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

FY18 Annual Review

15 October 2018

Robert Sakahara
Project Manager

Davis Hackenberg
Deputy Project Manager

Laurie Grindle
Associate Project Manager

William Johnson
Chief Engineer

April Jungers
Lead Resource Analyst

Agenda

8:30– 8:45	Welcome, Opening Remarks, Integrated Aviation Systems Program (IASP) Overview	Dr. Edgar Waggoner
8:45 – 9:30	UAS-NAS Overview	Davis Hackenberg
9:30 – 10:15	Technical Performance	William Johnson
10:15 – 10:30	Break	
10:30 – 11:00	Technical Performance	William Johnson
11:00 – 12:00	Project Level Performance & Fiscal Year (FY) 19 Look Ahead Review Summary	Laurie Grindle
12:00	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 FY19

Outline

- UAS Integration in the NAS (UAS-NAS) Overview
  - FY18 Summary
  - UAS-NAS Project Background
- Technical Performance
- Project Level Performance & FY19 Look Ahead
- Review Summary

FY18 Summary

- Successful completion of multiple Project Research Activities (simulations and flight tests) in support of Phase 2 Detect and Avoid (DAA) and Command and Control (C2) Technical Challenges (TC)

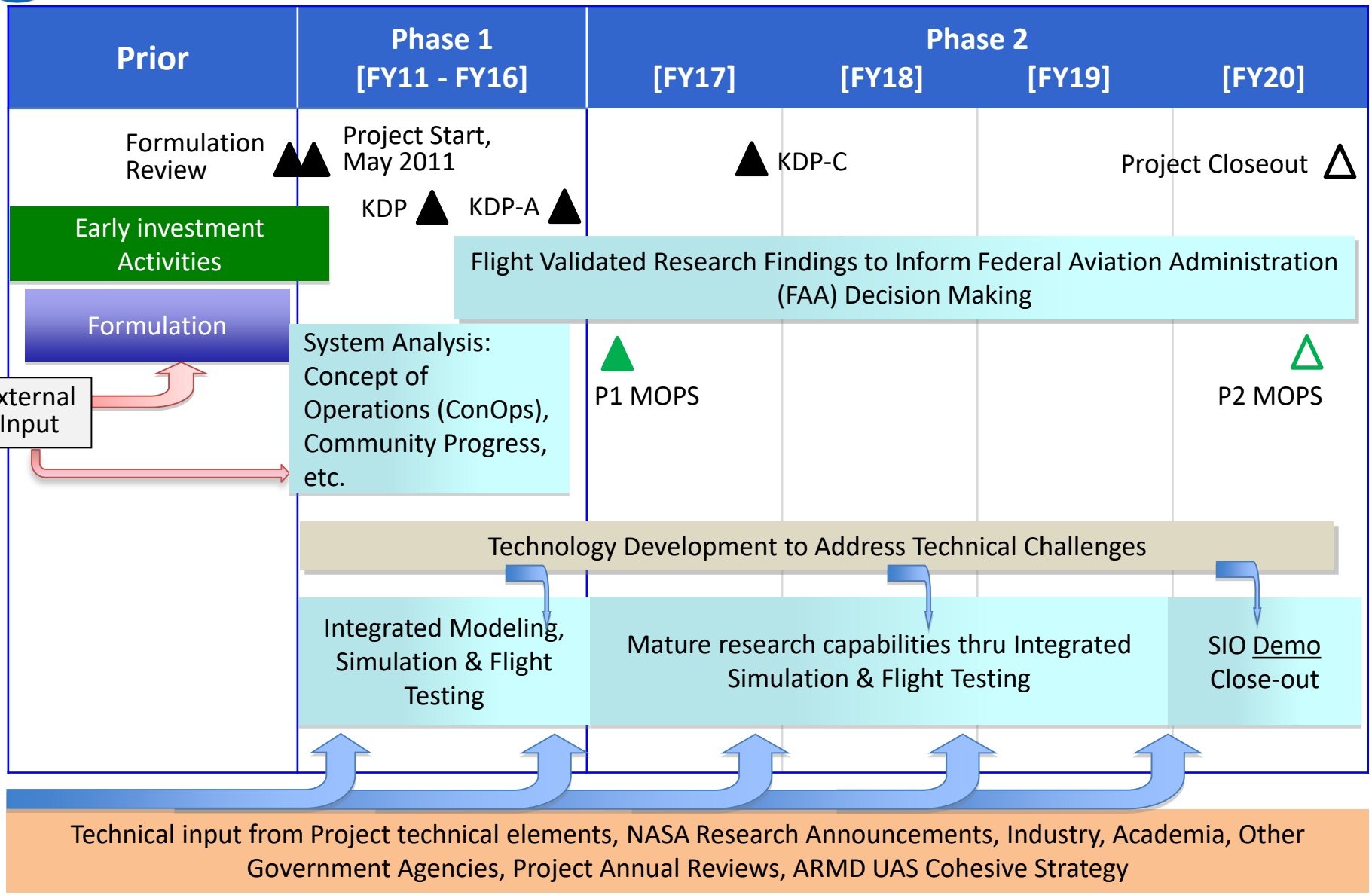
- Successfully advanced the Systems Integration and Operationalization (SIO) Demonstration through Cooperative Agreements (CA) with selected Industry Partners

- Established Research Transition Team (RTT) formally with the Federal Aviation Administration (FAA)

- Successful continuous risk management
  - Flight Test (FT) 5 and 6

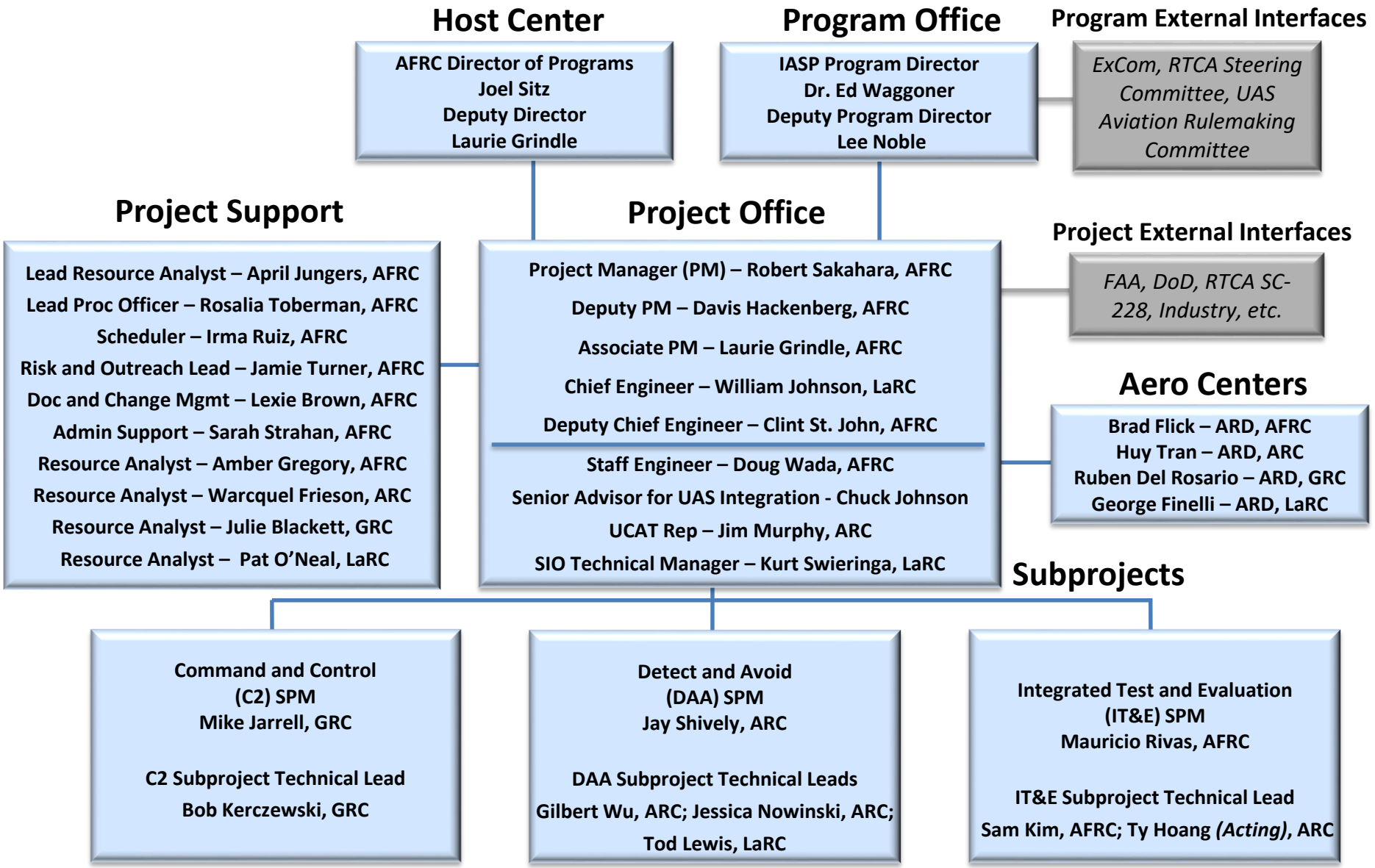
- Effective Schedule and Milestone management

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 Manager, UCAT: Urban Air Mobility Coordination Assessment Team, SIO: Systems Integration and Operationalization

Personnel Changes

- Data Redacted

NASA Strategic Plan Flow Down to UAS-NAS Project

STRATEGIC GOAL

3: Address national challenges and catalyze economic growth

OBJECTIVE

3.2: Transform aviation through revolutionary technology research, development, and transfer

PERFORMANCE GOAL
UAS-NAS

3.2.6: 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 UAS in the NAS, through the development and maturation of technologies and validation of data

Annual Performance Indicators (APIs)
UAS-NAS

AR-18-10: Complete the data collection, analysis, and reporting for DAA well clear / alerting requirements, foundational terminal operations, HITL simulation; and complete the initial test asset for the C2 Version 6 (V6) terrestrial communication system test

AR-19-10: Complete the data collection, analysis, and reporting for the DAA and IT&E FT5 and for the C2 V6 terrestrial communication system flight test

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 UAS into the NAS

ARMD Strategic Plan Flow Down to UAS-NAS Project

*AERONAUTICS STRATEGIC THRUST

Thrust 6: Assured Autonomy for Aviation Transformation

AERONAUTICS OUTCOME

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

AERONAUTICS Critical Commitment

Critical Commitment:
Deliver validated flight data to RTCA for MOPS enabling persistent UAS flight in Class E airspace

UAS-NAS *Technical Content*

TC-C2:
UAS Command & Control

TC-DAA:
Detect and Avoid

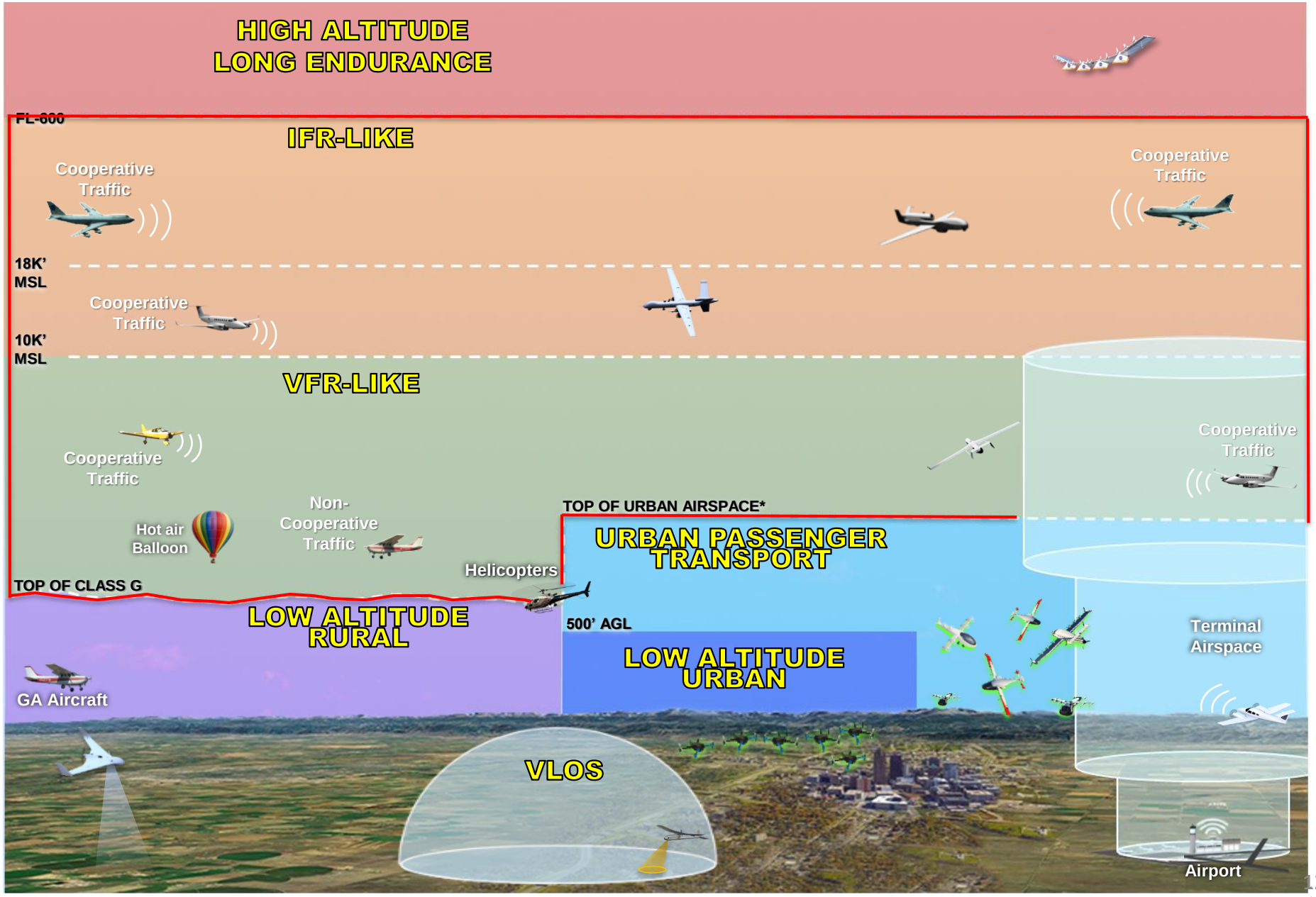
SIO:
Systems Integration and Operationalization

* Note: UAS-NAS is also related to Thrust 1 through the Thrust TC - Develop Operational Standards for UAS in NAS

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

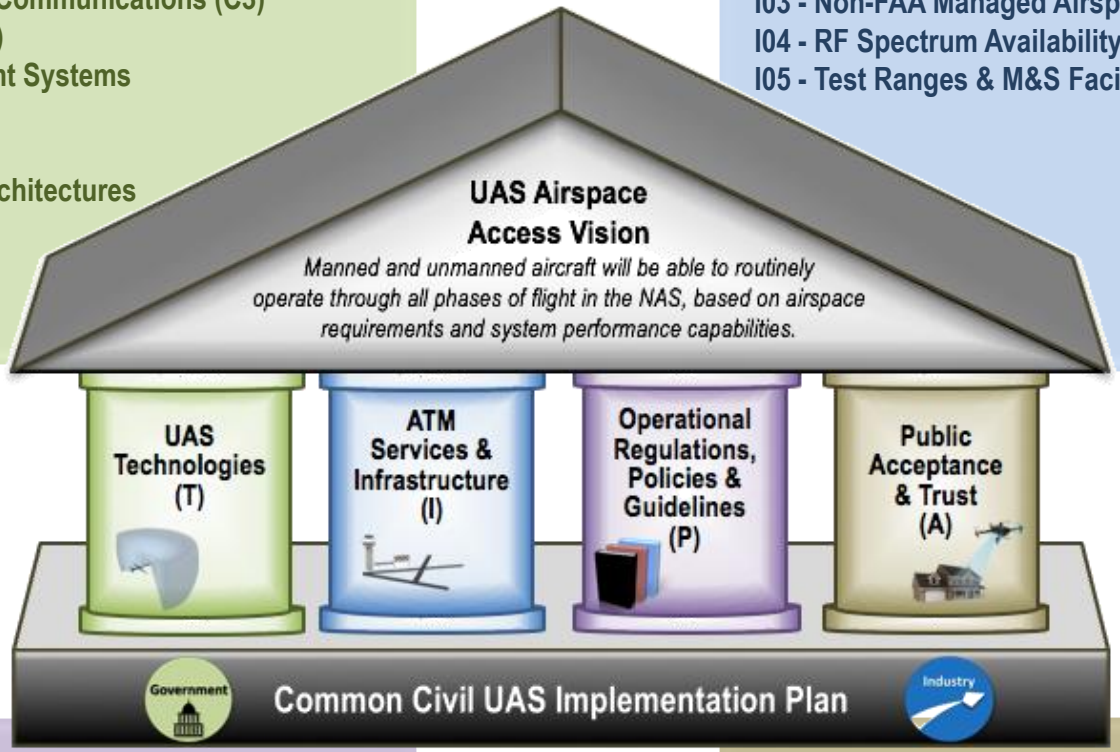
Commercial Operating Environments (OE)



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-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*
  - *Low Cost SWaP sensors*
  - *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

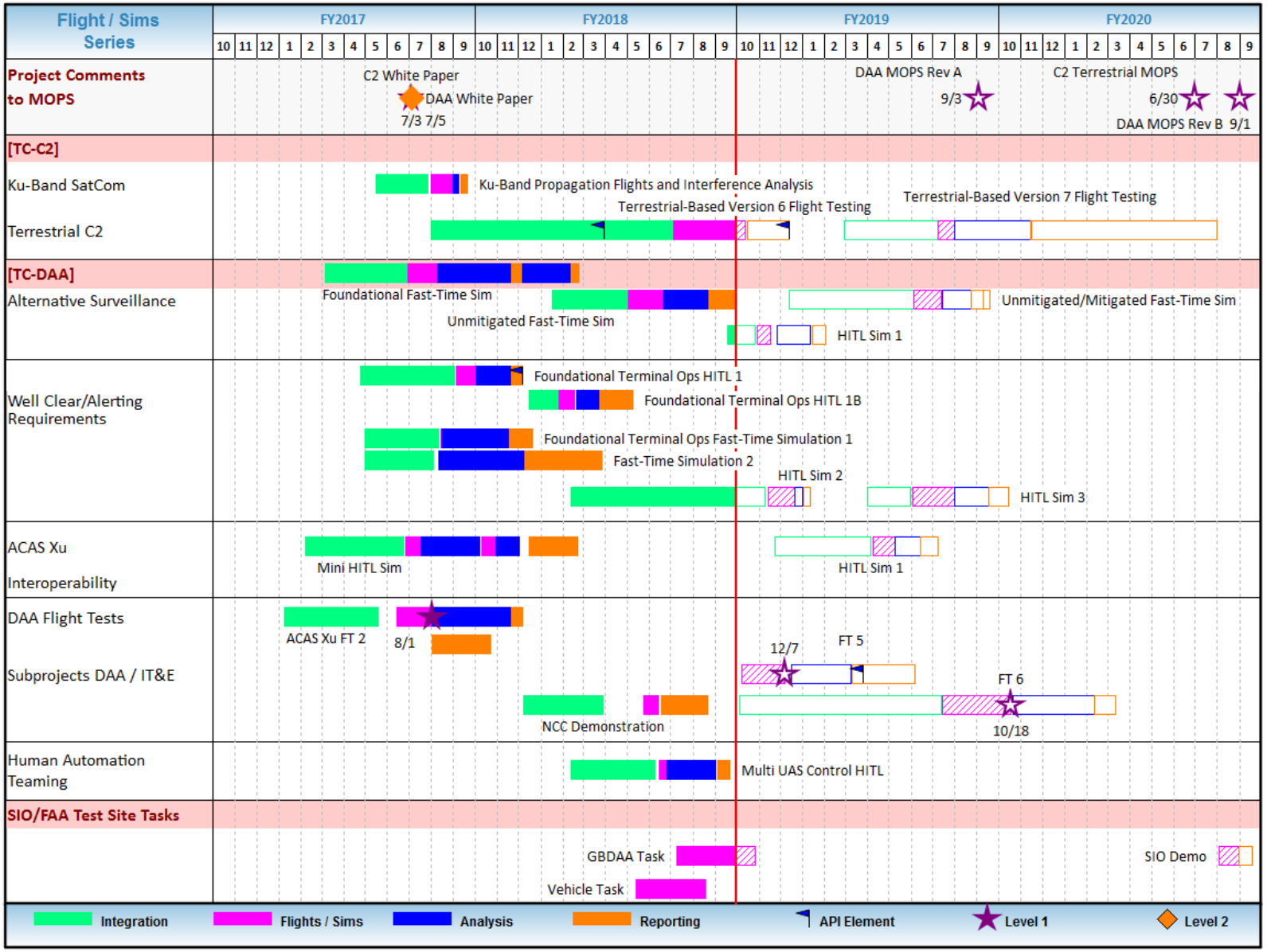
- Develop Robust NASA/Industry Partnership
- Document certification and airworthiness approaches
- Integrate Essential Technologies
- Conduct Demo

Key Products

- *C2 Performance Requirements to inform C2 MOPS*
  - RTCA Terrestrial MOPS
  - C2 MASPS
  - → C2 Technical Standard Order (TSO)
- *DAA Performance Requirements to inform DAA MOPS*
  - RTCA Non-Coop Sensor MOPS
  - GBDAA MOPS
  - → DAA Technical Standard Order (TSO)
- *Re-usable Test Infrastructure*
  - RTCA DAA MOPS Rev A/B
- *Progress Toward Certification*
  - → Generic Certification and Airworthiness Approaches

Resultant Outcomes

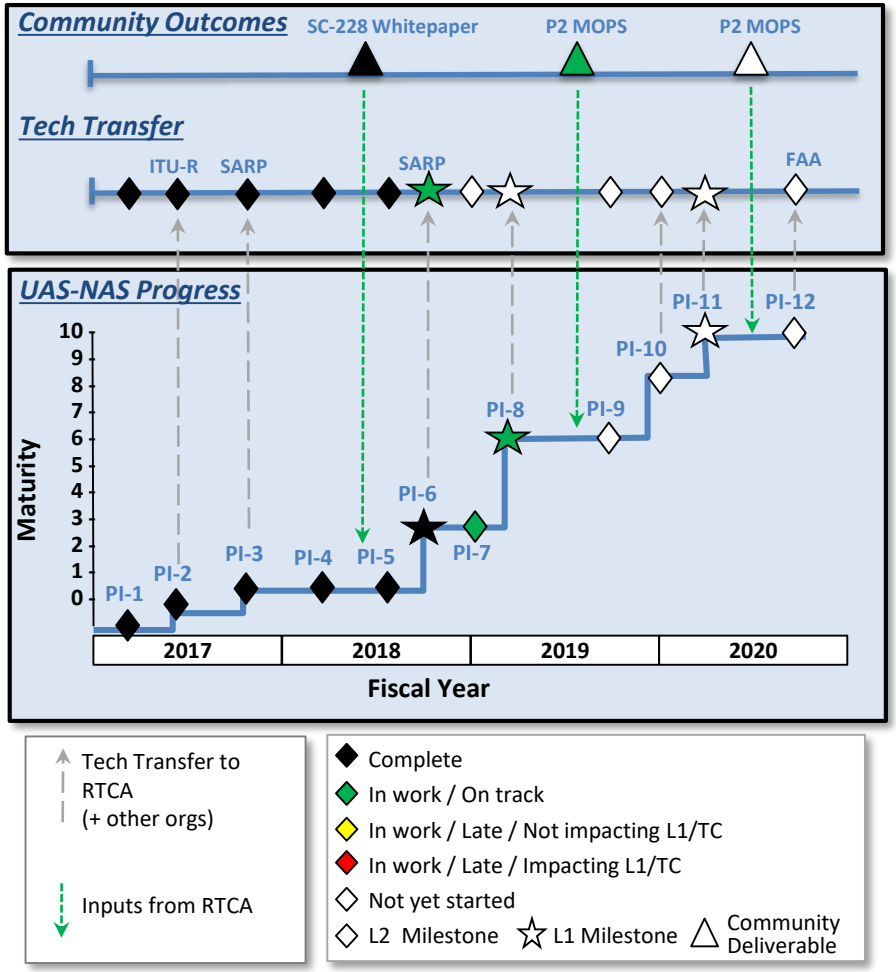
Phase 2 Flight and Simulation Overview



Red Status Line Date 9/30/18

Progress Indicator Definition

- Technical Challenge progress is tracked by means of Progress Indicators (PI)
  - Schedule Package (SP) L2 milestones are the data points for these plots
- Progress Indicators, i.e. lower portion of the plot, represent execution/data collection of Project SP activities
- Tech Transfer (i.e. upper portion of the plot), plotted to coincide with execution, represents the data analysis and reporting of SP Activities
- Assessed individual contribution towards achieving the overall technical challenge
  - High = 2, i.e. Integrated Tests
  - Moderate = 1, i.e. multiple subproject technologies
  - Low = 0, i.e. foundational activities
- Results normalized and placed on a 10 point maturity scale represents meeting the content of the TC



- Progress is tracked against all the tasks in the schedule package using a color indicator

Outline

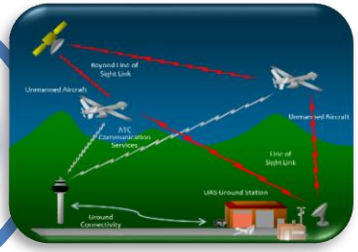
- UAS-NAS Overview
- Technical Performance
  - TC-DAA
  - TC-C2
  - SIO
- Project Level Performance & FY19 Look Ahead
- Review Summary

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

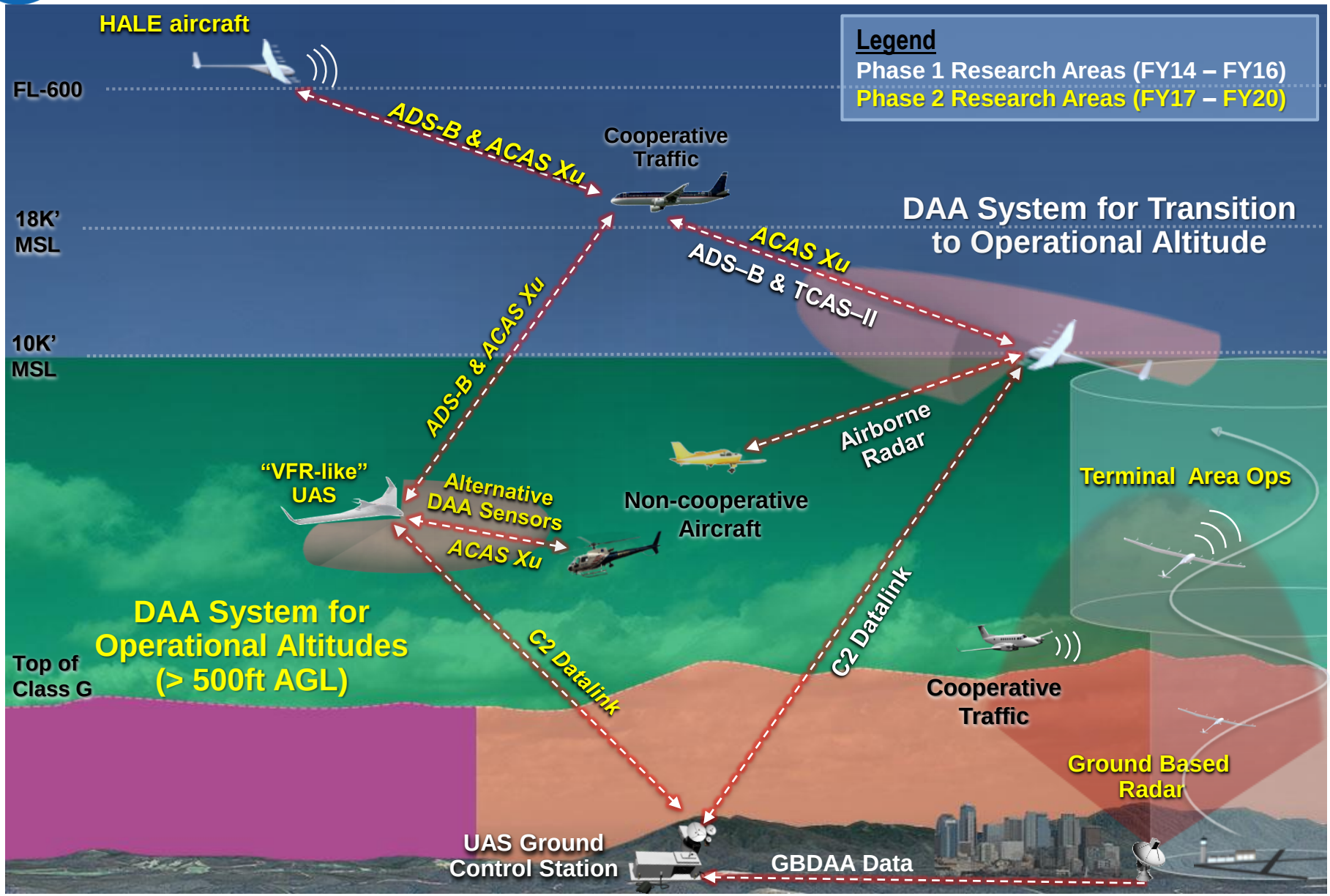
Technical Challenge-DAA: Detect and Avoid (DAA)



Technical Challenge-C2: Command and Control (C2)

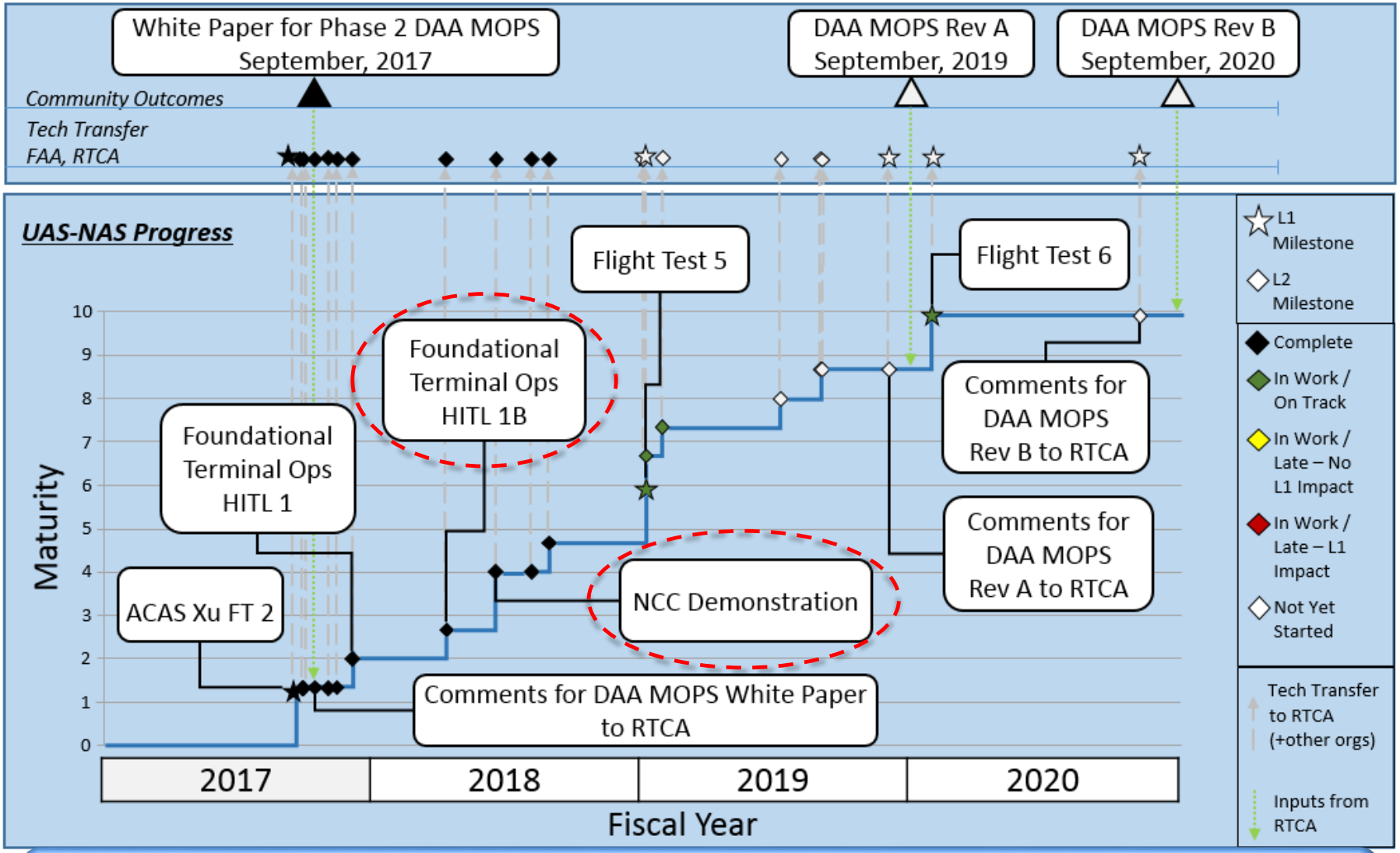
Systems Integration and Operationalization (SIO)

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



TC-DAA: Progress Indicator

As of 9/30/18



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

Well Clear/Alerting Requirements: Foundational Terminal Ops Human in the Loop (HITL) Simulation 1B

✓ Research Objective:

- Explore pilot performance and operational suitability issues associated with Class D terminal area operations
  - Implement two candidates for a terminal area DAA well clear (DWC) definition
  - Further investigate the efficacy of the DAA Corrective alert in the terminal area
  - Compare pilot and system performance to previous studies

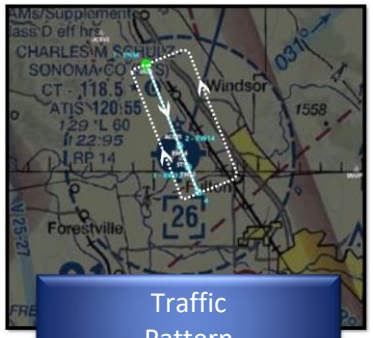
DWC Candidate (Within-Subjects):

	No Tau	Tau
Horizontal Threshold*	1500ft	1500ft
Vertical Threshold	450ft	450ft
modTau	N/A	15sec

*HMD in Tau definition

DWC Candidates

Vigilant Spirit Control Station



Traffic Pattern

- **Status:**
  - Experiment design completed December 2017
  - Data collection completed February 2018
  - Results dissemination completed May 2018
  - Technical Baseline Element completed May 2018

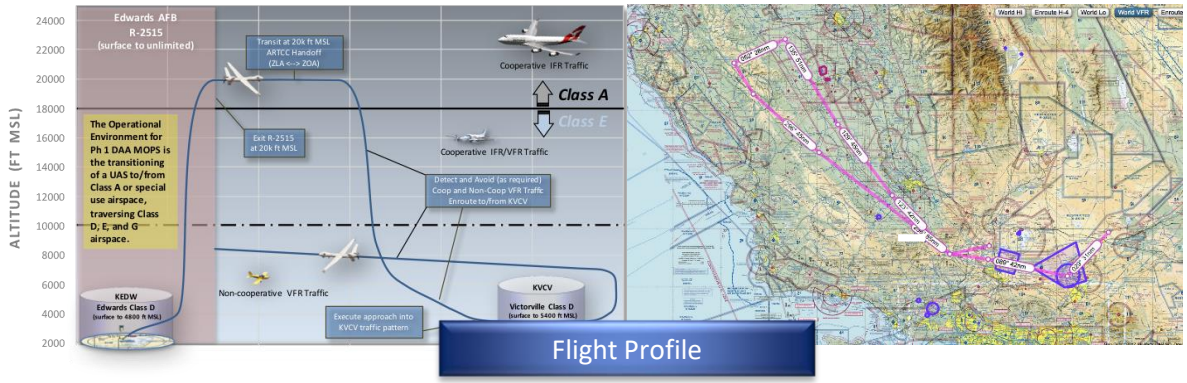
Results support definition of Terminal Area Well Clear

Technical Baseline Element Number: TBEN-024 (SP D.2.90)

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 an 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 Be	ies.

Description

- **Status:**
  - No-Chase COA (NCC) Objectives defined May 2017
  - Conducted NCC Kick-Off meeting with FAA May 2017
  - NCC Approval received March 2018
  - NCC Demonstration Flights completed June 2018
  - NCC Flight Test Report completed August 2018

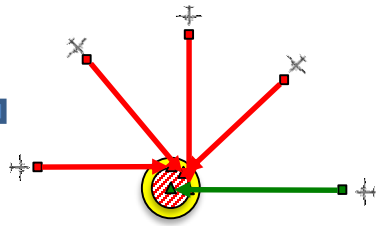
FAA (AJT): "…successful event … no different than a manned flight …"

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

DAA Flight Test 5 (FT5) - Original

NASA SIERRA-B
UAS

NASA AFRC
Test Range

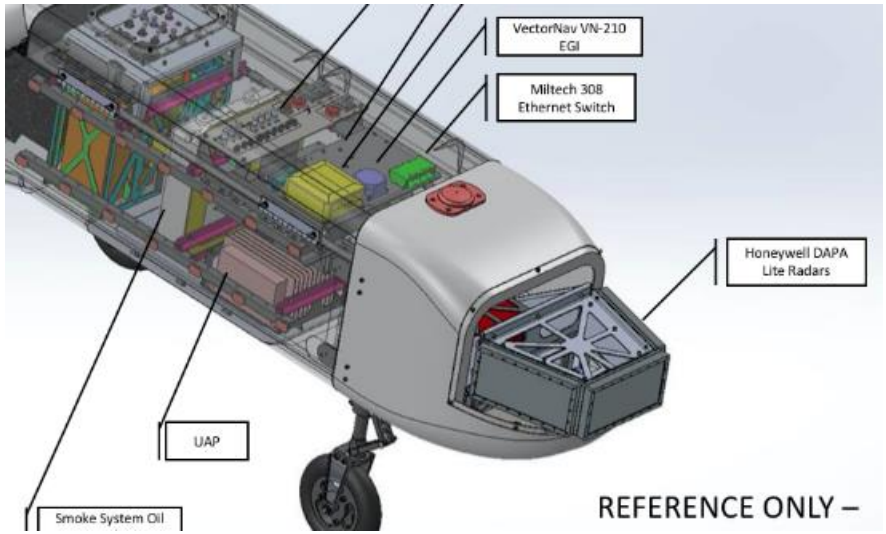


DAA Unmitigated
Encounters with
Intruders

Successful
Technology
Readiness for FT6

Flight Test ConOps

- NASA Sensor Integrated Environment Remote Research Aircraft (SIERRA-B) Group 3 UAS equipped with Low size, weight, and power (SWaP) air to air (A/A) sensors performing unmitigated DAA encounters with manned intruder(s)
  - A/A sensor tracks downlinked to the Ground Control Station (GCS) for processing by DAA algorithm
    - NASA SIERRA-B equipped with non-cooperative and cooperative (Automatic Dependent Surveillance-Broadcast (ADS-B) In) sensors and a tracker to correlate multiple sensor tracks
  - DWC alerts and maneuver guidance provided on standalone DAA display
  - UAS pilot employs DAA display to meet encounter test objectives



DAA Flight Test 5 (FT5) - New

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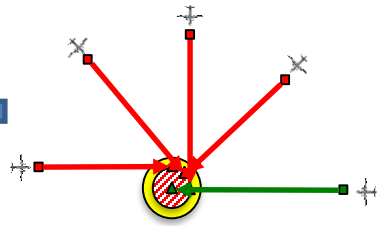


Honeywell AStar Helicopter

Honeywell Test Range

DAA Unmitigated Encounters with Intruders

Successful Technology Readiness for FT6

Flight Test ConOps

- ~~NASA SIERRA-B Group 3 UAS~~ Honeywell AStar manned helicopter equipped with Low SWaP A/A sensors performing unmitigated DAA encounters with manned intruder(s)
  - A/A sensor tracks ~~downlinked to the GCS~~ stored onboard the aircraft for post-processing by DAA algorithm
    - ~~NASA SIERRA-B~~ Helicopter equipped with non-cooperative and cooperative (ADS-B In) sensors and a tracker to correlate multiple sensor tracks
  - ~~DWC alerts and maneuver guidance provided on standalone DAA display~~
  - ~~UAS pilot employs DAA display to meet encounter test objectives~~

Picture removed

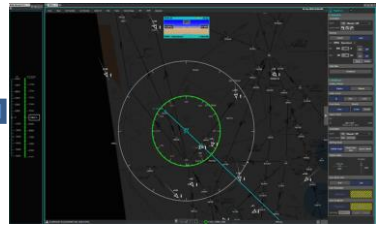
Addressed by analysis and post-processing of flight data

DAA Flight Test 6 (FT6) - Original

Original FT6 Operational Plans

NASA SIERRA-B
UAS

NASA AFRC
Test Range

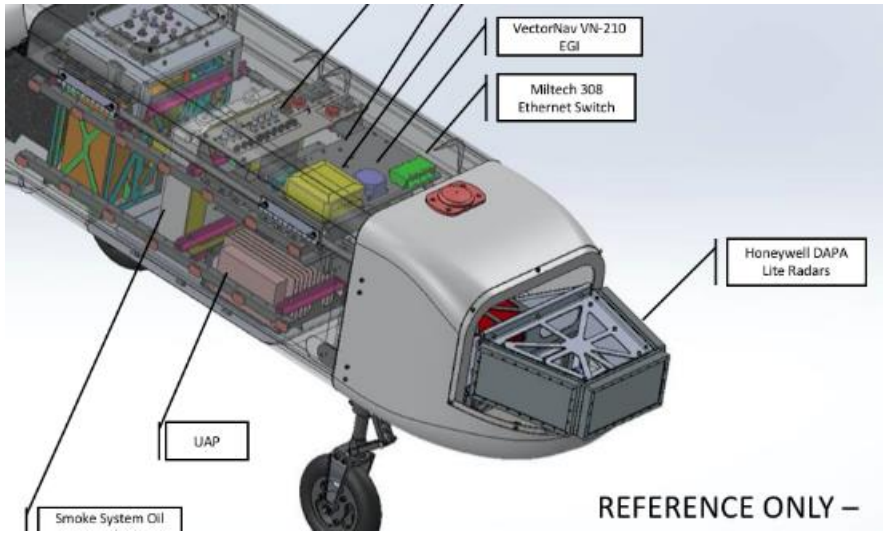


DAA Unmitigated
and Mitigated
Encounters with
Intruders

Successful Data
Collection for DAA
Standards
Development

Flight Test ConOps

- NASA SIERRA-B Group 3 UAS equipped with Low SWaP A/A sensors performing unmitigated and mitigated DAA encounters with manned intruder(s)
  - A/A sensor tracks downlinked to the GCS for processing by DAA algorithm
    - NASA SIERRA-B equipped with non-cooperative and cooperative (ADS-B In) sensors and a tracker to correlate multiple sensor tracks
  - DWC alerts and maneuver guidance provided on Vigilant Spirit Control System GCS
  - UAS pilot employs DAA display to meet encounter test objectives
  - Full mission operations with pilot performance data to validate Human in the Loop (HITL) results



Note: Blue font represents changes from FT5

DAA Flight Test 6 (FT6) – New

New FT6 Operational Plans

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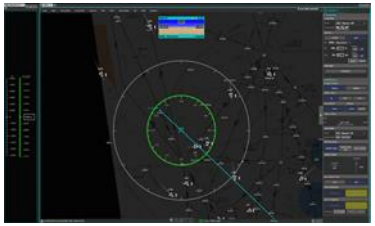
NASC TigerShark XP

NASA AFRC Test Range

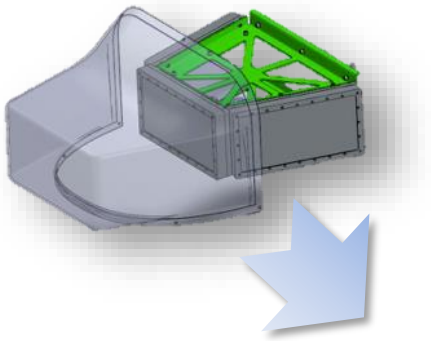


DAA Unmitigated and Mitigated Encounters with Intruders

Successful Data Collection for DAA Standards Development

Flight Test ConOps

- ~~NASA SIERRA-B~~ Navmar Applied Sciences Corporation (NASC) TigerShark XP Group 3 UAS equipped with Low SWaP A/A sensors performing unmitigated and mitigated DAA encounters with manned intruder(s)
  - A/A sensor tracks downlinked to the GCS for processing by DAA algorithm
    - ~~NASA SIERRA-B~~ NASC TigerShark XP equipped with non-cooperative and cooperative sensors and a tracker to correlate multiple sensor tracks
  - DWC alerts and maneuver guidance provided on Vigilant Spirit Control System GCS
  - UAS pilot employs DAA display to meet encounter test objectives
  - Full mission operations with pilot performance data to validate HITL results



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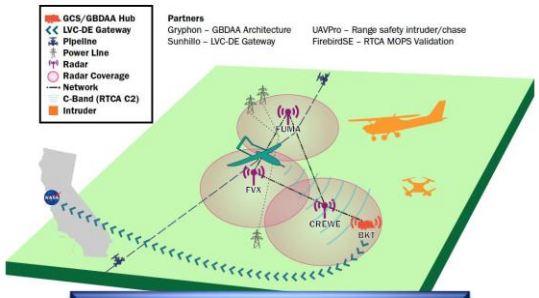
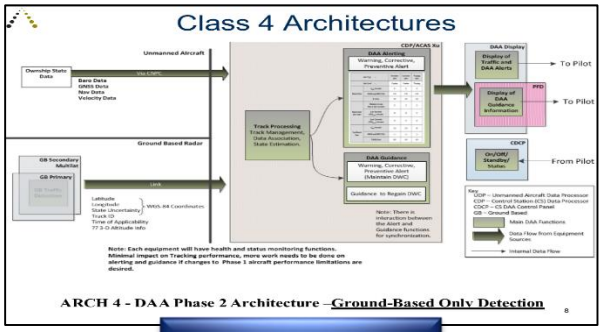
Nose section to be modified to accommodate the DAPA-Lite sensor and radome

FAA Test Site Ground Based Detect and Avoid Demonstration

- **Goal: Implement a GBDAA system with long term strategic value to NASA, FAA, and industry partners**
  - 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 a means for industry to evaluate technologies and procedures for low level BVLOS use cases
  - Provide a foundation for future commercial waivers seeking operational capability for industry applications



GBDAA Range Configuration



GBDAA Architecture

- **Status:**
  - Two of three flight campaigns using General Aviation (GA) aircraft have been completed
    - Campaign 1 completed July 10-12. 29 test instances flown with 1 GA aircraft using 3 radar sites
    - Campaign 2 completed August 1-2. 11 test instances flown with 2 GA aircraft using 3 radar sites
  - Sensor model development is ongoing
- **Next Steps**
  - Complete Campaign 3 fight test October 22-26
  - Sensor models and final report to be provided to NASA December 2018

Not included in Project Technical Baseline

TC-C2:
UAS Command and Control

TC-C2

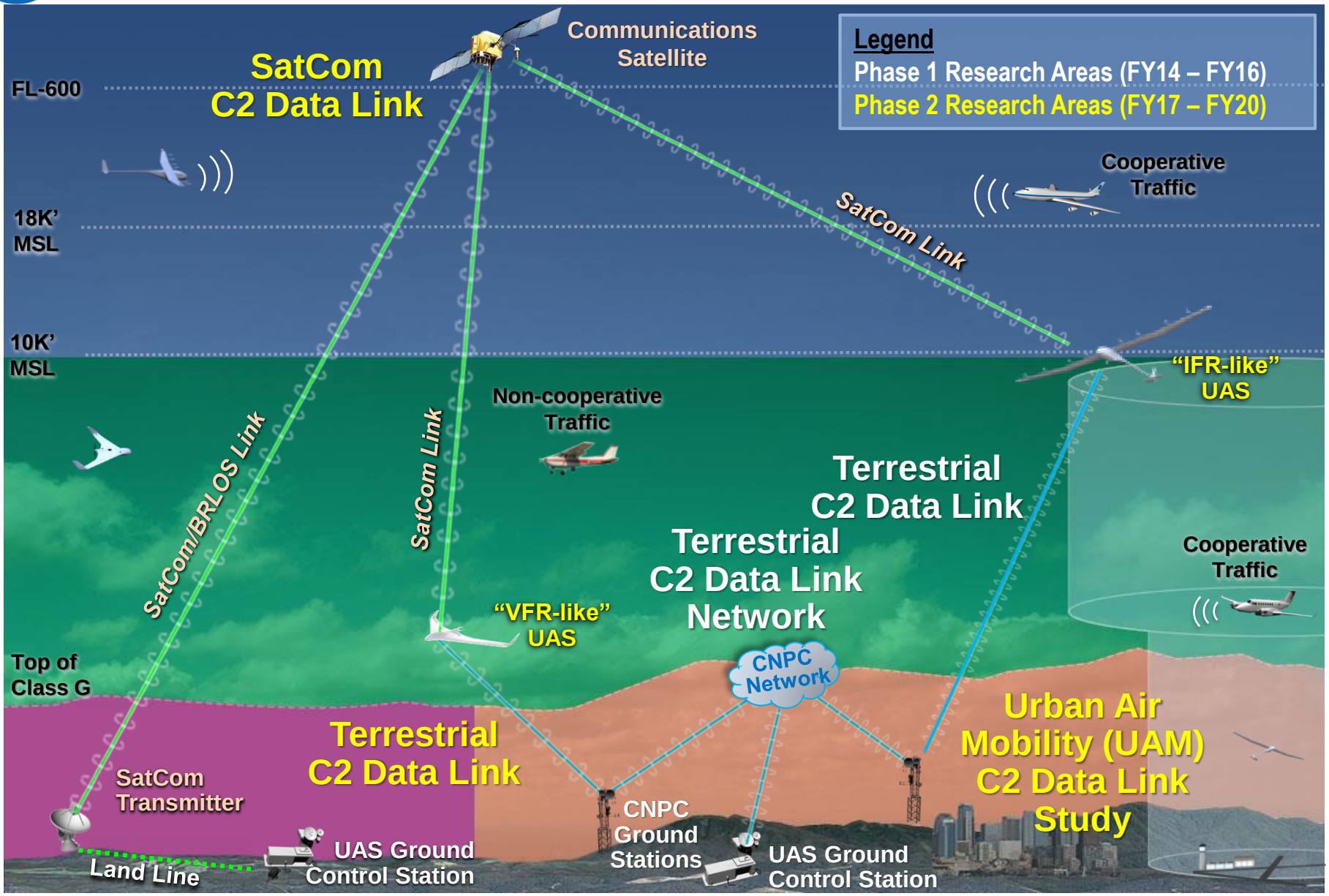
Develop Satellite (SatCom) and Terrestrial based Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage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

Technical Challenge-DAA: Detect and Avoid (DAA)

Technical Challenge-C2: Command and Control (C2)

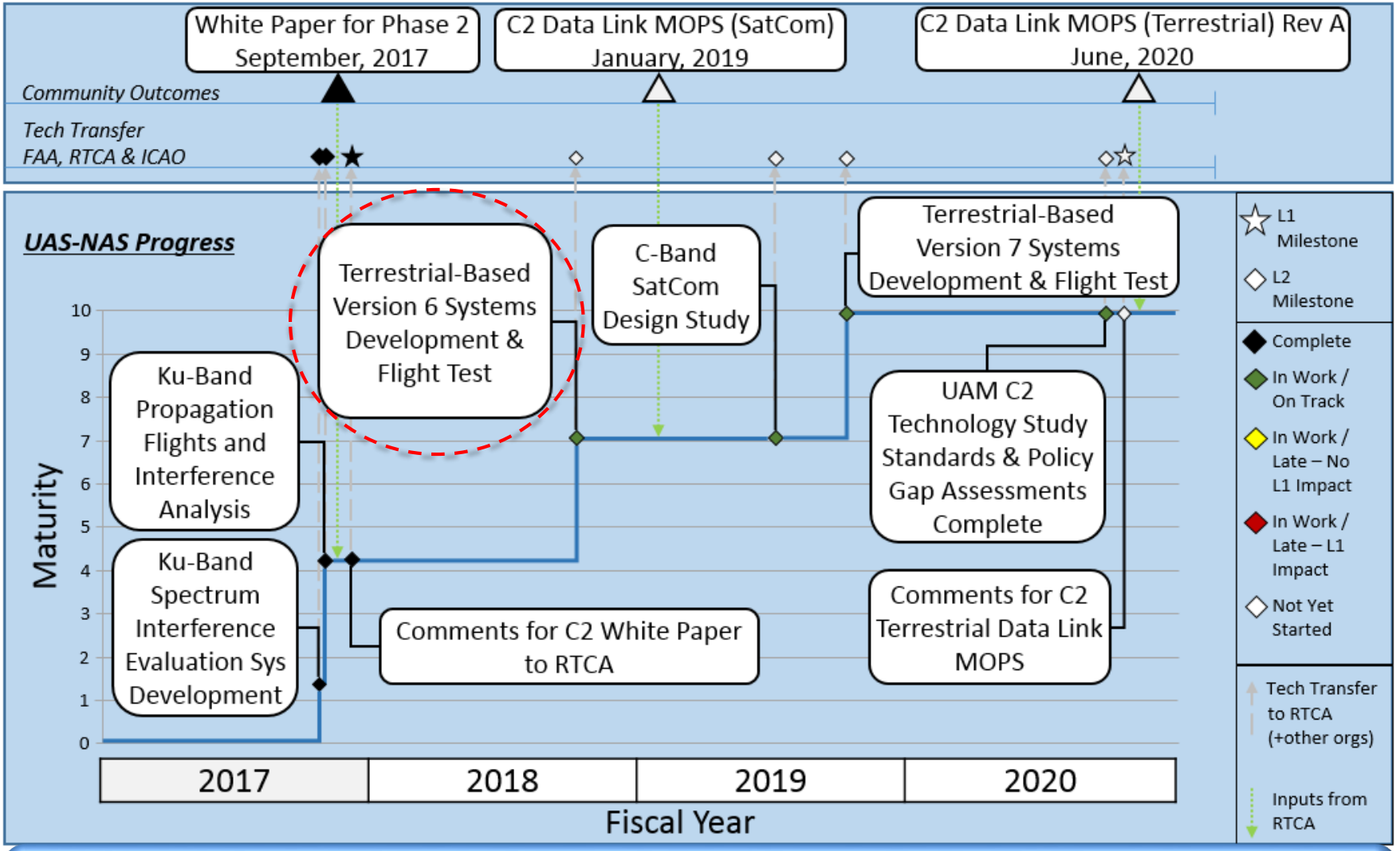
Systems Integration and Operationalization (SIO)

UAS Command and Control Operating Environments (OE)



TC-C2: Progress Indicator

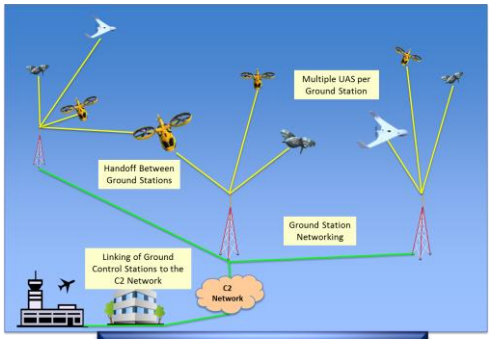
As of 9/30/18



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

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



Terrestrial Challenge


Phase 1 C2 Radio


Phase 2 C2 Radio

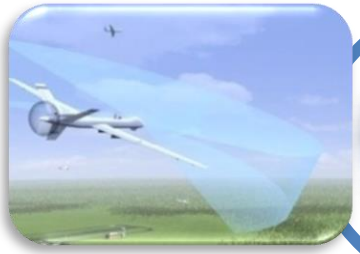
- **Status:**
  - Established Cooperative Agreement for C2 Terrestrial Extension radio January 2017
  - Version 6 (V6) Preliminary Design Review (PDR) completed July 2017
  - V6 Critical Design Review (CDR) completed October 2017
  - V6 Flight Test started July 2018
- **Next Steps:**
  - Terrestrial-Based V6 Flight Test to be completed October 2018
  - Terrestrial-Based Version 7 (V7) Flight Test to be completed July 2019
  - Terrestrial-Based UAS Command & Control Final Report to be completed July 2020

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

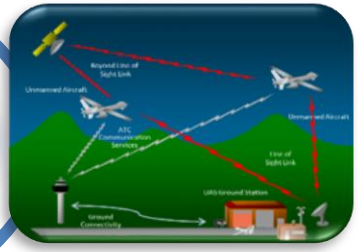
SIO:
Systems Integration and Operationalization

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



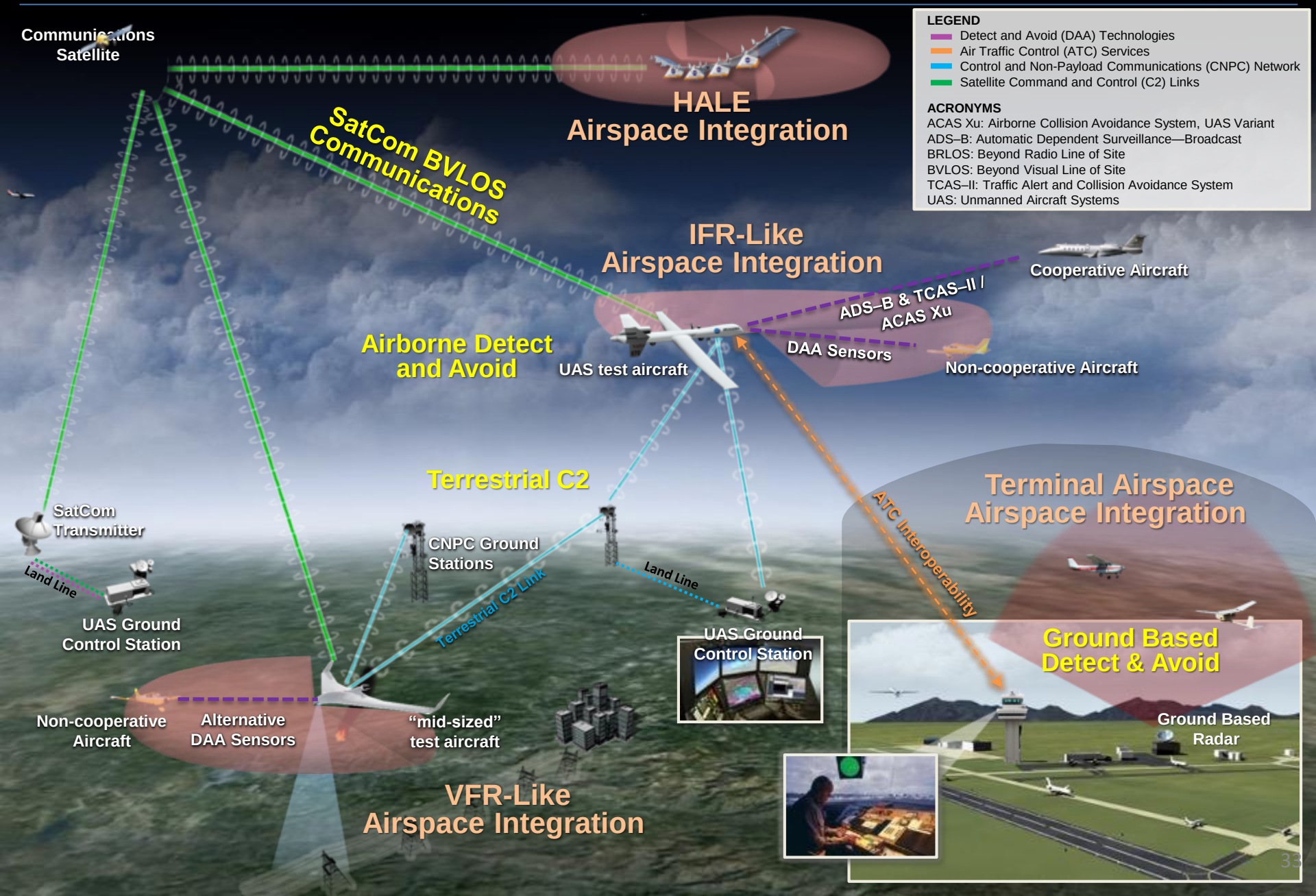
Technical Challenge-DAA: Detect and Avoid (DAA)



Technical Challenge-C2: Command and Control (C2)

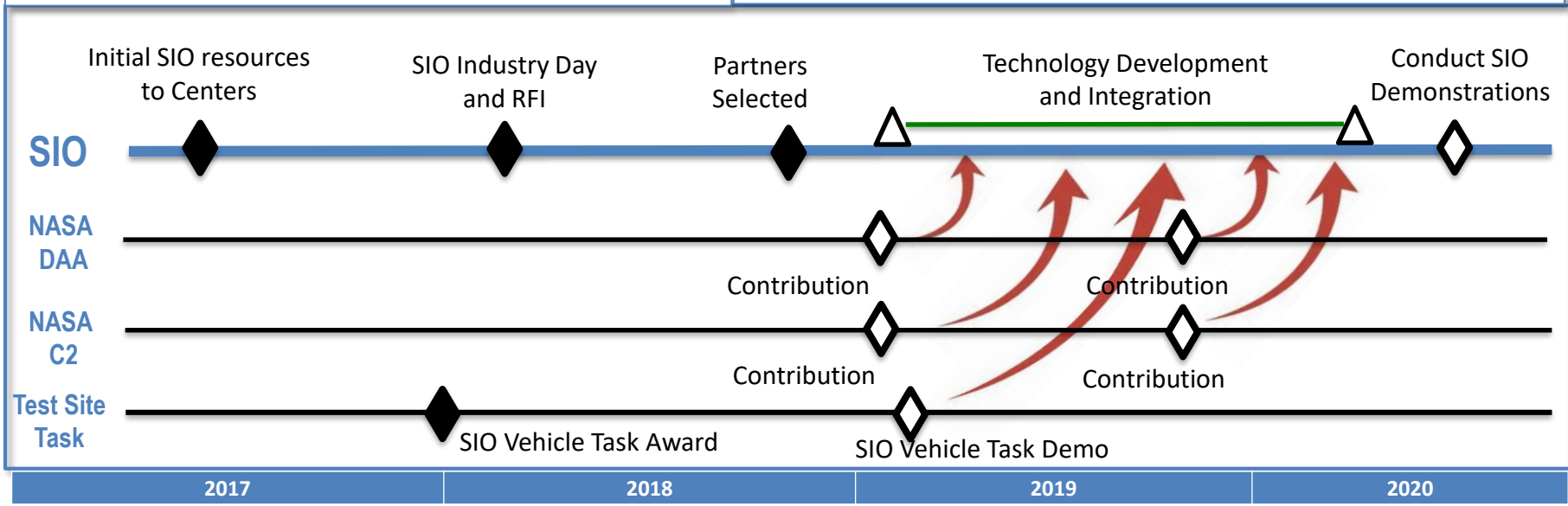
Systems Integration and Operationalization (SIO)

UAS-NAS Project – SIO Operational View Representation



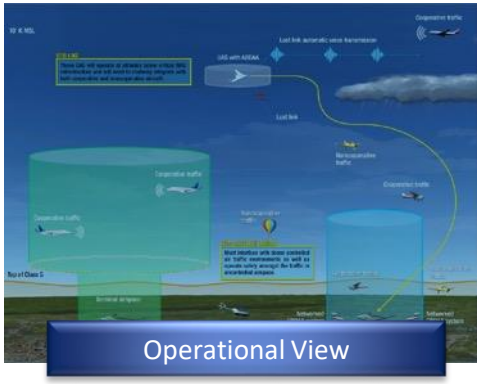
SIO Notional Demonstration Strategy

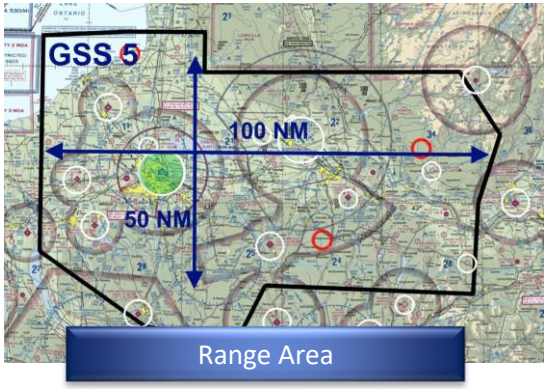
SIO Goals	SIO Partnership Strategy
Goal: Work toward routine commercial UAS operations in the NAS • Obtain approval to operate in the NAS for a FY20 flight demonstration • Demonstrate integrated DAA and C2 technologies • Progress toward Type Certification	Industry Partnership Strategy • Agreements established to conduct industry centric SIO demonstrations in FY20 • Leverage NASA expertise to inform UAS development and integration of DAA, C2, and other technologies required for commercial missions FAA Partnership Strategy • Work through the UAS Integration RTT to obtain approvals, and impact policy, procedures, and regulations



FAA UAS Test Site Vehicle Technology Demonstration Task

- **Research Objective:**
  - Assess the state-of-the-art of individual UAS vehicle technologies for a Concept of Operations (ConOps) that is consistent with NASA's UAS Operational Environments


Operational View



Range Area

- **Status:**
  - Two UAS flight demonstrations completed
    - Demo 1: Completed May 14-16, focused on nominal UAS operations
    - Demo 2: Completed July 16-19, focused on demonstration of technologies for lost link operations, including weather avoidance, an automated voice capability, and obstacle detection during taxi
  - An outreach day was held on July 19, and included representatives from NASA, Air Force Research Lab (AFRL), and industry

- **Next Steps:**
  - Key data from the flight demonstrations will be analyzed to inform RTCA SC228 and future NASA research areas
  - A report will be provided to NASA by October 2018

Not included in Project Technical Baseline

Selected/Awarded SIO Partners

Bell

Mission: Cargo delivery in urban areas

Vehicle: Autonomous Pod Transport - 70 (APT70) electric Vertical Take Off and Landing (VTOL) (240 to 500 lb, depending on configuration)

Test Locations: Wrangler Field (remote area), and Arlington Municipal Airport (urban), Texas

General Atomics

Mission: Infrastructure inspection in Instrument Flight Rules (IFR)-Like airspace

Vehicle: SkyGuardian (12,500 lb)

Test Location: Southern California and Arizona

PAE ISR (Awarded September 25)

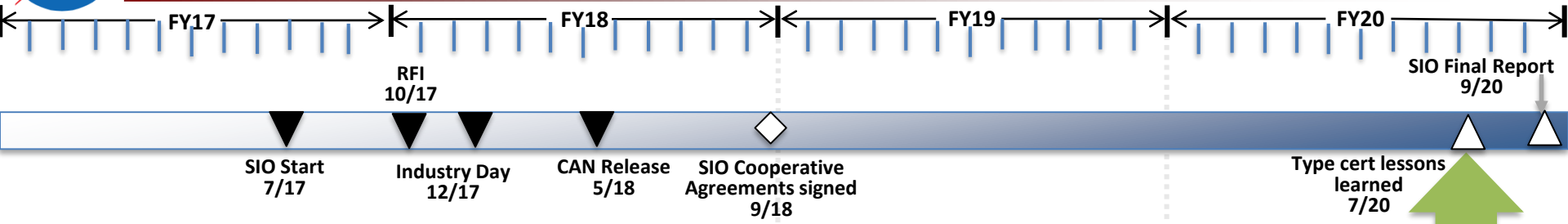
Mission: Pipeline inspection in Visual Flight Rules (VFR)-Like airspace

Vehicle: Resolute Eagle (210 lb)

Test Location: Pendleton Oregon UAS Range (part of Alaska FAA UAS test site)

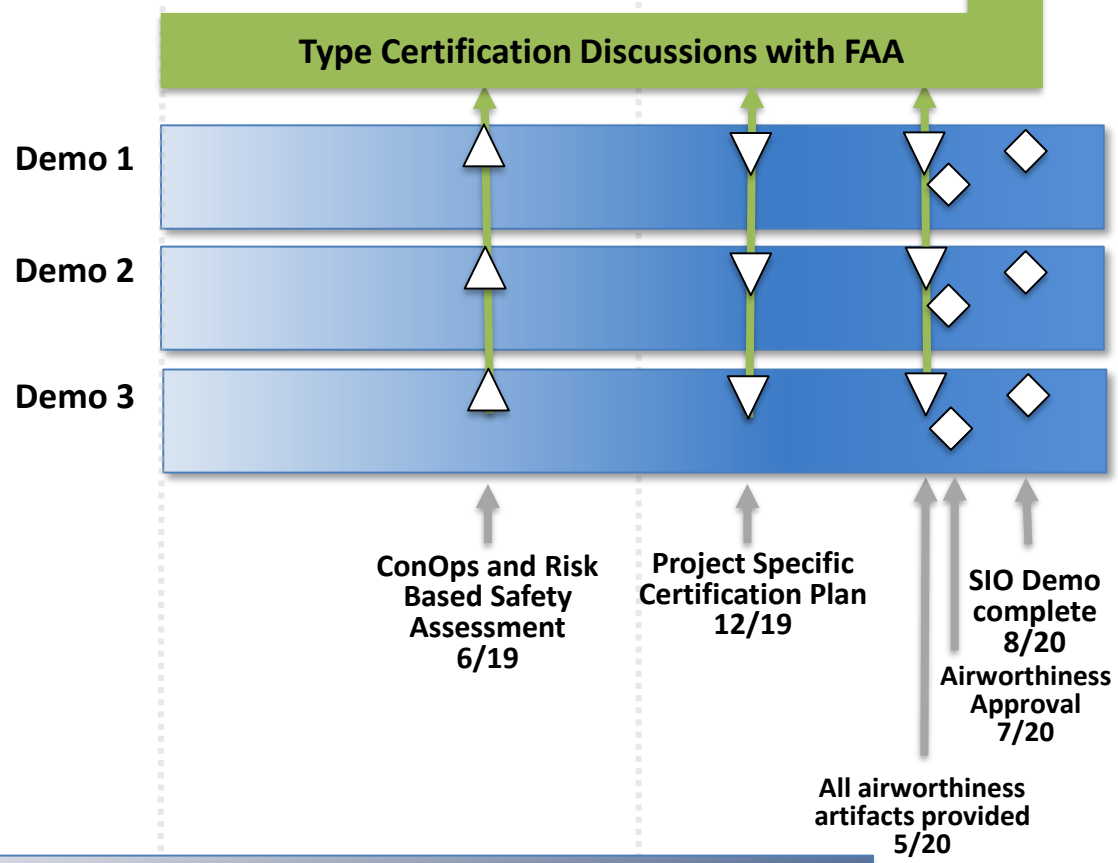
Systems Integration and Operationalization (SIO)

Timeline Not To Scale



Milestone	Type	Date
Cooperative agreements with Industry Partners signed	L2	9/30/18
Baseline *Mission ConOps* and *Risk-Based Safety Assessment* documents complete	L3	7/30/19
Airworthiness approvals for SIO demonstration	L2	7/30/20
Documentation of type certification lessons learned and guidelines provided to Project Office	L3	7/30/20
SIO demonstration complete	L2	8/31/20
SIO *Final Report* provided to project office and submitted for review and export release	L3	9/18/20

☆ - ***L1 Milestone***
◇ - ***L2 Milestone***
△ - ***L3 Milestone***
▽ - ***Significant Event***

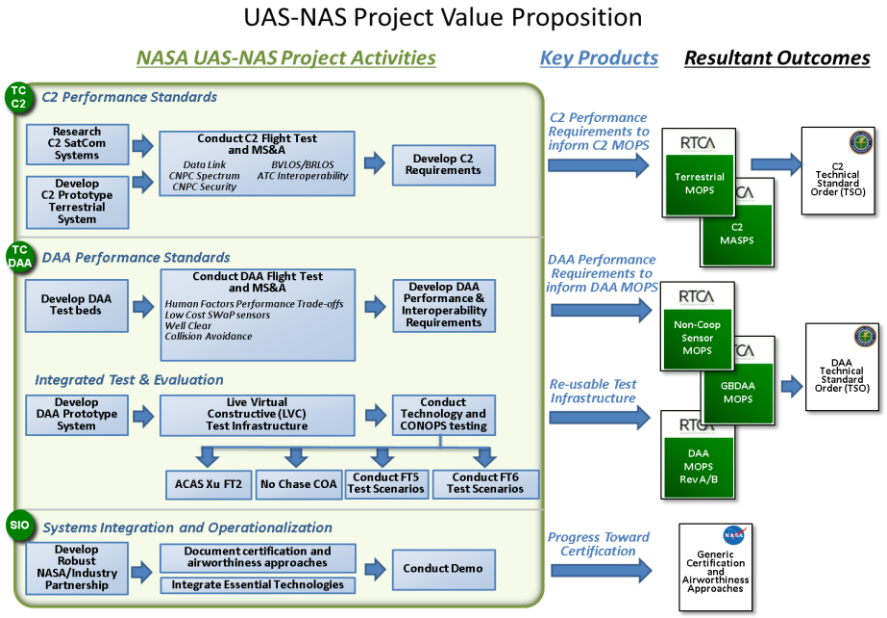


SC-228 P1 MOPS and Draft Phase 2 MOPS

Technical Performance Summary

- TC-DAA
  - Completed No Chase COA flights in the NAS
  - Completed experiment designs, infrastructure preparations, and/or data collection for multiple experiments
  - Delivered data from simulations

- TC-C2
  - Conducted terrestrial based Version 6 radio systems development
  - Completed C-Band Satellite Communications (SatCom) Payload & Earth Station Concept Design
  - ConOps for Urban Air Mobility (UAM) C2 Study delivered



- SIO
  - Three partners identified
  - ConOps presented at SIO RTT planning meeting
  - Detailed schedules in work and resources being assigned

Conducting experiments critical to C2 & DAA MOPS; SIO execution underway

Outline

- UAS-NAS Overview
- Technical Performance
- Project Level Performance & FY19 Look Ahead
  - Risk Summary
  - Resource Allocation and Utilization
  - Schedule Performance
  - Partnerships and Collaboration
  - FAA/NASA UAS Integration Research Transition Team
  - UAS-NAS and Urban Air Mobility (UAM)
  - International Participation and Collaboration
  - FY18 Accomplishments and FY19 Look Ahead
  - FY20 Closeout Planning
- Review Summary

FY18 Risk Management Summary

- Data Redacted

FY18 Top Risks

- Data Redacted

Storm Clouds

- Data Redacted

Resource Allocation against Baseline Budget

- Data Redacted

Resource Utilization FY18
Budget vs. Actuals Summary

- Data Redacted

UAS-NAS FY18 Project Funding

- Data Redacted

Schedule Performance

- Phase 2 Milestone Count
  - Completed 2 of 7 Level 1 Milestones
  - Completed 34 of 66 Level 2 Milestones
    - Experienced some delays to L2 milestones

Table Removed

- Causes of Level 2 Milestone Delays
  - DAA and C2 technical scope changes implemented to better align with community requirements
  - C2 Version 6 radio performance issues impacted delivery
  - SIERRA-B airworthiness and envelope expansion tests
  - FAA Spectrum Office RF authorization for No Chase COA
- Utilize continuous risk management to identify schedule impacts
- L2 Milestone delays did not impact downstream Level 1 or 2 Milestones

Successful Milestone Management

Current Active Collaborations/Partnerships Status (1 of 3)

Partner *(Project Area)*	Agreement In Place	Collaboration/ Partnership Role
Air Force Research Lab *(TC-DAA)*	Space Act *Mar-17 to Sep-18*	On-going collaboration with AFRL supporting use of Vigilant Spirit Control Station (VSCS) on DAA activities. AFRL has agreed to a NASA "leave behind" simulation capability after the agreement expires
Bell (SIO Selectee)	Cooperative Agreement *In Process*	Selectee for the SIO Demonstration. Mission is to conduct emergency medical supply delivery in Urban Areas with the Autonomous Pod Transport - 70 (APT70) electric VTOL
FAA UAS Integration *(Project Office, TC-DAA, TC-C2)*	RTT	Support by FAA leadership, management, and technical subject matter experts to validate work being done by the Project. On-going coordination of Research Transition Products (RTPs) within the UAS Integration RTT
FAA Aviation Safety (AVS) and NextGen (AUS) *(Project Office, TC-DAA, TC-C2)*	RTT	Coordination of RTPs within the UAS Integration RTT
FAA Air Traffic Organization (ATO) *(Project Office, TC-DAA, TC-C2)*	RTT / Controlled Airspace ARC	Primary organization managing the Controlled Airspace ARC where the project actively participates. Coordination of RTPs within the UAS Integration RTT
FAA UAS Test Sites *(Project Office)*	IDIQ Contract *Aug-15 to Sep-20*	Awarded Task 4 GBDAA (Gryphon Sensors LLC, Textron, UAVPro, FirebirdSE, Sunhillo, Dominion Energy, and Aviation Systems Engineering Company) and Task 5 Vehicle Task (Griffiss International Airport with the following subcontractors: Aurora, MTSI, NUAIR, AX Enterprize, Gryphon Sensors, Navmar Applied Sciences Corp.) Activities with the test sites are ongoing

Purple text indicates changes since FY17 Annual Review

Current Active Collaborations/Partnerships Status (2 of 3)

Partner *(Project Area)*	Agreement In Place	Collaboration/ Partnership Role
General Atomics *(TC-DAA)*	Space Act *Sep-14 to Feb-20*	Ikhana equipped with avionics and Proof of Concept DAA system directly supported by UAS-NAS Project. General Atomics supported the No Chase COA flight
General Atomics *(SIO Awardee)*	Cooperative Agreement *In process*	Selectee for the SIO Demonstration. Mission is to inspect infrastructure in IFR-like airspace with the SkyGuardian unmanned aircraft
Honeywell *(TC-DAA)*	Cooperative Agreement *Oct-17 to Sep-20*	Partner for the DAA low SWaP non-cooperative sensor in support of data-buy. Agreement modification processed to include data-buy in support of FT5
LinQuest *(TC-C2)*	Contract *Oct-17 to Sep-20*	Completed a conceptual system design study of the UAS C2 SatCom System, payload & earth station conceptual design, and Hosted Payload Study Report
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
NASC *(TC-DAA)*	Contract *Sep-18 to Oct-19*	The NASC TigerShark is the test vehicle for FT6
PAE-ISR *(SIO Awardee)*	Cooperative Agreement *Oct-18 to Aug-20*	SIO Demonstration awardee. Mission is to inspect infrastructure in VFR-like airspace with the Resolute Eagle unmanned aircraft

Purple text indicates changes since FY17 Annual Review

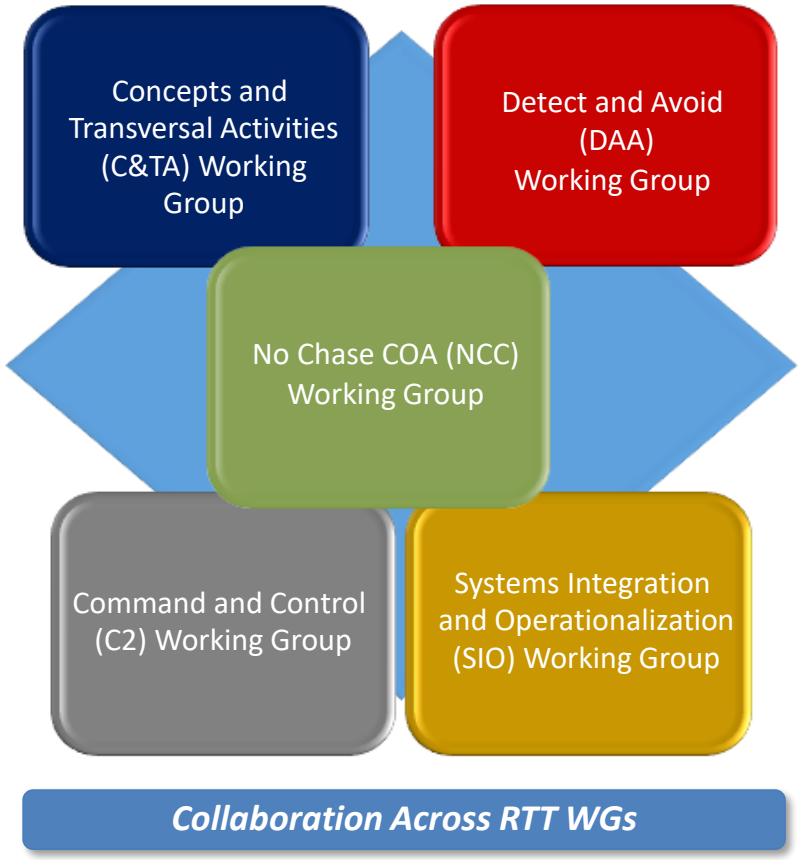
Current Active Collaborations/Partnerships Status (3 of 3)

Partner *(Project Area)*	Agreement In Place	Collaboration/ Partnership Role
Rockwell Collins (TC-C2)	Cooperative Agreement *Nov-11 to Oct-20*	Cost sharing agreement for CNPC radio development and flight test support for V6 radios in FY18 and V7 radios in FY19. FY20 support for final CNPC radio summary report
RTCA SC-228 (TC-C2, TC-DAA)	NA	On-going support to DAA and C2 working groups. NASA C2 CNPC radio testing is coordinated with SC-228 to support the development and validation of the C2 Link Systems MASPS and the CNPC Link System MOPS (terrestrial) DO-362A
RTCA SC-147 *(TC-DAA)*	NA	Close coordination on DAA standards required for success of P2 MOPS. Hosting workshops to ensure success of both working groups. Ad Hoc FAA/NASA working group established to coordinate ACAS Xu research
Science And Research Panel (SARP) *(TC-DAA)*	NA	Multi-UAS HITL results presented at the SARP special meeting on multi-UAS control. This work investigated the scalability of the Phase 2 well clear definition to multi-UAS control with clear applicability to other domains, e.g., UAM

Purple text indicates changes since FY17 Annual Review

FAA/NASA UAS Integration Research Transition Team

- Phase 2 collaboration between NASA and the FAA is being coordinated though a RTT that includes all FAA Lines of Business
- There are currently five Working Groups (WGs) within the UAS Integration RTT each with their own focus
  - C&TA WG: Developing commercial concepts of use for UAS Integration
  - DAA WG: Coordinating SC-228 related DAA research
  - C2 WG: Coordinating SC-228 related C2 research
  - NCC WG: Coordinating all aspects of the 2018 NCC Flight
  - SIO WG: Coordinating all aspects of the 2020 SIO demonstration



Accomplishments/Next Steps for the UAS Integration RTT

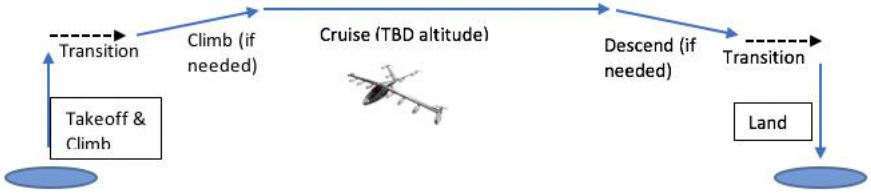
- 2018 Accomplishments
  - The Joint Management Plan (JMP) was signed February 5, 2018
  - All work under RTCA SC-228 for DAA and C2 were coordinated with the FAA lines of business
  - The NCC flight was successfully completed on June 12, 2018.
    - The FAA played a significant role in helping NASA with COA, operational, and frequency approvals
  - The C&TA WG provided input to NASA on potential SIO ConOps to assist in the CAN review process
    - The FAA provided three reviewers to assist in the SIO selection process.
  - A new SIO WG was established which will operate in a similar manner to the NCC WG as the 2020 demonstration approaches
- Next steps for the UAS Integration RTT
  - The NCC WG will be sunset at the next Executive Meeting
  - Continuation of Research Transition Product (RTP) delivery will occur throughout the duration of the Project
  - The FAA briefing of UAS Implementation Research Plan on September 27, 2018 may lead to future joint planning to help shape the ARMD UAS/autonomy research portfolio

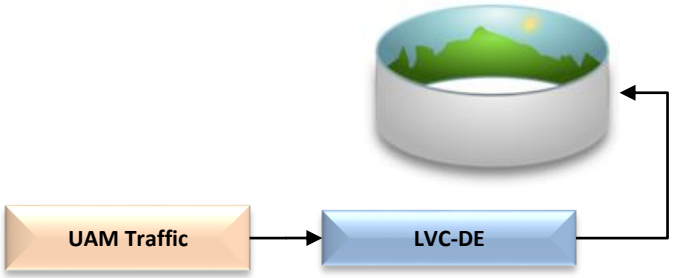
UAS-NAS and Urban Air Mobility (UAM) Partnerships and Technology Transitions

- Complex UAS technology testing and standards verification and validation (V&V) experience
  - Vehicle and airspace interfaces and test techniques for emerging technologies such as DAA and C2
  - Experience in scenario development for UAM HITLs and Grand Challenge
  - Experience on standards V&V and FAA approvals

- Live Virtual Constructive Development
  - Development of LVC-DE environment that supports varying test infrastructure needs
  - Adaptable to external test ranges and future UAM partners
  - UAMPort (i.e. vertiport) visualizations and demonstrations

- Partnerships lessons learned
  - SIO implemented and baselined; “mini-Grand Challenge”
  - Explores unique NASA/industry partnership models





Leveraging UAS-NAS technologies to assess the UAM concept and support research

International Participation and Accomplishments

- International Civil Aviation Organization (ICAO)
  - Accomplishments:
    - The Human In The System (HITS) outline was complete
    - Writing assignments were agreed upon and distributed
  - Next Steps:
    - The HITS team will write a chapter for the Remotely Piloted Aircraft Systems (RPAS) Panel's Remote Pilot Station (RPS) manual
      - Drafts are due March 1, 2019, Final to secretariat due July 1, 2020
    - The next HITS meeting will be at Ames
- European Organization for Civil Aviation Equipment (EUROCAE)
  - Accomplishments:
    - Participated in the development of the Operational Services Environment Description (OSED) for DAA related to European Classes A-C, D-G, and Very Low Level (VLL)
      - The OSEDs are an incremental step to creating international standards
      - The OSEDs for A-C and D-G are out for review
  - Next Steps:
    - OSED for VLL will be completed by the end of calendar 2018
    - Develop Minimum Aviation System Performance Standards (MASPS) and Minimum Operational Performance Standards (MOPS) to be submitted to ICAO for the development of global Standards and Recommended Practices (SARPS)

International standards organizations accepting US standards accelerates the time to market for UAS manufacturers

FY18 Accomplishments

- Rania Ghatas: won best paper and received publication in their bound volume for her paper on “The Effects of Alert Scoring and Alert Jitter on a MOPS UAS DAA System” at the 5th ENRI International Workshop on ATM/CNS (EIWAC)
- Dr. Lisa Fern: former DAA Tech Lead was recognized by RTCA for her contributions to DO-365, “DAA MOPS Phase 1 and DO-365, MOPS for Air-to-Air Radar DAA Systems Phase 1”
- DAA team: NASA Group Achievement Award for their work that formed the basis of national standard, “DO-365: MOPS for DAA Systems”
- Laurie Grindle: NASA Outstanding Leadership Medal
- Robert Sakahara: NASA Exceptional Achievement Medal
- Cesar Munoz: won the best in session and best in track awards for his paper on Sensor Uncertainty Mitigation and Well Clear Volumes In Detect and Avoid Alerting Logic for Unmanned Systems (DAIDALUS), at the Digital Avionics Systems Conference 2018

FY18 Accomplishments & FY19 Look Ahead

FY18 Accomplishments

- TC: Detect and Avoid
  - Simulations: Terminal Ops HITL 1B; Multi-UAS HITL Simulation
  - Flight Tests: No Chase COA Flight Demonstration; Flight Test 5/6 Planning
- TC: Command and Control
  - C-band SatCom: Hosted Payload Study Report
  - UAM Study: UAS C2 System ConOps
- Systems Integration and Operationalization
  - Industry coordination and CAN release
  - Industry Partner selection and award
- FAA Test Sites
  - GBDAA task order 4 test activities
  - Vehicle and ConOps task order 5 test activities
- Project
  - Establishment of Research Transition Team

Ikhana Unmanned Aircraft

Picture Removed

DAPA Lite Radar

CNPC Version 6 radio

FY19 Look Ahead

- DAA Simulations: ACAS Xu HITL, Terminal Area HITL, Fast Time Simulation
- Flight Tests: Data Collection for FT5 & FT6; CNPC Radio V6 & V7
- Submit Consolidated Input for DAA MOPS Rev A to RTCA

FY20 Closeout Planning

- Project Completion date set for September 30, 2020
  - Two years left on Project; ramping down personnel in FY20 for DAA, IT&E and C2
- Notional Closeout requirements/content
  - Transition of technologies and relationships to appropriate ARMD projects/programs
  - Final project plan to address:
    - Description of research and/or technology advancement
    - Performance relative to goals and threshold requirements
    - Lessons learned
    - Dissemination and/or storage/archival approach utilized, and
    - Results of any independent assessments
    - Continuation of contract mechanisms and partner agreements
  - AFRC Project closeout checklist (additional items)
    - Systems decommissioning/disposal
    - Risk status
    - Funding/budget
- Schedule:
  - Update Project Plan (new section) – November 2018
  - IASP Terms of Reference – December 2019
  - Closeout Review Meeting – July 2020
  - Project Final Report – September 2020

Outline

- UAS-NAS Overview
- Technical Performance
- Project Level Performance & FY19 Look Ahead
- Review Summary

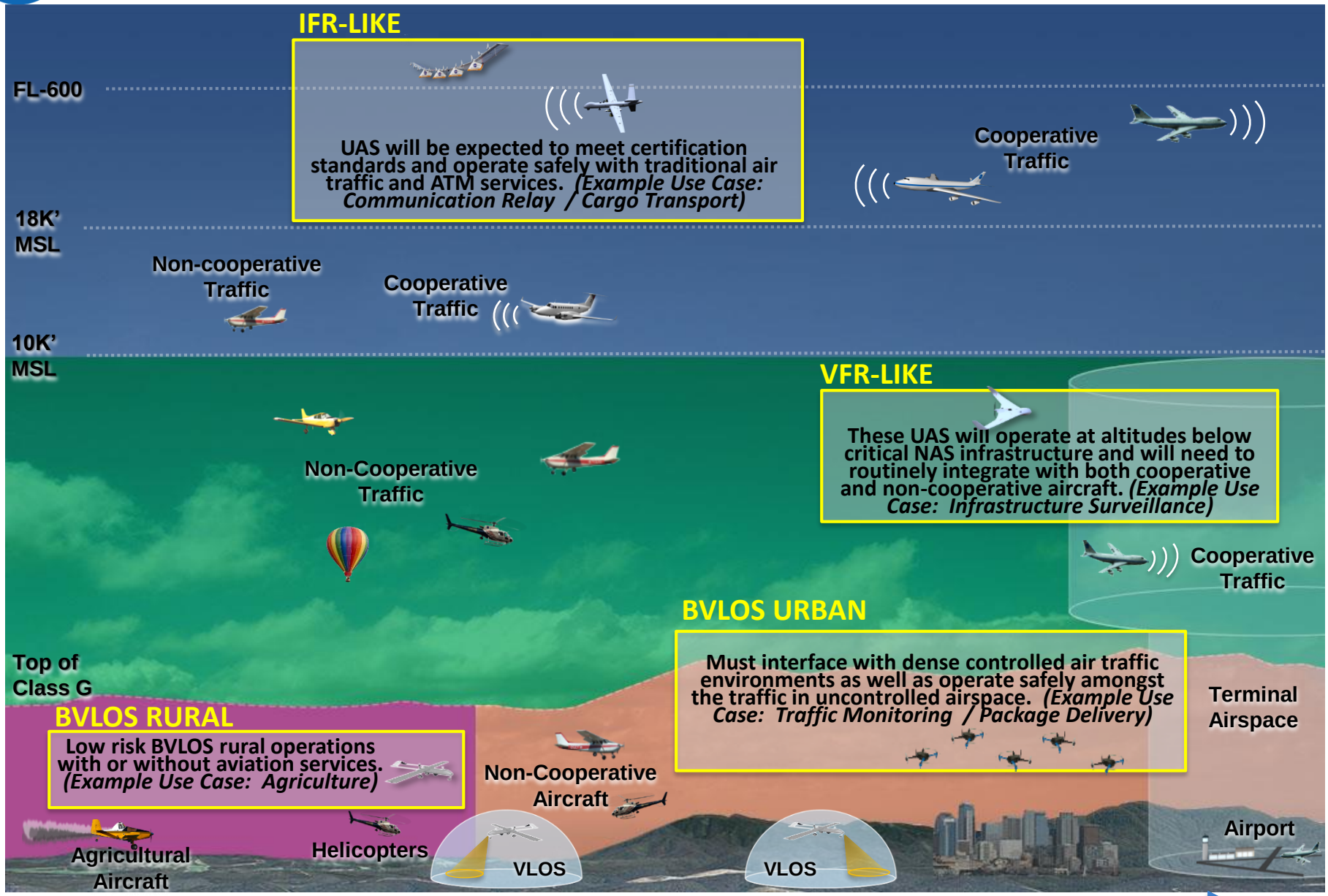
FY18 Summary

- ✓ Successful completion of multiple Project Research Activities (simulations and flight tests) in support of Phase 2 Detect and Avoid (DAA) and Command and Control (C2) Technical Challenges (TC)
- ✓ Successfully advanced the Systems Integration and Operationalization (SIO) Demonstration through Cooperative Agreements (CA) with selected Industry Partners
- ✓ Established Research Transition Team (RTT) formally with the Federal Aviation Administration (FAA)
- ✓ Successful continuous risk management
  - ✓ Flight Test (FT) 5 and 6
- ✓ Effective Schedule and Milestone management

Successfully executing technical portfolio

UAS-NAS Technical Performance
Backup Slides

Emerging Commercial UAS Operating Environments (OE)



UAS-NAS Technical Challenge Autonomy Contributions

AERONAUTICS STRATEGIC THRUST

Thrust 6: Assured Autonomy for Aviation Transformation

AERONAUTICS OUTCOME

Outcome (2015 – 2025): 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): 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

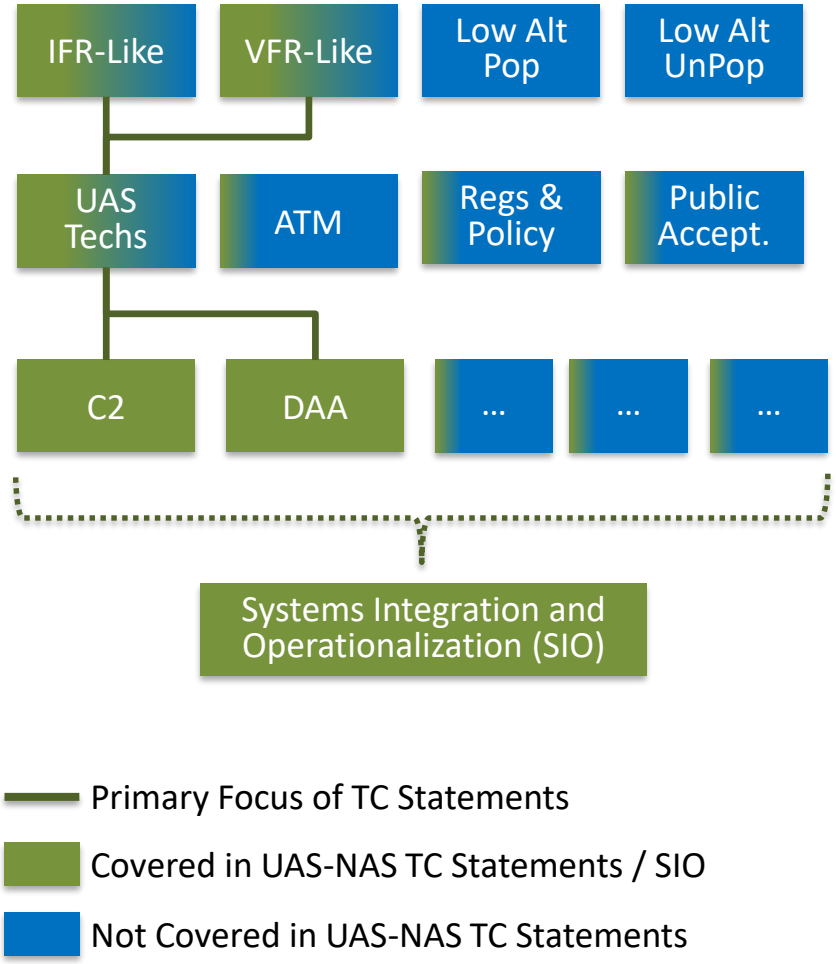
SIO

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

UAS Integration / Project Background

- Each OE has unique considerations with respect to each Pillar
- Program and Project core competencies focus on Integrated Vehicle technologies
- "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 for DAA and C2 do not cover the broad needs for all OEs or UAS Vehicle Technologies
- 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

TC-DAA Technical Baseline Elements (1/4)

Technical Baseline Element Number	Technical Baseline Title	Reference SP Numbers
TBEN-005	Alternative Surveillance and Well Clear/Alerting Requirements ConOps (Complete 1/19/18)	SP D.1.30, SP D.2.10
TBEN-006	Alternative Surveillance: Foundational Fast-time Simulation (FY17) (Complete 2/22/18)	SP D.1.40
TBEN-007	Alternative Surveillance: Display Requirements (Complete 2/13/18)	SP D.1.50
TBEN-008	Alternative Surveillance: Unmitigated Fast-time Simulation for Low SWaP Sensors Using Surveillance Volume and Uncertainties with Updated DAA Well Clear Definition (FY18) (Complete 9/27/18)	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

Current September 2018

TC-DAA Technical Baseline Elements (2/4)

Technical Baseline Element Number	Technical Baseline Title	Reference SP Numbers
~~TBEN-011~~	~~Deleted September 28 2017 MRB, CR164: Alternative Surveillance: HITL Simulation 2~~	~~SP D.1.90, SP T.7.40~~
TBEN-012	Well Clear/Alerting Requirements: Foundational Terminal Operations HITL Simulation 1 (Complete 12/29/17)	SP D.2.30, T.7.10
TBEN-013	Well Clear/Alerting Requirements: Foundational Terminal Operations Fast-time Simulation 1 (Complete 12/20/17)	SP D.2.40
TBEN-014	Well Clear/Alerting Requirements: Fast-time Simulation 2 (Complete 3/27/18)	SP D.2.50
~~TBEN-015~~	~~Deleted September 28 2017 MRB, CR178: 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 (Complete 2/20/18)	SP D.3.20

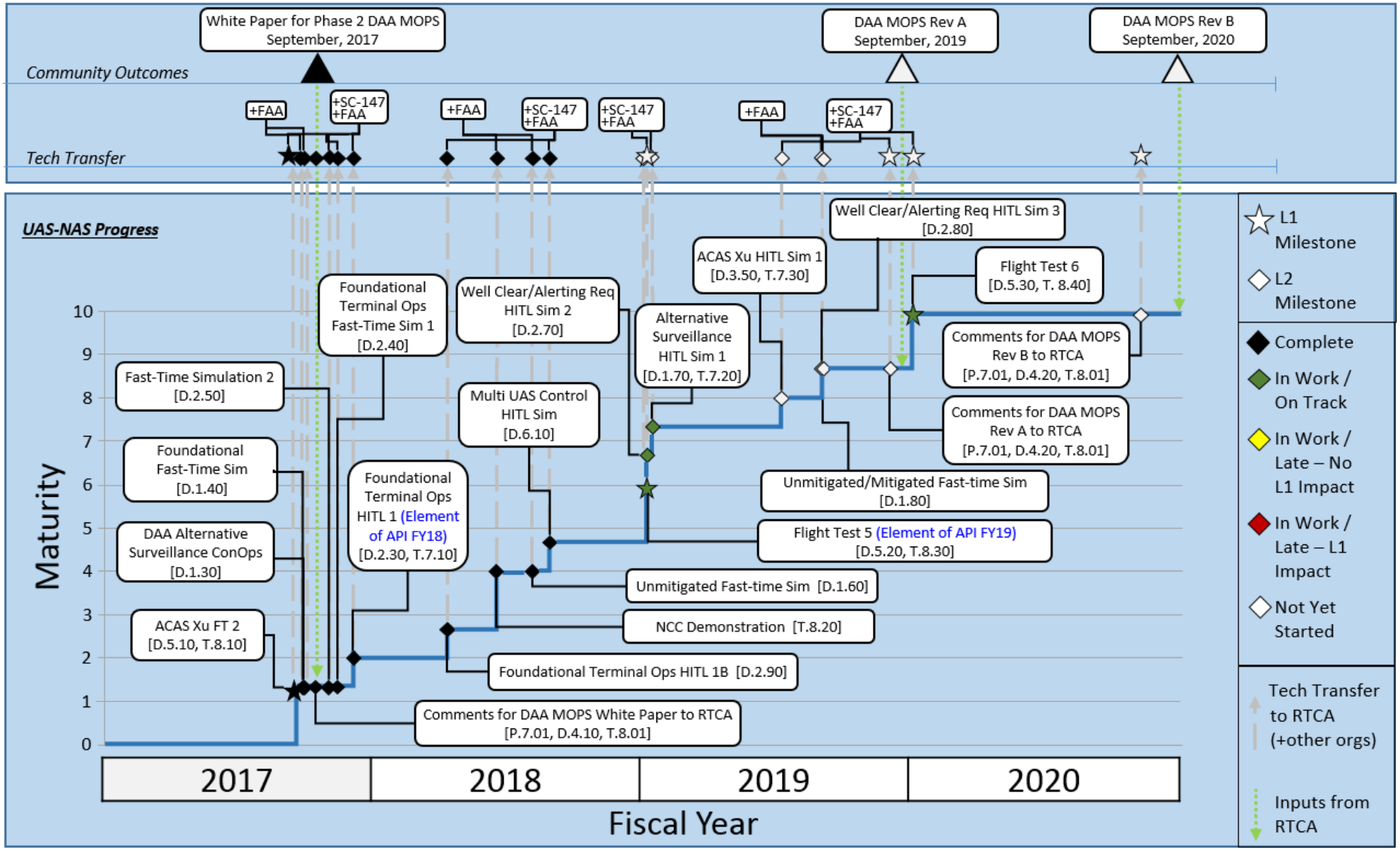
TC-DAA Technical Baseline Elements (3/4)

Technical Baseline Element Number	Technical Baseline Title	Reference SP Numbers
TBEN-019	ACAS-Xu: HITL Simulation 1	SP D.3.50, SP D.7.30
TBEN-020	Integrated Event: ACAS-Xu Flight Test 2 (Complete 10/23/17)	SP D.5.10, SP T.8.10
TBEN-021	Integrated Event: Flight Test 5	SP D.5.20
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 (Complete 8/20/18)	SP T.8.20
TBEN-024	Well Clear/Alerting Requirements: Foundational Terminal Ops HITL Simulation 1B (Complete 6/26/18)	SP D.2.90, T.7.50
~~TBEN-025~~	~~Deleted February 22, 2018 MRB, CR185: External Coordination: DAA-C2 Latency Sensitivity HITL Simulation~~	~~SP D.4.60, T.7.60~~

TC-DAA Technical Baseline Elements (4/4)

Technical Baseline Element Number	Technical Baseline Title	Reference SP Numbers
TBEN-026	Human Automation Teaming: Multi UAS HITL	SP D.6.10
TBEN-027	Human Automation Teaming: Automatic Execution of CA and Return to Course Analysis	SP D.6.20

TC-DAA: Progress Indicator



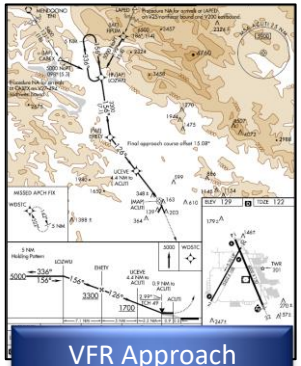
Well Clear/Alerting Requirements: Foundational Terminal Operations HITL Simulation 1

✓ Research Objective:

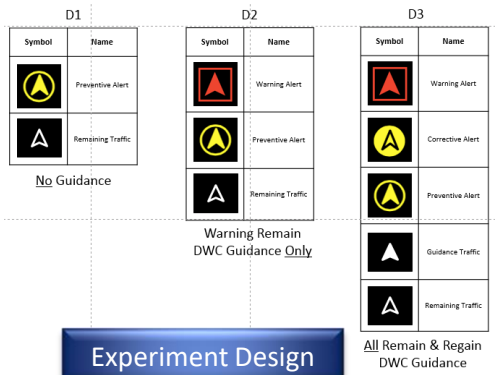
- Explore pilot performance and operational suitability issues associated with Class D terminal area operations

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
  - Data collection completed October 2017
  - Results dissemination completed December 2017
  - Technical Baseline Element completed December 2017

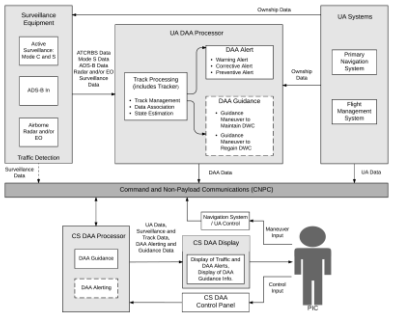
Results accepted by SC-228; Shaping DAA MOPS development

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

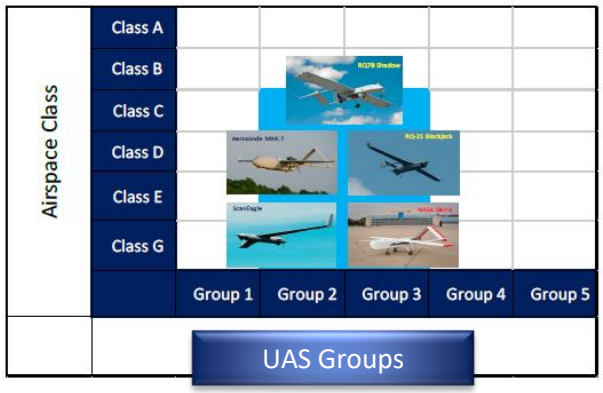
Alternative Surveillance and Well Clear/Alerting Requirements ConOps

✓ Research Objective:

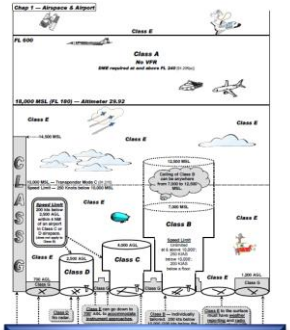
- Develop a ConOps describing the scope of DAA alternative surveillance and Well Clear Definition research to support the development of DAA Phase 2 MOPS and Non-Cooperative Sensor MOPS



Architecture



UAS Groups


Airspace Classes

- **Status:**
  - Alternative Surveillance ConOps completed November 2017
  - Well Clear/Alerting Requirements ConOps completed January 2018
  - Technical Baseline Element completed January 2018

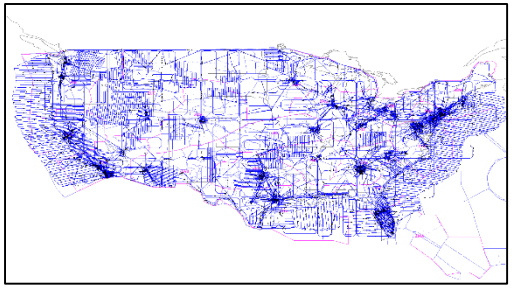
Alternative Surveillance and Well Clear/Alerting Requirements ConOps shaped future Project research and approach for MOPS development

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

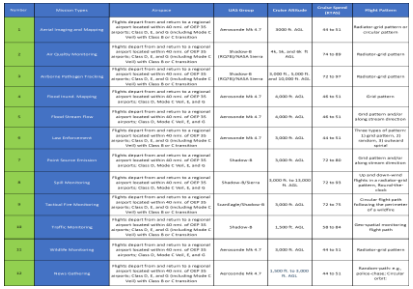
Alternative Surveillance: Foundational Fast-time Simulation (FY17)

✓ Research Objective:

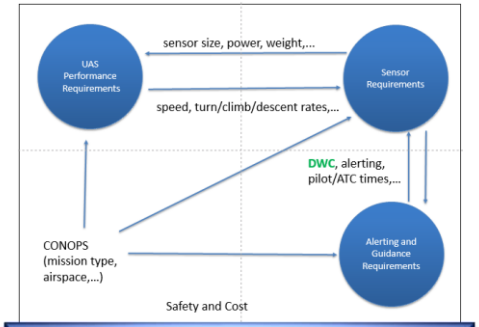
- Estimate the target performance of alternative surveillance within Phase 2 MOPS UAS operations in order to provide acceptable DAA alerting and guidance



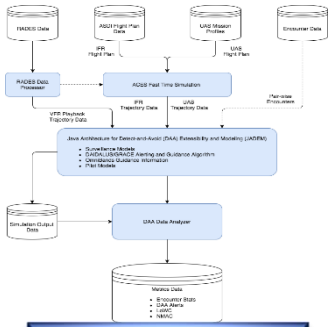
NAS Simulation



UAS Missions



Requirements Interrelationship



Architecture

- **Status:**
  - Experiment review completed July 2017
  - Data collection completed August 2017
  - Final results dissemination to SC-228 completed February 2018
  - Technical Baseline Element completed February 2018

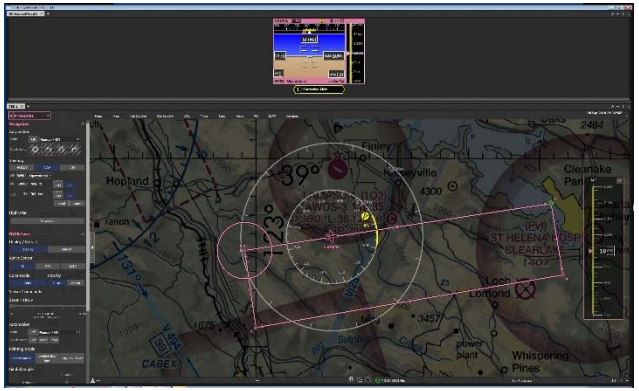
Results accepted by SC-228; Shaping Alternative Surveillance MOPS Requirements

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

Alternative Surveillance: Display Requirements

✓ **Research Objective:**

- Define DAA system display requirements for UAS with alternative surveillance systems within UAS operations associated with Phase 2 MOPS



- **Status:**
  - Definition of human factors issues completed February 2018
  - Definition of requirements completed February 2018
  - Definition of display options, as a list of display recommendations, completed February 2018
  - Technical Baseline Element completed February 2018

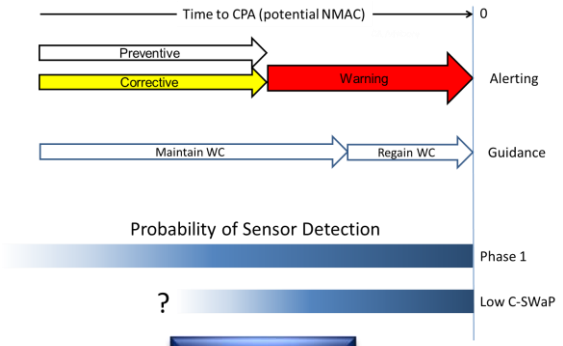
Display recommendations support future human-in-the-loop simulation

Technical Baseline Element Number: TBEN-007 (SP D.1.50)

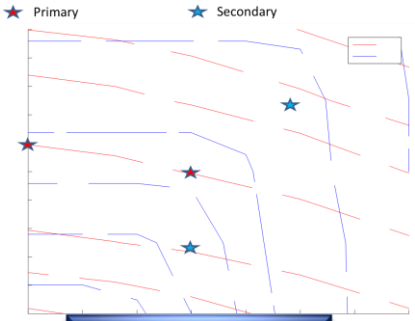
Alternative Surveillance: Unmitigated Fast-time Simulation (FY18)

✓ Research Objective:

- Verify DAA alerting and surveillance performance with surveillance volume and uncertainties and updated DAA Well Clear definition within UAS operations associated with Phase 2 MOPS



Timelines



Candidate DWC

Hazard Zones

- **Status:**
  - Experiment Review completed March 2018
  - Data Collection completed June 2018
  - Data analysis completed August 2018
  - Results disseminated September 2018

Technical Baseline Element Number: TBEN-008 (SP D.1.60)

Alternative Surveillance: HITL Simulation 1

- **Research Objective:**
  - Verify 1) UAS pilot performance of an DAA system with low size, weight, and power sensors, 2) interoperability of low size, weight, and power sensor requirements with DAA alerting, guidance, and display requirements, and identify modifications to alerting, guidance and display requirements for low size, weight, and power sensors as needed

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- **Status:**
  - Experiment design started April 2018
  - Experiment design completed September 2018
- **Next Steps:**
  - Data collection to be completed November 2018
  - Results dissemination to be completed January 2019

Technical Baseline Element Number: TBEN-009 (SP D.1.70, SP T.7.20)

Alternative Surveillance: Unmitigated/Mitigated Fast-time Simulation (FY19)

- **Research Objective:**
  - Inform and verify draft for final DAA and Non-cooperative Sensor Phase 2 MOPS

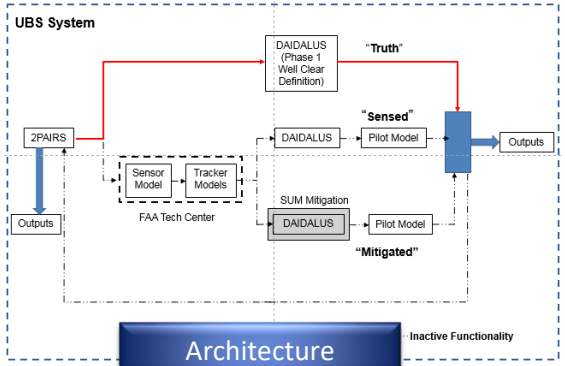
- **Next Steps:**
  - Experiment plan to be completed March 2019
  - Data collection to be completed April 2019
  - Results dissemination to be completed August 2019

Technical Baseline Element Number: TBEN-010 (SP D.1.80)

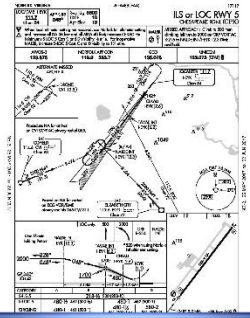
Well Clear/Alerting Requirements: Foundational Terminal Operations Fast-time Simulation 1

✓ Research Objective:

- Collect empirical data to address well clear issues



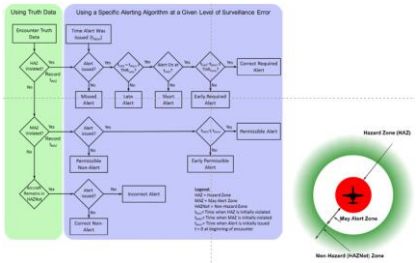
Architecture



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 and shakedown completed July 2017
  - Data collection completed August 2017
  - Results dissemination completed December 2017
  - Technical Baseline Element completed December 2017

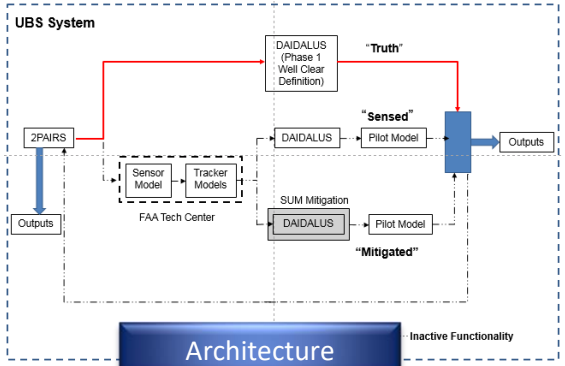
Results accepted by SC-228; Shaping future simulations and DAA MOPS development

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

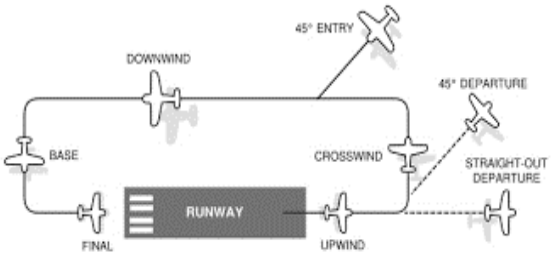
Well Clear/Alerting Requirements: Fast-time Simulation 2

✓ 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:

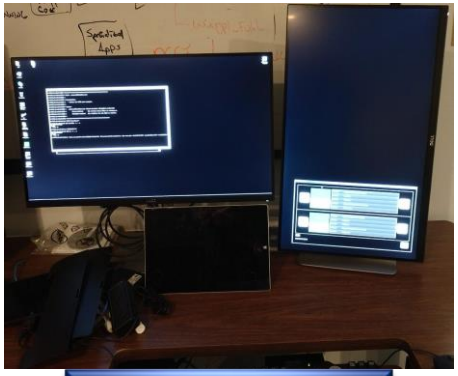
- Experiment design and shakedown completed July 2017
- Data collection completed August 2017
- Results dissemination completed March 2018
- Technical Baseline Element completed March 2018

Results accepted by SC-228; Shaping future simulations and DAA MOPS development

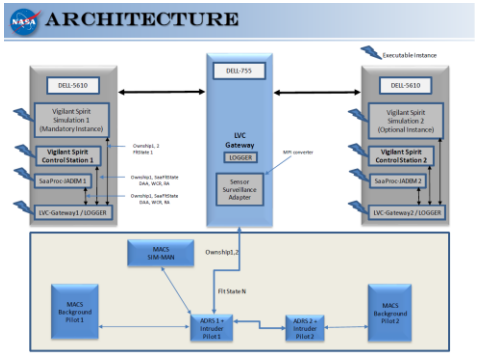
Technical Baseline Element Number: TBEN-014 (SP D.2.50)

Well Clear/Alerting Requirements: Well Clear/Alerting Requirements: HITL Simulation 2

- **Research Objective:**
  - Verify 1) pilot performance of Class D and E terminal area operations and 2) DAA algorithm configurable parameters for Class D and E terminal area operations



Communication Tools



Architecture

- **Status**
  - Preliminary Experiment Review completed May 2018
  - Final Experiment Plan completed September 2018
- **Next Steps:**
  - Data collection to be completed November 2018
  - Results dissemination to be completed January 2019

Technical Baseline Element Number: TBEN-016 (SP D.2.70)

Well Clear/Alerting Requirements: Well Clear/Alerting Requirements: HITL Simulation 3

- **Research Objective:**
  - Verify 1) pilot performance of Class E and G terminal area operations with no operating Airport Traffic Control Tower and 2) DAA algorithm configurable parameters for Class E and G terminal area operations with no operating Airport Traffic Control Tower

---

- **Next Steps:**
  - Experiment Design to be completed March 2019
  - Data collection to be completed July 2019
  - Results dissemination to be completed October 2019

Technical Baseline Element Number: TBEN-017 (SP D.2.80)

ACAS-Xu: Mini HITL Simulation

✓ Research Objective:

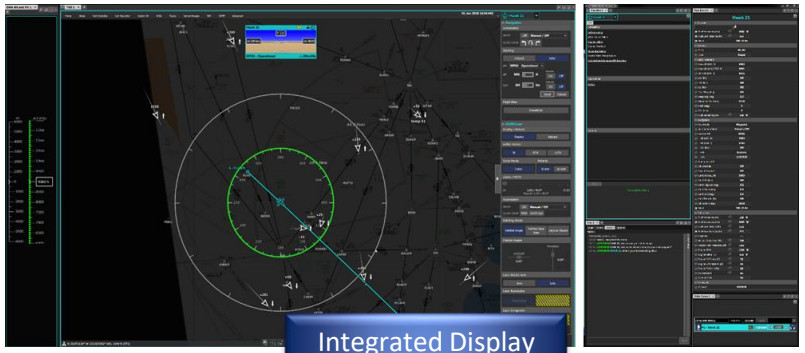
- 1) Determine that the Ames Research Centers Human Autonomy Teaming Laboratory components are installed properly and up to date for Project Phase 2 research (Primary) and 2) provide data on alerting, display and/or guidance Phase 1 DAA MOPS (Secondary)

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
  - Results dissemination completed February 2018
  - Technical Baseline Element completed February 2018

Laboratory components installation acceptable; DAA results accepted by SC-228

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

ACAS-Xu: HITL Simulation 1

- **Research Objective:**
  - Investigate highest priority interoperability issues related to the impact of ACAS Xu integrated DAA Remain Well Clear and collision avoidance alerting and guidance on pilot performance

- **Next Steps:**
  - Experimental design including Stakeholder input to be completed January 2019
  - Data Collection to be completed May 2019
  - Results dissemination to be completed July 2019
  - Technical Baseline Element to be completed July 2019

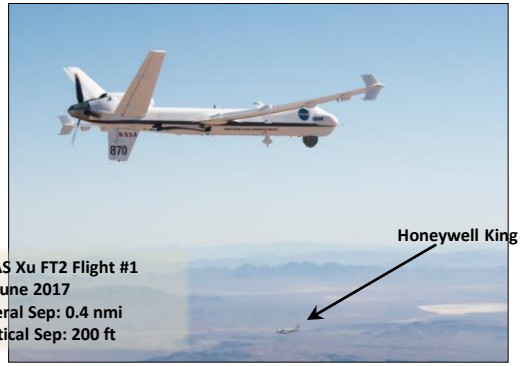
Technical Baseline Element Number: TBEN-019 (SP D.3.50, T.7.30)

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
- Compare DAA alerts and guidance between ACAS Xu and NASA algorithms
- Evaluate interoperability between ACAS Xu and NASA's DAA algorithms alerting and guidance


Team




Lab

- **Status:**
  - Flight test completed August 2017 (12 flight tests / 56 flight hours, 241 flight cards / test points)
  - Flight test data made available to FAA and contractor team following each flight
  - Comparison of ACAS-Xu and DAIDALUS Detect and Avoid Systems briefing completed November 2017
  - Public release of Flight test report completed October 23, 2017

Flight Test Data Supported ACAS Xu MOPS Development

Technical Baseline Element Number: TBEN-019 (SP D.5.10, T.8.10)

Integrated Event: Flight Test 5

- **Research Objective:**
  - Collect data to characterize the performance of the low size, weight ,and power radar and to support development of the sensor model

Removed Picture

Honeywell Helicopter

Test Area

- **Status:**
  - Contract modification with Honeywell completed September 2018
- **Next Steps:**
  - Data Collection to start October 2018
  - Data Delivery from Honeywell to be completed December 2018
  - Results to be disseminated March 2019

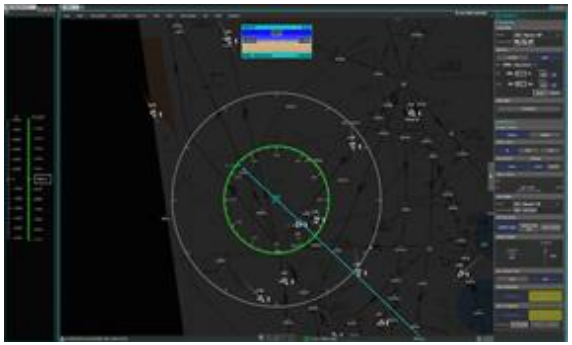
Technical Baseline Element Number: TBEN-021 (SP D.5.20, SP T.8.30)

Integrated Event: Flight Test 6

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

Removed Picture

NASC TigerShark



DAA Mitigated Encounters with Intruders

- **Status:**
  - Navmar Applied Sciences Corp awarded contract September 2018
- **Next Steps:**
  - Phase 2 CDR to be completed November 2018
  - System Checkout flights to be conducted May 2019
  - Radar Characterization flights to be conducted June 2019
  - FT6 Mission Flights to be conducted July 2019
  - Results to be disseminated March 2020

Technical Baseline Element Number: TBEN-022 (SP D.5.30, SP T.8.40)

Well Clear/Alerting Requirements: Foundational Terminal Ops HITL Simulation 1B

✓ Research Objective:

- Explore pilot performance and operational suitability issues associated with Class D terminal area operations
  - Implement two candidates for a terminal area DAA well clear (DWC) definition
  - Further investigate the efficacy of the DAA Corrective alert in the terminal area
  - Compare pilot and system performance to previous studies

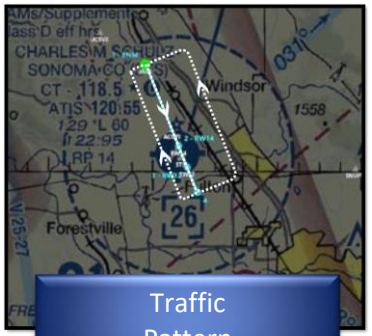
DWC Candidate (Within-Subjects):

	No Tau	Tau
Horizontal Threshold*	1500ft	1500ft
Vertical Threshold	450ft	450ft
modTau	N/A	15sec

*HMD in Tau definition

DWC Candidates

Vigilant Spirit Control Station



Traffic Pattern

• Status:

- Experiment design completed December 2017
- Data collection completed February 2018
- Results dissemination completed May 2018
- Technical Baseline Element completed May 2018

Results support definition of Terminal Area Well Clear

Technical Baseline Element Number: TBEN-024 (SP D.2.90)

Human Automation Teaming: Multi UAS HITL

- **Research Objective:**
  - Investigate highest priority issues related to integration of the DAA system with multi-UAS control operations; Examine viability of 1:N and M:N operations with DAA

5 UA Condition

Sensor Task Example – Traffic Accident

- **Status:**
  - Experiment design review complete June 2018
  - Data collection complete June 2018
- **Next Steps**
  - Results dissemination to be completed October 2018

Technical Baseline Element Number: TBEN-026 (SP D.6.10, T.7.70)

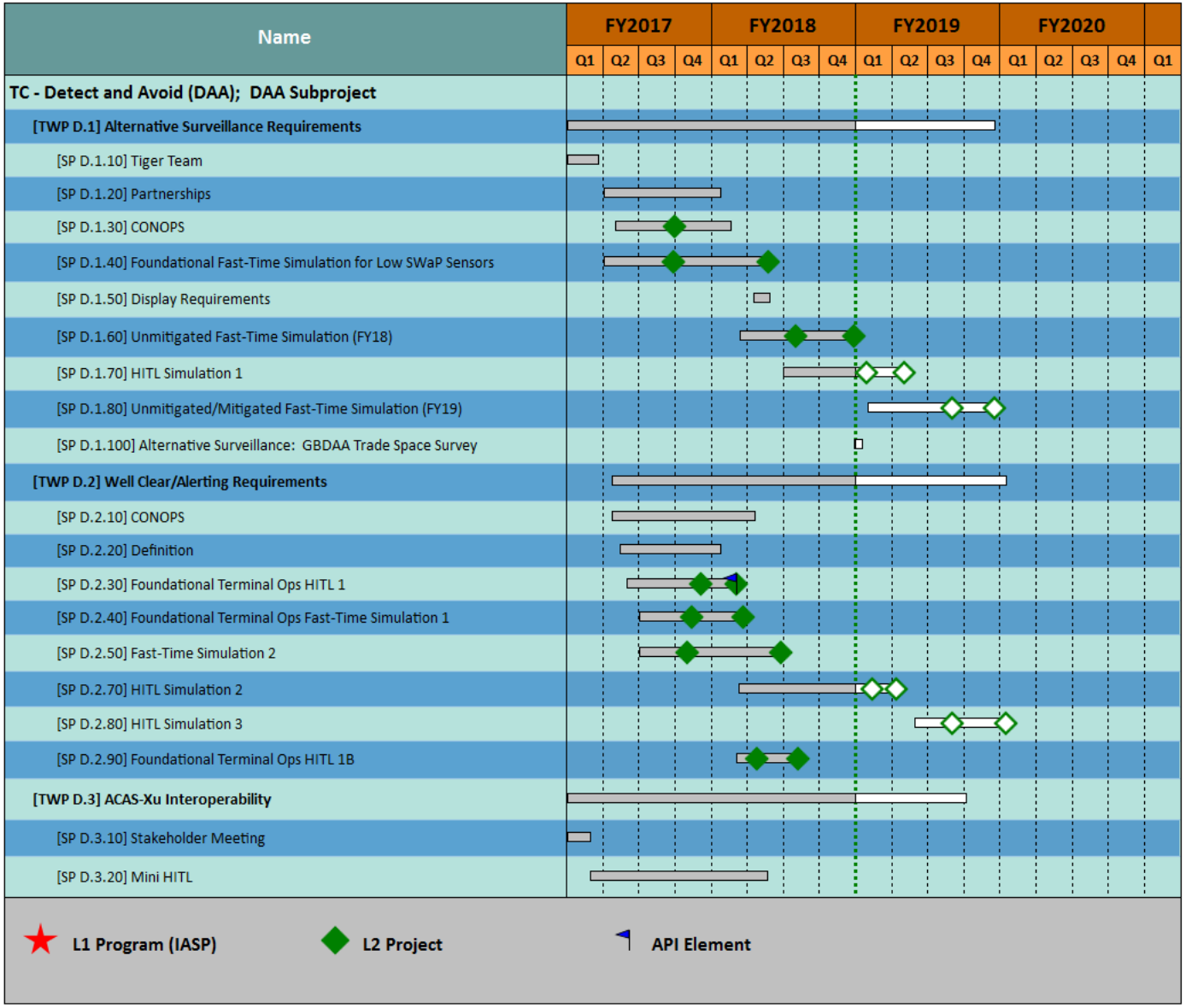
Human Automation Teaming: Automatic Execution of CA and Return to Course Analysis

- **Research Objective:**
  - Initial implementation of a Human Machine Interface to support effective auto-RA execution and return to course to inform SC-228 MOPS requirements development; Risk reduction for HITL testing of auto-RA and return to course in FY19

- **Status:**
  - Automation Workshop 2 complete May 2018
- **Next Steps**
  - Pilot-in-the-loop Engineering analysis to be completed January 2019
  - Recommendations for automation collision avoidance execution and return to course requirements presentation to be completed March 2019

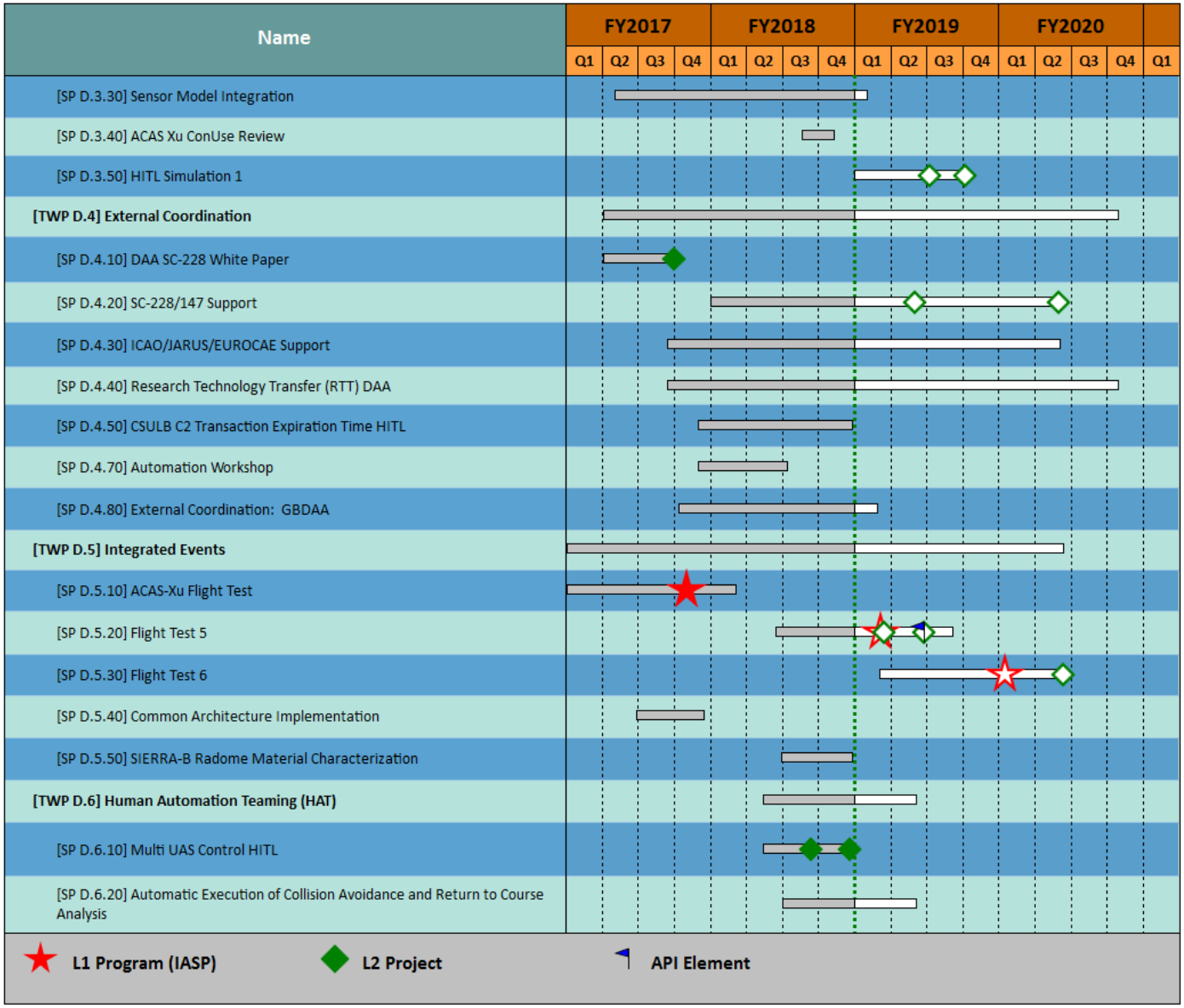
Technical Baseline Element Number: TBEN-027 (SP D.6.20)

TC-DAA (1 of 3)



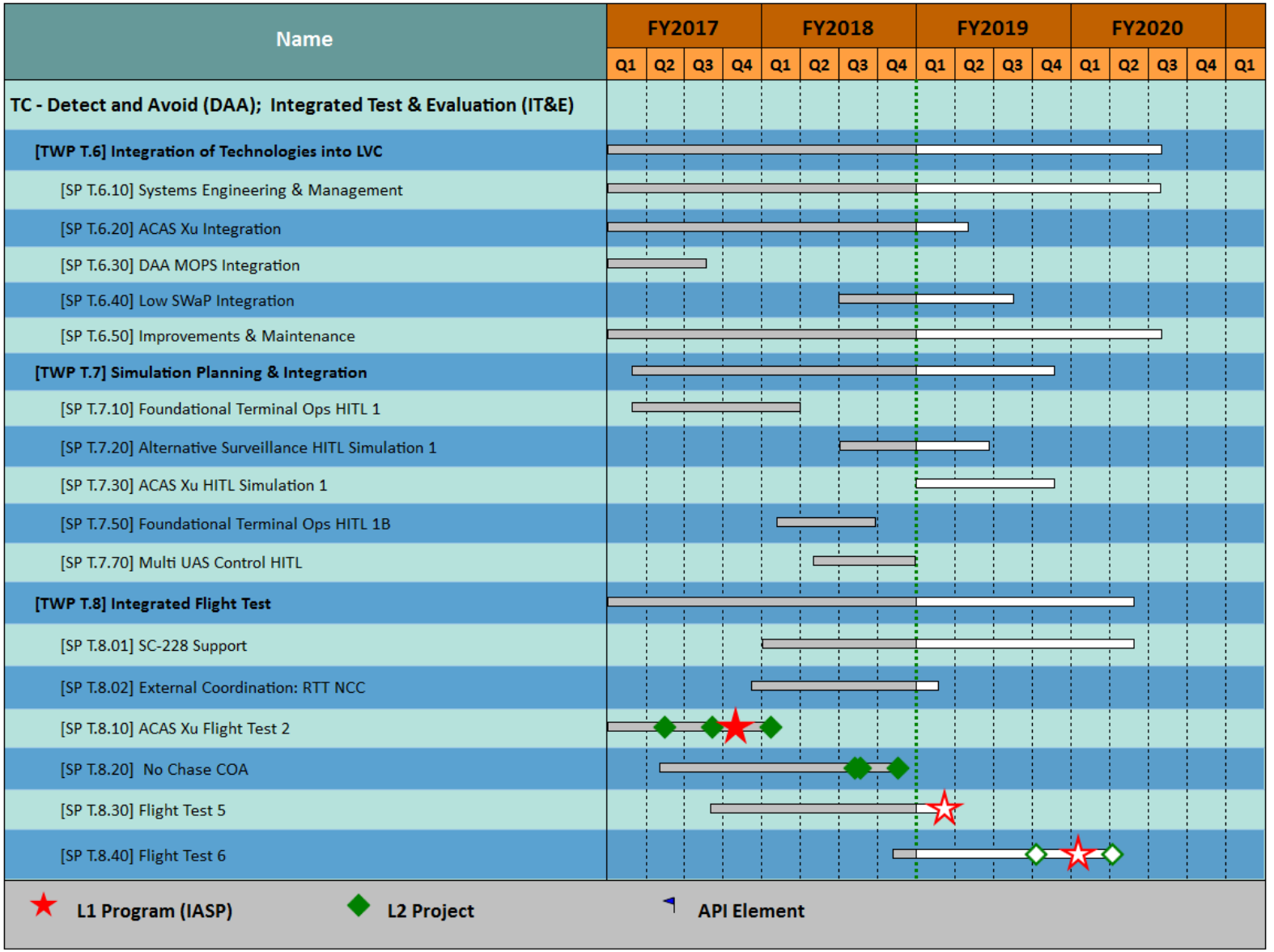
Green Status Line Date 9/30/18

TC-DAA (2 of 3)



Green Status Line Date 9/30/18

TC-DAA (3 of 3)

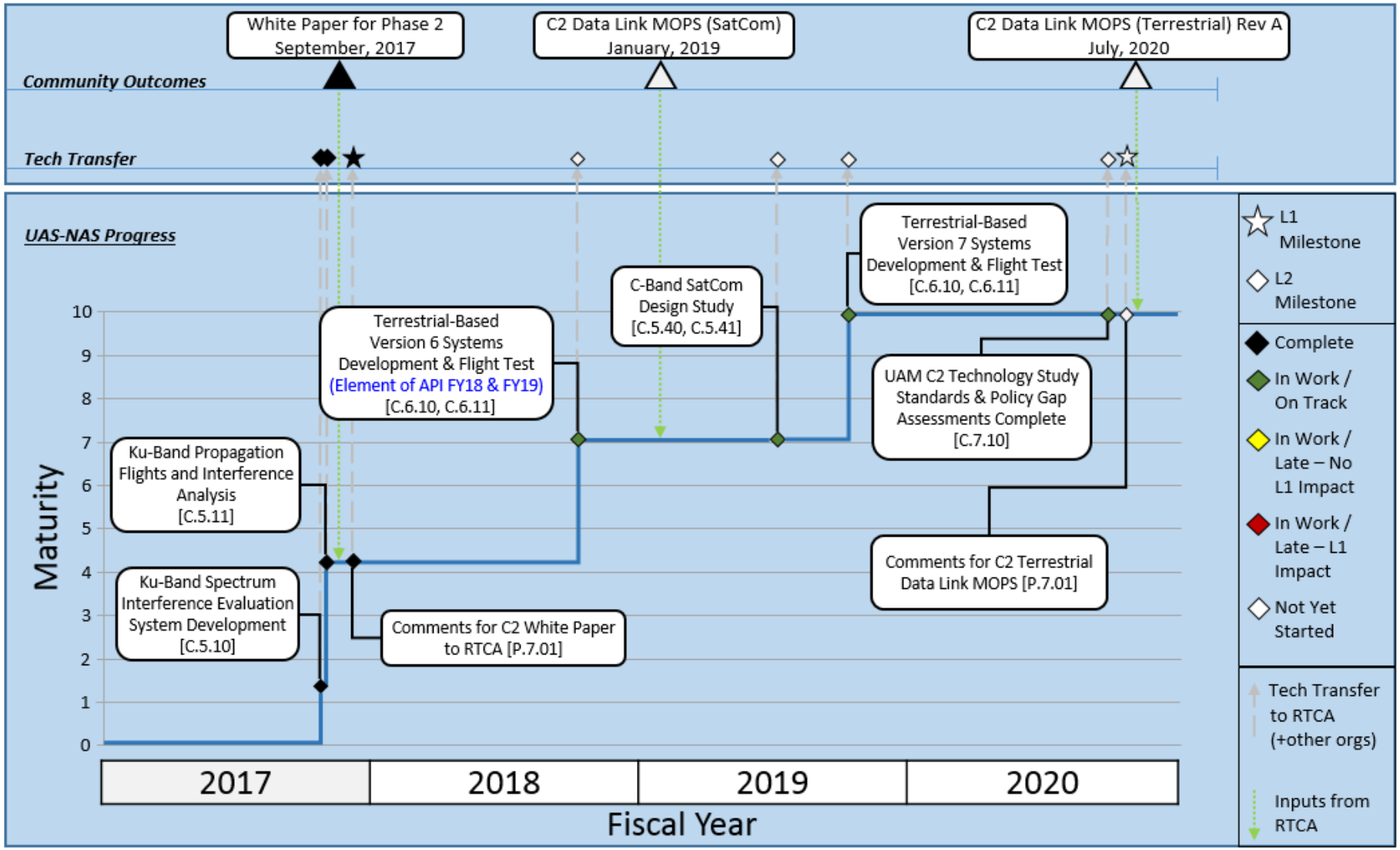


Green Status Line Date 9/30/18

TC-C2 Technical Baseline Elements

Technical Baseline Element Number	Technical Baseline Title	Reference SP Numbers
TBEN-001	Ku-Band Spectrum Interference Evaluation System Development (Completed 7/25/17)	SP C.5.10
TBEN-002	Ku-Band Propagation Flights and Interference Analysis (Completed 9/20/17)	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
TBEN-028	UAS Urban Air Mobility C2 Study	SP C.7.10

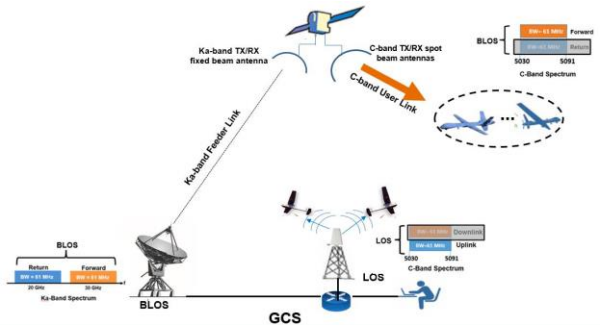
TC-C2: Progress Indicator



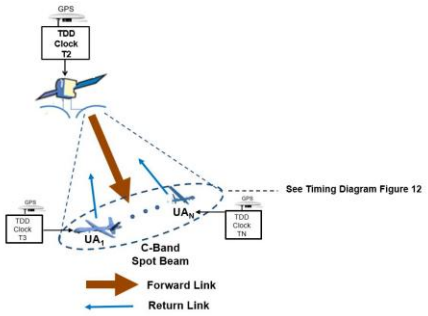
Technical Transfer Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office and ICAO

C-Band Design Study, Verification & Validation Planning

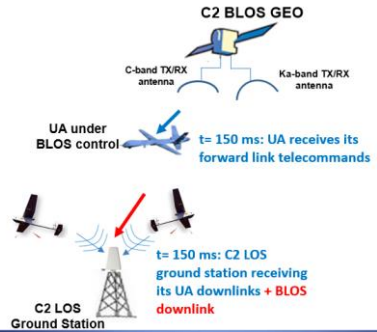
- **Research Objective:**
  - Transfer research data for the development and validation of standards for C-Band SatCom C2 data link



Notional UAS C2 Network



Link Synchronization



Potential Interference Scenario

- **Status:**
  - Contract awarded and Kickoff meeting completed June 2017
  - Conceptual System Design Study completed January 2018
  - Hosted Satellite Payload Study completed July 2018
- **Next Steps:**
  - Satellite payload design to be completed November 2018
  - 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

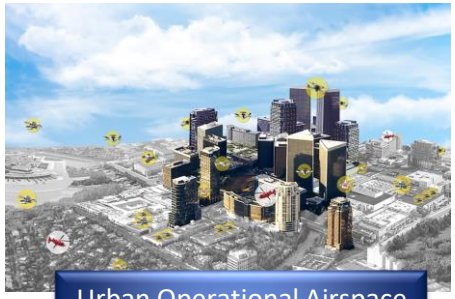
Technical Baseline Element Number: TBEN-003 (SP C.5.40, SP C.5.41)

UAS Urban Air Mobility C2 Study

- **Research Objective:**
  - Study the unique C2 challenges related to UAS to satisfy the perceived needs of the Urban Air Mobility emerging market

	Manned		Unmanned	
	Phase 1	Phase 2	**Phase 3**	Phase 4
Pilot	Expert Pilot	Skilled Pilot	**Ground Pilot**	No Pilot
Autonomy	None	Limited	**Partial**	Full
C2	None	Low	**Medium**	High

UAM Operational Phase



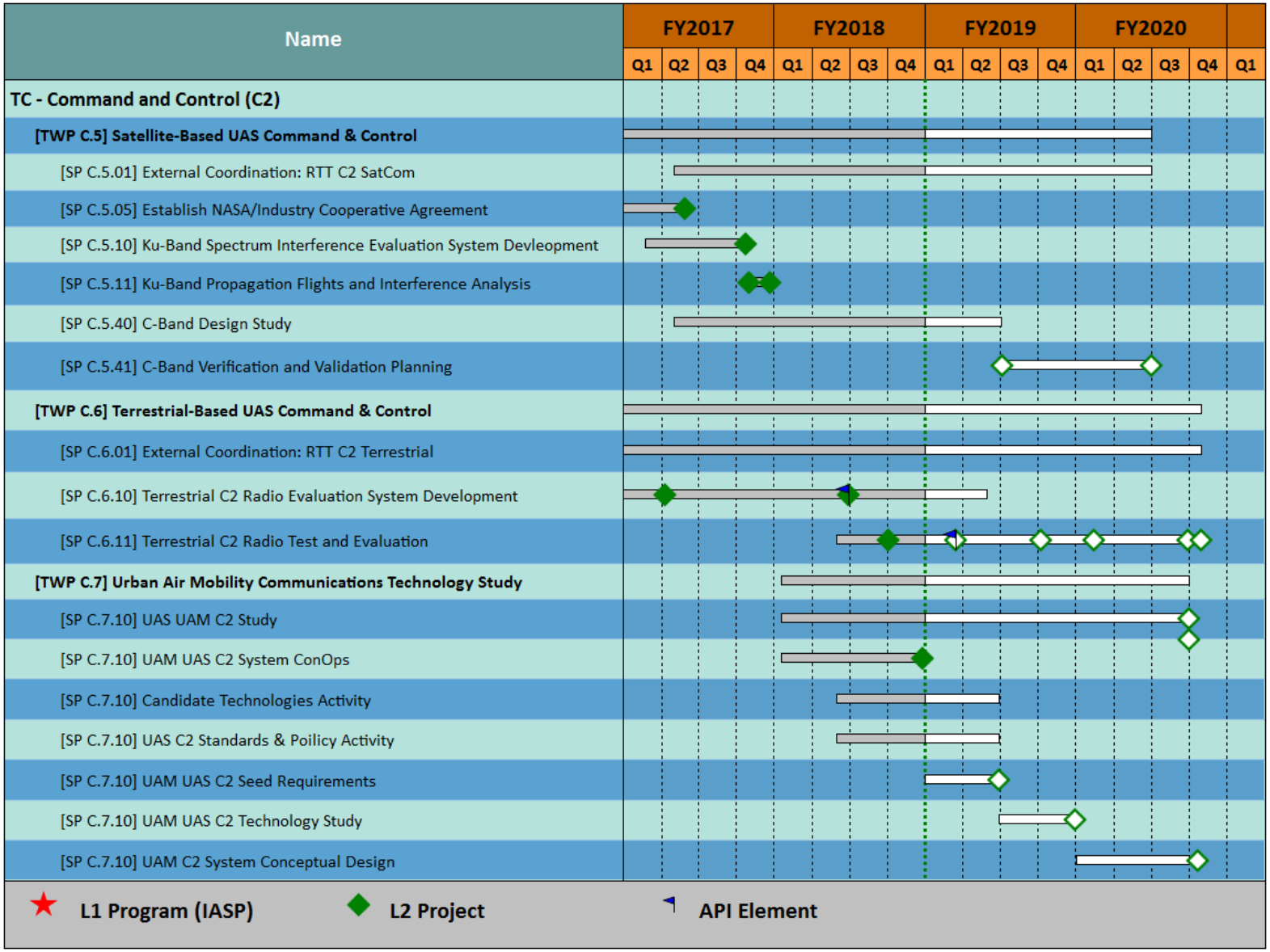
Urban Operational Airspace

Urban C2 Communications Environment

- **Status**
  - Baseline ConOps completed September 2018
- **Next Steps:**
  - Final Candidate Technologies for Study Criteria to be completed March 2019
  - Final Standards & Policies for Study Criteria to be completed March 2019
  - Baseline UAM C2 Seed Requirements to be delivered March 2019
  - UAM UAS C2 Technology Study to be completed September 2019
  - UAS C2 Standards & Policies Gap Assessment to be completed June 2020

Technical Baseline Element Number: TBEN-028 (SP C.7.10)

TC-C2



Green Status Line Date 9/30/18

NASA, FAA, and Industry Relationship for SIO

Maximum contribution from NASA

NASA

- Command and Control (C2) and Detect and Avoid (DAA)
- UAS Airworthiness
- Subject matter expertise
- Type certification lessons learned

UAS-NAS RTT (SC-228)

DAA/C2, Airworthiness Criteria

SIO

FAA role

FAA

- Approval to fly in the NAS
- Type Certification guidance
- Procedural, policy, and regulatory changes

Certification, Operational Approval

Industry

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

Minimum contribution from Industry

Systems Integration and Operationalization (SIO) Partnership

Project Level Performance
Backup Slides

Active Risk Status

- Data Redacted

Top Risk

- Data Redacted

Active Risks

- Data Redacted

FY18 Closed Risks

- Data Redacted

UAS-NAS Risk Summary Card

- Data Redacted

IASP Risk 02: UAS-NAS Project Focus Changes Due to External Influences

- Data Redacted

UAS-NAS FY18 Project Funding

- Data Redacted

Resource Allocation FY18 Budget

- Data Redacted

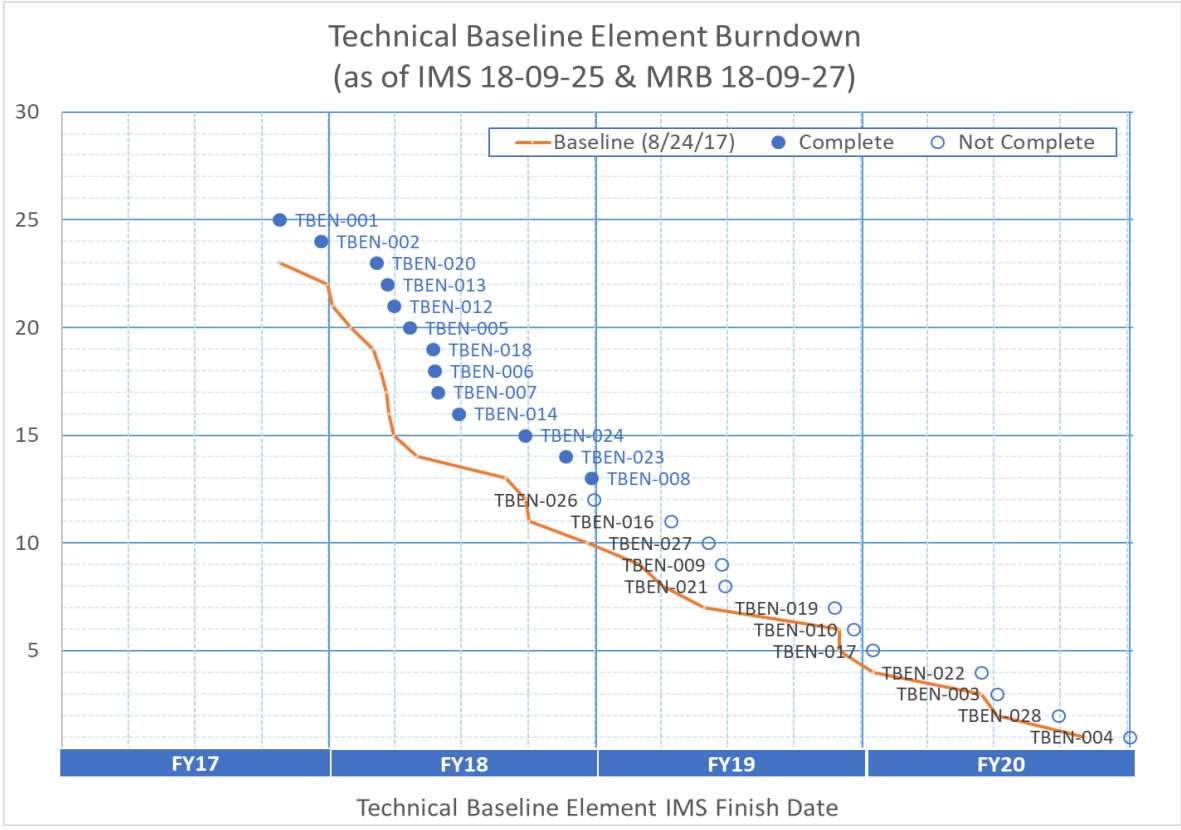
MRB Technical Baseline Summary
September 27, 2018

- August 23, 2018 MRB
  - TBEN-021 modified for FT5 re-plan

- Technical Baseline Elements Completed Since August 23, 2018 MRB
  - [SP D.1.60] Results Dissemination for Unmitigated Fast-time Simulation Study of Surveillance Volume and Alerting Timelines for Low SWaP Sensors to SC-228

- Technical Baseline Element Summary
  - 25 Approved
  - 13 Completed
  - 12 Open

TC	8/24/17 Baseline	Current MRB Approved Total	Total Completed	Total Remaining
C2	4	5	2	3
DAA	19	20	11	9
Total	23	25	123	12



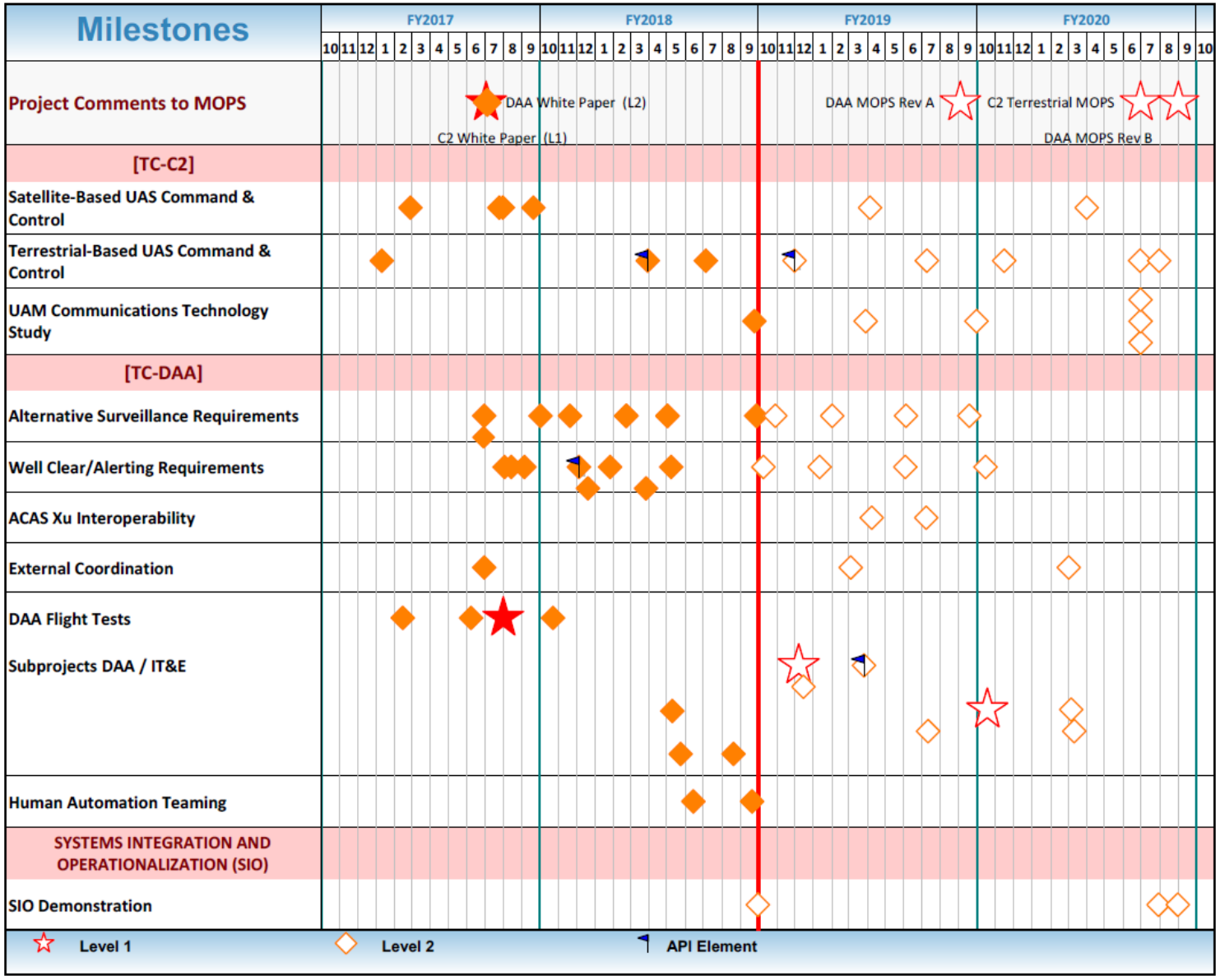
FY18 Project Deliverables (1 of 2)

FY18 Project Deliverables	Technical Challenge	Date	Type of Deliverable
ACAS Xu Flight Test 2 Flight Test Report	TC-DAA	Oct-17	Report
Foundational Terminal Ops Fast-Time Batch Simulation 1 Data Analysis	TC-DAA	Nov-17	Briefing
C-Band Cost/Benefit Assessment	TC-C2	Nov-17	Report
UAS-NAS Terminal Operations Human in the Loop 1 Test Report	TC-DAA	Dec-17	Report
Concept of Operations for UAS Detect-and-Avoid in Terminal Operations	TC-DAA	Jan-18	Paper
LinQuest Conceptual System Design Study of UAS C2 SatCom	TC-C2	Jan-18	Report
Low C-SWaP Well Clear Trade Study	TC-DAA	Feb-18	Briefing
Comparative Analysis of ACAS-Xu and DAIDALUS Detect-and-Avoid Systems	TC-DAA	Mar-18	NASA TM
Experiment Out-Brief: Well Clear/Alerting Requirements Foundational Terminal Ops HITL 1	TC-DAA	Mar-18	Briefing
Terminal Operations HITL 1B Primary Results	TC-DAA	Mar-18	Briefing
Warning Alert HITL Experiment Report	TC-DAA	Mar-18	Briefing
Terminal Area DAA Well-Clear Definition Results	TC-DAA	Mar-18	Briefing
Payload & Earth Station Conceptual Design	TC-C2	Apr-18	Report
An Interoperability Concept for Detect and Avoid and Collision Avoidance Systems: Results from a Human-in-the-Loop Simulation	TC-DAA	May-18	Paper
An Exploratory Evaluation of UAS DAA Operations in the Terminal Environment	TC-DAA	May-18	Paper
Well Clear Trade Study for Unmanned Aircraft System Detect And Avoid with Non-Cooperative Aircraft	TC-DAA	May-18	Paper

FY18 Project Deliverables (2 of 2)

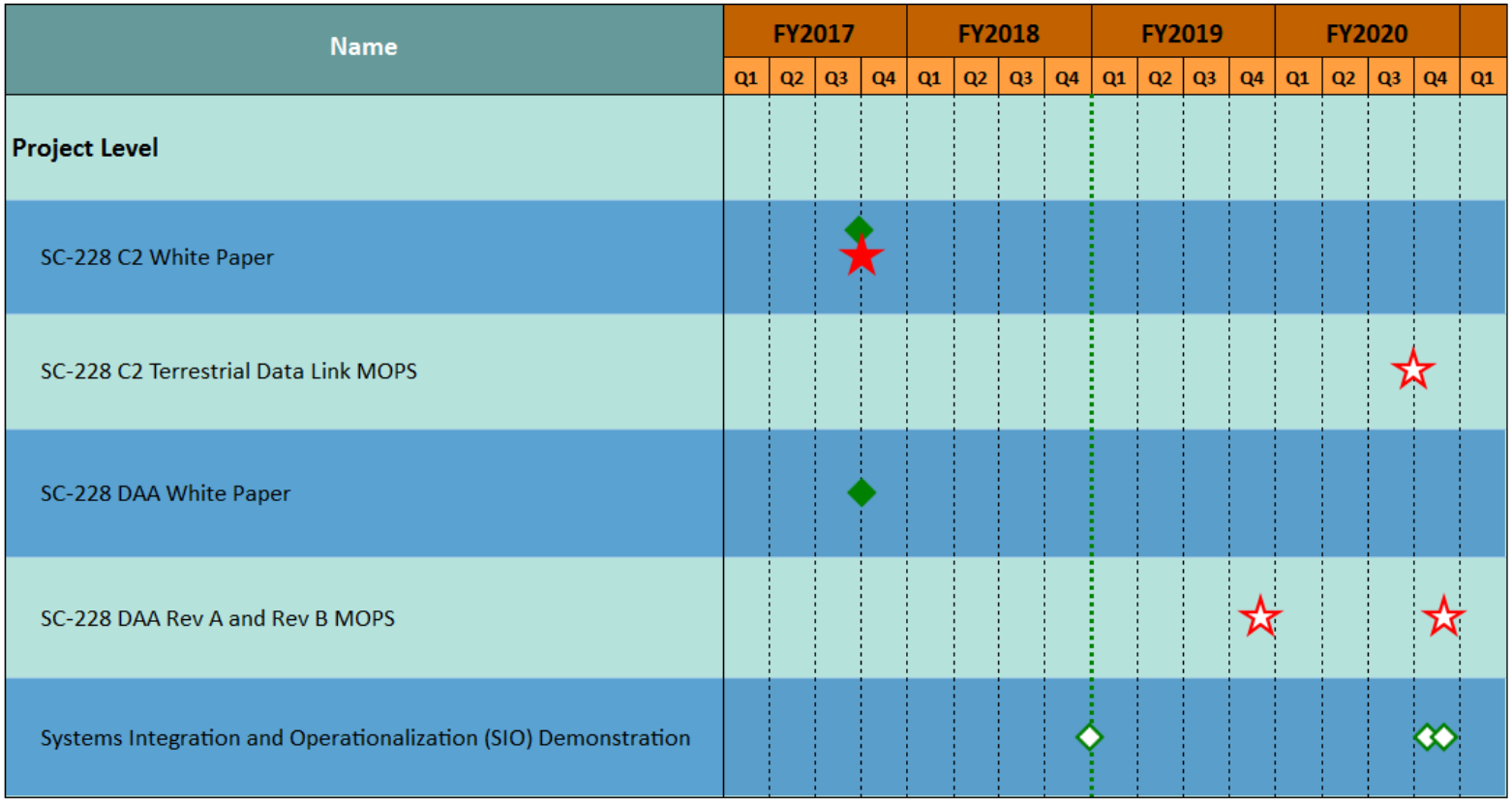
FY18 Project Deliverables	Technical Challenge	Date	Type of Deliverable
En Route Detect and Avoid Well Clear in Terminal Area Landing Pattern	TC-DAA	May-18	Paper
A Recommended DAA Well-Clear Definition for the Terminal Environment	TC-DAA	Jun-18	Paper
Sensitivity Analysis of Detect and Avoid Well Clear Parameter Variations on UAS DAA Sensor Requirements	TC-DAA	Jun-18	Paper
Analysis of Influence of UAS Speed Range and Turn Performance on Detect and Avoid Sensor Requirements	TC-DAA	Jun-18	Paper
UAS-NAS Terminal Operations Human in the Loop 1B Test Report	TC-DAA	Jun-18	Report
Hosted Satellite Payload Study Report	TC-C2	Jul-18	Report
No Chase COA Flight Test Report	TC-DAA	Aug-18	Report
Impact of the Transaction Expiration Time (TET) on ATC Performance and Acceptability	TC-DAA	Aug-18	Report
UAM C2 Baseline ConOps	TC-C2	Sep-18	Report
Trade Off between Alerting Timeline and Surveillance Volume	TC-DAA	Sep-18	Briefing
Sensor Uncertainty Mitigation and Dynamic Well Clear Volumes in DAIDALUS	TC-DAA	Sep-18	Report
PAE ISR Cooperative Agreement Signed	SIO	Sep-18	Agreement
Honeywell Cooperative Agreement Modification Signed	TC-DAA	Sep-18	Agreement
NASC Contract Signed	TC-DAA	Sep-18	Agreement

Phase 2 Milestone Summary



Red Status Line Date 9/30/18

Project Office



Green Status Line Date 9/30/18

Acronyms

A/A	Air-to-Air
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
APM	Associate Project Manager
APT	Autonomous Pod Transport
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 or Authority to Operate
AVS	Aviation Safety-FAA Organization

Acronyms

BRLOS	Beyond Radio Line of Sight
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
C3	Command, Control and Communication
CA	Collision Avoidance or Cooperative Agreement
CAN	Cooperative Agreement Notice
CAS	Collision Avoidance System
CDR	Critical Design Review
CE	Chief Engineer
Cert	Certification
CMB	Change Management Board
CNPC	Control and Non-Payload Communications
CNS	Communication, Navigation and Surveillance
COA	Certificate of Authorization or Waiver
Comm	Communications
CONOPS	Concept of Operations
COTS	Commercial off the Shelf
CRM	Continuous Risk Management
CS	Civil Servant
C-SWaP	Cost – Size, Weight, and Power

Acronyms

C&TA	Concepts & Transversal Activities
DAA	Detect and Avoid
DAIDALUS	Detect and Avoid Alerting Logic for Unmanned Systems
DAPA	Digital Active Phased Array
DoD	Department of Defense
DPM	Deputy Project Manager
DWC	Definition Well Clear
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FT	Flight Test
FTE	Full Time Equivalent
FY	Fiscal Year
FYE	Fiscal Year End
GA	General Aviation
GA-ASI	General Atomics Aeronautical Systems Inc.
GBDAA	Ground Based Detect and Avoid
GCS	Ground Control Station
Gen	Generation
GRC	Glenn Research Center
HALE	High Altitude Long Endurance
HAT	Human Autonomy Teaming
HF	Human Factors

Acronyms

HITL	Human-in-the-loop
HITS	Human in the System
HQ	Headquarters
IASP	Integrated Aviation Systems Program
lb.	Pounds
ICAO	International Civil Aviation Organization
IDIQ	Indefinite-Delivery, Indefinite-Quantity
IFR	Instrument Flight Rules
IMS	Integrated Master Schedule
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
LVC-DE	Live Virtual Constructive Distributed Environment
MASPS	Minimum Aviation System Performance Standards
MOPS	Minimum Operational Performance Standards
MRB	Management Review Board
M&S	Modeling and Simulation

Acronyms

MS&A	Modeling, Simulation, and Analysis
MSL	Mean Sea Level
N2	2nd upgrade to the original NBS
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASC	Navmar Applied Sciences Corporation
NCC	No Chase COA
NextGen	Next Generation
NRA	NASA Research Announcement
OE	Operating Environment
OSED	Operational Services Environment Description
OUSD	Office of the Under Secretary of Defense
OV-1	Operational View
P1	Phase 1
P2	Phase 2
PDR	Preliminary Design Review
PER	Preliminary Experiment Review
PI	Progress Indicator
PIL	Pilot in the loop
PM	Project Manager

Acronyms

PO	Project Office
PP	Project Plan
PRP	Performance Review Panel
RADAR	Radio Detection and Ranging
RF	Radio Frequency
RFI	Request for Information
RFP	Request for Proposal
RPAS	Remotely Piloted Aircraft Systems
RPS	Remote Pilot Station
RT	Research Theme
RTP	Research Transition Products
RTT	Research Transition Team
SAA	Sense and Avoid or Space Act Agreement
SARP	Science and Research Panel
SatCom	Satellite Communications
SC	Special Committee
SIERRA-B	Sensor Integrated Environmental Remote Research Aircraft
Sim	Simulation
SIO	Systems Integration and Operationalization
SME	Subject Matter Expert

Acronyms

SP	Schedule Package
SPM	Subproject Manager
SWaP	Size, Weight and Power
TB	Technical Baseline
TBE	Technical Baseline Element
TBEN	Technical Baseline Element Number
TC	Technical Challenge
TCAS	Traffic Alerting and Collision Avoidance System
TOPS	Terminal Operations
ToR	Terms of Reference
TRL	Technology Readiness Level
TSO	Technical Standard Order
UA	Unmanned Aircraft
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems
UAS-NAS	Unmanned Aircraft Systems Integration in the National Air Space System
UAV	Unmanned Aircraft Vehicle
UCAT	Urban Air Mobility (UAM) Coordination Assessment Team
UTM	UAS Traffic Management
V	Version

Acronyms

VFR	Visual Flight Rules
VLL	Very Low Level
VLOS	Visual Line of Sight
VSCS	Vigilant Spirit Control Station
VTOL	Vertical Take off and Landing
V&V	Verification and Validation
WC	Well Clear
WG	Working Group
WYE	Work Year Equivalent