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

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.

**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.

**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.

**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.

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 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

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

Subprojects/Technical Challenges (TC)
- Separation Assurance/Sense and Avoid Interoperability (SSI)
  - Co-PEs
    - Confesor Santiago- ARC
    - Maria Consiglio - 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.

Prior

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

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

FY11/12 FY13 FY14 FY15 FY16

KDP (Phase 1/Phase 2 Transition)

Flight Validated Research Findings to Inform FAA Decision Making

Technology Development to address Technical Challenges

External Input

Technical input from Project technical elements, NRAs, Industry, Academia, Other Government Agencies, Project Annual Reviews
UAS-NAS Project Formulation

Key Stakeholders and Influencing Factors

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
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-C2: C2 Performance Standards

TC-HSI: Human Systems Integration
UAS Integration in the NAS Project
Value Proposition Flow Diagram

**NASA UAS-NAS Project Activities**

**TC1**
- Develop SAA Performance Testbed
- Develop SAA Interoperability Testbed

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

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

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

**Integrated Test & Evaluation**

**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 Development
- Safety Substantiation Final Report & Safety Metrics Data

**Resultant Outcomes**
- RTCA DAA MOPS
- RTCA C2 MOPS
- RTCA C2 Technical Standard Order (TSO)
- RTCA DAA MOPS
- RTCA C2 MOPS
- SC-228 GCS & HF Whitepapers
- Re-usable Test Infrastructure
- Test Data to support SAA & C2 Standards Development
- Safety Substantiation Final Report & Safety Metrics Data

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

**Human Systems Integration**
- Develop HF Guidelines for SAA, C2 & GCS

**SAA Performance Standards**
- Conduct SAA Flight Test and MS&A

**C2 Performance Standards**
- Develop C2 Requirements

**Integrated Test & Evaluation**
- Conduct FT3 Test Scenarios
- Conduct FT4 Test Scenarios & Mission Based Flight Activity

**Test Data to support SAA & C2 Standards Development**

**Safety Substantiation Final Report & Safety Metrics Data**
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

Tools/Capabilities not integrated into LVC
Self-Separation Timeline

Time until CPA

- 110 sec: Detect Intruders
- 95 sec: Alert Pilots
- 85 sec: Gain Situational Awareness
- 55 sec: Pilots Determine Resolution
- 40 sec: TCAS Definition

- TASATS Simulation
- Beale Pilot Feedback
- Part Task 4 (SAA Traffic Display Evaluation)
- Full Mission Simulation (Levels of Automation)

Controller Acceptability Study
Communication Subproject Focus

Possible Future ATC and ATS Ground Connectivity

Manned or Surrogate Aircraft

CNPNetwork

Prototype radio

Secure and Scalable

CNPC Ground Station w/Prototype Radio

CNPC Satcomm Link

Message Generator

Ground Control Station

Ground Control Station

Ground Control Station

Message Generator

FAA (ATC & ATS)
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)
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
- Ikhana Data Link
  - C2
  - Voice
  - Health & Status
  - Video
  - Traffic (ADS-B and Radar)
- Ikhana GCS
  - CPDS
  - Stratway+
  - Autoresolver

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

ATC as Subject
- CNPC
  - ADS-B
  - 2nd CNPC
  - SAA
- Autoresolver
- Distributed Environment/Connectivity

Pseudo Pilots
- Stratway+

Research GCS
- Displays of Proximal Traffic
- SAA/DAA Algorithms

Multi-Aircraft Control System

Autoresolver

VPN
## Integrated Test Progression

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<tr>
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<tbody>
<tr>
<td><strong>GCS</strong></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 • Multiple GCSs</td>
</tr>
<tr>
<td><strong>SAA Algorithms</strong></td>
<td>• Self separation, idealized sensor data</td>
<td>• Multiple SAA algorithms • Collision avoidance on UAS and surrogate</td>
<td>• Multiple SAA algorithms • Collision avoidance on UAS and surrogate</td>
</tr>
<tr>
<td><strong>UAS</strong></td>
<td>• Simulated</td>
<td>• UAS Surrogate (T-34C) • SAA equipped UAS</td>
<td>• UAS Surrogate (T-34C) • SAA equipped UAS</td>
</tr>
<tr>
<td><strong>Sensor</strong></td>
<td>• Simulated</td>
<td>• On board SAA</td>
<td>• On board SAA • Possible SAA on surrogate aircraft</td>
</tr>
<tr>
<td><strong>Surveillance</strong></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><strong>Traffic</strong></td>
<td>• Simulated</td>
<td>• UAS/UAS Surrogate • Live Traffic • Simulated Traffic</td>
<td>• UAS/UAS Surrogate • Live Traffic • Simulated Traffic</td>
</tr>
<tr>
<td><strong>Command and Control Link</strong></td>
<td>• Modeled</td>
<td>• Prototype Equipment – single aircraft</td>
<td>• Prototype Equipment – multiple aircraft</td>
</tr>
<tr>
<td><strong>Test Scope</strong></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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Flight Test 3 and 4 schedules are being updated. Anticipated dates are:

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