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

FY17 Annual Review

Robert Sakahara
Project Manager (Acting)

Davis Hackenberg
Deputy Project Manager (Acting)

William Johnson
Chief Engineer

Agenda

8:30– 8:45	Welcome, Opening Remarks, Integrated Aviation Systems Program (IASP) Overview	Dr. Edgar Waggoner
8:45 – 9:45	UAS-NAS Overview	Davis Hackenberg
9:45 – 10:15	Technical Challenge Performance	Davis Hackenberg
10:15 – 10:30	Break	
10:30 – 11:30	Technical Challenge Performance (continued) Systems Integration and Operationalization (SIO) Status	Davis Hackenberg
11:30 – 12:30	Project Level Performance & Fiscal Year (FY) 18 Look Ahead Review Summary Short Video of Future Flight Central at Ames	Davis Hackenberg
12:30	Lunch	
1:00 – 3:00	Caucus	IRP and PRP separately
3:00 – 4:00	Initial Feedback	IRP and PRP
4:00	Adjourn	

Annual Review Overview

- Purpose - Conduct an assessment of the Project's quality and performance
- Approach - The Project will provide a programmatic review addressing the following:
  - Project's Goal and Technical Challenges (TC) and their alignment to NASA and Aeronautics Research Mission Directorate (ARMD) Strategy
  - Project background and alignment with community efforts
  - Key highlights and accomplishments for the Project's technical challenges
  - Project performance of the past year through examination of:
    - Cost/Resource, Schedule, and Technical Management
    - Progress in establishing partnerships/collaborations and their current status
  - Key activities, milestones, and "storm clouds" for FY18
  - Specific Topics:
    - Summarize final Command and Control (C2) work package scope
    - Describe current status of the Systems Integration and Operationalization work package

Outline

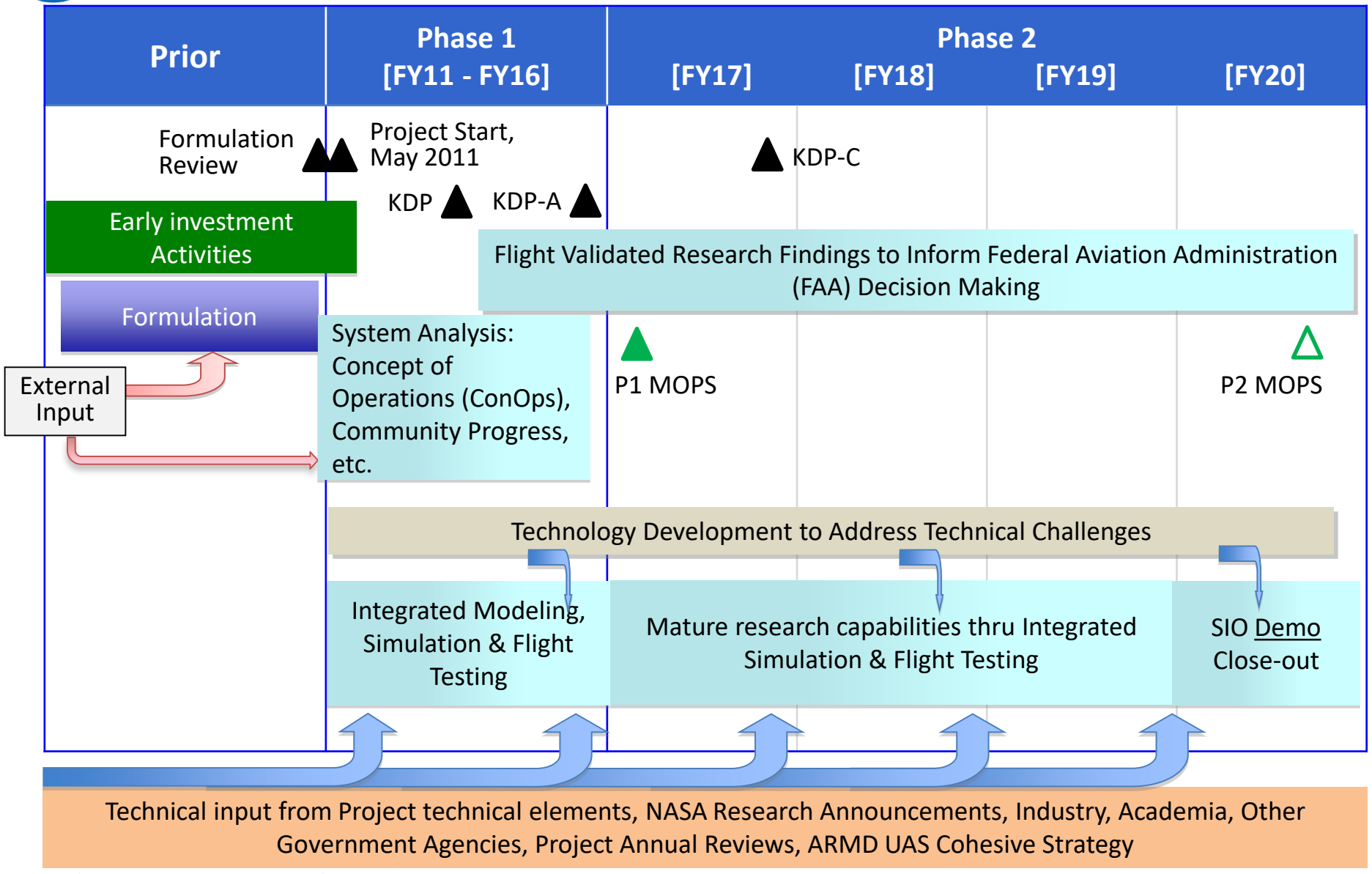
- UAS Integration in the NAS (UAS-NAS) Overview
  - FY17 Summary
  - UAS-NAS Project Background
- Technical Challenge Performance
- SIO Status
- Project Level Performance & FY18 Look Ahead
- Review Summary

FY17 Summary

- Established Project Phase 2 Detect and Avoid (DAA) and Command and Control Community Technical Challenges - ARMD approved
- Established Project Phase 2 Baseline - ARMD approved
- Successful on-time completion of multiple Project Research Activities
- Defined executable framework for Systems Integration and Operationalization Demonstration
- Provided significant contributions to the UAS Community
- Continued effective Project and Subproject management

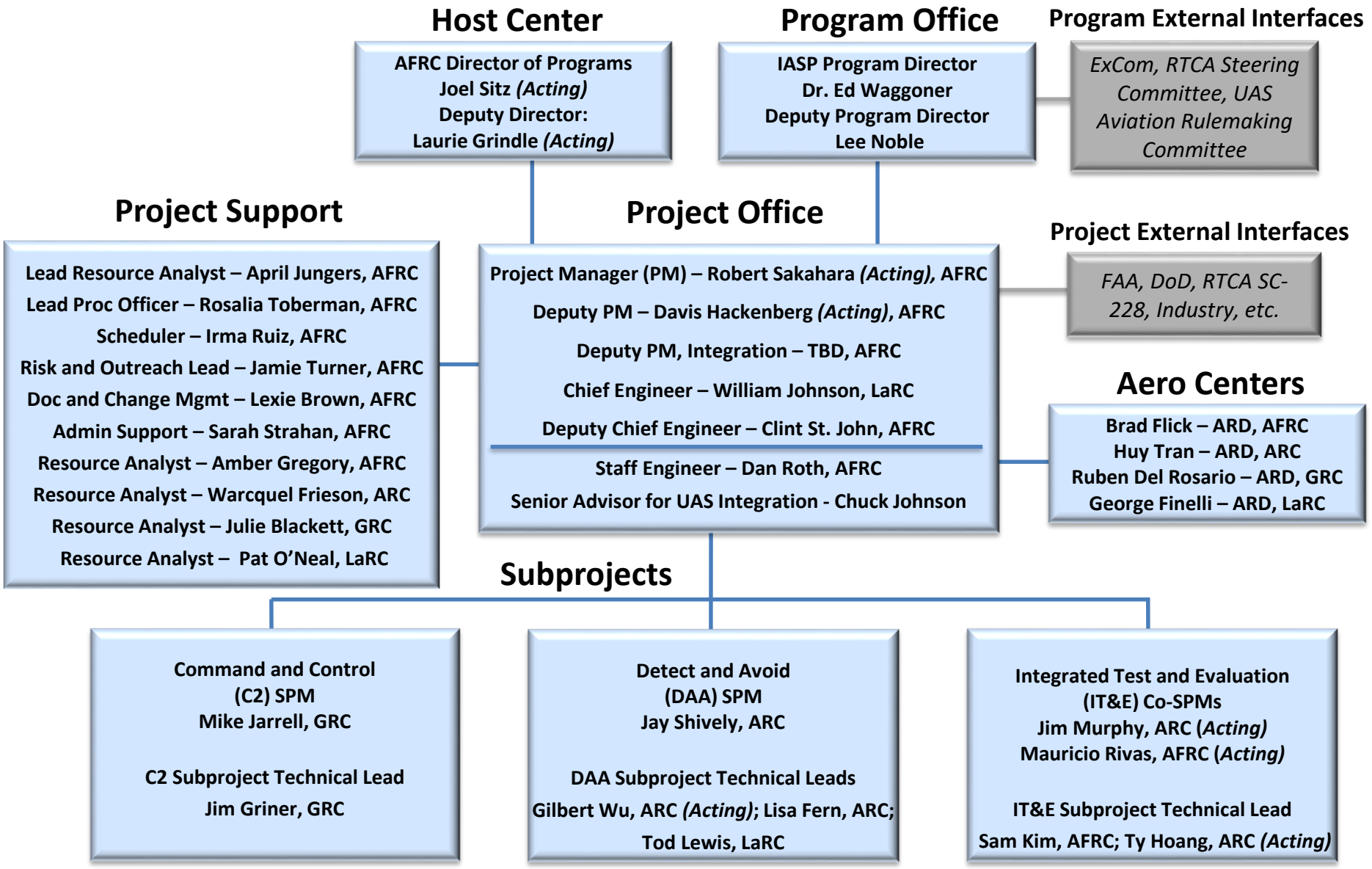
Successfully transitioned from Formulation to Implementation

UAS-NAS Project Lifecycle
Timeframe for impact: 2025



△ Key Decision Points △ SC-228 Deliverables, i.e. Minimum Operational Performance Standards (MOPS) Complete

UAS Integration in the NAS Organizational Structure



ARD: Aeronautics Research Director, PM: Project Manager, SPM: Subproject Manger

NASA Strategic Plan Flow Down to UAS-NAS Project

STRATEGIC GOAL

2: Advance understanding of Earth and develop technologies to improve the quality of life on our home planet

OBJECTIVE

2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research

PERFORMANCE GOAL *UAS-NAS*

2.1.6: Support transformation of civil aircraft operations and air traffic management through the development, application, and validation of advanced autonomy and automation technologies, including addressing critical barriers to future routine access of Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS), through the development and maturation of technologies and validation of data

Project GOAL *UAS-NAS*

Provide research findings, utilizing simulation and flight tests, to support the development and validation of DAA and C2 technologies necessary for integrating Unmanned Aircraft Systems into the National Airspace System.

ARMD Strategic Plan Flow Down to UAS-NAS Project

AERONAUTICS STRATEGIC THRUST

Thrust 1: Safe Efficient Growth in Global Operations

Thrust 6: Assured Autonomy for Aviation Transformation

AERONAUTICS OUTCOME

Outcome (2025): ATM+1 Improved NextGen operational performance in individual domains, with some integration between domains

Outcome (2025): Initial Introduction of aviation systems with bounded autonomy, capable of carrying out function-level goals

AERONAUTICS Research Theme

Research Theme:
Airspace Operations Performance Enablers

Research Themes:
Implementation and Integration of Autonomous Airspace and Vehicle Systems
Testing and Evaluation of Autonomous Systems

AERONAUTICS Overarching Technical Challenges

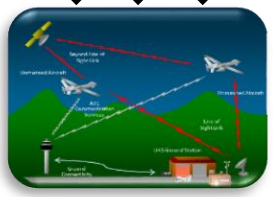
Develop Operational Standards for UAS in NAS

Select, develop, and implement autonomy applications compatible with existing systems

Develop policies, standards, & regulations framework of increasingly autonomous systems

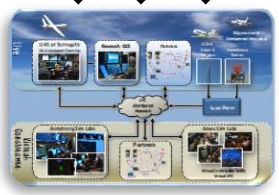
Test, evaluate & demonstrate selected small-scale applications of autonomy

UAS-NAS *Technical Content*



TC-C2:
UAS Command & Control

TC-DAA:
Detect and Avoid operational concepts and technologies



SIO:
System Integration & Operationalization

UAS-NAS Technical Challenge Autonomy Contributions

AERONAUTICS STRATEGIC THRUST

Thrust 6: Assured Autonomy for Aviation Transformation

AERONAUTICS OUTCOME

Outcome (2015 – 2025): Initial Introduction of aviation systems with bounded autonomy, capable of carrying out function-level goals

AERONAUTICS Research Theme

Implementation and Integration of Autonomous Airspace and Vehicle Systems

AERONAUTICS Overarching Technical Challenge

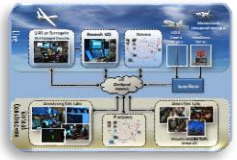
4B. Select, develop, and implement applications of autonomy that are compatible with existing systems

4C. Develop framework for co-development of policies, standards, and regulations with development and deployment of increasingly autonomous systems

UAS-NAS *Technical Content*

TC-C2

TC-DAA



SIO

TC-DAA Alignment:

- Development of requirements that can be leveraged for autonomous DAA guidance algorithm and alerting display
- Examples: removing the operator from the system and meeting the same requirements

TC-C2 Alignment:

- Development of requirements that support automatic and/or autonomous unmanned aircraft communication systems
- Examples: system wide removal of communication delays in time sensitive situations

SIO Alignment:

- Implement, test, evaluate and demonstrate selected applications of increasingly autonomous systems

UAS-NAS Technical Challenge Autonomy Contributions

AERONAUTICS STRATEGIC THRUST

Thrust 6: Assured Autonomy for Aviation Transformation

AERONAUTICS OUTCOME

Outcome (2015 – 2025): Initial Introduction of aviation systems with bounded autonomy, capable of carrying out function-level goals

AERONAUTICS Research Theme

Testing and Evaluation of Autonomous Systems

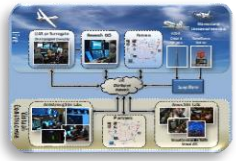
AERONAUTICS Overarching Technical Challenge

5B. Test, evaluate & demonstrate selected small-scale applications of autonomy

UAS-NAS *Technical Content*

TC-C2

TC-DAA



SIO

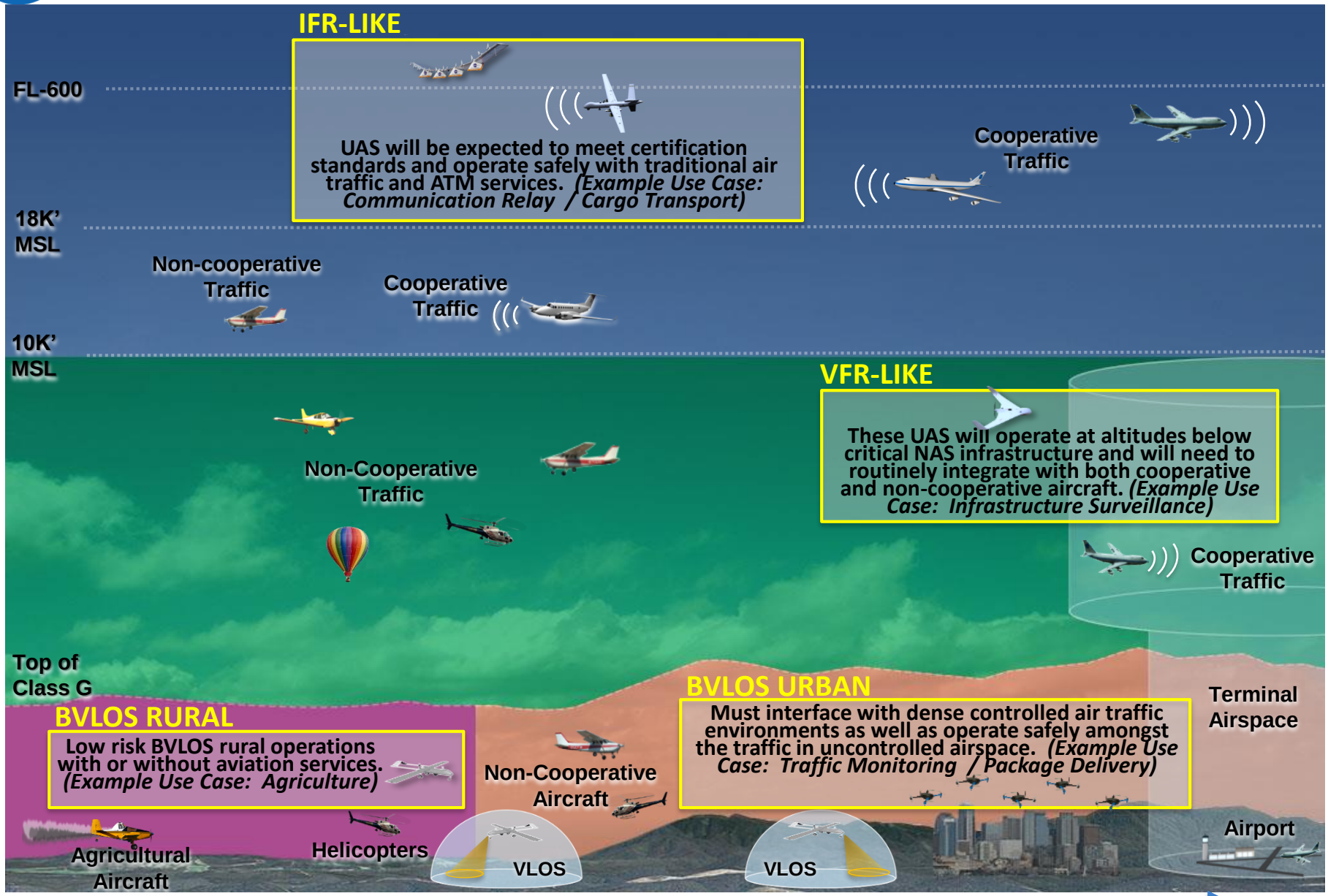
UAS-NAS Portfolio:

- Development of unmanned aircraft flight test methods and operational procedures relevant to small-scale applications of autonomy
  - Flight test of automatic and/or autonomous systems such as Airborne Collision Avoidance System (ACAS Xu)
  - Flight test of Detect and Avoid systems
  - Flight test of command and control radios
- Leverage NASA airworthiness safety processes to provide operational assessments for automatic and autonomous systems

Full UAS Integration Vision of the Future

Manned and unmanned aircraft will be able to routinely operate through all phases of flight in the NAS, based on airspace requirements and system performance capabilities

Emerging Commercial UAS Operating Environments (OE)



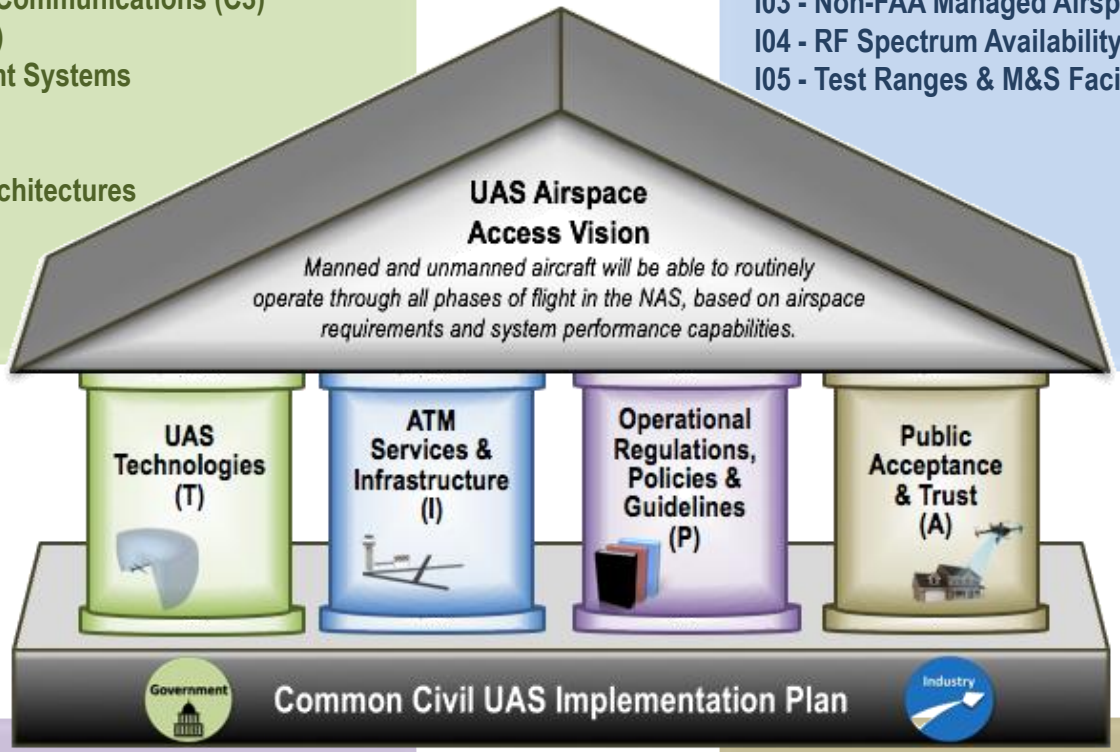
UAS Airspace Integration Pillars and Enablers

UAS Technologies:

T01 - Airport Operations Technologies
T02 - Airworthiness Standards
T03 – Command, Control, Communications (C3)
T04 - Detect & Avoid (DAA)
T05 - Flight & Health Mngmt Systems
T06 - GCS Technologies
T07 - Hazard Avoidance
T08 - Highly Automated Architectures
T09 – Navigation
T10 - Power & Propulsion
T11 - Weather

ATM Services & Infrastructure:

I01 - Airport Infrastructure
I02 - ATM Infrastructure
I03 - Non-FAA Managed Airspace Infrastructure
I04 - RF Spectrum Availability
I05 - Test Ranges & M&S Facilities



Operational Regulations, Policies & Guidelines:

P01 - ATM Regulations / Policies / Procedures
P02 - Airworthiness Regulations / Policies / Guidelines
P03 - Operating Rules / Regulations / Procedures
P04 - Safety Risk Mngmt & Methods of Compliance

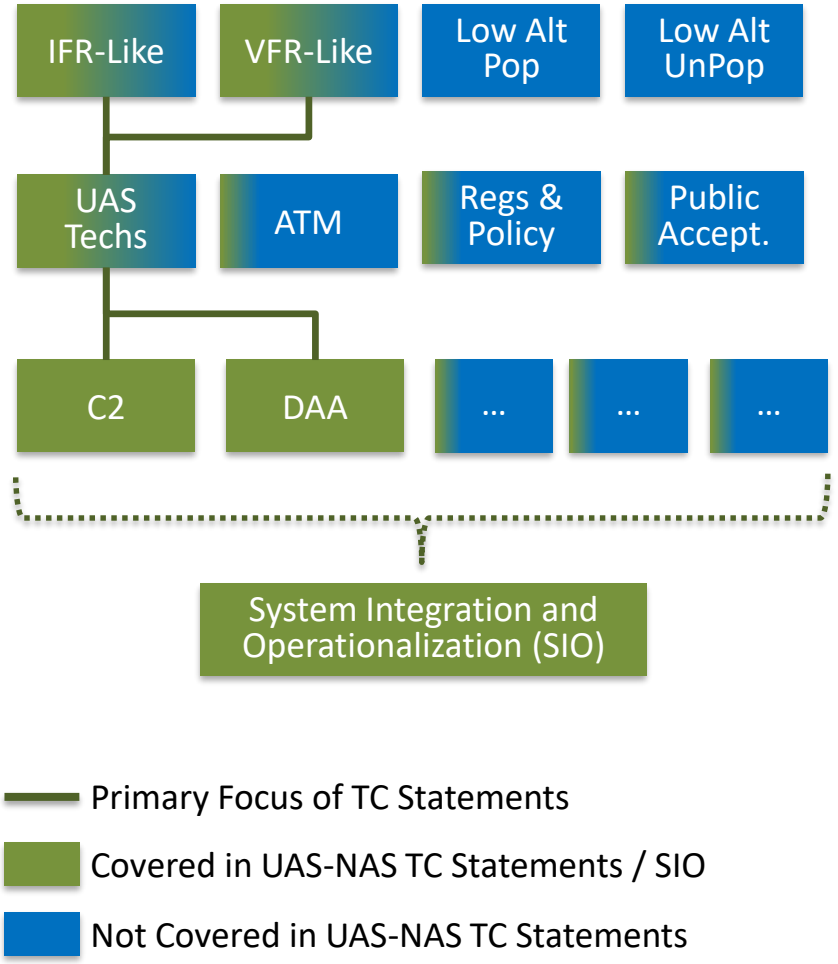
Public Acceptance & Trust:

A01 - Cybersecurity Criteria & Methods of Compliance
A02 - Legal & Privacy Rules / Guidelines
A03 – Noise Reductions
A04 - Physical Security Criteria & Methods of Compliance
A05 - Public Safety Confidence

The UAS Airspace Integration Pillars enable achievement of the Vision

UAS Integration / Project Background

- Each Operating Environment (OE) has unique considerations with respect to each Pillar
- Program and Project core competencies focus on Integrated Vehicle technologies
- I“IFR-Like” and “VFR-Like” OEs became the project focus due to considerations such as core competencies, Technology Readiness Level (TRL), other ARMD portfolio work, and community benefit
- Project Phase 2 TCs, i.e. detect and avoid (DAA) and command and control (C2), do not cover the broad needs for all Operating Environments or UAS Vehicle Technologies
- Systems Integration and Operationalization (SIO) Demonstration effort developed around integration of DAA and C2 while including efforts towards closing UAS Vehicle technology gaps for project relevant OEs
- Project currently does not support other Program/Project TCs



UAS Integration / Project Background

- NASA and FAA have determined DAA and C2 are highly significant barriers to UAS integration
- Project wrote TC statements that address the full barrier for DAA and C2 in the “VFR-Like” and “IFR-Like” Operating Environments
- Project identified the work required to complete the TCs and which aspects NASA should lead
- Project assessed and prioritized research to provide the greatest benefit to address the community barriers within resource allocations

NASA well positioned to lead research addressing most significant barriers, DAA and C2, to UAS integration

Project Phase 2 Formulation Review Background

- Key Decision Point (KDP)-A, Authorization to Proceed (ATP) with Formulation
  - Approved to proceed with the TC-C2 partnerships, ACAS Xu Flight Test 2 Partnership
  - Primary actions were to assess and add clarity to Technical Challenges, including descriptions of the portion of the industry that would benefit, and demand for the research in the next 5 years
- KDP-C, ATP for Implementation
  - Approved baseline of DAA and terrestrial C2 content, with considerations to broader aviation markets
  - Primary actions included re-assessing SatCom portfolio, including SIO in the project portfolio, and providing clarity on several miscellaneous items
- Post KDP-C
  - Responded to all ARMD actions
  - Baselined all technical content that was approved at KDP-C
  - Began study of UAS demand and economic benefit

Project Phase 2 formulation process leveraged to maximize NASA's contributions to the UAS community

UAS-NAS Project Value Proposition

NASA UAS-NAS Project Activities

TC C2 — C2 Performance Standards

- Research C2 SatCom Systems
- Develop C2 Prototype Terrestrial System
- Conduct C2 Flight Test and MS&A
  - *Data Link*
  - *CNPC Spectrum*
  - *CNPC Security*
  - *BVLOS/BRLOS*
  - *ATC Interoperability*
- Develop C2 Requirements

TC DAA — DAA Performance Standards

- Develop DAA Test beds
- Conduct DAA Flight Test and MS&A
  - *Human Factors*
  - *Performance Trade-offs*
  - *Interoperability*
  - *Self Separation*
  - *Low Cost SWaP sensors*
  - *CONOPs*
  - *Well Clear*
  - *Collision Avoidance*
- Develop DAA Performance & Interoperability Requirements

Integrated Test & Evaluation

- Develop DAA Prototype System
- Live Virtual Constructive (LVC) Test Infrastructure
- Conduct Technology and CONOPS testing
  - ACAS Xu FT2
  - No Chase COA
  - Conduct FT5 Test Scenarios
  - Conduct FT6 Test Scenarios

SIO — Systems Integration and Operationalization

- Develop Robust NASA/Industry Partnership
- Document certification and airworthiness approaches
- Integrate Essential Technologies
- Conduct Demo

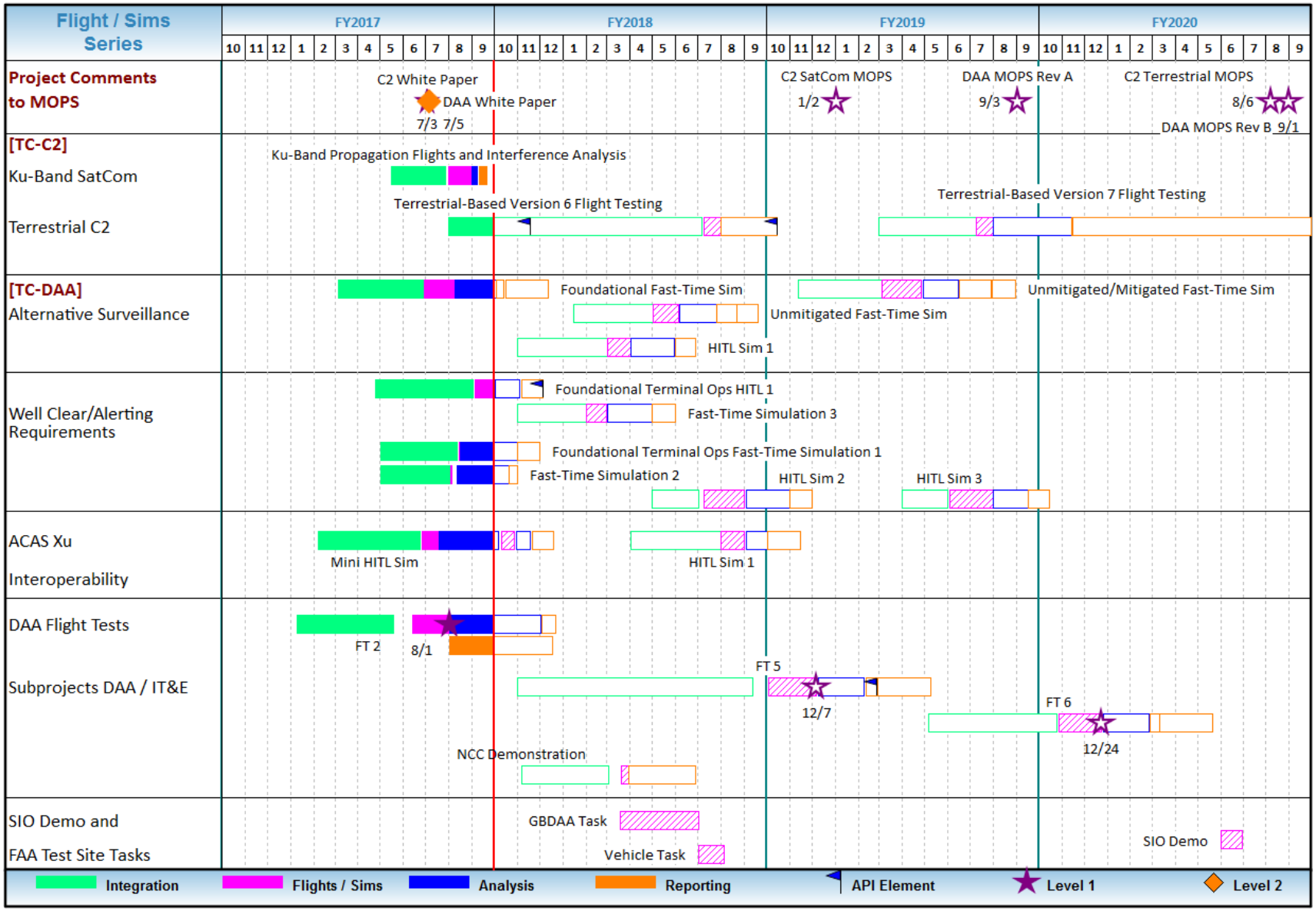
Key Products

- *C2 Performance Requirements to inform C2 MOPS* → RTCA Terrestrial MOPS
- *DAA Performance Requirements to inform DAA MOPS* → RTCA Non-Coop Sensor MOPS
- *Re-usable Test Infrastructure* → RTCA GBDAA MOPS; RTCA DAA MOPS Rev A/B
- *Substantiated path to certification* → Generic Certification Airworthiness Approaches

Resultant Outcomes

- C2 Technical Standard Order (TSO)
- DAA Technical Standard Order (TSO)

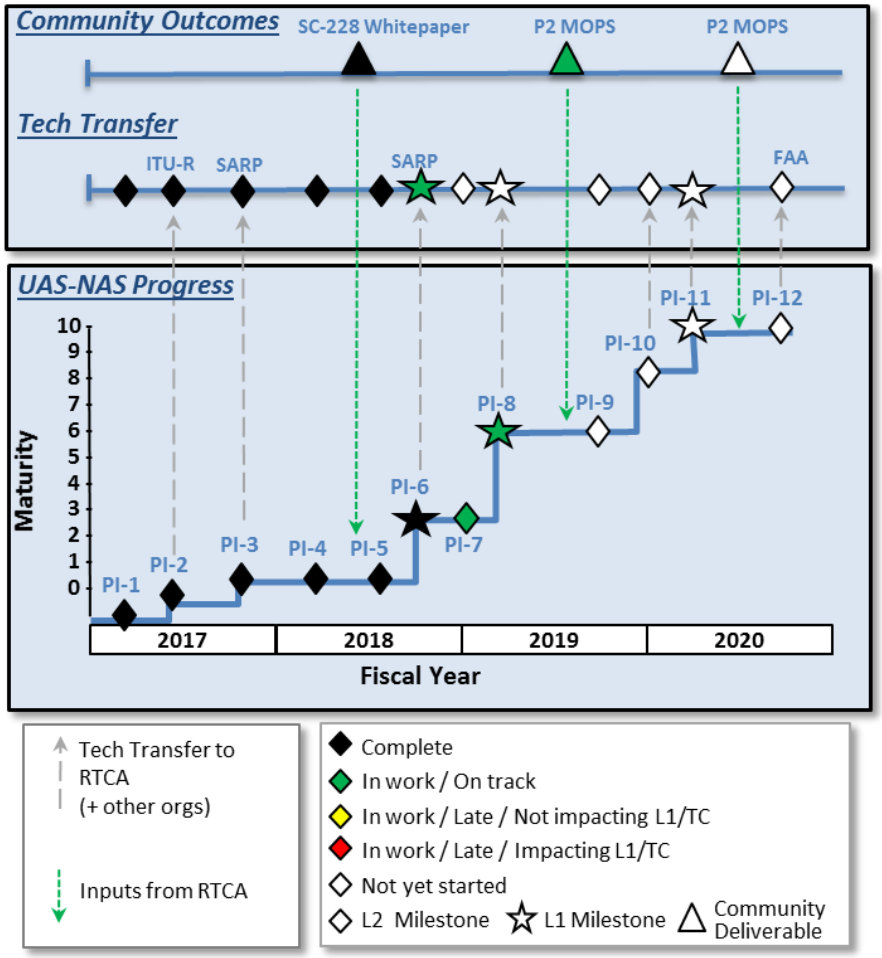
Phase 2 Flight and Simulation Overview



Red Status Line Date 9/30/17

Progress Indicator Definition

- Technical Challenge (TC) progress is tracked by means of Progress Indicators
  - TC completion represented by both UAS-NAS Progress and Community Outcome sections
- UAS-NAS Progress
  - Represents the execution/data collection of milestones for Project Schedule Packages (SP)
- Assessed maturity of Project research portfolio related to the technical challenge
  - High = 2, i.e. L1 Milestones and Flight Tests
  - Moderate = 1, i.e. Human in the Loop (HITLs), System Development Complete, and Demonstrations
  - Low = 0, Foundational activities, i.e. the rest
- Research portfolio maturity normalized on a 10 point scale represents Project progress towards TC completion
- Tech Transfer
  - Represents the data analysis and reporting milestones for Project SP
- Progress is tracked against all SP tasks and UAS Community Outcomes using a color indicator



Outline

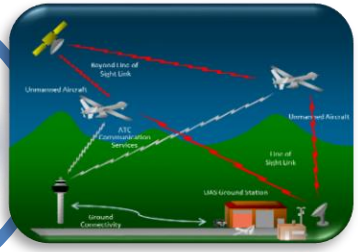
- UAS-NAS Overview
- Technical Challenge Performance
  - TC-DAA
  - TC-C2
- SIO Status
- Project Level Performance & FY18 Look Ahead
- Review Summary

TC-DAA:
UAS Detect and Avoid Operational Concepts and Technologies

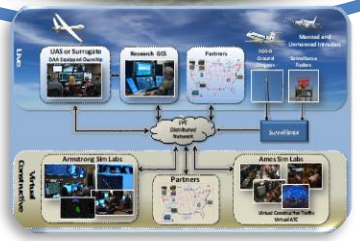
TC-DAA

Develop Detect and Avoid (DAA) operational concepts and technologies in support of standards to enable a broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to detect and avoid manned and unmanned air traffic

Technical Challenge-DAA: Detect and Avoid (DAA)

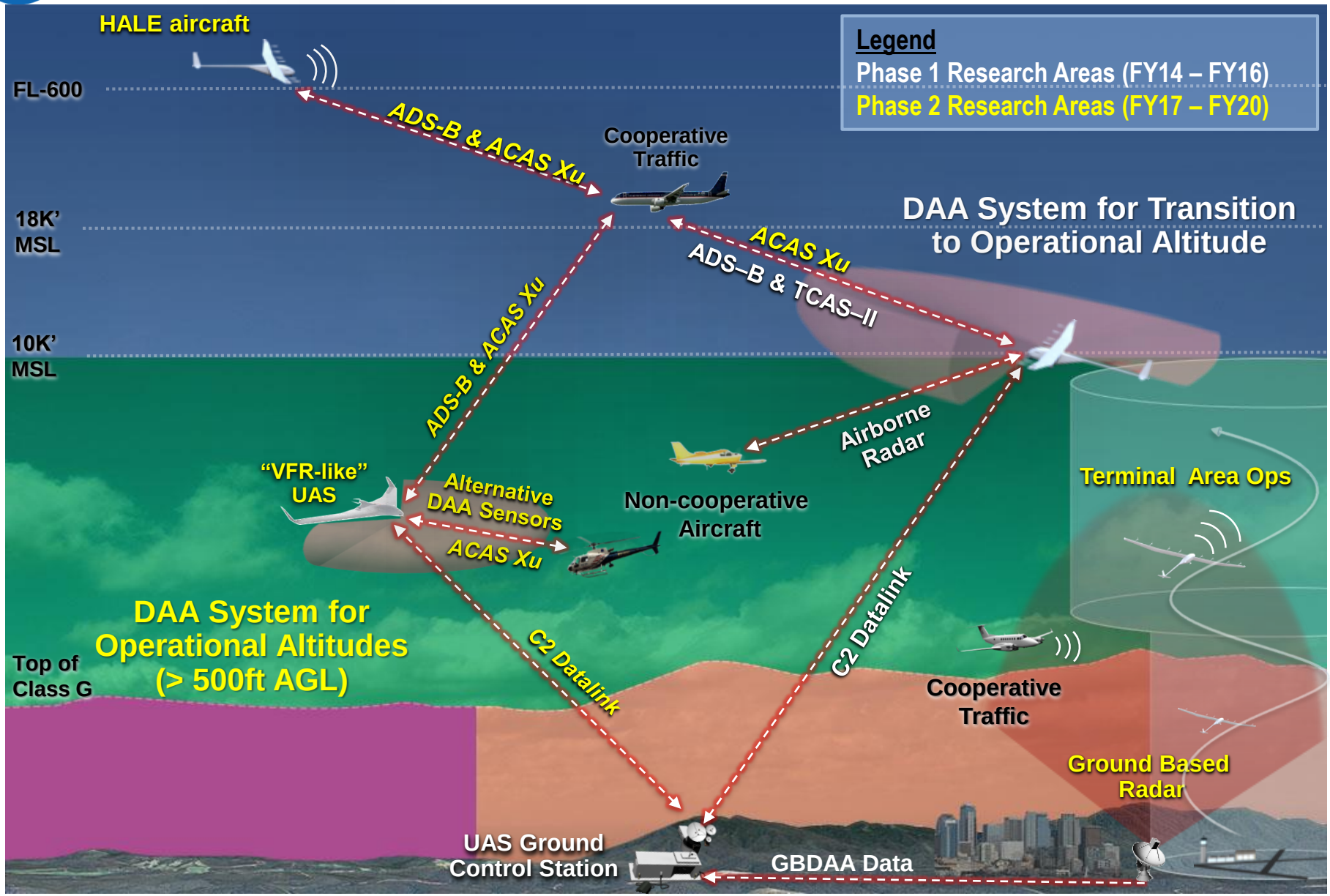


Technical Challenge-C2: Command and Control (C2)



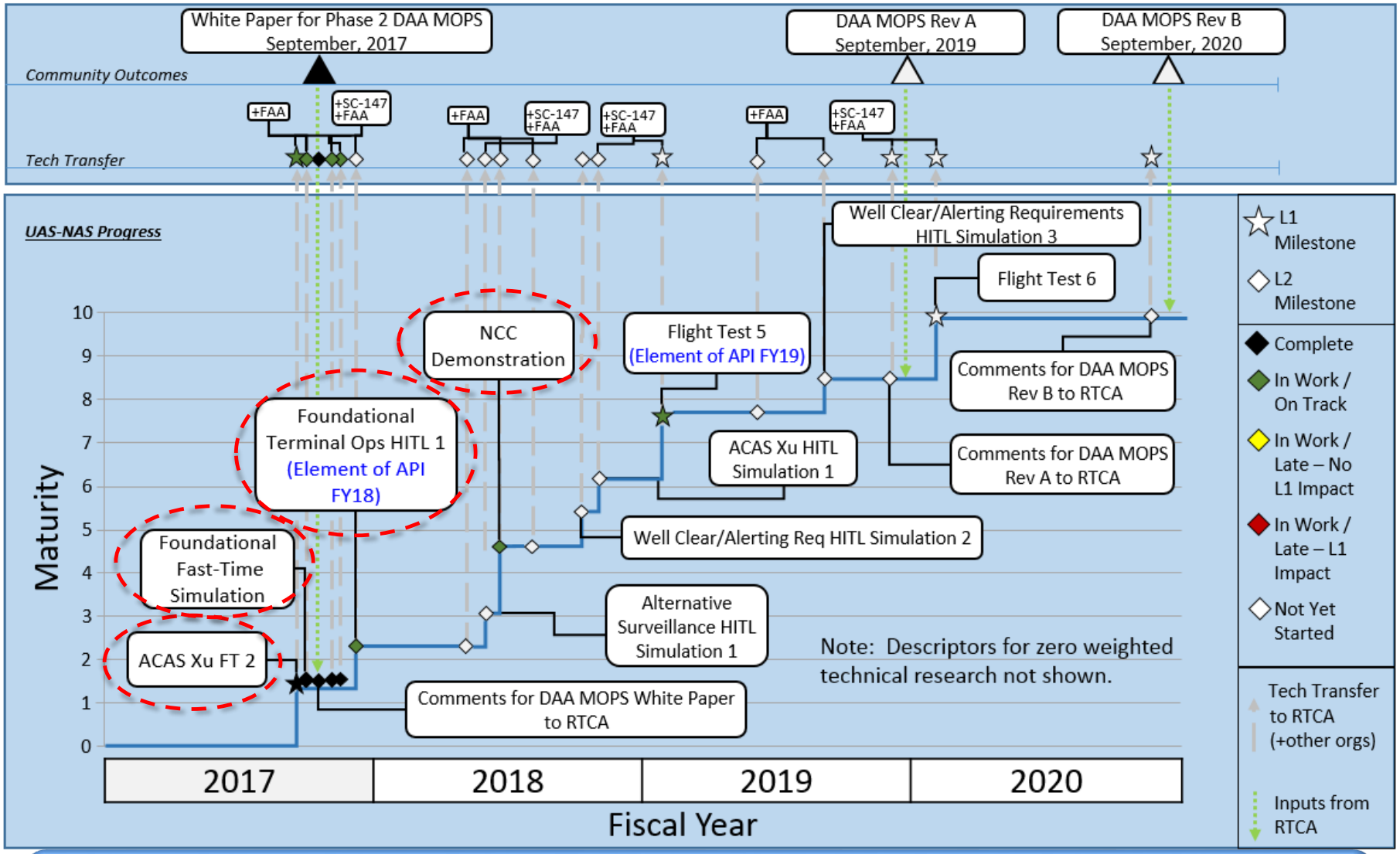
System Integration and Operationalization (SIO)

UAS Detect and Avoid (DAA) Operating Environments (OE)



TC-DAA: Progress Indicator

As of 9/30/17

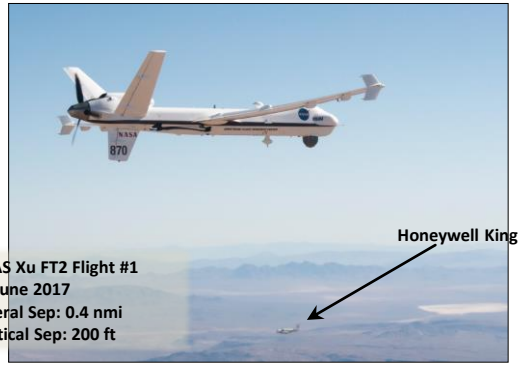


TC-DAA: Develop Detect and Avoid (DAA) operational concepts and technologies in support of standards to enable a broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to detect and avoid manned and unmanned air traffic

Integrated Flight Test: ACAS-Xu Flight Test 2

- **Research Objectives:**
  - Continue collaboration with the FAA TCAS Program Office-led partnership to mature the ACAS Xu software in support of ACAS Xu MOPS development (draft FY18, final FY20)
  - Demonstrate system behavior integrated on prototype avionics and UAS
  - Collect flight test data for performance evaluations and future Research and Development (R&D)
  - Validate modeling and simulations


Team

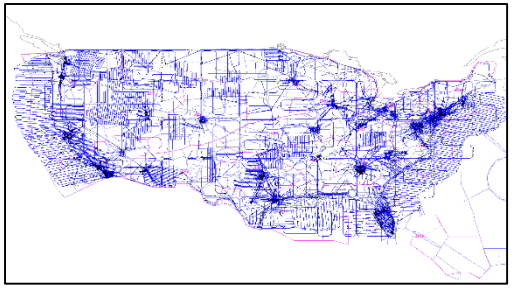



Lab

- **Status:**
  - Flight test completed August 2017
    - 12 flight tests / 56 flight hours
    - 6.5 weeks (13 June – 1 Aug) duration
    - 241 flight cards / test points flown
    - All priority 1 test points (114 flight cards) completed
  - Flight test data made available to FAA and contractor team following each flight
  - Flight test report (internal distribution only) completed September 2017
- **Next Steps:**
  - Public release of Flight test report to be completed October 2017

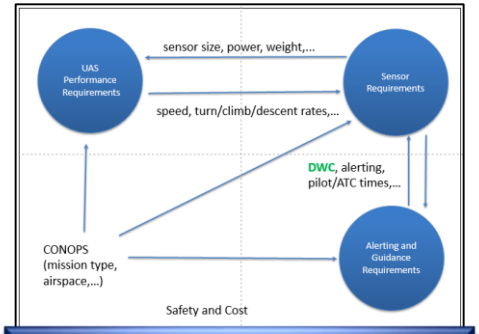
Alternative Surveillance: Foundational Fast-time Simulation (FY17)

- **Research Objective:**
  - Estimate the target performance of alternative surveillance within Phase 2 MOPS UAS operations in order to provide acceptable DAA alerting and guidance

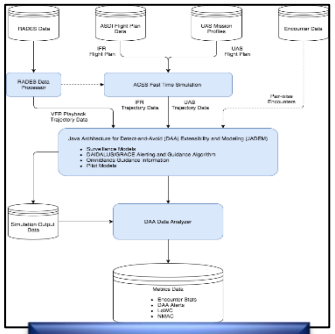


NAS Simulation

UAS Missions



Requirements Interrelationship



Architecture

- **Status:**
  - Experiment review completed July 2017
  - Data collection completed August 2017
- **Next Steps:**
  - Data analysis to be completed October 2017
  - Report to be completed December 2017

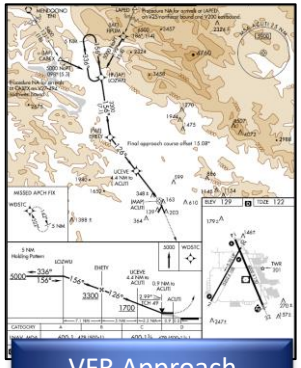
Technical Baseline Element Number: TBEN-006 (SP D.1.40)

Well Clear/Alerting Requirements: Foundational Terminal Operations HITL Simulation 1

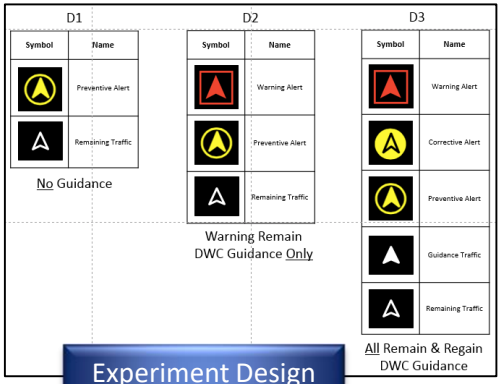
- **Research Objective:**
  - Explore pilot performance and operational suitability issues associated with Class D terminal area operations

Ownship Scenario	Description	Route Variations
Instrument Approach	• RNAV (GPS) Rwy 14 approach • Non-precision approach; flown via GPS avionics	1. Start point NW of CABEX 2. Start point NE of FIPUM
Visual Approach	• Approach conducted under IFR but through ATC-approved visual clearance • Pilot must report either airport or a lead aircraft detected to start procedure	1. Start point NW of KSTS 2. Start point NE of KSTS
Traffic Pattern	• Used to sequence (typically VFR) arrivals and departures • Prop pattern=1150ft	1. 45° entry into the downwind 2. Mid-field entry

Scenario Design



VFR Approach



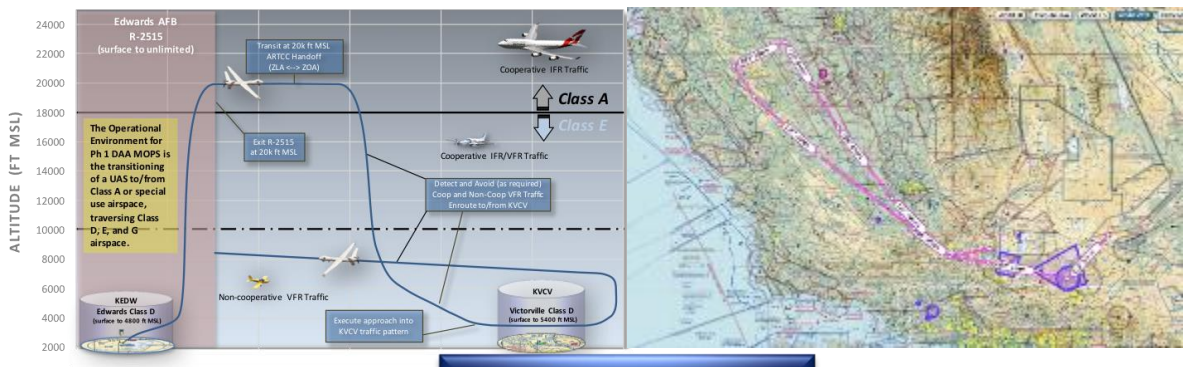
Experiment Design

- **Status:**
  - Experimental design, including Stakeholder/Partner Workshop, completed July 2017
  - Traffic scenarios completed August 2017
  - Shakedown completed September 2017
- **Next Steps:**
  - Data collection to be completed October 2017
  - Reports to be completed December 2017

Technical Baseline Element Number: TBEN-012 (SP D.2.30, T.7.10)

No Chase Certificate of Waiver or Authorization Flight Demonstration

- **Research Objective:**
  - Conduct unmanned aircraft flight demonstration as described in an FAA approved No Chase Certificate of Waiver or Authorization (COA)
  - Transfer of technology proving the feasibility of integrating a UAS with and alternate means of compliance with FAA FAR Part 91.113 (see and avoid).



Flight Profile

No Chase COA Demonstration	
Purpose	• Obtain Certificate of Authorization (COA) from FAA to fly Ikhana UAS without safety chase in multiple Classes of air space, including Class A, D and E. • Demonstrate UA transitioning to/from Class A or SUA to Class E and Class D employing the Phase 1 Detect and Avoid (DAA) and A/A Radar MOPS Systems as alternate compliance for 14CFR 91.113b.
Approach	• Complete gap analysis and safety case analysis justifying alternative method of compliance with FAR Part 91.113. • Work in partnership with General Atomics – Aeronautical Systems, Inc. (GA-ASI) to secure use of GA-ASI's DAA System as primary airborne de-conflicting tool.
Test Duration	• February, 2018 (2-3 flights)
Tech Transfer	• Demonstrate the Phase 1 DAA and Radar MOPS research findings through a "Capstone" event.
Project Benefit	• Demonstration of UAS-NAS Phase 1 DAA technologies.

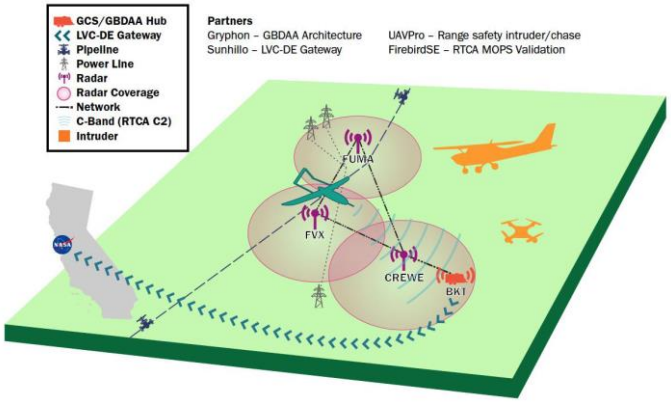
Description

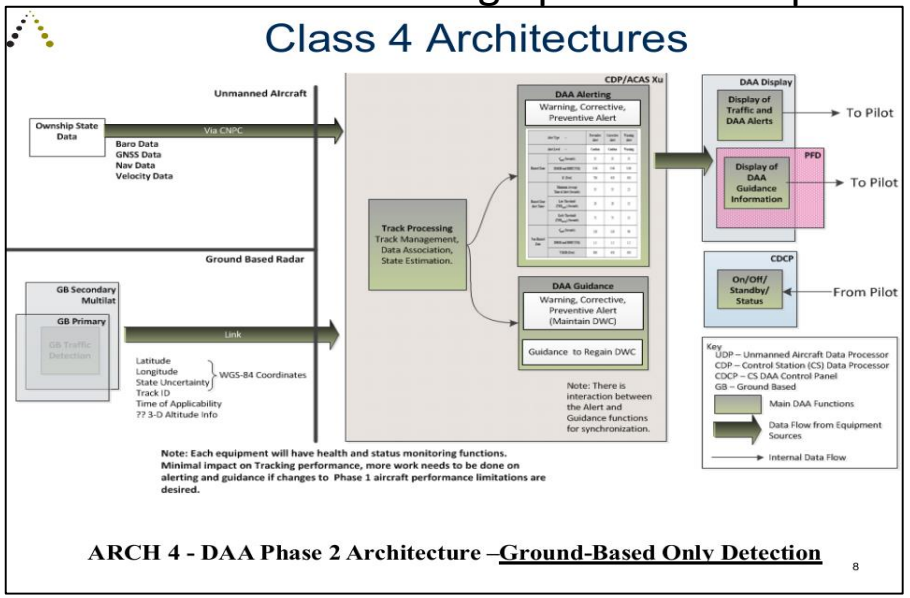
- **Status:**
  - No Chase COA (NCC) Objectives defined May 2017
  - Conducted NCC Kick-Off meeting with FAA May 2017
- **Next Steps:**
  - NCC Demonstration Flights to be completed March 2018
  - NCC report to be completed June 2018

Technical Baseline Element Number: TBEN-023 (SP T.8.20)

Ground Based Detect and Avoid (GBDAA)
Virginia UAS Test Site

- [Redacted funding] Competed across all six test sites
- The goal of the proposed effort is to implement a GBDAA system that will have long term strategic value to NASA (i.e. TC-DAA), FAA, and industry partners. The proposed system will:
  - Provide a foundation and testbed for validation and iteration of RTCA standards
  - Provide a foundation for FAA Beyond Visual Line of Sight (BVLOS) rulemaking activities
  - Provide an effective means for industry to evaluate technologies and procedures for conducting low level BVLOS use cases
  - Provide a foundation for future commercial waivers seeking operational capability for industry applications





TC-DAA Risk Summary

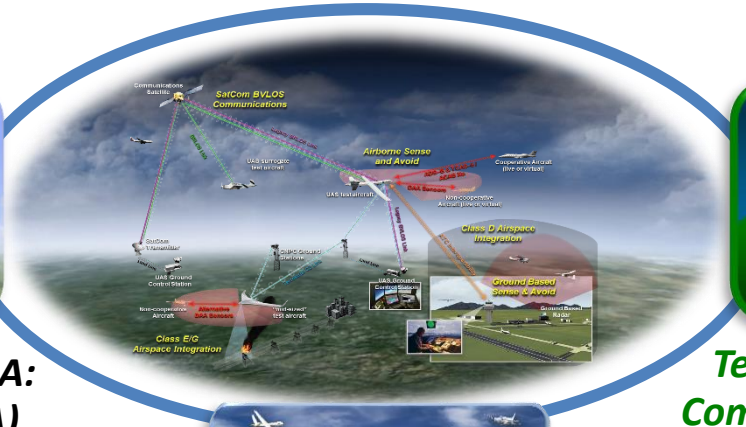
- Data Redacted

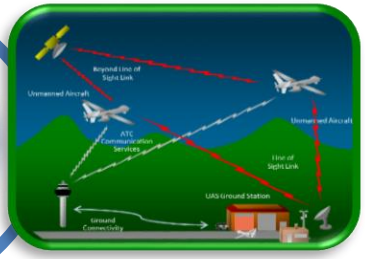
TC-C2:
UAS Command and Control

TC-C2

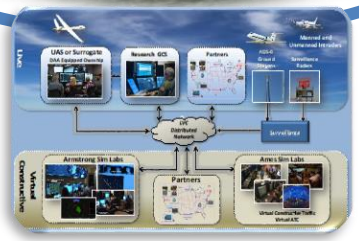
Develop Satellite (SatCom) and Terrestrial based Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage allocated protected spectrum

Technical Challenge-DAA: Detect and Avoid (DAA)



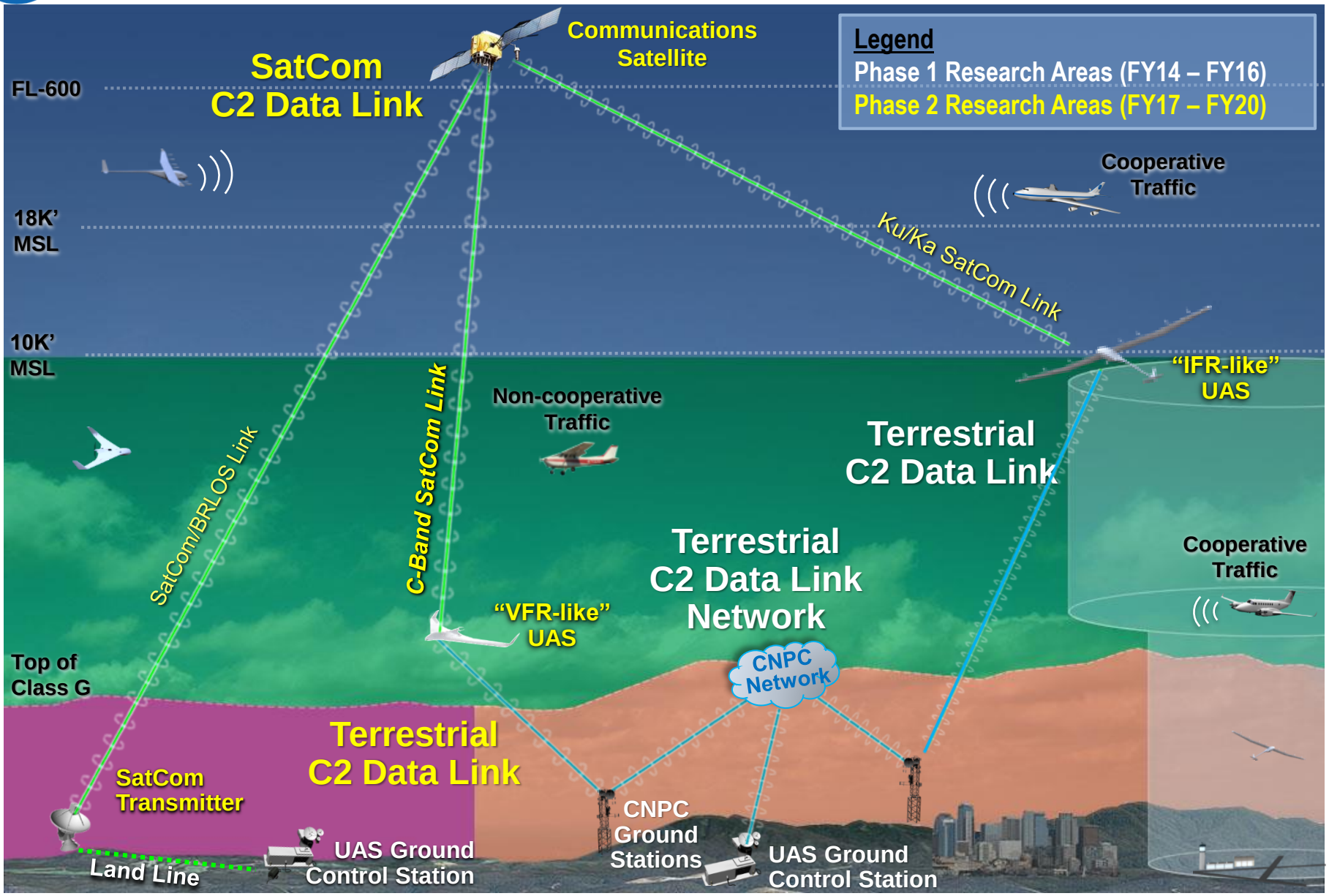


Technical Challenge-C2: Command and Control (C2)



System Integration and Operationalization (SIO)

UAS Command and Control Operating Environments (OE)

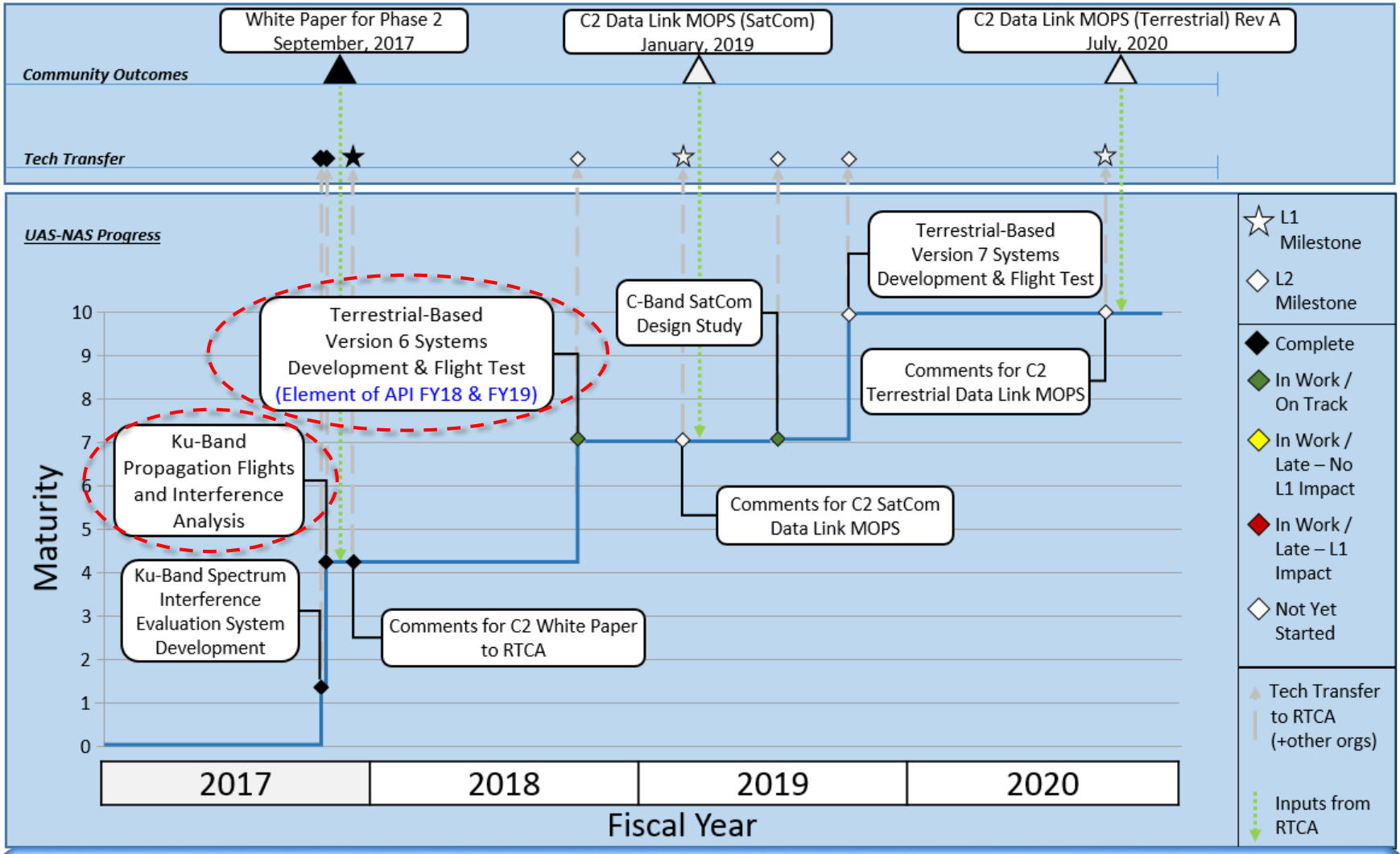


TC-C2 Technical Work Scope

- Terrestrial C-Band
  - Develop and standardize Control and Non-Payload Communications (CNPC) radios with Rockwell Collins
  - Flight Testing over Urban environments
  - Low-Size, Weight and Power (L-SWaP) configuration, Cooperative Agreement modification in work
- SatCom C-Band Study
  - Trade studies
- SatCom Ku-Band
  - FY17 propagation/interference system development and testing
- SatCom Ka-Band
  - No project technical content
- Addressing Urban Air Mobility (UAM) Communications Technology Study
  - New activity that will evaluate C2 UAM ConOps, technical requirements, candidate implementations, etc

TC-C2: Progress Indicator

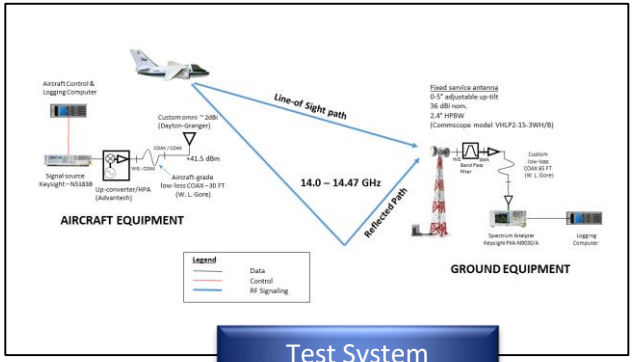
As of 9/30/17



TC-C2: Develop Satellite (SatCom) and Terrestrial based Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage allocated protected spectrum

Ku-Band Propagation Flights and Interference Analysis

- **Research Objective:**
  - Collect flight test data to validate earlier analysis of possible interference of Ku Unmanned Aircraft Systems (UAS) Command and Control (C2) SatCom radio systems with Ku fixed point-to-point ground stations in Europe needed for the development and validation of standards and spectrum allocation for a Ku-Band SatCom C2 data link



Test System

Viking S-3B

Flight Test Profile

- **Status:**
  - Ku interference flight test phase completed August 2017
    - Two final data collection flights
  - Ku interference data analysis completed September 2017
  - Ku interference final report completed September 2017
    - Provided to FAA
  - Technical Baseline Element completed September 2017

Ku-Band Spectrum Interference data provided to FAA Spectrum Office

Technical Baseline Element Number: TBEN-002 (SP C.5.11)

Terrestrial C2 Radio Evaluation System Development

- **Research Objective:**
  - Develop a Terrestrial C2 data link radio system and transfer technology and research data for the development and validation of standards for Terrestrial C2 data link

Phase 1 C2 Radio

Redesign

Phase 2 C2 Radio

- **Status:**
  - Established Cooperative Agreement for C2 Terrestrial Extension radio January 2017
  - Version 6 Preliminary Design Review (PDR) completed July 2017
- **Next Steps:**
  - Version 6 Critical Design Review (CDR) to be completed October 2017
  - Terrestrial-Based Version 6 Flight Test to be completed July 2018
  - Terrestrial-Based Version 7 Flight Test to be completed July 2019
  - Terrestrial-based UAS C2 Final Report to be completed September 2020

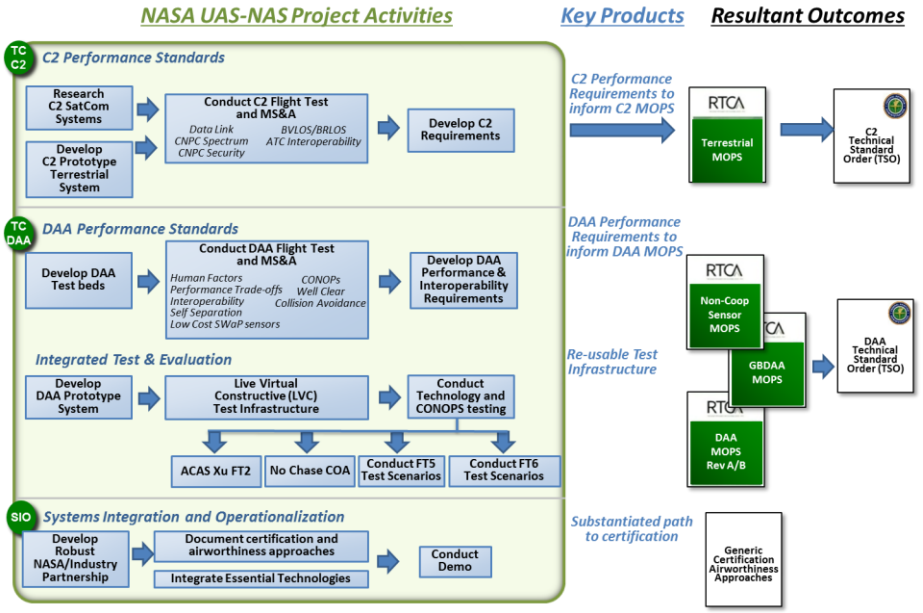
Technical Baseline Element Number: TBEN-004 (SP C.6.10, SP C.6.11)

TC-C2 Risk Summary

- Data Redacted

Technical Performance Summary

- SC-228 Support
  - Provided input into C2 and DAA White Papers to further scope the RTCA SC228 Phase 2 efforts
  - Leading/co-leading several topical subgroups
  - Presented DAA experiment plans
  - Presented analyses results to support publication of errata for DO-362



- TC-C2
  - Completed Ku-Band Spectrum Interference ground and flight systems design, systems installation, and flight test
  - Provided FAA Spectrum Office Ku-Band Spectrum Interference data

- TC-DAA
  - Completed ACAS Xu Flight Test 2
  - Developed Alternative Surveillance and Well Clear/Alerting Requirements ConOps
  - Completed experiment designs, infrastructure preparations, and/or data collection for multiple experiments

Preparing and conducting experiments collecting data critical to C2 and DAA MOPS

Outline

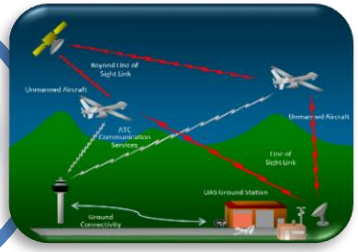
- UAS-NAS Overview
- Technical Challenge Performance
- SIO Status
- Project Level Performance & FY17 Look Ahead
- Review Summary

SIO:
Systems Integration and Operationalization

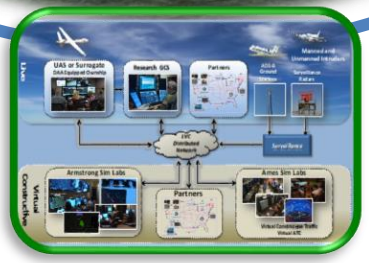
SIO

Integrate state of the art DAA and C2 technologies into Unmanned Aircraft Systems (UAS) to ensure sufficient aircraft level functional and operational requirements, and perform demonstrations in the NAS to inform Federal Aviation Administration creation of policies for operating UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations

Technical Challenge-DAA: Detect and Avoid (DAA)



Technical Challenge-C2: Command and Control (C2)



Systems Integration and Operationalization (SIO)

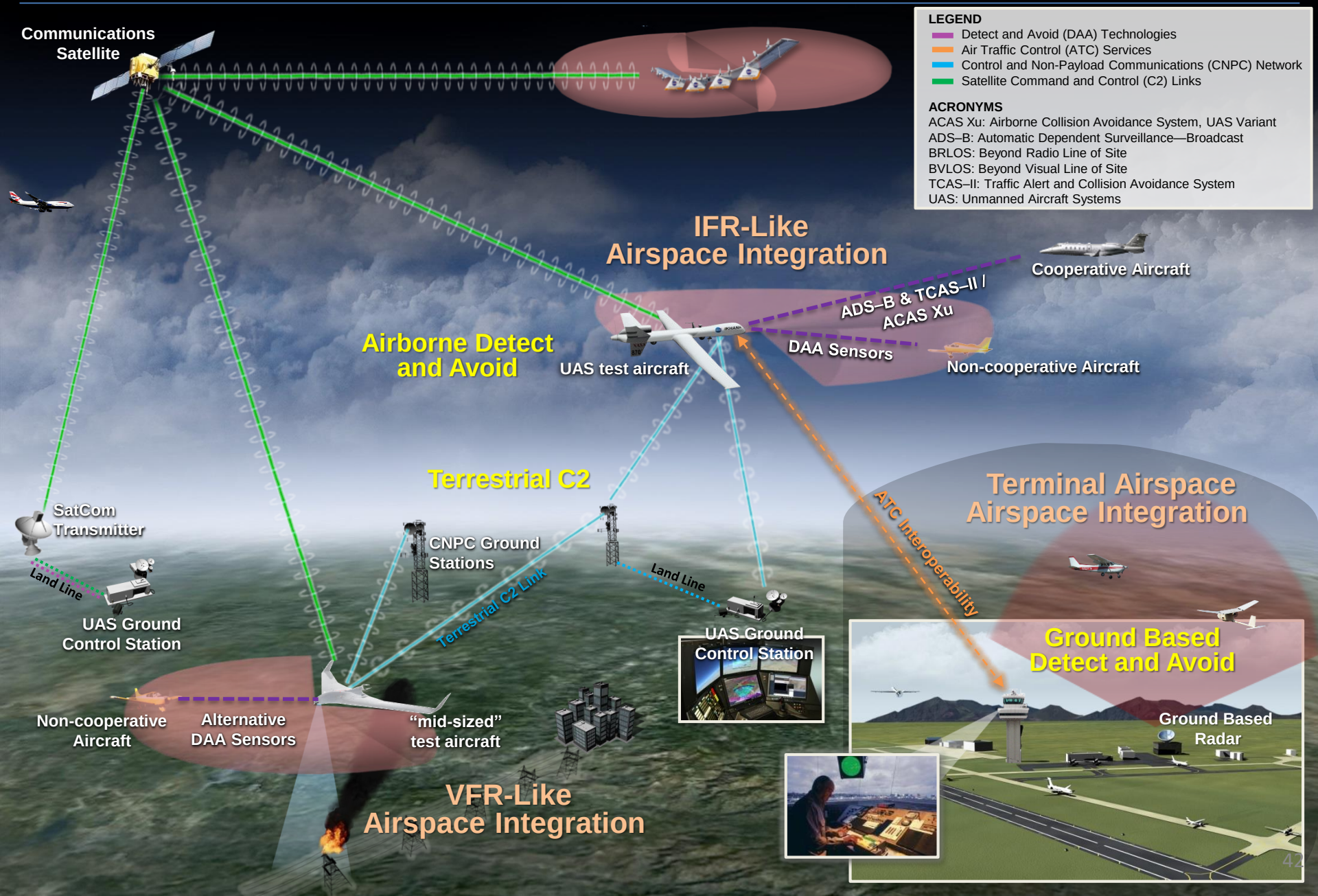
SIO Overview

- The SIO activity and associated FY20 demonstration will be a partnership between NASA and Industry in concert with the FAA to support the vision of UAS Integration in the NAS
- Primary Objectives are to:
  - Demonstrate UAS operations in the NAS by leveraging integrated DAA, C2, and other state of the art UAS technologies on an unmanned aircraft
  - Ensure relevant project research transitions into UAS stakeholder community
  - Accelerate certification basis for UAS new entrants
  - Advance the state of the art for UAS technologies
- Planning Considerations:
  - UAS Integration focused demonstration flight(s) with one or more partner provided UAS
  - Considers all ground and flight needs necessary to implement the proposed UAS mission (e.g. all phases of flight, take-off through landing, etc)
  - All UAS equipped with operationally relevant, DAA and C2 systems that have a pathway to certification (not necessarily SC-228 developed standards)
  - All vehicle technologies assessed to determine the most state of the art solution set that can meet airworthiness expectations for the demonstration
  - Operating Environment is MOPS-like, with primary operating altitude being above 500 feet above ground level (AGL) in controlled airspace
  - All Vehicles will be greater than 55 lbs (25 kg)

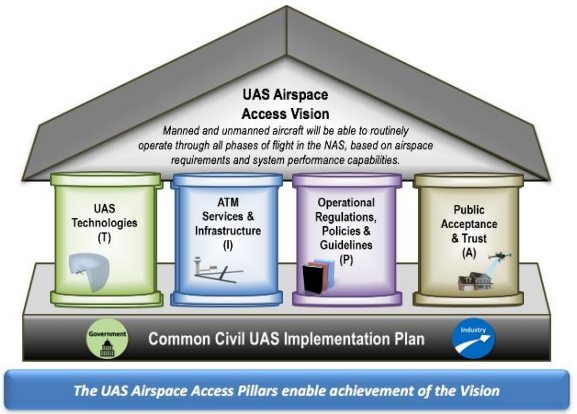
Obtain Industry partner(s) who demonstrate integrated DAA and C2 technologies in the NAS, leverage vehicle technologies that enable end-to-end mission performance without operational restrictions, and compile the necessary artifacts and data to support regulatory compliance

Potential SIO Operational View Representation

National Aeronautics and Space Administration



NASA/FAA/Industry Relationship for SIO



Maximum contribution from NASA

NASA

- C2 and DAA Technologies
- UAS Airworthiness
- ARMD-wide Technologies
- Generic Type Cert Requirements

UAS Int. RTT (SC-228)

DAA/C2, Airworthiness Criteria

SIO

FAA role

FAA

- Approval to fly in the NAS
- Type Cert guidance
- Procedural / policy / regulatory changes

TSOs, Ops Approval

Industry

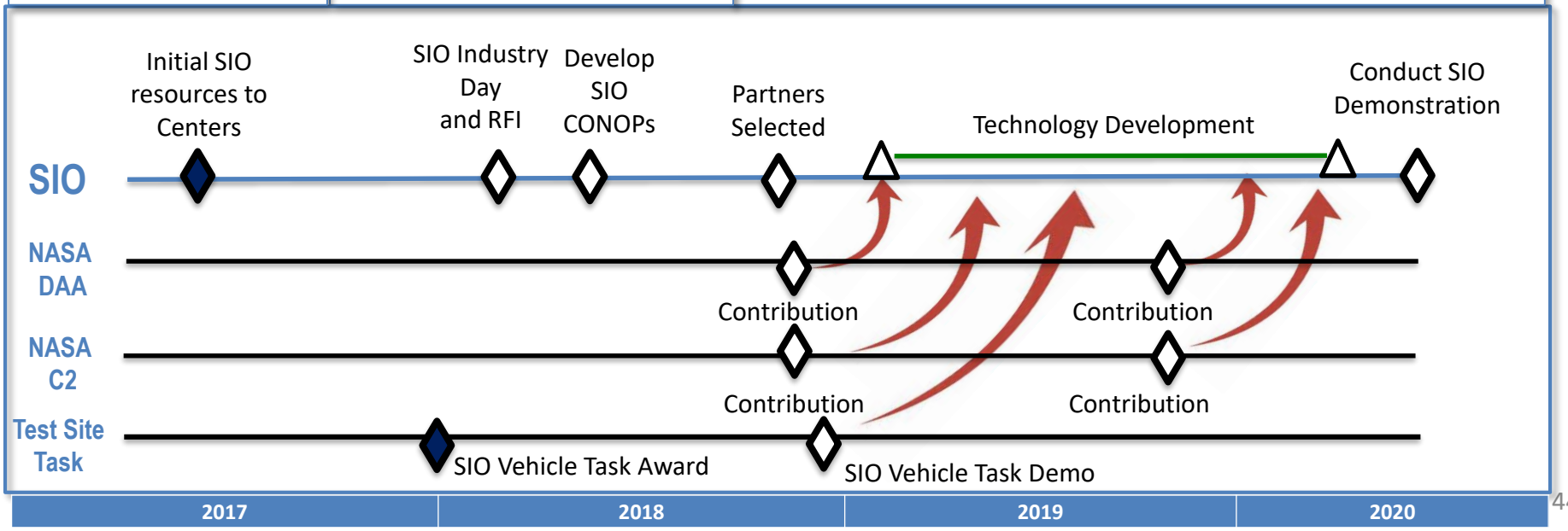
- Airworthy vehicle with integrated C2 and DAA equipage
- Other gap filling technologies required
- Specific Type Cert Basis

Minimum contribution from Industry

Systems Integration and Operationalization (SIO) Partnership Venn

SIO Notional Demonstration Strategy

SIO Potential Stakeholders	SIO Potential Partners	SIO Engagement Strategy
• RTCA SC-228 • FAA and Other Government Agencies • Industry • ICAO, EUROCAE	• Industry Aircraft OEMs • Industry Sensor Manufacturers • Industry Communication Providers • FAA UAS Test Sites • AFRL, US Army • Service Providers	Industry Partnership Strategy • Develop agreements with substantial industry investments, and leveraging NASA SMEs, to conduct the SIO demonstration • Industry to integrate C2 and DAA technologies in concert with essential vehicle technologies • Conduct industry centric SIO demonstration FAA Partnership Strategy • Work through the UAS Integration RTT to impact policy/procedural/regulatory/approval changes



SIO Staffing Maturation

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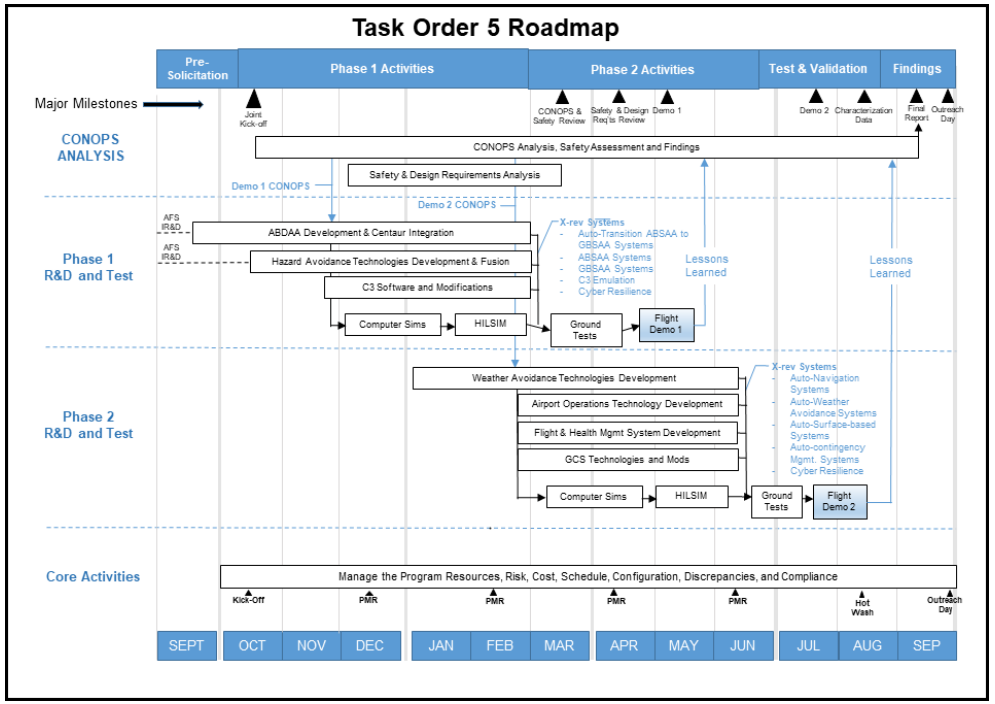
Initial SIO Demo
New York UAS Test Site

- [Redacted funding] ; competed across all six test sites
- Demonstration task to assess individual UAS vehicle technology state of the art for a Concept of Operations (ConOps) that is consistent with NASA's UAS Operational Environments
- The proposed effort is expected to inform planning efforts for the SIO FY20 demonstration and establish a foundation for future test platforms that are relevant to NASA ARMD initiatives
- Key Characteristics
  - Griffiss Airport in upstate NY
  - Tremendous airspace enables full missions
  - Several technology demonstrations including DAA, C2, and many others
  - Vehicle Partner: Aurora Flight Sciences – Centaur
  - Collaboration on dissemination of outcomes to community
  - Demonstration in July



SIO Path Forward

- Address SIO Concerns (Storm Clouds)
  - Define acquisition/partnership strategy
  - Identification of an Industry partner willing to provide adequate resources
  - Staffing to support SIO within subprojects, filling open positions, and addressing potential need for certification expertise
  - Increased tasks due to FY20 SIO demonstration (Project resources reduced for closeout in N2 Budget)

- SIO Demonstration Request for Information (RFI) for Industry ConOps, Technology Maturation, and Rough Orders of Magnitude
  - Communicate NASA expectations for the NASA partnership development process at industry day
  - Industry Day Announcement released in FedBizOps on October 4
    - https://www.fbo.gov/index?s=opportunity&mode=form&id=7b629912df70effbb2a7a97c5918623b&tab=core&_cview=1
  - RFI to be released by October 25
  - Industry day to be held on November 30 in San Diego, CA
  - RFI responses due December 15
  - RFI evaluation complete by end of January

- Project plans to release request for proposal to Industry by February 2018

Outline

- UAS-NAS Overview
- Technical Challenge Performance
- SIO Status
- Project Level Performance & FY18 Look Ahead
  - Risk Status
  - Resource Allocation and Utilization
  - Schedule Performance
  - Technical Baseline Summary
  - Partnerships and Collaboration
  - FY17 Accomplishments and FY18 Look Ahead
- Review Summary

Risk Status

- Data Redacted

Resource Allocation against Baseline Budget

- Data Redacted

Resource Utilization FY17 Budget vs. Actuals Summary

- Data Redacted

UAS FY17 Project Funding

- Data Redacted

FY17 Schedule Performance

- Milestone Count
  - Total of 8 Level 1 milestones, 2 completed to date, 6 remain open
  - Total of 56 Level 2 milestones, 15 completed to date, 41 are incomplete
- Causes of Milestone Delays
  - Level 1 Milestone
    - Delay in one Level 1 milestone due to Federal Registry delays
  - Level 2 Milestones
    - Alternative Surveillance Cooperative Agreement delayed longer than expected
    - Technical scope changes implemented to better align with community requirements
- Impacts of Milestone Delays
  - Alternative Surveillance CAN delays has slipped the start of FT 5 to October 2018
  - Acceptable impacts to downstream test and simulation activities

Successful Milestone Management

Current Active Collaborations/Partnerships Status

Partner *(Project Area)*	Agreement In Place	Collaboration/ Partnership Role
Air Force Research Lab *(TC-DAA)*	Ames Space Act	Coordinate activities on Vigilant Spirit Control Station. On-going collaboration with AFRL supporting use of Visual Spirit Control Station (VSCS) on DAA activities
FAA Office of UAS Integration *(Project Office)*	RTT	Support by FAA leadership, management, and technical subject matter experts (SME)s to validate work being done by the Project. On-going coordination of Project deliverables. Research Transition Team participation
FAA R&D Integration *(Project Office)*	RTT	Primary organization on RTT collaborations, on-going coordination of Project deliverables
FAA Air Traffic Organization *(Project Office)*	RTT / Controlled Airspace ARC	Primary organization managing the Controlled Airspace ARC for which the project will actively participate. Research Transition Team participation
FAA TCAS Program Office (ACAS Xu) *(TC-DAA)*	Software	Coordinating on collaboration for ACAS-Xu FT2 software and associated flight tests
FAA UAS Test Sites *(Project Office)*	IDIQ Contract	Awarded Task 4 GBDAA (Gryphon Sensors LLC, Textron, UAVPro, FirebirdSE, Sunhillo, Dominion Energy, and Aviation Systems Engineering Company) and Task 5 Vehicle Task (Aurora, MTSI, NUAIR, Griffiss International Airport, AX Enterprize, Gryphon Sensors, Navmar Applied Sciences Corp.)
General Atomics *(TC-DAA)*	Space Act	Ikhana equipped with avionics and Proof of Concept DAA system directly supported by UAS-NAS Project and supported FT4. General Atomics supported ACAS-Xu FT2 and is currently collaborating to support the No Chase COA flight

Purple text indicates changes since FY16 AR

Current Active Collaborations/Partnerships Status

Partner *(Project Area)*	Agreement In Place	Collaboration/ Partnership Role
Honeywell *(TC-DAA)*	Cooperative Agreement	Selectee for DAA subproject cooperative agreement
Honeywell *(TC-C2)*	Cooperative Agreement	Selectee for C2 subproject cooperative agreement for SatCom Ka-band development. Agreement was canceled.
NASA AOSP (Project Office)	NA	Coordination with Airspace Operations and Safety Program (AOSP) on UAS Traffic Management (UTM), SMART NAS, autonomy roadmapping, and other activities including collaborative effort on UAS integration strategies and LVC development. Full UAS Cohesive Strategy currently being worked
Rockwell Collins *(TC-C2)*	Cooperative Agreement	CNPC radio development and flight test. Cost sharing with Rockwell Collins concentrated in FY11-13, totaling $3M contribution from Rockwell. Rockwell Collins delivered Gen-5 radios
RTCA SC-228 *(TC-C2, TC-DAA)*	NA	On-going support to DAA and C2 working groups
RTCA SC-147 *(TC-DAA)*	NA	Close coordination between ACAS Xu and DAA standards required for success of P2 MOPS Hosting workshops and performing flight test to ensure success of both working groups

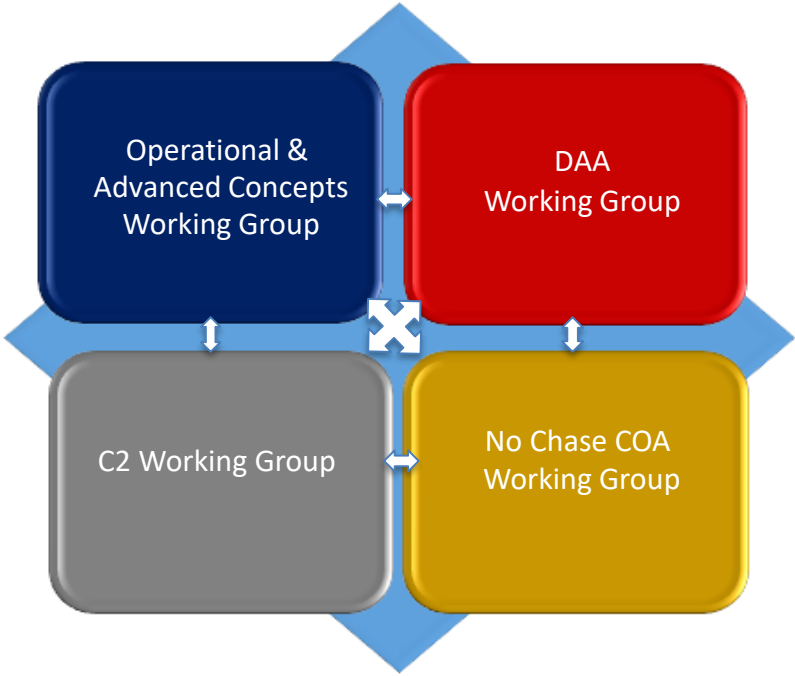
Purple text indicates changes since FY16 AR

Project Related UAS Integration Progress

- Phase 1 Technical Challenge Community Outcomes
  - FAA published Technical Standard Order (TSO)-C211 Detect and Avoid and TSO-C212 ATAR for Traffic Surveillance
  - FAA published TSO for DO-362 is under review within the FAA
  - No Chase COA is driving the community towards the first flight of an UAS in the NAS with a technology solution for ”see and avoid” rules (i.e. Part 91)

- Phase 2 Technical Content Progress
  - Project baseline portfolio (M&S, HITLS, and Flight Tests) used to set aggressive goals for DAA and C2 within the community
  - Significant input to SC-228 white papers scoping upcoming standards
  - NASA challenging the community to demonstrate critical technologies and accelerate commercial operational approvals

- Phase 2 partnerships with the FAA are being coordinated though a Research Transition Team (RTT) that includes all Lines of Business



FY17 Accomplishments & FY18 Look Ahead

FY17 Accomplishments

- Detect and Avoid Subproject
  - Phase 1 MOPS Published
  - SC-228 DAA White Paper
- Integrated Test and Evaluation Subproject
  - ACAS Xu Flight Test 2
  - No Chase COA Planning
  - Flight Test 5 Planning
- Project Office
  - ICAO/VIP Day
  - Key Decision Point – C (Baseline Review)
  - ARMD UAS Cohesive Strategy and FAA Research Transition Team
- Command and Control Subproject
  - Phase 1 MOPS Published
  - Ku-Band interference testing
  - Ka-Band cooperative agreement award and subsequent deletion
  - SC-228 C2 White Paper
- Awards
  - ARMD Associate Administrator (AA) Group award for technology and innovation for IT&Es work on Flight Test Series 4
  - Joseph J. Jacobs Master Builder Award for UAS in the NAS Fight Test 4 project

FY18 Look Ahead

- DAA HITL Simulation
- No Chase COA Flight Demonstration
- SIO Demo Industry Day and Partner Collaboration
- CNPC Radio Version 6 Flight Test

Summary

- ✓ Established Project Phase 2 Detect and Avoid and Command and Control Community Technical Challenges
- ✓ Established Project Phase 2 Baseline
- ✓ Successful On-time Completion of Multiple Project Research Activities
- ✓ Defined Executable Framework for SIO
- ✓ Provided Significant Contributions to the UAS Community
- ✓ Continued Effective Project and Subproject Management

Project continues to provide positive impacts towards the Integration of UAS into the NAS

UAS-NAS Technical Challenge Performance
Backup Slides

TC-DAA Technical Baseline Elements (1/3)

Technical Baseline Element Number	Technical Baseline Element Title	Reference Schedule Package Numbers
TBEN-005	Alternative Surveillance and Well Clear/Alerting Requirements ConOps	SP D.1.30, SP D.2.10
TBEN-006	Alternative Surveillance: Foundational Fast-time Simulation (FY17)	SP D.1.40
* TBEN-007	Alternative Surveillance: Display Requirements	SP D.1.50
* TBEN-008	Alternative Surveillance: Unmitigated Fast-time Simulation (FY18)	SP D.1.60
* TBEN-009	Alternative Surveillance: HITL Simulation 1	SP D.1.70, SP T.7.20
* TBEN-010	Alternative Surveillance: Unmitigated/Mitigated Fast-time Simulation (FY19)	SP D.1.80
* TBEN-011	DELETED September 2017 MRB: Alternative Surveillance: HITL Simulation 2	SP D.1.90, SP T.7.40

* Accomplishment chart not included

TC-DAA Technical Baseline Elements (2/3)

Technical Baseline Element Number	Technical Baseline Element Title	Reference Schedule Package Numbers
TBEN-012	Well Clear/Alerting Requirements: Foundational Terminal Operations HITL Simulation 1	SP D.2.30, T.7.10
TBEN-013	Well Clear/Alerting Requirements: Foundational Terminal Operations Fast-time Simulation 1	SP D.2.40
TBEN-014	Well Clear/Alerting Requirements: Fast-time Simulation 2	SP D.2.50
* TBEN-015	Well Clear/Alerting Requirements: Fast-time Simulation 3	SP D.2.60
* TBEN-016	Well Clear/Alerting Requirements: HITL Simulation 2	SP D.2.70
* TBEN-017	Well Clear/Alerting Requirements: HITL Simulation 3	SP D.2.80
TBEN-018	ACAS-Xu: Mini HITL Simulation	SP D.3.20
* TBEN-019	ACAS-Xu: HITL Simulation 1	SP D.3.50, SP D.7.30

* Accomplishment chart not included

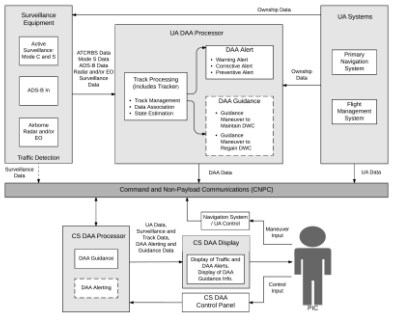
TC-DAA Technical Baseline Elements (3/3)

Technical Baseline Element Number	Technical Baseline Element Title	Reference Schedule Package Numbers
TBEN-020	Integrated Event: ACAS-Xu Flight Test 2	SP D.5.10, SP T.8.10
TBEN-021	Integrated Event: Flight Test 5	SP D.5.20, SP T.8.30
* TBEN-022	Integrated Event: Flight Test 6	SP D.5.30, SP T.8.40
TBEN-023	No Chase Certificate of Waiver or Authorization Flight Demonstration	SP T.8.20

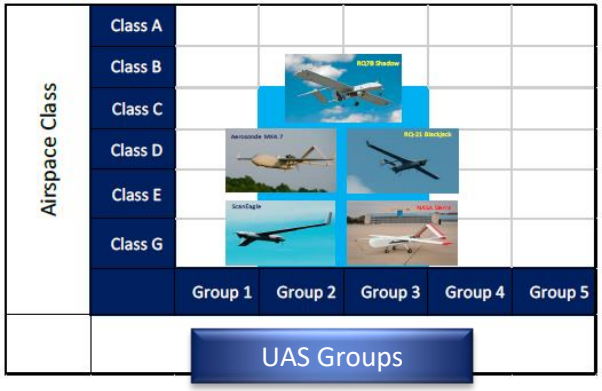
* Accomplishment chart not included

Alternative Surveillance and Well Clear/Alerting Requirements ConOps

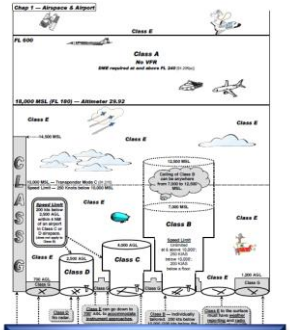
- **Research Objective:**
  - Develop a ConOps describing the scope of DAA alternative surveillance and Well Clear Definition research to support the development of DAA Phase 2 MOPS and Non-Cooperative Sensor MOPS



Architecture



UAS Groups



Airspace Classes

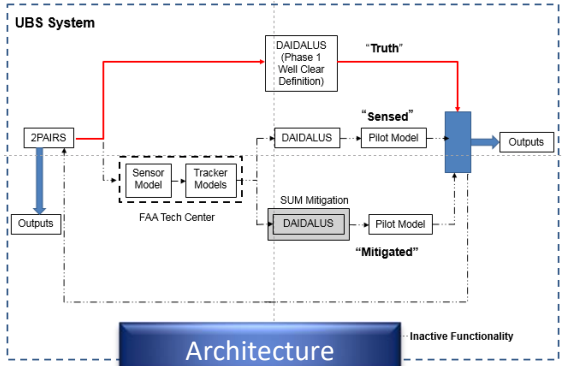
- **Status:**
  - Alternative Surveillance ConOps completed June 2017
    - Internal Project document
  - Well Clear/Alerting Requirements ConOps completed August 2017
- **Next Steps:**
  - Public release of Well Clear/Alerting Requirements ConOps to be completed October 2017

Alternative Surveillance and Well Clear/Alerting Requirements ConOps available to shape future Project research

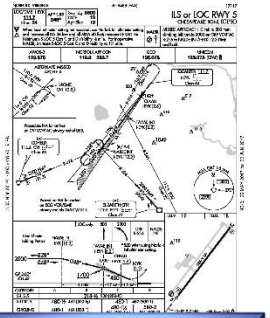
Technical Baseline Element Number: TBEN-005 (SP D.1.30, SP D.2.10)

Well Clear/Alerting Requirements: Foundational Terminal Operations Fast-time Simulation 1

- **Research Objective:**
  - Collect empirical data to address well clear issues



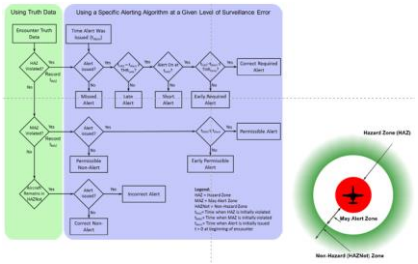
Architecture



Mission Profile

	Geometry	Encounters
1	45-degree Entry	558
2	Midfield Entry	558
3	Downwind	15
4	Extended Downwind	45
5	Turn to Base	140
6	Base	31
7	Base Entry	31
8	Turn to Final	31
9	45-degree Departure	54
10	Straight Departure	54

Test Matrix



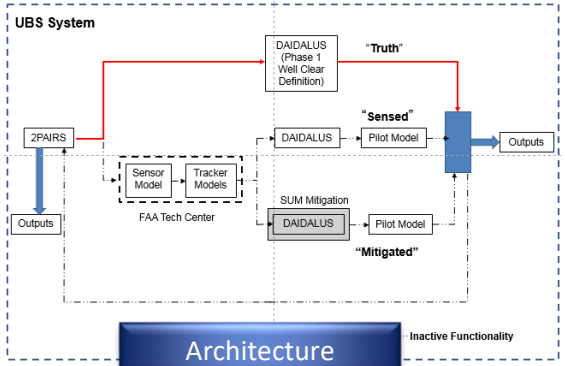
Phase 1 DAA Metrics

- **Status:**
  - Experiment design, shakedown, and data collection completed August 2017
    - Phase 1 Well clear Definition
- **Next Steps:**
  - Report to be completed November 2017

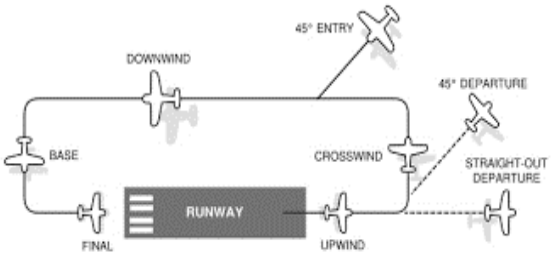
Technical Baseline Element Number: TBEN-013 (SP D.2.40)

Well Clear/Alerting Requirements: Fast-time Simulation 2

- **Research Objective:**
  - Collect empirical data to address well clear issues



Architecture



Traffic Pattern

	Geometry	Encounters
1	45-degree Entry	558
2	Midfield Entry	558
3	Downwind	15
4	Extended Downwind	45
5	Turn to Base	140
6	Base	31
7	Base Entry	31
8	Turn to Final	31
9	45-degree D	
10	Straight De	

DAA Well Clear Parameters

Tuning Thresholds	Phase 1 DAA Well Clear	Batch Simulations		
		Minimum	Maximum	Increment
τ_{mod}	35 sec	[0, 15]	35	10
HMD^*	4000 ft	2000	4000	500
h^*	450 ft	200	450	50

Test Matrix/Independent Variables

- **Status:**
  - Experiment design, shakedown, and data collection completed August 2017
    - Independent variables: Well Clear Definition parameters
- **Next Steps:**
  - Report to be completed October 2017

Technical Baseline Element Number: TBEN-014 (SP D.2.50)

ACAS-Xu: Mini HITL Simulation

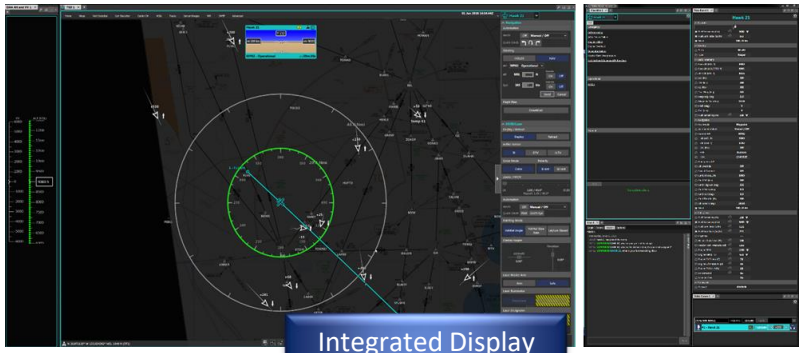
- **Research Objective:**
  - 1) Determine that the Ames Research Centers Human Autonomy Teaming Laboratory components are installed properly and up to date for Project Phase 2 research (Primary) and 2) provide data on alerting, display and/or guidance Phase 1 DAA MOPS (Secondary)

Pilot #	Trial 1	Trial 2	Trial 3	Trial 4
P01	D1_Integrated_T1	D1_Integrated_T2	D1_Standalone_T2	D1_Standalone_T1
P02	D2_Standalone_T1	D2_Standalone_T2	D2_Integrated_T2	D2_Integrated_T1
P03	D3_Integrated_T2	D3_Integrated_T1	D3_Standalone_T1	D3_Standalone_T2
P04	D1_Standalone_T1	D1_Standalone_T2	D1_Integrated_T2	D1_Integrated_T1
P05	D2_Integrated_T2	D2_Integrated_T1	D2_Standalone_T1	D2_Standalone_T2
P06	D3_Integrated_T1	D3_Integrated_T2	D3_Standalone_T2	D3_Standalone_T1
P07	D1_Standalone_T2	D1_Standalone_T1	D1_Integrated_T1	D1_Integrated_T2
P08	D2_Integrated_T1	D2_Integrated_T2	D2_Standalone_T2	D2_Standalone_T1
P09	D3_Standalone_T2	D3_Standalone_T1	D3_Integrated_T1	D3_Integrated_T2
P10	D1_Integrated_T2	D1_Integrated_T1	D1_Standalone_T1	D1_Standalone_T2
P11	D2_Standalone_T2	D2_Standalone_T1	D2_Integrated_T1	D2_Integrated_T2
P12	D3_Standalone_T1	D3_Standalone_T2	D3_Integrated_T2	D3_Integrated_T1
P13	D1_Integrated_T1	D1_Integrated_T2	D1_Standalone_T2	D1_Standalone_T1
P14	D2_			Integrated_T1
P15	D3_			Standalone_T2

Test Matrix

D1: Caution Only			D2: Warning Aural			D3: Warning Aural + Symbol		
Symbol	Name	Aural Alert Verbiage	Symbol	Name	Aural Alert Verbiage	Symbol	Name	Aural Alert Verbiage
N/A	N/A	N/A		DAA Warning Alert	"Traffic, Maneuver Now" x2		DAA Warning Alert	"Traffic, Maneuver Now" x2
	Corrective DAA Caution Alert	"Traffic, Avoid"		Corrective DAA Caution Alert	"Traffic, Avoid"		Corrective DAA Caution Alert	"Traffic, Avoid"
	*Preventive DAA Alert	"Traffic, Monitor"		*Preventive DAA Alert	"Traffic, Monitor"		*Preventive DAA Alert	"Traffic, Monitor"
	Guidance Traffic	N/A		Guidance Traffic	N/A		Guidance Traffic	N/A
	None (Target)	N/A		None (Target)	N/A		None (Target)	N/A

Alerting Logic



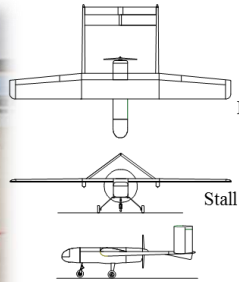
Integrated Display

- **Status:**
  - Experimental Design including Stakeholder input completed January 2017
  - Data Collection completed August 2017
- **Next Steps:**
  - Report to be completed December 2017

Technical Baseline Element Number: TBEN-018 (SP D.3.20)

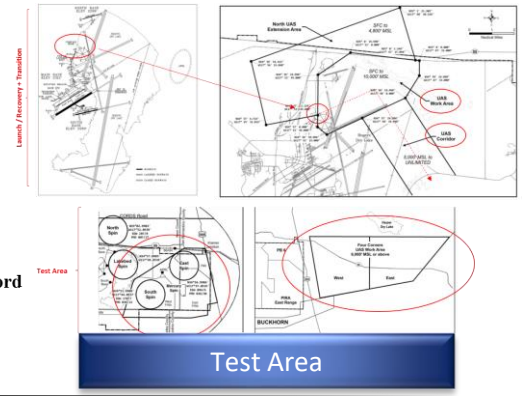
Integrated Event: Flight Test 5

- **Research Objective:**
  - Conduct a flight test providing data to support development of the RTCA SC-228 Phase 2 Detect and Avoid and Alternative Surveillance MOPS

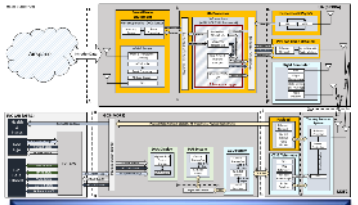


Wing Span	20 ft.
Length	11.8 ft.
Height	4.6 ft.
Wing Area	42.4 sq. ft.
Empty Weight	340 lbs.
Gross Weight	480 lbs.
Max Speed	79 kts.
Cruise Speed	55-63 kts.
Stall Speed (clean)	35 kts.
Aspect ratio	9.43
Rate of Climb	545 ft./min.
CG Position	29-32% Chord
Payload weight	~100lbs
Payload power	28V DC
Duration	8-10 hrs

Sierra Unmanned Aircraft



Test Area

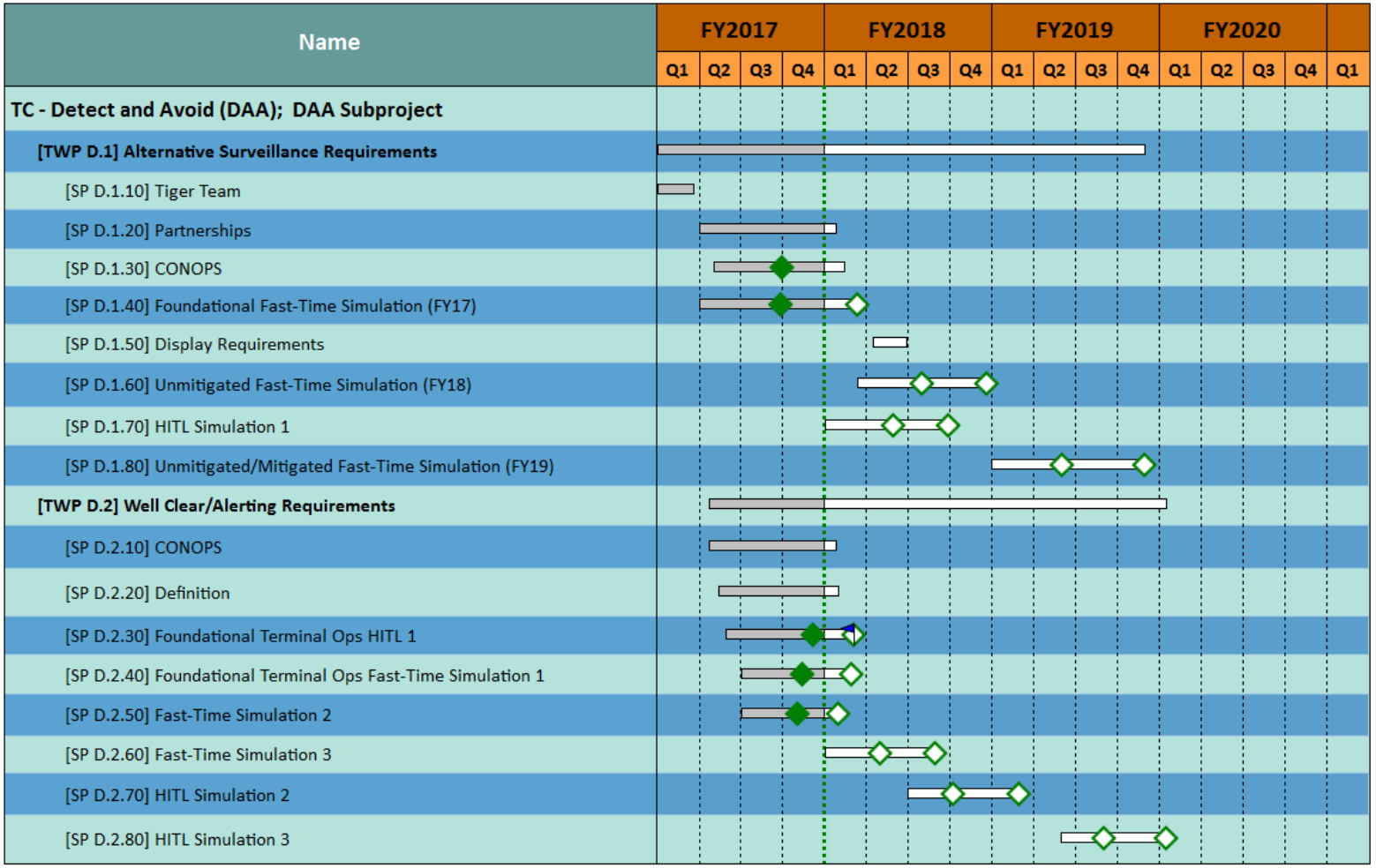


Architecture

- **Status:**
  - ConOps and System Requirements Review completed August 2017
- **Next Steps:**
  - Flight Test 5 to be completed December 2018
  - Flight Test 5 reports to be completed February 2019

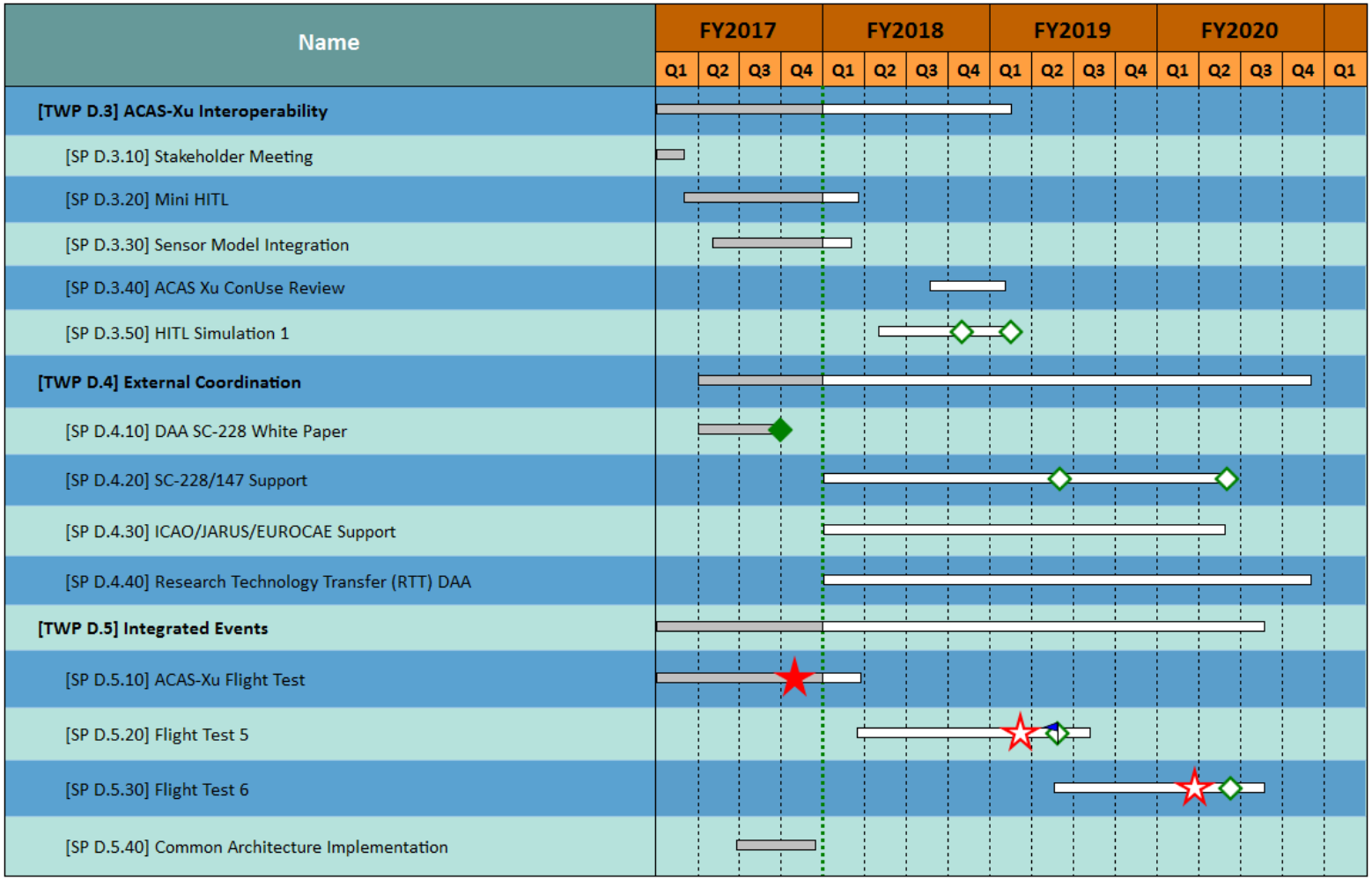
Technical Baseline Element Number: TBEN-021 (SP D.5.20, SP T.8.30)

TC-DAA (1 of 3)



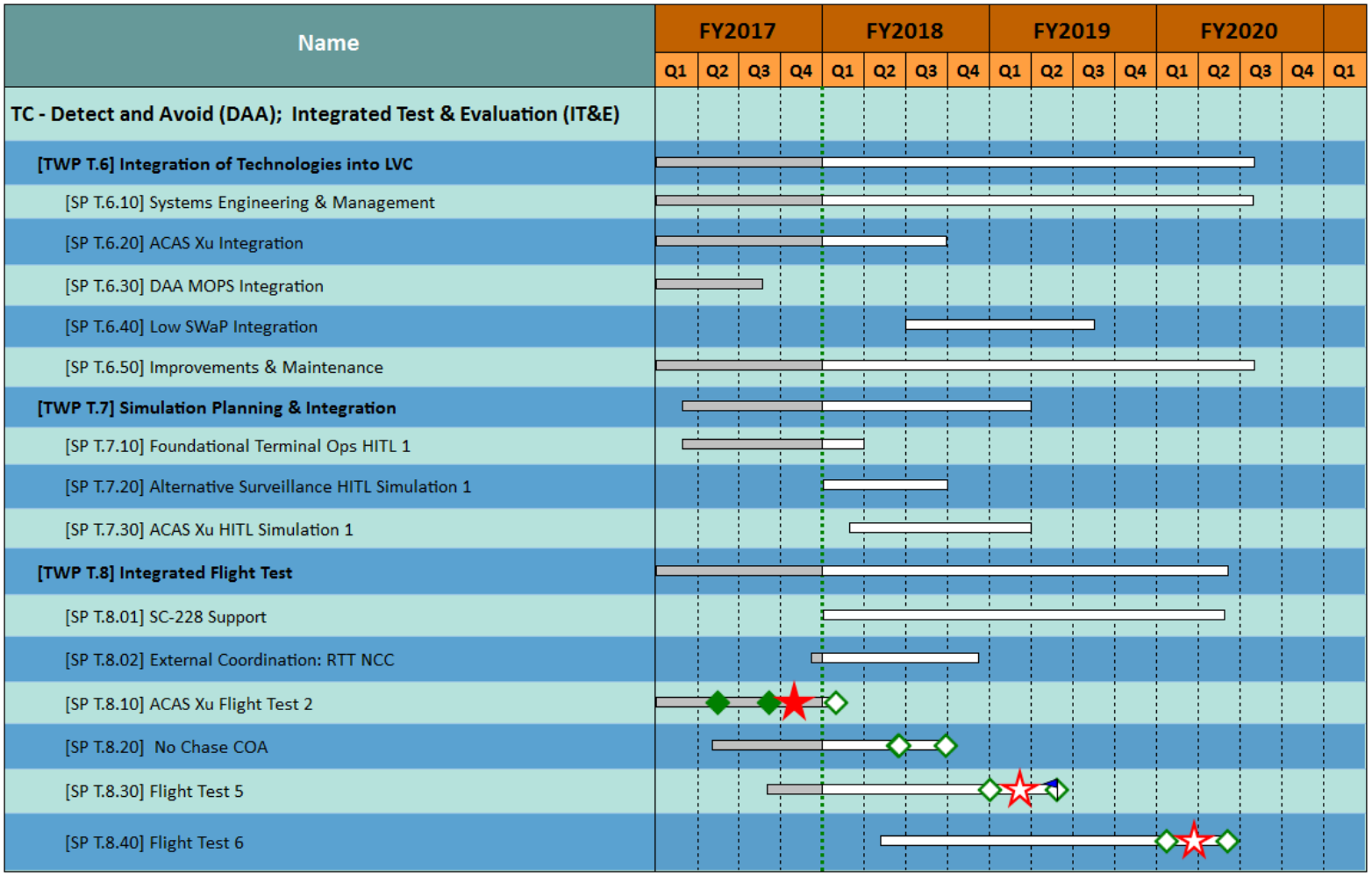
Green Status Line Date 9/30/17

TC-DAA (2 of 3)



Green Status Line Date 9/30/17

TC-DAA (3 of 3)



Green Status Line Date 9/30/17

TC-DAA Risk

- Data Redacted

TC-DAA Risk

- Data Redacted

TC-DAA Risk

- Data Redacted

TC-DAA Risk

- Data Redacted

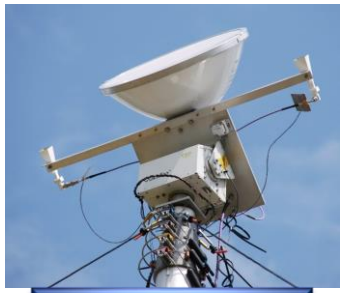
TC-C2 Technical Baseline Elements

Technical Baseline Element Number	Technical Baseline Element Title	Reference Schedule Package Numbers
TBEN-001	Ku-Band Spectrum Interference Evaluation System Development	SP C.5.10
TBEN-002	Ku-Band Propagation Flights and Interference Analysis	SP C.5.11
TBEN-003	C-Band Design Study, Verification & Validation Planning	SP C.5.40, SP C.5.41
TBEN-004	Terrestrial C2 Radio Evaluation System Development and Test and Evaluation	SP C.6.10, SP C.6.11

Ku-Band Spectrum Interference Evaluation System Development

- **Research Objective:**
  - Develop the Ku-Band interference evaluation system


Ground Station


Receive Antenna

Viking S-3B


Aircraft Omni Antenna

- **Status:**
  - System design, installation, and integration completed July 2017
  - Technical Baseline Element completed July 2017

Ku-Band Spectrum Interference Evaluation System ready for flight test and evaluation

Technical Baseline Element Number: TBEN-001 (SP C.5.10)

C-Band Design Study, Verification & Validation Planning

- **Research Objective:**
  - Transfer research data for the development and validation of standards for C-Band SatCom C2 data link

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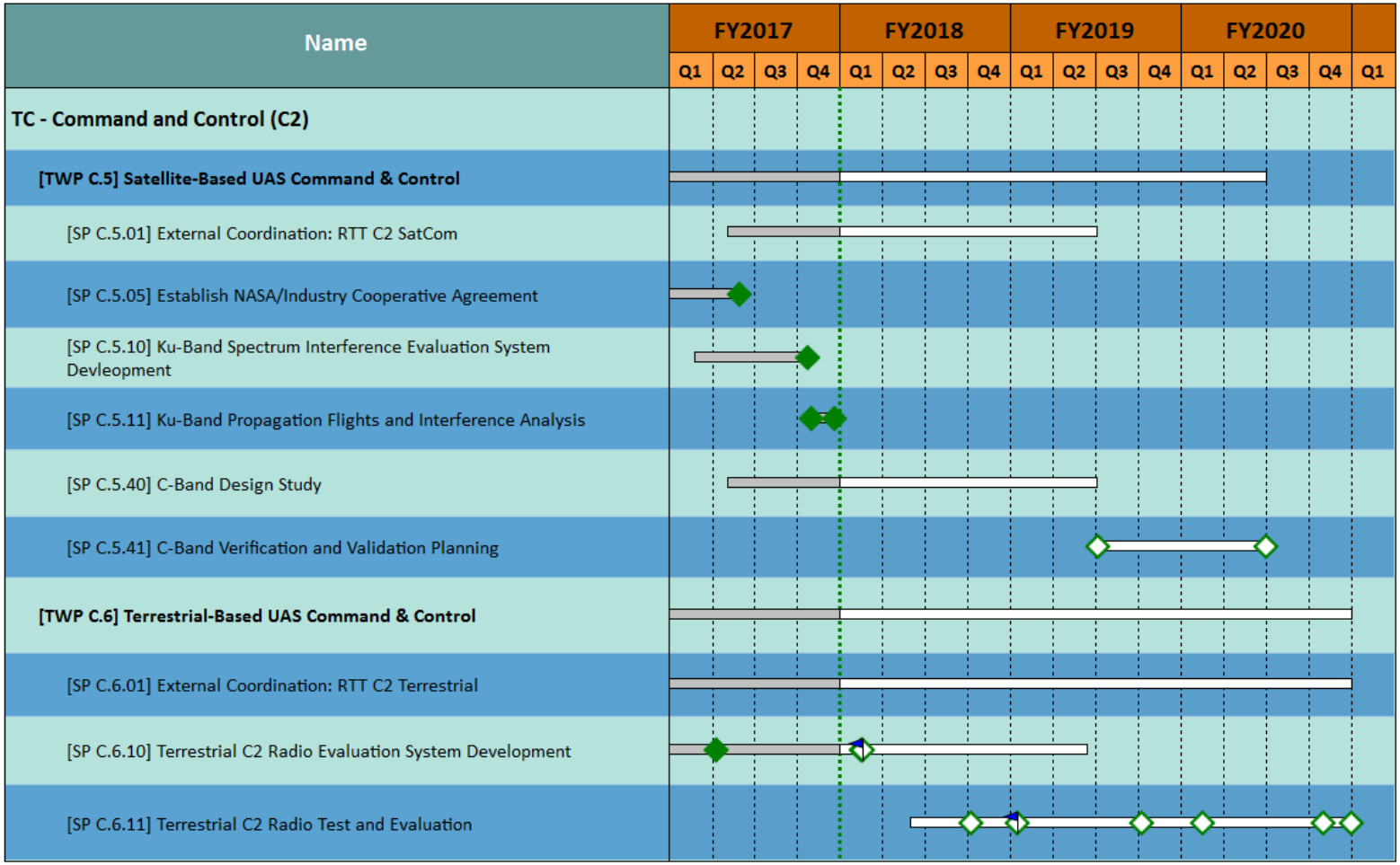
- **Status:**
  - Contract awarded and Kickoff meeting completed June 2017
- **Next Steps:**
  - Review with contractor to be completed October 2017
  - Earth station design to be completed April 2019
  - Verification and Validation Plan to be completed July 2019
  - C-Band SatCom final report to be completed April 2020

Technical Baseline Element Number: TBEN-003 (SP C.5.40, SP C.5.41)

TC-C2



Green Status Line Date 9/30/17

TC-C2 Risk

- Data Redacted

UAS-NAS SIO Status
Backup Slides

SIO Community Benefit Statements

Systems Integration and Operationalization from the Technology perspective:

- **[All OEs]** Integrated Testing of Systems: Development of vehicle technologies (i.e. DAA, C2, and others) is insufficient to close complex integrated system gaps. Technologies must be integrated into vehicle systems and systematically tested in a relevant operational environment

- **[IFR/VFR-Like]** Creation of standards typically leverage RTCA guidance for drafting performance standards that include expectations for meeting aircraft level functional and operational requirements. Other essential vehicle technologies are not being address by RTCA.

Technology Benefits of SIO

NASA's leadership in vehicle technology development through performance of high profile integrated tests can push the industries state of the art UAS development, while ensuring aircraft level functional and operational performance criteria are included in standards activities.

SIO Community Benefit Statements

Systems Integration and Operationalization from the Policy perspective

- **[All OEs]** UAS Operationalization: Integration of UAS is a broad multi-faceted problem that requires a systems level approach for implementation of technologies into the NAS, with a focus on ensuring FAA policy is created in a timely manner

- **[IFR/VFR-Like]** Creation of standards largely benefits the Aviation Safety line of business at the FAA, but does not ensure broad FAA policy for operational approvals will follow
  - Risks of inconsistent operational approval policies are significantly reduced by standards, but in order for policies to be created in time for industry operations the FAA needs ongoing efforts consistent with those that were leveraged to develop the standards
  - The high risk nature of system implementation without policy guidance creates an environment of opportunity for federal entities to assume some of this risk

Policy Benefits of SIO

Increasing confidence in the maturity of integrated C2, DAA, and other vehicle technologies an SIO demonstration will provide FAA the opportunity to stress/modify the approval process, leading to a playbook for industry to gain access for IFR/VFR-Like missions for extended operations within Classes D,E, and G Airspace.

Project Level Performance
Backup Slides

Project Office Risk Summary

- Data Redacted

Project Office Risk

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Project Office Risk

- Data Redacted

FY17 Closed Risks

- Data Redacted

UAS-NAS Risk Summary Card

- Data Redacted

Resource Allocation FY17 Budget

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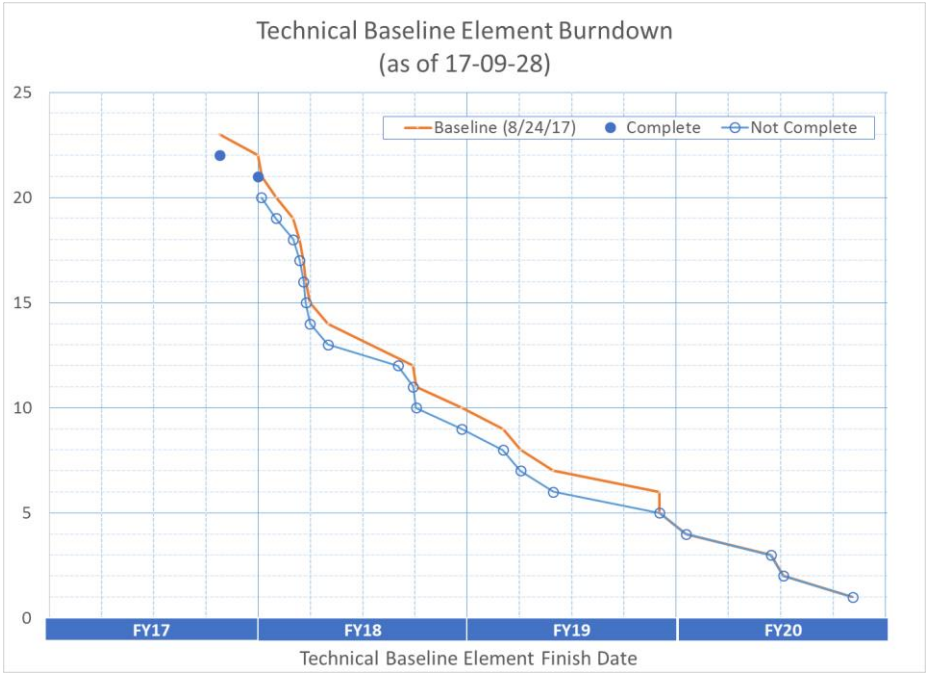
Technical Baseline FY17 Summary

- Twenty-three Technical Baseline Elements approved 24 August 2017
- Twenty remain open at end of FY17
- One deleted
  - TBEN-011 (SP D.1.90, SP T.7.40)
    - Verify and Validate 1) UAS pilot performance of a DAA system with low size, weight, and power sensor, 2) interoperability of low size, weight, and power sensor requirements with DAA alerting, guidance, and display requirements, and 3) the final DAA and Non-cooperative sensor Phase 2 MOPS
- Two completed
  - TBEN-001 (SP C.5.10)
    - Ku-Band Spectrum Interference Evaluation System Development
  - TBEN-002 (SP C.5.11)
    - Transfer technology and interference research data for the development and validation of standards for Ku-Band SatCom C2 data link

TC	Baseline, 8/24/17	FY17 Deleted	FY17 Completed	Total Remaining
C2	4	0	2	2
DAA	19	1	0	18
Total	23	1	2	20

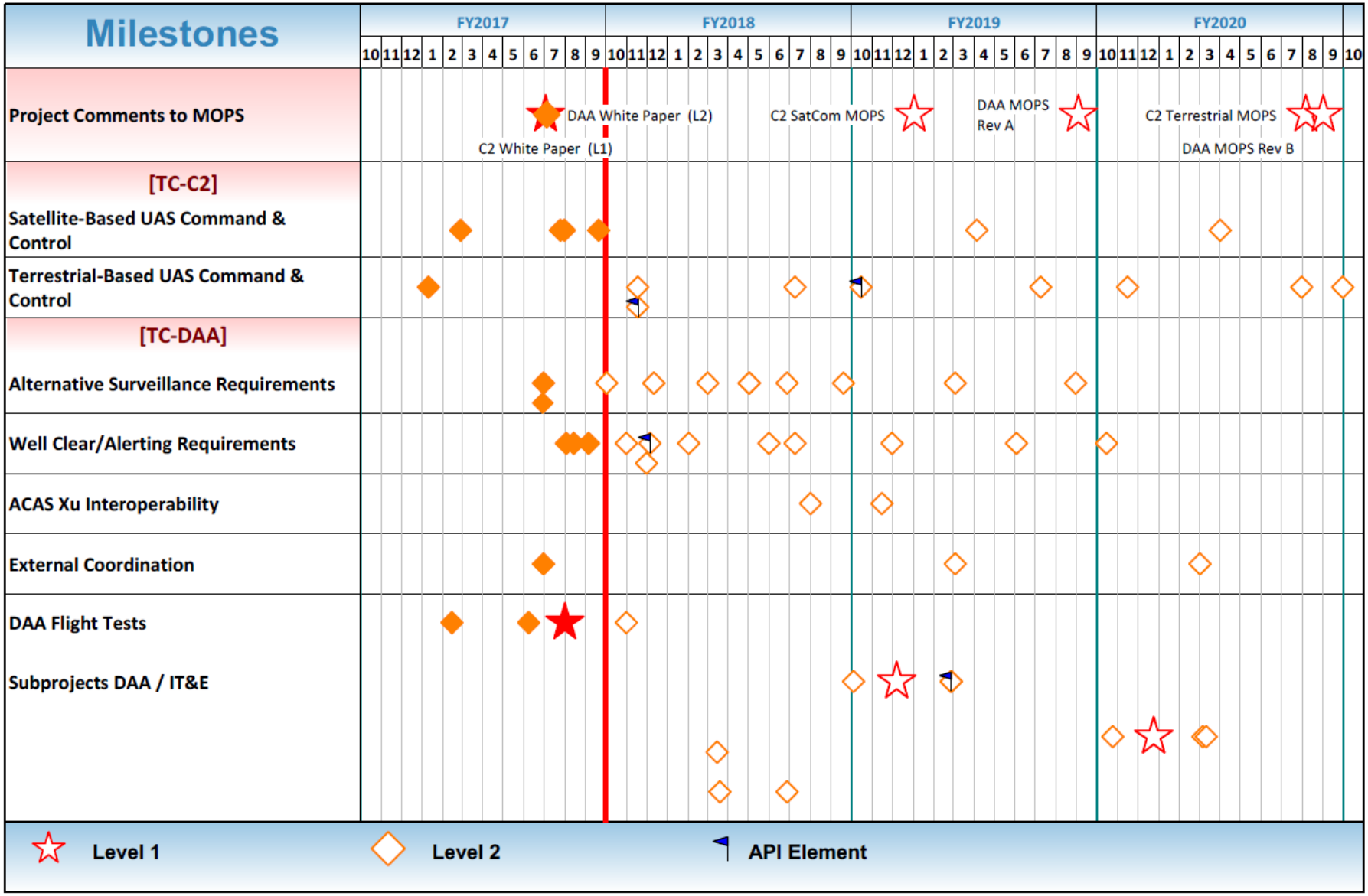


As of 8/30/2017 IMS

FY17 Project Deliverables

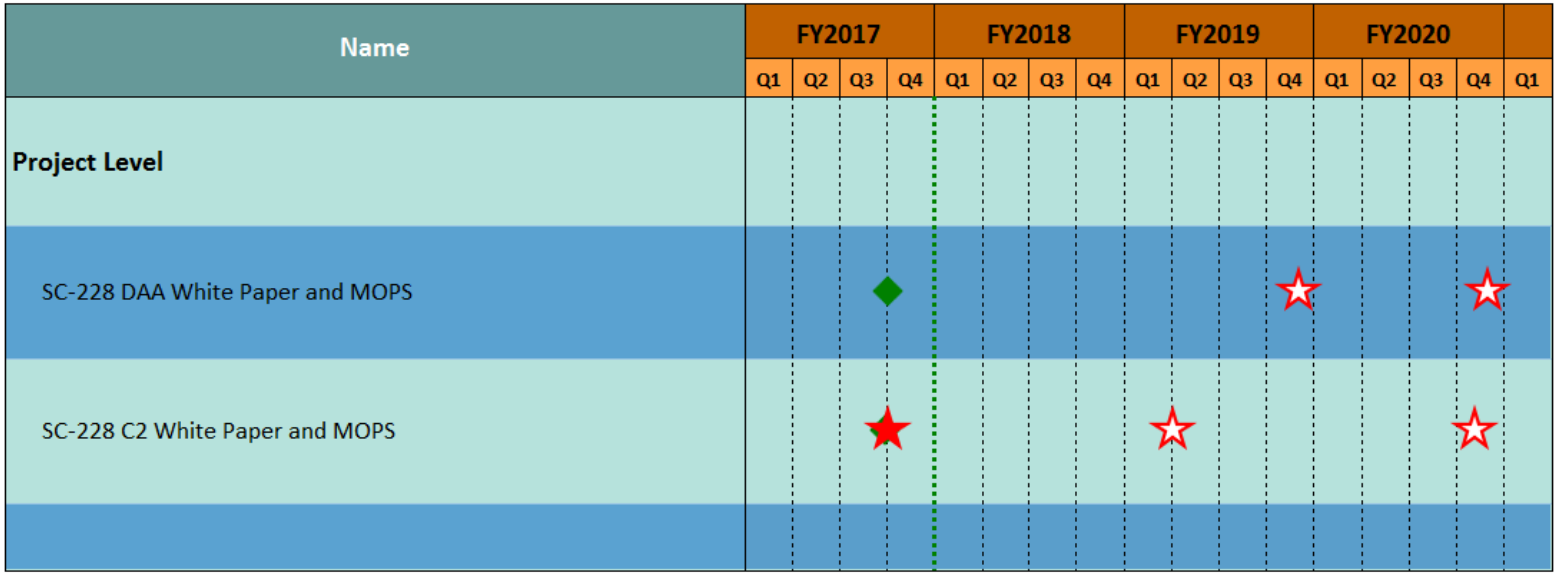
FY17 Project Deliverables	Technical Challenge	Date	Type of Deliverable
Flight Testing Future Technologies to Overcome the Barriers of integrating UAS into the NAS	TC-DAA	Feb-17	Briefing
Cohesive Full UAS Integration Strategy	Project Office	Feb-17	Briefing
Tech Activity Update US (NASA) HAT-MAPP Models, Agents Principles and Patterns (MAPP)	TC-DAA	May-17	Briefing
Performing a Comprehensive Unmanned Aircraft System Full Integration Analysis for NASA ARMD	Project Office	Mar-17	Report
Ikhana UAS Overview	TC-DAA	May-17	Briefing
Unmanned Aircraft Systems Detect and Avoid System: End-to-End Verification and Validation Simulation Study of Minimum Operational Performance Standards for Integrating Unmanned Aircraft into the National Airspace System Briefing	TC-DAA	Jun-17	Briefing
DAIDALUS Results from UAS in the NAS Flight Test 4	TC-DAA	Jun-17	Paper
UAS Well Clear Recovery against Non-Cooperative Intruders using Vertical Maneuvers	TC-DAA	Jun-17	Paper
An Alternative Time Metric to Modified Tau for Unmanned Aircraft System Detect And Avoid	TC-DAA	Jun-17	Paper
Generic Resolution Advisor and Conflict Evaluator (GRACE) in Applications to Detect-And-Avoid (DAA) Systems of Unmanned Aircraft	TC-DAA	Jun-17	Paper
UAS-NAS Flight Testing Overview	TC-DAA	Jun-17	Briefing
Unmanned Aircraft Systems Detect and Avoid System: End-to-End Verification and Validation Simulation Study of Minimum Operational Performance Standards for Integrating Unmanned Aircraft into the National Airspace System	TC-DAA	Jun-17	Report
Validation of Minimum Display Requirements for a UAS Detect and Avoid System	TC-DAA	Jun-17	Report
Ku-Band Air-to-Ground Propagation Measurement System Overview	TC-C2	Sep-17	Report

Phase 2 Milestone Summary



Red Status Line Date 9/30/17

Project Office



L1 Program (IASP) L2 Project

Green Status Line Date 9/30/17

Acronyms

ACAS	Airborne Collision Avoidance System
ACAS-Xu	Version of ACAS for Unmanned Aircraft
ADS-B	Automatic Dependent Surveillance - Broadcast
AFRC	Armstrong Flight Research Center
AFRL	Air Force Research Lab
AGL	Above Ground Level
AOSP	Airspace Operations and Safety Program
API	Annual Performance Indicator
AR	Annual Review
ARC	Ames Research Center or Aviation Rule Making Committee
ARD	Aeronautics Research Director
ARMD	Aeronautics Research Mission Directorate
ATC	Air Traffic Controller
ATM	Air Traffic Management
ATO	Air Traffic Organization-FAA Organization/Authority to Operate
BLOS	Beyond Line of Sight
BRLOS	Beyond Radio Line of Sight
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CA	Collision Avoidance
CAN	Cooperative Agreement Notice

Acronyms

CAS	Collision Avoidance System
CDR	Critical Design Review
CE	Chief Engineer
Cert	Certification
CNPC	Control and Non-Payload Communications
CNS	Communication, Navigation and Surveillance
COA	Certificate of Authorization or Waiver
Comm	Communications
CONOPS	Concept of Operations
CR	Change Request or Continuing Resolution
CS	Civil Servant
DAA	Detect and Avoid
DAIDALUS	Detect and Avoid Alerting Logic for Unmanned Systems
DoD	Department of Defense
E2V2	End to End Verification and Validation
EUROCAE	European Organization for Civil Aviation Equipment
ExCom	Executive Committee
FAA	Federal Aviation Administration
FL	Flight Level
FRAC	Final Review and Comment
FT	Flight Test

Acronyms

FTE	Full Time Equivalent
FY	Fiscal Year
GA	General Atomics
GA-ASI	General Atomics Aeronautical Systems Inc.
GBDAA	Ground Based Detect and Avoid
GBSAA	Ground Based Sense and Avoid
GCS	Ground Control Station
GDS	Great Dismal Swamp
Gen	Generation
GPS	Global Positioning System
GRC	Glenn Research Center
HF	Human Factors
HITL	Human-in-the-loop
HMD	Horizontal Missed Distance
HSI	Human Systems Integration
HQ	Headquarters
IASP	Integrated Aviation Systems Program
ICAO	International Civil Aviation Organization
IDIQ	Indefinite-Delivery, Indefinite-Quantity
IFR	Instrument Flight Rules
IHITL	Integrated Human-In-The-Loop

Acronyms

IMS	Integrated Master Schedule
IR	Infra Red
IRP	Independent Review Panel
IT&E or ITE	Integrated Test and Evaluation
KDP	Key Decision Point
L1	Level 1
L2	Level 2
LaRC	Langley Research Center
LOS	Line of Sight
LoWC	Losses of Well Clear
LS	Large Scale
LVC	Live Virtual Constructive
LVC-DE	Live Virtual Constructive Distributed Environment
MACS	Multi Aircraft Control Station
MIT-LL	Massachusetts Institute of Technology Lincoln Labs
MITRE	MITRE Corporation
MOA	Memorandum of Agreement
MOPS	Minimum Operational Performance Standards
M&S	Modeling and Simulation
MS&A	Modeling, Simulation, and Analysis
MSL	Mean Sea Level

Acronyms

N2	2nd upgrade to the original NBS
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NCC	No Chase COA
NextGen	Next Generation
NRA	NASA Research Announcement
ODM	On Demand Mobility
OE	Operating Environment
OEM	Original Equipment Manufacturer
OPNET	OPNET Technologies
OSD	Office of the Secretary of Defense Slide 15
OV-1	Operational View
P1	Phase 1
P2	Phase 2
PDR	Preliminary Design Review
PE	Project Engineer
PER	Preliminary Experiment Review
PI	Progress Indicator
PM	Project Manager
PO	Project Office
PP	Project Plan

Acronyms

PPBE	Planning, Programming, Budgeting, and Execution
PRD	Project Requirements Document
PRP	Performance Review Panel
PT	Part Task
PVS	Prototype Verification System
Q	Quarter
RA	Resolution Advisory
RADAR	Radio Detection and Ranging
R&D	Research and Development
RF	Radio Frequency
RFI	Request for Information
RFP	Request for Proposal
RPAS	Remotely Piloted Aircraft Systems
RT	Research Theme
RTT	Research Transition Team
SAA	Sense and Avoid or Space Act Agreement
SatCom	Satellite Communications
SC	Special Committee
SEMP	System Engineering Management Plan
SIERRA	Sensor Integrated Environmental Remote Research Aircraft
Sim	Simulation

Acronyms

SIO	Systems Integration Operationalization
SME	Subject Matter Expert
SP	Schedule Package
SPM	Subproject Manager
SS	Self Separation
SWaP	Size Weight and Power
TB	Technical Baseline
TBD	To Be Determined
TBEN	Technical Baseline Element Number
TC	Technical Challenge
TCAS	Traffic Collision Avoidance System
ToR	Terms of Reference
TRL	Technology Readiness Level
TSO	Technical Standard Order
TT	Technology Transfer
TWP	Technical Work Package
UA	Unmanned Aircraft
UAS	Unmanned Aircraft Systems
UAS-NAS	Unmanned Aircraft Systems Integration in the National Air Space System
UAV	Unmanned Aircraft Vehicle
UNITD	UAS-NAS Interoperability for TCAS and DAA

Acronyms

US	United States
UTM	UAS Traffic Management
VFR	Visual Flight Rules
VIP	Very Important Person
VLOS	Visual Line of Sight
vMDIO	Virtual Mission Directorate Integration Office
VSCS	Vigilant Spirit Control Station
WG	Working Group
WYE	Work Year Equivalent