



# UAS-COE

NextGEN

Center of Excellence *for* Unmanned Aircraft Systems

*Public Meeting*

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**Federal Aviation Administration**

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# FAA UAS R&D Portfolio

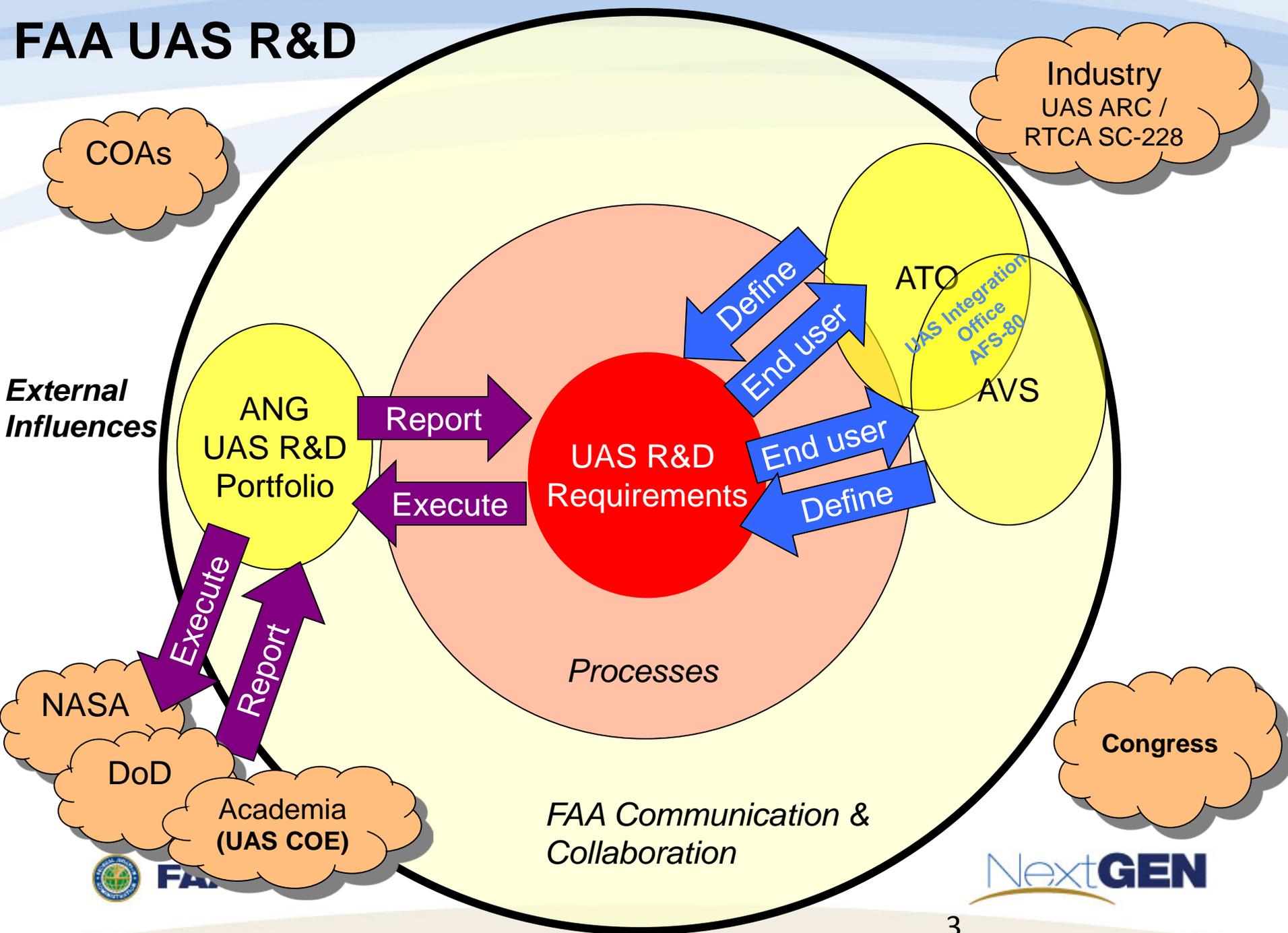
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R&D Portfolio Manager, ANG-C2**

May 28, 2014



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# FAA UAS R&D

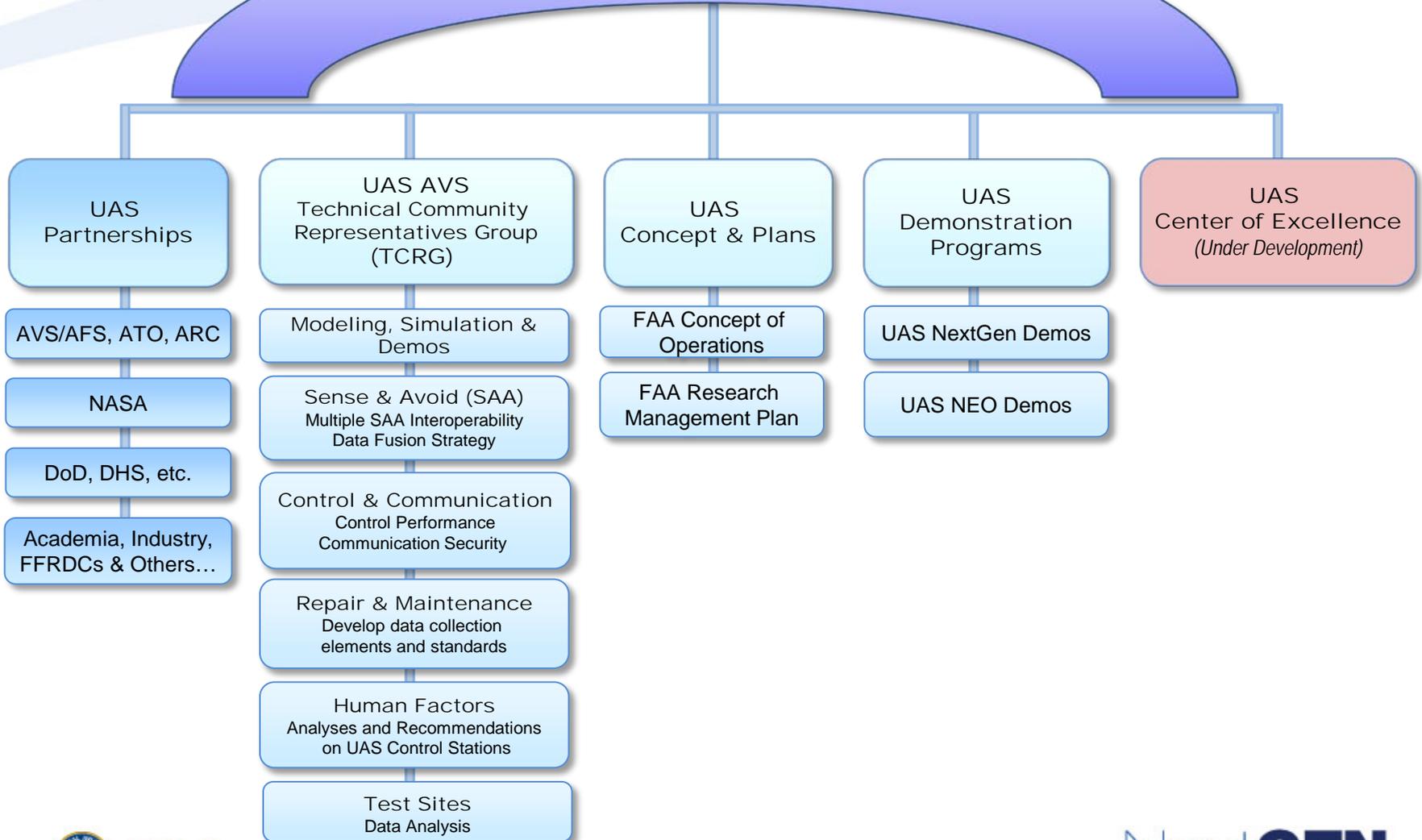


# UAS R&D Objectives

- **Explore UAS integration into current and future National Airspace System (NAS)**
  - Establish modeling and simulation (M&S) capabilities
  - Capture system performance baselines
  - Provide critical information to refine near-term operating concepts
  - Explore NextGen technologies & concepts with UAS
- **Support standards development, safety case, RTCA Special Committee-228**
- **Leverage partners (NASA, DoD, etc.) research**

# UAS R&D Portfolio

UAS R&D Portfolio Management  
Sabrina Saunders-Hodge, ANG-C2



# UAS R&D Timeline

2008

- ✓ Establishment of initial UAS Modeling and Simulation Capability
- ✓ Traffic Collision Avoidance System (TCAS) on UAS Working Group Study
- ✓ RQ-7B Shadow Achieved Performance Model Verification (“Demo 1-S”)
- ✓ MQ-9 Predator B Achieved Performance Model Verification (“Demo 1-P”)
- ✓ RQ-7B Shadow coupled with a Flight Management System (“Demo 2”)
- ✓ RQ-7B Shadow UAS Operational Assessment: Marine Corps Air Station, Cherry Point, NC (“Cherry Point”)
- ✓ Multi-UAS Operational Assessment: Class D Airspace
- ✓ Initial NAS Integration Simulation-1
- ✓ UAS NAS Integration: RQ-7B Shadow with FMS Simulation
- ✓ Net Enabled Operations (NEO) UAS Demonstrations (“Demos 5, 6”)
- ✓ UAS NextGen Demonstration (“Demo 3”) – NASA, DHS/CBP, USAF, ERAU
- ✓ UAS NextGen Demonstration (“Demo 4”) – NASA, DHS/CBP, USAF, ERAU
- ✓ ScanEagle Achieved Performance Model Verification (“Demo 1-SE”)
- ➔ Integration of UAS into the NAS Concept of Operations (ongoing)
- ➔ Integration of UAS into the FAA Enterprise Architecture

Present

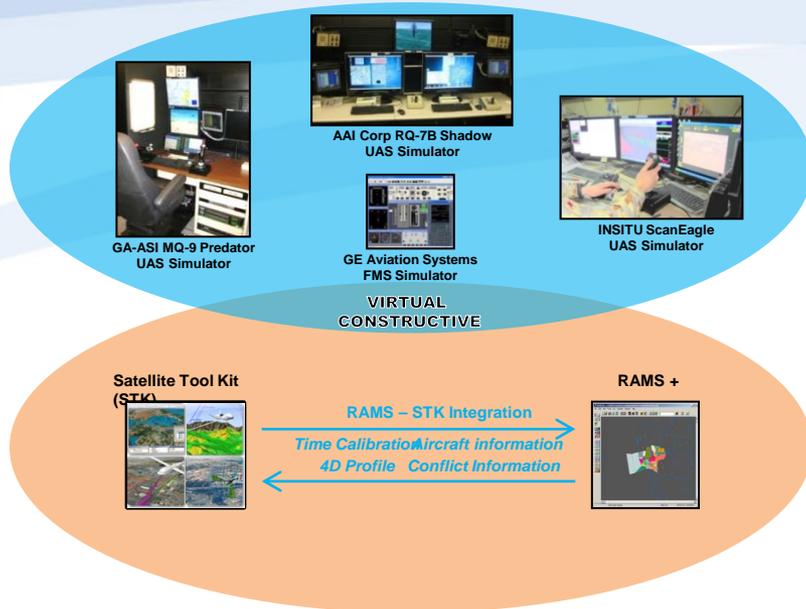
➔ UAS FY11 - FY14 R&D Initiatives in Progress/Planning



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# UAS Modeling & Simulation Capability



# Milestones/Deliverables

## Capability Development:

- Integration of Shadow, Predator-B , ScanEagle HITL simulators
- Coupling of FMS with Shadow simulator
- Remote maintenance access for Industry Partners
- Display of live and simulated ADS-B data on CDTI/MSDS
- Data Comm and VOIP simulation capability: Q2 FY13
- Sense-and-Avoid capability evaluation : Q1 FY13
- **Laboratory expansion: Q3 FY14**

# Project Description

- FAA and Industry partnership effort
- UAS M&S Capabilities
  - Constructive/Fast-Time Simulations
  - Virtual/Real-Time HITL Simulations
  - Field/Live Demonstrations
- UAS M&S Infrastructure
  - Established June '10 as part of NextGen Integration and Evaluation Capability (NIEC)
  - Constructive models (RAMS, STK) integrated
  - **Assets include four UAS simulators (Shadow, ScanEagle, Predator B, Global Hawk), an FMS, NextGen enabling technologies (ADS-B, CDTI)**
  - Upgrading and expanding to include other technologies (e.g. NVS, Data Comm, TBO), UAS platforms (tbd)

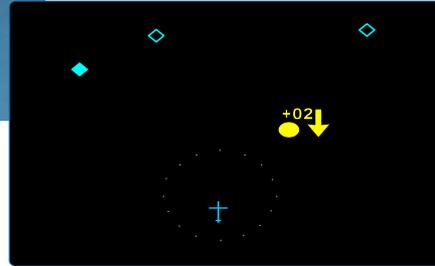
# Partners/Stakeholders

- Partners
  - AAI Corp
  - General Atomics – ASI
  - GE Aviation Systems
  - Boeing Insitu
  - **Northrup Grumman**
  - FAA AVS and ATO
  - NASA
  - DoD

# Traffic Collision Avoidance System (TCAS) on UAS Working Group Study



Predator



TCAS Display

## Outcomes/Deliverables

- Outcome:
  - Evaluation of TCAS on UAS intended functions
- Deliverable:
  - Final Report: MAR 2011

## Project Description

- Identify and study potential uses of TCAS on UAS, including applications outside TCAS intended and approved functions
- Determine if any value could be provided from the installation of TCAS on UAS
- To develop FAA guidance for installation and use of TCAS on UAS, if any benefit is determined to be gained once a risk assessment study is performed



## Partners/Stakeholders

- Partners
  - FAA UAPO (AVS) - lead
  - MITRE
  - General Dynamics
  - USAF (Jacobs Technology)
  - NASA



## Achieved Performance Model Verifications (“Demo 1 series”)



## Outcomes/Deliverables

- Outcome
  - The overall performance of the RQ-7B Shadow and MQ-9 Predator B simulators integrated within the FAA’s laboratory suite is acceptable and sufficient to be utilized in further simulations. (ScanEagle acceptance is pending completion of study.)
- Deliverables
  - Demo 1-Shadow Final Report: OCT 2011
  - Demo 1-Predator Final Report (internal): FEB 2011
  - Demo 1-Scan Eagle Final Report:

## Project Description

- Independent assessments and calibration of the UAS simulators (and their models) against the performance of the actual aircraft
- Verification of successful integration of the UAS simulators into the NextGen Integration and Evaluation Capability (NIEC) air traffic control simulators
- Part of a series of interrelated exercises that build in complexity
  - Building block activities for simulation studies and future UAS Demonstrations



## Partners/Stakeholders

- Partners
  - AAI Corp
  - General Atomics – ASI
  - Boeing Insitu
  - FAA AVS and ATO
  - DoD
  - DHS
  - University of North Dakota



# UAS NAS Integration Simulations



Simulation

# Outcomes/Deliverables

- Outcomes:
  - **UAS Initial NAS Integration Simulation-1:** Measurements of UAS performance (Shadow and Predator B), human performance, and impacts to the NAS during normal and contingency UAS operations
  - **UAS NAS Integration: RQ-7B Shadow with FMS:** Capture of performance characteristics for UAS operations within the NAS environment during normal and contingency operations both with and without an integrated Flight Management System. Also examined latencies of UAS pilot responses to air traffic control, as well as elapsed time between command inputs and aircraft compliance
- Deliverables:
  - **UAS Initial NAS Integration Simulation-1** Final Report (internal): MAR 2012
  - **UAS NAS Integration: RQ-7B Shadow with FMS** Final Report:

# Project Description

- Industry collaboration to examine potential concepts and technologies in support of UAS **integration** into NAS/NextGen
  - Establish system performance baselines
  - Measure UAS performance, human performance, and impacts to NAS during normal and contingency UAS operations
  - Explore 4-dimensional trajectory (4DT) concepts on UAS
  - Support development of standards, safety case, and validation of RTCA SC-203 requirements



# Partners/Stakeholders

- Partners
  - AAI Corp
  - General Atomics – ASI
  - GE Aviation Systems
  - FAA AVS and ATO
  - DoD
  - DHS
  - University of North Dakota



## UAS NAS Integration Simulation: Shadow with FMS



Shadow 200



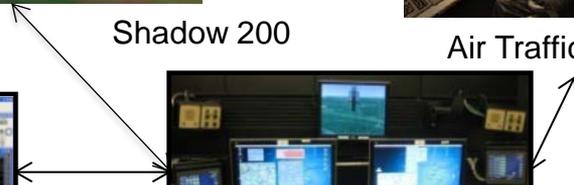
Air Traffic Control



FMS Simulator



UAS GCS



## Outcomes/Deliverables

- Outcome
  - Capture of performance characteristics for UAS operations within the NAS environment during normal and contingency operations both with and without an integrated Flight Management System. Also examined latencies of UAS pilot responses to air traffic control, as well as elapsed time between command inputs and aircraft compliance
- Deliverables:
  - HITL Conducted: 30 NOV – 2 DEC 2010
  - Final Report:

## Project Description

- Industry collaboration to examine potential concepts and technologies in support of UAS **integration** into NAS/NextGen
  - Establish system performance baselines
  - Measure UAS performance, human performance, and impacts to NAS during normal and contingency UAS operations
  - Explore 4-dimensional trajectory (4DT) concepts on UAS
  - Support development of standards, safety case, and validation of RTCA SC-203 requirements



## Partners/Stakeholders

- Partners
  - AAI Corp
  - GE Aviation Systems
  - FAA AVS and ATO
  - DoD
  - DHS



# Near-Term Operational Assessment Studies



# Outcomes/Deliverables

- Outcomes:
  - **UAS MCAS Cherry Point:** Proposed operation was successful as simulated with limited scope and assumptions: concept merits further exploration; no loss of separation, workload was not an issue, Shadow successfully transited; recommended further refinement of procedures, comprehensive safety and validation studies when a final concept is complete
  - **Multi-UAS Class D Airspace:** Identify and document events and their effects on the NAS associated with mixing UAS operations with manned aircraft operations in Class D airspace; explore feasibility of proposed multiple UAS operations, examine safety and efficiency effects
- Deliverables:
  - **UAS MCAS Cherry Point Final Report:** FEB 2011
  - **Multi-UAS Class D Airspace Final Report (internal):** MAR 2012

# Project Description Summaries

- Operational assessments to support near-term UAS-NAS integration efforts
- **UAS Operational Assessment: MCAS Cherry Point**
  - ATC and UAS (Shadow) virtual simulation to refine USMC proposed Ground Based Sense and Avoid (GBSAA) concept
- **Multi-UAS Operational Assessment: Class D Airspace**
  - Evaluation of Air Traffic Control procedures when there are simultaneous multiple UAS operations in Class D airspace
  - Currently FAA allows only one segregated UAS in Class D airspace at a time
  - Exploring potential for multiple UAS operations in Class D airspace
  - Includes Raven, Hummingbird, Predator A, UAS blimp

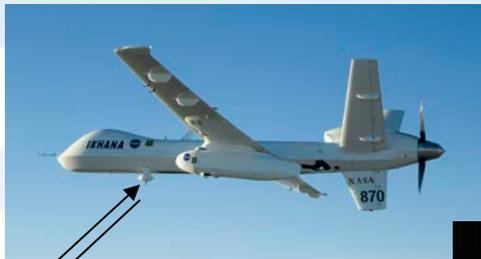


# Partners/Stakeholders

- **UAS Operational Assessment: MCAS Cherry Point**
  - Partners
    - FAA ATO
    - FAA UAPO (AVS)
    - AAI Corp
    - DoD
- **Multi-UAS Operational Assessment: Class D Airspace**
  - Partners
    - FAA ATO
    - Serco, Inc.



## Control and Communications (C2) Research



Predator B



UAS Pilot



Air Traffic Control

## Outcomes/Deliverables

- Outcome
  - Supports development of FAA UAS requirements and standards for C2
- Deliverables:
  - Task 1 White and Working Papers:
  - Task 2 Final Report: SEP 2012
  - Task 3 White Paper:

## Project Description

- Task 1: Provide Control and Communications Security Technical support initially for small UAS. Provide support in alternative analysis and selection of security features / mechanisms for ground/ground (G-G) voice and data and air/ground (A-G) data communications.
- **Task 2: Measure response of manned aircraft in current NAS Evaluate link control latency requirements for UA control stability**
- Task 3: Modeling and Simulation of UAS TT95 values for time critical pilot control



## Partners/Stakeholders

- Partners
  - FAA AVS/TCRG and ATO
  - FAA NextGen
- Stakeholders
  - NASA
  - DoD
  - RTCA



# Maintenance and Repair Research



ScanEagle Skyhook

## Outcomes/Deliverables

- Outcome
  - Supports the development of data collection standards and system for UAS maintenance and repair
- Deliverables:
  - Data elements and descriptions: SEP 2012
  - Prototype database with data elements: SEP 2012

## Project Description

- Task includes activities to support the **development of sUAS maintenance and repair standards** for safe sUAS NAS operations.
  - Research and establish sUAS maintenance data elements and descriptions.
  - Establish prototype M&R database with sUAS maintenance data elements and populate with sample data.
  - Collect and populate database with readily available sUAS maintenance and repair data from sUAS industry partners, operators, and FAA R&D test flights.
  - Coordinate efforts with ASTM F-38 and FAA sUAS NPRM standards/regulations.



## Partners/Stakeholders

- Partners
  - FAA AVS/TCRG and ATO
  - FAA NextGen
  - Boeing/Insitu
- Stakeholders
  - Air National Guard
  - Embry-Riddle Aeronautical University (ERAU)
  - University of North Dakota (UND)
  - University of Alaska Fairbanks (UAF)
  - DOD





## Outcomes/Deliverables

- Outcomes
  - Provide human factors input to FAA UAS regulatory and guidance material (Regulations, ACs. etc)
- Deliverables
  - Final reports on all three tasks

## Project Description

- Provide HF analyses and recommendations for UAS control station to ensure safe and effective operator performance
- **Task 1: Task Analysis - Human/Automation Function Allocation**
  - Determine and define pilot and operator tasks
  - Delineate current function allocation – tasks performed by pilots and by automation
- **Task 2: Control Station Certification Requirements**
  - Define requirements for UAS Control Station Certification
- **Task 3: Pilot Training and Certification Requirements**
  - Define UAS pilot and operator training requirements
  - Determine pass/fail criteria for pilots characteristics (e.g., age limits, physicals, etc.) and/or pilot training (e.g., pilot ratings, currency)



## Partners/Stakeholders

- Partners
  - FAA UAS Integration Office
  - CAMI
  - SE2020 Contractor
- Stakeholders
  - RTCA



# FY11 UAS R&D Portfolio Requirements/Initiatives

## Sense and Avoid

- ✓ Engineering Analysis and Technical Evaluation
- ✓ Integrate Multiple SAA logic and algorithms for use
- ✓ Devise methods for SAA logic and algorithms validation
- ✓ Conduct series of NAS feasibility studies for SAA
- ✓ Optimization Study of Surveillance Data Fusion Strategies

## Control and Communication (C2)

- ✓ C2 Security Technical Support
- ✓ C2 Link Performance Requirements

## Minimum Requirements for UAS Control Stations

- ✓ Analysis-Human/Automation Function Allocation
- ✓ Control Station Certification Requirements
- ✓ Training and Certification of UAS Pilots and Other Crew

## UAS Maintenance and Repair Tracking System

- ✓ UAS Maintenance and Repair Tracking System



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# FY12 UAS R&D Portfolio Requirements/Initiatives

## Sense and Avoid

- ✓ Minimum Necessary SAA Information Required for UAS Pilot to Execute Collision Avoidance Maneuver

## Control and Communication (C2)

- ✓ Time Critical Low Latency Control Response for UAS with Low Levels of Automation



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# FY13 UAS R&D Portfolio Requirements/Initiatives



## Detect and Avoid

- ✓ DAA System Certification Obstacles
- ✓ Visual Means
- ✓ Visual Compliance
- ✓ Well Clear Modeling, Simulation and Analysis

## **DAA Multi-Sensor Surveillance Data Fusion Strategies**

- ✓ DAA Multi-Sensor Surveillance Data Fusion Strategies

## **Control and Communication (C2)**

- ✓ Time Critical Low Latency Control Response for UAS w/ Low Levels of Automation

## **UAS Acceptable Communication Delay Values**

- ✓ UAS Acceptable Communication Delay Values Associated with Step-Ons
- ✓ Ground Communication Architecture Task
- ✓ Contingency Operations



# FY14 UAS R&D Portfolio Requirements/Initiatives



## Detect and Avoid

- DAA System Multi-Sensor Surveillance Data Fusion Strategies (FY15, FY16)

## DAA System Certification Obstacles

- DAA System Certification Obstacles (FY15, FY16)

## Integration of ACAS-X into Detect and Avoid for UAS (FY15, FY16)

## Safety

- UAS System Safety Criteria for Airborne & Ground (FY15, FY16)

## Control and Communication (C2)

Evaluation of Communication Strategies in the Context of UAS Operations

- Ground Architecture
- Lost Link

## Simulating Oversight of UAS in NAS Operations

- Simulating Oversight of UAS in NAS Operations

Present



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# Research Partnership

## NASA UAS in the NAS Project

### Need/Approach

**Need** – The NASA Unmanned Aircraft Systems (UAS) Integration in the National Airspace Systems (NAS) Project will demonstrate solutions in specific technology areas that address operational and safety issues related to UAS access to the NAS.

**Approach** – NASA is collaborating with the FAA in four technical areas and a systems level integration and test area. This project is based on stakeholder input and covers:

- Detect and Avoid
- Human Systems Integration (HSI)
- Communications
- Certification
- Integrated Test and Evaluation (IT&E)

### Partners

- NASA
- ANG
- AFS-80
- RTCA SC-228



### Major Activities

- Night Visual Observer Study (informs Roadmap)
- DoD Sense and Avoid Research Panel (DoD, NASA, FAA)
- NASA Sense and Avoid Research – Informs the FAA’s Well Clear Research
- Primary collaboration opportunity with NASA is via RTCA SC-228 and the SARP
- NASA providing direct support to FAA’s ACAS-Xu Research
  - WJHTC providing an aircraft for the flight test
- iHITL – Live Virtual Construct (Distributed Simulation) – June 2014
  - NASA connected to the WJHTC
- NASA ACAS-Xu Integrated Flight Tests (end of 2014)

### Anticipated Use of Research

- Separation assurance will address issues related to ensuring adequate aircraft separation as well as defining operational requirements.
- HSI will address issues related to developing ground control station (GCS) standards and modifications for NAS compliance.
- Communications will address issues related to secure data communications and constraints of frequency spectrum allocation.

# Research Partnership

## DOD NORTHCOM UAS Aircraft Integration Joint Test (UAS AI JT)

### Need/Approach

**Need** – UAS procedures are not standardized to support effective UAS operations in the National Airspace System. The Department of Defense research seeks to contribute in this area.

**Approach** - Participation in the UAS AI JT creates a collaborative and synergistic environment with the DoD which results in research efficiencies. Examples include:

- Identification of research that is being duplicated as well as intersection points between research projects.
- Leveraging the completed research of others into existing research.

### Partners

- DoD NORTHCOM
- DoD AFRL
- DoD OSD
- AFS-80
- ANG



### Major Activities

- General Officer Steering Committee (December 2013)
- ANG has been working collaboratively with DOD on M&S Deterministic Study
- ANG has been coordinating the upcoming DOD Human-In-The-Loop (HITL) Simulation at the WJHTC. (En Route controllers )
- DOD UAS Memorandum of Understanding (MOA) Scenario development (March 2014)
- DOD UAS AI JT Reimbursable Agreement (March 2014)
- ANG has worked collaboratively with DOD AI JT to understand GCS assessments
- DoD UAS AI JT HITL in July 2014
- DoD UAS AI JT Flight Test in August/September 2014

### Anticipated Use of Research

- Test may inform future versions of FAA UAS CONOP
- Lessons learned and standardized DoD procedures may inform future regulatory development
- May contribute to expedited COA process for DOD operations and may benefit other public UAS operations
- Improves predictability of UAS flight
- Standardized DoD procedures for UAS flight operations

# UAS COE Research Focus Areas

- **Air Traffic Control Interoperability**
- **Airport Ground Operations**
- **Control and Communication**
- **Detect and Avoid (DAA)**
- **Human Factors**
- **Spectrum Management**
- **Unmanned Aircraft (UA) Pilot Training and Pilot Certification Including Other UA Crewmembers**



# Air Traffic Control Interoperability

- **Air Traffic Control Interoperability Objectives:**
  - ✦ Conduct research that validates the required functional and performance capabilities for safe operation of UAS within the various airspaces of the NAS
  - ✦ Assess ATC interoperability requirements that will be allocated to appropriate Air Traffic program and UAS integration efforts
  - ✦ Employ existing strategies to conduct UAS integration safety analysis within SMS Manual guidance supporting ATC interoperability
  - ✦ Research on Detect and Avoid algorithms for interoperability with evolving Next Generation Air Transportation System (NextGen) ATC systems and manned collision avoidance systems
  - ✦ Research on Air Traffic Controller training as it relates to UAS

# Airport Ground Operations

- **Airport Ground Operations Objectives:**
  - ✦ Evaluate the Pilot In Command's (PIC) ability to read and interpret taxiway signage, taxi on the center line, taxi on a specific taxiway, etc.
  - ✦ Assess UAS compliance with Air Traffic Control instruction in this environment
  - ✦ Identify operational and communication challenges, and compliance of unmanned aircraft in the airport ground operations environment



# Control and Communication

- **Control and Communication Objectives:**
  - ✦ Develop and validate UAS control link prototype
  - ✦ Assess the vulnerability of UAS safety critical communications
  - ✦ Conduct large-scale simulations and flight testing of initial performance requirements
  - ✦ Analyze potential frequency allocation strategies (Spectrum Management)

# Detect and Avoid

- **Detect and Avoid (DAA) Objectives:**
  - ✦ Support with the establishment of DAA system definitions and performance levels
  - ✦ Assess DAA system multi-sensor use and other technologies
  - ✦ Support the development of the minimum DAA information set required for collision avoidance maneuvering

# Human Factors

- **Human Factors Objectives:**

- ✦ Conduct research to support the development of effective human-automation interaction (level; trust; and mode awareness).
- ✦ Conduct research to support the design of pilot-centric control station (displays; sensory deficit and remediation; and sterile cockpit).
- ✦ Evaluate traffic/airspace information displays (separation assurance interface).
- ✦ Assess the predictability and contingency management of lost link status, lost ATC communication, and ATC workload
- ✦ Conduct evaluations to support define the communication roles and responsibilities among flight crew, ATC, and flight dispatcher
- ✦ Conduct research to support the development of National Airspace System (NAS) human performance requirements



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# Spectrum Management

- **Spectrum Management Objectives:**
  - ✦ Assist with the identification of satellite communication spectrum from the ITU through its WRC
  - ✦ Assist with the verification and validation of control communication final performance requirements
  - ✦ Support the establishment of UAS control link national/international standards
  - ✦ Conduct research to develop and validate technologies to mitigate vulnerabilities



# Unmanned Aircraft (UA) Crew Training and Certification Including Pilots

- **Unmanned Aircraft (UA) Crew Training and Certification Including Pilots Objectives:**
  - ✦ Support the development of standards for UAS pilots and other crewmembers
  - ✦ Support define the knowledge, skills, and abilities required of a UAS pilot in command and other crewmembers such as sensor operators
  - ✦ Recommend training programs for pilot and other crewmember certification



# Questions?