National Aeronautics and Space Administration

The UAS ARC Activities and NASA Project Alignment

Presented by: Dr. Edgar Waggoner

Director, Integrated Systems Research Program

And: Mr. Chuck Johnson

Manager, UAS Integration in the NAS Project

NASA Advisory Council, Aeronautics Committee, UAS Subcommittee
February 26, 2013

Agenda

- **What is the UAS Aviation Rulemaking Committee (ARC)?**
  - **Dr. Waggoner**
- **What is the relationship between the ARC and the FAA ConOps and Roadmap?**
  - **Dr. Waggoner**
- **What is the relationship between the ARC and the JPDO Comprehensive Plan?**
  - **Dr. Wagoner**
- **What is the relationship between the Project and the ARC**
  - **Mr. Johnson**

UAS ARC Charter

Objectives and Scope of the Committee

This committee will provide a forum for the U.S. aviation community to discuss, prioritize, and resolve issues. provide direction for U.S. UAS operational criteria, support the NextGen Implementation Plan, and produce U.S. consensus positions for global harmonization

The general objectives and scope are to:

a. Develop the means to continue integration of UAS with manned NAS operations that address safety, capacity, and efficiency objectives consistent with global aviation

b. Coordinate the resolution of any comments on related proposed rulemaking

c. Develop and recommend to the FAA draft advisory circular language and a strategy, process, and schedule for the integration of UAS into the NAS

d. Develop and recommend to the FAA updated guidance material, notices, handbooks, and other relevant materials for UAS operation

e. Make recommendations. including rulemaking and additional tasking. to the Administrator through the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer

UAS ARC Procedures

Committee Procedures

- The committee provides advice and recommendations to the Associate Administrator for Aviation Safety and the ATO Chief Operating Officer. The committee acts solely in an advisory capacity.

- The committee will discuss and present information, guidance, and recommendations that the committee considers relevant to disposition issues. Discussion will include, but is not limited to, the following:
  1) Operational objectives, recommendations, and requirements
  2) Airworthiness criteria and means of compliance to meet the operational objectives
  3) Recommendations for rulemaking necessary to meet objectives
  4) Guidance material and the implementation processes
  5) Global harmonization issues and recommendations
  6) Documentation and technical information to support recommendations

UAS ARC Committee Membership

- The committee will consist of approximately 15 members, selected by the FAA, representing aviation associations, industry operators, manufacturers, employee groups or unions, other Government entities, and other aviation industry participants.
- The membership will be balanced in points of view, interests, and knowledge of the objectives and scope of the committee. Each member or participant on the committee should represent an identified part of the aviation community and have the authority to speak for that part. Membership on the committee will be limited to promote discussions. Active participation and commitment by members will be essential for achieving the committee objectives and for continued membership on the committee. The committee may invite additional participants as subject matter experts to support specialized work groups.
- Scott Dann – General Atomics (Chair), Jim Williams – FAA (FAA Designated Representative)
- Members include FAA, NASA, DoD PBFA, DoD AFRL, DHS , DOJ, MITRE, New Mexico State University, Insitu, General Atomics, Aerovironment, Lockheed Martin, Honeywell, General Electric, Raytheon, AAI Textron, Airlines for America, AOPA, ALPA, NBAA

UAS ARC and FAA ConOps and Roadmap

- The ARC was provided a copy of the FAA UAS ConOps and the FAA Roadmap
- The ARC will continue to monitor and recommend updates to the these documents
- Many of the ARC members believe the assumptions in the ConOps are overly restrictive and limit the ability to fully integrate UAS into the Next Generation Air Transportation System
  - **All UAS must file and fly an IFR flight plan**
  - **All UAS will be required to be equipped with ADS-B (out)**
  - **The PIC has full control, or override authority to assume control at all times during normal UAS operations – no autonomous operations will be permitted**

FAA UAS ConOps Assumptions

The following general requirements and assumptions apply to all UAS operations that are integrated into the NAS. Requirements for integration apply universally, regardless of type of user or operational domain. Subsequent sections discuss each of these requirements and assumptions in more detail. Small UAS (aircraft weighing less than 55 pounds) designed to operate exclusively within visual line-of-sight (VLOS) of the flight crew are not addressed in the concept narrative and are not bound by these requirements for integration.

1. UAS operators comply with existing, adapted, and/or new operating rules or procedures as a prerequisite for NAS integration.
2. Civil UAS operating in the NAS obtain an appropriate airworthiness certificate while public users retain their responsibility to determine airworthiness.
3. **All UAS must file and fly an IFR flight plan.**
4. **All UAS are equipped with ADS-B (Out) and transponder with altitude-encoding capability. This requirement is independent of the FAA's rulemaking for ADS-B (Out).**
5. UAS meet performance and equipage requirements for the environment in which they are operating and adhere to the relevant procedures.

FAA UAS ConOps Assumptions

6. Each UAS has a flight crew appropriate to fulfill the operators' responsibilities, and includes a PIC. Each PIC controls only one UA.
7. **Autonomous operations are not permitted. The PIC has full control, or override authority to assume control at all times during normal UAS operations.**
8. Communications spectrum is available to support UAS operations.
9. Nonewclassesortypesofairspacearedesignatedorcreatedspecificallyfor UAS operations.
10. FAA policy, guidelines, and automation support air traffic decision-makers on assigning priority for individual flights (or flight segments) and providing equitable access to airspace and air traffic services.
11. Air traffic separation minima in controlled airspace apply to UA.
12. ATC is responsible for separation services as required by class of airspace and type of flight plan for both manned and unmanned aircraft.
13. The UAS PIC complies with all ATC instructions and uses standard phraseology per FAA Order (JO) 7110.65 and the Aeronautical Information Manual (AIM).
14. ATC has no direct link to the UA for flight control purposes.

UAS ARC and JPDO Comprehensive Plan

- The UAS ARC is providing substantial inputs into the JPDO Comprehensive Plan
- Many of the ARC members are part of the JPDO team responsible for developing the Comprehensive Plan, and are providing inputs based on their organizational positions
- The Implementation Plan Working Group (IPWG) was established under the ARC to develop consensus driven content to populate the milestones associated with the Comprehensive Plan
- The IPWG will identify what needs to be accomplished, when it needs to be accomplished, which organizations are responsible for the specific milestones, and a rough estimate of the costs associated with the JPDO Comprehensive Plan
- The IPWG will consider policy, procedures, technology development, and infrastructure requirements

Project Role in JPDO Roadmap Activities

Significant involvement throughout JPDO activities related to UAS

- Provided subject matter expertise during the development of the “NextGen UAS Research Development and Demonstration (RD&D) Roadmap” due to OMB at the end of FY11. These SMEs continue to provide inputs into the RD&D Roadmap updates.
- Provided subject matter expertise to the “UAS National Goals and Objectives” planning process. This process is ongoing and the SMEs will continue to be involved as long as necessary.
- Provided subject matter expertise to the “UAS Comprehensive Plan” planning process. This process is ongoing and the SMEs will continue to be involved as long as necessary. Ideally, much of the work being conducted through the Aviation Rulemaking Committee will be incorporated into this comprehensive plan.
- The Project will continue to support all UAS related activities as requested by the JPDO.

UAS ARC Implementation Plan Working Group

- **Statement of Objective, i.e. what is the problem/requirement:** The goal of the Implementation Planning Working Group (IPWG) is to define a master plan for the implementation of the FAA Civil UAS Roadmap.

- **Statement of scope of task/activity:** The FAA's Civil UAS Roadmap is a guide for the aviation community and stakeholders to understand the goals and challenges for the safe integration of civil UAS into the NAS. The implementation plan will build upon the Roadmap by defining the means, resources, and schedule necessary for the aviation community, stakeholders, and government to safely and expeditiously integrate Civil UAS into the NAS. It is understood that there is no one organization with the charter, breadth of responsibility or aggregate resources to accomplish this goal in isolation. The plan should define a means to coordinate and leverage current and future initiatives necessary to meet the objectives of the Civil UAS Roadmap.

Implementation Plan

At a minimum, the implementation plan shall contain the following sections:

- Executive Summary
- Technical Approach
  - Plan Solution/Approach Summary
  - Summary of current funded efforts and gap analysis
  - Work Break Down (WBS) Structure for implementation plan
  - Master Integrated Schedule for implementation plan
  - List of Major and Mini Milestones tied to WBS Tasks
- Management Plan
  - Governance Structure
  - Coordination Approach
  - List of Roles and Responsibilities by WBS item (i.e. FAA, Industry, NASA, DoD, DHS, etc.)
- Cost Estimate
  - First Order Cost Estimate by WBS
  - First Order Cost Estimate by stakeholder
- First Order Cost Estimate by GFY

Implementation Plan Lays Out a Multi-Year Program & Framework for UAS Integration

- Provides a programmatic framework to achieve civil UAS integration
  - Plan is laid out in 3 over-lapping phases: "Accommodate – Integrate – Evolve"
  - Plan produces specific products needed for System Certification, for Pilot/Crew Qualification and for Operational Approvals
  - Plan uses a proven Management/Governance structure modeled after NextGen
- Leverages the large investment in UAS already made to date

- Coordinates ongoing efforts across government and industry
- Allows U.S. to continue its lead role in UAS development and integration

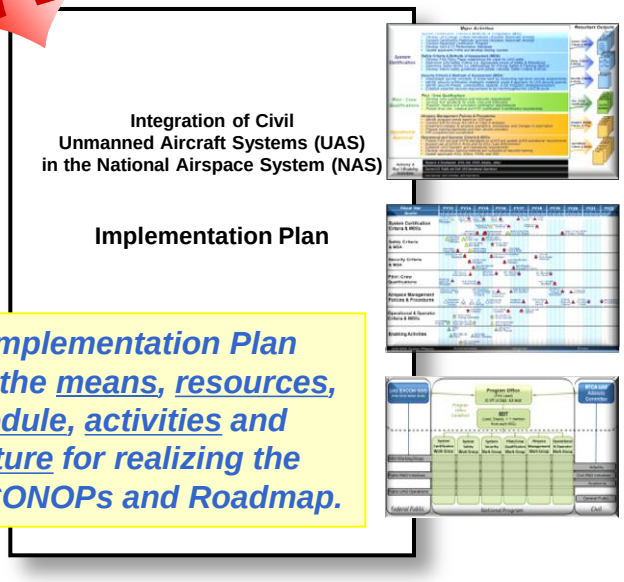
Provides all applicable stakeholders clear guidance as to how the FAA intends to safely integrate this technology into the NAS

Civil UAS Implementation Plan build upon the FAA's Civil UAS CONOPs & Roadmap

- The FAA's *Concept of Operations (CONOPs)* and *Roadmap* establish the vision and define the path forward for safely integrating civil UAS operations into the National Airspace System (NAS)

- The *Civil UAS Implementation Plan* builds upon the FAA CONOPs and Roadmap by defining:
  - The means, resources and schedule necessary for the aviation community and stakeholders to safely and expeditiously integrate civil UAS into the NAS
  - An overall management/governance structure that will facilitate required public and private activities
  - The activities needed to safely integrate UAS including:
    - The identification of gaps in current UAS technologie regulations, standards, policies or procedures
    - The development of new technologies, regulations, standards, policies and procedures
    - The identification of early enabling activities to advance routine UAS NAS integration
    - The development of guidance material, training, and certification of aircraft, enabling technologies ,and airmen

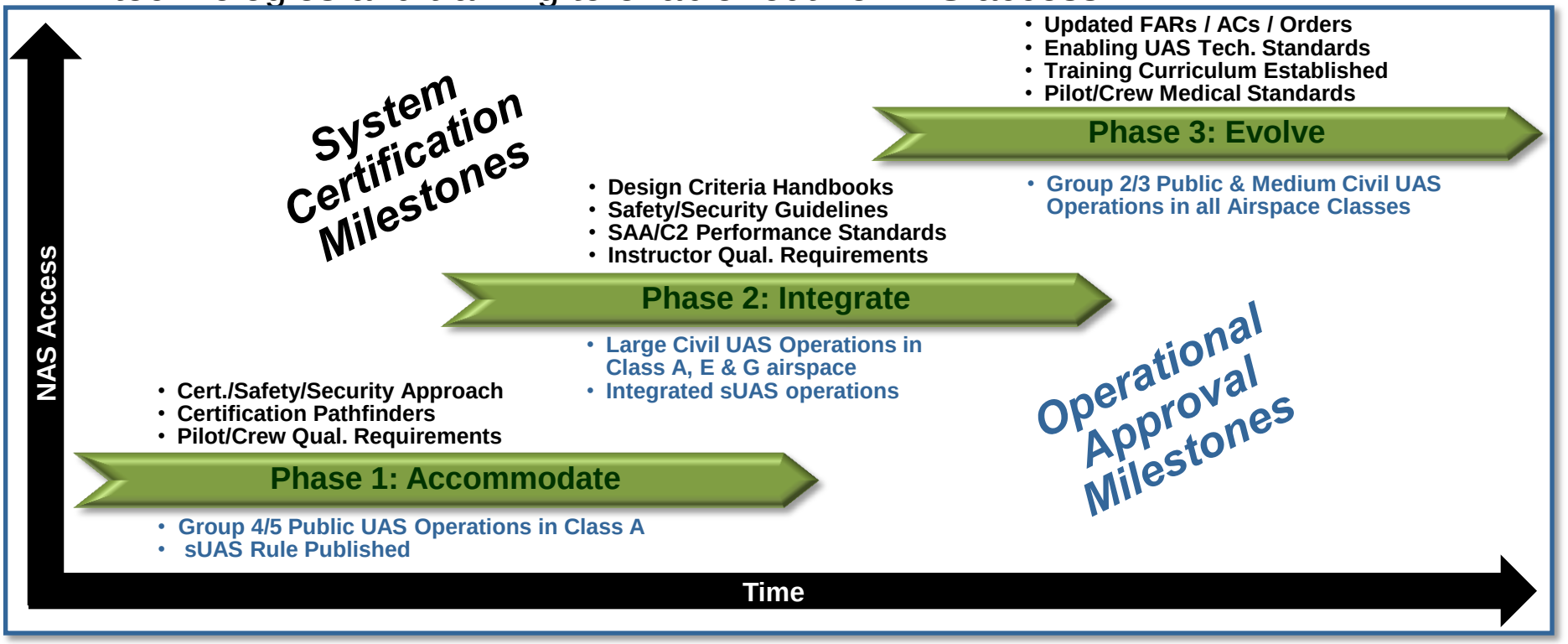
The FAA CONOPs & Roadmap establish the vision and define the path forward for Civil UAS Integration into the NAS.



The Implementation Plan defines the means, resources, schedule, activities and structure for realizing the FAA's CONOPs and Roadmap.

Phases of the Plan

- **Phase 1: Accommodate** – Utilize existing rules and guidelines and apply special mitigations and procedures to expand the limited NAS access currently in place
- **Phase 2: Integrate** – Establish UAS certification criteria, threshold performance requirements and standards to increase NAS access
- **Phase 3: Evolve** – Establish all required policy, regulations, procedures, technologies and training to enable routine NAS access



Major Activities & Resultant Outputs

Major Activities

System Certification

System Certification Criteria & Methods of Compliance (MOC)
- Develop UAS Design Criteria Handbooks (Airplane, Rotorcraft, Airship)
- Conduct Certification Pathfinder activities (Airplane, Rotorcraft, Airship)
- Conduct Restricted Certification Program
- Develop SAA & C2 Performance Standards
- Update applicable FARs and develop training courses

Safety Criteria & Methods of Assessment (MOA)
- Develop FAA Policy Paper establishing the vision for UAS safety
- Determine UAS Safety Criteria (i.e. Appropriate Levels of Safety & Allocations)
- Determine Safety MOAs (i.e. Methodology for Proving Safety & Tracking Metrics)
- Develop interim safety guidelines and update / develop Safety Criteria & MOAs

Security Criteria & Methods of Assessment (MOA)
- Adopt/adapt security concepts, & scope work by conducting high-level security assessments
- Identify security certification strategies, establish scope & approach for UAS security assmts
- Identify security threats, vulnerabilities, hazards, & risk mitigation strategies/solutions
- Establish essential security requirements to be met throughout the UAS life cycle

Pilot / Crew Qualifications

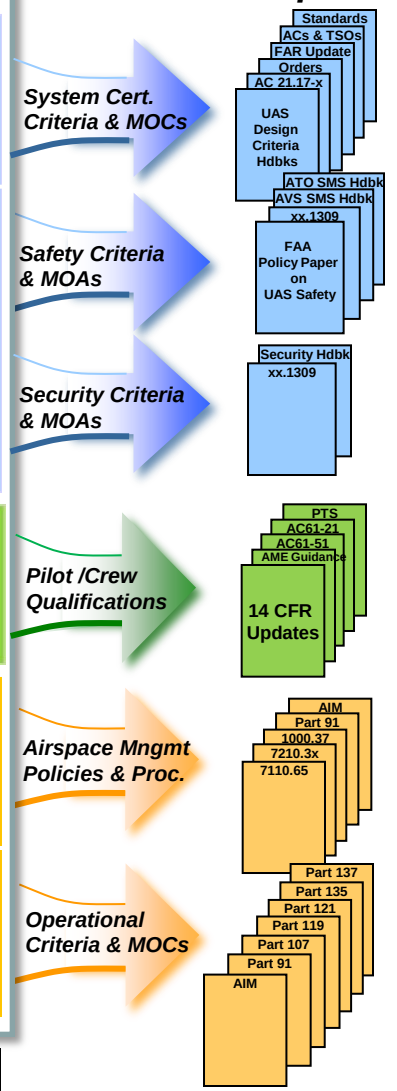
Pilot / Crew Qualifications
- Develop crew qualifications and instructor requirements
- Develop test standards for pilots, crew and instructors
- Establish medical and simulation certification requirements
- Publish final crew, medical and FTD qualification & certification requirements

Operational Approval

Airspace Management Policies & Procedures
- Identify airspace needs based on UAS type
- Conduct EIP for Group 4/5 UAS in Class A airspace
- Implement changes to airspace operations, procedures and changes to automation
- Prepare training playbooks and train service providers
- FIP completed and coordinated

Operational and Operator Criteria & MOCs
- Publish FAA rule and ASTM standards on sUAS and update sUAS operational requirements
- Expand use of sUAS in Arctic and for DOJ / Law Enforcement
- Establish UAS Operator and Operational requirements
- Develop necessary training material and complete all required training
- Update applicable ACs, Orders, FARs, and AIM

Resultant Outputs



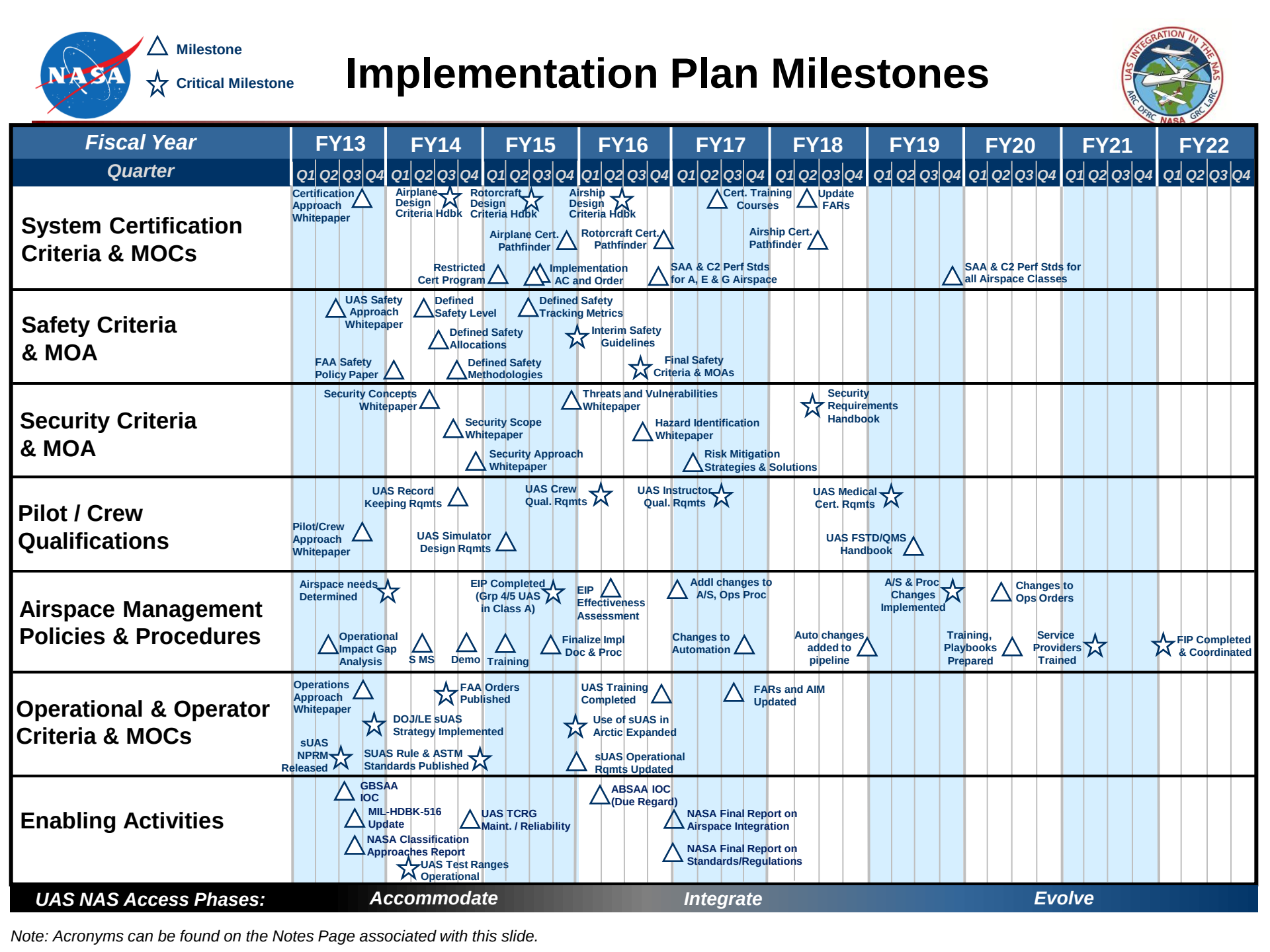
Industry & Gov't Enabling Activities

- Research & Development (FAA, DoD, NASA, Industry, other)
- Current U.S. Public and Civil UAS Operational Experience
- International UAS Activities and Experience

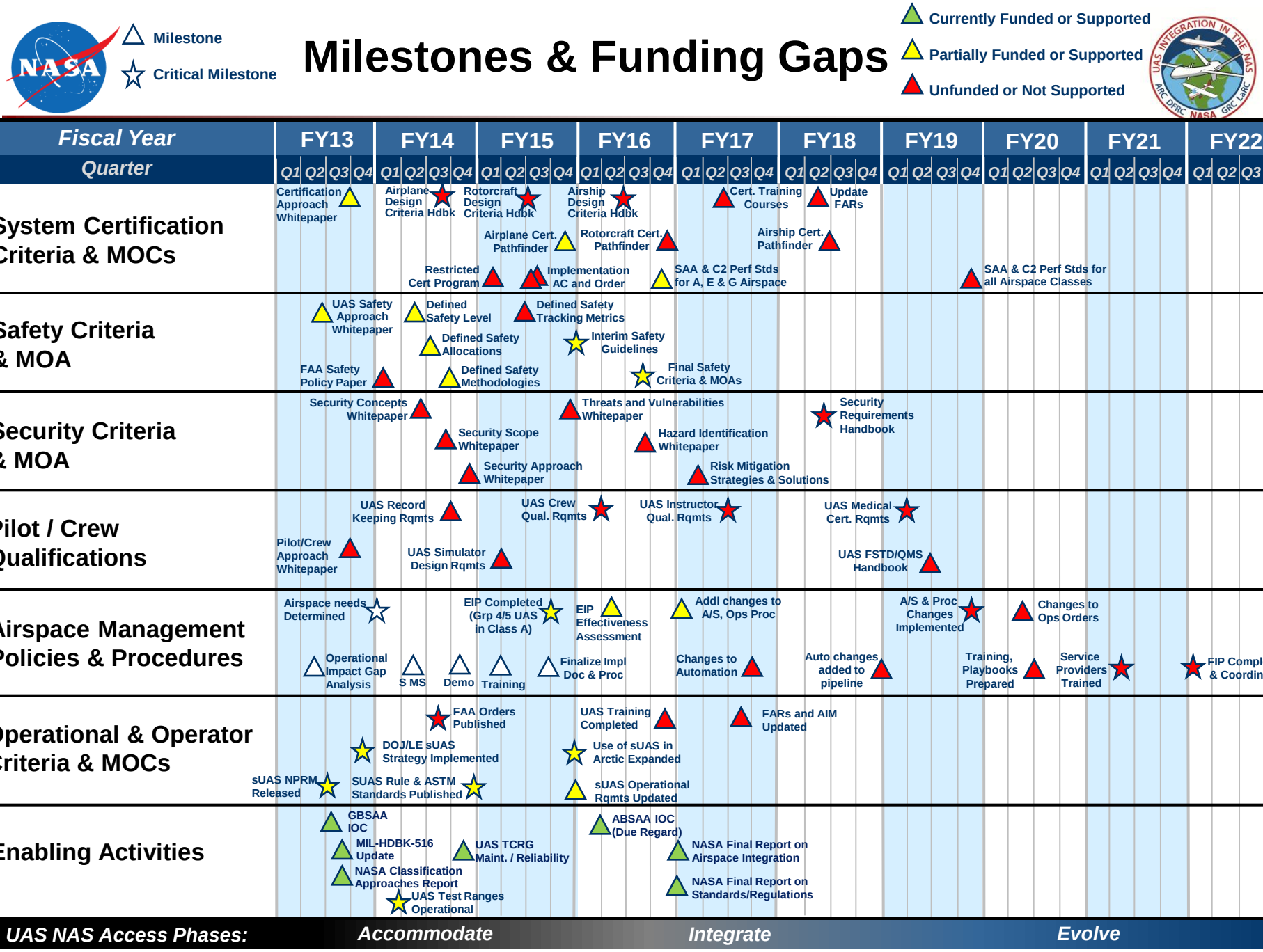
Milestone

Critical Milestone

Implementation Plan Milestones



Note: Acronyms can be found on the Notes Page associated with this slide.


Milestone
Critical Milestone
Milestones & Funding Gaps
Currently Funded or Supported
Partially Funded or Supported
Unfunded or Not Supported
Fiscal Year
Quarter
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20
FY21
FY22
Q1 Q2 Q3 Q4
System Certification Criteria & MOCs
Certification Approach Whitepaper
Airplane Design Criteria Hdbk
Rotorcraft Design Criteria Hdbk
Airship Design Criteria Hdbk
Cert. Training Courses
Update FARs
Airplane Cert. Pathfinder
Rotorcraft Cert. Pathfinder
Airship Cert. Pathfinder
Restricted Cert Program
Implementation AC and Order
SAA & C2 Perf Stds for A, E & G Airspace
SAA & C2 Perf Stds for all Airspace Classes
Safety Criteria & MOA
UAS Safety Approach Whitepaper
Defined Safety Level
Defined Safety Tracking Metrics
Defined Safety Allocations
Interim Safety Guidelines
FAA Safety Policy Paper
Defined Safety Methodologies
Final Safety Criteria & MOAs
Security Criteria & MOA
Security Concepts Whitepaper
Threats and Vulnerabilities Whitepaper
Security Requirements Handbook
Security Scope Whitepaper
Hazard Identification Whitepaper
Security Approach Whitepaper
Risk Mitigation Strategies & Solutions
Pilot / Crew Qualifications
UAS Record Keeping Rqmts
UAS Crew Qual. Rqmts
UAS Instructor Qual. Rqmts
UAS Medical Cert. Rqmts
Pilot/Crew Approach Whitepaper
UAS Simulator Design Rqmts
UAS FSTD/QMS Handbook
Airspace Management Policies & Procedures
Airspace needs Determined
EIP Completed (Grp 4/5 UAS in Class A)
EIP Effectiveness Assessment
Addl changes to A/S, Ops Proc
A/S & Proc Changes Implemented
Changes to Ops Orders
Operational Impact Gap Analysis
S MS
Demo
Training
Finalize Impl Doc & Proc
Changes to Automation
Auto changes added to pipeline
Training, Playbooks Prepared
Service Providers Trained
FIP Completed & Coordinated
Operational & Operator Criteria & MOCs
FAA Orders Published
UAS Training Completed
FARs and AIM Updated
DOJ/LE sUAS Strategy Implemented
Use of sUAS in Arctic Expanded
sUAS NPRM Released
SUAS Rule & ASTM Standards Published
sUAS Operational Rqmts Updated
Enabling Activities
GBSAA IOC
ABSAA IOC (Due Regard)
MIL-HDBK-516 Update
UAS TCRG Maint. / Reliability
NASA Final Report on Airspace Integration
NASA Classification Approaches Report
NASA Final Report on Standards/Regulations
UAS Test Ranges Operational
UAS NAS Access Phases:
Accommodate
Integrate
Evolve

Milestone

Critical Milestone

NASA Project Contributions

Partially Funded or Supported by UAS in the NAS Project

Fiscal Year	FY13				FY14				FY15				FY16				FY17				FY18				FY19				FY20				FY21				FY22			
Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
System Certification Criteria & MOCs	Certification Approach Whitepaper				Airplane Design Criteria Hdbk				Rotorcraft Design Criteria Hdbk				Airship Design Criteria Hdbk				Cert. Training Courses				Update FARs																			
									Airplane Cert. Pathfinder				Rotorcraft Cert. Pathfinder								Airship Cert. Pathfinder																			
					Restricted Cert Program						Implementation AC and Order				SAA & C2 Perf Stds for A, E & G Airspace												SAA & C2 Perf Stds for all Airspace Classes											
Safety Criteria & MOA			UAS Safety Approach Whitepaper				Defined Safety Level				Defined Safety Tracking Metrics																													
							Defined Safety Allocations						Interim Safety Guidelines																											
	FAA Safety Policy Paper						Defined Safety Methodologies								Final Safety Criteria & MOAs																									
Security Criteria & MOA			Security Concepts Whitepaper										Threats and Vulnerabilities Whitepaper								Security Requirements Handbook																			
							Security Scope Whitepaper								Hazard Identification Whitepaper																									
									Security Approach Whitepaper								Risk Mitigation Strategies & Solutions																							
Pilot / Crew Qualifications					UAS Record Keeping Rqmts						UAS Crew Qual. Rqmts				UAS Instructor Qual. Rqmts								UAS Medical Cert. Rqmts																	
	Pilot/Crew Approach Whitepaper						UAS Simulator Design Rqmts																		UAS FSTD/QMS Handbook															
Airspace Management Policies & Procedures			Airspace needs Determined						EIP Completed (Grp 4/5 UAS in Class A)				EIP Effectiveness Assessment				Addl changes to A/S, Ops Proc								A/S & Proc Changes Implemented				Changes to Ops Orders									
		Operational Impact Gap Analysis			S MS		Demo		Training		Finalize Impl Doc & Proc						Changes to Automation				Auto changes added to pipeline				Training, Playbooks Prepared		Service Providers Trained				FIP Completed & Coordinated							
Operational & Operator Criteria & MOCs	Operations Approach Whitepaper						FAA Orders Published						UAS Training Completed						FARs and AIM Updated																			
			DOJ/LE sUAS Strategy Implemented										Use of sUAS in Arctic Expanded																											
	sUAS NPRM Released				SUAS Rule & ASTM Standards Published								sUAS Operational Rqmts Updated																											
Enabling Activities			GBSAA IOC										ABSAA IOC (Due Regard)																											
			MIL-HDBK-516 Update				UAS TCRG Maint. / Reliability										NASA Final Report on Airspace Integration																							
			NASA Classification Approaches Report														NASA Final Report on Standards/Regulations																							
					UAS Test Ranges Operational																																			

UAS NAS Access Phases:	Accommodate	Integrate	Evolve

Note: Acronyms can be found on the Notes Page associated with this slide.

Benefits of Executing the Proposed Implementation Plan

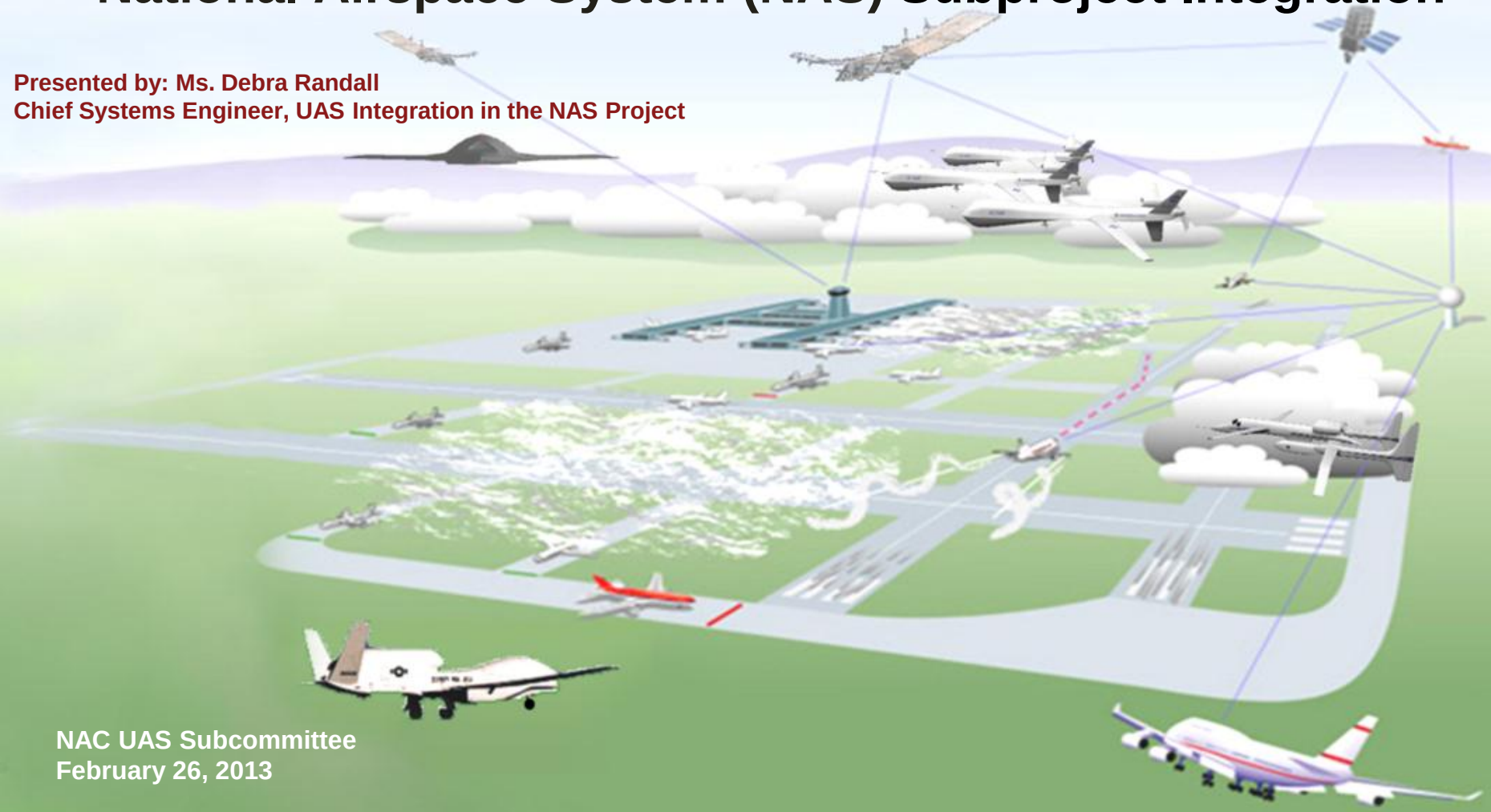
- National interest program that maintains U.S. competitiveness
- Leverages extensive government and industry investments
- Coordinates ongoing efforts across government and industry
- Allows for civil use of UAS while expediting safe integration of civil UAS into the NAS
- Establishes a basis for obtaining / allocating resources and funding
- Identifies responsibilities of key stakeholders and provides for oversight and accountability
- Provides a mechanism to assess/measure progress
- Facilitates NextGen development

Recommend leadership secure the necessary funding and assign the appropriate organization(s) with the responsibility to execute this plan.

National Aeronautics and Space Administration

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

Presented by: Ms. Debra Randall
Chief Systems Engineer, UAS Integration in the NAS Project



NAC UAS Subcommittee
February 26, 2013

Purpose

- Provide a UAS NAS Project briefing on Subproject Integration

- Explain the Project's approach to System Integration relative to systems development

Agenda

- Needs, Goals, Objectives, and Technical Challenges
- Systems Development and Integration
- Subproject Integration
- Stakeholder Coordination

Needs, Goals, Objectives

- There is an increasing need to fly UAS in the NAS to perform missions of vital importance to National Security and Defense, Emergency Management, and Science. There is also an emerging need to enable commercial applications such as cargo transport (e.g. FedEx)

Capitalizing on NASA's unique capabilities, the project will utilize integrated system level tests in a relevant environment to eliminate or reduce critical technical barriers of integrating UAS into the NAS

- The project will develop a **body of evidence (validated data, algorithms, analysis, and recommendations)** to support key decision makers, establish policies, procedures, standards, and regulations to enable routine UAS access to the NAS

- The project will also provide a methodology for developing airworthiness requirements for UAS, and **data to support development of certification standards and regulatory guidance for civil UAS**

- The project will support the development of a national UAS access roadmap

Project Technical Challenges

- **Airspace Integration**
  - Validate technologies and procedures for unmanned aircraft systems to remain an appropriate distance from other aircraft, and to safely and routinely interoperate with NAS and NextGen Air Traffic Services (ATS)

- **Standards/Regulations**
  - Validate minimum system and operational performance standards and certification requirements and procedures for unmanned aircraft systems to safely operate in the NAS

- **Relevant Test Environment**
  - Develop an adaptable, scalable, and schedulable relevant test environment for validating concepts and technologies for unmanned aircraft systems to safely operate in the NAS

Subproject Technical Challenge Alignment

Airspace Integration

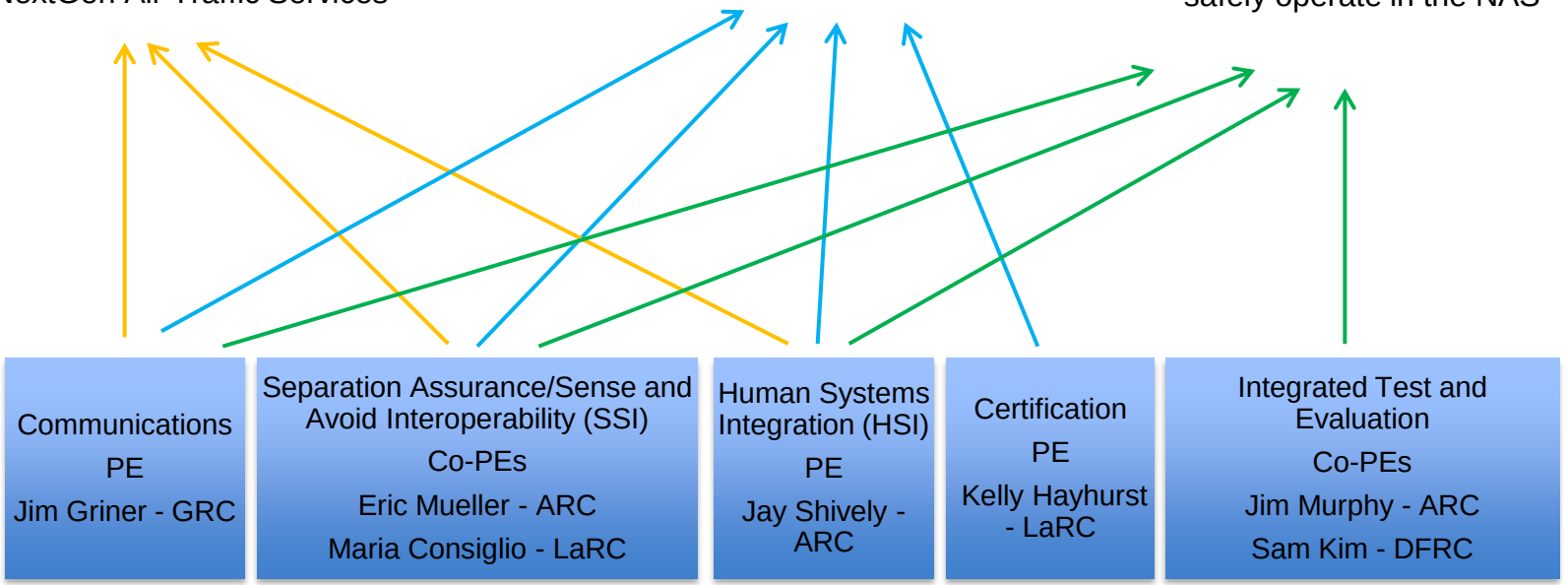
Validate technologies and procedures for unmanned aircraft systems to remain an appropriate distance from other aircraft, and to safely and routinely interoperate with NAS and NextGen Air Traffic Services

Standards/Regulations

Validate minimum system and operational performance standards and certification requirements and procedures for unmanned aircraft systems to safely operate in the NAS

Relevant Test Environment

Develop an adaptable, scalable, and schedulable relevant test environment for validating concepts and technologies for unmanned aircraft systems to safely operate in the NAS



PE – Project Engineer

Subproject Objectives
SSI, HSI, & Communications

- SSI
  - Assess the interoperability of UAS sense-and-avoid systems with the Air Traffic Control (ATC) environment
  - Assess the effects of UAS mission and performance characteristics, communications latencies and changes to separation roles and responsibilities on the NAS
- HSI
  - Develop a research test-bed and database to provide data and proof of concept for Ground Control Station (GCS) operations in the NAS.
  - Coordinate with standards organizations to develop human factors guidelines for GCS operation in the NAS
- Communications
  - Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS
  - Develop and validate candidate UAS Command Non-Payload Communications (CNPC) system/subsystem test equipment which complies with UAS international/national frequency regulations, International Civil Aviation Organization (ICAO) Standards and Recommended Practices, and FAA/RTCA Minimum Operational Performance Standards/Minimum Aviation System Performance Standards for UAS
  - Perform analysis and propose CNPC security recommendations for public and civil UAS operations
  - Perform analysis to support recommendations for integration of CNPC and ATC communications to ensure safe and efficient operation of UAS in the NAS

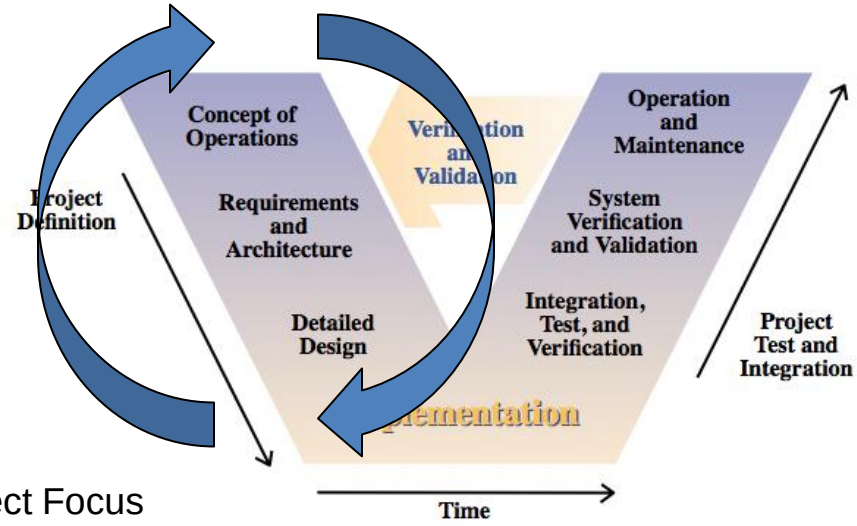
Subproject Objectives
Certification & IT&E

- Certification
  - Methodology for Classification of UAS and Determination of Airworthiness standards for avionics aspects of UAS
  - Hazard and risk related data to support development of regulation
- IT&E
  - Define and develop infrastructure that will create operationally relevant environments that is adaptable and scalable to incorporate the concepts and technologies to be evaluated by the SSI, Communications, HSI, and Certification subprojects
  - Employ systems level integrated simulations and flight tests to validate models, assess system interactions, and determine the effectiveness of the concepts and technologies at reducing the technical barriers associated with routine UAS access into the NAS

Systems Development and Integration

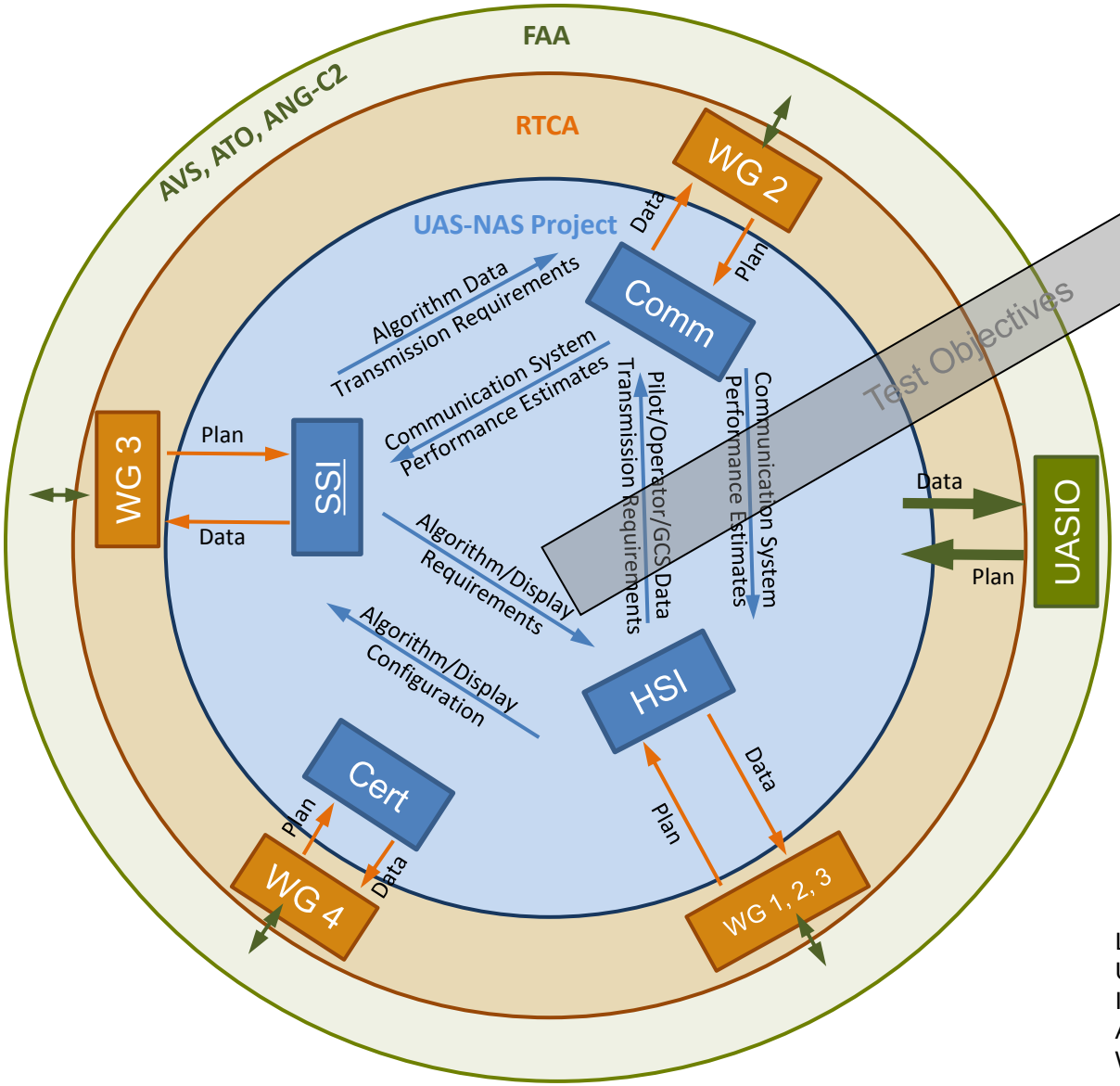
- Traditional Systems Integration
  - Requirements definition based on stakeholder need
  - Design and development
  - ~~Operations and maintenance~~

- UAS NAS Project integration focuses on the first two bullets above using an iterative approach



Project Focus

Subproject Integration and Stakeholder Coordination



1) Body of Evidence

2) Relevant Environment

Legend:
UASIO – Unmanned Aircraft Systems Integration Office
AVS, ATO, ANG-2 – FAA Organizations
WG – Working Group

Subproject Integration Body of Evidence

Body of evidence integration process follows a modified systems integration approach which relies on integrated test planning

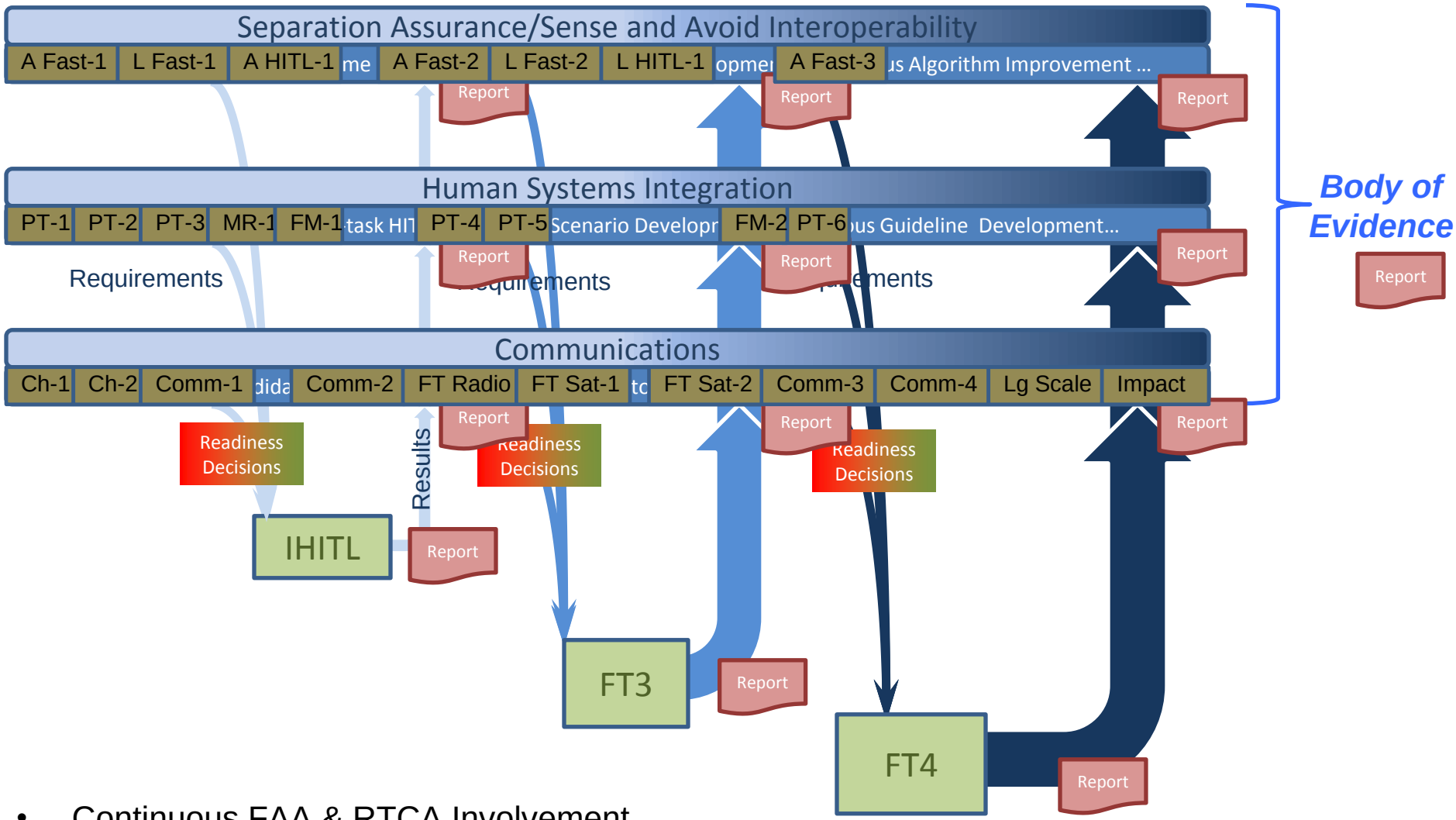
- Objectives Definition
- Test Planning and Interdependencies

Subproject Integration Relevant Environment

Live Virtual Constructive Distributed Environment (LVC-DE) development enables integrated test to occur in a relevant environment to validate the body of evidence follows a modified systems integration approach

- Requirements Definition
- Development and Integration
  - Asset development
  - Simulation capability integration
  - Distributed connectivity
  - Review process
  - Characterization test
    - Bound simulation capabilities
    - Test latency and bandwidth between components
- Enable Integrated Test

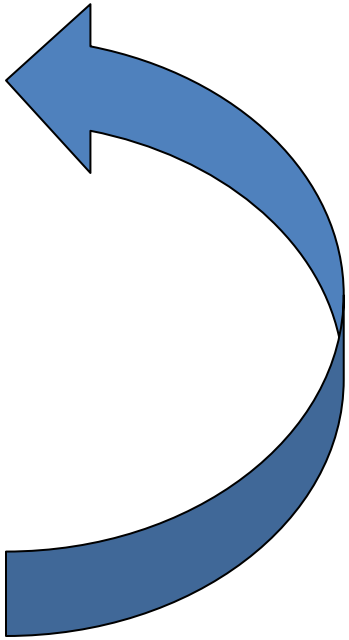
Subproject Integration



- Continuous FAA & RTCA Involvement
  (Right Research, Right Methods, Right Deliverables)

Objectives Definition

- Stakeholder Expectations
- Objectives Definition
- Operational Concept Development
- Performance Parameters



- Internal Project Activities
  - Stakeholder Expectations
  - Objectives Definition
  - Operational Concept Development
  - Performance Parameters

Test Planning Activities

- Internal subproject tests
  - Preparation and execution tasks identified
- Integrated tests
  - Preparation and execution tasks with networking dependencies identified
    - Integrated test infrastructure initial architecture development/demonstration/characterization; examples:

- Ground control station (GCS) connections
- Air traffic control (ATC) workstation development
- Infrastructure checkouts/shakedowns
- Ikhana (UAS) simulation
- Multi aircraft control system (MACS) modification for UAS and SSI algorithms

    - Integrated test planning; examples:

- Scenario selection and development
- Airspace adaptation
- Airspace demonstration/test
- Test plan matrix
- Data Analysis Plan
- Dry runs/shakedowns
- Host Center Reviews (IRT, FRR, AFSRB, Tech Brief)
- Reporting

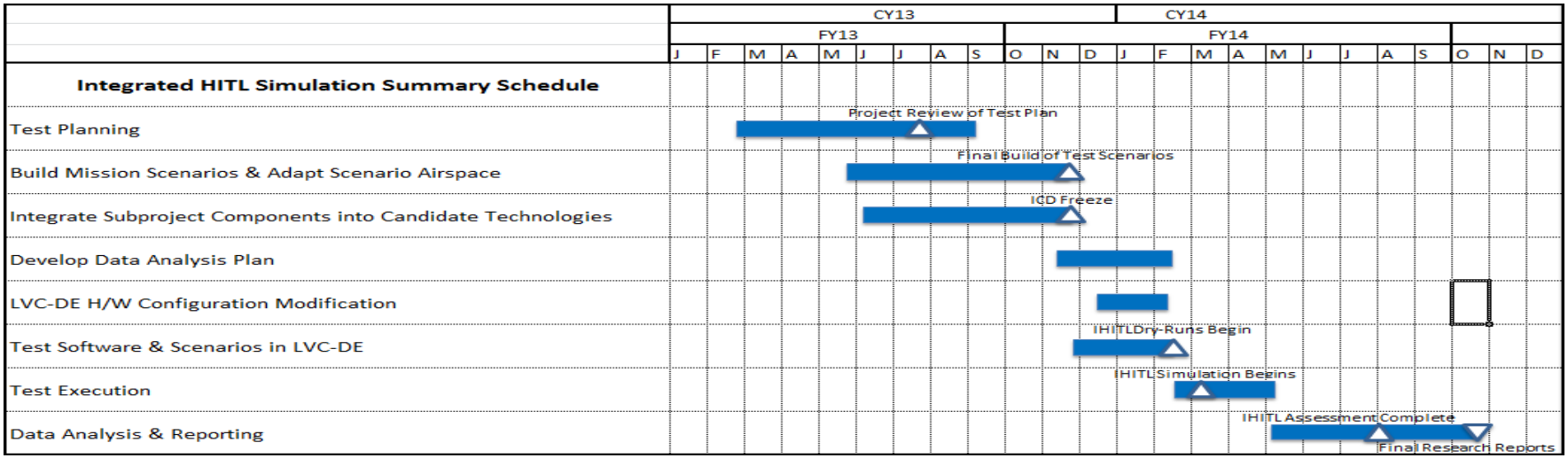
Examples of Interdependencies

- Communication latency
  - Cross referencing communication data with HSI and SSI requirements to ensure appropriate information is provided
  - Latency distributions are representative of today's communication architecture between ATC and pilot
- Integration of SSI algorithms into HSI ground control stations (GCS) and/or surrogate aircraft
- Incorporation of SSI display aspects into GCS
- Coordinate human role in each phase of separation assurance and collision avoidance
- Coordination of fast time simulations for measured response data (larger distributions will be evaluated in HITL)
- Integrated environment to ensure consistency
  - Simulation facilities, simulation components, and data collection

Example of Integrated Test Planning

Walk through the test planning of the first integrated event

- Goal the Integrated Human in the Loop (IHITL) is to test interoperability of sense and avoid with controller separation assurance in order to evaluate pilot and controller alerting of SAA advisories
  - See and avoid -> sense and avoid
  - Airspace is to be determined (Class A and E likely)
  - Increased scope/fidelity/uncertainty
  - Provide data to validate Communication models
    - Latency and bandwidth requirements



Example of Integrated Test Plan Development

- Test Plan Outline
  - Introduction
    - Purpose, Background, Resources
  - Test Objectives
    - What we are testing
    - Details for each specific objective
  - Test Procedures
    - How we are conducting each data run
  - Test Reporting
    - Description of the expected output
- Stakeholder Coordination
- Project Office Review

Stakeholder Coordination

- FAA and UAS-NAS Project collaboration and coordination
  - Final agreement on products/deliverables
  - Definition of how research will be used by the FAA
  - Alignment of activities with timeframe needed by FAA
- FAA - UAS-NAS Project Management Reviews (PMRs) – Target quarterly
  - FAA UAS Integration Office Director
  - UAS-NAS Project Manager
  - FAA Coordination Team Leads and UAS-NAS Project Chief System Engineer (CSE)
  - FAA SMEs and UAS-NAS Subproject PEs
- FAA & UAS-NAS Coordination Team – Currently weekly
  - FAA Coordination Team Leads and UAS-NAS Project CSE and FAA Liaison
  - Quad chart development
- FAA & UAS-NAS Research Specific Meetings – Constant
  - FAA SMEs and UAS-NAS Subproject PEs

Stakeholder Coordination

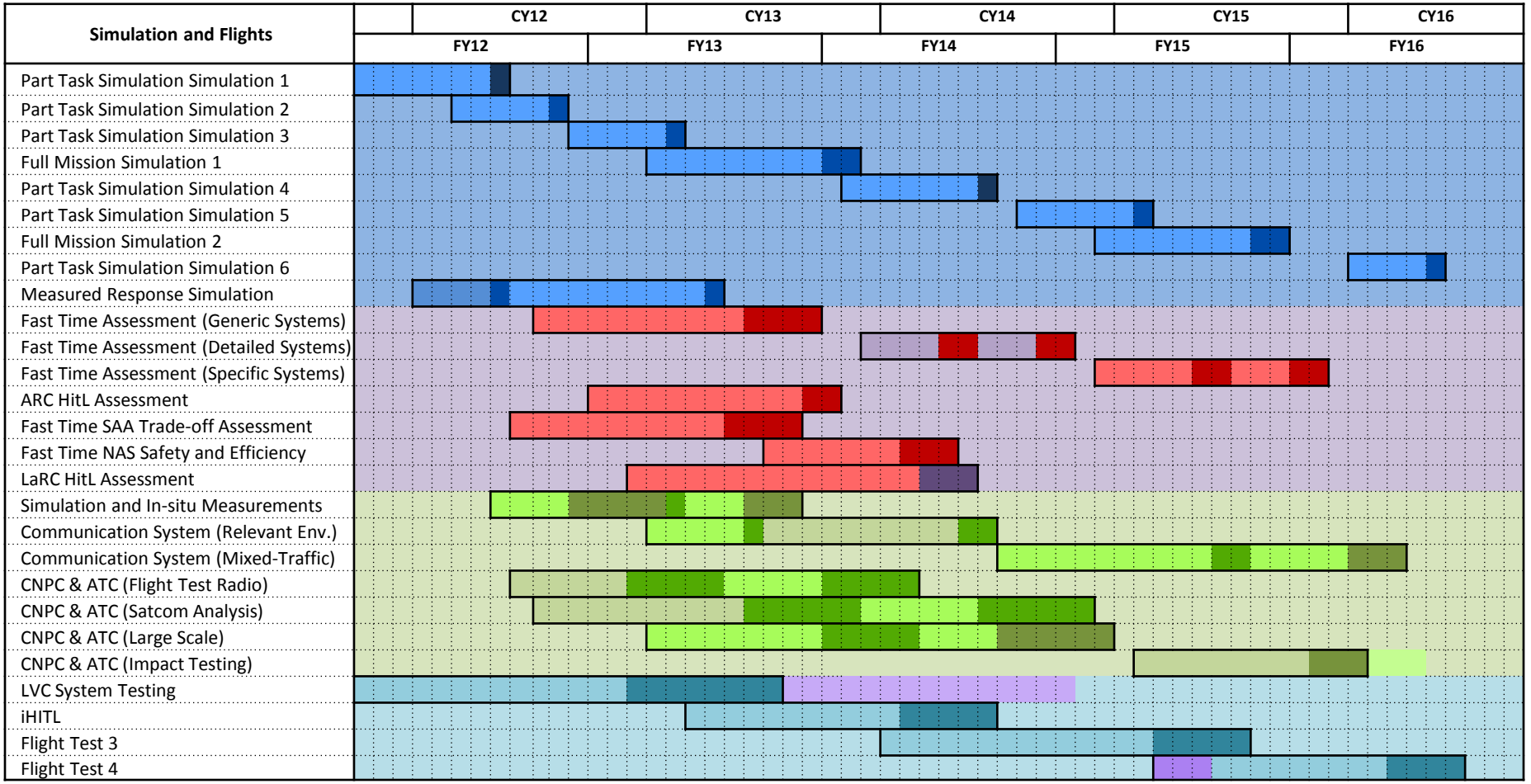
- RTCA and UAS-NAS Project collaboration and coordination through SC-203 Plenary sessions and Working Group Meetings
  - Definition of subproject objectives and products/deliverables
  - Definition of how research will be used by the SC-203
  - Alignment of activities with timeframe needed by SC-203
  - Current activity to define the methodology to report progress
    - Similar to FAA methodology (Quad Charts)
- JPDO
- Other Government Agencies (DOD, DHS)
- International Community

Summary

- Chief System Engineer oversees systems integration approach
- Understanding interdependencies between subprojects is important to ensure the body of evidence developed by each subproject takes full advantage of the work and knowledge of the other subprojects and the work/data is credible
- Coordination of subproject objectives/deliverables with our external customers important to ensure Body of Evidence contributes to the ability of key decision makers to establish policy, procedures, standards and regulations to enable routine UAS access in the NAS

Backup

Simulation and Flight Schedule



HSI	
SSI	
Communications	
Integrated Tests	

Requirements Definition

- Stakeholder Expectations Definition
  - Meeting of experts
  - NASA Need/Strategic Alignment
  - FAA
  - RTCA
  - FAA & RTCA expectations validation process
    - Ongoing series of meetings with FAA & RTCA defining and aligning research needs
    - Validated expectations to be briefed as part of Project Phase 1/Phase 2 Transition Review

Requirements Definition (continued)

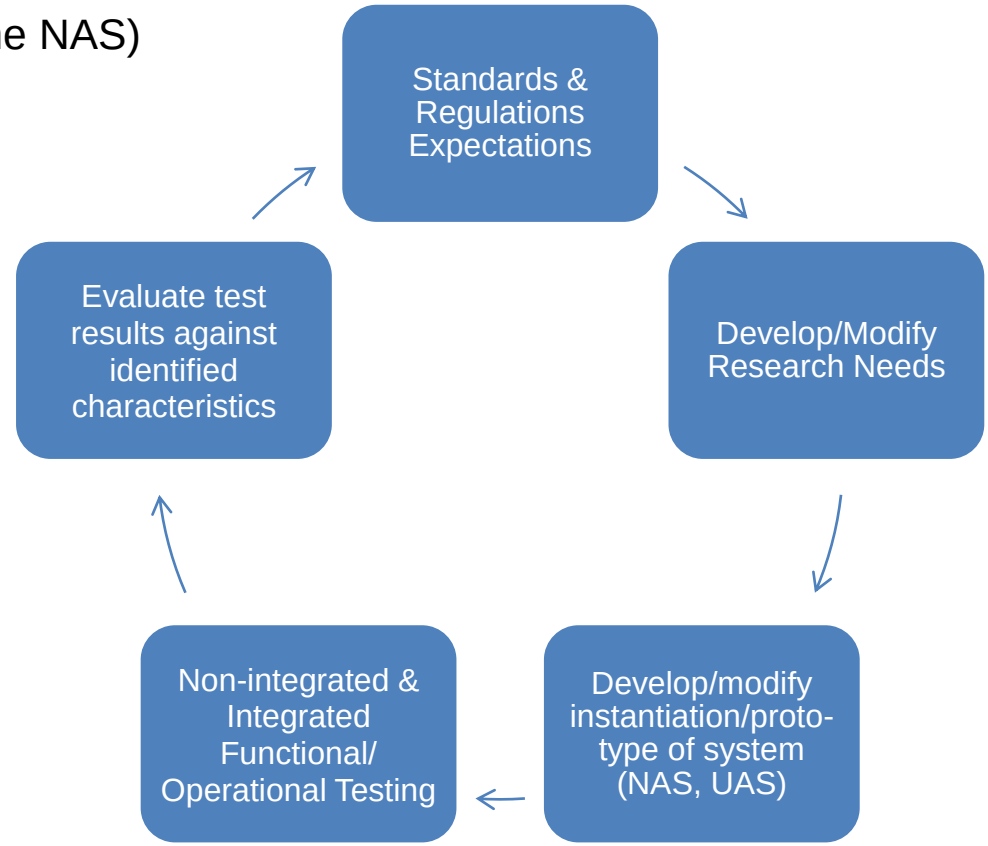
- Operational Concept
  - RTCA Operational Services and Environment Definition (OSED)
  - FAA ConOps – To be published
  - Project
    - SSI Concepts of Integration
      - Delegation of separation assurance authority allocations
    - Traffic densities
    - Airspace class
    - UAS scenarios or missions

Requirements Definition (continued)

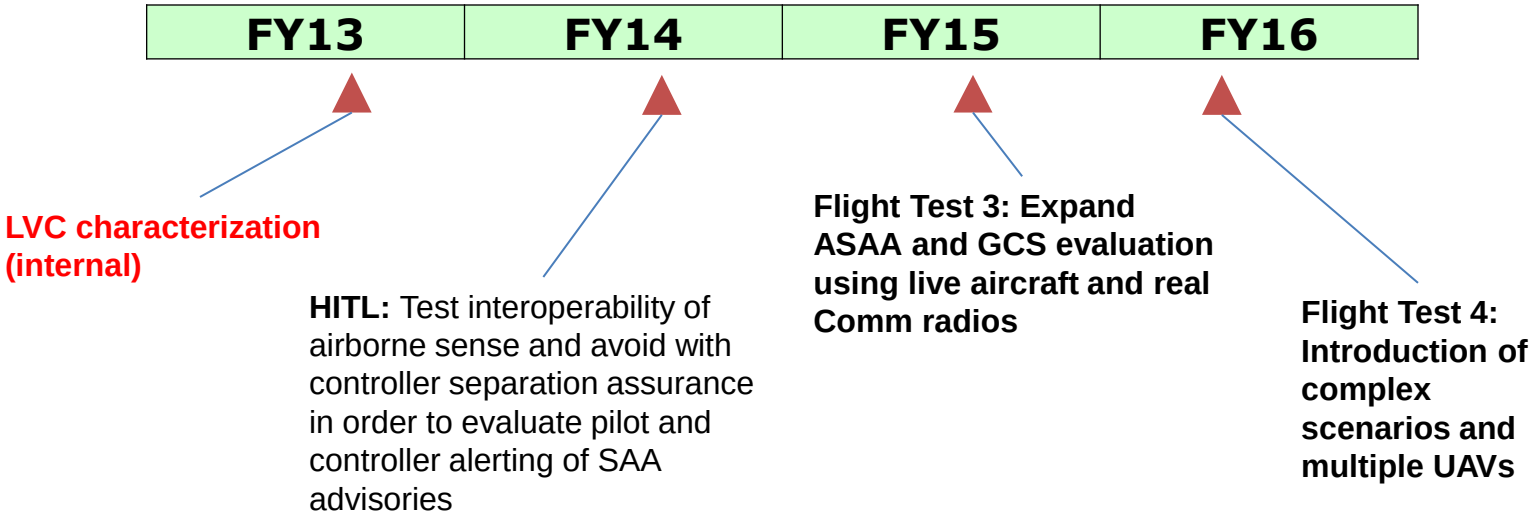
- Enabling Support Strategies
  - Develop body of evidence from
    - "Non-integrated" analysis, fast-time simulations, part-task human-in-the-loop simulations, and flight tests
      - Non-integrated = individual subproject focused objectives and infrastructure
    - "Integrated" human-in-the-loop and flight tests
      - Integrated = integrated objectives; common test infrastructure (LVC-DE), scenarios, and airspace to maximum degree possible
  - Develop LVC-DE to support validation – most relevant NAS representative infrastructure
    - Develop and integrate unique NASA Center infrastructure
      - ARC simulation capabilities
      - DFRC simulation and flight capabilities
    - Collaborate with FAA to provision LVC-DE infrastructure
    - Collaborate with partners to identify potential LVC-DE infrastructure opportunities for Project and partner

Requirements Definition (continued)

- Measures of Effectiveness (MOE)
  - Inform development of performance standards/regulations (the body of evidence)
  - Provide insight into “system” performance (system = UAS operating in the NAS)
- MOEs
  - NAS Safety
  - NAS Efficiency
  - NAS Capacity



Integrated Events Recap



Three primary events

- Each containing multiple sim/flight test series
- Many supporting simulations have integration aspect
- Looking for collaboration areas

Test Planning

- Integrated Master Schedule
  - Internal subproject tests
    - Preparation and execution tasks identified
  - Integrated tests
    - Preparation and execution tasks with networking dependencies identified
      - Integrated test infrastructure initial architecture development/demonstration/characterization; examples:

- GCS connections
- ATC workstation development
- Ikhana simulation
- FAA Tech Center Connection
- Infrastructure checkouts/shakedowns
- Ikhana ADS-B
- High Desert TRACON feed
- MACS modification for ERAM
- MACS modification for UAS and SSI algorithms
- ACES modifications

      - Integrated test planning; examples:

- Scenario selection and development
- Airspace adaptation
- Airspace demonstration/test
- Test plan matrix
- Data analysis plan
- Dry runs/shakedowns
- GCS modifications
- Aircraft modifications
- ATC controller training
- Pseudo pilot training
- Host Center Reviews (IRT, FRR, AFSRB, Tech Brief)
- Reporting

Integrated Flight Test 3 and Flight Test 4

Integrated flight test (FT) 3 goal is to expand SAA and GCS display evaluation using live aircraft and real Communication radios

- Airspace is to be determined
- Real-world uncertainties
  - Using prototype Communication systems
  - Added wind/speed/position uncertainties
- Higher fidelity
  - Live aircraft

Integrated flight test (FT) 4 goal is to evaluate SAA and GCS displays with complex scenarios and multiple UAVs

- Airspace is to be determined
- Potential for live intruders (using surrogates)
- Demonstration flight in the NAS (surrogate)