not To Scale

Integrated Human in the Loop Sim
- Preliminary MOPS Development
- MOPS Verification & Validation
- Preliminary MOPS Inputs
  - Aug 2014
  - Jan 2015
  - July 2015

ACAS-XU / Self Separation
- Critical Design Reviews
- Airworthiness & Fit Safety Review
- Tech Brief
- Ikhana Mods
- Flts

Flight Test-3
- Comp’t Testing
- Integration / V&V
- System Testing
- Ikhana Mods
- Flts
- Tech Brief

FT-3 Scripted Encounters Research Goals:
- Validate results previously collected during project simulations with live data
- Evaluate TCAS II/SS interoperability
- Inform final DAA MOPS
- Reduce risk for FT-4

Flight Test-4
- Comp’t Testing
- Integration / V&V
- Ikhana Mods
- Design
- Tech Brief

FT-4
- Flts

Timeline:
- FY14
- FY15
- FY16

Brands:
- NASA
- General Atomics Aeronautical Systems
- Honeywell
- Federal Aviation Administration
FT3 Integration Roles & Responsibilities Summary

**NASA – AFRC (UAS-NAS / IT&E)**
- Provide Research Ground Control Station (RGCS) Infrastructure
- Provide Live Virtual Constructive (LVC) Env. Infrastructure
- Provide Intruder Aircraft (T-34/King Air)
- Provide ownship aircraft (Ikhana)
- Test Conductor Station

**NASA – ARC (UAS-NAS / HSI)**
- Provide Vigilant Spirit Control Station (from AFRL) and display definition

**NASA - ARC (UAS-NAS / SSI)**
- Provide JADEM (Autoresolver) DAA
- Provide Uncertainty model
- Devise Encounter matrix

**NASA - LaRC (UAS-NAS / SSI)**
- Provide DAIDALUS (Stratway+) DAA
- Devise Encounter matrix

**GA-ASI**
- Provide proof of concept DAA system (Engineering Development Model (EDM) Due Regard Radar (DRR), Sense and Avoid Processor (SAAP), etc.)
- Conflict Prediction Display System (CPDS) Display and IO Server

**Honeywell**
- Provide surveillance tracking software for DAA system
- Provide instrumented TCAS II equipped intruder aircraft

**NASA Partner**

**NASA**
Flight Test 3 Scripted Encounters Requirements

• Live Ownship (OS)
  – Low Speed OS – DRR, ADS-B, and TCAS Sensors, Sensor Fusion
    • Ikhana
      – EDM DRR (±110° az and ±15° elev) non-coop sensor
      – ADS-B coop sensor
      – TCAS II v7.1 coop sensor
      – HON STM (sensor fusion/tracker)

• Live Intruder(s)
  – ADS-B equipped
  – TCAS II Instrumentation for interoperability test
  – High speed (250 KGS capable)
  – Multiple – 2

Work Area:
EAFB R-2515 and Buckhorn MOA
Four Corners, Mercury Spin

Honeywell King Air, N3GC  T-34, NASA 865  F-18, NASA 850
Flight Test Series 3 (June 17 – July 24, 2015)
- Ikhana vs. manned intruder(s)
- 11 flights completed
  - Over 200 air to air encounters
  - DAA maneuver guidance and alerting logic checks
  - Auto TCAS II maneuvers
  - EDM radar performance near scan volume limits
  - EDM radar low altitude performance tests
  - Higher closure rate encounters with FA-18
  - Stressing multi-intruder encounters

Flight Test 3 Encounters Summary

Configuration 1 Nomenclature

<table>
<thead>
<tr>
<th>Series</th>
<th>Minimum Altitude Offset</th>
<th>Vertical Profile</th>
<th>Encounter Angle</th>
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<tbody>
<tr>
<td>L</td>
<td>1 = 1000 ft / 2 = 200 ft / 3 = 300 ft / 4 = 400 ft / 5 = 500 ft / 6 = 300 ft / 7 = 400 ft / 8 = 400 ft / 9 = 4000 ft</td>
<td>Level / H-Level / Climb / Descent / Level / Climb / Descent / Level / Climb / Descent / Level / H-Level / L-Level</td>
<td>M = Turning 135 degrees / N = Turning 90 degrees / P = Zig-Zag / Q = 0 / R = 0 / S = 0 / 90 / T = 0 / 135 / U = 20 / V = 45 / W = 90 / 135 / X = Turning 45 degrees / 180 degrees</td>
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QUESTIONS???
FAA UAS Test Site Contracts

• NASA and the FAA UAS Test Sites have entered into an Indefinite Delivery Indefinite Quantity (IDIQ) contract to perform relevant UAS Testing
• NASA will leverage the contract to bring industry and the Test Sites together to partner on technology development specific to NASA’s technical goals
• 2 Tasks have been awarded, each to all 6 Test Sites
  – Task 1 UTM Integration: Test Sites to integrate build 1 of UTM and fly 4 aircraft simultaneously
  – Task 2 Prototype LVC-DE Connection: Test Sites to Leverage LVC-DE ICD and demonstrate prototype connection leveraging a P2 MOPS capability