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

**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
NASA Aeronautics Portfolio in FY2013

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.

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.

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.

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

ExCom, RTCA Steering Committee, UAS Aviation Rulemaking Committee
External Interfaces
FAA, DoD, RTCA SC-228, Industry, etc.

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 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

DPMf – ARC
Duc Tran

DPMf – GRC
Amy Jankovsky

DPMf – LaRC
Vince Schultz

AFRC ARD
ARC ARD
GRC ARD
LaRC ARD

ExCom, RTCA Steering Committee, UAS Aviation Rulemaking Committee
External Interfaces
FAA, DoD, RTCA SC-228, Industry, etc.

Senior Advisor: Chuck Johnson - 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

Formulation

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

Prior

FY11/12

FY13

FY14

FY15

FY16

P2 Portfolio Developed

Flight Validated Research Findings to Inform FAA Decision Making

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
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 Diagram

NASA UAS-NAS Project Activities

**SAA Performance Standards**
- TC1: Develop SAA Performance Testbed
- TC1: Develop SAA Interoperability Testbed
- TC3: Develop Prototype GCS
- TC2: Develop C2 Prototype System
- TC6: Develop LVC Test Infrastructure

**C2 Performance Standards**
- TC2: Conduct C2 Flight Test and MS&A
- TC2: Conduct Human Factors (HF) Flight Test and MS&A

**Human Systems Integration**
- TC3: Conduct Human Factors (HF) Flight Test and MS&A
- TC3: Conduct Human Factors (HF) Flight Test and MS&A

**Integrated Test & Evaluation**
- TC6: Develop LVC Test Infrastructure
- TC3: Conduct Human Factors (HF) Flight Test and MS&A

**Certification & Safety**
- TC6: Develop LVC Test Infrastructure
- TC6: Conduct IHITL Testing

**Key Products**
- RTCA: DAA MOPS
- RTCA: C2 MOPS
- SC-228 GCS & HF Whitepapers
- Re-usable Test Infrastructure
- Test Data to support SAA & C2 Standards Devlpmt

**Resultant Outcomes**
- Resultant Outcomes
- 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

**NASA UAS-NAS Project Activities**
- TC1: Develop SAA Performance Testbed
- TC1: Conduct SAA Flight Test and MS&A
- TC1: Develop SAA Performance & Interoperability Requirements
- TC2: Develop C2 Prototype System
- TC2: Conduct C2 Flight Test and MS&A
- TC2: Develop C2 Requirements
- TC3: Develop Prototype GCS
- TC3: Conduct Human Factors (HF) Flight Test and MS&A
- TC3: Develop HF Guidelines for SAA, C2 & GCS
- TC6: Conduct FT3 Test Scenarios
- TC6: Conduct FT4 Test Scenarios & Mission Based Flight Activity
- TC6: Analyze Classification Factors for UAS
- TC6: Conduct Restricted Category Study
- TC6: Analyze Case Study Results

**Resultant Outcomes**
- RTCA: DAA MOPS
- RTCA: C2 MOPS
- SC-228 GCS & HF Whitepapers
- Re-usable Test Infrastructure
- Test Data to support SAA & C2 Standards Devlpmt

**SAA Performance Requirements to inform DAA MOPS**
- SAA Performance Requirements to inform DAA MOPS

**C2 Performance Requirements to inform C2 MOPS**
- C2 Performance Requirements to inform C2 MOPS

**SC-228 GCS & HF Whitepapers**
- SC-228 GCS & HF Whitepapers

**Re-usable Test Infrastructure**
- Re-usable Test Infrastructure

**Test Data to support SAA & C2 Standards Devlpmt**
- Test Data to support SAA & C2 Standards Devlpmt

**Safety Substantiation Final Report & Safety Metrics Data**
- Safety Substantiation Final Report & Safety Metrics Data
UAS-NAS Modeling & Simulation
Tools and Capabilities Phase 2

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)

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

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

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

Tools/Capabilities not integrated into LVC

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
- GRC S-3B

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

ADS-B Out

Need Common Airspace

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

ATC as Subject
- Multi-Aircraft Control System
- Autoresolver

Pseudo Pilots
- Honeywell King Air
- DFRC Ikhana
- GRC T-34C
- GRC S-3B

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

Autoresolver

GRC Ikhana - CPDS - Stratway+ - Autoresolver

Stratway+

VPN

Distributed Environment/Connectivity
# 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>
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<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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<td></td>
<td></td>
<td></td>
<td>• Possible SAA on surrogate aircraft</td>
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<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>
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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