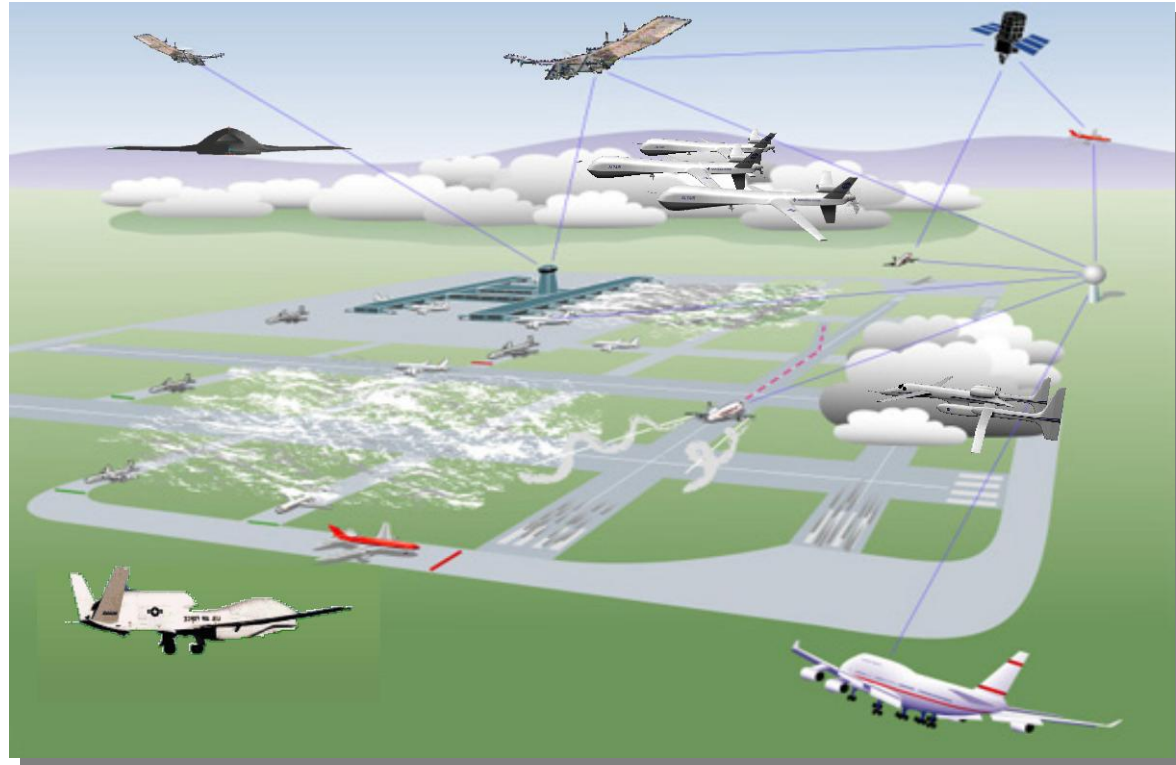




UAS Integration into the NAS Project

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Project Planning Lead



**Meeting of Experts on NASA's Unmanned Aircraft System (UAS) Integration in
to the National Airspace Systems (NAS) Project**

**Aeronautics and Space Engineering Board
National Research Council
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Outline

- **Problem Statement & Background**
- **Project Goals & Objectives**
- **Scope**
- **Approach**
- **Project Milestones**
- **Partnerships**
- **Resources & Acquisition Strategy**



Problem Statement

- Requirements do not exist for routine UAS operations in the NAS
 - **Complicating Factors**
 - No one has defined success
 - Lack of a broadly accepted plan for what needs to be done to enable access makes identifying and working solutions difficult**
 - Today's airspace system "Now Generation (NowGen)" versus Next Generation (NextGen)
 - We don't want to solve the problem for today's environment only to have to solve it again when NextGen is implemented**
 - Public versus civil UAS operations
 - Civil UAS operations require FAA certification and those requirements and/or guidance do not exist**
 - Public agencies can self certify by supplying the FAA with an airworthiness statement**
 - UAS represent a wider performance regime than current aircraft
 - Smaller, autonomous, pilot in-the-loop, pilot on-the-loop, extremely long endurance, very slow, etc.**
 - Requirements for access will need to account and vary for each class**



Some of the Requirements for UAS in the NAS Access

- Ensuring separation assurance (sense and avoid – obstacles, weather, etc.)
- Ensuring adequate collision avoidance
- Ensuring robust and secure communications technologies
- Solving the constraints of frequency spectrum allocation
- Developing robust PAIs
- Developing ground control station standards
- Defining airworthiness and operational standards
- Defining pilot certifications requirements
- Developing certification standards for automated systems
- Defining appropriate level of safety through systematic safety analysis
- Developing certification standards for a wide range and/or type of UAS
- Developing integrated solutions for off-nominal operations
- Defining operational requirements for current and future missions sets
- Developing Ground Control Stations (GCSs) modifications for NAS compliance
- Defining display requirements for aircraft registration numbers
- Defining UAS lighting requirements
- Defining right-of-way procedures
- Developing surface operations procedures



What the UAS Community Needs from NASA

Joint Planning and Development Office (JPDO)

- Needs NASA to extend ATM research to address UAS integration in NextGen (algorithms for separation assurance and demonstrations (demos) of concepts and technologies).
- Needs NASA to work with JPDO and partners to develop a UAS ConOps (roadmap).

FAA (UAS Program Office & Technical [Tech] Center)

- UAS Program Office which has requested NASA help in addressing human factors issues related to pilot-aircraft interface
- FAA, along with RTCA-203 have requested NASA expertise on UAS communication issues related to UAS communication security risks/vulnerabilities, risk mitigation, architectures, latencies, etc.
- FAA has requested access to NASA UAS aircraft to support integrated testing

DoD

- Access to NASA flight platforms to assist with their technology development.

Standards Organizations

- Define and validate spectrum requirements, frequency models, and analyses for UAS communications at World Radio Conference (WRC).

UAS ExCom Senior Steering Group

- COA improvement support
- Roadmap support



What Have We Been Doing to Prepare for the Initiation of the Project?

- **Funding for short duration (1 yr) focused activities to accelerate project efforts**
- **American Recovery and Reinvestment Act (ARRA) Funding**
 - Developing a UAS NextGen ConOps
 - The ConOps will serve as input to the NextGen ConOps and assist the JPDO in meeting their 2012 milestone for incorporating UAS into their plans
 - The ConOps will influence the Integrated Work Plan (IWP)
 - Tools Development
 - Developing infrastructure to support the UAS NextGen ConOps validation primarily in the areas of simulation
- **FY10 In-Guide Funding**
 - Extend the tools development work begun with ARRA funds
 - Three focus areas:
 - Separation assurance and collision avoidance
 - Simulation and modeling
 - Systems Analysis to validate technical focus



Project Goals & Objectives

The goal of the UAS Integration in the NAS Project is to contribute capabilities that reduce technical barriers related to the safety and operational challenges associated with enabling routine UAS access to the NAS

This goal will be accomplished through a two-phased approach of system-level integration of key concepts, technologies and/or procedures, and demonstrations of integrated capabilities in an operationally relevant environment. Technical objectives include:

PHASE 1

- Validating the key technical areas identified by this project. System-level analyses, a State of the Art Analysis (SOAA), and a ConOps will identify the challenges and barriers preventing routine UAS access to the NAS.
- Developing a national roadmap and gap analysis identifying specific deliverables in the area of operations, procedures, and technologies that will impact future policy decisions.

PHASE 2

- Provide regulators with a methodology for developing airworthiness requirements for UAS and data to support development of certifications standards and regulatory guidance.
- Provide systems-level integrated testing of concepts and/or capabilities that address barriers to routine access to the NAS. Through simulation and flight testing, address issues including separation assurance, communications requirements, and Pilot Aircraft Interfaces (PAIs) in operationally relevant environments.



Project Scope

- Demonstrate solutions in four specific technology disciplines, which will address operational and/or safety issues related UAS access to the NAS.
 - **Separation Assurance and/or Collision Avoidance**
 - **Pilot Aircraft Interface**
 - **Certification Requirements**
 - **Communications**
- Each discipline will transfer technologies to relevant stakeholders (including the FAA, DoD, standards organizations, and industry).
- The timeframe for impact will be 2015-2025.
- Support the UAS ExCom in developing a national roadmap/plan for Federal Public UAS in the NAS integration.



How We Determined the Project Focus

- Executive branch direction
- Listened to stakeholders
- Broad applicability
- Enables others to act
- Work align with NASA skills and expertise
- Demonstrated commitment by external community to utilize the deliverable
- Uniqueness (not duplicative work) and leverage
- Technical maturity (higher has priority over lower)



Technical Approach

- Project will consist of a 2-Phased Approach
- Phase 1 will focus on activities laying the foundation for the project
 - **Development of ConOps, systems analysis, state-of-the-art assessments, gap analysis**
 - **Development of a national roadmap for UAS access into the NAS**
 - **Activities will either validate NASA investments or suggest modifications to research portfolio**
- Phase 2 will focus on maturing research concepts/capabilities and integrating and testing them in operationally relevant environments (fast-time simulations, human-in-the-loop simulations, flight tests)
- Project consists of 6 technical sub-elements
 - **Roadmap**
 - **Integrated Test & Evaluation of key research areas**
 - **Separation Assurance & Collision Avoidance**
 - **Pilot-Aircraft Interface**
 - **Communications**
 - **Certification**



Where NASA will Focus

Roadmap for Civil UAS Access

- Support broader community in defining the success criteria for civil UAS in the NAS access

Separation Assurance and Conflict Avoidance

- Separation assurance in the NextGen environment
- Nominal and off-nominal sense and avoid

Communications

- Allocation of spectrum
- Robust data-link and satellite communications
- Secure data-link communications

UAS Pilot Aircraft Interface

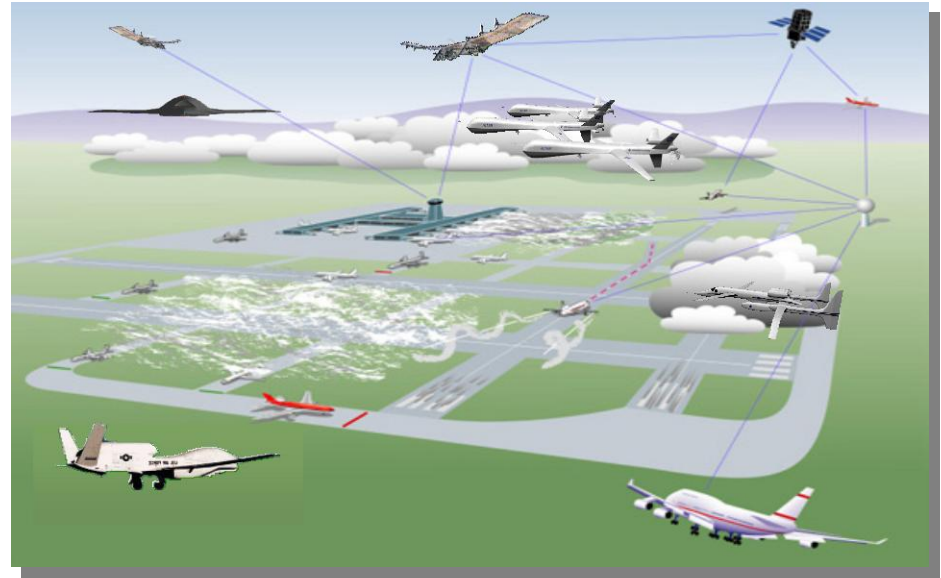
- Pilot control interface
- Definitions of roles and responsibilities between pilots and controllers

Certification

- Airworthiness requirements, starting with systems and equipment
- Type design criteria

Integrated Test & Evaluation (IT&E)

- Simulations and flight tests *in a relevant environment*





Relevance of Project Focus Areas to Safety

- **Pilot Aircraft Interface**
 - This area was selected due to the number a UAS accidents attributed to poor pilot interface design with the intention of improving operational safety.
- **Separation Assurance**
 - All of the work in the separation assurance has a direct impact of the safety of the NAS.
- **Communications**
 - Work to secure the command and control link is driven by safety considerations.
- **Certification**
 - Certification is intended to develop the methodology by which designs are deemed safe for routine operation in the NAS.
 - Airworthiness requirements, starting with systems and equipment
 - Type design criteria



What We Are NOT Focusing On (In a Broad Sense)

- **NowGen Solutions**

- Immediate Certificate of Authorization (COA) issues
- Near-term technology development with limited long-term applicability
 - For example ground-based sense and avoid

- **Airframe Development**

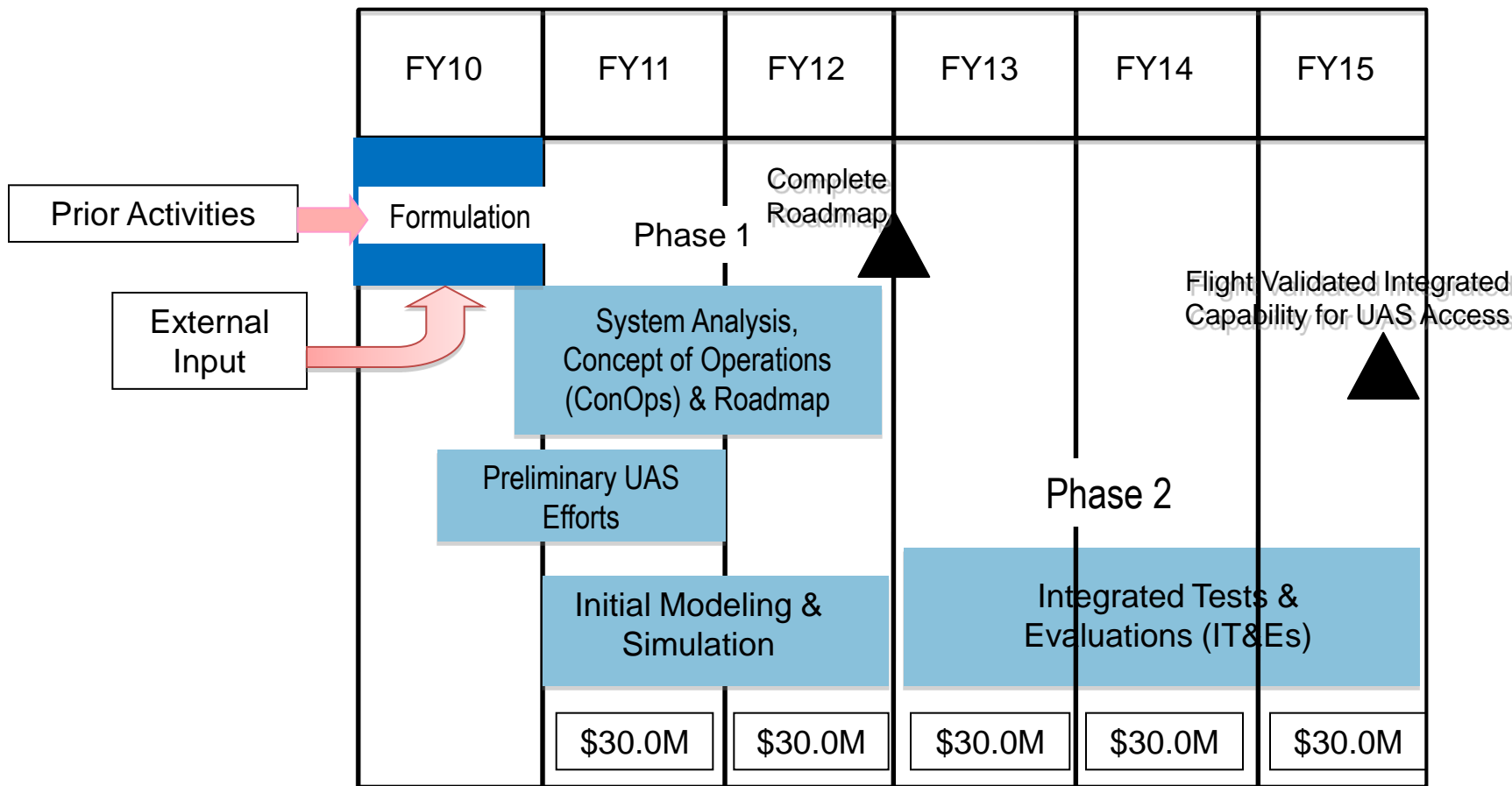
- Technology developments to improve a specific vehicle's performance.
- Development of new vehicle capabilities (endurance, altitude, payload fraction, etc.).

- **Rule Making**

- Data generated may support rule-making actions, but we will not work to develop any specific rule.



UAS Integration in the NAS Project Flow



Technical Input from Fundamental Programs, NASA Research Announcements (NRAs), Industry, Academia, Other Government Agencies



Phase 1 Roadmapping

- **Scope**
 - Support the national effort to develop a global civil UAS access plan
- **Objectives**
 - Leverage ExCom roadmapping efforts to develop the global civil UAS roadmap
 - Use the outputs to inform our Phase 2 IT&E test objectives
- **Approach**
 - Utilize a systems engineering process for developing a top-down plan
 - Leverage ARRA investments and FY10 In-Guide funding to complete the systems engineering product set
 - Early work in technology sub-elements will support roadmap detail development
- **Key Deliverables**
 - Version 1.0 of civil UAS Access Roadmap
- **Potential Partners**
 - UAS ExCom (DoD, DHS, FAA), JPDO, EUROCAE, RTCA, and other standards organizations



Partnership Relationships

UAS ExCom

- **This Committee is supported at very senior levels within the FAA, DoD, Department of Homeland Security (DHS), and NASA to address the immediate needs of public UAS access to the NAS. NASA has a role as both a provider of technology and a beneficiary of the outputs to enable science missions.**
 - Bi-weekly interactions are underway to understand issues and what each agency is currently doing to address each issue.

FAA

- **Direct interactions with relevant FAA organizations is necessary to ensure the Project understands their challenges. This will help validate the Project's course direction.**
 - Numerous meetings have occurred with the FAA UASPO, Air Traffic Organization, and Tech Center to ensure understanding and synergy.

JPDO

- **The JPDO is tasked with defining the Next Generation (NextGen) Air Transportation System. Since UAS must be incorporated into NextGen, this relationship is critical.**
 - Leverage already occurs with Aeronautics Research Mission Directorate primarily through the Airspace Systems Program. The Project has and will continue to meet routinely with JPDO to synch outputs with the national roadmap consistent with NextGen.

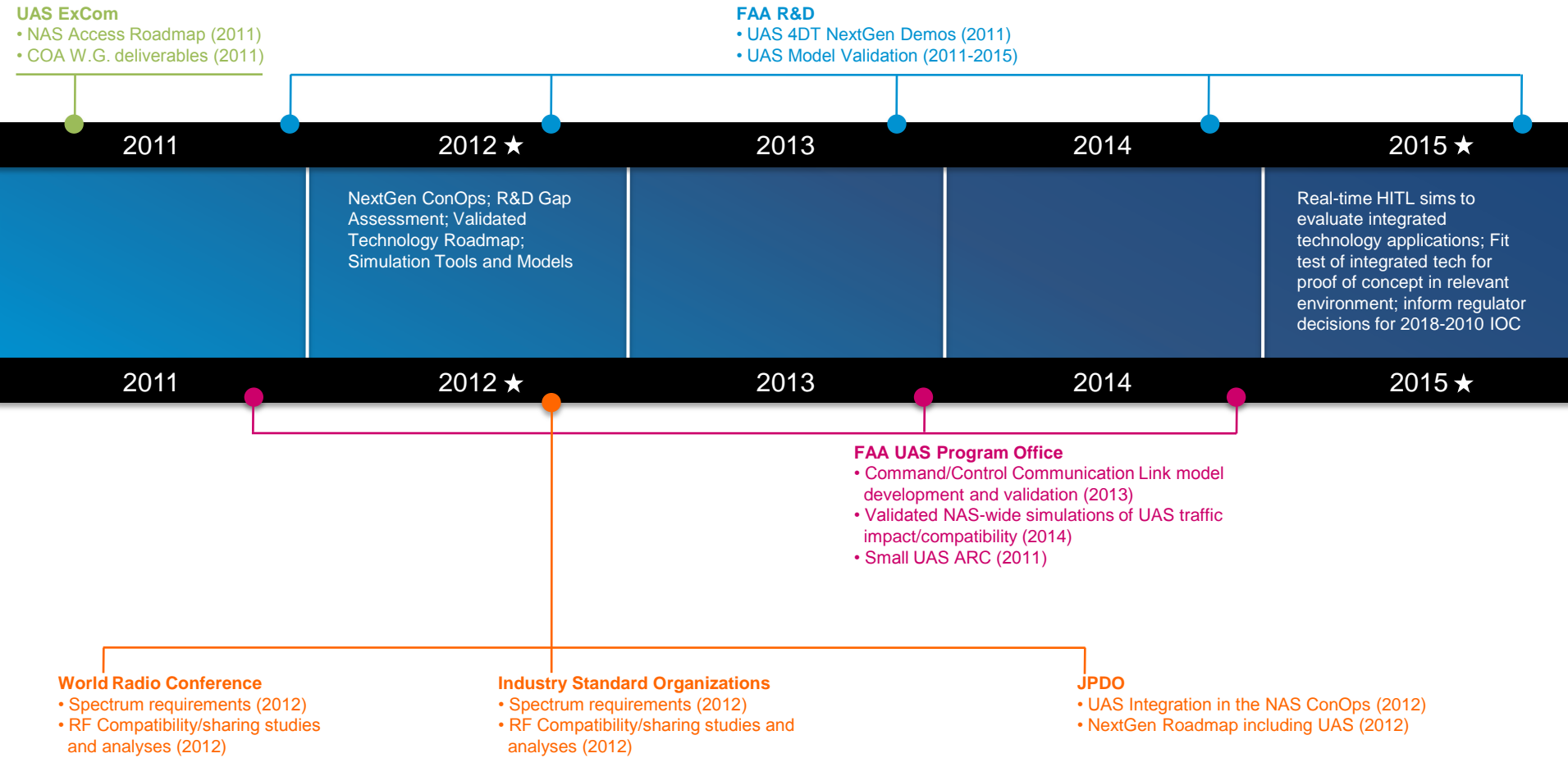
Industry Standards Organizations

- **The FAA relies on standards organizations to bring industry recommendations forward for consideration. Partnering with these organizations is essential to developing the data and technologies necessary for the FAA to approve civil UAS access.**
 - Ongoing participation in committees like RTCA Special Committees, ASTM, and the WRC



Partnership Interaction

PROJECT OUTCOMES





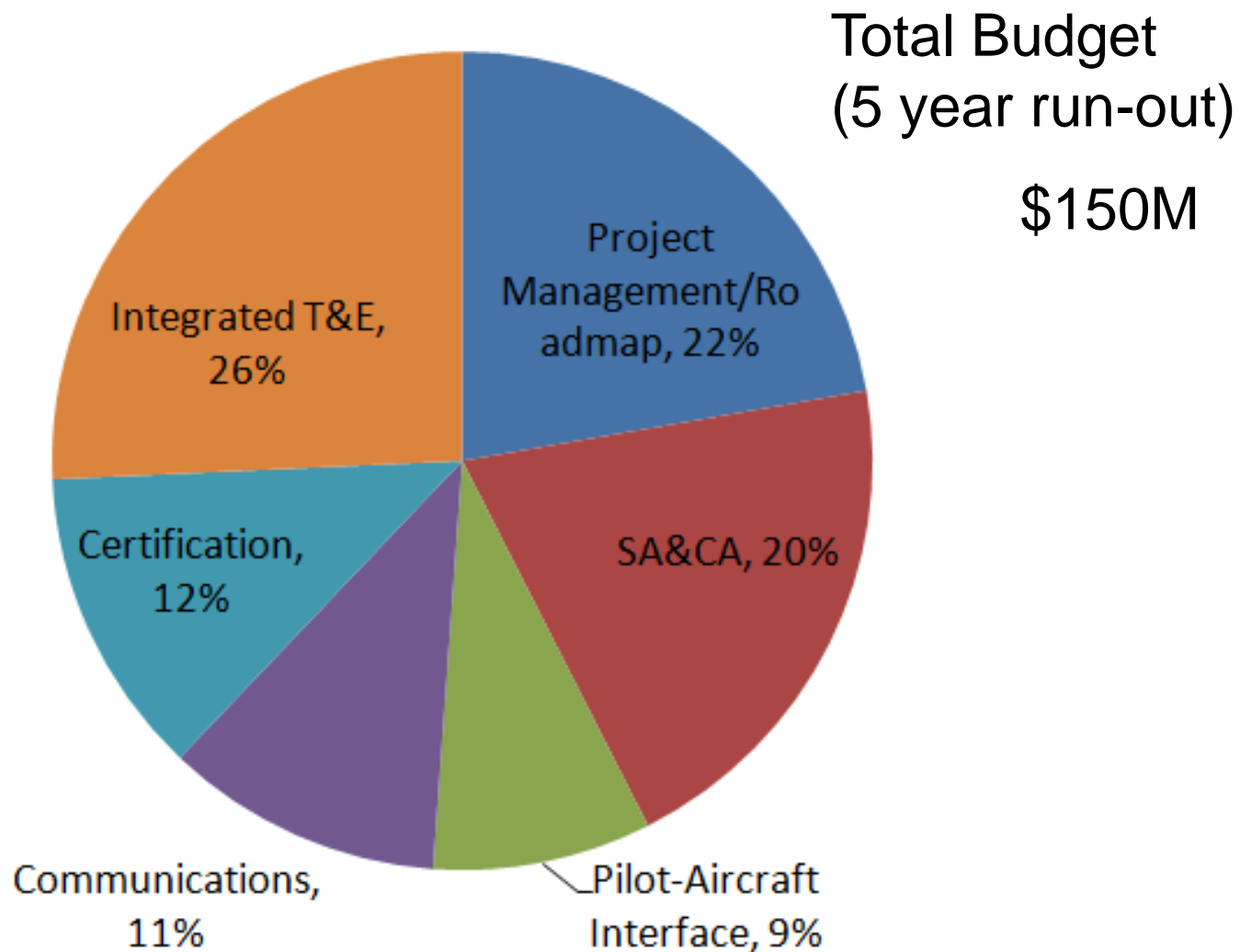
Project Milestones

| | FY 11 | FY 12 | FY 13 | FY 14 | FY 15 |
|--|--|---|---|--|---|
| Road Map | | Nat'l Roadmap Gap Analysis | | | |
| Separation Assurance & Collision Avoidance | UAS NAS Impact Study | Tactical SA Fast Time Sim Study | Tactical SA HITL | Off Nominal Ops HITL Tactical SA Flight Demo | Off Nominal Flight Demo CA Performance Requirements |
| Pilot Aircraft Interface | UAS in the NAS Human Factors Workshop Proceedings. | Draft of Guidelines for GCS compliance UAS in the NAS. | | Final Guidelines for GCS compliance UAS in the NAS. | Integrated Flight Demonstration of NAS compliant GCS. |
| Communications | Provide data requirements and initial RF analysis for Working Party 5B frequency band studies CNPC threat and vulnerabilities analysis report | Provide RF analysis at World Radio Conference 2012 Candidate RF spectrum band simulations and in-situ measurements | CNPC Performance NAS-wide simulations | Prototype CNPC system performance Security mechanism performance simulations and in-situ measurements | CNPC impact on air traffic capacity NAS-wide simulations CNPC prototype compliance report |
| Certification | Gap analysis for hazard and risk-related data collection | Report on service-based approach to UAS classification and certification Comparative analysis of certification methodologies | | | Case study of candidate methodology for UAS airworthiness Reliability assessment for select UAS components, systems and subsys Report on UAS type design and best practices |
| Integrated Test & Evaluation | Fly Ikhana with ADS-B and FMS | Specific Objectives for Phase 2 integrated tests | HITL for SA, PAI and comm objectives Fly 2 UAS for SA and PAI objectives | Fly 3 UAS, 2 manned a/c for SA, PAI and comm objectives | Fly 3 UAS, 1 UAS Surrogate, 2 manned a/c for SA, PAI and comm objectives |

Blue = Project Level Milestone



Budget Summary





Acquisition Strategy

- Competitively awarded contracts will be used to engage the external community in collaborative development and field trials ensuring contributions from key technical expertise. Will use all available and necessary acquisition tools.
 - External procurements will be employed to a greater extent than current foundational research programs
- All four NASA Research Centers (Ames, Dryden, Glenn, and Langley) will participate with their unique competencies and facilities.
 - Approximately 45 FTE per year across all centers

Note: The acquisition strategy will be fully developed during the remaining formulation process and briefed to the Agency Associate Administrator for formal approval.