National Aeronautics and Space Administration

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

Presented by: Mr. Chuck Johnson

Manager, UAS Integration in the NAS Project

Agenda

Problem Statement, Goals, Objectives

Technical Challenges

- **Project Alignment to Address Them**
- **Barriers/Project Contributions**
- **Performance Measures**
- **Technical Accomplishments**

Project Schedule

Project Management and Risks

Partnerships/Collaborations

Resources

Annual Review Findings and Action Items

Issues/Concerns

Summary

Problem Statement, 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

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

Project Alignment to Address Technical Challenges

Airspace Integration

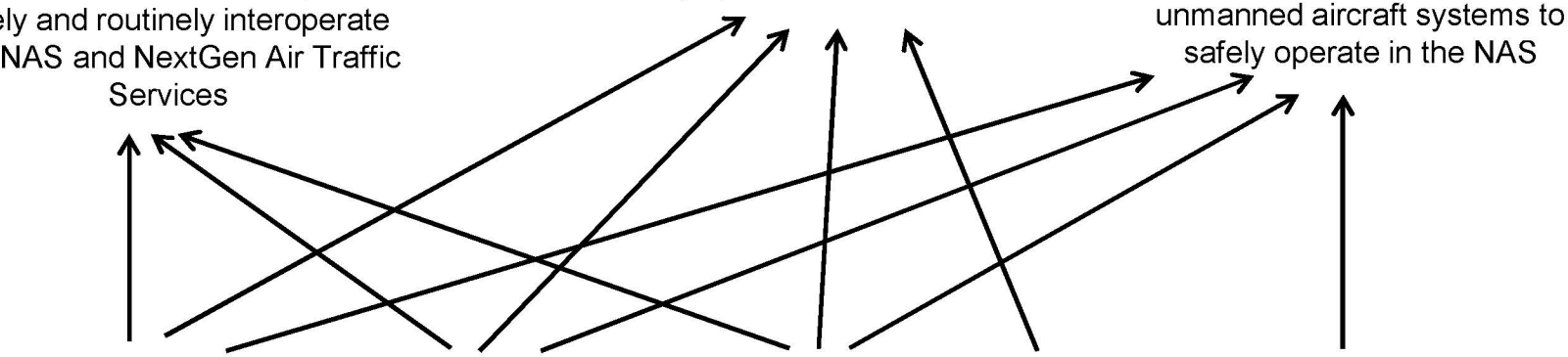
Validate technologies and procedures for unmanned aircraft systems to remain an appropriate distance from other aircraft, and to safely and routinely interoperate with NAS and NextGen Air Traffic Services

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



Communications	Separation Assurance/Sense and Avoid Interoperability (SSI)	Human Systems Integration (HSI)	Certification	Integrated Test and Evaluation
PE	Co-PEs	PE	PE	Co-PEs
Jim Griner - GRC	Eric Mueller - ARC Maria Consiglio - LaRC	Jay Shively - ARC	Kelly Hayhurst - LaRC	Jim Murphy - ARC Sam Kim - DFRC

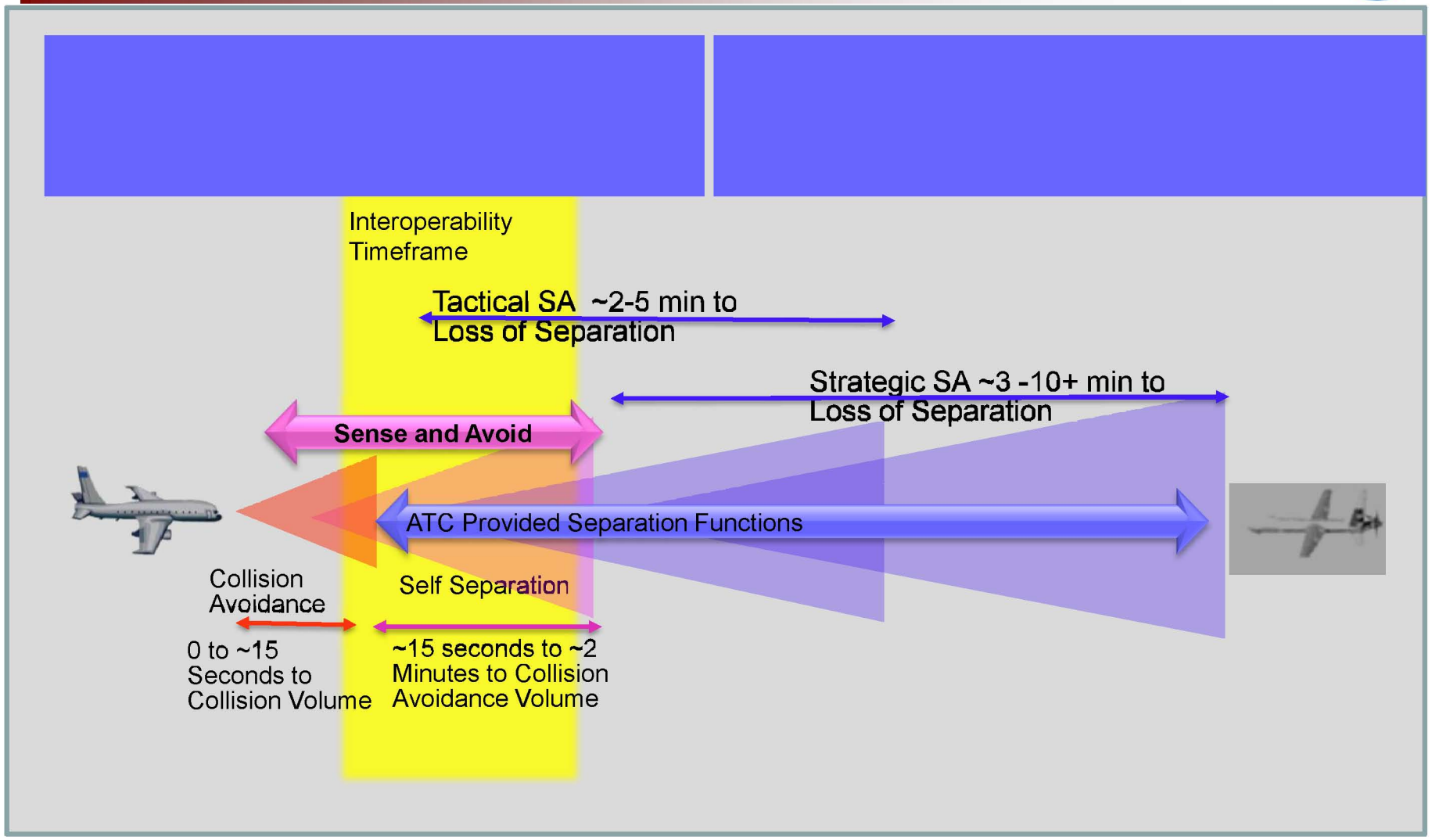
PE – Project Engineer

Airspace Integration Technical Challenge

- **Barriers Being Addressed by NASA**
  - Uncertainty surrounding the ability of UAS to interoperate in ATC environments and maintain safe separation from other aircraft in the absence of an on-board pilot
  - Lack of requirements for Sense and Avoid (SAA) systems and their interoperability with Separation Assurance (SA) functions
  - Lack of standards and guidelines with respect to UAS display/information
  - Lack of civil safety of flight frequency spectrum allocation for UAS control and non-payload communication (CNPC) data link communications

- **Project Contributions to Advance the State of the Art**
  - We will analyze capacity, efficiency and safety impacts of SAA-equipped UAS in the ATC environment to validate the requirements for SAA and SA/SAA interoperability through simulation and flight tests
  - We will evaluate ground control station (GCS) system human intervention in automated systems to inform and validate standards for UAS GCSs through prototyping, simulation and flight tests
  - We will develop and validate candidate UAS CNPC system prototype proposed performance requirements to validate that candidate civil UAS spectrum is secure, scalable, and suitable for safety-of-flight operations

Airspace Integration Technical Challenge

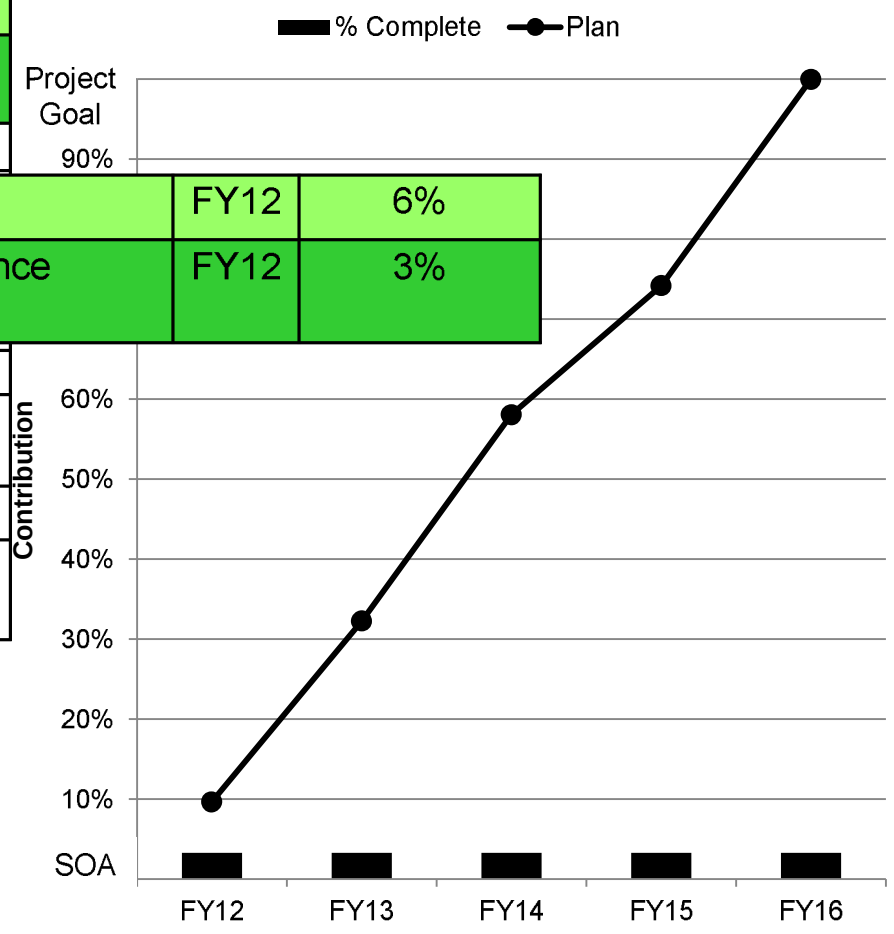


Notional depiction of overlapping detection look-ahead times for different SA and SAA functions (not to scale)
Look-ahead times vary with different algorithms

Airspace Integration
Technical Challenge Performance Measure

Technical Milestone/Activity	FY	Contribution
Concept of Integration (SSI)	FY12	6%
Support 2012 World Radio Conference (Comm)	FY12	3%
Fast-time assessment (SSI)	FY13	19%
Candidate frequency b characterization (Com		
HITL simulation (SSI)		
Integrated-HITL simula		
Flight Test 3 (SSI)	FY15	10%
Prototype Interface/Candidates II definition (HSI)	FY15	6%
Flight Test 4 (SSI, HSI)	FY16	22%
Initial CNPC system operational capabilities validation (Comm)	FY16	6%

Concept of Integration (SSI)	FY12	6%
Support 2012 World Radio Conference (Comm)	FY12	3%



Airspace Integration TC Accomplishments

- **Draft Concept of Integration developed (SSI)**
  - Developed candidate concepts for integrating UAS with the NAS considering the operational environment and goals for UAS integration

- **Aerodynamic performance models developed to support simulation and flight tests (SSI and NRA)**
  - Completed "4 DoF" models Predator (MQ-1), Reaper (MQ-9), and Global Hawk (RQ-4) integrated with ACES (SSI)
  - Completed "6 DoF" models Shadow (RQ-7) and Global Hawk (RQ-4) additional models under development (NRA)
  - Validated UAS performance models contribute to the relevance of the simulation and flight test results

- **Spectrum requirements analysis provided to the International Telecommunication Union Radiocommunication Sector (ITU-R) Working Party (WP) 5B (Comm)**
  - Contributed to the WP5B adopting a proposal for radiofrequency spectrum allocation of the 5030-5091 MHz frequency band to support UAS CNPC

- **Communication subproject process to assess candidate technologies for the CNPC link provided at the ICAO Aeronautical Communications Panel Working Group F (Frequency) Meeting (Comm)**
  - Solicited feedback on communication assessment process from domestic and international partners to ensure resulting CNPC flight tests will contribute to the body of knowledge

Standards/Regulations Technical Challenge

- **Barriers Being Addressed by NASA**
  - Lack of standards and guidelines with respect to UAS display/information
  - Lack of GCS design requirements to operate in the NAS
  - Lack of validated regulations, standards, and practices for safe, secure, and efficient UAS control and non payload data link communications including integration with air traffic control communications
  - Lack of safety-related data available to support decision making for defining airworthiness requirements
  - Lack of airworthiness requirements specific to the full range of UAS, or for their avionics systems or other components

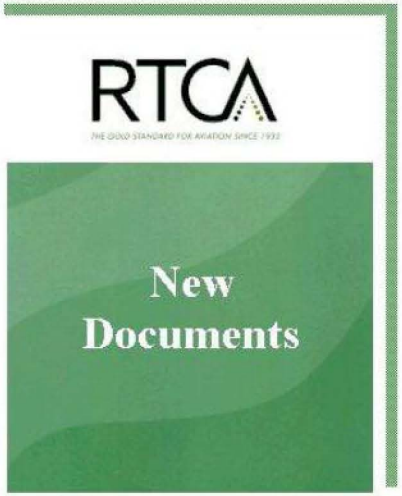
- **Project Contributions to Advance the State of the Art**
  - We will determine the required information to be displayed in the GCS to support the development of standards and guidelines through prototyping and simulation
  - We will analyze integration of UAS CNPC system and ATC communications to validate recommendations for regulations and standards
  - We will collect and analyze UAS hazard and risk related data to support safety case recommendations for the development of certification/regulation development
  - We will conduct a “virtual” type design certification effort to develop a “UAS playbook” for industry to obtain type design certificates

Standards/Regulations Technical Challenge

No person may operate an aircraft unless it is in an airworthy condition (FAR 91.7a)

- conforms to its type design and is in a condition for safe operation (FAR 3.3)

- What is the best approach to prescribing airworthiness requirements on UAS, especially their avionics? By categories?
- What does existing data from UAS failures/incidents/accidents tell us to help us know what regulation is needed?
- What would the certification process look like for a UAS? By example...

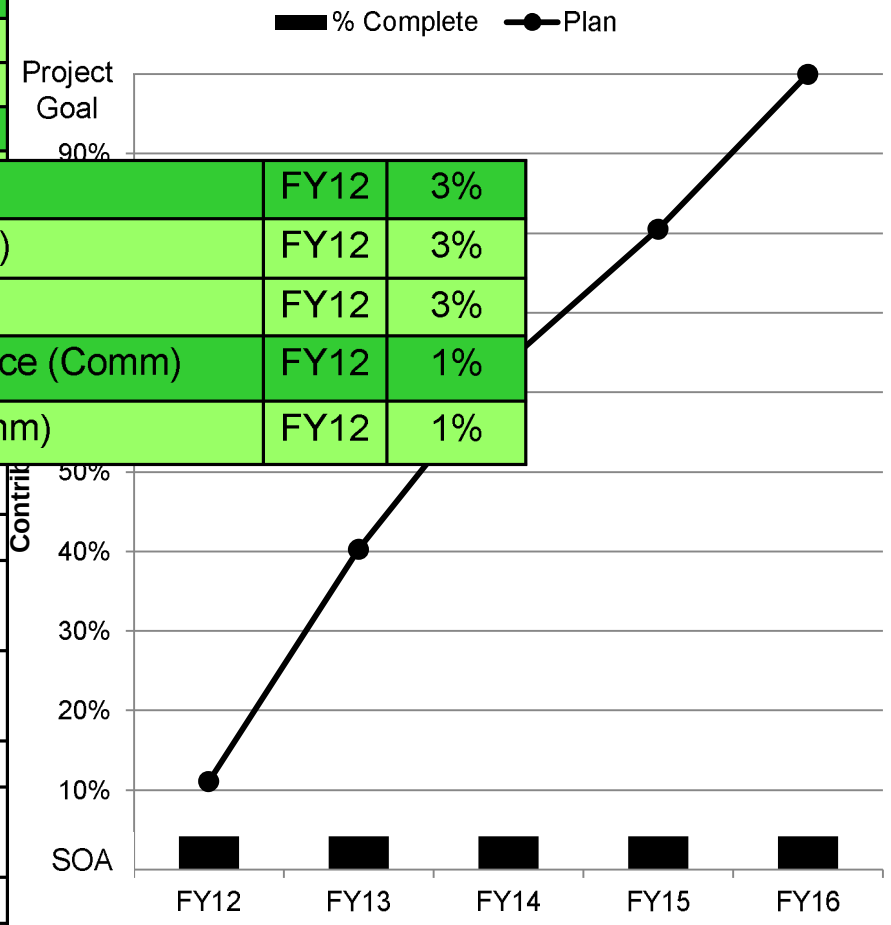


- Human factors guidelines for GCS operation in the NAS
- SSI Requirements
- Communication Requirements
- Support of the MASPS process

Standards/Regulations
Technical Challenge Performance Measure

Technical Milestone/Activity	FY	Contribution
Workshop (HSI)	FY12	3%
GCS information Requirements (HSI)	FY12	3%
Candidate GCS Suite (HSI)	FY12	3%
Support 2012 WRC (Comm)	FY12	1%
CNPC system risk as		
Fast-time assessmen Class guidelines (HSI		
CNPC/Spectrum anal		
Risk/Airworthiness an		
Integrated-HITL simu		
CNPC prototype/secu development and NAS-wide simulation		
Risk/Airworthiness validation (Cert)	FY14	7%
Flight Test 3 (SSI) and Candidates II definition/HITL simulation (HSI)	FY15	9%
CNPC system security mitigations verification in flight environment (Comm)	FY15	1%
Risk/Airworthiness final analysis (Cert)	FY15	5%
Flight Test 4 (SSI, HSI) and final GCS guidelines (HSI)	FY16	13%
CNPC NAS-wide analysis (Comm)	FY16	6%
Final type design certification criteria report (Cert)	FY16	1%

Workshop (HSI)	FY12	3%
GCS information Requirements (HSI)	FY12	3%
Candidate GCS Suite (HSI)	FY12	3%
Support 2012 World Radio Conference (Comm)	FY12	1%
CNPC system risk assessment (Comm)	FY12	1%



Standards/Regulations TC Accomplishments

- **First Part-Task Simulation completed (HSI)**
  - Developed networked simulation environment
  - Established baseline operations for UAS flying in center airspace with manned aircraft and positive ATC control
  - Supports development of human factor guidelines for ground control stations

- **Human Systems Integration Workshop completed (HSI)**
  - Identification of UAS human factor issues relevant to community
  - Results distributed to RTCA SC-203 to inform recommended guidelines

- **Prototype CNPC communication radio development procured through a cost-sharing agreement (Comm)**
  - 40/60 cost sharing agreement to develop prototype radio
  - Significant investment for partner

- **"Virtual Type Certification" case study initiated (Cert)**
  - RFI solicitation was issued on February 9, 2012 and closed March 26, 2012
  - FAA fully supporting effort
  - Strong response from industry

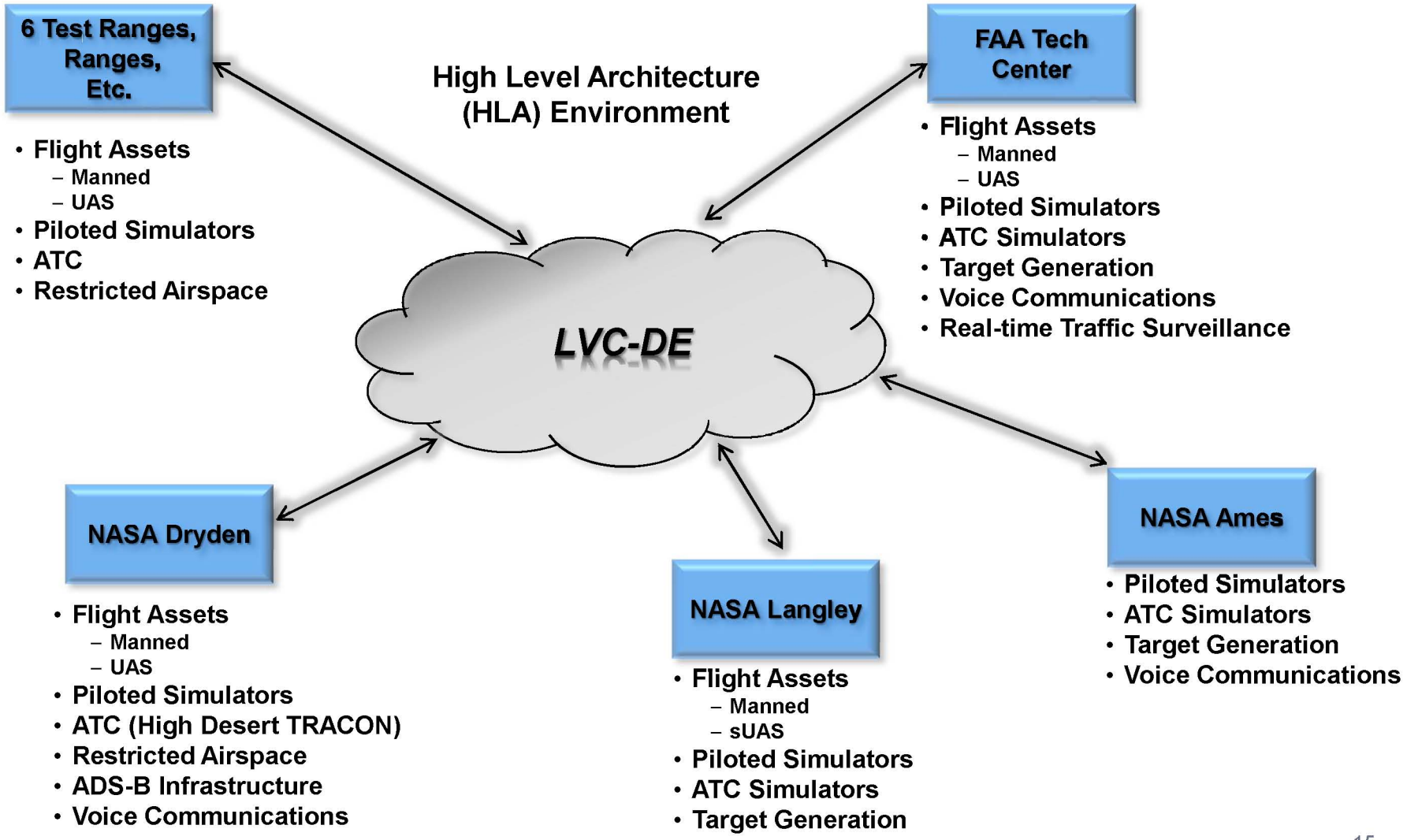
Relevant Test Environment Technical Challenge

- **Barriers Being Addressed by NASA**
  - Lack of an adaptable, scalable, and schedulable operationally relevant test infrastructure/environment for evaluating UAS SSI, HSI, and CNPC NASA UAS/NAS subproject concepts and technology developments (IT&E)

- **Project Contributions to Advance the State of the Art**
  - We will develop a relevant test environment to support evaluation of UAS concepts and technologies using a Live Virtual Constructive – Distributed Environment (LVC-DE)
  - We will instantiate a GCS with display/information to demonstrate compliance with requirements
  - We will verify a CNPC system prototype in a relevant and mixed traffic environment to support the allocation of spectrum for UAS safety of flight operations

Live Virtual Constructive-Distributed Environment

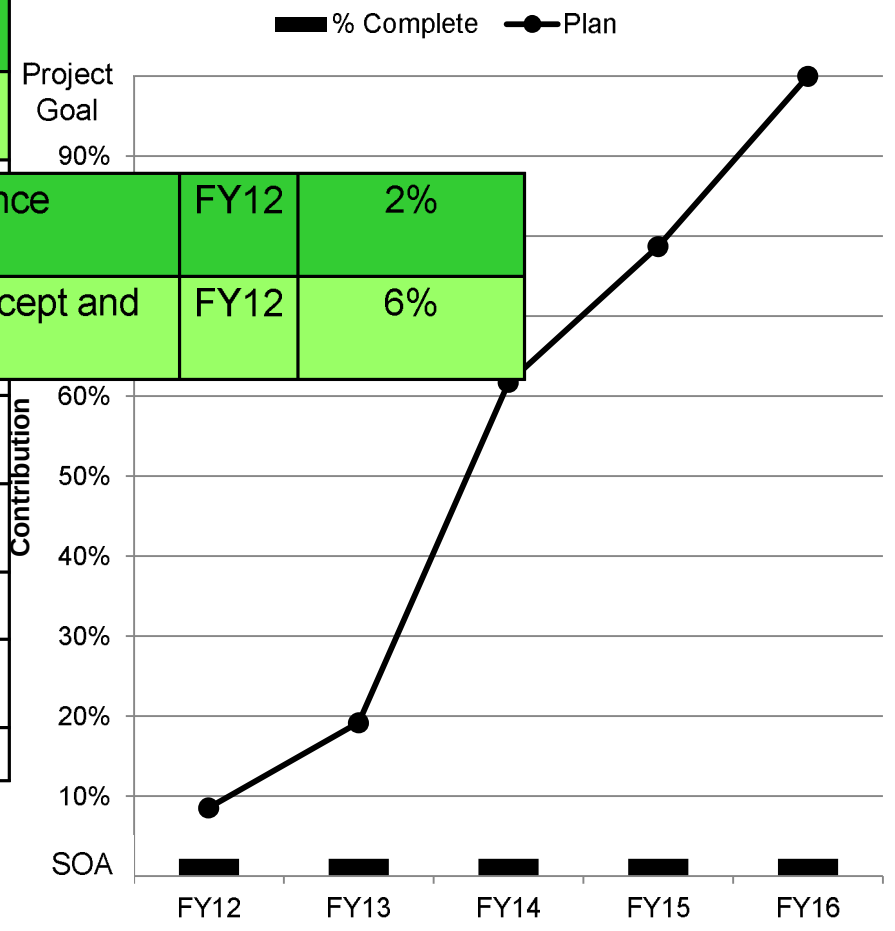
Notional Distributed Simulation and Flight Test Environment



Relevant Test Environment
Technical Challenge Performance Measure

Technical Milestone/Activity	FY	Contribution
Support 2012 World Radio Conference (Comm)	FY12	2%
Integrated-HITL and Flight Test Concept and Objectives development (IT&E)	FY12	6%
LVC-DE development/		
CNPC prototype syste development/modificat		
CNPC system security development/testing (C		
Integrated-HITL simulation (SSI, HSI, IT&E)	FY14	30%
CNPC system security mitigations verification in flight environment (Comm)	FY15	2%
Flight Test 3 (SSI, IT&E)	FY15	15%
Initial CNPC system operational capabilities validation (Comm)	FY16	4%
Flight Test 4 (SSI, HSI, IT&E)	FY16	17%

Support 2012 World Radio Conference (Comm)	FY12	2%
Integrated-HITL and Flight Test Concept and Objectives development (IT&E)	FY12	6%



Relevant Test Environment TC Accomplishments

- **LVC-DE infrastructure expanded from work completed through a 2010 ARRA task**
  - Established a gateway at DFRC to connect the Ikahna simulator with the cockpit situation displays (CSD) at ARC's Distributed Simulation Research Lab (DSRL)
  - Conducted detailed planning for integration of NASA's North Texas Field Station (NTX) live FAA air traffic feed into the LVC infrastructure at ARC
  - Installed an ADS-B real-time tracking surveillance (RTTS) capability at ARC to display live ADS-B and TIS-B traffic from FAA Tech Center

- **Stand-alone prototype LVC-DE developed and tested**
  - Provided MACS and ADRS installation and integration to DFRC for local scenario playback and testing
  - Integrated Ikhana Pilot Simulator with LVC-DE

- **UAS ADS-B Out Flight Test**
  - Installed ADS-B on Ikhana UAS
  - Validated by FAA
  - Informs latencies for Integrated HITL and Flight Test Series

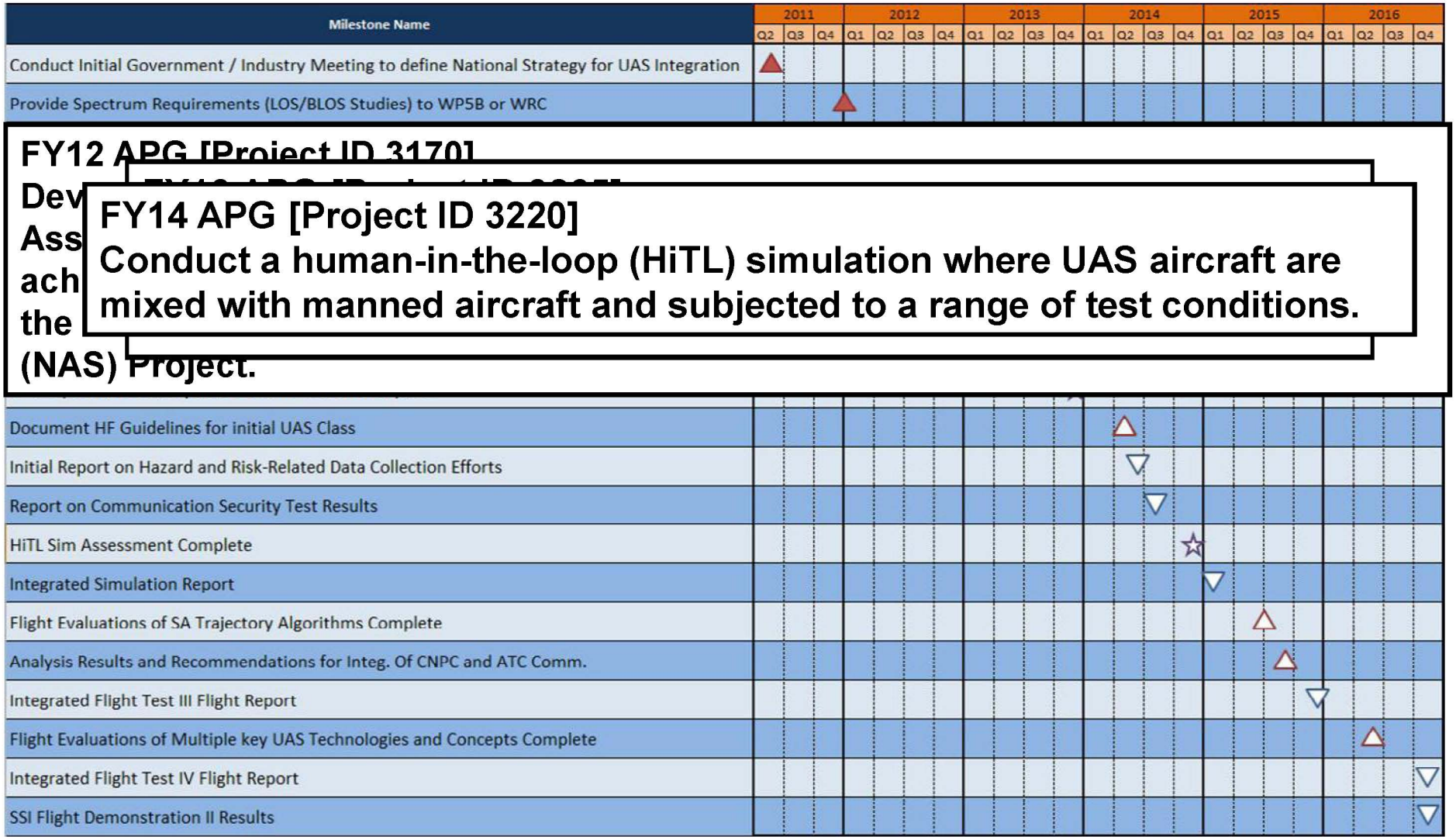
Ground track created with ADS-B data during Ikhana flight test

Project Accomplishments

- **11 NRA awards in FY11 total $7.2M**
  - 3 Simulation and Modeling
  - 2 Systems Analysis
  - 4 Certification
  - 2 Test Techniques

- **4 Phase 1 SBIR awards in FY12 under UAS/NAS subtopic**
  - 2 Desktop Simulation System
  - 1 UAS Model Construction
  - 1 Rapid Mission Planning

Project Schedule



FY12 APG [Project ID 3170]
Dev
Ass
ach
the
(NAS) Project.

FY14 APG [Project ID 3220]
Conduct a human-in-the-loop (HiTL) simulation where UAS aircraft are mixed with manned aircraft and subjected to a range of test conditions.

APG ☆ ★ L1 Program (ISRP) △ ▲ L2 Project ▽ ▼

Hollow symbols are planned. Filled symbols are complete

UAS Project Decisional and Status Forums

UAS Management Review Board (UAS MRB)

Chair: Chuck Johnson

Meets: Monthly

UAS Change Management Approvals for:

- Risk Management Assessments
- Milestone Variance
- Cost/Technical Performance Variance
- Change/Data Management

Technical

Programmatic

PM/DPMf Meeting	Risk Meeting	CSE All Subproject TIM	SSI Subproject TIM	Comm Subproject TIM	HSI Subproject TIM	Cert Subproject TIM	IT&E Subproject TIM
Chair: PM	**Chair:** DPM	**Chair:** CSE	**Chair:** CSE	**Chair:** CSE	**Chair:** CSE	**Chair:** CSE	**Chair:** CSE
Meets: Bi-weekly	**Meets:** Monthly	**Meets:** ~Monthly	**Meets:** Bi-weekly	**Meets:** Bi-weekly	**Meets:** Bi-weekly	**Meets:** Bi-weekly	**Meets:** Bi-weekly

Project Risks

- **Progress since Annual Review (Nov 2011)**
  - Accomplished initial risk review
  - Initial Risk Review Meeting considered 23 candidate risks
    - 16 recommended to Mitigate status
    - 1 each recommended to Research, Watch, Accept, and Close
    - 3 recommended to Reject
  - Management Review Board briefed and approved all recommendations
  - Supported ISRP Risk Management Board, 1 risk elevated, Closed by project

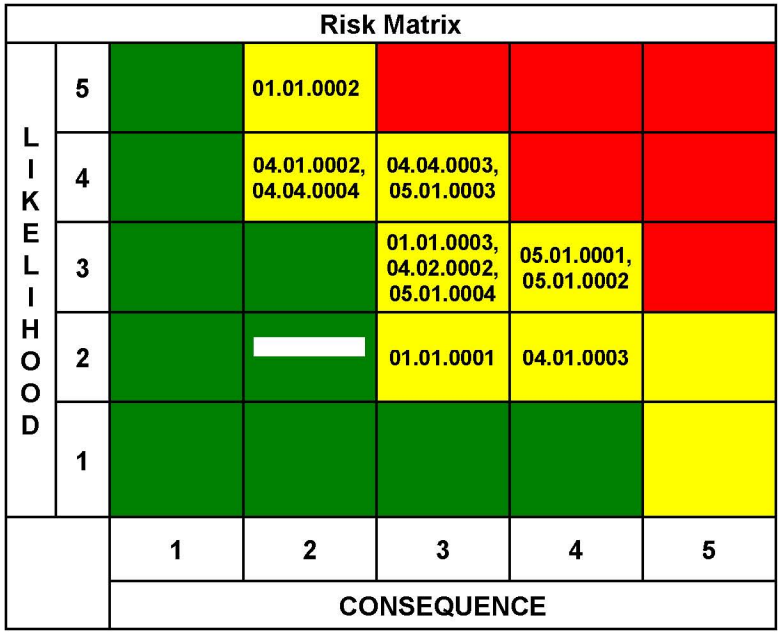
- **Top Risks**
  - Budget restrictions impacting travel plan (U.01.01.0002)
  - Realism of predicted UAS mission profiles/Availability of accurate traffic models/profiles for projected UAS flights (U.01.01.0004)
  - Perception of competing projects (U.04.02.0003)

Project Risks

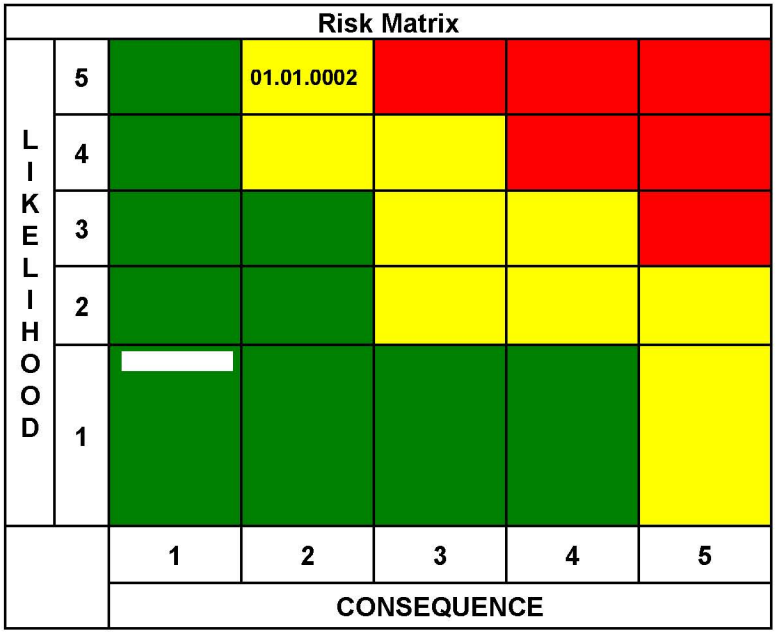
- **Remaining Risks**
  - **Research**
    - Availability of test bed for airborne sense and avoid flight tests equipped with the CNPC radio
  - **Watch**
    - Applicability of NextGen separation assurance concepts and algorithms for manned operations to UAS NAS integration
  - **Mitigate**
    - Subproject technology development delays impacting integrated test events
    - Relevance of subproject work to customers/stakeholders
    - Availability of NextGen “Operational Improvements” and infrastructure upgrades
    - Availability of UAS performance models for separation assurance fast-time simulations and subsequent HITL tests
    - Delay (or unavailability) of simulation infrastructure
    - Ability to fully validate the general applicability of the certification methodology
    - Limited data collection due to insufficient access to those with data (e.g., DoD, NMSU)
    - Obtaining/maintaining appropriate skill mix on team and dedicated work time
    - Lack of firm LVC-DE requirements
    - Connectivity requirements to external partners not defined
    - Lack of common voice communication system for LVC simulations and flight tests
    - Availability of assets
    - Overload of information to UAS operators
    - Unavailability of UAS operators with appropriate experience to participate in simulation

UAS/NAS Risk Projection as of March 15, 2012

Current

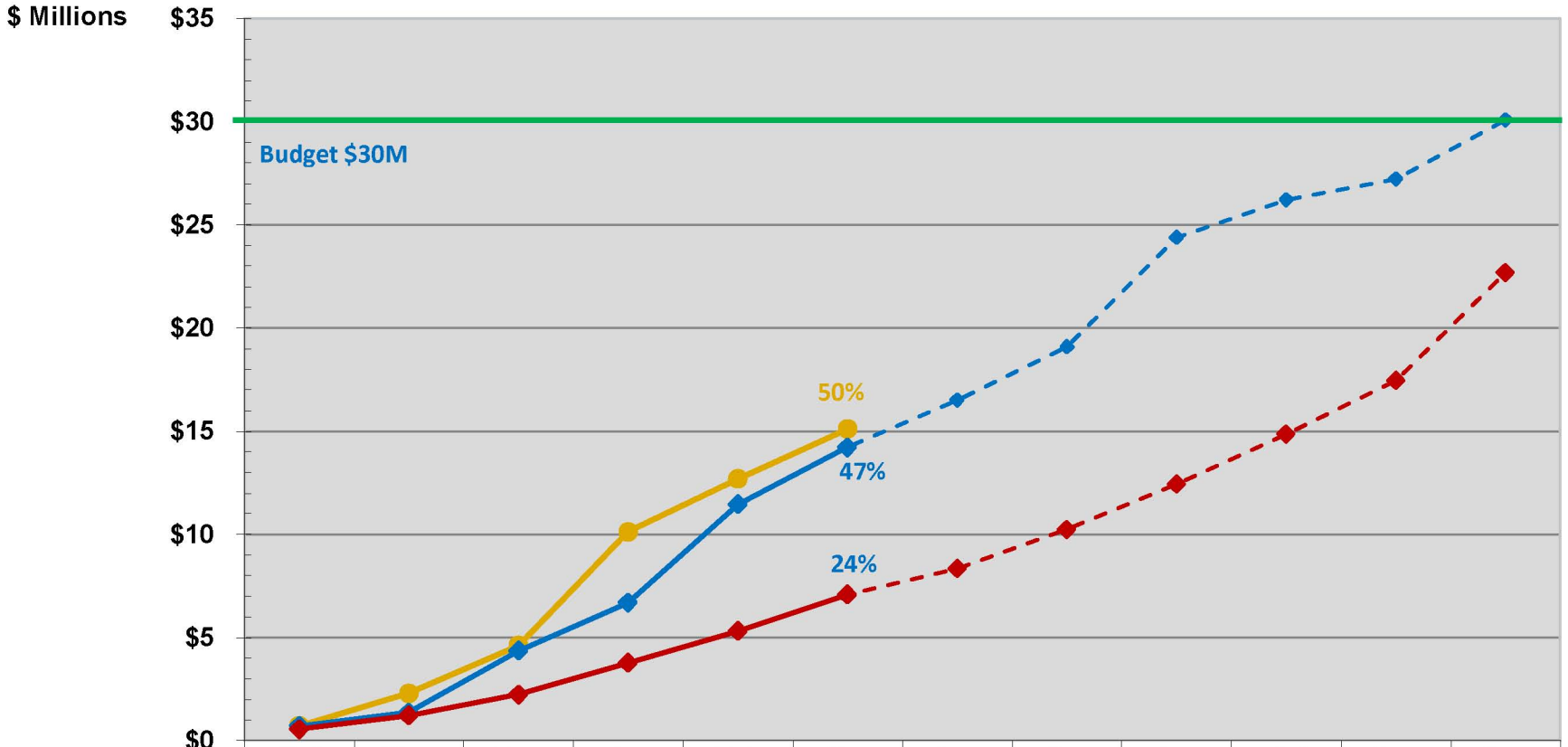


Target
(After Mitigations Complete)



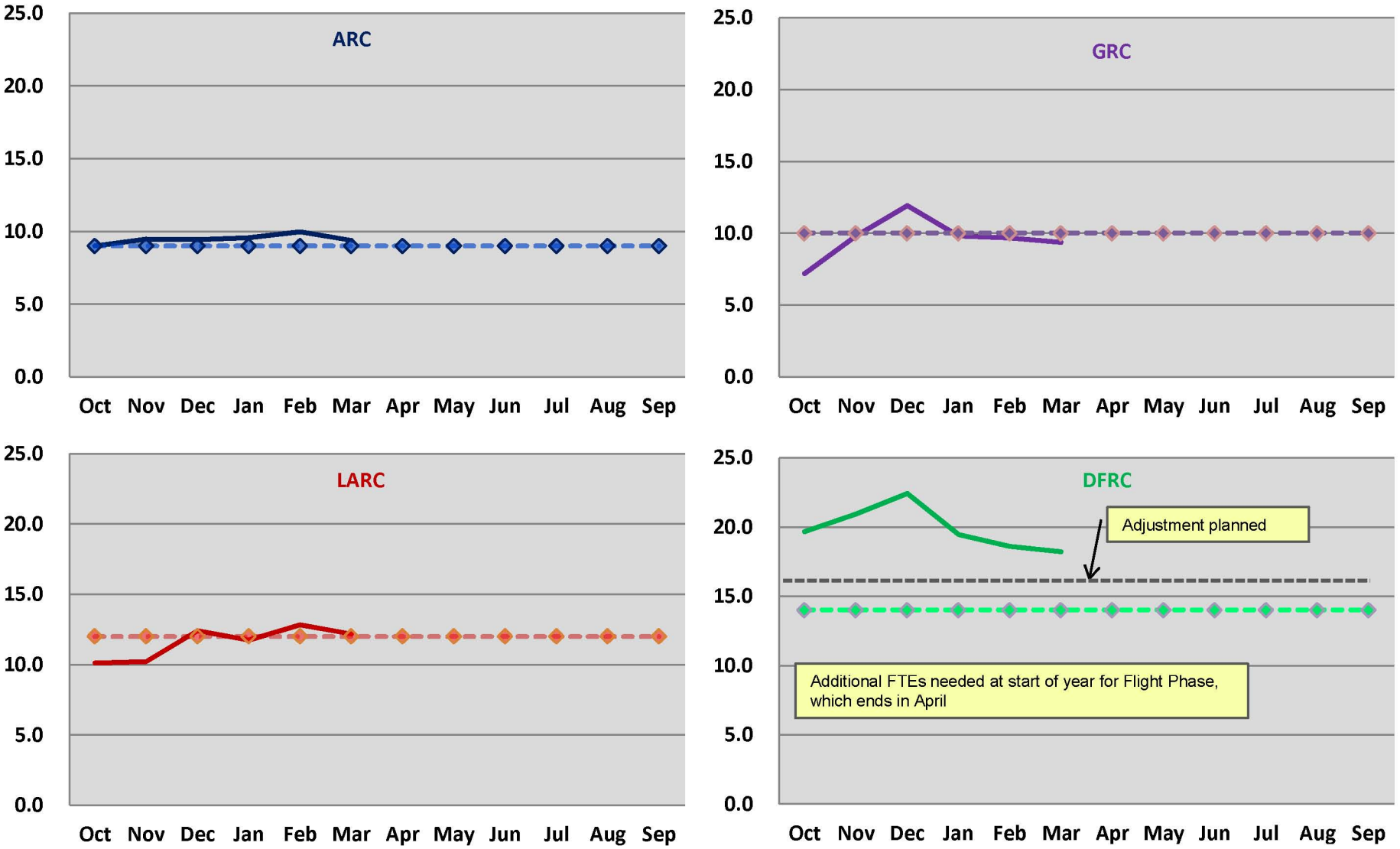
Partnerships and Collaborations

FY12 Budget Performance – ISRP UAS



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Committed	$0.7	$2.3	$4.6	$10.1	$12.7	$15.1						
Obligated	$0.7	$1.4	$4.4	$6.7	$11.5	$14.2						
Obligation Plan	$0.7	$1.4	$4.4	$6.7	$11.5	$14.2	$16.5	$19.1	$24.4	$26.2	$27.2	$30.1
Cost	$0.6	$1.2	$2.2	$3.8	$5.3	$7.1						
Cost Plan	$0.6	$1.2	$2.2	$3.8	$5.3	$7.1	$8.3	$10.2	$12.4	$14.9	$17.5	$22.7

FY12 FTE Performance – ISRP UAS



Annual Review Findings

DPMC Findings:

- *Clearly define the Technical Challenges and progress indicators.*
  - **Response:** Information presented in this presentation defines the new Technical Challenges and their associated progress indicators

- *The degree to which separation assurance (SA) research within the UAS Project is aligned with SA research in the Airspace Systems Program was not evident. The ISRP and ASP Programs should work collaboratively to insure there is no duplication or gaps in SA research.*
  - **Response:** The UAS Project and the ASP CTD Project have coordinated and aligned SA research
  - Through meetings with FAA and RTCA, Project has restructured the SA Subproject to be the Separation Assurance/Sense and Avoid Interoperability (SSI) Subproject
  - The ARMD AA has approved the new focus under SSI and the collaboration steps that UAS and CTD have established

Annual Review Findings (continued)

IRP Findings:

- *Clearly define a vision, goals, and objectives with relevant metrics for the UAS/NAS Project.*
  - **Response:** This briefing has addressed the vision (needs), goals, objectives, and relevant metrics associated with the project

Issues/Concerns

Issues

None

Concern

The ability to coordinate appropriately with Collaboration Partners and our internal Project Team may be impacted by travel constraints. This may impact the quality of our deliverables and the ability to perform optimal technology transfer

- Estimated travel requirements are $420K per year
- Expected travel budget is approximately $250K per year
- Mitigated this year through forward funding from FY11 budget

Possible Impact

- Planned face-to-face interactions between Centers and key stakeholders will be reduced, which may impact the ability to transfer technologies to our stakeholders

Summary

Quality

•Since the initiation of the project, and more predominantly over the past six months, numerous technical accomplishments have been completed

Performance

•Technical performance

- The project has established a mechanism to track technical progress against our Technical Challenges and we are on track to meet all milestones

•Fiscal performance

- The project met or exceeded all of the fiscal metrics established over the past six months

•Project performance

- The project has established processes to track progress for technology development, budget, risk, and change management

Collaboration and Partnerships

•The project has conducted a series of meetings with our most prominent customers and stakeholders over the past six months. These collaborations have led to the reshaping of our Technical Challenges and the research plans necessary to deliver products which can reduce or eliminate the barriers associated with those Technical Challenges

Questions?

Back Up

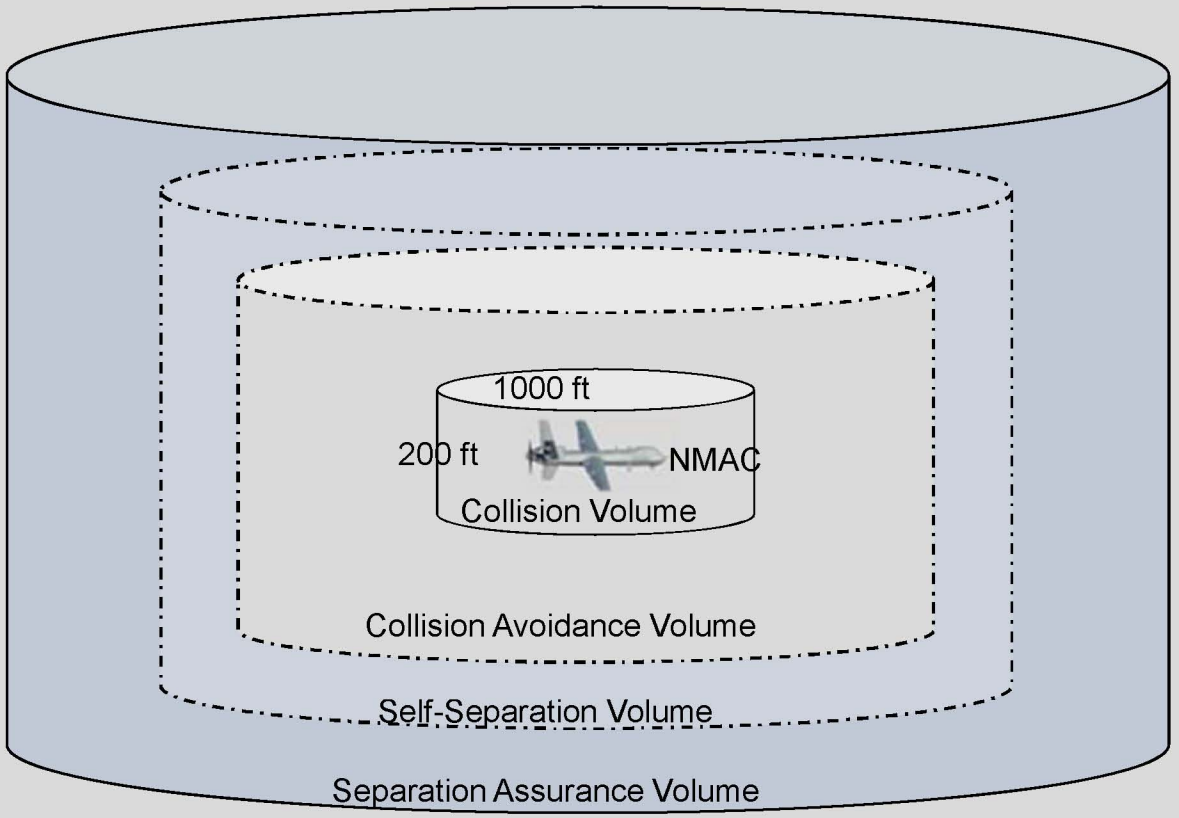
Sense and Avoid (SAA) System

The SAA system includes both Self Separation and Collision Avoidance functions

The Collision Volume Threshold is a fixed distance based boundary

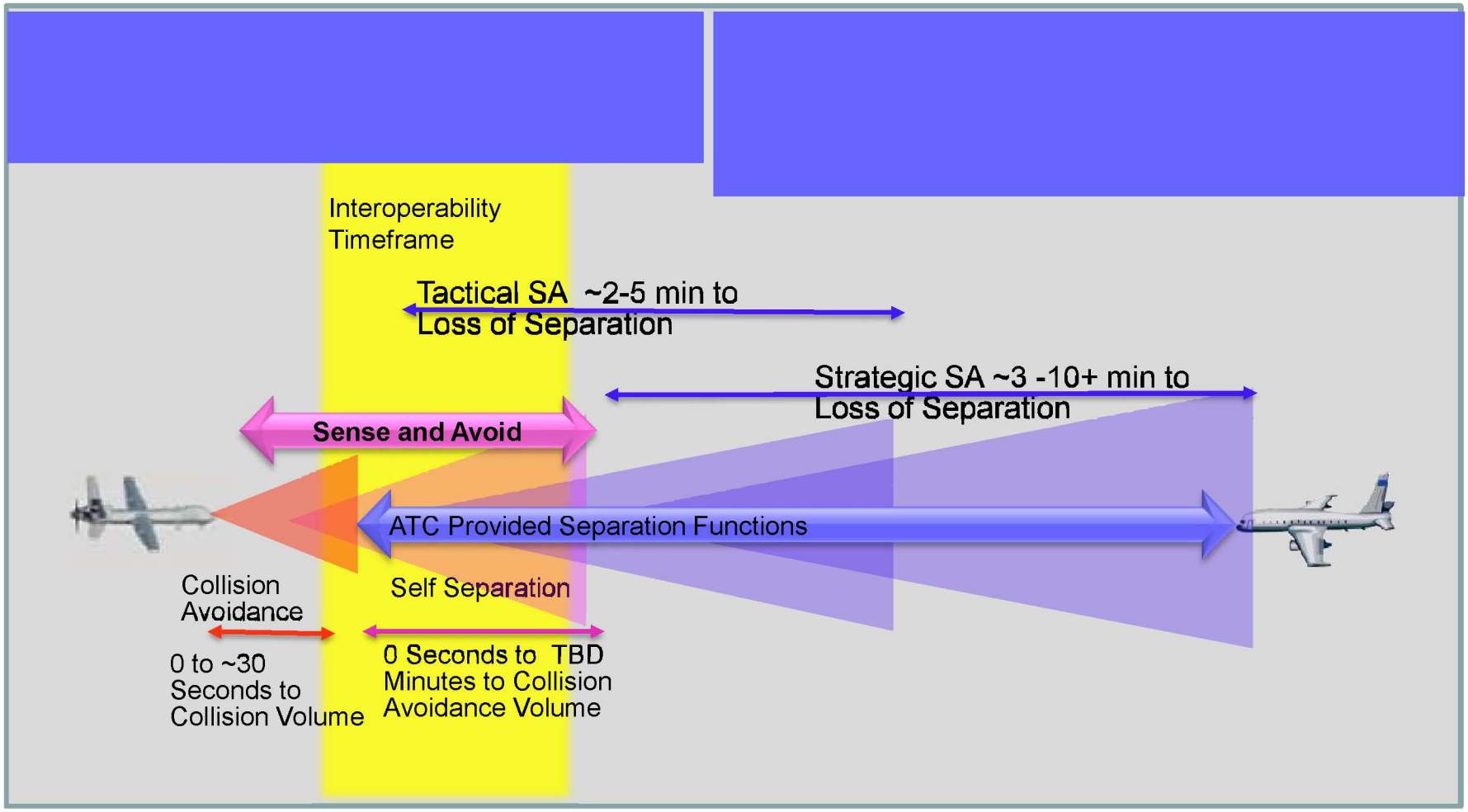
The Collision Avoidance Threshold is a variable boundary that depends on time, distance, maneuverability, and other parameters.

The Self Separation Threshold (well clear) is a variable boundary that depends on time, distance, maneuverability, and other parameters.



FAA -SAA

SAA/SA Interoperability



Notional depiction of overlapping detection look-ahead times for different SA and SAA functions (not to scale).
Look-ahead times vary with different algorithms.

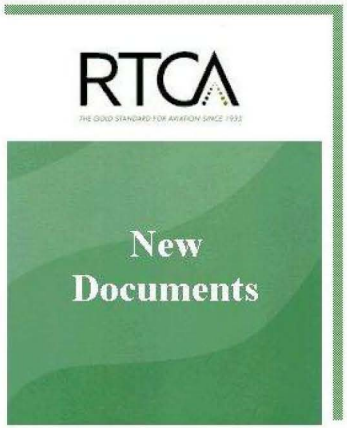
HSI Subproject

Coordinate with ATC - respond w/o increase to ATC workload

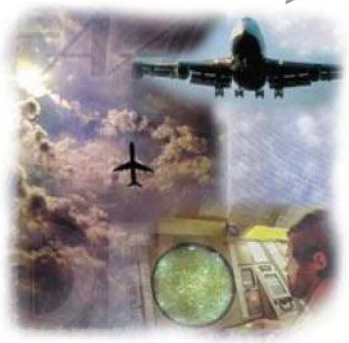
Efficiently manage contingency operations w/o disruption of the NAS

Seamlessly interact with SSI

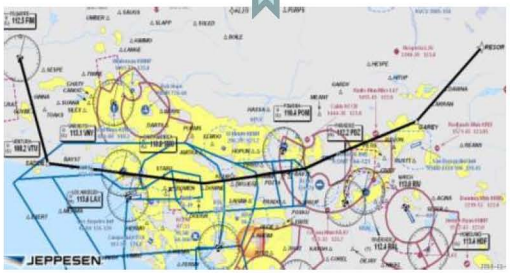
Research **test-bed and database to provide data and proof of concept for GCS operations in the NAS**



Human factors guidelines for GCS operation in the NAS



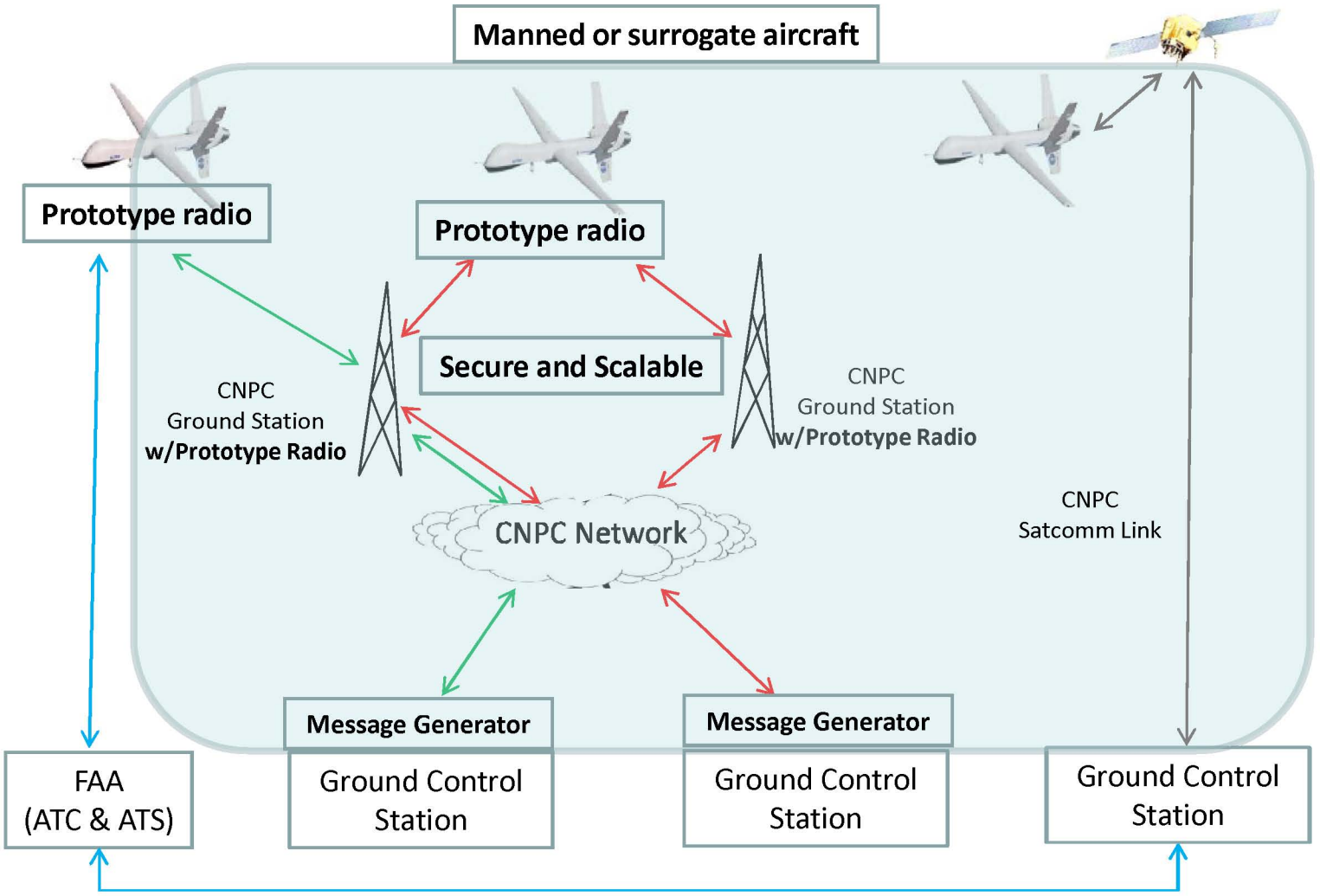
Ensure operator knowledge of complex airspace and rules



Standard aeronautical database for compatibility

Traffic information for situation awareness and separation (NextGen)

Communication Subproject Focus



Possible Future ATS and ATC Ground Connectivity

Certification Subproject: Regulatory Framework

Title 14 Code of Federal Regulations
a.k.a. Federal Aviation Regulations (FARs)

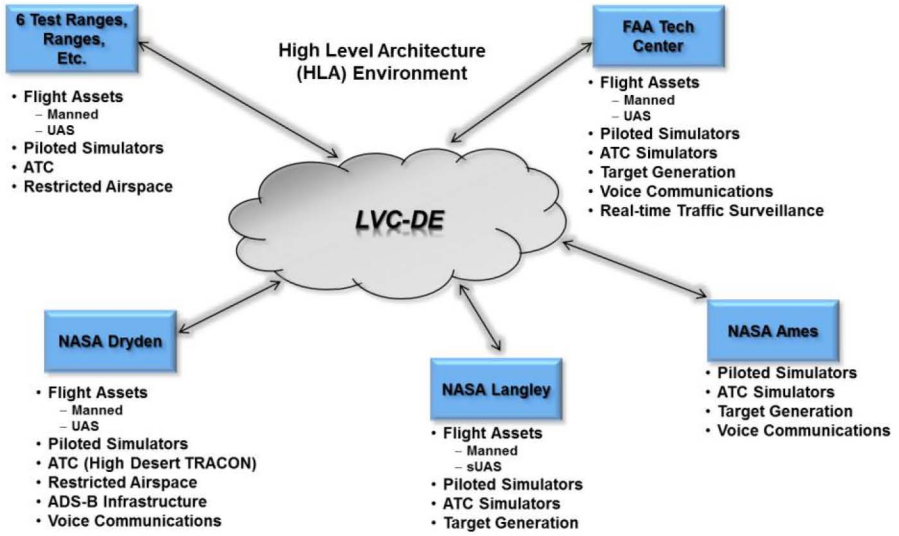
No person may operate an aircraft unless it is in an airworthy condition (FAR 91.7a)

- conforms to its type design and is in a condition for safe operation (FAR 3.3)

- What is the best approach to prescribing airworthiness requirements on UAS, especially their avionics? By categories?
- What does existing data from UAS failures/incidents/accidents tell us to help us know what regulation is needed?
- What would the certification process look like for a UAS? By example…

Notional LVC Distributed Environment

- Core connectivity between Dryden and Ames
- Distributed environment provides the opportunity to utilize unique assets from geographically dispersed facilities
- Virtual simulations inject human interactions into a central role by exercising the decision making process and communications
- Virtual traffic generated to present complex conflict scenarios without imposing collision risks to “live” aircraft
- Complex airspace can be evaluated while the “live” aircraft fly in “safe” restricted airspace



Risks

Risk ID No.	Risk Title	Owner Name	Initial L x C:	Current L x C: As of: 12-03-14	Target L x C:	Status
U.01.01.0001	Subproject Technology Development Delays impacting integrated test events (I-HITL, FT Series)	Randall	2 x 3	2 x 3	1 x 3	Mitigate
U.01.01.0002	Budget restrictions impacting travel plan	Johnson	5 x 3	5 x 2	5 x 2	Accept
U.01.01.0003	Relevance of subproject work to customers/stakeholders	Johnson	3 x 4	3 x 3	1 x 1	Mitigate
U.01.01.0004	SSI: Realism of predicted UAS mission profiles; Comm: Availability of accurate traffic models/profiles for projected UAS flights	Randall	3 x 5	3 x 5	2 x 2	Mitigate
U.04.01.0001	Applicability of NextGen separation assurance concepts and algorithms for manned operations to UAS NAS integration	Mueller	2 x 4			Watch
U.04.01.0002	Availability of NextGen "Operational Improvements" and infrastructure upgrades	Consiglio/ Mueller	4 x 2	4 x 2	4 x 1	Mitigate
U.04.01.0003	Availability of UAS performance models for separation assurance fast-time simulations and subsequent HITL tests	Consiglio/ Mueller/ Kim/ Murphy	3 x 4	2 x 4	1 x 1	Mitigate
U.04.01.0004	Availability of test bed for airborne Sense and Avoid flight tests equipped with the CNPC radio	Consiglio/ Mueller				Research
U.04.02.0002	Overload of information to UAS operators	Shively	4 x 5	3 x 3	1 x 1	Mitigate
U.04.02.0003	Perception of competing projects	Shively	4 x 4	2 x 2	1 x 1	Mitigate
U.04.02.0005	Unavailability of UAS Operators with appropriate experience to participate in simulation	Shively	5 x 4	3 x 2	1 x 1	Mitigate
U.04.02.0006	Delay (or unavailability) of simulation infrastructure	Shively	2 x 3	2 x 2	1 x 1	Mitigate
U.04.04.0001	Ability to fully validate the general applicability of the certification methodology	Hayhurst	3 x 2	3 x 2	2 x 1	Mitigate
U.04.04.0003	Limited data collection due to insufficient access to those with data (e.g., DoD, NMSU)	Hayhurst	4 x 3	4 x 3	2 x 2	Mitigate
U.04.04.0004	Obtaining/maintaining appropriate skill mix on team and dedicated work time	Hayhurst	4 x 3	4 x 2	4 x 1	Mitigate
U.05.01.0001	Lack of Firm LVC Distributed Environment Requirements	Kim/ Murphy	3 x 4	3 x 4	1 x 2	Mitigate
U.05.01.0002	Connectivity Requirements to External Partners Not Defined	Kim/ Murphy	3 x 4	3 x 4	1 x 3	Mitigate
U.05.01.0003	Lack of Common Voice Communication System for LVC Simulations and Flight Tests	Kim/ Murphy	4 x 3	4 x 3	1 x 1	Mitigate
U.05.01.0004	Availability of assets	Kim/ Murphy	3 x 3	3 x 3	1 x 2	Mitigate

Airspace Integration TC Accomplishments

- Held kickoff meeting for SBIR Phase 1 on UAS future traffic demand modeling (SSI)
- Submitted article to Air Traffic Control Quarterly (ATCQ) special issue on UAS (SSI)
- Received Honeywell NRA midterm deliverable on sense-and-avoid architecture and assessment of state-of-the-art (SSI)
- Received the Air Force Research Lab (AFRL) Jointly Optimal Conflict Avoidance (JOCA) sense-and-avoid algorithm and have started integrating it with ACES fast-time simulation and Multi Aircraft Control System (MACS)

  (SSI)

Standards/Regulations TC Accomplishments

- Presented NASA paper *L-Band and C-Band Air-Ground Channel Measurement Campaign* to the ICAO Aeronautical Communications Panel Working Group F (Frequency) Meeting (Comm)

- Briefed the UAS communications modeling and simulation effort and the CNPC technology assessment activities were prepared for RTCA SC-203 20th Plenary Meeting (Comm)

Relevant Test Environment TC Accomplishments

- Received AFRL Vigilant Spirit Control Station (VSCS) software and have started installation to support ground control station (GCS) prototype (HSI)
- Submitted patent application that addresses the ADS-B architecture and installation with respect to the aircraft and ground control station interconnectivity and display (IT&E)
- Collaborated with the FAA William J. Hughes Technical Center (FAATC)

FY 12 APG Steps

Steps to complete the FY12 APG UAS NAS Project Test Concept and Objectives Document

- Feb 2012 – Developed outline ✔
- April 2012 – Subproject Concept Definition and Review (in progress)
- May 2012 – Project Office Review of Concept Definition
- May 2012 – Subproject Objectives Definition and Review
- June 2012 – Project Office Review of Objectives
- July 2012 – Program Office Review of Concept and Objectives

Phase 1 Success Criteria

- Align Subproject objectives, supporting tasks and deliverables with key stakeholders needs and requirements
- Complete Test Concept and Flight Objectives (APG-FY12)
- Complete Prototype LVC-DE
- Complete LVC-DE Critical Design Review
- Complete Integrated HITL and Flight Test supporting activities
  - Fast-Time simulations
  - Part Task simulations
  - First Model Prototype Radio

Small Business Innovative Research (SBIR) Phase 1 Awards

Sub-project	Title	Company	Description	Benefit
SSI (ARC)	*Real-time Estimation of UAS Performance Using Efficient Sampling of Functional Models*	**Numerica Corporation** Loveland, CO Award Date: 2/13/2012	To develop advanced algorithms for constructing a UAS vehicle model from ATC surveillance data in real-time.	The developed techniques use functional models and are agnostic to specific trajectory predictions techniques. Thus they could assist traffic controllers in assessing potential conflicts in the strategic collision avoidance timeline.
SSI (ARC)	*A UAS-ATC Simulation Test-Bed*	**Sandia Research Corporation** Mesa, AZ Award Date: 2/23/2012	The proposed solution is to create a high fidelity simulation environment that merges a UAS ground control station (GCS) simulator with an air traffic control (ATC) simulator.	The primary application of UAS-ATC Test-Bed will allow researchers to test and evaluate a wide variety of issues surrounding the integration of UAS into the National Airspace System. 1. Testing of UAS in the NAS and NextGen ConOps 2. Testing of system resilience given off-nominal events 3. Evaluation of technological innovations 4. Training evaluations

Small Business Innovative Research (SBIR) Phase 1 Awards (continued)

Sub-project	Title	Company	Description	Project Benefit
IT&E (DFRC)	*UAS Demand Generation and Airspace Performance Impact Prediction*	**Intelligent Automation, Inc.** Rockville, MD Award Date: 2/17/2012	IAI and its academic partner propose to develop technology that will generate credible future demand for UAS vehicles given proposed UAS missions.	Development of a data warehouse containing potentially thousands of UAS flights
IT&E (DFRC)	*Rapid Automated Mission Planning System*	**Mosaic ATM, Inc.** Leesburg, VA Award Date: 2/13/2012	The proposed innovation is an automated UAS mission planning system that will rapidly identify emergency (contingency) landing sites, manage contingency routing, and dynamically evaluate route changes for viability and safe operations in the NAS.	Use as a mission planning augmentation system to improve safety of NASA UAS flight operations and as a research and development tool supporting in-house simulations of UAS activity in the NAS.

NASA RESEARCH ANNOUNCEMENT (NRA) FY2010 Awards

Company name	COTR/TM	Description	Benefit
Boeing	COTR - Eric Mueller (ARC) Award Date: 9/23/2011 Supports SSI Subproject	Develop medium fidelity simulation models: MLB corporation Bat 3, Queensland University of Technology (QUT) Uninhabited Aerial System (QUAS) Silverstone Flamingo, Boeing Raven, QUT Airborne Systems Laboratory (ASL) Optionally piloted Cessna 172, QF-4. Initial snapshot of models delivered. Identify UAS operational requirements and limitations. In progress. Survey communication, navigation and surveillance mechanisms.	Provides a modeling and simulation environment to assess vehicle performance and interactions with other vehicles. A broad set of UAS models in the BADA format for use in both the Boeing simulation environment and the NASA fast-time and HITL simulations. Risk reduction for the project.
Intelligent Automation, Inc.	TM - Maria Consiglio (LaRC) Award Date: 9/19/2011 Supports SSI Subproject	Analyze twelve UAS vehicles using industry-standard tools, to create Base of Aircraft Data (BADA)-formatted aerodynamic data for each one. Models to be used in the ARC analytic tools Airspace Concepts Evaluation System (ACES) and Multi Aircraft Control System (MACS). Identify operational limitations for those same twelve vehicles. Deliver all vehicle models, including source code, underlying aerodynamic data, associated BADA files, trajectory models, and ancillary plug-ins for various models to NASA. These data and files will become the property of NASA and be available to the larger aviation analysis community.	Provides a broad set of models in the BADA format for the fast-time and HITL simulations. Integration with the NASA simulation systems. Risk reduction for the Project.

NASA RESEARCH ANNOUNCEMENT (NRA) FY2010 Awards

Company name	COTR/TM	Description	Benefit
Honeywell	COTR - Doug Issacson (ARC) Award Date: 9/19/2011 Supports SSI Subproject	Develop traffic projections cooperative and non-cooperative targets for use in fast-time and HITL analyses of separation assurance algorithms, procedures and certification processes. SOA sense and avoid assessment.	Simulation environment to assess impact of traffic and SSI on UAS in NextGen environment. Quantification of expected sense and avoid performance and functional hazard assessment.
Logic Evolved Technologies, Inc.	TM - Mike Sorokach (LaRC) Award Date: 9/15/2011 Supports CSE Systems Analysis	Develop a portfolio analysis framework using Logic Gate Models, UAS Scenario development, and a set of inference models that will allow cost/benefit and risk-based prioritization.	Provides a framework through scenario development to assess technology impact on the NAS
Sensis Corporation	TM - Mike Sorokach (LaRC) Award Date: 9/15/2011 Supports CSE Systems Analysis	Perform a portfolio analysis including a top-down assessment of the vision, goals, objectives, capabilities, and requirements, as well as an assessment of bottom-up programs, technologies, and current investments, identify potential risks, and create a benefit cost model.	Provides a framework aligned with ARMD to assess portfolio prioritization

NASA RESEARCH ANNOUNCEMENT (NRA) FY2010 Awards

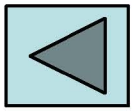
Company name	COTR/TM	Description	Benefit
University of Michigan	TM - Francis Enomoto (ARC) Award Date: 8/12/2011 Supports Certification Subproject	Three tasks: (1) small UAS, scenario, and failure characterization, (2) hazard and risk analysis, (3) UAS accident/incident data collection and mining along with anecdotal evidence collection to support task (2)	Provides an important link to small UAS, especially in the area of identifying unique failure conditions and hazards, that complements the work planned under the Certification subproject. There is a significant lack of data available for small UAS, and this effort has potential to start addressing that gap.
Embry-Riddle Aeronautical University	TM - Jeff Maddalon (LaRC) Award Date: 8/12/2011 Supports Certification Subproject	Identify properties of unmanned aircraft systems (UAS) that can be used to derive a new classification scheme or schemes for unmanned aircraft	Provides a classification scheme from an academic perspective.
Modern Technology Solutions Inc.	TM - Kelly Hayhurst (LARC) Award Date: 9/1/2011 Supports Certification Subproject	Identify failure conditions and risk factors unique to UAS	Provides a classification scheme through interaction with primary stakeholders.

NASA RESEARCH ANNOUNCEMENT (NRA) FY2010 Awards

Company name	COTR/TM	Description	Benefit
Sensis Corporation; Seagull Technology Center	TM - Bob Thomas (LARC) Award Date: 9/8/2011 Supports Certification Subproject	Perform the following six steps: 1) survey existing analysis and simula-tion capabilities, 2) generate and disseminate a survey report, 3) develop a concept validation strategy, 4) conduct a simulation capability gap analysis, 5) identify potential new technologies, and 6) document and present the results	Provides a methodology to compare multiple classification schemes.
NMSU PSL	COTR - Debra Randall (DFRC) TM - Mike Logan (LaRC) Award Date: 8/12/2011 Supports IT&E Subproject	Assess the performance of UAS pilots in different contexts and under different mission profiles (Experiment 1), and the sense-and-avoid capabilities of manned aircraft pilots in the same airspace as UAS, as well as observers of small UAS (Experiment 2).	Provides test planning for airborne and ground observations to explore factors involved in detecting, identifying, tracking to measure, detect, see-and-avoid (DSA) capability of UAS vehicles.
Utah State University	TM - Mike Logan (LARC) Award Date: 8/12/2011 Supports IT&E Subproject	Assess, evaluate, and report on UAS autopilot test technologies for robotic CONOPS that include decision making strategies for nominal and off nominal operations under both single and multi-UAV settings.	Investigate usage of auto-pilot technologies to support single and multi-aircraft UAS scenarios. Also testing of various sensor technologies to support sensing of surrounding environment.

Project Top Risk (U.01.01.0002)

Budget restrictions impacting travel plan. Travel budget reductions may contribute to 1) an inability to efficiently accomplish detailed planning, 2) efficiently collaborate with partners, and 3) a reduction conferences, meetings, etc. where results from technology developments were planned to be presented (U.01.01.0002)	1. Prioritize Travel. Direct more teleconferences/WebExs. PO implement process that PM approve all travel requests



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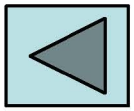
Project Top Risk (U.01.01.0004)

Realism of predicted UAS mission profiles/Availability of accurate traffic models/profiles for projected UAS flights.

The nature of UAS operations in the future, particularly in civil applications, is poorly known. Constructing realistic sets of flight plans, traffic profiles/models, and determining how many UAS should be flying at a time is therefore uncertain, which means the results of simulation evaluations may not reflect future operations. (U.01.01.0004)

1. IAI SBIR
2. Work with other organizations to understand and predict future operations, and use predictions that may already exist
3. Determine NAS impact of UAS operations on a per-mission basis rather than an overall impact basis



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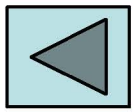
Project Top Risks (U.04.02.0003)

Perception of competing projects. Perception of duplication of efforts with DoD, FAA, industry. (U.04.02.0003)	1. Maintain collaborations with JPDO and AFRL to ensure uniqueness 2. JPDO review and continual contact with DoD, FAA. Review of industry efforts



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Annual Review IRP Action

Need Statement

The Unmanned Aircraft Systems (UAS) Community needs routine access to global airspace for all classes of UAS

Project Goal

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

Technology Development Areas

Separation Assurance/Sense and Avoid Interoperability (SSI), Human Systems Integration (HSI), Communications, Certification, Integrated Test & Evaluation

Key Stakeholders

UAS ExCom, FAA, JPDO/NextGen, DoD, SC-203 and other Standards/Regulatory Organizations