NASA UAS Integration in the NAS Project

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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

**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
Fundamental Aeronautics Program
Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

Integrated Systems Research Program
Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment.

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

Airspace Systems Program
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.

Aeronautics Test Program
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

**Host Center**
- AFRC Director of Programs: Dennis Hines
- Deputy Director: Joel Sitz

**Program Office**
- ISRP Program Director: Dr. Ed Waggoner
- Deputy PD: Cathy Bahm

**External Interfaces**
- ExCom, RTCA Steering Committee, UAS Aviation Rulemaking Committee
- FAA, DoD, RTCA SC-228, Industry, etc.
- Senior Advisor: Chuck Johnson - AFRC

**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

**DPMf**
- AFRC: Heather Maliska
- ARC: Duc Tran
- GRC: Amy Jankovsky
- LaRC: Vince Schultz

**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

Early investment Activities

Sys Analysis: ConOps, Community Progress, etc.

Technology Development to address Technical Challenges

Phase 1 (P1)
Initial Modeling, Simulation, & Flight Testing

Phase 2 (P2)
Integrated Modeling, Simulation, & Flight Testing

Flight Validated Research Findings to Inform FAA Decision Making

Prior

FY11/12

FY13

FY14

FY15

FY16

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.
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
Project Goal, Research Themes, & Technical Challenges

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.

TC-ITE: Integrated Test & Evaluation
TC-SAA: SAA Performance Standards
TC-HSI: Human Systems Integration
TC-C2: C2 Performance Standards
**UAS Integration in the NAS Project**

**Value Proposition Flow Diagram**

### NASA UAS-NAS Project Activities

**TC1 (SAA Performance Standards)**
- Develop SAA Performance Testbed
- Conduct SAA Flight Test and MS&A
  - Perf. Trade-offs
  - Interoperability
  - Self Separation
- Develop SAA Performance & Interoperability Requirements

**TC2 (C2 Performance Standards)**
- Develop C2 Prototype System
- Conduct C2 Flight Test and MS&A
  - Data Link
  - CNPC Spectrum
  - CNPC Security
  - LOS
  - BLOS
  - ATC Interop.
- Develop C2 Requirements

**TC3 (Human Systems Integration)**
- Develop Prototype GCS
- Conduct Human Factors (HF) Flight Test and MS&A
  - Conting. Mgmt
  - Pilot Response
  - Autonomy
- Develop HF Guidelines for SAA, C2 & GCS

**TC6 (Integrated Test & Evaluation)**
- Develop LVC Test Infrastructure
- Conduct IHITL Testing
- Conduct FT3 Test Scenarios
- Conduct FT4 Test Scenarios & Mission Based Flight Activity

### Key Products

**SAA Performance Requirements** to inform DAA MOPS
- DAA MOPS
- RTCA DAA Technical Standard Order (TSO)

**C2 Performance Requirements** to inform C2 MOPS
- C2 MOPS
- RTCA C2 Technical Standard Order (TSO)

**SC-228 GCS & HF Whitepapers**
- RTCA DAA MOPS
- RTCA C2 MOPS

### Resultant Outcomes

**Re-usable Test Infrastructure**
- Test Data to support SAA & C2 Standards Devlpmt
- RTCA C2 Technical Standard Order (TSO)

**Safety Substantiation Final Report & Safety Metrics Data**
- RTCA C2 Technical Standard Order (TSO)

### Certification & Safety

**Analyze Classification Factors for UAS**
- Conduct Restricted Category Study
- Analyze Case Study Results

**NASA UAS-NAS Project Activities**

**Resultant Outcomes**

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**SC-228 GCS & HF Whitepapers**
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UAS-NAS Modeling & Simulation
Tools and Capabilities Phase 2

SATCOM

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

UAS

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

GCS

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)

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)

Intruder Aircraft

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

ATC

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

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**

- **Time until CPA**
  - 110 sec
  - 95 sec
  - 85 sec
  - 55 sec
  - 40 sec

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

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

- **TASATS Simulation**
  - Beale Pilot Feedback

- **Controller Acceptability Study**

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Communication Subproject Focus

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

Live Ownership
- DFRC Ikhana
- OR
- GRC S-3B

Virtual/Constructive Intruders
- Honeywell King Air
  - ADS-B
  - TCAS II Instm
  - High speed
- ADS-B Out

Need Common Airspace

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

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

UAS Pilot as Subject
- Research GCS
- Displays of Proximal Traffic SAA/DAA Algorithms

Stratway+
- Autoresolver

Autoresolver
- Distributed Environment/Connectivity

ATC as Subject
- Multi-Aircraft Control System

Pseudo Pilots
- Live Ownship
- UAS Pilot as Subject
- Virtual/Constructive Intruders

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

VPN
## Integrated Test Progression

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<tr>
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<tbody>
<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>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Multiple GCSs</td>
</tr>
<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>
</tr>
<tr>
<td>UAS</td>
<td>• Simulated</td>
<td>• UAS Surrogate (T-34C)</td>
<td>• UAS Surrogate (T-34C)</td>
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<tr>
<td></td>
<td></td>
<td>• SAA equipped UAS</td>
<td>• SAA equipped UAS</td>
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<tr>
<td>Sensor</td>
<td>• Simulated</td>
<td>• On board SAA</td>
<td>• On board SAA</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Possible SAA on surrogate aircraft</td>
</tr>
<tr>
<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>
</tr>
<tr>
<td>Traffic</td>
<td>• Simulated</td>
<td>• UAS/UAS Surrogate</td>
<td>• UAS/UAS Surrogate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Live Traffic</td>
<td>• Live Traffic</td>
</tr>
<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>
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</tr>
</tbody>
</table>
Flight Test 3 and 4 schedules are being updated. Anticipated dates are:

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