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.

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.

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

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

**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

**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

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

Prior Activities

Early investment Activities

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.
UAS Integration in the NAS Project
Value Proposition Flow Diagram

NASA UAS-NAS Project Activities

Key Products

Resultant Outcomes

TC1

SAA Performance Standards
- Develop SAA Performance Testbed
- Conduct SAA Flight Test and MS&A
- Develop SAA Performance & Interoperability Requirements

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

TC2

C2 Performance Standards
- Develop C2 Prototype System
- Conduct C2 Flight Test and MS&A
- Develop C2 Requirements

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

TC3

Human Systems Integration
- Develop Prototype GCS
- Conduct Human Factors (HF) Flight Test and MS&A
- Develop HF Guidelines for SAA, C2 & GCS

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

TC6

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

- Re-usable Test Infrastructure
- Test Data to support SAA & C2 Standards Devlpmt
- RTCA DAA MOPS
- RTCA C2 MOPS

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

- Safety Substantiation Final Report & Safety Metrics Data
- RTCA DAA MOPS
- RTCA C2 MOPS
- RTCA SAA 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)

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)

Intruder Aircraft

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

SATCOM Simulation Models (GRC)

NAS-wide CNPC System Performance (GRC)

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

- Background Traffic (ARC)

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

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**: negotiates clearance with ATC and uplink maneuver to aircraft
  - **40 sec**: 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
Non-cooperative Aircraft
Air Traffic Services (Enroute)
Backup UAS Control Station
Urban Environment

Detect and Avoid

Human Systems Integration

UAS Restricted Use Certification

Precision Agriculture
2015, 2016 Flight Test (i.e. FT3, FT4)

Live Ownship

DFRC Ikhana

OR

GRC S-3B

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

Live Ownship

DFRC Ikhana

Virtual/Constructive Intruders

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

ADS-B Out

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

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)

GRC S-3B - CPDS - Stratway+ - Autoresolver

Stratway+

Autoresolver

Autoresolver

Research GCS

Displays of Proximal Traffic SAA/DAA Algorithms

ATC as Subject

VPN

Multi-Aircraft Control System

Pseudo Pilots

Distributed Environment/Connectivity

Autoresolver
## Integrated Test Progression

<table>
<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 • Multiple GCSs</td>
</tr>
<tr>
<td>SAA Algorithms</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>UAS</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>Sensor</td>
<td>• Simulated</td>
<td>• On board SAA</td>
<td>• On board SAA • 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 • Live Traffic • Simulated Traffic</td>
<td>• UAS/UAS Surrogate • Live Traffic • 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>
</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