NASA UAS Integration in the NAS Project

Davis Hackenberg
UAS Integration in the NAS Project
Deputy Project Manager, Integration

ICAP UAS Subcommittee
March 26, 2014
Briefing Outline

• NASA ARMD Research
• NASA Project Organizational Chart
• Project Overview
• Project Technical Challenges and Technical Work Packages
• Capabilities Overview
• Integrated Test Overview
Aeronautics Mega-Drivers and R&T Thrusts

**Mega-Drivers**

**Strategic Research & Technology Thrusts**

**Safe, Efficient Growth in Global Operations**
- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

**Innovation in Commercial Supersonic Aircraft**
- Achieve a low-boom standard

**Ultra-Efficient Commercial Transports**
- Pioneer technologies for big leaps in efficiency and environmental performance

**Transition to Low-Carbon Propulsion**
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

**Real-Time System-Wide Safety Assurance**
- Develop an integrated prototype of a real-time safety monitoring and assurance system

**Assured Autonomy for Aviation Transformation**
- Develop high impact aviation autonomy applications
Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.

Preserve and promote the testing capabilities of one of the United States’ largest, most versatile and comprehensive set of flight and ground-based research facilities.
UAS Integration in the NAS Organizational Structure

Project Support
- Lead Resource Analyst – Cindy Brandvig - AFRC
- Lead Procurement Officer – R. Toberman - AFRC
- Lead Scheduler – John Percy – AFRC
- Mgmt Support Specialist – Jamie Turner - AFRC
- Administrative Support – Giovanna Seli – AFRC

Project Office
- Project Manager - Laurie Grindle - AFRC
- Deputy Project Manager – Robert Sakahara – AFRC
- Deputy Project Manager, Integration – Davis Hackenberg - AFRC
- Chief Systems Engineer – Debra Randall – AFRC
- Staff Systems Engineer – Dan Roth - AFRC

Subprojects/Technical Challenges (TC)
- Separation Assurance/Sense and Avoid Interoperability (SSI)
  - Co-PEs
  - Confesor Santiago - ARC
  - Maria Consiglio - LaRC
- Communications
  - PE
  - Jim Griner - GRC
- Human Systems Integration (HSI)
  - PE
  - Jay Shively - ARC
- Integrated Test and Evaluation (IT&E)
  - Co-PEs
  - Sam Kim - AFRC
  - Jim Murphy - ARC
- Certification
  - PE
  - Kelly Hayhurst - LaRC

PE: Project Engineer, DPMf: Deputy Project Manager for
KDP (Phase 1/Phase 2 Transition)

Prior Activities

External Input

Prior

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<tr>
<th>FY11/12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
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<tbody>
<tr>
<td>Formulation</td>
<td>Early investment Activities</td>
<td>P2 Portfolio Developed</td>
<td>Flight Validated Research Findings to Inform FAA Decision Making</td>
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<td>Tech. Development to address Technical Challenges</td>
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<tr>
<td>Phase 1 (P1)</td>
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<tr>
<td>Initial Modeling, Simulation, &amp; Flight Testing</td>
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<tr>
<td>Phase 2 (P2)</td>
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<tr>
<td>Integrated Modeling, Simulation, &amp; Flight Testing</td>
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- Technical input from Project technical elements, NRAs, Industry, Academia, Other Government Agencies, Project Annual Reviews
The NASA UAS-NAS Project is influenced by several key stakeholders within the UAS Community which helped guide its formulation.

**Project Focus:**

*Unencumbered NAS Access for Civil / Commercial UAS*

**Key Stakeholders & Influencing Factors**

- NAC Aeronautics Committee
- UAS Subcommittee
- UAS Meeting of Experts
- NASA Aeronautics Centers
- NASA ARMD
- RTCA SC-228
- OSD
- SAA
- SARP
- World Radio-communications Conference
- FAA
- UAS ExCom
- UAS ARC
- Industry
- JPDO
Phase 2 of the UAS-NAS Project has some fundamental characteristics of note

- The Technology Development outputs are primarily research findings (validated data, algorithms, and recommendations) which contribute to an outcome of the elimination or reduction of barriers to NAS access
  - Project timeframe for impact is 2015 - 2025

- The UAS-NAS Project is operating in an ever-changing environment and must remain agile and adapt as the customer/community needs change
  - While the base of what the Project is planning to deliver doesn’t change, the specifics of the final products may change to better meet the community need
Goal: Provide research findings to reduce technical barriers associated with integrating Unmanned Aircraft Systems into the National Airspace System utilizing integrated system level tests in a relevant environment.

Research Theme 1: UAS Integration - Airspace integration procedures and performance standards to enable UAS integration in the air transportation system.

Research Theme 2: Test Infrastructure - Test infrastructure to enable development and validation of airspace integration procedures and performance standards.
UAS Integration in the NAS Project
Value Proposition Flow Flow Diagram

**NASA UAS-NAS Project Activities**

**SAA Performance Standards**
- TC1: Develop SAA Performance Testbed
- TC2: Develop SAA Performance and MS&A
- TC3: Develop SAA Performance & Interoperability Requirements

**C2 Performance Standards**
- TC1: Develop SAA Performance Testbed
- TC2: Develop C2 Performance Testbed
- TC3: Develop C2 Performance & Interoperability Requirements

**Human Systems Integration**
- TC3: Develop Prototype GCS
- TC3: Conduct Human Factors (HF) Flight Test and MS&A
- TC3: Develop HF Guidelines for SAA, C2 & GCS

**Integrated Test & Evaluation**
- TC6: Conduct IHITL Testing
- TC6: Conduct FT3 Test Scenarios
- TC6: Conduct FT4 Test Scenarios & Mission Based Flight Activity

**Certification & Safety**
- TC6: Analyze Classification Factors for UAS
- TC6: Conduct Restricted Category Study
- TC6: Analyze Case Study Results

**Key Products**
- SAA Performance Requirements to inform DAA MOPS
- C2 Performance Requirements to inform C2 MOPS
- SC-228 GCS & HF Whitepapers
- Re-usable Test Infrastructure
- Test Data to support SAA & C2 Standards Devlpmt
- Safety Substantiation Final Report & Safety Metrics Data
UAS-NAS Modeling & Simulation
Tools and Capabilities Phase 2

**C2 Simulation Capability**
- CNPC 1 Radio Model (GRC)
- SATCOM Simulation Models (GRC)
- NAS-wide CNPC System Performance (GRC)

**Unmanned Aircraft Models**
- 17 UAS BADA Models (ARC, LaRC)
- Ikhana Simulator (DFRC)
- T34C Surrogate (GRC)
- YO-3A Surrogate (DFRC)
- Global Hawk Simulator (DFRC & NGC)

**SAA Performance & Interoperability Tools**
- Sensor Models / Fusion Tracker (ARC, DFRC, LaRC)
  - ADS-B Model, TCAS II Model, Airborne Radar, Electro-Optical
  - ACES - Airspace Concept Evaluation System (ARC, GRC)
  - 2 PAIRS / 6 PAIRS (LaRC)
- Multiple SAA Algorithms
  - Stratway+, AFRL-JOCA, ACAS-Ua
  - AutoResolver (ARC, LaRC)

**Control Station Simulation Capability**
- MACS – Multi-Aircraft Control System (LaRC)
- MUSIM - Multiple UAS Simulator (ARC)
- CSD - Cockpit Situation Display (ARC)
- VSCS - Vigilant Spirit Control Station (ARC, GRC, AFRL)
- Research GCS (DFRC)

**ATC Simulation Capability**
- ACES - Airspace Concept Evaluation System (ARC)
- MACS – Multi-Aircraft Control System (ARC, LaRC)

**ATC**
- Background Traffic (ARC)
- S-3B (GRC)
- B-747 Flight Simulator (ARC)
- T34C Surrogate (GRC)
- SR-22 Surrogate (LaRC)

**Intruder Aircraft Models**
- Background Traffic (ARC)
- S-3B (GRC)
- B-747 Flight Simulator (ARC)
- T34C Surrogate (GRC)
- SR-22 Surrogate (LaRC)

**Unmanned Aircraft Models**
- 17 UAS BADA Models (ARC, LaRC)
- Ikhana Simulator (DFRC)
- T34C Surrogate (GRC)
- YO-3A Surrogate (DFRC)
- Global Hawk Simulator (DFRC & NGC)

**Legend:** Also Used in Phase 1 = Black text, New for Phase 2 = Purple text

Note: All acronyms are defined in the Notes Page
Self-Separation Timeline

- **Detect Intruders**
  - Alert Pilots
  - Gain Situational Awareness
  - Pilots Determine Resolution

- **Negotiate Clearance**
  - with ATC and uplink maneuver to aircraft

- **Aircraft Maneuvers**

- **Well Clear**
  - Threshold

- **Controller Acceptability Study**

- **TASATS Simulation**
  - Beale Pilot Feedback

- **Part Task 4**
  - (SAA Traffic Display Evaluation)

- **Full Mission Simulation**
  - (Levels of Automation)

- **TCAS Definition**

- **Time until CPA**
  - 110 sec
  - 95 sec
  - 85 sec
  - 55 sec
  - 40 sec
Communication Subproject Focus

Possible Future ATC and ATS Ground Connectivity
2015, 2016 Flight Test (i.e. FT3, FT4)

Live Ownship

DFRC Ikhana

OR

GRC S-3B

Need Common Airspace

Virtual/Constructive Intruders

Honeywell King Air
- ADS-B
- TCAS II Instrm
- High speed

ADS-B Out

GRC T-34C
- ADS-B
- 2nd CNPC
- SAA

CNPC Data Link
- C2
- Voice
- Health & Status
- Video
- Traffic (ADS-B and Radar)

Autoresolver

Stratway+

Pseudo Pilots

Multi-Aircraft Control System

UAS Pilot as Subject

Display of Proximal Traffic SAA/DAA Algorithms

VPN

Distributed Environment/Connectivity

ATC as Subject

Research GCS
# Integrated Test Progression

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<tr>
<td>GCS</td>
<td>• Research Ground Control Station (RGCS) with traffic displays and alerting logic</td>
<td>• RGCS with UAS Surrogate (T-34C) Command and Control</td>
<td>• RGCS with UAS Surrogate (T-34C) C2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Multiple GCSs</td>
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<tr>
<td>SAA Algorithms</td>
<td>• Self separation, idealized sensor data</td>
<td>• Multiple SAA algorithms</td>
<td>• Multiple SAA algorithms</td>
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<tr>
<td></td>
<td></td>
<td>• Collision avoidance on UAS and surrogate</td>
<td>• Collision avoidance on UAS and surrogate</td>
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<tr>
<td>UAS</td>
<td>• Simulated</td>
<td>• UAS Surrogate (T-34C)</td>
<td>• UAS Surrogate (T-34C)</td>
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<tr>
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<td></td>
<td>• SAA equipped UAS</td>
<td>• SAA equipped UAS</td>
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<td>Sensor</td>
<td>• Simulated</td>
<td>• On board SAA</td>
<td>• On board SAA</td>
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<td></td>
<td></td>
<td></td>
<td>• Possible SAA on surrogate aircraft</td>
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<td>Surveillance</td>
<td>• Modeled mixed ADS-B and radar</td>
<td>• ADS-B/TIS-B, modeled and real</td>
<td>• ADS-B/TIS-B, modeled and real</td>
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<tr>
<td>Traffic</td>
<td>• Simulated</td>
<td>• UAS/UAS Surrogate</td>
<td>• UAS/UAS Surrogate</td>
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<tr>
<td></td>
<td></td>
<td>• Live Traffic</td>
<td>• Live Traffic</td>
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<tr>
<td></td>
<td></td>
<td>• Simulated Traffic</td>
<td>• Simulated Traffic</td>
</tr>
<tr>
<td>Command and Control Link</td>
<td>• Modeled</td>
<td>• Prototype Equipment – single aircraft</td>
<td>• Prototype Equipment – multiple aircraft</td>
</tr>
<tr>
<td>Test Scope</td>
<td>Simulation sessions over an 8 week period</td>
<td>Multiple flights over an 8 week period (~30 flight hours)</td>
<td>Multiple flights over an 8 week period (~30 flight hours)</td>
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Flight Test 3 and 4 schedules are being updated. Anticipated dates are:

- Flight Test 3, June-July 2015
- Flight Test 4, January-February 2016