UAS Situational Awareness Shortcomings, Gaps, and Future Research Needs

Integrated Communications Navigation and Surveillance (ICNS) 2018

April 10, 2018
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Outline

• Motivation and Project Overview
• UAS situational awareness challenges
• Concept of operations and five scenarios
• Architecture
• Research Roadmap and Recommendations

Project Team
Mosaic ATM, Aviation Management Associates, Systems Enginuity Inc., NUAIR Alliance

We thank NASA Glenn Research Center for their sponsorship and acknowledge David Fuller, the NASA Technical lead.
Motivation

- UAS pilots today have limited situational awareness
- May be unable to sense incipient problems and to formulate effective responses
- As UAS operations evolve to increasingly higher levels of autonomy, these challenges will become increasingly acute
- Therefore we are identifying UAS situational awareness issues and intervention procedures for off-nominal events
System Engineering Approach

**Task 1 & 2 Study Objective**
- For the UAS Situational Awareness Component: Define the requirements (functional requirements (needs), performance requirements or conceptual description).
- And for these understand the current TRL status and importance while under of nominal operations.
Project Work Products and Reports

Task 1
- Literature Report
- Failure Mode Analysis

Task 2
- CONOPs
  - Architecture
  - Off-Nominal Conditions Table / Hazard Analysis Worksheet

Task 3
- TRL Analysis
  - Situational Awareness Specification Research Gap Candidates
  - Stakeholder Survey
  - Final Report Research Roadmap

Task 4

Subject to disclosure statement shown on title page
What Is An “Off-Nominal” Event?

- We define off-nominal events to include common off-nominal scenarios, abnormal scenarios, and emergency scenarios.
Task 1: Literature Survey

- Observations
  - Cognitive Overload
  - UAS Crew Rotation
  - Degraded Situation Awareness
  - Initially Minor Events
  - Example Flight Instability
  - Example Altitude Drift
  - Example Route Error
  - Example Altitude Error
UAS Pilot Cognitive Overload

• Traditional detection of off-nominal events involve levels of situational awareness not available to UAS pilot
  – Subtle sounds, smells, vibrations, visuals, etc.

• For the UAS pilot, there is typically no direct indication of what the on-board crew takes for granted
UAS Pilot Cognitive Overload

• There is, on the other hand, often a plethora of data for UASs.
  – Sometimes more of an analyst’s workstation than a control station
    • Numeric tables and graphs rather than traditional gauges and dials.
  – Cognitive overload, high workload, mental stress, burnout
UAS Crew Rotation

• To mitigate mental stress and overload, it is important to rotate crews to limit the time on station in a given shift.
• Ironically, this can degrade situational awareness even further, as PICs for such long-endurance flights lack the continuity that on-board flight crews have.
Degraded Situational Awareness

• Given the highly cognitive nature and burden of the PIC position, and given the stress factors discussed above:
• PICs require more time to detect and identify off-nominal events

• The situational awareness challenge for UASs introduces an entirely different set and type of detection problems than for traditional crewed aircraft
Initially Minor Events

• Off-nominal events often of concern for UASs are utterly mundane for crewed aircraft.
  – Events which require cognitive attention for the UAS PIC to detect are immediately obvious to the on-board crew

• Example
  – A UAS may fly at a dramatically different altitude than intended, due to a logical programming error.
  – Such an event would have been immediately noticed by on-board crew
Initially Minor Events

• Major system failures are not as likely to escape the attention of the UAS PIC, simply because such events trigger alerts and warnings.
• Therefore, an important conclusion is that the situational awareness challenge for UASs is more likely to cause problems with mundane, or what are initially mundane, events.
  – Mundane events can rapidly escalate to significant problems, when not noticed.
  – Mundane off-nominal events will eventually be detected. The problem is not the failure of their detection, but the time delay in their detection.
Example: Flight Instability

- UAVs more susceptible to turbulence, wind shear, etc.
- In one incident a UAV lost about five thousand feet of altitude on climb-out, apparently due to inclement weather, though no adverse weather was observed.
- The PIC detected the event, regained control, and resumed the climb. But events such as these would likely be detected and responded to much earlier by an on-board crew.
Example: Altitude Drift

- Clear air turbulence, such as from mountain waves, can cause a UAV to deviate in altitude by hundreds of feet.
- The PIC has no direct sense of such an event.
  - Must infer the event from the altitude deviation.
  - A faster method is to detect the turbulence event in the angle of attack indicator, which becomes erratic.
  - Example of the high-level of cognitive processes required to track mentally, rather than feel, the flight conditions.
Example: Route Error

- UAVs sometimes must fly unintended routes, such as when inclement weather, or a communication link failure, forces an abort.
- In one incident, the PIC noticed that the UAV was flying an inappropriate, and uncleared, route.
  - But this was after a time delay.
  - In a crewed cockpit this situation would have promptly detected and corrected.
Example: Altitude Error

• UAVs sometimes fly unintended altitudes.
• In one incident, a logical programming error caused a UAV to descend from FL 190, on its way to 6000 ft, when it should have maintained level flight.
  – This was shortly after a crew handoff, and the new PIC did not detect the off-nominal event until the UAV had lost over 1000 ft.
Task 2 ConOps – PITL+, POTL, POM

Key Assumptions
55+ pounds / No air space limitations
Evolution of UAS Automation

- Pilot in the loop
- Pilot on the loop
- Pilot Observer/Monitor
Off-Nominal Scenarios

- To analyze off-nominal scenarios, we used five different operational scenarios depicting various UAS missions:
  - Inspection of infrastructure and resources
  - Low-altitude wide area surveillance operations
  - High-altitude wide area surveillance operations
  - Linear inspection and surveillance operations
  - Point-to-point delivery operations.
Task 2 Architecture

- Separate sections for each automation level, building upon each other.
  - Describe PITL+ as baseline
  - Describe changes for POTL
  - Describe changes for POM
- For each automation level
  - UA System
  - UA Segment
  - CS Segment
  - DAA
  - ATC Communications
  - Information Flows and Processing
UAS POM System Architecture

- We used our operational scenarios and concept of operations to derive PITL, POTL, and POM UAS NAS Architectures.
# POM Information Flows and Decision Points

## POM Flight Functions

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td><strong>UA Segment</strong></td>
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<td>DAA Sensors</td>
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<td>UA DAA Processor</td>
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<td>Health Monitor</td>
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<td>Autonomous Processor</td>
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<td>Autopilot</td>
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<td>FMS</td>
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<td>CNPC</td>
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<td>ATC Voice</td>
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<td><strong>Control Segment (CS)</strong></td>
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<tr>
<td>CNPC</td>
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<td>Flight Data Proc &amp; Display</td>
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<td>UA Flight control interface</td>
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<tr>
<td>ATC Comm Control Interface</td>
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<tr>
<td>CS DAA Processor</td>
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<td><strong>UAO</strong></td>
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<td><strong>ATC</strong></td>
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<tr>
<td><strong>Flight Services</strong></td>
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<td><strong>Mission Operations</strong></td>
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<tr>
<td><strong>Support Segment</strong></td>
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</tr>
</tbody>
</table>

- Components involved in Function
- Primary Decision making / Autonomous actions
- Auxiliary Decision making / Autonomous actions
- Initiation Point
- Termination Point

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## POM Information Flows and Decision Points
Communications

- UAS communications span:
  - ATC voice
  - ATC data link
  - UAV C2
  - Mission payload
  - Flight services links
Detect and Avoid

- Our architecture also included surface and airborne detect and avoid capabilities.
Task 2: Off Nominal Conditions

- Flight Planning
- Contingency Planning
- Weather Monitoring
- UA Health Monitoring and Contingency Response
- Communications links and Contingency Response
- Separation Assurance and DAA
- Flight Stability
- Human Interaction
- Cyber Security/Trust /Certification
- Situational Awareness Inference Engine
- Airport/Runway/Taxiway Issues
- Weather/Atmospheric Hazards
- Airspace Issues
- Security Vulnerabilities
## Off-Nominal Conditions Table

<table>
<thead>
<tr>
<th>Index Number</th>
<th>Hazard/Failure Condition</th>
<th>HAW Reference</th>
<th>Scenario Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Aircraft Equipment Failure or degradation (Air data, Navigation)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*3.1.1</td>
<td>Loss of UA altitude, airspeed and vertical speed information</td>
<td>Hazard 6.0 Effect</td>
<td>10.3.2.1</td>
</tr>
<tr>
<td>*3.2.1</td>
<td>Loss of UA attitude, heading and track information</td>
<td>Hazard 6.0 Effect</td>
<td>10.3.2.1</td>
</tr>
<tr>
<td>*3.3.1</td>
<td>Loss of UA position information</td>
<td>Hazards 1.1, 1.2, 6.0 Effect</td>
<td>10.3.2.1</td>
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<tr>
<td>*3.4.1</td>
<td>Loss of temporal (clock) data to UAS</td>
<td>Hazard 6.0 Effect</td>
<td>10.5.2.1, 10.6.2.1</td>
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<td>*3.5.1</td>
<td>Loss of UA trajectory definition</td>
<td>Hazard 6.0 Effect</td>
<td>10.5.2.1</td>
</tr>
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<td>3.6.1</td>
<td>Loss of GPS receiver</td>
<td>Hazard 1.1, 1.2, 3.0, 17.0 Causes</td>
<td>10.6.2.2</td>
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<td>3.7.1</td>
<td>Loss of UA FMS or Flight Navigator (This is about aircraft equipment failure)</td>
<td>Hazard 6.0 Description Hazard 7.1 Cause</td>
<td>10.6.2.2</td>
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<tr>
<td></td>
<td><strong>Erroneous Flight Information Reported by UAV</strong></td>
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<td></td>
</tr>
<tr>
<td>*3.1.2</td>
<td>Erroneous UA altitude, airspeed and vertical speed information</td>
<td>Hazard 7.1 Cause</td>
<td>10.3.2.1, 10.3.2.3, 10.4.2.1</td>
</tr>
<tr>
<td>*3.2.2</td>
<td>Erroneous UA attitude and heading information</td>
<td>Hazard 7.1 Cause</td>
<td>10.3.2.1, 10.4.2.1</td>
</tr>
<tr>
<td>*3.3.2</td>
<td>Erroneous UA position information</td>
<td>Hazards 1.1, 1.2, 7.1 Causes</td>
<td>10.4.2.1, 10.4.2.2, 10.5.2.1</td>
</tr>
<tr>
<td>*3.4.2</td>
<td>Erroneous temporal data from UAS</td>
<td>Hazard 7.1 Cause</td>
<td>10.5.2.1</td>
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<tr>
<td>*3.5.2</td>
<td>Erroneous aircraft trajectory</td>
<td>Hazard 7.1 Cause</td>
<td>10.3.2.3</td>
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<tr>
<td></td>
<td><strong>Aircraft Flight Controls Failure (Flight Controls/Control Surfaces)</strong></td>
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<tr>
<td>*4.1.1</td>
<td>Loss of command of UA flight control</td>
<td>Hazard 8.0 Effect</td>
<td>10.2.2.1, 10.2.2.3, 10.6.2.2</td>
</tr>
<tr>
<td>*4.2.1</td>
<td>Loss of feedback from UA flight controls</td>
<td>Hazard 8.0 Effect</td>
<td>10.6.2.2</td>
</tr>
</tbody>
</table>
Failure Identification and Response

- We included a UAS failure analysis to identify gaps in identification and mitigation of UAS off-nominal events. (Extract shown below)

|------------|--------------------------|---------------|-------------------------|---------|------------------|---------------------|----------------|------------|---------------------------------------|
| 1.1        | Loss of ability to detect and avoid in flight  
• Traffic  
• Obstacles | - Loss of video link  
- Targeting pod camera failure  
- Secondary forward-looking cameras fail  
- Loss of external data from UA to proximate traffic  
- GPS  
  - Jamming  
  - Spoofing  
- Environmental  
- ADS-B  
  - Jamming  
  - Spoofing  
- Erroneous sensory or self-separation/collision avoidance information or execution  
- Erroneous cloud clearance information  
- DAA sensor/processor failure | Class B airspace, High traffic density and complexity, Terminal environment | - Loss of ability to provide clearance from structures, obstacles, and terrain  
- Erroneous execution of clearance from structures, obstacles, and terrain  
- Loss of ability to maintain cloud clearance minimums | Piloted  
Cockpit | TCAS  
OTW, pilot scans | <1 second for out the window  
Loss of radio to ATC 30 seconds to 2 minutes | Minimal  
Probability is low an intrusion will occur at the moment out the window detection is lost. Sufficient time to react.  
Minor  
ATC would be separating other aircraft away | 30-60 seconds  
Time to get established in a holding pattern and coordinate with ATC |
|            | Pilot In the Loop (PITL) | Pilot recognition of loss of data/visual feed | Based on latency 2-5 seconds  
Frozen picture/display 6-30 seconds | Minimal  
Probability is low an intrusion will occur within the latency period. Sufficient time to react.  
Major  
No UA should be within 30 second of a collision. TCAS alerts with an RA 45 seconds | 30-60 seconds  
Time to get established in a holding pattern and coordinate with ATC |
|            | Pilot on the Loop (POTL) | CWA alerting system  
Pilot recognition of loss of data/visual feed | Based on latency 2-5 seconds | Minimal  
Probability is low an intrusion will occur within the latency period. Sufficient time to react. | 30-60 seconds  
Time to get established in a holding pattern and coordinate with ATC |
|            | Pilot Observer/ Monitor (POM) - Autonomous | Once thresholds are violated, the automation  
If detected, the response should be very quick | Dependently on detection – | | Within 20-30 seconds  
The POM should either rectify the situation or alert the pilot |
Operational Scenario Analysis (Example)

<table>
<thead>
<tr>
<th>Hazard/Failure</th>
<th>Effect on Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAV-2: Ability to detect and avoid weather:</td>
<td>The UA must be able to assess current weather conditions as well as access future weather in the area. Without accurate and correct weather information the UA is unable to avoid adverse weather conditions.</td>
</tr>
<tr>
<td>• 1.4.1 Loss of ability to remain safely clear of atmospheric or meteorological hazards</td>
<td></td>
</tr>
<tr>
<td>• 1.4.2 Errorneous Information on hazardous atmospheric or meteorological conditions</td>
<td></td>
</tr>
<tr>
<td>• Loss of ability of UA access/uplink weather information</td>
<td></td>
</tr>
<tr>
<td>UAV-5: Aircraft Equipment Failure (Air data, INS)</td>
<td>If the UA report inaccurate altitude, heading/course, and position information this may make mission/FPL changes difficult for the UAS crew who may be reviewing the data.</td>
</tr>
<tr>
<td>• 3.1.1 Loss of UA altitude information</td>
<td></td>
</tr>
<tr>
<td>• 3.1.2 Loss of UA heading and course information</td>
<td></td>
</tr>
<tr>
<td>• 3.1.3 Loss of UA ground position information</td>
<td></td>
</tr>
<tr>
<td>UAV-6: Errorneous Flight Information Reported by UAV</td>
<td>If the UA report inaccurate altitude, heading/course, and position information this may make mission/FPL changes difficult for the UAS crew who may be reviewing the data. In addition, ATC may receive inaccurate information when performing separation from other aircraft.</td>
</tr>
<tr>
<td>• 3.1.2 Errorneous UA altitude information</td>
<td></td>
</tr>
<tr>
<td>• 3.2.2 Errorneous UA heading information</td>
<td></td>
</tr>
<tr>
<td>UAV-10: Air Traffic Control Issues</td>
<td>ATC needs accurate data to provide separation services while in IFR conditions.</td>
</tr>
<tr>
<td>• Errorneous aircraft position displayed to ATC</td>
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</tr>
<tr>
<td>• Errorneous direction or information from ATC</td>
<td></td>
</tr>
<tr>
<td>• GPS System Failure / Degraded Mode</td>
<td></td>
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<tr>
<td>• Data Comms Failure / Degraded Mode</td>
<td></td>
</tr>
<tr>
<td>• ADS-B Failure / Degraded Mode</td>
<td></td>
</tr>
<tr>
<td>UAV-12: Weather/Atmospheric Hazards</td>
<td>Adverse weather may make it difficult for the UA to stay on the programmed flight plan and make it difficult to avoid other traffic in VFR conditions.</td>
</tr>
<tr>
<td>• Low Visibility (mission related)</td>
<td></td>
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<tr>
<td>• Wind Shear</td>
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Task 3: Specifications For Off-Nominal Response

• Major sections
  – Requirements
  – Functional design
  – Gap analysis
  – Functional analysis
  – Higher-order inference and recommendation engine
  – Research and development needs
  – Conclusions
Research Need Items Groupings

• Groupings
  – Flight Planning
  – Contingency Planning
  – Weather Monitoring
  – UA Health & Monitoring
  – Comm links & Contingency Plan
  – Separation Assurance & DAA
  – Flight Stability
  – Human Interaction
  – Cybersecurity, Trust, Certification
  – Situation Inference Engine

• For each research need item determined:
  – Current technology level, Tech Dev Assessment, Rating, Rationale
Task 4: Research Roadmap for Autonomous UAS

- The fourth phase of this study is the creation of a research roadmap for autonomous unmanned aircraft systems.
  - Will guide the development of future autonomous system behaviors for detection, option development and decision making related to off-nominal events.
  - Taking Research Items and assigning:
    - Technical Development Rating (includes importance for safety)
    - Function Critically
    - Research Critically
  - Then parsed by ConOps timeframes
Research Roadmap – Summary

The study identifies 130 individual research needs organized into 10 high level categories and 30 subcategories. The table below summarizes the distribution of these research needs by research criticality and timeframe.

<table>
<thead>
<tr>
<th>Research Criticality</th>
<th>Near Term</th>
<th>Mid term</th>
<th>Far Term</th>
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<tr>
<td>Major</td>
<td>21</td>
<td>5</td>
<td>32</td>
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<tr>
<td>Moderate</td>
<td>21</td>
<td>5</td>
<td>15</td>
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<tr>
<td>Minor</td>
<td>4</td>
<td>2</td>
<td>7</td>
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</table>
# Research Roadmap – Example

## Flight Planning Research Needs

<table>
<thead>
<tr>
<th>ID</th>
<th>Flight Planning Research Needs</th>
<th>Research Need</th>
<th>Near Term</th>
<th>Mid term</th>
<th>Far Term</th>
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<tr>
<td></td>
<td>Flight Plans</td>
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<tr>
<td>2.1.9</td>
<td>Flight Plans above 60,000 feet</td>
<td>Major</td>
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<td>2.1.10</td>
<td>Flight Plan processing for low altitudes</td>
<td>Major</td>
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<td>C2</td>
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<tr>
<td>2.1.2a</td>
<td>Integrate Coverage Maps into flight Planning Software</td>
<td>Moderate</td>
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<tr>
<td>2.1.2b</td>
<td>Reconcile Coverage Maps from Multiple Service Providers</td>
<td>Moderate</td>
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<tr>
<td>2.1.6</td>
<td>Outage or performance degradation information</td>
<td>Moderate</td>
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<td>2.1.7</td>
<td>Link Coverage at altitude</td>
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<tr>
<td>2.1.8</td>
<td>Link Coverage - FirstNet</td>
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<td></td>
<td>Pre-Flight Verification</td>
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<td>2.1.4</td>
<td>Verify accuracy of data sources</td>
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<td>2.1.3a</td>
<td>Verify accuracy of pre-programmed flight modes</td>
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<td>Moderate</td>
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<tr>
<td>2.1.3b</td>
<td>Verify accuracy of autonomous flight plans</td>
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<td>Moderate</td>
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<td></td>
<td>Weather</td>
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<td>2.1.1a</td>
<td>Develop UAS autonomous evaluation of weather</td>
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<td>Minor</td>
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<tr>
<td>2.1.1b</td>
<td>Develop UAS autonomous flight plan adjustment for weather</td>
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<td>Minor</td>
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### Table 3. Micro Weather Research Need Summary.

<table>
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<th>ID</th>
<th>Title</th>
<th>Autonomy</th>
<th>Technology Development</th>
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<tr>
<td>2.3.1a</td>
<td>Weather information needs</td>
<td>PITL+ POTL POM</td>
<td>Develop approaches to collect and distribute micro weather. In discussion of micro climate weather with the boundary layer offers some intriguing opportunities to add spatial and temporal density to weather sensors (think AT&amp;T cell phone towers) and develop models for micro weather below 5,000 feet AGL. This helps ATC be potentially removing uncertainty in wind conditions affecting time based separation and PBN.</td>
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<th>Dev Rating</th>
<th>Failure Condition</th>
<th>Research Need Assessment</th>
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<td>Major</td>
<td>Major</td>
<td>Micro weather will be a major safety issue for UA. Research may also benefit manned operations in class G airspace.</td>
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1. Determine how much UA system monitoring information is necessary and design inference logic capable of using this information to safely mitigate the aberrant behavior, for resolving aberrant flight behavior both remotely and autonomously.

2. Examine and propose means for validation and verification of algorithms used in autonomous UAs and their operations. Define minimum success levels for determining aberrant behavior, the causal factor(s), the impact on the flight, and the actions taken by the UAS.

3. Explore the human factor issues for situational awareness for all aspects of POM operations. POM human factors are as significant as POM equipage and POM autonomous logic. For example, when assuming control from an automated or autonomous flight, and for the challenges presented by managing multiple UA and multiple simultaneous off-nominal events.

4. Investigate alternative traffic management paradigms to address the interaction between 55+ pound BVLOS operations and UTM.

5. Analyze C2 service issues including service availability and reliability at all altitudes and in all environments, multi-service resolution across multiple service providers and multiple technologies and spectrums, and spectrum and channel allocations in dense UA operating environments.

6. Address issues related to autonomous UA communications with ATC.
7. Establish minimum performance levels for Surface DAA encompassing all UA types and operating environments. Assess alternative sources of DAA information.
   a. Incorporate UA sensor data, for example from EO, IR, and Lidar sensors.
   b. Assess other detection technologies, for example millimeter wave.
   c. Establish a system to capture, synthesize, and distribute UA airborne DAA information.
   d. Establish a system to capture, synthesize, and distribute ground based non-aviation information related to atmospheric conditions, traffic activity, intrusion events, and obstacle presence.
8. Establish a system to capture, synthesize, and distribute UA airborne weather information.
9. Develop a specification for a minimum level of contingency planning, UA system and flight monitoring equipment, and real-time analysis capability.
10. Research and propose resolution to security concerns spanning GPS, ADS-B, and C2 link vulnerabilities, flight data and flight service vulnerabilities, and verification of automated flight modes and flight plans.
11. Evaluate issues related to multiple UA operations including linked failure modes, management of simultaneous off-nominal events, and unique fleet DAA behaviors.
12. Assess Minimum degree of precursor analysis for off-nominal events. Use trend analysis to predict off-nominal events and enable mitigations before the events occur.
Recommendations

- We recommend as a next step these research needs be assessed against on-going and planned research in the FAA, NASA, the DoD, and the related research community to assist identifying and prioritizing future NASA research.
- We recommend NASA initiate a UAS lab equipped with the components identified in the system awareness specification, to be used to drive research in sensors and inference engines supporting situational awareness of off-nominal events.
- We recommend NASA foster a forum for a long term POM vision for larger UAS. The vision developed in this study as detailed in the POM ConOps and the Architecture documents can serve as the baseline for this vision. The objective is to assist the development and evolution of UAS automation/autonomy. The forum would mirror to an extent the ACCESS-5 and UNITE forums of the early 2000s.
- We recommend NASA coordinate with the FAA Unmanned Aircraft System (UAS) Integration Office (AUS-300) to prepare a study briefing for the UAS EXCOM/SSG as recommended by a Stakeholder Survey participant.
  - “Your work will inform the UAS EXCOM/SSG Members including one of the research priorities assigned to the SARP: Determine the barriers to more than one UA operated by a single pilot.”
- We recommend NASA assess the study needs and implications for the Urban Air Mobility (Air Taxi) initiative.
- We recommend NASA Study the fundamental development and application of inference engines to replace human analysis and judgment to lay the foundation for autonomous UAS operations.
Questions/Discussion

For a copy of the presentation / Study please leave business card or send an email

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Project Summary

- NASA Contract: NNC16CA29C
- Title: Argument Based –UAV Situational Awareness for Off-Nominal Events.
- Work Description:
  - Project purpose is to develop a vetted autonomy research roadmap for unmanned air vehicles which will guide the development of future autonomous system behaviors for detection, option development and decision making within the context of “safety and regularity of flight “ under three envisioned increasingly autonomous Concept of Operations covering both large and small unmanned aircraft.
  - Perform Four 4 Major Work Tasks
    - 1 – Literature Review
    - 2 – Defined Architecture and Concept of Operations
    - 3 – Stakeholder Survey
    - 4 – Recommendations
  - Perform Task and Program Status Reviews
  - Perform project management and reporting.
  - Indirectly support NASA UAS NAS Integration Program, NASA UTM Project and RTCA activities.
- Subcontractors: Aviation Management Associates, Systems Enginuity, NUAIR Alliance
- Deliverables: 6 Task related reports and one Final Report (12/1/17).
- Period of Performance: Start 5/24/16, duration 18 months