NASA UAS Integration in the NAS Project

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

ICAP UAS Subcommittee
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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.

**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

**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

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

**ExCom, RTCA Steering Committee, UAS Aviation Rulemaking Committee**

**Exernal Interfaces**
- FAA, DoD, RTCA SC-228, Industry, etc.

**Senior Advisor:**
- Chuck Johnson - AFRC

**AFRC ARD**
- ARC ARD
- GRC ARD
- LaRC ARD

**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**: Formulation
- **Early investment Activities**: Sys Analysis: ConOps, Community Progress, etc.

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

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

**KDP (Phase 1/Phase 2 Transition)**

- Flight Validated Research Findings to Inform FAA Decision Making
- Technical input from Project technical elements, NRAs, Industry, Academia, Other Government Agencies, Project Annual Reviews

**Timeline**
- FY11/12
- FY13
- FY14
- FY15
- FY16
UAS-NAS Project Formulation
Key Stakeholders and Influencing Factors

Project Focus:
Unencumbered NAS Access for Civil / Commercial UAS

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

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**

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

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

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

**Integrated Test & Evaluation**
- TC6: 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**
- RTCA DAA MOPS
- RTCA C2 MOPS
- SC-228 GCS & HF Whitepapers

**Resultant Outcomes**
- SAA Performance Requirements to inform DAA MOPS
- C2 Performance Requirements to inform C2 MOPS
- 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

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

**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)

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

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

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

Note: All acronyms are defined in the Notes Page

Tools/Capabilities not integrated into LVC
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**
Communication Subproject Focus

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 Communications Satellite

Beyond Line of Site Link (Legacy)

Non-cooperative Aircraft

Detect and Avoid

Ikhana UAS SAA Test Aircraft

UAS Control Station

Human Systems Integration

UAS Restricted Use Certification

sUAS Operational Procedures

Urban Environment

Air Traffic Services (Enroute)

Air Traffic Services Integration

Air Traffic Services (Terminal)

Control & Communications

T-34 UAS Surrogate CNPC Test Aircraft

CNPC Network

CNPC Ground Station

Air Traffic Services (Terminal)

ATC Interaction

Backup UAS Control Station

Enroute Air Traffic Services

Air Traffic Services Integration

Detected and Avoided

RADAR and Electro-optical

NAS Element Link (Legacy)
2015, 2016 Flight Test (i.e. FT3, FT4)

UAS Pilot as Subject

ATC as Subject

Multi-Aircraft Control System

Pseudo Pilots

Need Common Airspace

Live Ownship

Virtual/Constructive Intruders

Honeywell King Air

- ADS-B
- TCAS II Instm
- High speed

ADS-B Out

GRC T-34C

- ADS-B
- 2nd CNPC
- SAA

DFRC Ikhana

GRC S-3B

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)

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

Research GCS

Displays of Proximal Traffic
SAA/DAA Algorithms

VPN

Distributed Environment/Connectivity

Autoresolver

Autoresolver

stratway+

Live Ownship

UAS Pilot as Subject

ATC as Subject

Distributed Environment/Connectivity

Autoresolver
## Integrated Test Progression

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<thead>
<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>
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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>
<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>
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<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>
<td>Multiple flights over an 8 week period (~30 flight hours)</td>
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</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