Joint Detect and Avoid Flight Testing

Heather Maliska – Deputy Project Manager for Armstrong Flight Research Center
Ramon Estrada – Due Regard Radar Program Manager, Mission Systems, General Atomics Aeronautical Systems Inc.

Eric Euteneuer – Need Title
Chester Gong – Need Title
Keith Arthur - Separation Assurance/Sense and Avoid Interoperability Co-Project Engineer
UAS-NAS Test Flow

Timeline Not To Scale

Integrated Human in the Loop Sim
- Comp’t Testing
- V&V
- IHITL Sim Complete

ACAS-XU / Self Separation
- Critical Design Reviews
- Airworthiness & FIt Safety Review
- Flts

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

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

Inputs
- Preliminary MOPS: Aug 2014
- Final MOPS: Oct 2015
- Final MOPS: July 2016

Rqmts Rev.
- FY14
- FY15
- FY16

Design Rev.
- Test Readiness Rev.
- Preliminary MOPS Inputs: Jan 2015
- Preliminary MOPS: July 2015
- Final MOPS Inputs: Oct 2015
- Final MOPS: Aug 2016

Preliminary MOPS Development
- MOPS Verification & Validation
- Preliminary MOPS Inputs: Aug 2014
- Preliminary MOPS: July 2015
- Final MOPS Inputs: Oct 2015
- Final MOPS: Aug 2016

Preliminary MOPS: July 2015
- Final MOPS: Oct 2015
- Final MOPS: Aug 2016

Preliminary MOPS Inputs: Jan 2015
- Preliminary MOPS: July 2015
- Final MOPS Inputs: Oct 2015
- Final MOPS: Aug 2016

Inputs
- Preliminary MOPS: Aug 2014
- Final MOPS: Oct 2015
- Final MOPS: Aug 2016

Tech Brief
- Design Review
- Rqmts Review
- System Rqmts Reviews
- Final Design Review
- 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

Ikhana Mods
- Flts
- Flts
- Flts
- Flts

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

NASA
GENERAL ATOMICS
AERONAUTICAL
Honeywell
FAA
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**
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 3 Encounters Summary

- 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

Configuration 1 Nomenclature

<table>
<thead>
<tr>
<th>Series</th>
<th>Min Altitude Offset</th>
<th>Vertical Profile</th>
<th>Encounter Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>0</td>
<td>Level</td>
<td>A = 0 degrees</td>
</tr>
<tr>
<td>H</td>
<td>20</td>
<td>Level / H-Level</td>
<td>B = 20 degrees</td>
</tr>
<tr>
<td>M</td>
<td>45</td>
<td>Multiship</td>
<td>C = 45 degrees</td>
</tr>
<tr>
<td>1</td>
<td>1000</td>
<td>Descent / Level</td>
<td>D = 90 degrees</td>
</tr>
<tr>
<td>2</td>
<td>200 f/700 ft</td>
<td>Level / H-Level</td>
<td>E = 120 degrees</td>
</tr>
<tr>
<td>3</td>
<td>300 ft</td>
<td>Multiship</td>
<td>F = 135 degrees</td>
</tr>
<tr>
<td>4</td>
<td>400 ft</td>
<td>Descent / Level</td>
<td>G = 160 degrees</td>
</tr>
<tr>
<td>5</td>
<td>500 ft</td>
<td>Level / H-Level</td>
<td>H = 180 degrees</td>
</tr>
<tr>
<td>6</td>
<td>300 f/700 ft</td>
<td>Level / H-Level</td>
<td>J = 45 degrees</td>
</tr>
<tr>
<td>7</td>
<td>400 f/500 ft</td>
<td>Level / H-Level</td>
<td>K = 90 degrees</td>
</tr>
<tr>
<td>8</td>
<td>2500 f</td>
<td>Level / H-Level</td>
<td>L = 135 degrees</td>
</tr>
<tr>
<td>9</td>
<td>4000 f</td>
<td>Level / H-Level</td>
<td>M = Turning 45 degrees</td>
</tr>
</tbody>
</table>

Vertical Profile (Ownership / Intruder)

- 1 = H-Level / Level
- 2 = Level / H-Level
- 3 = Level / Climb
- 4 = Level / Descent
- 5 = Climb / Level
- 6 = Descent / Level
- 7 = Climb / Descent
- 8 = Descent / Climb
- 9 = Level / H-Level / L-Level
**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