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

**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
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.

**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

ExCom, RTCA Steering Committee, UAS Aviation Rulemaking Committee

External Interfaces
FAA, DoD, RTCA SC-228, Industry, etc.

Senior Advisor:
Chuck Johnson - AFRC

AFRC ARD
ARC ARD
GRC ARD
LaRC ARD

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

DPMf – ARC
Duc Tran

DPMf – GRC
Amy Jankovsky

DPMf – LaRC
Vince Schultz

Subprojects/Technical Challenges (TC)
Separation Assurance/Sense and Avoid Interoperability (SSI)
PE: Project Engineer, DPMf: Deputy Project Manager for
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
## KDP (Phase 1/Phase 2 Transition)

<table>
<thead>
<tr>
<th>Prior</th>
<th>FY11/12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
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<tbody>
<tr>
<td>Prior Activities</td>
<td>Formulation</td>
<td>P2 Portfolio Developed</td>
<td>Flight Validated Research Findings to Inform FAA Decision Making</td>
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<td>Technical input from Project technical elements, NRAs, Industry, Academia, Other Government Agencies, Project Annual Reviews</td>
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- **Phase 1 (P1)**: Initial Modeling, Simulation, & Flight Testing
- **Phase 2 (P2)**: Integrated Modeling, Simulation, & Flight Testing
- **KDP (Phase 1/Phase 2 Transition)**

**External Input**
- SyS Analysis: ConOps, Community Progress, etc.
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 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
  - CONOPs
  - Well Clear
  - Coll. Avoid.
- Develop SAA Performance & Interoperability Requirements

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

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

Certification & Safety
- Analyze Classification Factors for UAS
- Conduct Restricted Category Study
- 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

Resultant Outcomes
- DAA MOPS
- C2 MOPS
- RTCA DAA Technical Standard Order (TSO)
- RTCA C2 Technical Standard Order (TSO)
- RTCA C2 Technical Standard Order (TSO)
- RTCA C2 Technical Standard Order (TSO)
UAS-NAS Modeling & Simulation Tools and Capabilities Phase 2

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

SATCOM

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)

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

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

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

- **TASATS Simulation**
  - Beale Pilot Feedback

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

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

- **TCAS Definition**

- **Controller Acceptability Study**
Communication Subproject Focus

Manned or Surrogate Aircraft

Prototype radio

Secure and Scalable

CNPC Network

CNPC Ground Station w/Prototype Radio

Prototype radio

Message Generator

Message Generator

Ground Control Station

Ground Control Station

Ground Control Station

Possible Future ATC and ATS Ground Connectivity
NASA UAS NAS Project OV-1
Validated through Integrated Test

Legend:
- NAS Element
- Enabling Capability
- DAA Technologies
- Air Traffic Services
- CNPC Network
- LOS C2 Links (legacy)
- BLOS C2 Links (legacy)

- Cooperative Aircraft
- Non-cooperative Aircraft
- Radar and Electro-optic
- Air Traffic Services (Enroute)
- Enroute Air Traffic Services
- Control & Communications
- SATCOM Uplink
- CNPC Ground Station
- Air Traffic Services (Terminal)
- T-34 UAS Surrogate CNPC Test Aircraft
- Ikhana UAS SAA Test Aircraft
- SATCOM Uplink
- CNPC Network
- Urban Environment
- Precision Agriculture
- DAAS Restricted Use Certification
- Human Systems Integration
- Control Station Hand-off
- Air Traffic Services Integration
- Backup UAS Control Station
- sUAS Operational Procedures
- Detect and Avoid
2015, 2016 Flight Test (i.e. FT3, FT4)

Research GCS

UAS Pilot as Subject

ATC as Subject

Multi-Aircraft Control System

Need Common Airspace

Virtual/Constructive Intruders

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

ADS-B Out

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

GRC S-3B
- Ikhana Data Link
  - C2
  - Voice
  - Health & Status
  - Video
  - Traffic (ADS-B and Radar)

Ikhan GCS
- CPDS
- Stratway+
- Autoresolver

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

Live Ownship

UAS Pilot as Subject

VNP

Distributed Environment/Connectivity

Autoresolver

Pseudo Pilots

ATC as Subject

Multi-Aircraft Control System

Research GCS

Displays of Proximal Traffic SAA/DAA Algorithms

Stratway+

Autoresolver

VPN
## Integrated Test Progression

|------------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| GCS                          | • Research Ground Control Station (RGCS) with traffic displays and alerting logic | • RGCS with UAS Surrogate (T-34C) Command and Control                       | • RGCS with UAS Surrogate (T-34C) C2  
• Multiple GCSs                |
| SAA Algorithms                | • Self separation, idealized sensor data                                      | • Multiple SAA algorithms  
• Collision avoidance on UAS and surrogate   | • Multiple SAA algorithms  
• Collision avoidance on UAS and surrogate   |
| UAS                          | • Simulated                                                                    | • UAS Surrogate (T-34C)  
• SAA equipped UAS                    | • UAS Surrogate (T-34C)  
• SAA equipped UAS                    |
| Sensor                        | • Simulated                                                                    | • On board SAA                                                            | • On board SAA  
• Possible SAA on surrogate aircraft   |
| Surveillance                  | • Modeled mixed ADS-B and radar                                               | • ADS-B/TIS-B, modeled and real                                            | • ADS-B/TIS-B, modeled and real                                            |
| Traffic                       | • Simulated                                                                    | • UAS/UAS Surrogate  
• Live Traffic  
• Simulated Traffic            | • UAS/UAS Surrogate  
• Live Traffic  
• Simulated Traffic            |
| Command and Control Link      | • Modeled                                                                      | • Prototype Equipment – single aircraft                                    | • Prototype Equipment – multiple aircraft                                   |

| Test Scope                    | Simulation sessions over an 8 week period                                    | Multiple flights over an 8 week period (~30 flight hours)                  | Multiple flights over an 8 week period (~30 flight hours)                  |
Flight Test 3 and 4 schedules are being updated. Anticipated dates are:

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