Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project

TAAC 2016

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Davis Hackenberg
Deputy Project Manager, Integration
Airspace Operations and Safety Program

Advanced Air Vehicles Program

Integrated Aviation Systems Program

Transformative Aeronautics Concepts Program

Safe, Efficient Growth in Global Operations
Real-Time System-Wide Safety Assurance
Assured Autonomy for Aviation Transformation

Ultra-Efficient Commercial Vehicles
Innovation in Commercial Supersonic Aircraft
Transition to Low-Carbon Propulsion
Assured Autonomy for Aviation Transformation

Flight research-oriented, integrated, system-level R&T that supports all six thrusts
X-planes/test environment

High-risk, leap-frog ideas that support all six thrusts
Critical cross-cutting tool development

MISSION PROGRAMS

SEEDLING PROGRAM

ARMD Organizational Structure, Programs Overview

IASP Projects
- UAS-NAS
- Environmentally Responsible Aviation (ERA)
- Flight Demonstrations & Capabilities (FDC)
Emerging Commercial UAS Operational Environments (OE)

**IFR -like**
UAS will be expected to meet certification standards and operate safely with traditional air traffic and ATM services.
(Example Use Case: Communication Relay / Cargo Transport)

**Low-Altitude Unpopulated**
Low risk BVLOS rural operations without aviation services.
(Example Use Case: Agriculture)

**Low-Altitude Populated**
Must interface with dense controlled air traffic environments as well as operate safely amongst the traffic in uncontrolled airspace.
(Example Use Case: Traffic Monitoring / Package Delivery)

**Tweeners**
These UAS will operate at altitudes below critical NAS infrastructure and will need to routinely integrate with both cooperative and non-cooperative aircraft.
(Example Use Case: Infrastructure Surveillance)

**Cooperative Traffic**

**Non-cooperative Traffic**

**MINIMUM ENROUTE ALTITUDE**

**60K’ MSL**

**18K’ MSL**

**10K’ MSL**

**500’ AGL**
Recent Accomplishments: C2 Phase 1 MOPS

**Spectrum Compatibility Analysis**
Objective: Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS

Accomplishment: NASA conducted sharing study results delivered at the 2015 World Radiocommunication Conference (WRC-15) to support Ku & Ka Band frequency Allocations

**Verify and Validate C2 MOPS Requirements**
Objective: Analyze the performance of fifth generation Control and Non-Payload Communication System (CNPC) prototypes

Accomplishment: Utilized Gen-5 radios at three CNPC ground stations and onboard GRC S-3B aircraft in order to collect data for performance in two relevant environments

Final C2 MOPS released through RTCA in July 2016
C2 Subproject Structure for Project Phase 2

Command and Control
<TC-C2>
Subproject Manager (SPM)
Mike Jarrell, GRC
Subproject Technical Leads
Jim Griner, GRC

Ku/Ka-Band SATCOM
Terrestrial Extension
C-Band SATCOM
Integrated Flight Test Support (IT&E TWP)

C2 Performance Standards
- Develop C2 Prototype System
- Conduct C2 Flight Test and MS&A
  - Data Link
  - CNPC Spectrum
  - CNPC Security
  - BVLOS/BRLOS
  - ATC Interoperability
- Develop C2 Requirements
- C2 Performance Requirements to inform C2 MOPS
- C2 MOPS
- RTCA
- C2 Technical Standard Order (TSO)
Detect and Avoid (DAA) Performance Standard Operational Environments (OE)

Legend
- Current Research Areas (FY14- FY16)
- Proposed Research Areas (FY17 – FY20)

- HALE aircraft
- ADS-B & ACAS Xu
- Cooperative Traffic
- Non-cooperative Aircraft
- Airborne Radar
- ADS-B & TCAS-II ACAS Xu
- Altitude
- Ground Based Radar
- GBSAA Data
- UAS Ground Control Station
- "Tweener" UAS
- Alternative DAA Sensors
- “Tweener” UAS
- DAA System for Transition to Operational Altitude
- C2 Datalink
- Terminal Area Ops
- DAA System for Operational Altitudes (> 500ft AGL)

60K' AGL
18K' AGL
10K' AGL
500' AGL
MINIMUM ENROUTE ALTITUDE

Terminal Area Ops

UAS Ground Control Station

"Tweener" UAS
Recent Accomplishments: DAA Phase 1 MOPS

**Human Systems Integration “Part Task 6”**
Objective: Conduct final V&V activity in support of the SC-228 DAA human machine interface requirements for displays, alerting, and guidance

Accomplishment: Verified pilot performance against minimum requirements, re-evaluated performance differences between a standalone and integrated DAA displays

**DAA End to End V&V**
Objective: Verify and Validate (V&V) a MOPS-representative Detect and Avoid (DAA) system in an End-to-End simulation environment representative of the MOPS

Accomplishment: Final closed-loop, pilot (model)-in-the-loop, end-to-end simulation evaluation of MOPS leveraging encounter sets from MOPS test cases & MIT/LL NAS encounter model

Final DAA MOPS scheduled to be released through RTCA in December 2016
Recent Accomplishments: DAA Phase 1 MOPS

Integrated Test and Evaluation FT4

Objective:
• Conduct Flight Test Series 4 integrating the latest SSI algorithms, HSI displays, and active test aircraft sensors using the Live, Virtual, Constructive test environment
• Document the performance of the test infrastructure in meeting the flight test requirements

Accomplishment: FT4 successfully completed on 6/30/2016
• 2 system checkout and 19 data collection flight tests
• 11 weeks (April 12 - June 30)
• 321 air-to-air encounters

Final DAA MOPS scheduled to be released through RTCA in December 2016
DAA Subproject Structure for Project Phase 2

Detect and Avoid
<TC-DAA>
Subproject Manager (SPM)
Jay Shively, ARC
Subproject Technical Leads
Confesor Santiago, ARC, Tod Lewis, LaRC, TBD, ARC

Alternate Surveillance Requirements
Well Clear Alerting Requirements
ACAS Xu
External Collaborations
Integrated Events

SAA Performance Standards
Develop DAA Test beds
Conduct SAA Flight Test and MS&A
Human Factors
Performance Trade-offs
Interoperability
Self Separation
CONOPS
Well Clear Collision Avoidance
Develop SAA Performance & Interoperability Requirements
SAA Performance Requirements to inform DAA MOPS
RTCA
DAA MOPS
SAA Technical Standard Order (TSO)
Integrated Test & Evaluation

Subproject Manager (SPM)
Heather Maliska, AFRC
Subproject Technical Leads
Sam Kim, AFRC, Jim Murphy, ARC

Integration of Technologies into LVC-DE
Simulation Planning & Integration
LVC-DE Infrastructure Sustainment
Integrated Flight Test

Develop DAA Prototype System
Develop Live Virtual Constructive (LVC) Test Infrastructure
Conduct TC Specific Testing
Re-usable Test Infrastructure
Conduct FT2
Conduct FT5 Test Scenarios
Conduct FT6 Test Scenarios