



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

KDP-C Review

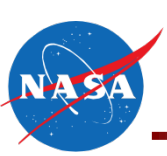
Laurie Grindle
Project Manager

Robert Sakahara
Deputy PM

Davis Hackenberg
Deputy PM, Integration

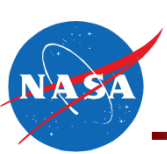
William Johnson
Chief Engineer





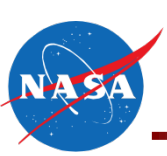
Agenda

8:30 – 8:45	Opening Remarks	Dr. Jaiwon Shin/ Dr. Ed Waggoner
8:45 – 10:15	KDP-A Outcomes & KDP-C Overview UAS Community Overview and Technical Challenge Development	Davis Hackenberg
10:15 – 10:30	Break	
10:30 – 11:30	Technical Baseline	William Johnson
11:30 – 12:30	Lunch	
12:30 – 1:30	Technical Baseline continued	William Johnson
1:30 – 2:00	Project Summary Briefing Summary	Laurie Grindle
2:00 – 3:30	Review Panel Caucus	PRP
3:30 – 4:00	Review Panel Assessment and Recommendations	Review Panel Chair
4:00 – 4:30	ARM D AA Decision and Closing Remarks	Dr. Jaiwon Shin
4:30	Adjourn	



KDP-A Results & Action Summary

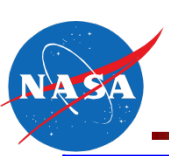
- KDP-A Outcome
 - Approved to proceed with the TC-C2 partnerships, ACAS Xu Flight Test 2 Partnership, and overall project formulation
- KDP-A Actions to be addressed at or before KDP-C per KDP-A memo
 - Assess whether IT&E should or shouldn't be a Technical Challenge. Brief recommendation NLT KDP-C. **[Project Tag-up with the AA on March 13, 2017]**
 - Sharpen DAA and C2 TC wording along the lines of TC guidelines to clearly describe the technical barrier being addressed (see assessment and recommendations). Brief these, along with explanation of overarching applicability to community needs, NLT KDP-C. **[Project Tag-up with the AA on March 13, 2017]**
 - Prepare discussion material for a future Project Tag-up with the AA that addresses the following:
 - Describe the relationship between LVC-DE and the FAA Test Sites **[Project Tag-up with the AA on December 5, 2016]**; LVC-DE/SMART NAS meeting with ARMD Leadership **[February 15, 2017]**
 - Include any examples of LVC-DE use by other organizations
 - Offer current thoughts on what portion of the UAS industry we expect to benefit from our work in the next 5 years...Is there a real demand in that timeframe? **[Pre-SPMR]**
 - Has the current UAS focus excluded any vehicle classes?
 - Schedule and present at a KDP-C in the 2nd Quarter of FY17 **[Today]**



KDP-C ToR Overview

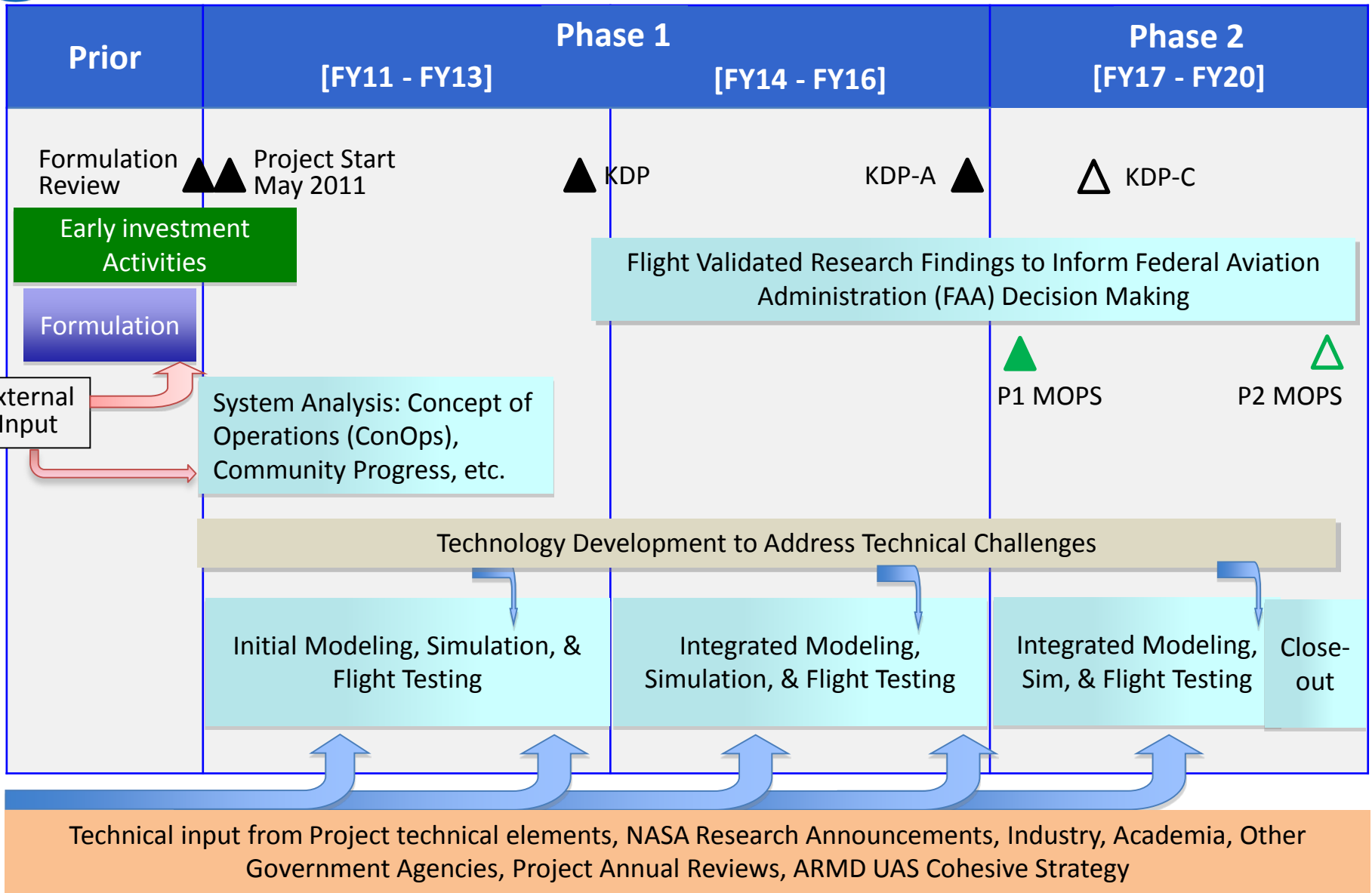
- During this review, the Project will address the terms of reference (ToR) intent and demonstrate readiness to proceed
- *The project will be approved to move from formulation to implementation if the Project Management Team can effectively convey that the:*
 - 1) *Technical plans are relevant to the agency's mission and vision as well as, the ARMD Strategic Implementation Plan, and customer/stakeholder needs*
 - 2) *Technical plans are feasible and executable*
 - 3) *Planned resources and schedule are adequate to meet the stated goals and objectives of the Project with the acceptable level of risk*
 - 4) *Management process updates and partnership approaches are sound for the proposed UAS-NAS Project*
- Decision the Project is seeking today
 - Approval to proceed with execution of the baseline plan

These charts reflect removal of budget/resource information.
Additionally, actions from brief will affect Baseline

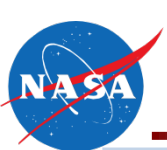


UAS-NAS Project Lifecycle

Timeframe for impact: 2025




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



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

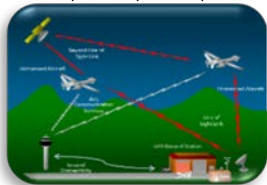
AERONAUTICS
Technical
Challenges

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
Challenges



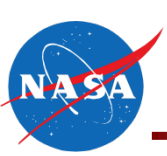
TC-C2:
Command & Control



TC-DAA:
Detect and Avoid

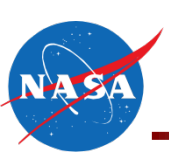


TC-SIO:
System Integration & Operationalization



Outline

- KDP-A Outcomes & KDP-C Overview
- UAS Community Overview and Technical Challenge Development
 - Description
 - Budgets
 - Project Organization
- Technical Baseline
- Project Summary
- Briefing Summary



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)

IFR-LIKE

UAS will be expected to meet certification standards and operate safely with traditional air traffic and ATM services. (Example Use Case: Communication Relay / Cargo Transport)

FL-600

18K' MSL

10K' MSL

Non-cooperative Traffic

Cooperative Traffic

Cooperative Traffic

VFR-LIKE

These UAS will operate at altitudes below critical NAS infrastructure and will need to routinely integrate with both cooperative and non-cooperative aircraft. (Example Use Case: Infrastructure Surveillance)

Non-Cooperative Traffic

Cooperative Traffic

Top of Class G

BVLOS RURAL

Low risk BVLOS rural operations with or without aviation services. (Example Use Case: Agriculture)

BVLOS URBAN

Must interface with dense controlled air traffic environments as well as operate safely amongst the traffic in uncontrolled airspace. (Example Use Case: Traffic Monitoring / Package Delivery)

Terminal Airspace

Airport

Agricultural Aircraft

Helicopters

Non-Cooperative Aircraft

VLOS

VLOS

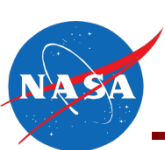
RURAL

URBAN

Restricted Access

TIME (Notional)

Routine Access



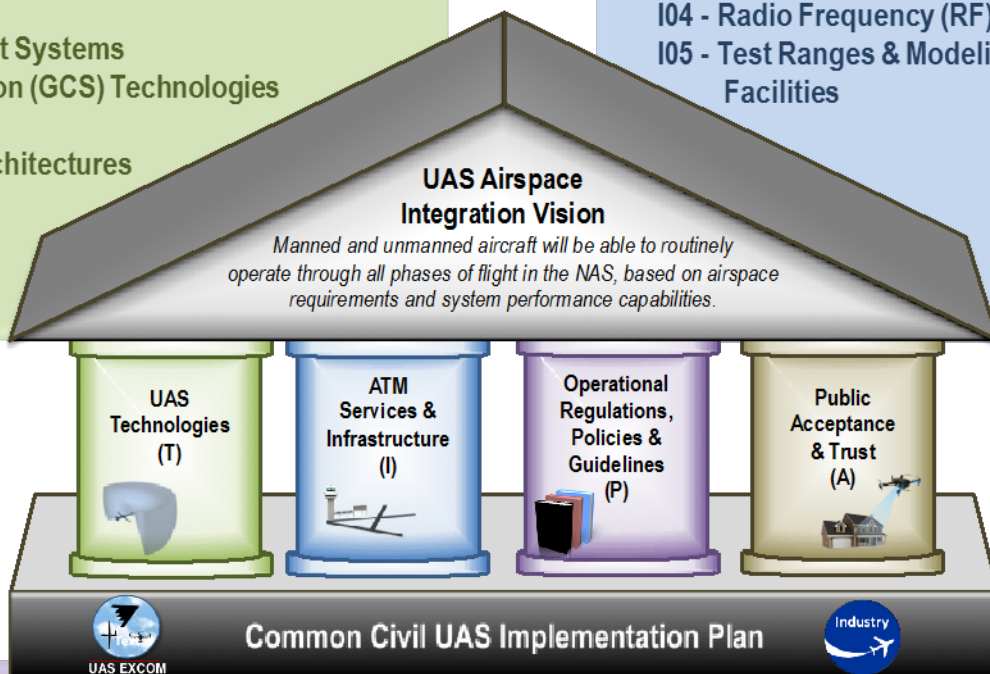
UAS Airspace Integration Pillars and Enablers

UAS Technologies:

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

ATM Services & Infrastructure:

- I01 - Airport Infrastructure
- I02 - Air Traffic Management (ATM) Infrastructure
- I03 - Non-FAA Managed Airspace Infrastructure
- I04 - Radio Frequency (RF) Spectrum Availability
- I05 - Test Ranges & Modeling & Simulation (M&S) Facilities



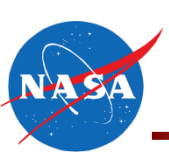
Operational Regulations, Policies & Guidelines:

- 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:

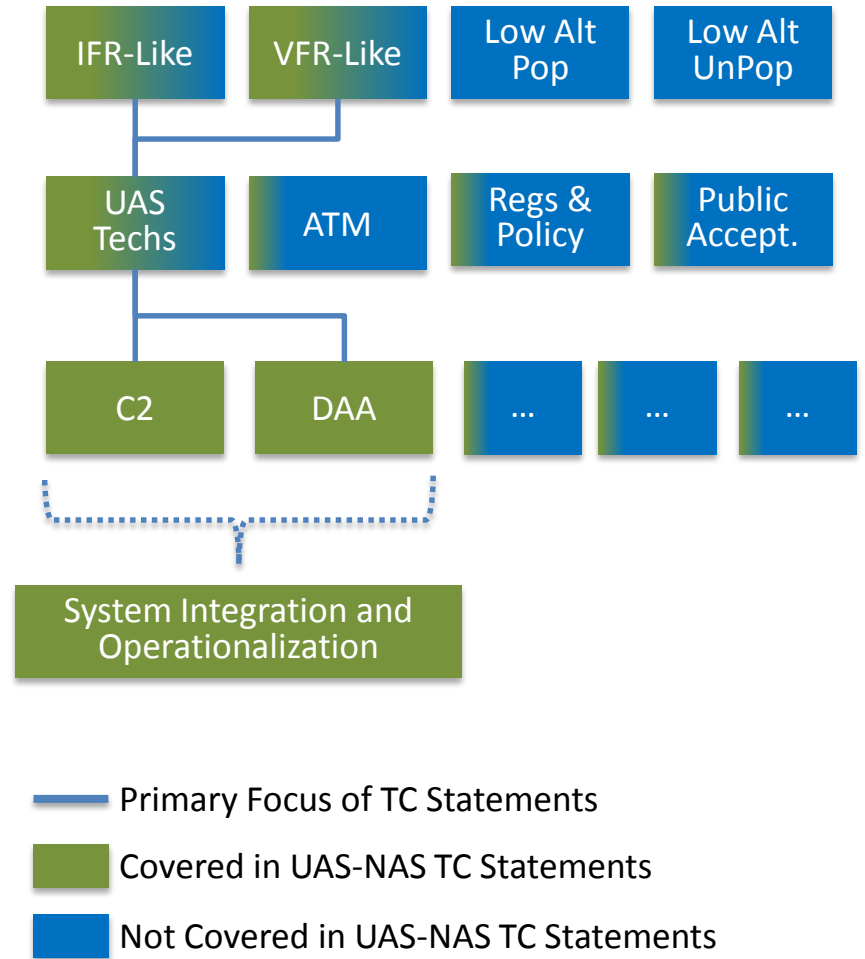
- A01 - Cyber Security Criteria & Methods of Compliance
- A02 - Legal & Privacy Rules / Guidelines
- A03 - Noise Reductions
- A04 - Physical Security Criteria & Methods of Compliance
- A05 - Public Safety Confidence

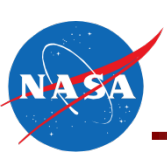
The UAS Airspace Integration Pillars enable achievement of the Vision



UAS Integration / Project Background

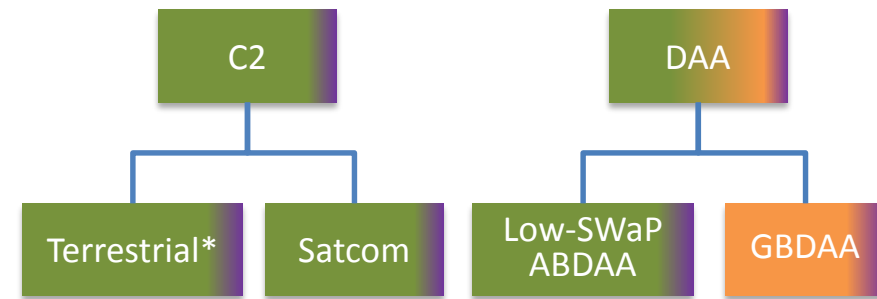
- Each Operating Environment has unique considerations with respect to each Pillar
- Program and Project core competencies focus on Integrated Vehicle technologies
- “IFR-Like” and “VFR-Like” Operating Environments became the project focus due to considerations such as core competencies, TRL, other ARMD portfolio work, and community benefit
- KDP-A proposed 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








UAS Integration / Project Background

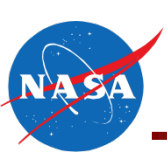
- NASA and FAA have determined DAA and C2 are the most significant barriers to UAS integration
- Project wrote TC statements that address the full barrier for DAA and C2 in the “VFR-Like” and “IFR-Like” Operating Environments
- Project identified the work required to complete the TCs and which aspects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



-  Covered in UAS-NAS TC Statement and baseline resources
-  Not Covered by UAS-NAS P2 Resource Allocation
-  Not Covered by UAS-NAS P2 Resource Allocation, specific to SIO

* Portions of Terrestrial C2 completed as part of Phase 1 project specific to “IFR-Like”, but work remains for “VFR-Like”

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



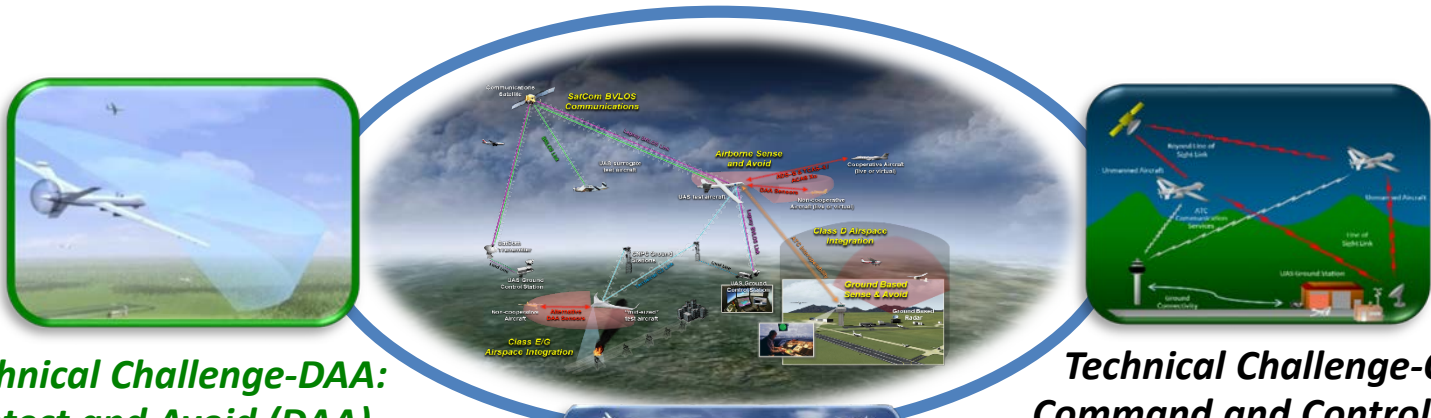
Project TC Definitions

- Background
 - Sets the stage for the current state of the UAS Community with respect to the element being discussed, i.e. Command and Control (C2), Detect and Avoid (DAA), or System Integration and Operationalization (SIO) for UAS
- Barrier
 - What's needed to be overcome for the UAS Community to move forward
- Community Objectives
 - Decomposition of the barrier, i.e. what the Project and UAS Community hope to achieve
- TC Statement
 - Written for the full barrier for the “VFR-Like” and “IFR-Like” Operating Environments and what the UAS Community needs
- Project Approach
 - The work that the Project is doing to address the community need/barrier
 - Defines how the Project is working with the community to accomplish the community objectives
 - Defines the overarching approach on which the baseline content is based

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

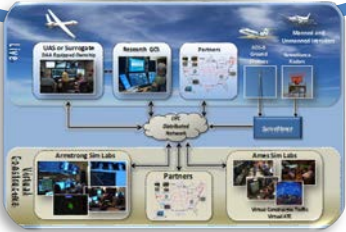
Project Goal

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

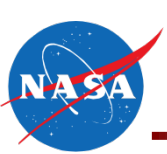


Technical Challenge-DAA: Detect and Avoid (DAA)

Technical Challenge-C2: Command and Control (C2)



Technical Challenge-SIO: System Integration and Operationalization (SIO)



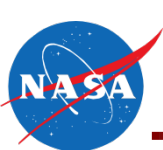
UAS Detect and Avoid Operational Concepts and Technologies Technical Challenge Statement

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

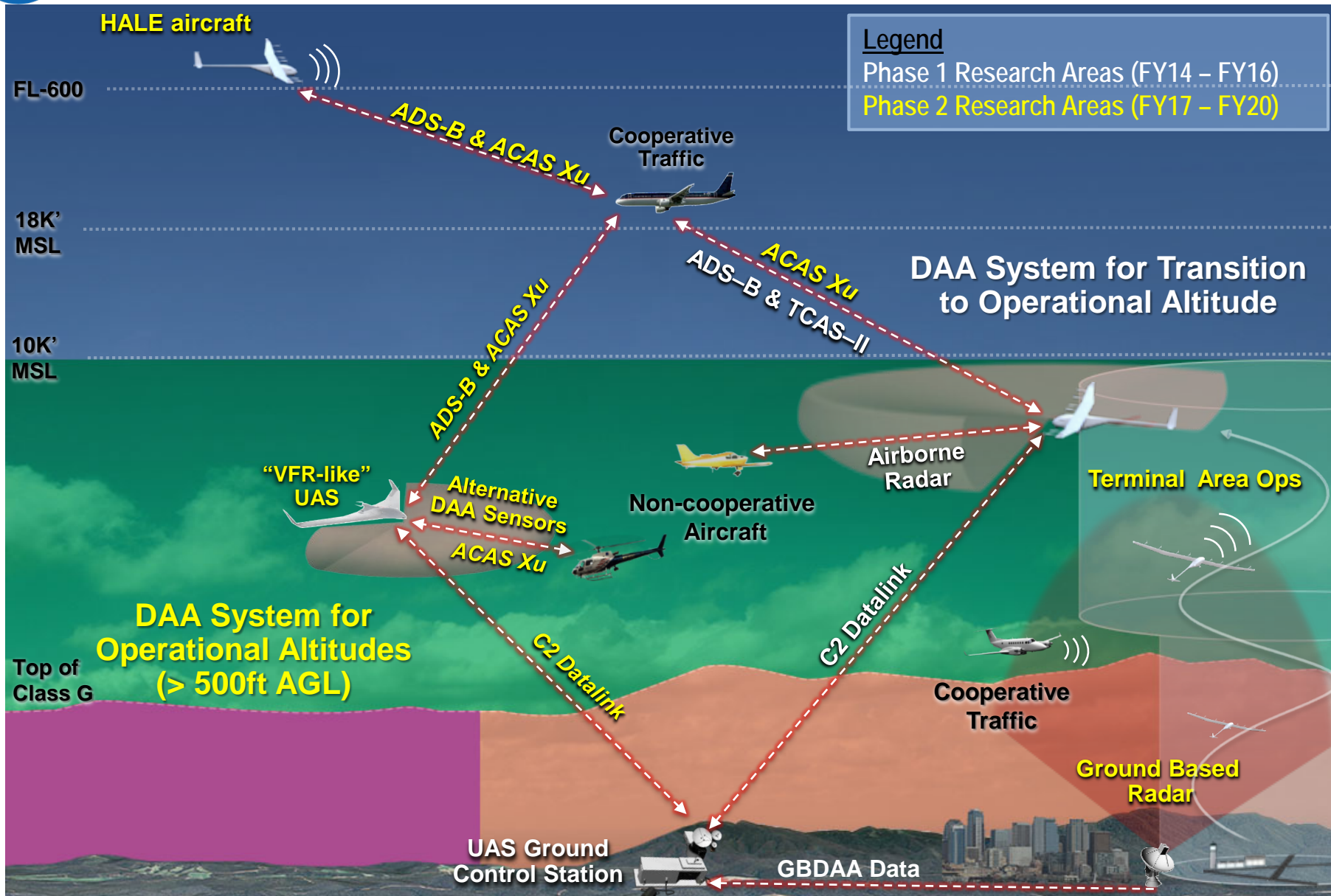
Develop Detect and Avoid (DAA) operational concepts and technologies in support of standards to enable a broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to detect and avoid manned and unmanned air traffic

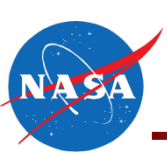
- Community Objectives:
 - Develop and validate UAS DAA requirements for Low-SWaP airborne DAA systems to support standardization through the evaluation of commercial and engineering prototype DAA systems that enable a broader set of UAS operations
 - Implement state of the art DAA technologies into an UAS and test in operationally relevant scenarios
 - *Develop and validate UAS DAA requirements for Ground Based DAA systems to support standardization through the evaluation of commercially available radars integrated with airborne DAA architectures*
 - *Develop and validate human machine interface requirements to support human automation teaming and higher levels of autonomy for UAS DAA systems*
- Project Approach:
 - Develop Concept of Operations and performance standards in coordination with RTCA and FAA (including international)
 - Solicit industry partnerships to develop DAA technologies
 - Perform modeling and simulation to characterize the trade space of the DAA for critical areas such as well clear, collision avoidance interoperability, human machine interfaces, and others
 - Flight Test and V&V of DAA technologies for performance standard requirements and DAA system technology builds

Bullets in italics are not covered by UAS-NAS P2 resource allocation



Detect and Avoid (DAA) Performance Standard Operating Environments (OE)



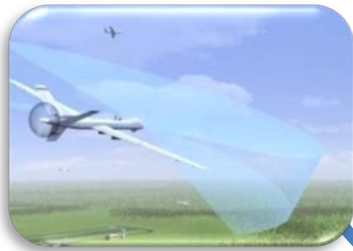


TC-C2:

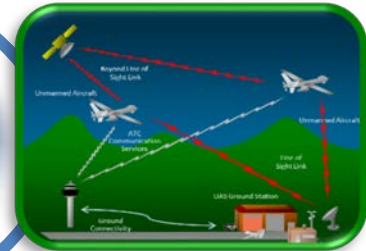
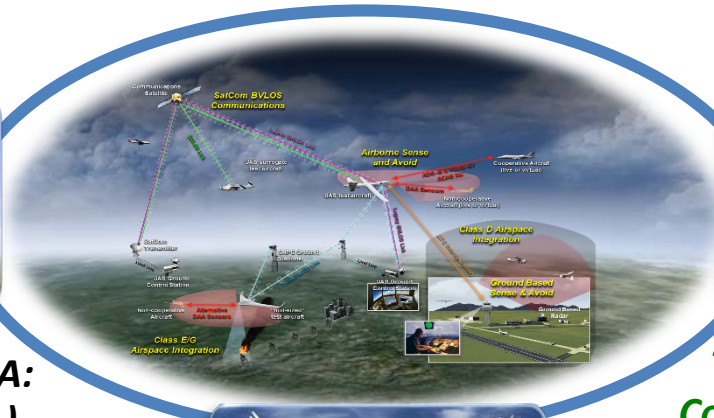
UAS Satcom and Terrestrial Command and Control

Project Goal

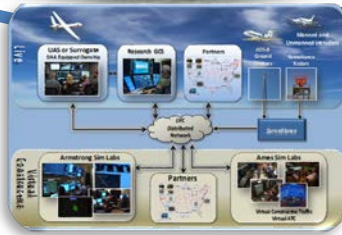
Provide research findings, utilizing simulation and flight tests, to support the development and validation of DAA and C2 technologies necessary for integrating Unmanned Aircraft Systems into the National Airspace System



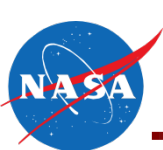
**Technical Challenge-DAA:
Detect and Avoid (DAA)**



**Technical Challenge-C2:
Command and Control (C2)**



**Technical Challenge-SIO:
System Integration and Operationalization (SIO)**

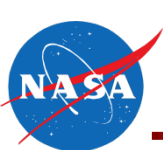


UAS Satcom and Terrestrial Command and Control Technical Challenge Statement

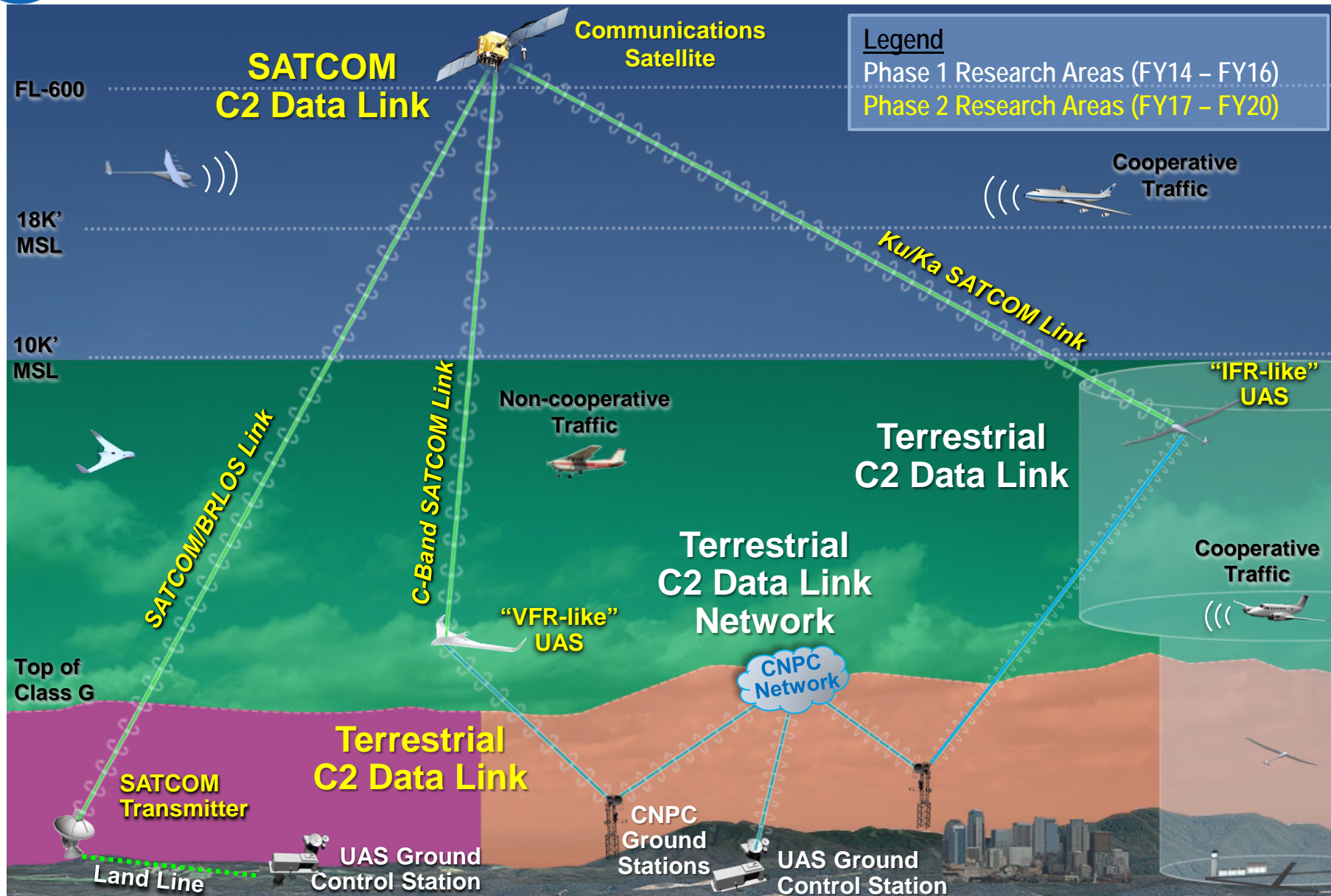
TC-C2: UAS Satcom and Terrestrial Command and Control

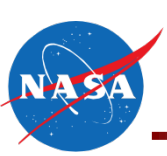
Develop Satellite (Satcom) and Terrestrial based Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage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

- **Community Objectives:**
 - Develop and validate UAS C2 requirements and radio spectrum allocation decisions to support C2 standardization through the evaluation of commercial and engineering prototype Ku/Ka Satcom radio systems
 - Develop and validate UAS C2 requirements to support C2 standardization through the evaluation of commercial and engineering prototype multiple access C-Band Terrestrial radio systems
 - Provide system design studies (payload and earth station) and system design requirements of C-band Satcom systems for C2 standardization
- **Project Approach:**
 - Develop Concept of Use to be leveraged for initial requirements for C2 partnerships, and coordination with RTCA and FAA
 - Jointly develop performance standards with RTCA and FAA (including international) throughout lifecycle of concept and technology development
 - Solicit industry partnerships to develop radio technologies in Satcom and terrestrial frequency bands
 - Performance assessment of satellite-based CNPC in existing Fixed Satellite Service bands
 - Flight Test and V&V of radio technologies for performance standard requirements and radio technology builds



UAS Satcom and Terrestrial Command and Control Operating Environments (OE)



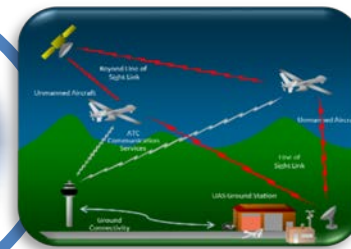


Project Goal

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



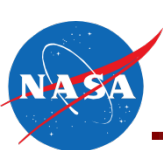
**Technical Challenge-DAA:
Detect and Avoid (DAA)**



**Technical Challenge-C2:
Command and Control (C2)**



**Technical Challenge-SIO:
System Integration and Operationalization (SIO)**



System Integration and Operationalization for UAS Technical Challenge Statement

TC-SIO: System Integration and Operationalization for UAS

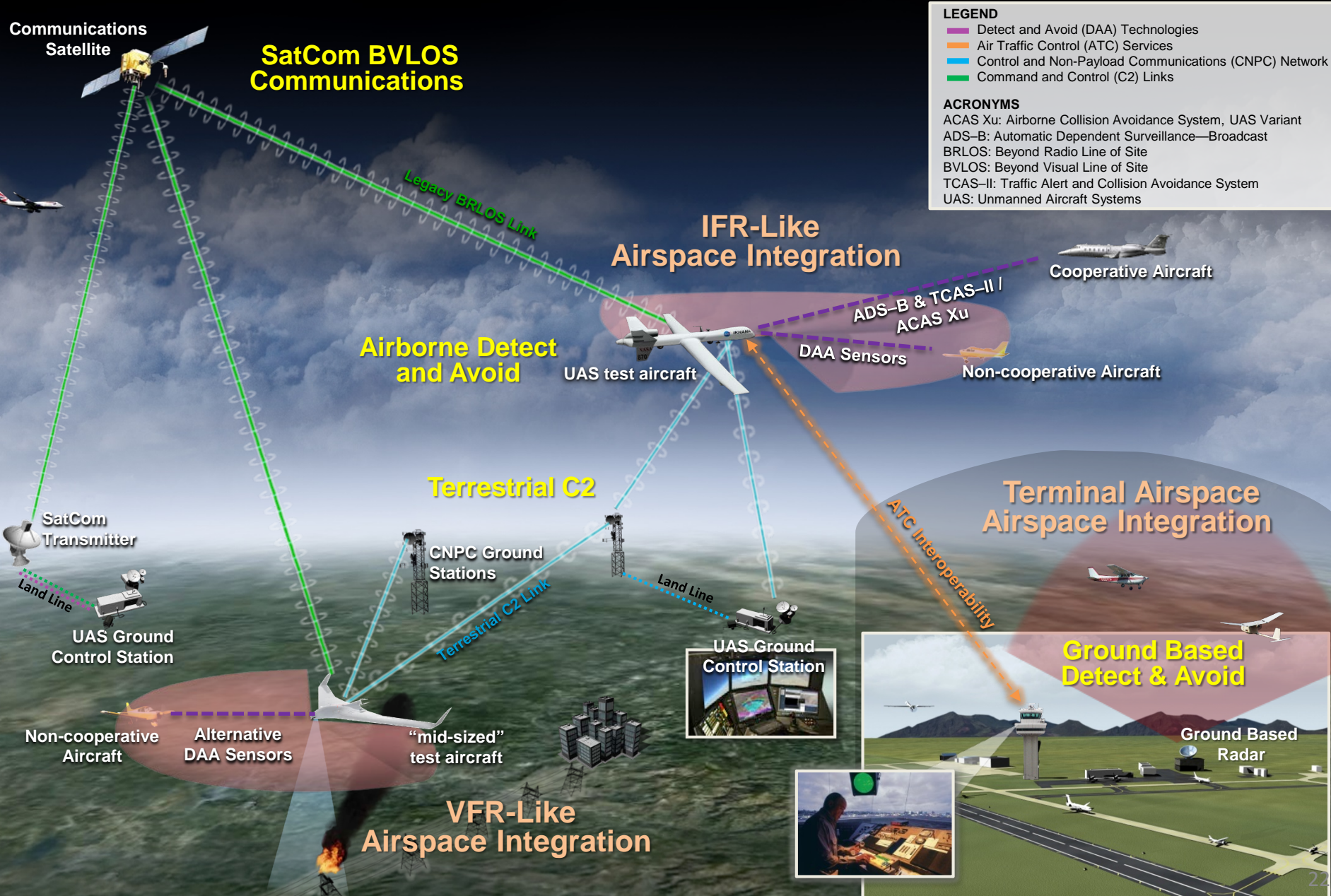
Integrate state of the art DAA and C2 technologies into Unmanned Aircraft Systems (UAS) to ensure sufficient aircraft level functional and operational requirements, and perform demonstrations in the NAS to inform Federal Aviation Administration creation of policies for operating UAS that have Communication,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

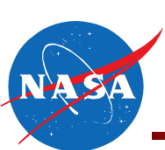
- Community Objectives:
 - Obtain FAA approval to demonstrate SC-228 Phase 1 DAA MOPS technologies on an unmanned aircraft in the NAS as an alternative means of compliance to FAR Part 91 “see and avoid” rules (i.e. No Chase COA)
 - Support coordination between DAA and C2 activities within RTCA
 - *Perform operational demonstrations of integrated Phase 2 MOPS DAA and C2 technologies in their NAS operating environments to assist the FAA in developing the policies for UAS integration aircraft that will fly IFR*
- Project Approach:
 - Leverage Phase 1 DAA MOPS developed technologies to obtain an operational approval, in partnership with ATO, to fly the DAA system in the NAS with as few restrictions as possible (No Chase COA)
 - Develop C2-DAA interface requirements and Phase 2 DAA and C2 integrated ConOps

Note: SIO is foundational to Vehicle Technology elements from the UAS Cohesive Strategy

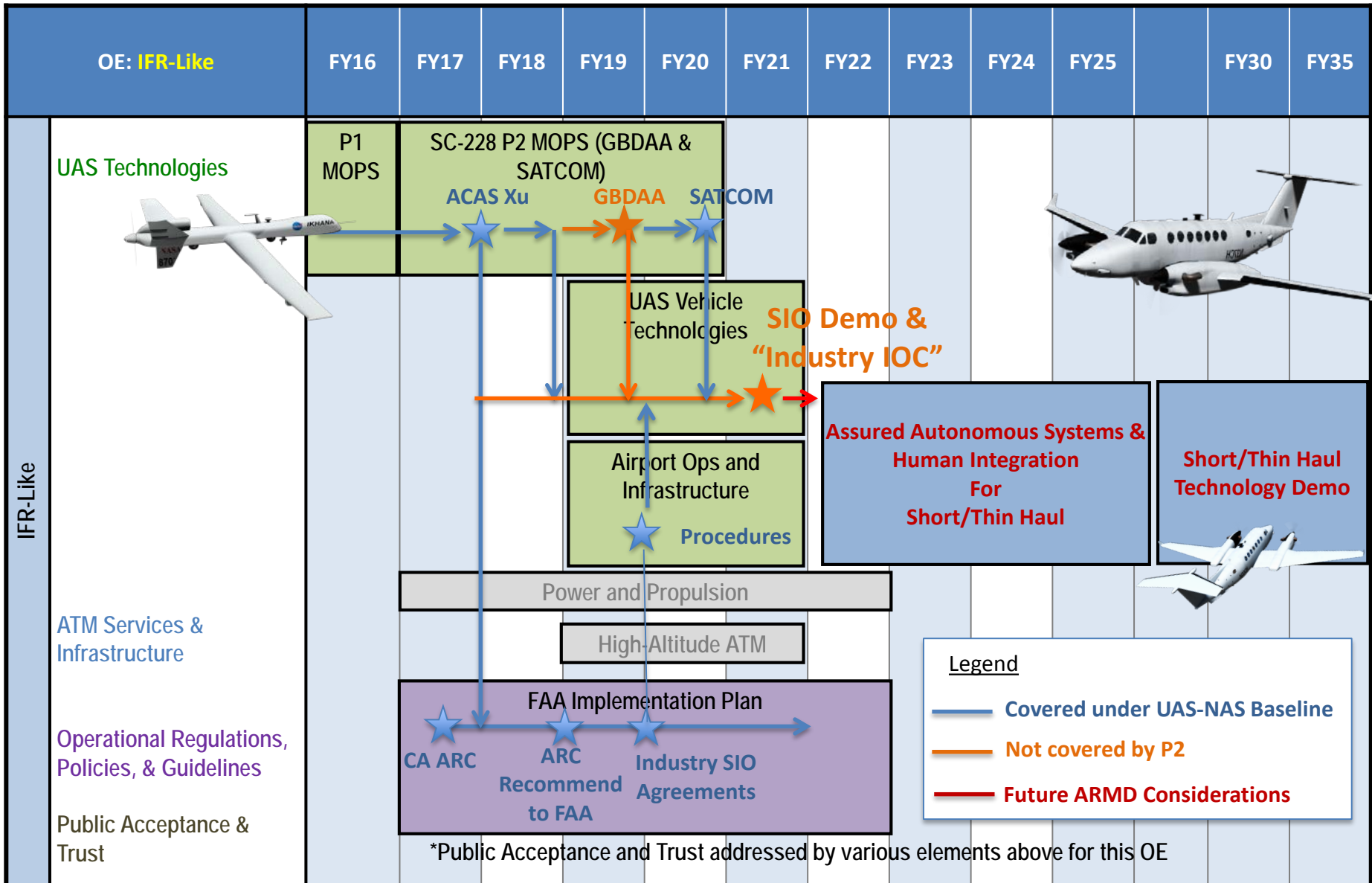
Bullets in italics are not covered by UAS-NAS P2 resource allocation

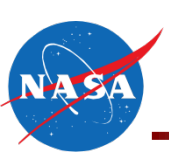
UAS-NAS Project - DAA and C2 Operational View Representation



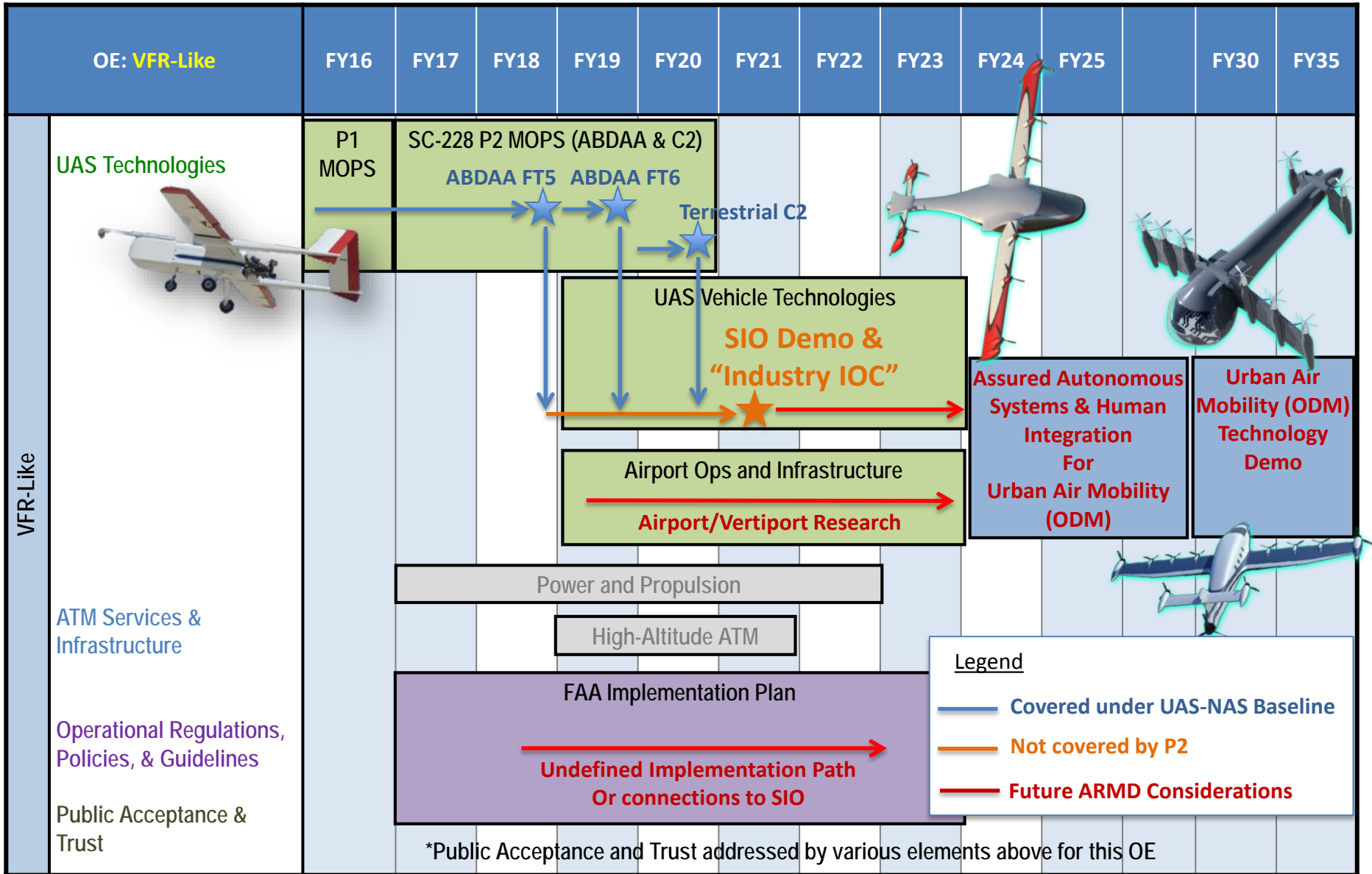


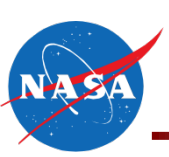
Potential “IFR-Like” Transition to “Thin/Short Haul”





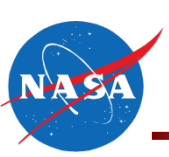
Potential “VFR-Like” Transition to “Urban Air Mobility”





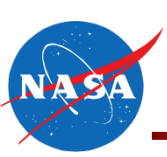
Project Resource Overview

- Data Removed



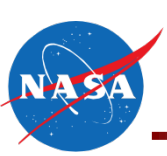
Total Planned Budget (\$K) by TC and Project Management

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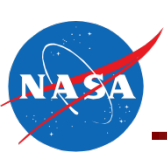
Risk Mitigation Summary

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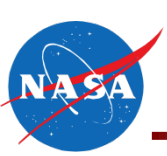
UAS-NAS Phase 2 Project Organization Structure

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Outline

- KDP-A Outcomes & KDP-C Overview
- UAS Community Overview and Technical Challenge Development
- **Technical Baseline**
 - Technical Baseline Overview
 - Technical Challenges
 - Emerging TC
- Project Summary
- Briefing Summary



Technical Baseline Development

Technical Challenges (TC)

- Defined by UAS Community Needs

Technical Work Packages (TWP)

- Defined at KDP-A, Refined at KDP-C
- Subject areas of the Technical Challenges
- Required content to accomplish TCs
- Identified Resources (FTE/WYE/Procurement)
- Documented TWP Objectives in the Technical Baseline

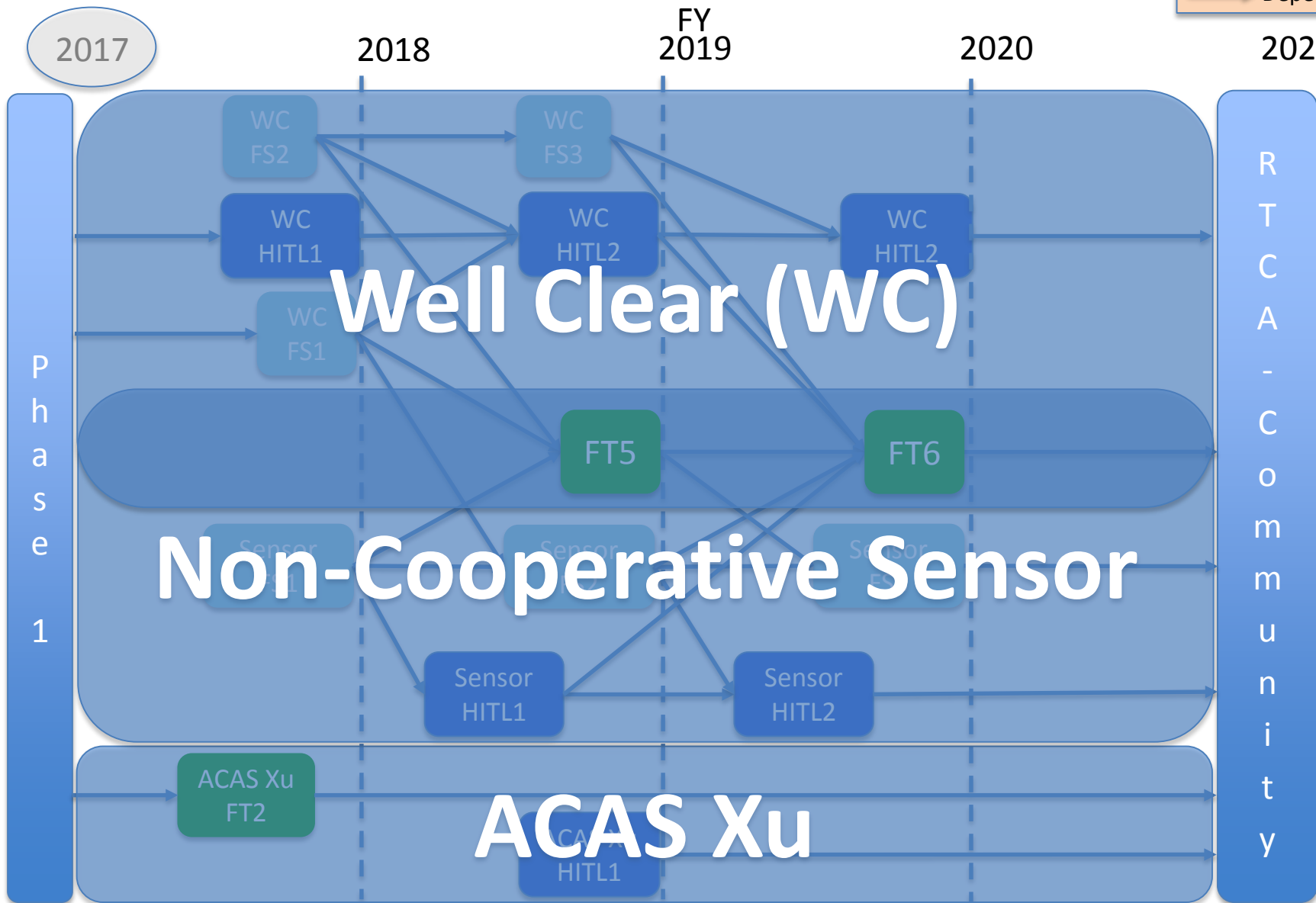
Schedule Packages (SP)

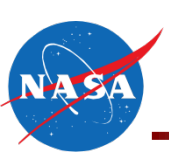
- Described the Phase 2 technical content and significantly enhanced technical detail
- Defined by discrete activities and tasks necessary to accomplish a TWP; generally with research findings as the outcome
- Documented SP Objective, Approach, and Deliverable in Technical Baseline
- Project Milestones defined



Technical Baseline Overview (TC-DAA)

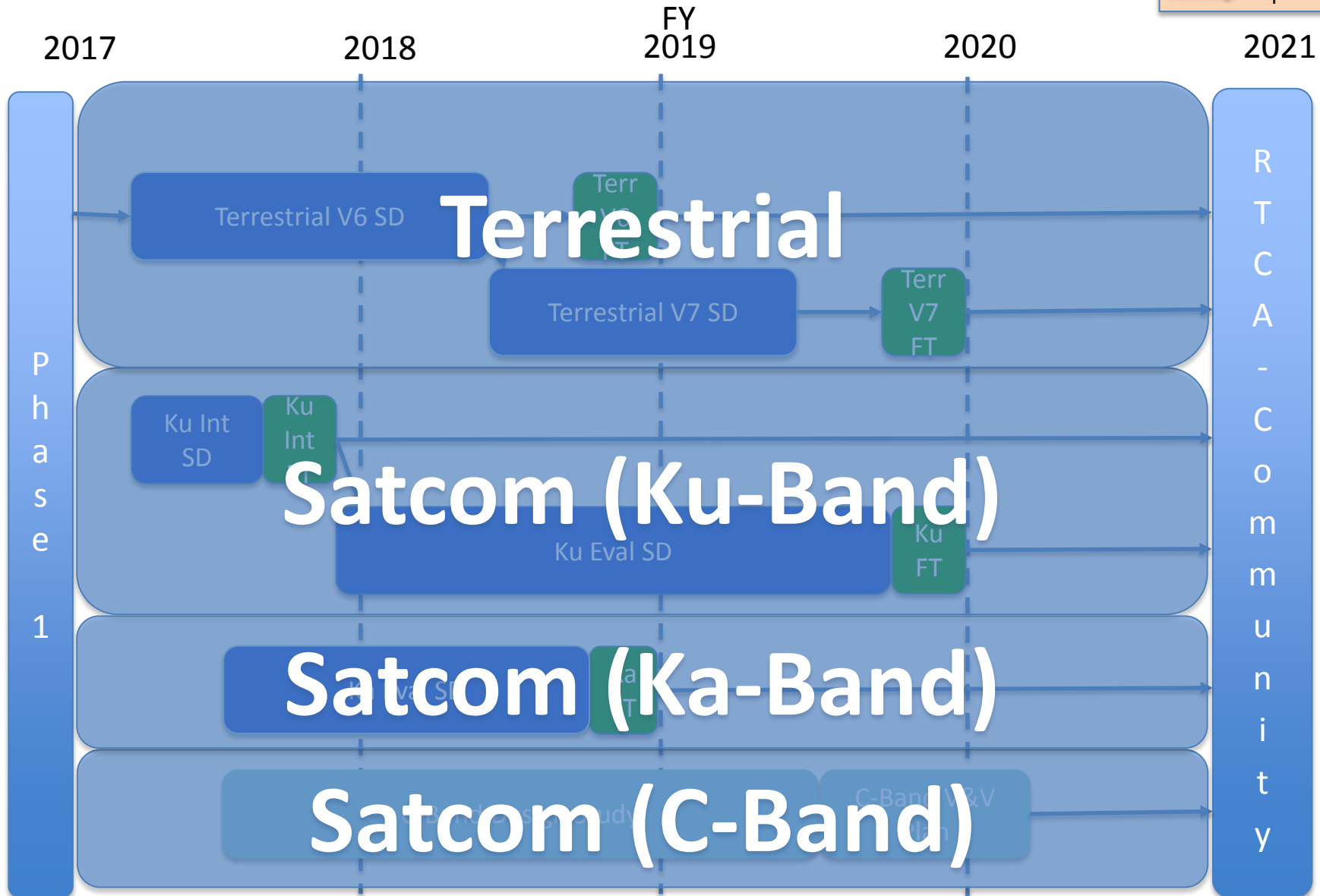
- Fast-time Sim
- HITL Sim
- Flight Test
- Dependency

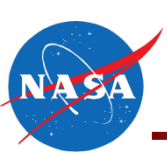




Technical Baseline Overview (TC-C2)

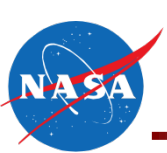
- Study
- System Dev
- Flight Test
- Dependency





Outline

- KDP-A Outcomes & KDP-C Overview
- UAS Community Overview and Technical Challenge Development
- **Technical Baseline**
 - Technical Baseline Overview
 - **Technical Challenges**
 - Emerging TC
- Project Summary
- Briefing Summary



TC-DAA: Detect and Avoid Operational Concepts and Technologies

Research Theme Thrust 1

– Airspace Operations Performance Enablers

Research Theme Thrust 6

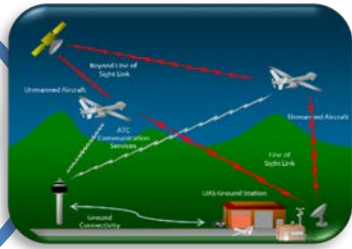
– Implementation and Integration of Autonomous Airspace and Vehicle Systems

TC-DAA

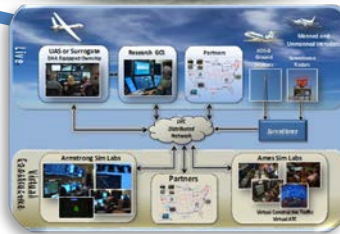
– Develop Detect and Avoid (DAA) operational concepts and technologies in support of standards to enable a broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to detect and avoid manned and unmanned air traffic



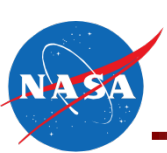
Technical Challenge-DAA: Detect and Avoid (DAA)



Technical Challenge-C2: Command and Control (C2)



Technical Challenge-SIO: System Integration and Operationalization for UAS (SIO)



TC-DAA: Overview

Description: The Detect and Avoid (DAA) effort will lead the **Unmanned Aircraft System (UAS) community** through **concepts and technology development** of DAA technologies applicable to a **broad range of aircraft with low cost size, weight, and power (SWaP)** availability. The DAA system will **detect** other aircraft in their vicinity, **predict** if the aircraft trajectories will be in conflict with each other, and **determine the appropriate guidance** to display to the UAS pilot in command. Pilot responses to the system will be assessed in order to **validate standards** being developed for UAS **within RTCA SC-228**. Robust safety and collision risk assessments, algorithm development, and ground control station display development will be performed in **collaboration with other government agencies and industry stakeholders** to support the broad needs of detect and avoid for the UAS community.

Objectives

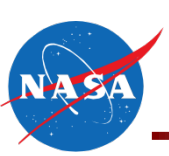
- **Develop and validate UAS DAA requirements** for Low-SWaP airborne DAA systems to support standardization through the evaluation of commercial and engineering prototype DAA systems that enable a broader set of UAS operations
- **Implement** state of the art **DAA technologies** into an UAS and test in operationally relevant scenarios

Approach

- **Develop Concept of Operations and performance standards** in coordination with RTCA and FAA (including international)
- **Solicit industry partnerships** to develop DAA technologies
- **Perform modeling and simulation to Characterize the trade space of the DAA system** for critical areas such as well clear, collision avoidance interoperability, human machine interfaces, and others.
- **Flight Test and V&V** of DAA technologies for performance standard requirements, and DAA system technology builds

Deliverables

- RTCA Standards Inputs:
 - DAA Phase 2 MOPS
 - Sensor Phase 2 MOPS
 - ACAS Xu MOPS
- Technical papers & presentations to technical and regulatory organizations
- Candidate DAA guidance, displays, & alerting
- Integrated design documents for each integrated event



TC-DAA: DAA and IT&E Subprojects

Detect and Avoid - Technical Challenge

TECHNICAL
CHALLENGE
LEVEL

DAA Subproject

**D.1
Alternative
Surveillance
Requirements**

**D.2
Well Clear
Alerting
Requirements**

**D.3
ACAS Xu**

**D.4
External
Coordination**

**D.5
Integrated Events**

TECHNICAL WORK
PACKAGE LEVEL

IT&E Subproject

**T.6
Integration of
Technologies into
LVC-DE**

**T.7
Simulation Planning &
Testing**

**T.8
Integrated
Flight Test**



TC-DAA: DAA Subproject

Detect and Avoid Subproject

Subproject Manager

Jay Shively, ARC

Subproject Technical Leads

Confesor Santiago, ARC; Tod Lewis, LaRC; Lisa Fern, ARC

**D.1 Alternative
Surveillance
Requirements**

D.1.10 / D.1.20 /
D.1.30 / D.1.50

Tiger Team,
Partnerships,
ConOps, Display

D.1.40 / D.1.60 /
D.1.80

Three Fast-time
Sims

D.1.70 / D.1.90
Two HITL Sims

**D.2 Well
Clear/Alerting
Requirements**

D.2.10
ConOps

D.2.20
Well Clear
Definition

D.2.30 / D.2.70 /
D.2.80
Three HITL Sims

D.2.40 / D.2.50 /
D.2.60
Three Fast-time
Sims

**D.3 ACAS Xu
Interoperability**

D.3.10 / D.3.40
Stakeholder
Meeting, ConUse
Review

D.3.20
Mini HITL Sim

D.3.30
Sensor Model
Integration

D.3.50
HITL Sim 1

**D.4 External
Coordination**

D.4.10 / D.4.20 /
D.4.30 / D.4.40
SC-228 White
Paper,
Stakeholder
Support

**D.5 Integrated
Events**

D.5.10 / D.5.20 /
D.5.30
Support Three
Flight Tests

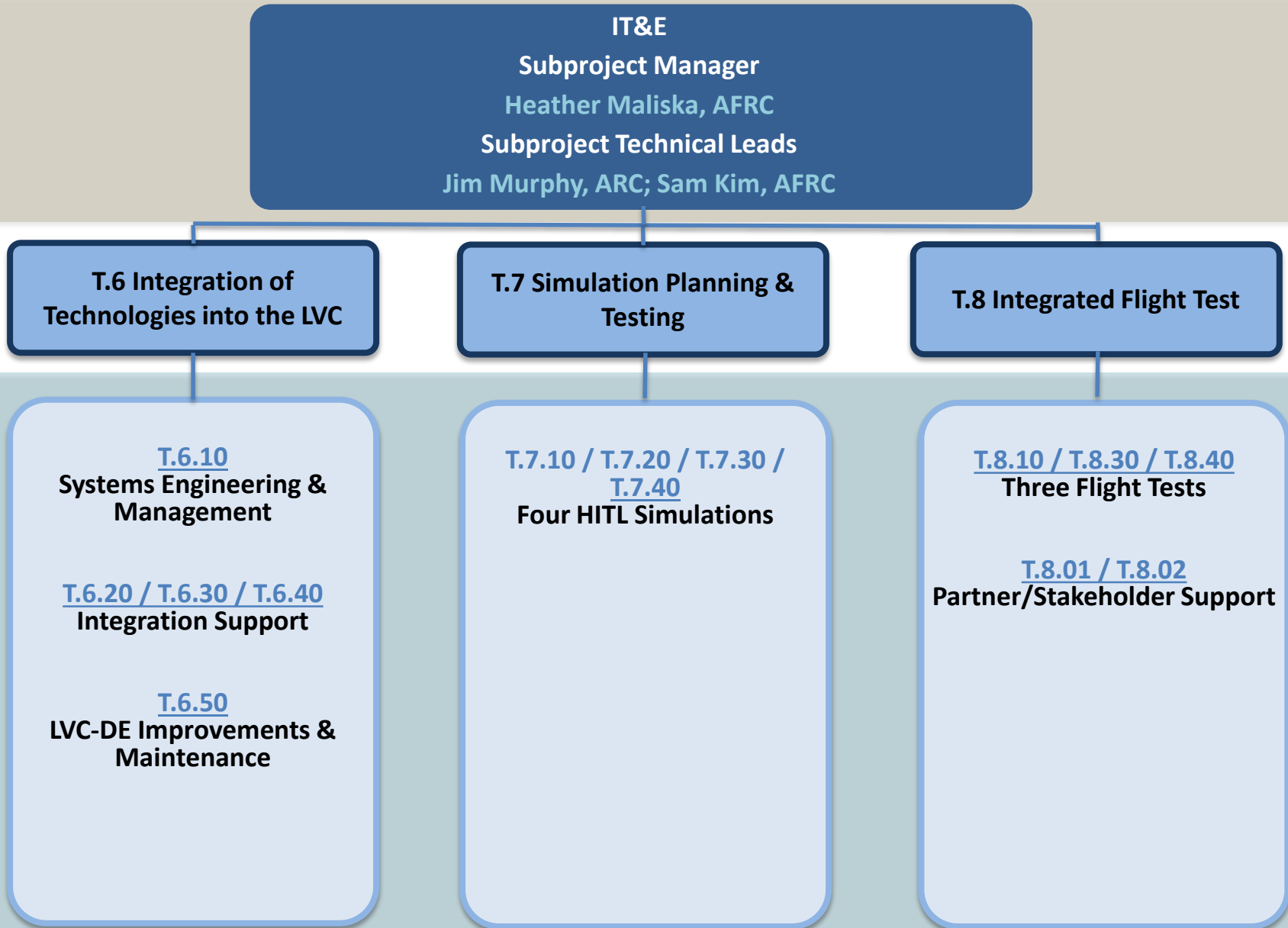
D.5.40
Common
Architecture
Implementation

SUBPROJECT TECHNICAL
WORK
PACKAGE

SCHEDULE
PACKAGE

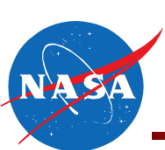


TC-DAA: IT&E Subproject

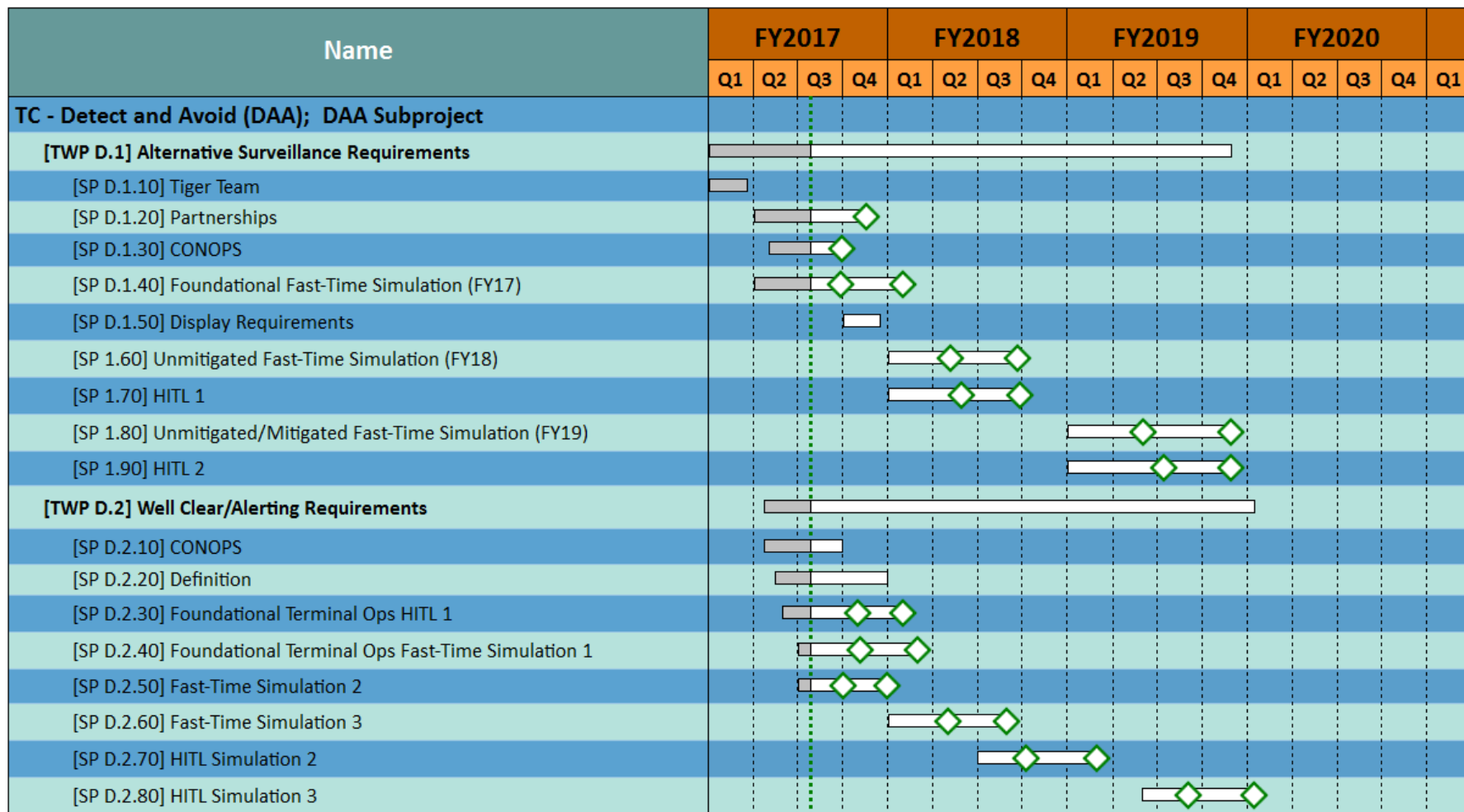


SUBPROJECT TECHNICAL WORK PACKAGE

SCHEDULE PACKAGE

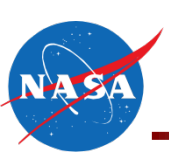


TC-DAA: DAA Subproject Schedule Summary

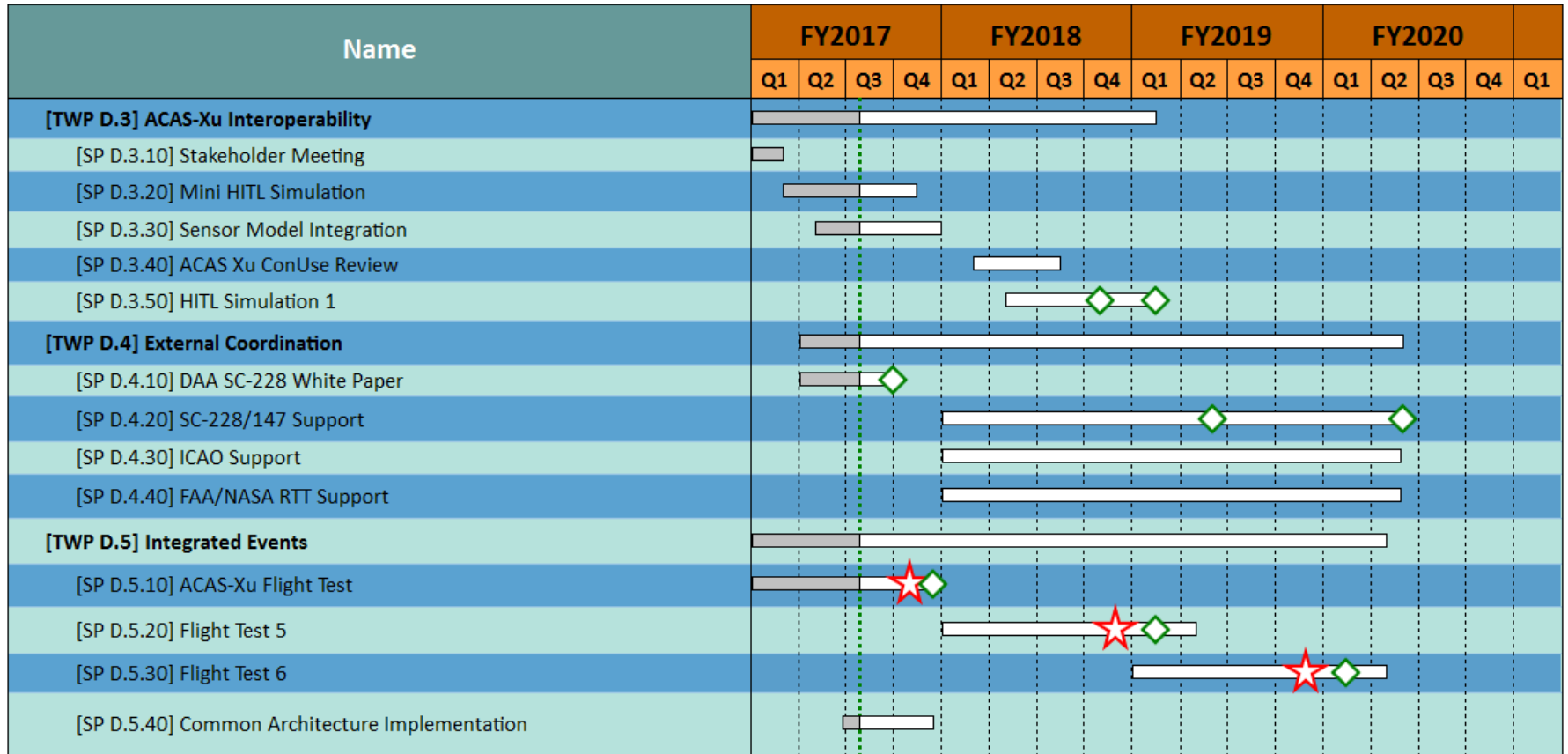




★ L1 Program (IASP)

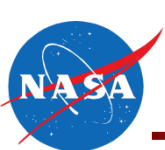
◆ L2 Project



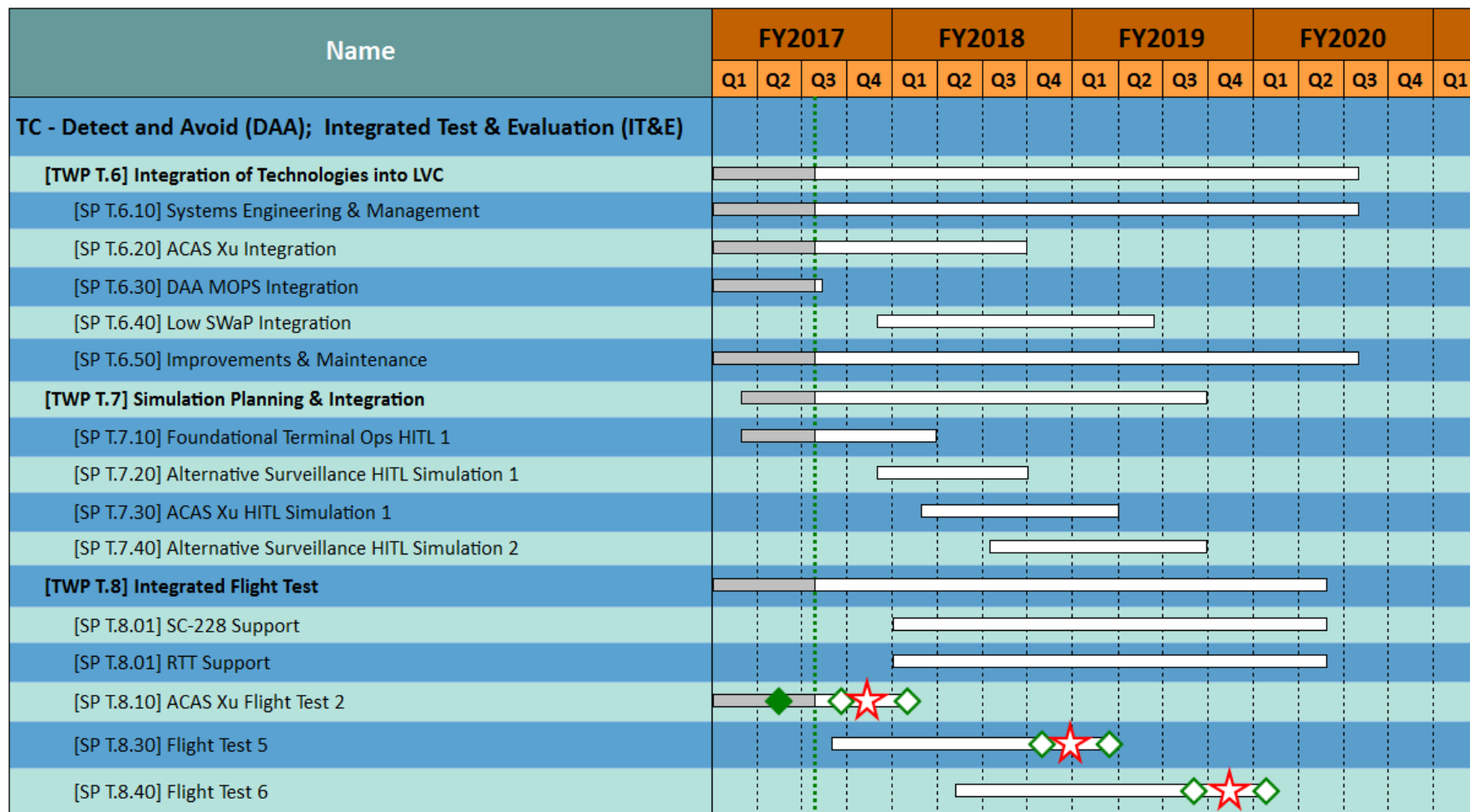
TC-DAA: DAA Subproject Schedule Summary





 L1 Program (IASP)
  L2 Project

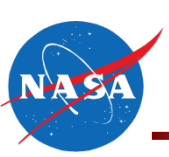


TC-DAA: IT&E Subproject Schedule Summary



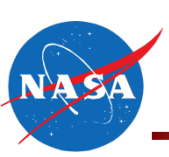
 L1 Program (IASP)

 L2 Project



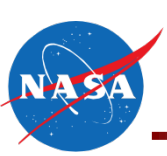
TC-DAA: Partners

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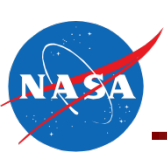
TC-DAA: Partners

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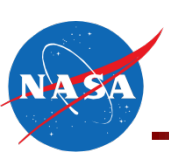
TC-DAA: Partners

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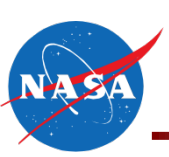


TC-DAA: Risk Summary

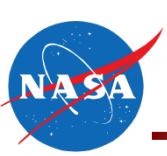
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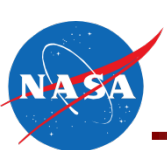


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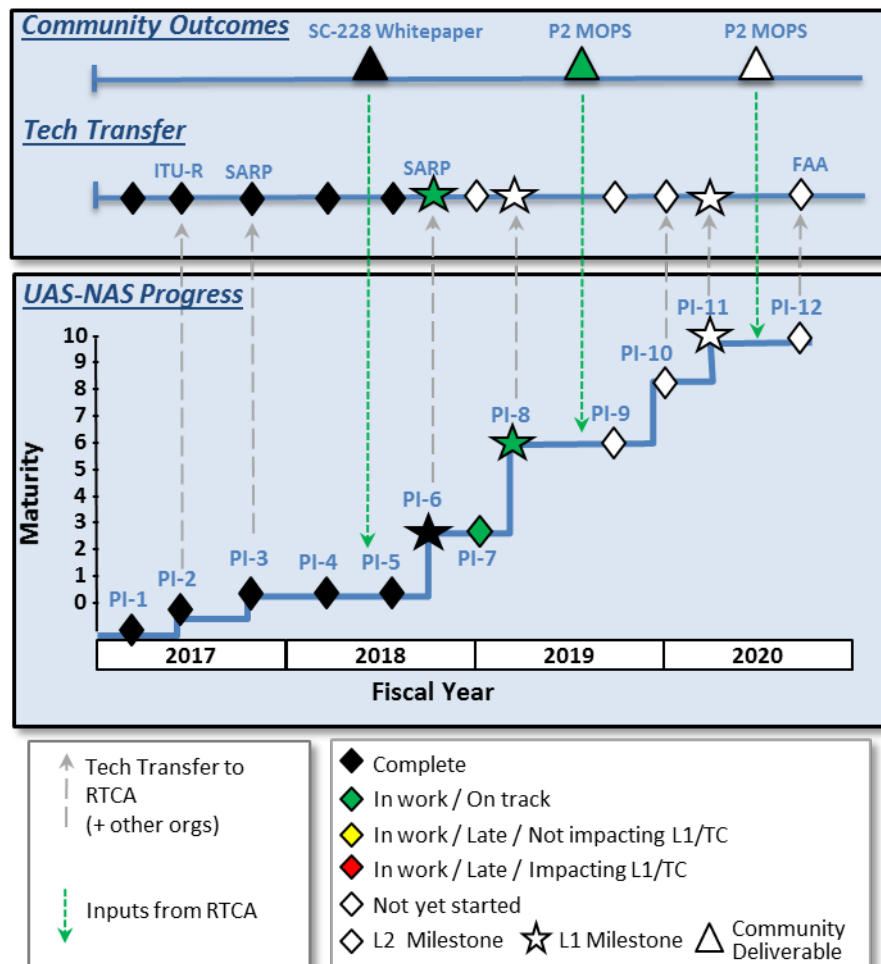
TC-DAA: Planned Resources (\$K)

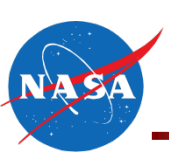
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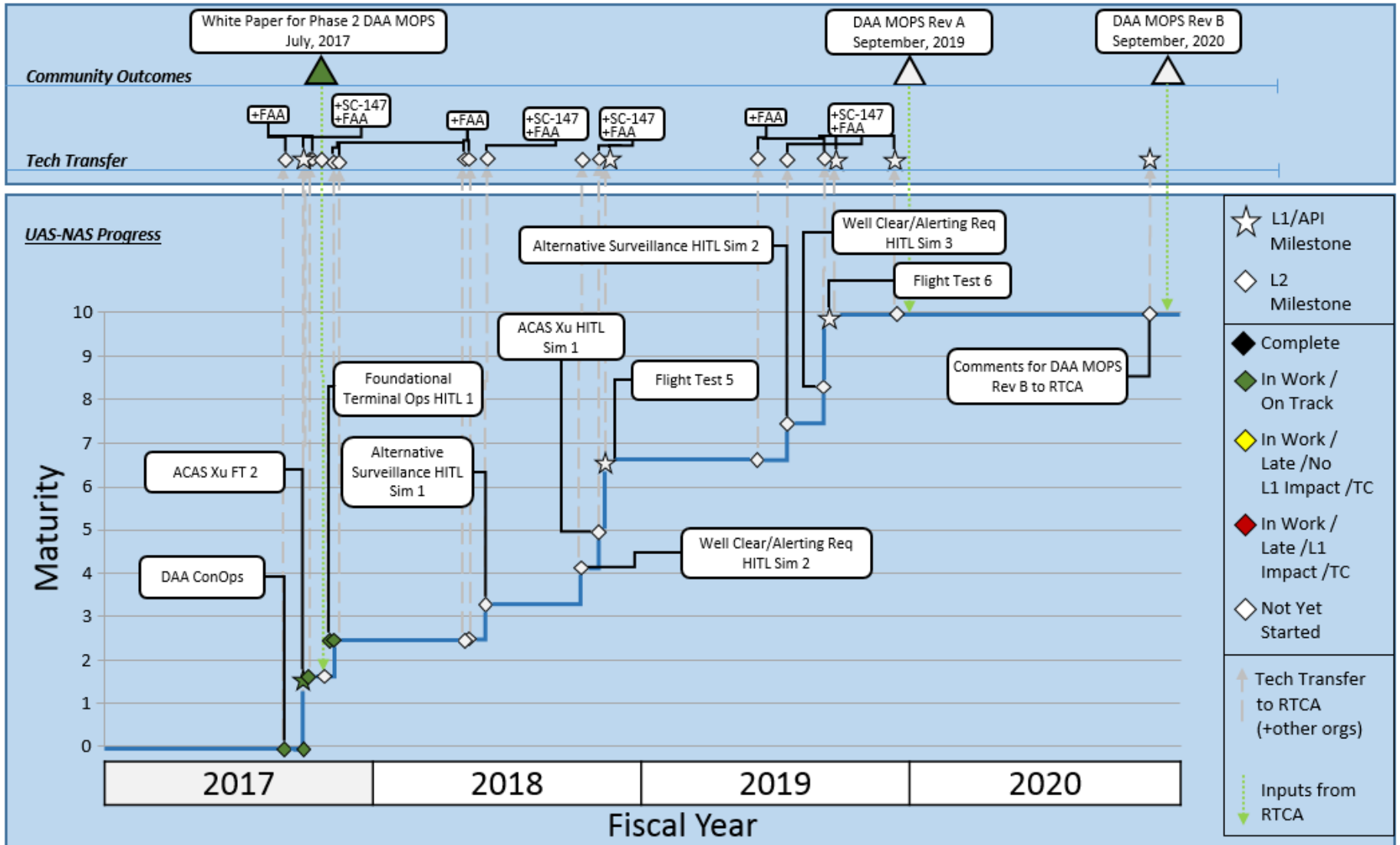
Progress Indicator Definition

- 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 elements 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. 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 elements for Project SP
- Progress is tracked against all SP tasks and UAS Community Outcomes using a color indicator





TC-DAA: Progress Indicator





TC-C2: UAS Satcom and Terrestrial Command and Control

Research Theme Thrust 1

– Airspace Operations Performance Enablers

Research Theme Thrust 6

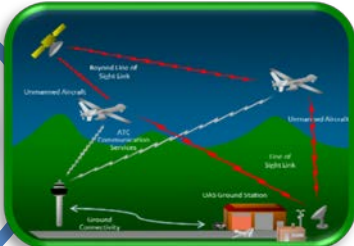
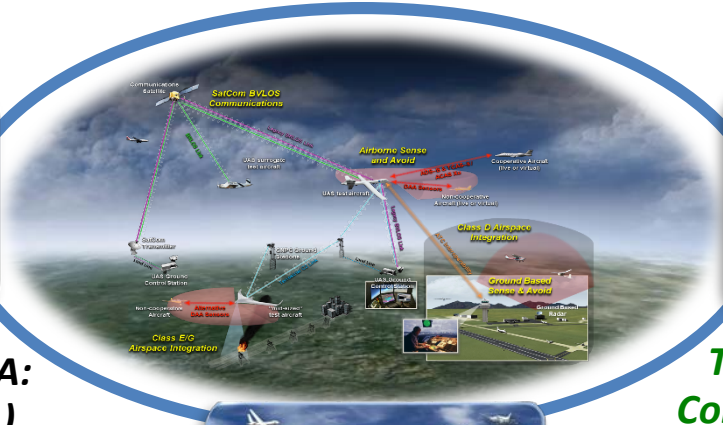
– Implementation and Integration of Autonomous Airspace and Vehicle Systems

TC-C2

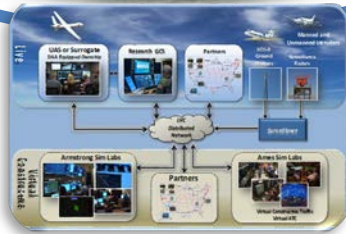
– Develop Satellite (Satcom) and Terrestrial based Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage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



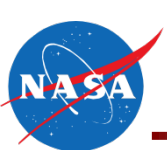
**Technical Challenge-DAA:
Detect and Avoid (DAA)**



**Technical Challenge-C2:
Command and Control (C2)**



**Technical Challenge-SIO:
System Integration and
Operationalization for UAS (SIO)**



TC-C2: Overview

Description: The Command and Control (C2) effort will lead the **UAS community** through **concept and technology development** of **Terrestrial and Satellite based C2 systems** that are consistent with **international/national regulations, standards, and practices**. C2 will **develop and analyze robust datalinks in designated spectrum** and propose **security recommendations for civil UAS** control communications. All of the identified activities will be accomplished by **collaborating with other government agencies and industry partners** to address the technical barriers.



- **Develop and validate UAS C2 requirements and radio spectrum allocation decisions** to support C2 standardization through the evaluation of commercial and engineering prototype **Ku/Ka Satcom** radio systems
- **Develop and validate UAS C2 requirements** to support C2 standardization through the evaluation of engineering prototype **Networked C-Band Terrestrial** radio systems
- Provide **system design studies** (payload and earth station) and system design requirements of **C-band Satcom** systems for C2 standardization

- **Develop Concept of Operations** to be leveraged for initial requirements for C2 partnerships, and coordination with RTCA and FAA
- Jointly **develop performance standards** with RTCA and FAA (including international) throughout lifecycle of concept and technology development
- **Solicit industry partnerships** to develop radios technologies in Satcom and terrestrial frequency bands.
- **Performance assessment** of satellite-based CNPC in existing Fixed Satellite Service bands
- **Flight Test and V&V** of radio technologies for performance standard requirements, and radio technology builds

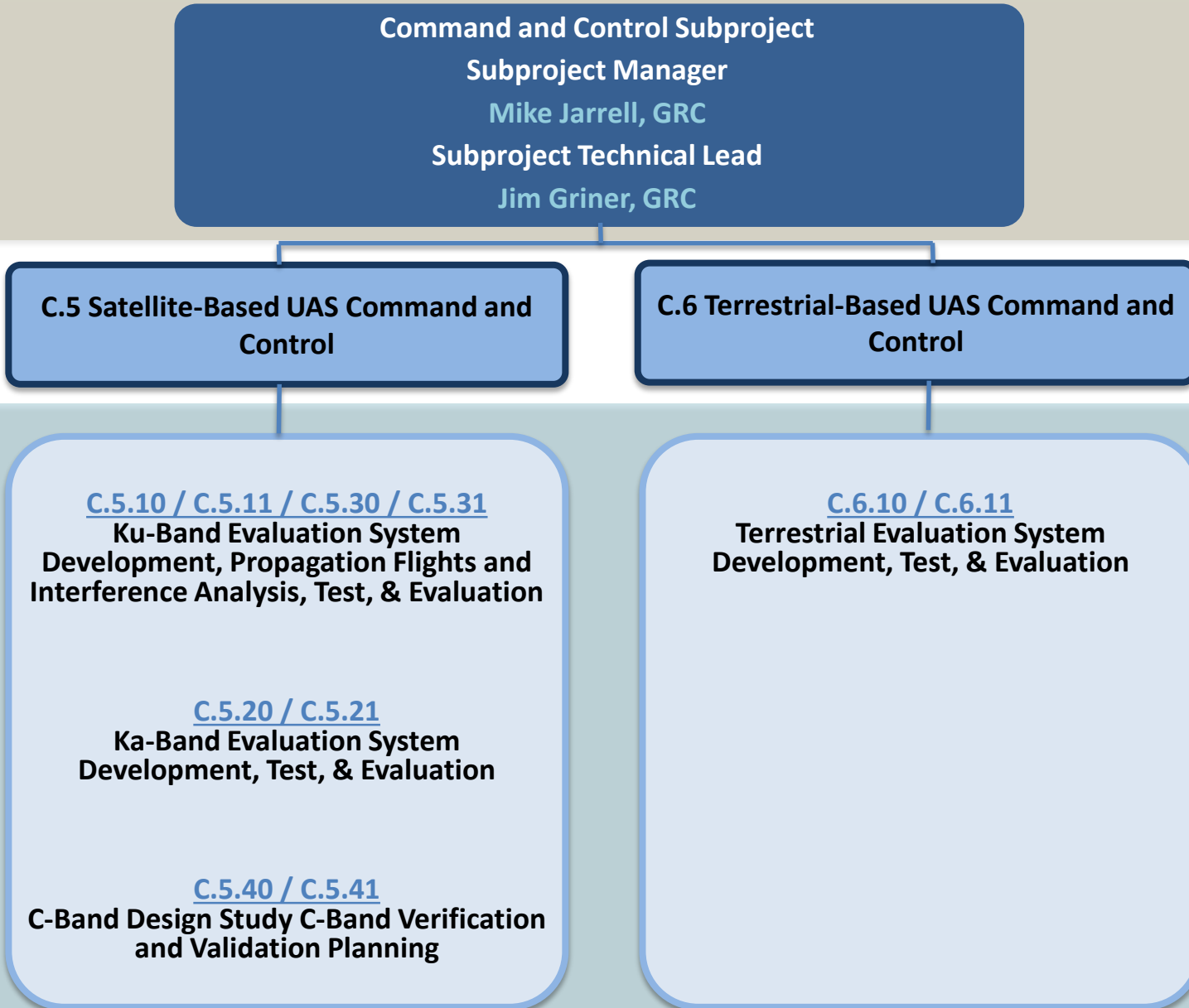
- RTCA Standards Inputs
 - CNPC Link MASPS
 - Ku/Ka Satcom MOPS
 - C-Band Terrestrial MOPS Update
- Technical papers & presentations to technical and regulatory organizations

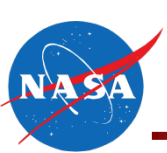


TC-C2: C2 Subproject

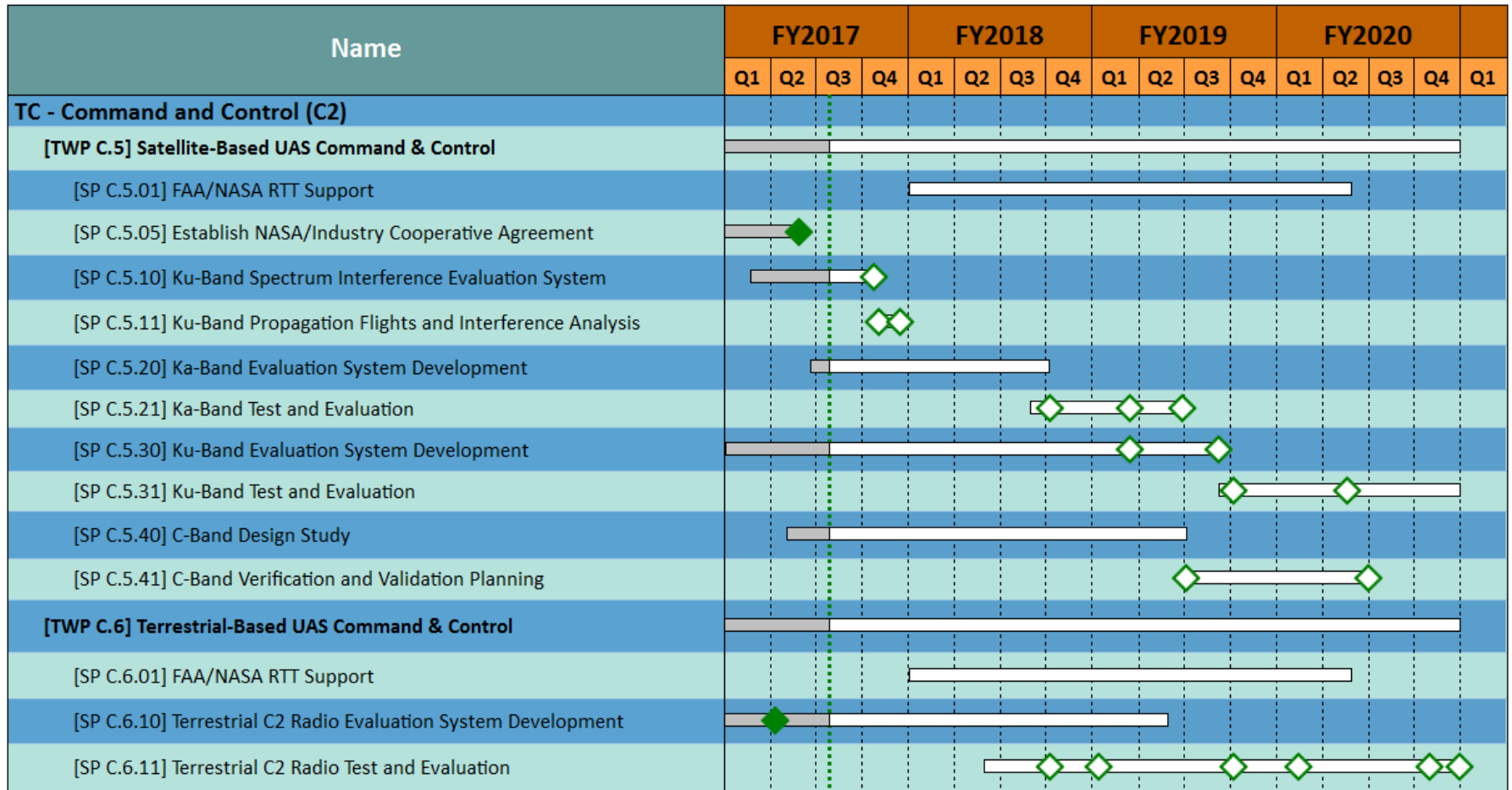
SUBPROJECT TECHNICAL
WORK
PACKAGE

SCHEDULE
PACKAGE



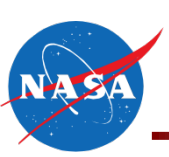


TC-C2: Schedule Summary



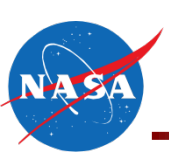
★ L1 Program (IASP)

◆ L2 Project



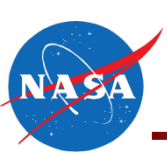
TC-C2: Partners

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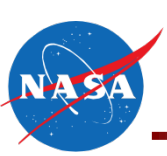
TC-C2: Partners

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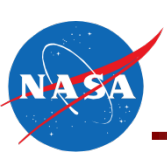
TC-C2: Risk Summary

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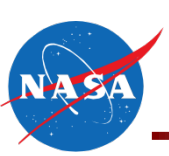
TC-C2 Risk

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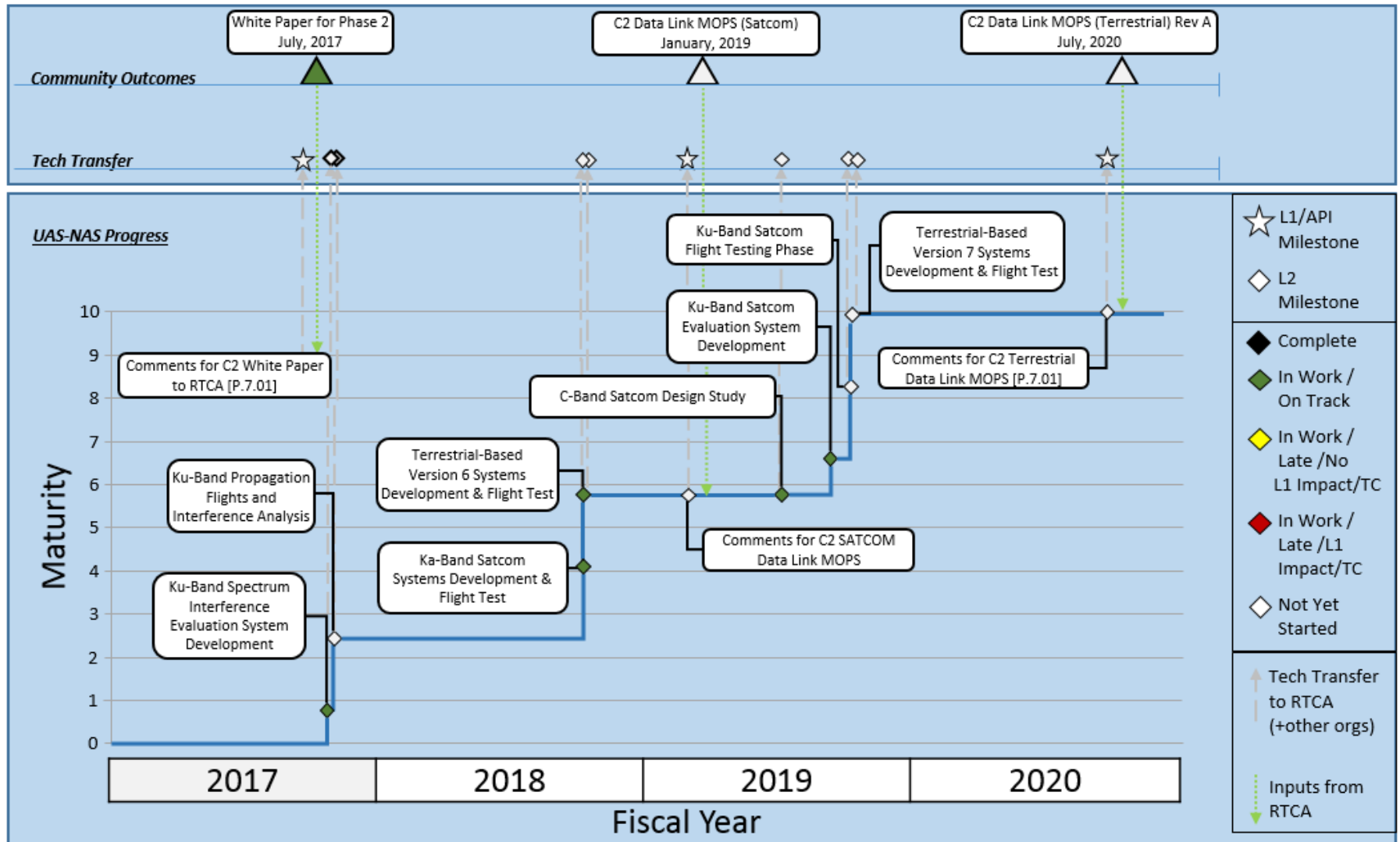


TC-C2: Planned Resources (\$K)

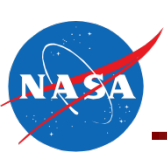
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TC-C2: Progress Indicator

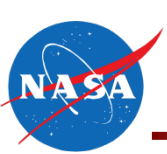


Technical Transfer Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office and ICAO



Outline

- KDP-A Outcomes & KDP-C Overview
- UAS Community Overview and Technical Challenge Development
- **Technical Baseline**
 - Technical Baseline Overview
 - Technical Challenges
 - **Emerging TC**
- Project Summary
- Briefing Summary



ETC-SIO: Overview

Description: System Integration and Operationalization (SIO) addresses two primary areas required for the **integration of UAS into the NAS**. Developing robust performance standards that ensure a pathway to vehicle certification requires consideration of **aircraft level functional and operational requirements**. Integration of UAS into the National Airspace System (NAS) is a broad multi-faceted problem that requires **operationalization of technologies into the NAS** through **partnership with industry and the FAA** to inform timely policy creation.

Objectives

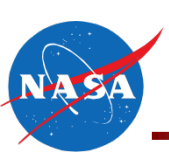
- Obtain FAA approval to **demonstrate SC-228 Phase 1 DAA MOPS technologies** on an unmanned aircraft in the NAS as an alternative means of compliance to FAR Part 91 “see and avoid” rules (i.e. No Chase COA)
- Support **coordination between DAA and C2** activities within RTCA

Approach

- Leverage Phase 1 DAA MOPS developed technologies on Ikhana to **obtain FAA approval to fly the DAA system in the NAS** with as few restrictions as possible (No Chase COA)
- Develop C2-DAA **interface requirements** and Phase 2 **DAA and C2 integrated ConOps**

Deliverables

- No-Chase COA Application Package
- Phase 1 DAA Flight Demonstration
- Integrated ConOps
- Technical papers & presentations to technical and regulatory organizations



ETC-SIO: Organization

System Integration and Operationalization
<ETC-SIO>

IT&E Subproject Manager (SPM)
Heather Maliska, AFRC

IT&E Subproject Technical Leads
Sam Kim, AFRC, Jim Murphy, ARC

SUBPROJECT
LEVEL

**TWP: Integrated
Flight Test**

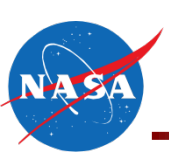
TECHNICAL
WORK PACKAGE
LEVEL

**SP: No Chase
COA**

**SP: System
Engineering
Activities**

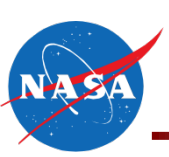
SCHEDULE PACKAGE
LEVEL

- TWP: Technical Work Package
- SP: Schedule Package



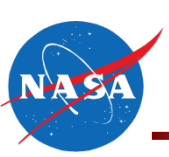
ETC-SIO: Partners

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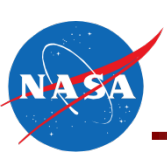
ETC-SIO: Risk Summary

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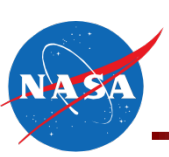
ETC-SIO: Planned Resources (\$K)

- Data Removed



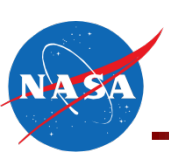
Outline

- KDP-A Outcomes & KDP-C Overview
- UAS Community Overview and Technical Challenge Development
- Technical Baseline
- **Project Summary**
 - Phase 2 Milestone Overview
 - Budget
 - Risks
 - Other Collaborations
 - Process, Document, and Organization Changes
- Briefing Summary



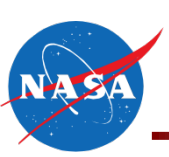
Current Services Budget vs. Project FY17-FY20 Budget (\$K)

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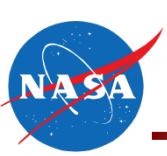
Project FY17-FY20 Budget by Center

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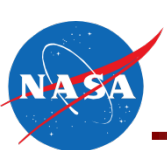
UAS-NAS Top Risk Summary

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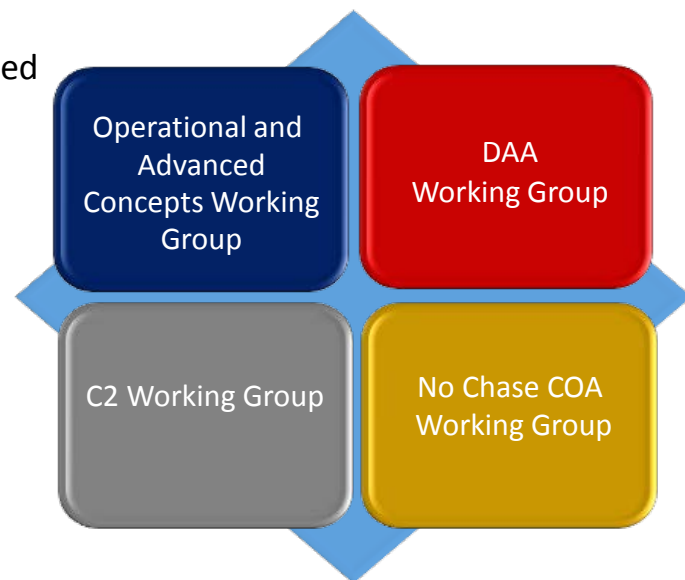
Additional Active Collaborations

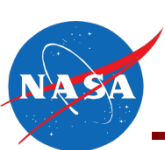
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FAA UAS Integration Research Transition Team

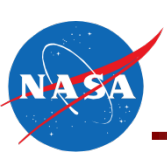
- FAA Coordination Background
 - Phase 1: UAS-NAS Project and FAA coordinated research through shared objectives and quad charts
 - Phase 2: Increased formality of the relationship with the creation of an Research Transition Team (RTT)
 - Kick-off of UAS Integration RTT held on January 26, 2017
- NASA and FAA determined need for four Working Groups (WG); each with NASA and FAA co-leads
 - Operational and Advanced Concept
 - Develop the full global UAS integration ConOps and expand the current FAA UAS ConOps to incorporate both the concepts and plans for addressing existing barriers and gaps
 - DAA
 - Leverage Phase 2 MOPS development research for extended operations within Class D/E/G airspace by smaller, more diverse aircraft that lack the SWaP capabilities to accommodate a robust radar system onboard
 - C2
 - Leverage Phase 2 MOPS development research for both Terrestrial communications and Satcom
 - No Chase COA (NCC)
 - The WG will leverage Phase 1 MOPS research findings, in combination with the EIP to develop the concept of operations, requirements, and partnerships for the NCC
- RTT Development Status and Next Steps
 - Groups established, but FAA Co-Lead for Operational and Advanced Concept WG not yet identified
 - Executive status meeting planned for May 18, 2017 will address:
 - RTT Joint Management Plan (JMP) development
 - Working group status including objectives and Research Transition Products (RTPs)





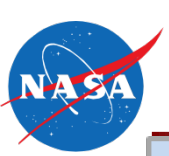
Phase 2 Organization and Process Updates

- Organization Updates
 - Subproject Managers (SPM) vs Deputy Project Managers for (DPMf)
 - Chief Engineer (CE) vs Chief Systems Engineer (CSE)
- Process/Plan Updates
 - Technical Management
 - CE has incorporated additional oversight to the technical plans and execution
 - Establish a minimum set of project technical reviews required for all test activities
 - CE participation in Center reviews, if they can also address Project review requirements
 - Internal outbrief to CE of results from all technical activities
 - Technology Transfer Plan
 - Updated for Phase 2 Partners
 - Change Management
 - MRB Quorum
 - Risk Management
 - Dedicated Risk Manager
 - Concerns
 - Schedule Management
 - Addition of L3 Milestones

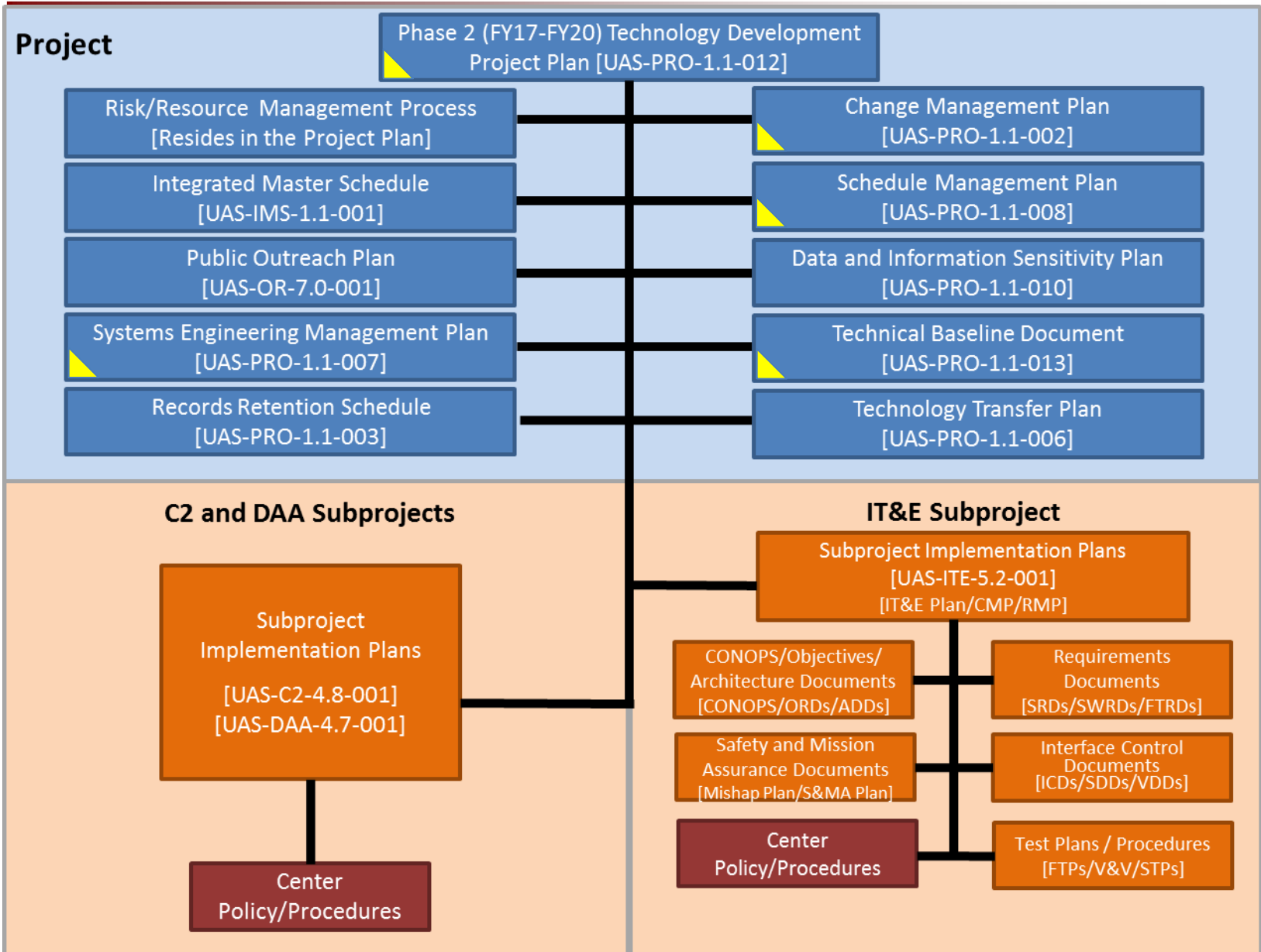


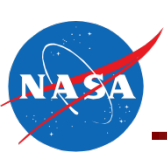
Success Criteria for Test Activities

- All test activities have objectives and test matrices that are reviewed through processes established in the Systems Engineering Management Plan (SEMP)
- As part of the planning process, the technical team defines the priorities within a test activity
 - These are priority 1, 2, 3 elements associated with the matrix or priority across test objectives
 - These are defined up front well before the test and agreed to by the test team/all parties:
 - Includes personnel involved with test execution and recipients of the results
 - The priority 1 level defines the minimum success for the test
 - Includes those things that must be accomplished in order to get anything useful out of the test
- During the test
 - The test team strives to achieve all objectives/the entire test matrix, i.e. full success
 - As unforeseen things occur, the team can incrementally de-scope lower priorities until reaching the minimum success that was defined upfront



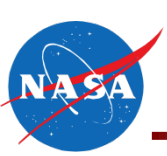
Project Document Tree





Outline

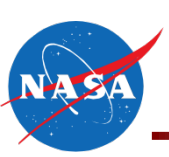
- KDP-A Outcomes & KDP-C Overview
- UAS Community Overview and Technical Challenge Development
- Technical Baseline
- Project Summary
- **Briefing Summary**



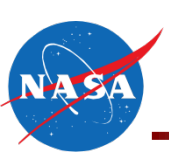
Briefing Summary

- KDP-C demonstrated:
 - ✓ Technical plans are relevant to the agency's mission and vision as well as, the ARMD Strategic Implementation Plan, and customer/stakeholder needs
 - ✓ Technical plans are feasible and executable
 - ✓ Planned resources and schedule are adequate to meet the stated goals and objectives of the Project with the acceptable level of risk
 - ✓ Management process updates and partnership approaches are sound for the proposed UAS-NAS Project
- Request approval to proceed with execution of the baseline plan

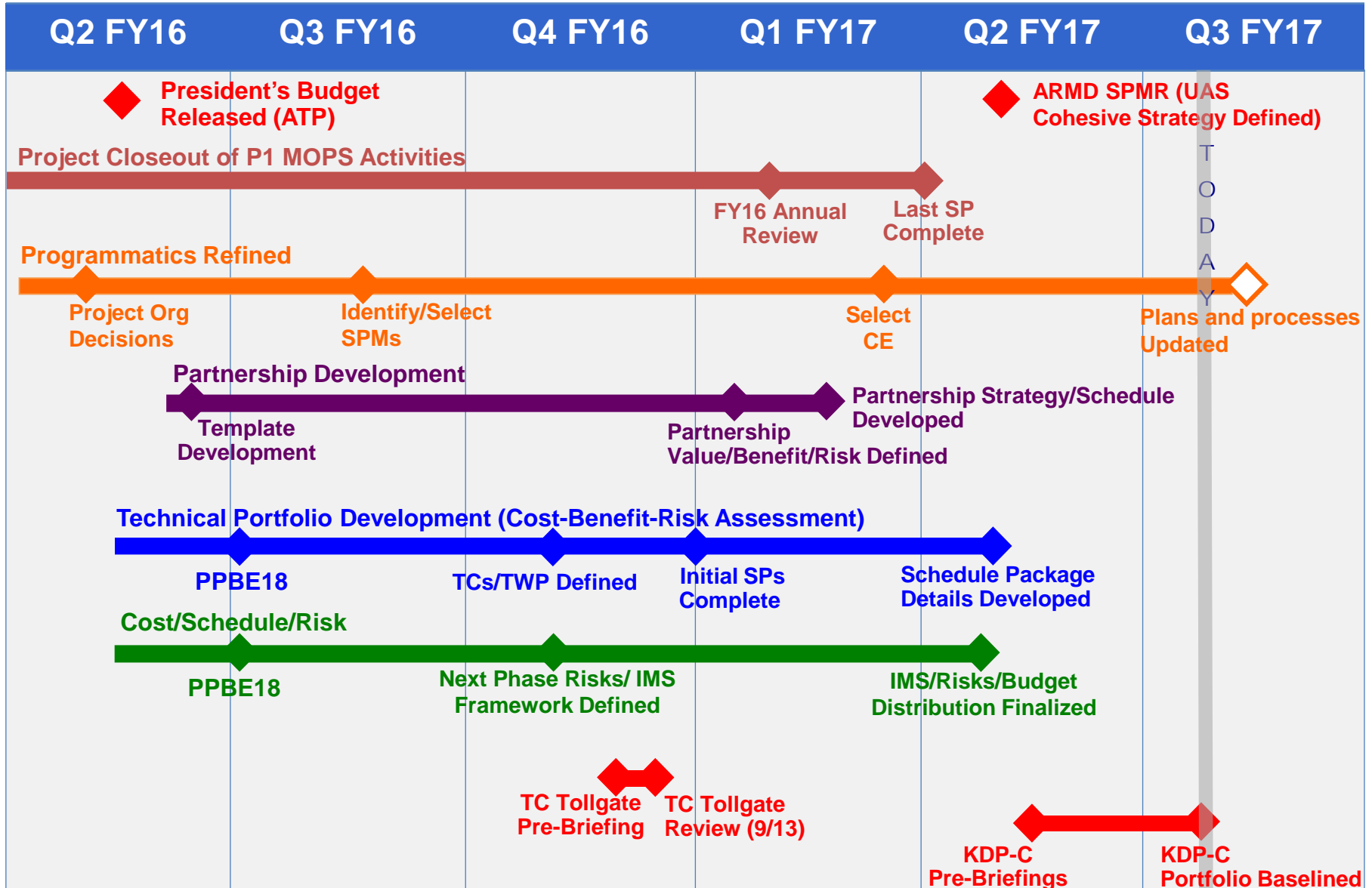
Project is executing and managing performance against the proposed baseline and has high confidence of successful execution

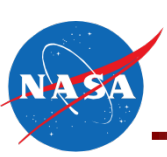


Backup Slides

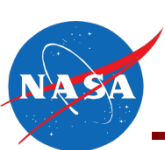


Overview Schedule to KDP-C





UAS Community Overview and Technical Challenge Development Backup Slides



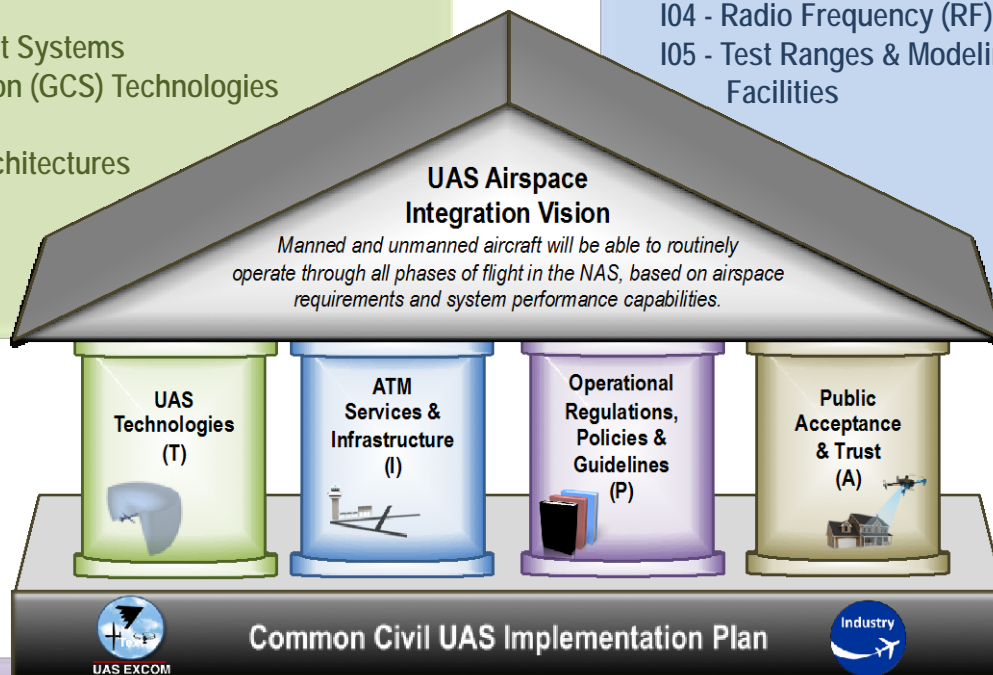
UAS Airspace Integration Pillars and Enablers

UAS Technologies:

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

ATM Services & Infrastructure:

- I01 - Airport Infrastructure
- I02 - Air Traffic Management (ATM) Infrastructure
- I03 - Non-FAA Managed Airspace Infrastructure
- I04 - Radio Frequency (RF) Spectrum Availability
- I05 - Test Ranges & Modeling & Simulation (M&S) Facilities



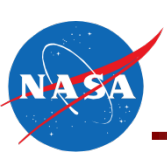
Operational Regulations, Policies & Guidelines:

- 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:

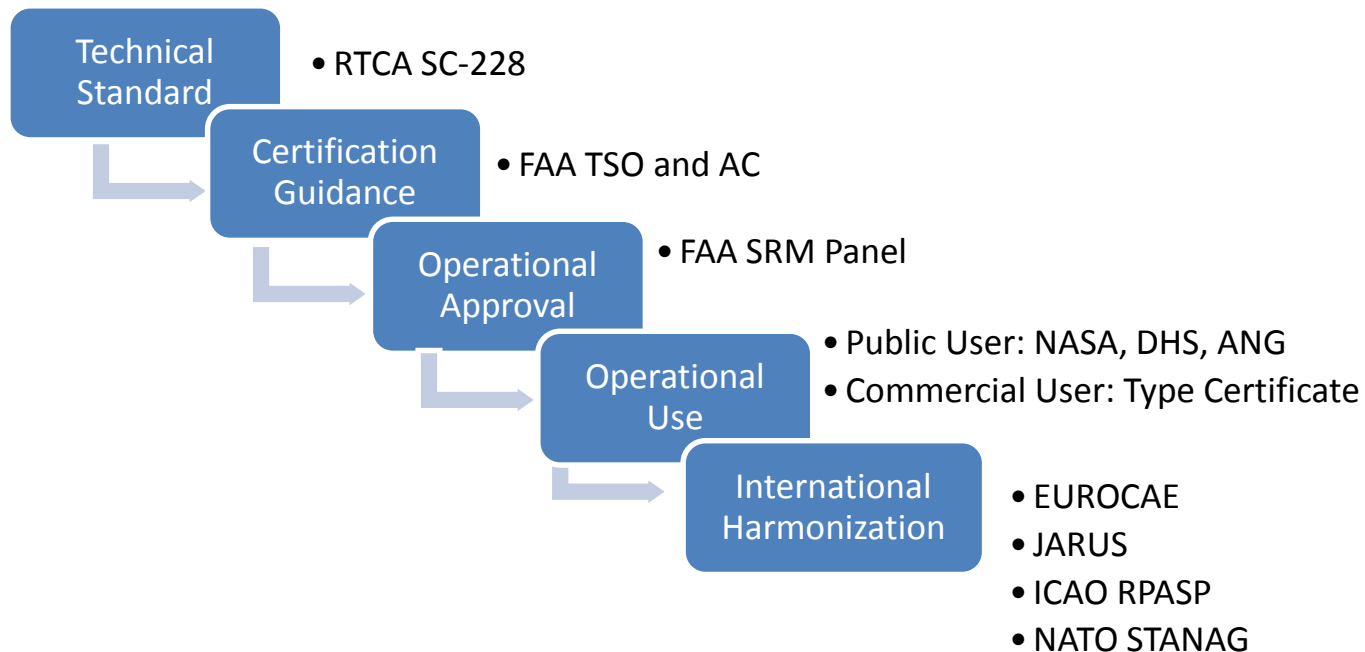
- A01 - Cyber Security Criteria & Methods of Compliance
- A02 - Legal & Privacy Rules / Guidelines
- A03 - Noise Reductions
- A04 - Physical Security Criteria & Methods of Compliance
- A05 - Public Safety Confidence

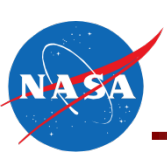
The UAS Airspace Integration Pillars enable achievement of the Vision



Why Now?

- Phase 1 performance standards developed --> but, insertion of technologies into operational use requires type certification which can take several years
- Delaying standards development for critical technologies inserts significant risk into industry investment in certifiable aircraft development
 - ~2-3 years to develop a MOPS for complex technologies with critical interoperability considerations
 - At minimum, 2-3 years to build and certify vehicles. --> VFR-like vehicles have other major technology challenges that cannot be addressed procedurally



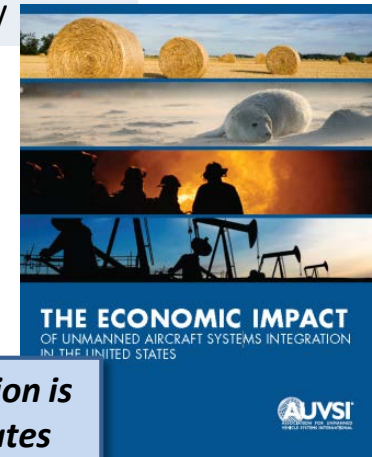


Demand for UAS Integration

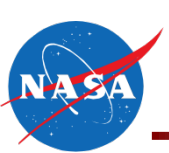
- Several civil/commercial markets are poised to take full advantage of the capabilities UAS offer

Demand Scenario	Automation Assisted	Highly Automated	Autonomous
Low Altitude Rural	Aerial Photography	Wildlife Surveillance	Precision Agriculture
IFR-Like	Broad Area Surveillance	Cargo Transport	Communication Relay
Low Altitude Urban	Search and Rescue	Traffic Monitoring	Local Package Delivery
VFR-Like	Horizontal Infrastructure	Passenger Transport	Cargo Delivery

- Unfortunately, the UAS market is not able to achieve this level of growth until the barriers and challenges, currently preventing full integration, are addressed



“For every year integration is delayed, the United States loses more than \$10B in potential economic impact (\$27.6M per day).” – AUVSI Economic Report 2013



Importance of Standardizing DAA and C2 Technologies

- The FAA's *UAS CONOPS* and *Roadmap* establish the **vision** and define **the path forward** for safely integrating civil UAS operations into the NAS
 - These documents establish the importance of standards development; explicitly DAA and C2 standards
 - DAA Foundational Challenge: Sense & Avoid vs. See & Avoid
 - C2 Foundational Challenge: Robust and secure communication links
- Standards are essential for multiple stakeholders:
 - Regulators
 - UAS Operators
 - UAS Manufacturers
 - Avionics and Service Providers
- RTCA SC-203 was, and SC-228 now is, chartered by the FAA to establish UAS DAA and C2 Standards

September 26, 2012

Federal Aviation Administration

Integration of Unmanned Aircraft Systems into the National Airspace System
Concept of Operations
v2.0

U.S. Department of Transportation
Federal Aviation Administration

Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap

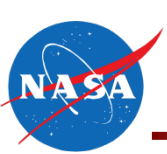
First Edition – 2013

*“Therefore, it is necessary to develop new or revised regulations/ procedures and operational concepts, **formulate standards**, and promote technological development that will enable manned and unmanned aircraft to operate cohesively in the same airspace. **Specific technology challenges include two critical functional areas:***

- 1. **Detect and Avoid (DAA) capability***
- 2. **Control and Communications (C2) system performance requirements”***

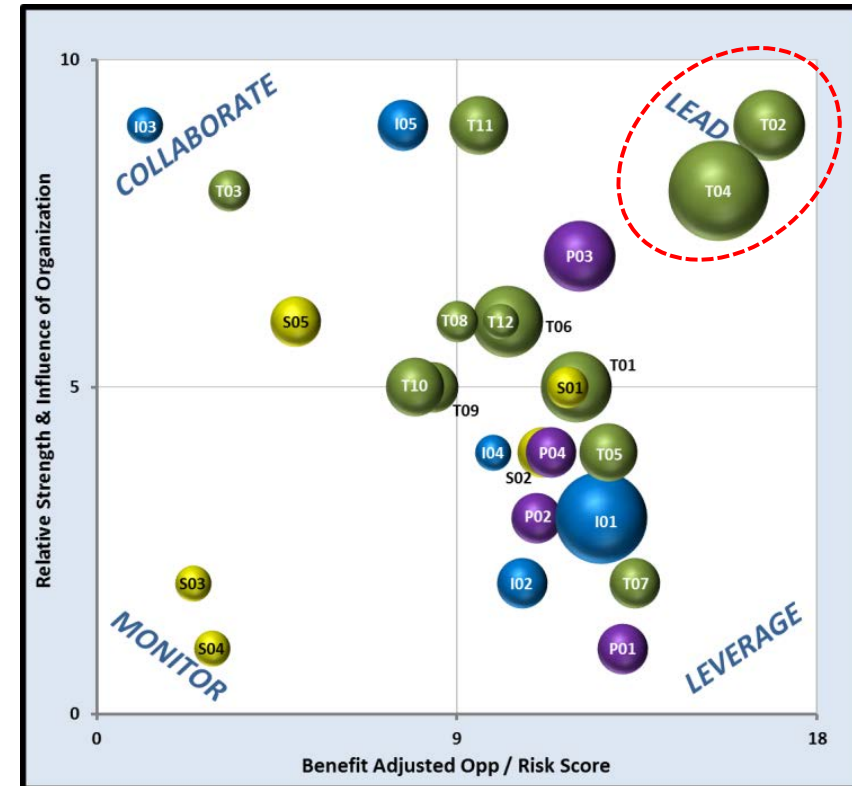
- FAA Integration of Civil UAS in the NAS Roadmap, First Edition 2013

Once the RTCA SC-228 ToR deliverables are approved and their requirements fulfilled, FAA well positioned to eliminate most of the DAA and C2 barriers for integration



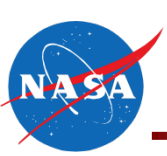
Importance of NASA Involvement with DAA and C2 Technologies

- NASA has determined Detect and Avoid (DAA) and Command and Control (C2) are the most significant barriers to UAS integration
- NASA is capable of playing a significant role in addressing UAS airspace integration challenges
 - NASA's long-standing history assisting the FAA with complex aviation challenges
 - NASA involvement instills confidence in industry standards development activities
- NASA held in high regard by others in UAS community due to our:
 - Prior research and contribution to standards development
 - Existing leadership role in ongoing efforts and working groups
 - Ability to leverage previous assets used for Phase 1 MOPS



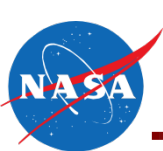
Full Integration study identified NASA as being well positioned to Lead the DAA (T02) and C2 (T04) airspace integration challenges

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



Project TC Definitions

- **Background**
 - Sets the stage for the current state of the UAS Community with respect to the element being discussed, i.e. Command and Control (C2), Detect and Avoid (DAA), or System Integration and Operationalization (SIO) for UAS
- **Barrier**
 - What's needed to be overcome for the UAS Community to move forward
- **Community Objectives**
 - Decomposition of the barrier, i.e. what the Project and UAS Community hope to achieve
- **TC Statement**
 - Written for the full barrier for the “VFR-Like” and “IFR-Like” Operating Environments and what the UAS Community needs
- **Project Approach**
 - The work that the Project is doing to address the community need/barrier
 - Defines how the Project is working with the community to accomplish the community objectives
 - Defines the overarching approach on which the baseline content is based

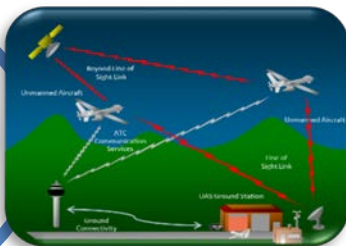


TC-DAA:

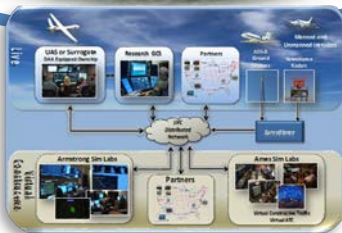
UAS Detect and Avoid Operational Concepts and Technologies



**Technical Challenge-DAA:
Detect and Avoid (DAA)**



**Technical Challenge-C2:
Command and Control (C2)**

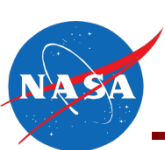


**Technical Challenge-SIO:
System Integration and Operationalization (SIO)**



UAS Detect and Avoid Operational Concepts and Technologies Background

- Removal of the pilot from the cockpit has created a need for UAS pilots to meet existing FAA “See and Avoid” requirements
- From the Policy perspective:
 - **[All OEs]** DAA technologies are required across a majority of the NAS. DAA will be designed for UAS-UAS and UAS-Manned encounters, with considerations to a broad set of aircraft performance parameters and airspace integration requirements
 - **[IFR/VFR-Like]** DAA technologies for UAS will require a combination of cooperative and non-cooperative sensors to mimic See and Avoid requirements that are part of the NAS today. These technologies will be required to be interoperable with a complex NAS environment (i.e. TCAS II, ACAS X, and ATC).
 - **[Low Altitude]** DAA technologies for low Size, Weight, and Power (SWaP) UAS and are immature. Policy decisions depend significantly on the state of the art of surveillance technologies and the determination of how the airspace will be managed for UAS.
- From the Technology perspective:
 - **[All OEs]** There is not a one-size-fits-all solution to DAA for all aircraft. Combinations of active and passive Airborne and Ground Based surveillance sensors will be applicable across the trade space
 - **[IFR/VFR-Like]** DAA technologies have significant challenges in proving interoperability with manned aircraft and existing airspace regulations, and are expensive to develop. Although technologies and concepts exist, significant research will be required to achieve an integration solution and prove final safety cases.
 - **[Low Altitude]** UAS operating in uncontrolled, self managed, airspace will require lower size, weight, and power design and airworthiness. UTM architectures may allow removal of some of the sensor requirements from on-board the aircraft. There are many policy decisions that need to be made considering safety and proving airworthiness for DAA systems on board highly automated aircraft.
- The Project is focused on higher TRL technologies with increased likelihood of approval for IFR flight. Sensor and algorithm prototypes exist that can be developed and approved for IFR flight.

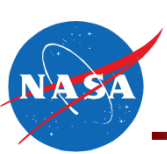


UAS Detect and Avoid Operational Concepts and Technologies

TC Supporting Information

- Barrier:
 - Beyond the scope of Phase 1 MOPS (airborne DAA for vehicles capable of transitioning to class A airspace), certifiable DAA technologies do not exist for a broad set of UAS that will operate via IFR flight in the NAS
 - i.e. Phase 2 MOPS DAA standards must apply to a smaller vehicle class, and provide DAA capabilities in terminal airspace
 - System Performance requirements do not exist that are broadly applicable to all of industry, and will allow the FAA to create associated policy
- Community Objectives:
 - Develop and validate UAS DAA requirements for Low-SWaP airborne DAA systems to support standardization through the evaluation of commercial and engineering prototype DAA systems that enable a broader set of UAS operations
 - Implement state of the art DAA technologies into an UAS and test in operationally relevant scenarios
 - *Develop and validate UAS DAA requirements for Ground Based DAA systems to support standardization through the evaluation of commercially available radars integrated with airborne DAA architectures*
 - *Develop and validate human machine interface requirements to support human automation teaming and higher levels of autonomy for UAS DAA systems*

Bullets in italics are not covered by UAS-NAS P2 resource allocation



UAS Detect and Avoid Operational Concepts and Technologies Technical Challenge Statement

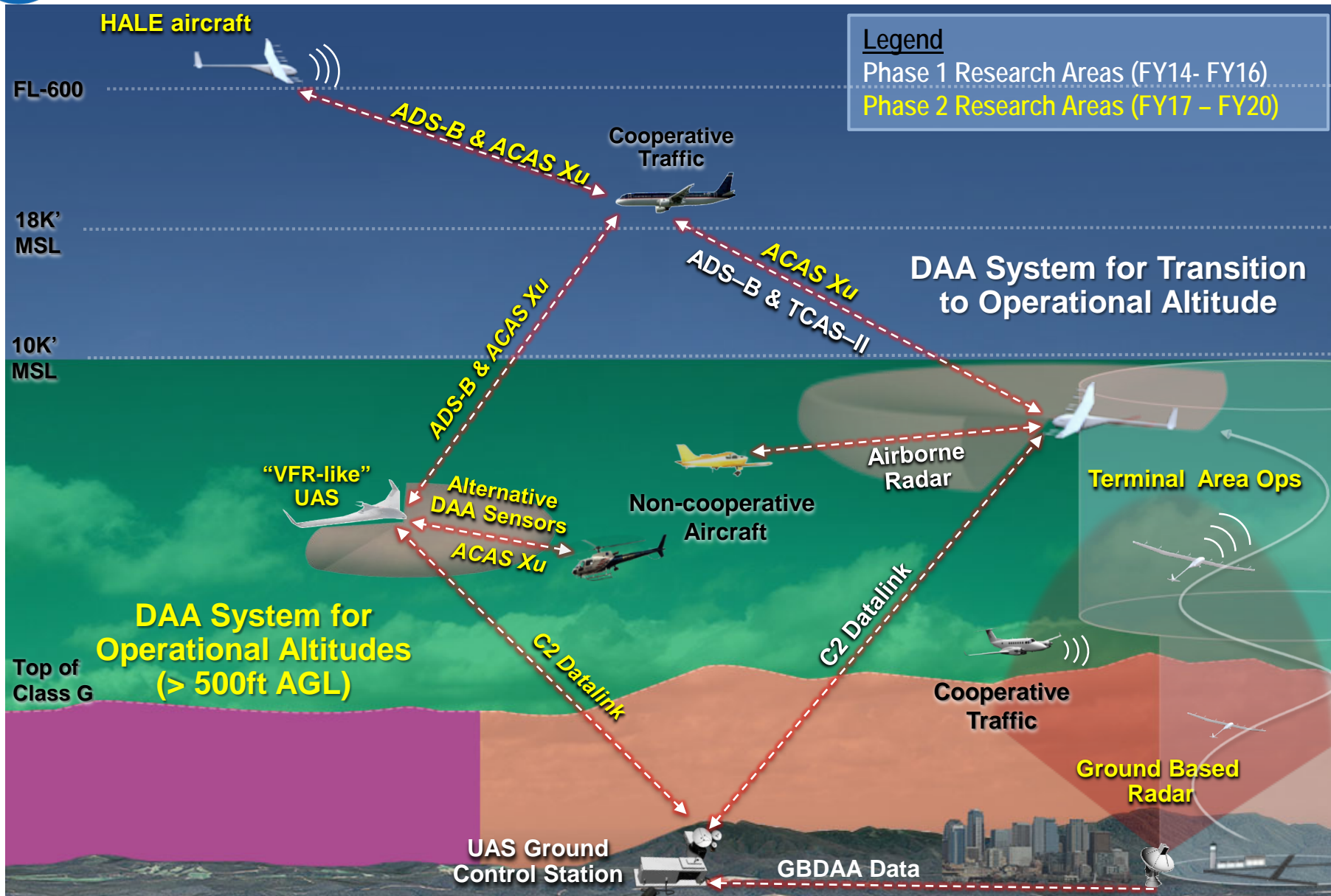
TC-DAA: UAS Detect and Avoid Operational Concepts and Technologies

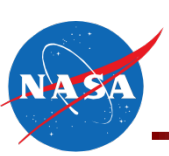
Develop Detect and Avoid (DAA) operational concepts and technologies in support of standards to enable a broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to detect and avoid manned and unmanned air traffic

- Project Approach:
 - Develop Concept of Operations in coordination with RTCA and FAA
 - Solicit industry partnerships to develop DAA technologies
 - Perform modeling and simulation to characterize the trade space of the DAA for critical areas such as well clear, collision avoidance interoperability, human machine interfaces, and others
 - V&V of DAA technologies for performance standard requirements, and DAA system technology builds
 - Jointly develop performance standards with RTCA and FAA throughout lifecycle of concept and technology development
 - Validation and proposed modification of national and international standards for DAA



Detect and Avoid (DAA) Performance Standard Operating Environments (OE)



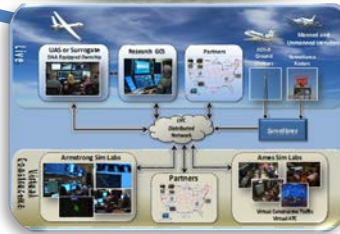


TC-C2: UAS Satcom and Terrestrial Command and Control

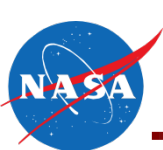


**Technical Challenge-DAA:
Detect and Avoid (DAA)**

**Technical Challenge-C2:
Command and Control (C2)**



**Technical Challenge-SIO:
System Integration and
Operationalization (SIO)**



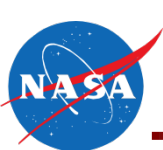
UAS Satcom and Terrestrial Command and Control Background

- Removing the pilot from the cockpit has created a need for robust command and control (C2) between the ground and a UAS
- From the Policy perspective:
 - **[All OEs]** UAS do not have spectrum identified and analyzed that can solve C2 issues across any specific OE, let alone being appropriate across all UAS OE
 - **[IFR/VFR-Like]** Terrestrial and Satcom spectrum have been allocated during WRC11 and WRC15, but is specific to aircraft that might be approved to operate in controlled airspace, be certified, and leverage protected spectrum
 - **[Low Altitude]** Spectrum for aircraft that may operate outside of traditional aviation protected spectrum bands still need to be identified as viable (i.e. LTE) and accepted to be sufficient for specific ConOps
- From the Technology perspective:
 - **[All OEs]** Lack of Policy direction creates a significant risk to C2 technology development as broad technology acceptance may not occur for radios in any particular frequency band
 - **[IFR/VFR-Like]** WRC allocated spectrum studies are needed to prove viability for highly capable aircraft. Due to the high risk nature of that spectrum being officially designated, industry is hesitant to invest in technology solutions on their own.
 - **[Low Altitude]** Technology solutions for aircraft that will operate outside of traditional aviation protected spectrum are being developed by the low altitude UAS community. These technologies have similarly high risks to implementation.
- The UAS-NAS project works with higher TRL technologies with increased likelihood of approval for IFR flight. WRC spectrum allocations align with these criteria due to the international credibility (although the risk of technology acceptance is still extremely high).



UAS Satcom and Terrestrial Command and Control TC Supporting Information

- Barrier:
 - Outside of Phase 1 Terrestrial MOPS, certifiable C2 concepts and technologies do not exist that apply to allocated WRC spectrum, and will operate in the NAS
 - System Performance requirements do not exist that are broadly applicable to all of industry, and will allow the FAA to create associated policy
- Community Objectives:
 - Develop and validate UAS C2 requirements and radio spectrum allocation decisions to support C2 standardization through the evaluation of commercial and engineering prototype Satcom radio systems
 - Develop and validate UAS C2 requirements to support C2 standardization through the evaluation of commercial and engineering prototype multiple access C-Band Terrestrial radio systems
 - Provide system design studies (payload and earth station) and system design requirements of C-band Satcom systems for C2 standardization

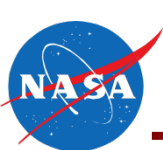


UAS Satcom and Terrestrial Command and Control Technical Challenge Statement

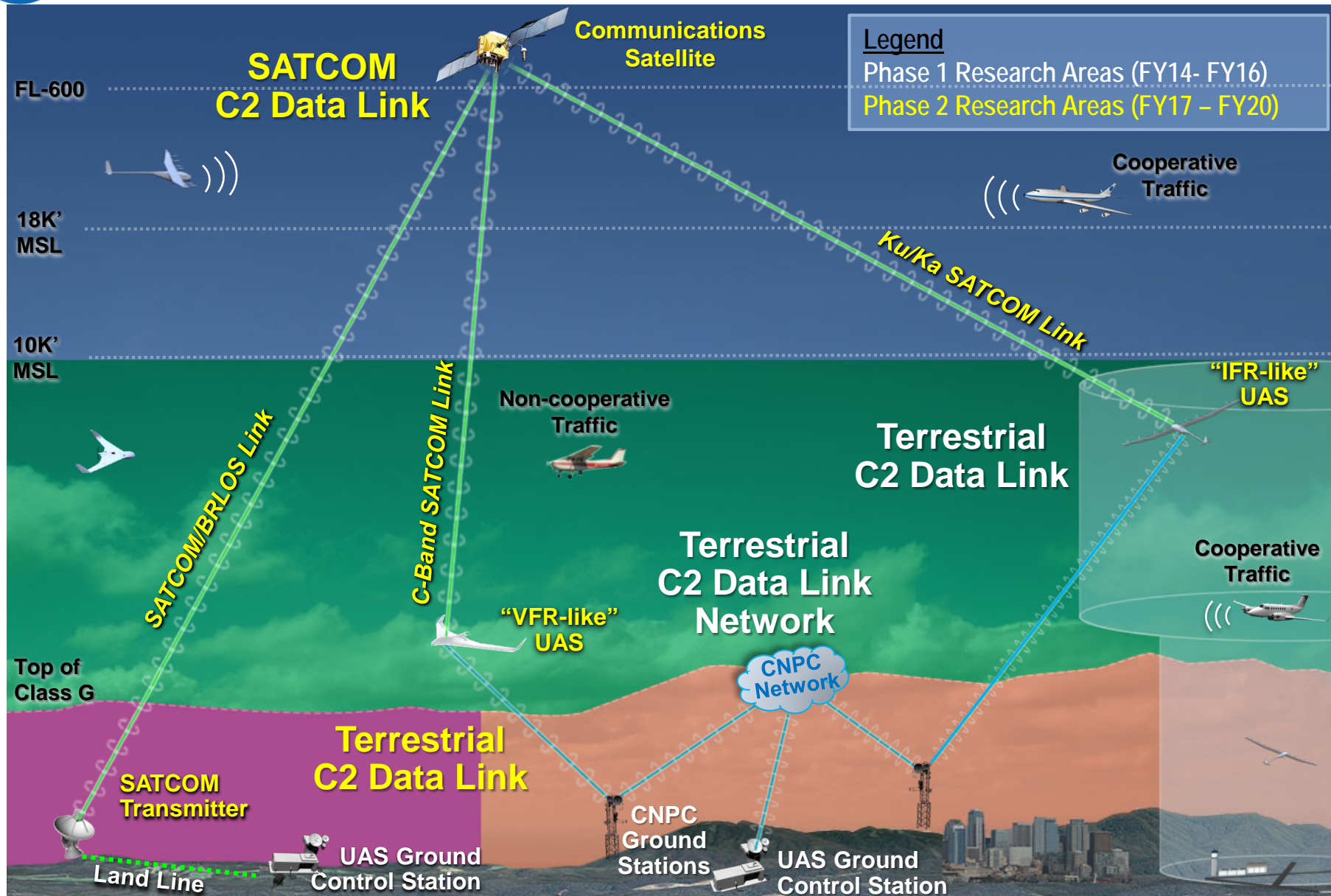
TC-C2: UAS Satcom and Terrestrial Command and Control

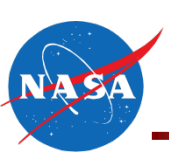
Develop Satellite (Satcom) and Terrestrial based Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage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

- Project Approach:
 - Develop Concept of Use to be leveraged for initial requirements for C2 partnerships, and coordination with RTCA and FAA
 - Solicit industry partnerships to develop radios technologies in Satcom and terrestrial frequency bands
 - Performance assessment of satellite-based CNPC in existing Fixed Satellite Service bands
 - V&V of radio technologies for performance standard requirements, and radio technology builds
 - Jointly develop performance standards with RTCA and FAA throughout lifecycle of concept and technology development
 - Validation and proposed modification of National and International standards for CNPC



UAS Satcom and Terrestrial Command and Control Operating Environments (OE)

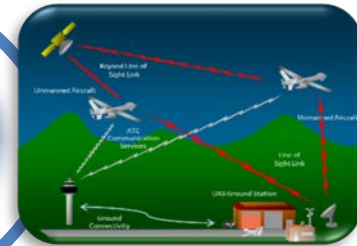




TC-SIO: System Integration and Operationalization for UAS



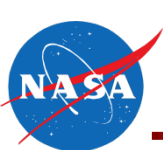
**Technical Challenge-DAA:
Detect and Avoid (DAA)**



**Technical Challenge-C2:
Command and Control (C2)**



**Technical Challenge-SIO:
System Integration and
Operationalization (SIO)**



System Integration and Operationalization for UAS Background

- Projects, technologies, and standards have been focused on specific technological aspects of UAS Integration into the NAS, such as DAA and C2
- 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
- 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 includes expectations of meeting aircraft level functional and operational requirements
- The UAS-NAS project will focus on system level integration and operationalization of vehicle technologies developed in conjunction with UAS community standards

- Barrier:
 - State of the art UAS vehicle technologies and airspace integration concepts have not been integrated and tested in their actual operating environments
 - Initiatives for the FAA to create a complete set of appropriate policies have not been fully planned or executed
- Community Objectives:
 - Obtain FAA approval to demonstrate SC-228 Phase 1 DAA MOPS technologies on an unmanned aircraft in the NAS as an alternative means of compliance to FAR Part 91 “see and avoid” rules (i.e. No Chase COA)
 - Perform operational demonstrations of integrated Phase 2 MOPS DAA and C2 technologies in their NAS operating environments to assist the FAA in developing the policies for UAS integration aircraft that will fly IFR



System Integration and Operationalization for UAS Technical Challenge Statement

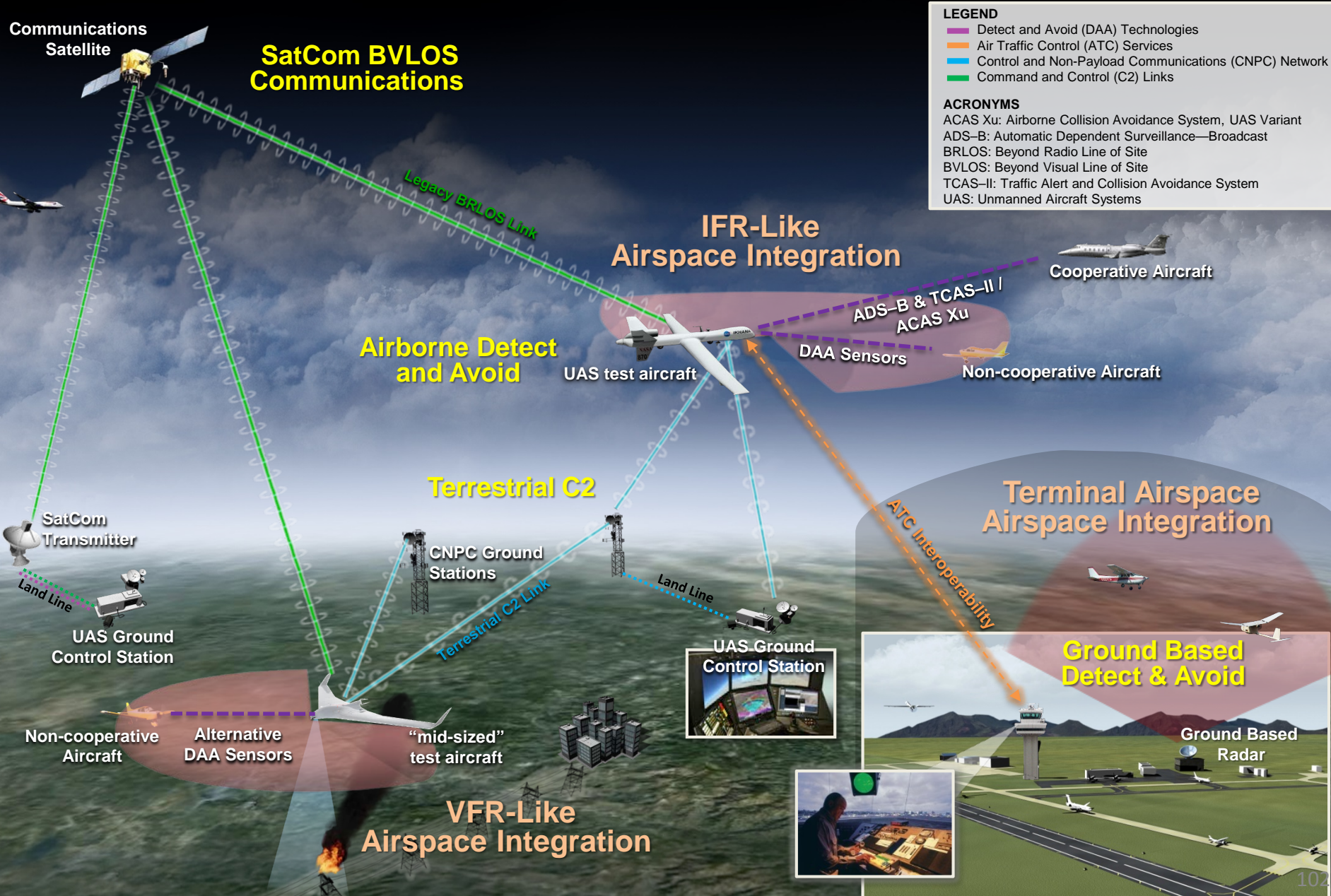
TC-SIO: System Integration and Operationalization for UAS

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

- Project Approach:
 - Leverage Phase 1 DAA MOPS developed technologies to obtain an operational approval, in partnership with ATO, to fly the DAA system in the NAS with as few restrictions as possible (No Chase COA)
 - Develop C2-DAA interface requirements and Phase 2 DAA and C2 integrated ConOps

Note: SIO is foundational to Vehicle Technology elements from the UAS Cohesive Strategy

UAS-NAS Project - DAA and C2 Operational View Representation

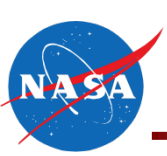


LEGEND

- Detect and Avoid (DAA) Technologies
- Air Traffic Control (ATC) Services
- Control and Non-Payload Communications (CNPC) Network
- Command and Control (C2) Links

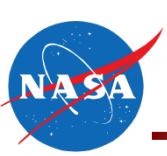
ACRONYMS

- ACAS Xu: Airborne Collision Avoidance System, UAS Variant
- ADS-B: Automatic Dependent Surveillance—Broadcast
- BRLOS: Beyond Radio Line of Site
- BVLOS: Beyond Visual Line of Site
- TCAS-II: Traffic Alert and Collision Avoidance System
- UAS: Unmanned Aircraft Systems



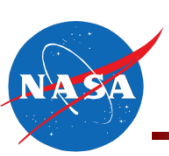
Human Automation Teaming

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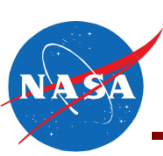
Ground Based Detect and Avoid

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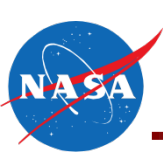
System Integration and Operationalization Phase 2 MOPS

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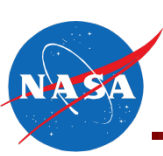
Not Covered by UAS-NAS P2 Resource Allocation Center Rollup

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Not Covered by UAS-NAS P2 Resource Allocation TC-DAA: Human Automation Teaming

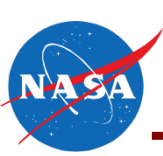
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Not Covered by UAS-NAS P2 Resource Allocation

TC-DAA: Ground Based Detect and Avoid System Standards

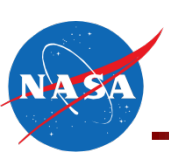
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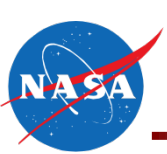
Not Covered by UAS-NAS P2 Resource Allocation

TC-SIO: Phase 2 MOPS SIO Demo

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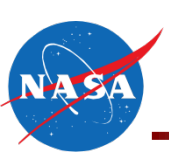
Technical Baseline Backup Slides



LVC-DE Status

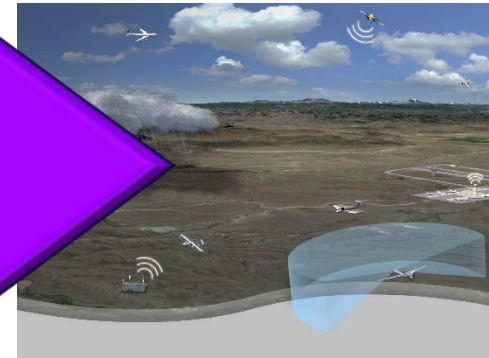
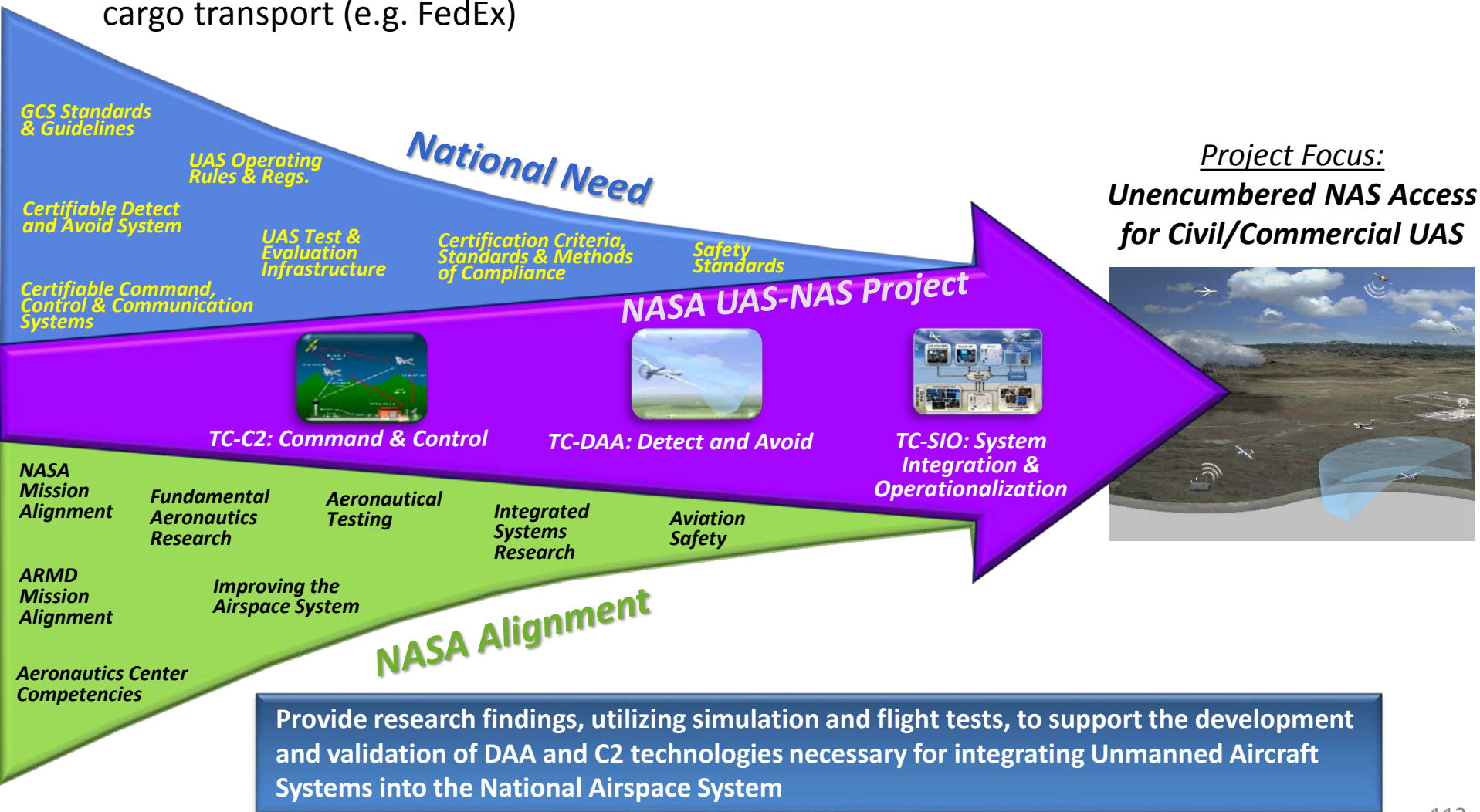
- LVC-DE will be leveraged by UAS-NAS Project to complete P2 MOPS research needs, but not upgraded to support future projects
 - The FAA UAS Test Sites are not currently required to be used to support the P2 MOPS research portfolio and the LVC-DE connection with the test sites will not be maintained
- LVC-DE will be prepared for a formal transition to SMART NAS (or other projects with similar test requirements)
 - SMART NAS Testbed already uses LVC-DE for virtual aircraft connection
 - Final documentation of LVC-DE in baseline plan
- Working with SMART NAS Testbed team to integrate the LVC-DE and formalize hand-off
 - Documenting dependencies between the LVC-DE and SMART NAS
 - SMART NAS is documenting simulation capability needs for future projects, and determining how SMART NAS can be leveraged

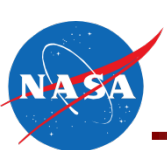
***Baseline project includes plans for LVC-DE transition
at the end of the project***



Developing the Project

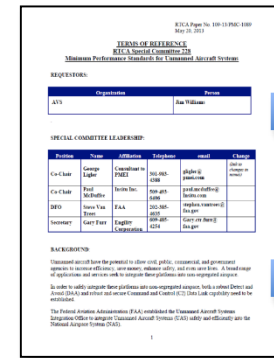
There is an increasing need to fly UAS in the NAS to perform missions of vital importance to National Security and Defense, Emergency Management, and Science. There is also an emerging need to enable commercial applications such as cargo transport (e.g. FedEx)



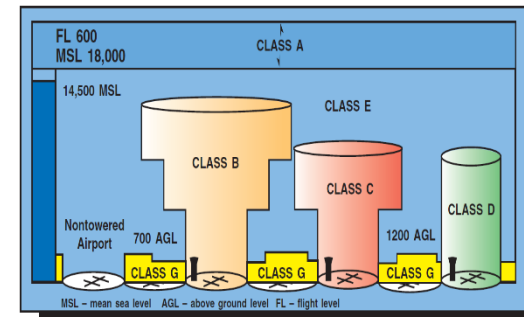
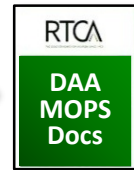
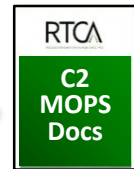


RTCA SC-228 MOPS Terms of Reference

- RTCA SC-228 Terms of Reference (ToR) defined a path forward to develop Minimum Operational Performance Standards (MOPS)
 - Phase 1 MOPS were addressed by UAS-NAS (FY14 – FY16) Portfolio
 - Phase 2 MOPS included in the original ToR, but had several TBDs
 - ToR development team established to ensure DAA & C2 scope broad enough to fully enable the operating environments relevant UAS were expected to leverage (e.g. Manned Like IFR and Tweeners)
- Phase 2 MOPS ToR Scope
 - C2: Use of SATCOM in multiple bands and terrestrial extensions as a C2 Data Link to support UAS and address networking interoperability standards for both terrestrial and satellite systems
 - DAA: Extended UAS operations in Class D, E, and G, airspace, and applicability to a broad range of civil UAS capable of operations Beyond Visual Line of Sight (BVLOS)
- SC-228 Final Documents

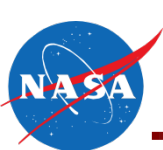


RTCA SC-228 ToR



Phase 1	Phase 2	
<ul style="list-style-type: none"> C2 Terrestrial Datalink MOPS (September 2016) DAA MOPS (to be published 2017) DAA Air to Air Radar MOPS (to be published 2017) 	<ul style="list-style-type: none"> C2 SATCOM & Network MASPS (Oct 2017 & Jan 2019) C2 SATCOM Data Link MOPS (Jul 2019*) C2 Terrestrial Data Link MOPS Rev A (Jul 2020) 	<ul style="list-style-type: none"> Ground Based Primary Radar MOPS & DAA MOPS Rev A (Sep 2019) Non-Cooperative Sensor MOPS & DAA MOPS Rev B (Sep 2020)

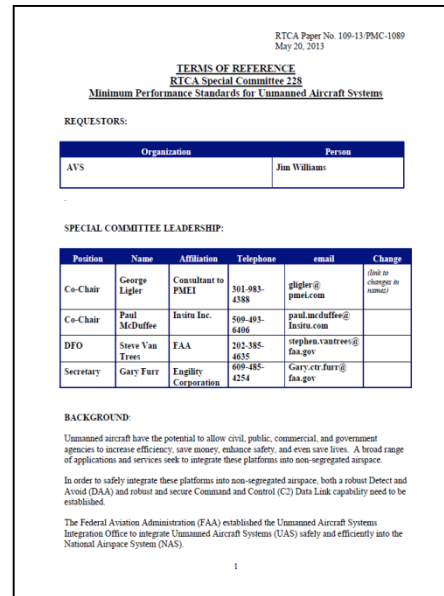
* Date under discussion within RTCA SC-228



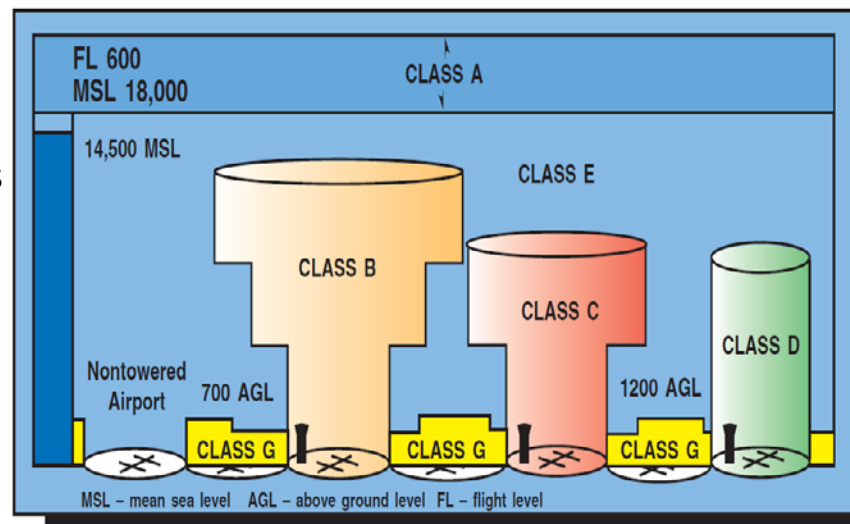
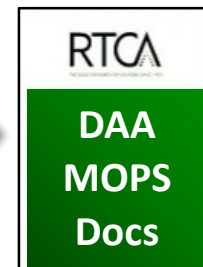
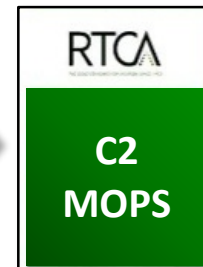
RTCA SC-228 Phase 1 MOPS Terms of Reference

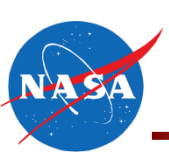
RTCA SC-228 Terms of Reference (ToR) has defined a path forward to develop Minimum Operational Performance Standards (MOPS)

- Phase 1 MOPS are addressed by UAS-NAS Current (FY14 – FY16) Portfolio
 - Command and Control (C2) Data Link MOPS – Performance Standards for the C2 Data Link using L-Band Terrestrial and C-Band Terrestrial data links
 - Detect and Avoid (DAA) MOPS – Performance standards for transitioning of a UAS to and from Class A or special use airspace, traversing Class D and E, and perhaps Class G airspace
- SC-228 Deliverables
 - C2 & DAA White Papers (Dec 2013) - Assumptions, approach, and core requirements for UAS DAA and C2 Equipment
 - C2 & DAA MOPS for Verification and Validation (July 2015) – Preliminary MOPS Including recommendations for a Verification and Validation test program
 - C2 & DAA MOPS (July 2016) – Final MOPS

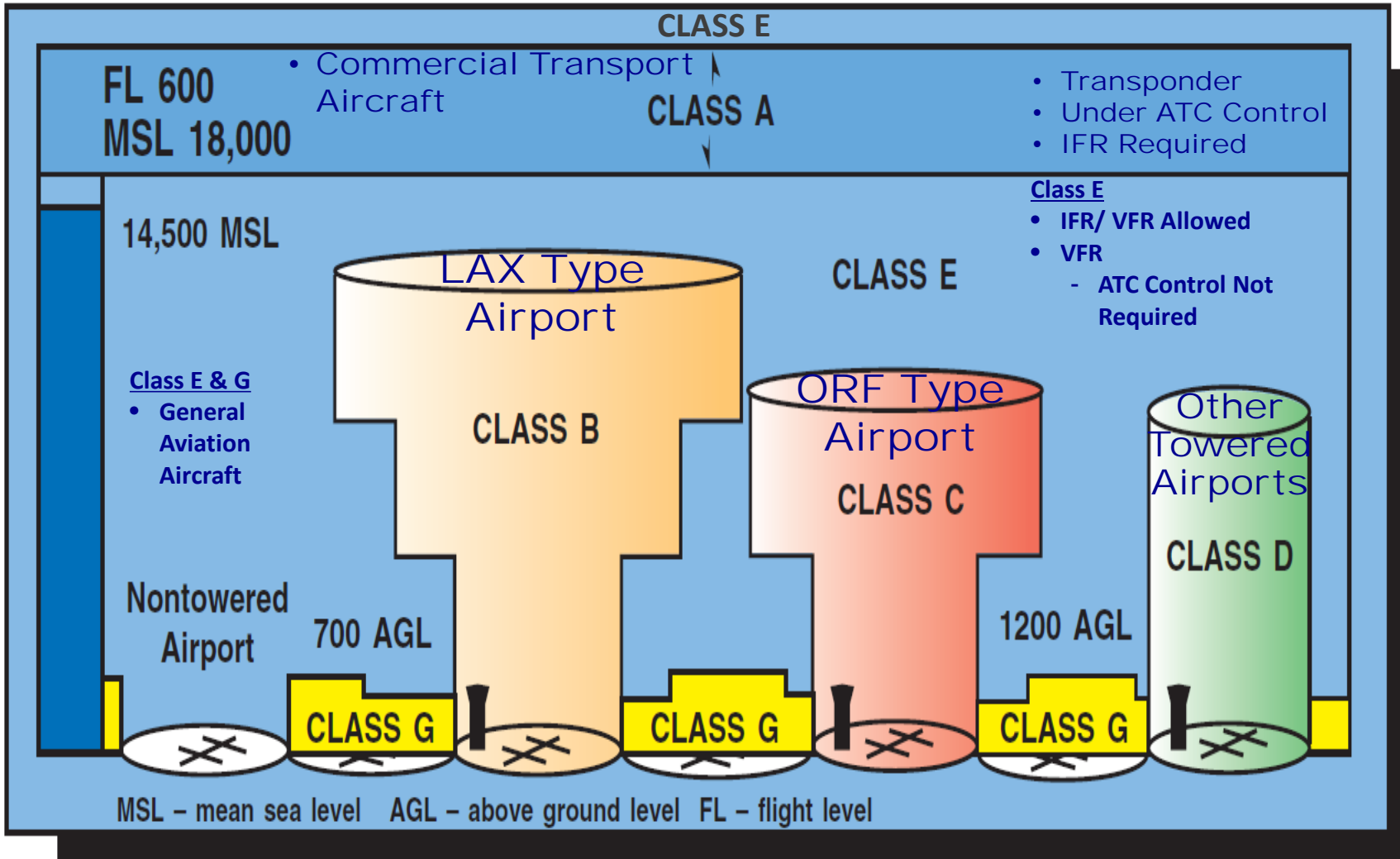


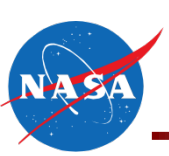
RTCA SC-228 ToR





FAA Designated Airspace Classes





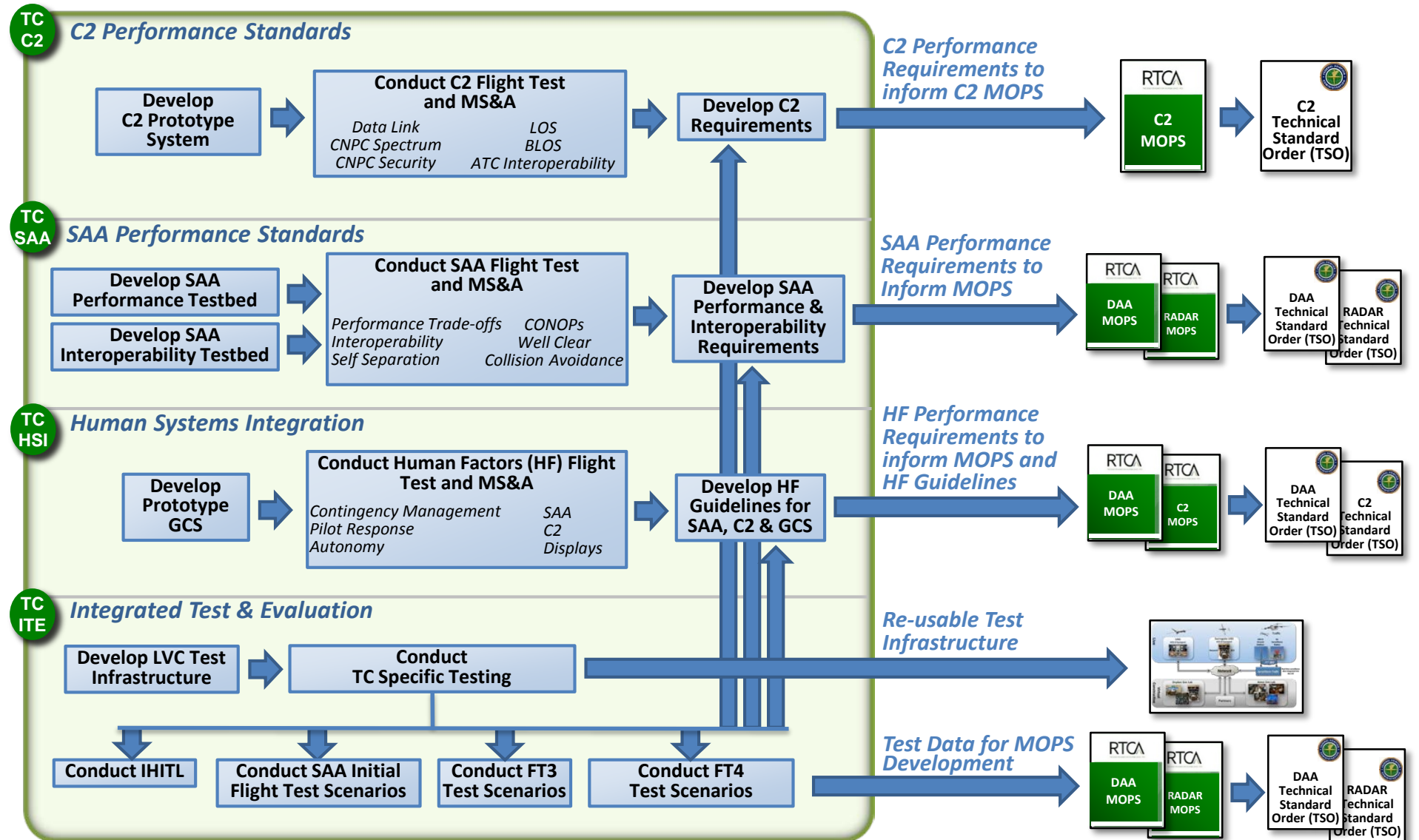
UAS Integration in the NAS Project

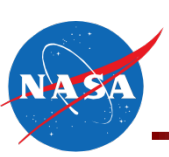
Phase 1 MOPS Value Proposition Flow Diagram

NASA UAS-NAS Project Activities

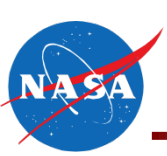
Key Products

Resultant Outcomes



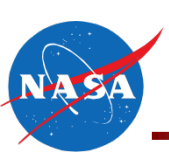


TC-DAA: Backup Slides

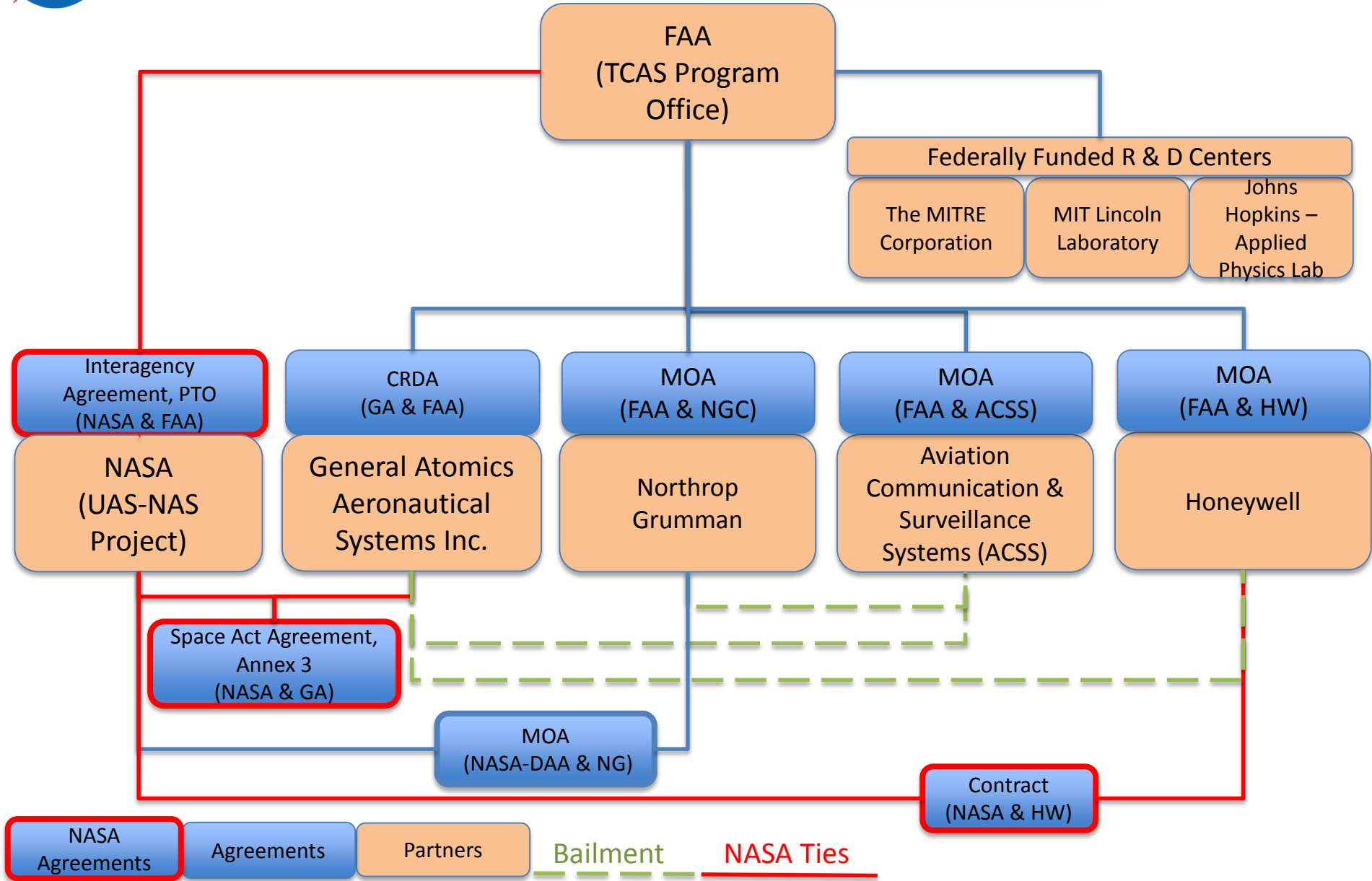


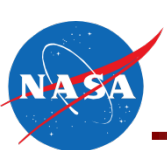
DAA Tiger Team Alternative Sensor vs. GBSAA

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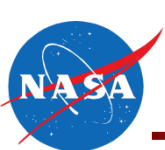
ACAS Xu FT2 Partnership Tree





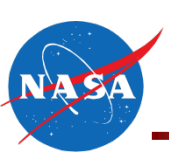
TC-DAA: Technical Baseline Elements (1/3)

Technical Baseline Number	Technical Baseline Title	Reference SP Numbers
TB-#	Alternative Surveillance and Well Clear/Alerting Requirements Research ConOps	SP D.1.30 SP D.2.10
TB-#	Alternative Surveillance: Foundational Fast-time Simulation (FY17)	SP D.1.40
TB-#	Alternative Surveillance: Display Requirements	SP D.1.50
TB-#	Alternative Surveillance: Unmitigated Fast-time Simulation (FY18)	SP D.1.60
TB-#	Alternative Surveillance: HITL 1 (FY18)	SP D.1.70, SP T.7.20
TB-#	Alternative Surveillance: Unmitigated/Mitigated Fast-time Simulation(FY19)	SP D.1.80
TB-#	Alternative Surveillance: HITL 2 (FY19)	SP D.1.90, SP T.7.40



TC-DAA: Technical Baseline Elements (2/3)

Technical Baseline Number	Technical Baseline Title	Reference SP Numbers
TB-#	Well Clear/Alerting Requirements: Fast-time Simulation 1 (FY17)	SP D.2.30
TB-#	Well Clear/Alerting Requirements: Simulation 2 (FY18)	SP D.2.40
TB-#	Well Clear/Alerting Requirements: Terminal Operations HITL Simulation 1 (FY18)	SP D.2.50
TB-#	Well Clear/Alerting Requirements: Terminal Operations HITL Simulation Terminal Operations 2 (FY19)	SP D.2.60
TB-#	ACAS-Xu: Mini HITL	SP D.3.30
TB-#	ACAS-Xu: HITL 1	SP D.3.40 SP D.7.10
TB-#	ACAS-Xu: HITL 2	SP D.3.50, SP T.7.30



TC-DAA: Technical Baseline Elements (3/3)

Technical Baseline Number	Technical Baseline Title	Reference SP Numbers
TB-#	Integrated Event: ACAS-Xu FT2	SP D.5.10, SP T.8.10
TB-#	Integrated Event: Flight Test 5	SP D.5.20, SP T.8.30
TB-#	Integrated Event: Flight Test 6	SP D.5.30, SP T.8.40
TB-#	No-Chase Certificate of Waiver or Authorization Flight Demonstration	SP T.8.20



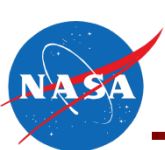
Research: Alternative Surveillance and Well Clear/Alerting Requirements Research ConOps

- <Technical Baseline Element number>; SP D.1.30 & D.2.10
- **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
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the Phase 2 MOPS
 - The ConOps will describe the scope of research related to 1) alternative surveillance and 2) the Phase 1 MOPS Well Clear definition applicability in the Phase 2 MOPS operational environment. The ConOps may include description of the operational environment, unmanned aircraft missions, operational procedures, expected intruder traffic patterns, etc. The ConOps will be developed in collaboration with RTCA DAA Working Group and other Stakeholders
 - The UAS-NAS Project Alternative Surveillance and Well Clear/Alerting Requirements ConOps (which may be one ConOps when completed) will be closely related to two SC-228 DAA Working white papers (Well Clear; Low-size, weight, power surveillance)
- **Deliverables:**
 - Type: Paper(s)
 - Recipients: RTCA SC-228 DAA Working Group, FAA, UAS Community



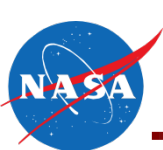
Research: Alternative Surveillance: Foundational Fast-time Simulation (FY17)

- <Technical Baseline Element number>; SP D.1.40
- **Objective:** Estimate the target performance of alternative surveillance within UAS operations associated with Phase 2 MOPS
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct an Airspace Concept Evaluation System simulation to inform DAA requirements for alternative surveillance, inform understanding of the interactions between these alternative sensor requirements and existing or proposed DAA alerting and guidance requirements, and understanding the interactions of sensor range and aircraft performance
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The Airspace Concept Evaluation System software will be updated. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, FAA, UAS Community



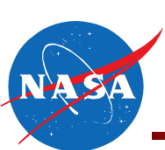
Research: Alternative Surveillance: Display Requirements

- <Technical Baseline Element number>; SP D.1.50
- **Objective:** Define DAA system display requirements for UAS with alternative surveillance systems within UAS operations associated with Phase 2 MOPS
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Collaborate with Stakeholders, Human Factors, and UAS Community experts to define DAA display requirements (guidance and alerting) for low size, weight, and power surveillance systems associated with lower performing aircraft in expanding airspace operations relative to the Phase 1 DAA MOPS
 - Lab mock-ups of display features will be used to expand understanding of display features and requirements
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community



Research: Alternative Surveillance: Unmitigated Fast-time Simulation (FY18)

- <Technical Baseline Element number>; SP D.1.60
- **Objective:** Verify DAA alerting and surveillance performance with surveillance uncertainties and updated DAA well clear definition within UAS operations associated with Phase 2 MOPS
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct an Airspace Concept Evaluation System simulation experiment to inform draft alternative surveillance requirements. The simulation will incorporate the new DAA Well Clear definition and alternative surveillance uncertainty. The simulation will not include ownship maneuvering in response to DAA alerting and guidance
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The Airspace Concept Evaluation System software will be updated. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, FAA, UAS Community



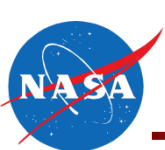
Research: Alternative Surveillance: HITL 1 (FY18)

- <Technical Baseline Element number>; SP D.1.70, SP T.7.20
- **Objective:** Verify UAS pilot performance of an UAS DAA system with low size, weight, and power sensors, 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
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct a human-in-the-loop simulation to verify pilot performance with a DAA system for smaller/slower UAS equipped with a low size, weight, and power non-cooperative sensor within the Phase 2 Minimum Operational Performance Operational Environment
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The human-in-the-loop simulation infrastructure will be updated. Scenarios will be developed and the simulation system will be verified and validated prior to data collection. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community



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

- <Technical Baseline Element number>; SP D.1.80
- **Objective:** Inform/verify the final Phase 2 MOP with fast-time simulation data on DAA alerting, guidance, and surveillance performance with surveillance uncertainties, updated DAA well clear definition, and DAA pilot model
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct an Airspace Concept Evaluation System simulation experiment to inform draft alternative surveillance requirements. The simulation will incorporate the new DAA Well Clear definition and alternative surveillance uncertainty. The simulation will include ownship maneuvering in response to DAA alerting and guidance
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The Airspace Concept Evaluation System software will be updated. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community




Research: Alternative Surveillance: HITL 2 (FY19)

- <Technical Baseline Element number>; SP D.1.90, SP T.7.40
- **Objective:** V&V pilot performance of UAS DAA with low SWAP sensors, interoperability of low SWAP sensor requirements with DAA alerting, guidance, and display requirements and the final Phase 2 MOPS
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct a human-in-the-loop simulation to serve as final validation for alternative surveillance requirements and interoperability with a DAA system for smaller/slower UAS equipped with a low size, weight, and power non-cooperative sensor and updated alerting and guidance within the Phase 2 Minimum Operational Performance Operational Environment
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The human-in-the-loop simulation infrastructure will be updated. Scenarios will be developed and the simulation system will be verified and validated prior to data collection. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community



Research: Well Clear/Alerting Requirements: Fast-time Simulation 1 (FY17)

- <Technical Baseline Element number>; SP D.2.30
- **Objective:** Determine the appropriateness of an initial DAA Well Clear definition in Class D and E terminal airspace with an operating Airport Traffic Control Tower and no surveillance capability limitations
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct a fast-time simulation to collect empirical data to address issues associated to the application of the DAA Phase 1 MOPS Well Clear definition to the Phase 2 MOPS alternative surveillance and operational environment
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The fast-time simulation infrastructure will be updated. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community



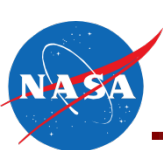
Research: Well Clear/Alerting Requirements: Simulation 2 (FY18)

- <Technical Baseline Element number>; SP D.2.40
- **Objective:** Determine the appropriateness of the Phase 1 MOPS Well Clear definition in lower-altitude, Class E and G non-terminal airspace, including low-size, weight, and power surveillance sensor limitations
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct either a fast-time or human-in-the-loop simulation to collect empirical data to address issues associated to the application of the DAA Phase 1 MOPS Well Clear definition in lower-altitude, Class E and G non-terminal airspace, including low-size, weight, and power surveillance sensor limitations
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The simulation infrastructure will be updated. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community



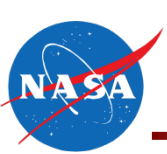
Research: Well Clear/Alerting Requirements: Terminal Operations HITL Simulation 1 (FY18)

- <Technical Baseline Element number>; SP D.2.50
- **Objective:** Verify pilot and controller performance of Class D and E terminal area operations and Verify DAA algorithm configurable parameters for Class D and E terminal area operations
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct a human-in-the-loop simulation to collect data to verify expected pilot and controller performance with a DAA system is achieved, to verify expected DAA system performance with human interaction is achieved, and to update DAA algorithm configurable parameters
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The human-in-the-loop simulation infrastructure will be updated. The DAA algorithm configurable parameters will be initially set for the latest Phase 2 MOPS Well Clear definition. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community



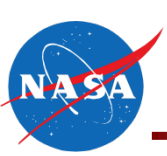
Research: Well Clear/Alerting Requirements: Terminal Operations HITL Simulation Terminal Operations 2 (FY19)

- <Technical Baseline Element number>; SP D.2.60
- **Objective:** Verify pilot and controller performance of Class E and G terminal area operations with no operating Airport Traffic Control Tower and Verify DAA algorithm configurable parameters for Class E and G terminal area operations with no operating Airport Traffic Control Tower
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct a human-in-the-loop simulation to collect data to verify expected pilot and controller performance with a DAA system is achieved, to verify expected DAA system performance with human interaction is achieved, and to update DAA algorithm configurable parameters
 - The simulation requirements/design will be defined in collaboration with RTCA DAA Working Group and other Stakeholders. The human-in-the-loop simulation infrastructure will be updated. The DAA algorithm configurable parameters will be initially set for the latest Phase 2 MOPS Well Clear definition. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, UAS Community



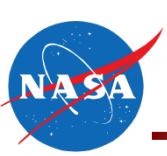
Research: ACAS-Xu: Mini HITL

- <Technical Baseline Element number>; SP D.3.30
- **Objective:** Determine that the Ames Research Centers Human Autonomy Teaming Laboratory components are installed properly for Project Phase 2 research (Primary) and provide data on alerting, display and/or guidance Phase 1 DAA MOPS (Secondary)
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to the interoperability of DAA Remain Well Clear alerting and guidance and the FAA's Airborne Collision Avoidance System For Unmanned Aircraft (ACAS Xu) Remain Well Clear and Collision Avoidance functionalities that support minimum operational performance standards for integrated collision avoidance and Remain Well Clear alerting, guidance, and displays
 - Conduct a human-in-the-loop simulation to ensure the Ames Research Centers Human Autonomy Teaming Laboratory is operating properly to allow Phase 2 DAA research. The experiment design will also provide relevant data to further refine/validate alerting, display and/or guidance Phase 1 DAA MOPS
 - The simulation requirements/design will be defined in collaboration with the RTCA DAA Working Group, SC-147 ACAS Xu Working Group, and other Stakeholders. The Ames Research Center's Human Autonomy Teaming Laboratory will be updated. Scenarios will be developed and the simulation system will be verified and validated prior to data collection. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, RTCA SC-147 ACAS Xu Working Group, FAA, UAS Community



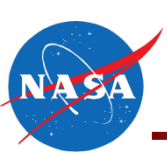
Research: ACAS-Xu: HITL 1

- <Technical Baseline Element number>; SP D.3.40, T.7.10
- **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
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to the interoperability of DAA Remain Well Clear alerting and guidance and the FAA's Airborne Collision Avoidance System For Unmanned Aircraft (ACAS Xu) Remain Well Clear and Collision Avoidance functionalities that support minimum operational performance standards for integrated collision avoidance and Remain Well Clear alerting, guidance, and displays
 - Conduct a human-in-the-loop simulation to investigate the highest priority interoperability issues related to integrated Remain Well Clear and collision avoidance alerting, guidance and displays providing data to inform requirements for ACAS Xu collision avoidance logic/functionality (SC-147) and updates to Phase 1 DAA requirements for Remain Well clear (SC-228)
 - The simulation requirements/design will be defined in collaboration with the RTCA DAA Working Group, SC-147 ACAS Xu Working Group, and other Stakeholders. The Ames Research Center's Human Autonomy Teaming Laboratory will be updated. Scenarios will be developed and the simulation system will be verified and validated prior to data collection. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, RTCA SC-147 ACAS Xu Working Group, FAA, UAS Community



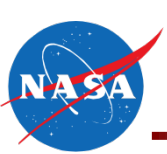
Research: ACAS-Xu: HITL 2

- <Technical Baseline Element number>; SP D.3.50, SP T.7.30
- **Objective:** Validate the SC-228 DAA and SC-147 ACAS Xu MOPS requirements for the integrated ACAS Xu Remain Well Clear and collision avoidance alerting, guidance and displays
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to the interoperability of DAA Remain Well Clear alerting and guidance and the FAA’s Airborne Collision Avoidance System For Unmanned Aircraft (ACAS Xu) Remain Well Clear and Collision Avoidance functionalities that support minimum operational performance standards for integrated collision avoidance and Remain Well Clear alerting, guidance, and displays
 - Conduct a human-in-the-loop simulation to validate DAA and ACAS Xu MOPS requirements for an integrated ACAS Xu Remain Well Clear and collision avoidance alerting, guidance and display system by evaluating whether pilot performance is equivalent to, or better than observed during NASA Phase 1 Part Task 6 Verification and Validation human-in-the-loop simulation effort
 - The simulation requirements/design will be defined in collaboration with the RTCA DAA Working Group, SC-147 ACAS Xu Working Group, and other Stakeholders. The Ames Research Center’s Human Autonomy Teaming Laboratory will be updated. Scenarios will be developed and the simulation system will be verified and validated prior to data collection. Experiment data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, RTCA SC-147 ACAS Xu Working Group, FAA, UAS Community



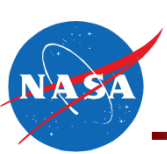
Research: Integrated Event: ACAS-Xu FT2

- <Technical Baseline Element number>; SP D.5.10, SP T.8.10
- **Objective:** Evaluate interoperability between FAA ACAS Xu and NASA's DAA algorithms (compare alerting and guidance)
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to the interoperability of DAA Remain Well Clear alerting and guidance and the FAA's Airborne Collision Avoidance System For Unmanned Aircraft (ACAS Xu) Remain Well Clear and Collision Avoidance functionalities that support minimum operational performance standards for integrated collision avoidance and Remain Well Clear alerting, guidance, and displays
 - Conduct a flight test to collect data to evaluate Live, Virtual, and Constructive Distributed Environment enhancements including new ownship/intruder state and ACAS Xu messaging, better understand the differences/similarities between ACAS Xu and NASA's algorithm Remain Well Clear alerting and guidance, and to evaluate ACAS Xu Remain Well Clear and collision avoidance functional interoperability
 - While the primary flight test requirements/design will be defined by the FAA, a portion of them will be defined by NASA in collaboration with the SC-228 DAA Working Group and other Stakeholders. Flight test infrastructure and test/support aircraft will be modified. Flight test environment will be verified and validated prior to data collection. Scripted encounters will be defined. Flight data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, RTCA SC-147, FAA, UAS Community



Research: Integrated Event: Flight Test 5

- <Technical Baseline Element number>; SP D.5.20, SP T.8.30
- **Objective:** Conduct a flight test providing data to support development of the RTCA SC-228 Phase 2 Detect and Avoid and Alternative Surveillance Minimum Operational Performance Standards
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct a flight test on a mid-sized unmanned vehicle implementing detect and avoid (alerting, guidance) and alternative surveillance systems to provide data contributing to the development, verification, and validation of models and simulations, and development of Phase 2 Detect and Avoid and Alternative Surveillance Minimum Operational Performance Standards
 - The flight test requirements/design will be defined in collaboration with the RTCA DAA Working Group. Flight test infrastructure and test/support aircraft will be modified. Flight test environment will be verified and validated prior to data collection. Encounters will be defined. Flight data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, RTCA SC-147, FAA, UAS Community



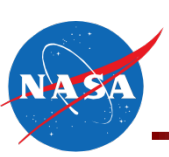
Research: Integrated Event: Flight Test 6

- <Technical Baseline Element number>; SP D.5.30, SP T.8.40
- **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 Minimum Operational Performance Standards
- **Approach:**
 - The UAS-NAS Project DAA Technical Challenge includes several Technical Baseline Elements related to alternative surveillance technology (specifically a low size, weight, and power radar) and expanded operational environments (airspace classes) that support the development of the minimum operational performance standards
 - Conduct a flight test on a mid-sized unmanned vehicle implementing detect and avoid (alerting, guidance) and alternative surveillance systems to provide data contributing to the development, verification, and validation of models and simulations, and Phase 2 Detect and Avoid and Alternative Surveillance Minimum Operational Performance Standards
 - The flight test requirements/design will be defined in collaboration with the RTCA DAA Working Group. Flight test infrastructure and test/support aircraft will be modified. Flight test environment will be verified and validated prior to data collection. Encounters will be defined. Flight data will be collected and analyzed
- **Deliverables:**
 - Type: Briefing
 - Recipients: RTCA SC-228 DAA Working Group, RTCA SC-147, FAA, UAS Community



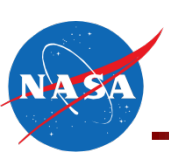
Research: No-Chase Certificate of Waiver or Authorization Flight Demonstration

- <Technical Baseline Element number>; SP.8.20
- **Objectives:** Conduct unmanned aircraft flight demonstration as described in an FAA approved No Chase Certificate of Waiver or Authorization
- **Approach:**
 - Establish a progressive approach with the FAA leading to a demonstration flight with developmental DAA (remain well clear, collision avoidance) and non-cooperative sensor (radar) equipment that satisfy Phase 1 DAA and Radar MOPS transiting through as many Classes of airspace (including A, D, E and G) as pertinent
 - Collaborate with FAA on development of operational approach and safety criteria for a no-chase Certificate of Waiver or Authorization. Develop a “Safety Case” if needed. Request FAA approval of a No Chase Certificate of Waiver or Authorization
 - Conduct UAS flight demonstration as outlined in FAA approved No Chase Certificate of Waiver or Authorization
 - Document UAS flight demonstration results
- **Deliverables:**
 - Type: Data, No Chase Certificate of Waiver or Authorization, Report
 - Recipients: NASA, FAA, DAA Subproject, SC-228 DAA Working Group, UAS Community



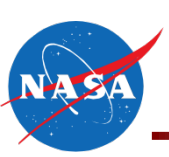
DAA Risk

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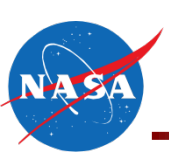
DAA Risk

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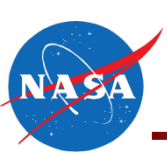


DAA Risk

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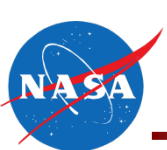


TC-C2: Backup Slides



CNPC Prototype Radio Evolution

- Generation 1
 - L-Band only, single aircraft, single ground station
- Generation 2
 - Added C-Band, added multiple ground stations; single aircraft
 - Hand-offs between ground stations
- Generation 3
 - Multiple aircraft, multiple ground stations
- Generation 4
 - Update of data rates to perform testing/analysis for preliminary C2 MOPS
- Generation 5
 - Updates to radio to align with final C2 MOPS
 - Used to perform C2 MOPS Verification & Validation



TC-C2: Technical Baseline Elements

Technical Baseline Number	Technical Baseline Title	Reference SP Numbers
TB-#	Ku-Band Spectrum Interference Evaluation System Development	SP C.5.10
TB-#	Ku-Band Propagation Flights and Interference Analysis	SP C.5.11
TB-#	Ka-Band Evaluation System Development and Test and Evaluation	SP C.5.20 SP C.5.21
TB-#	Ku-Band Evaluation System Development	SP C.5.30,
TB-#	Ku-Band Test and Evaluation	SP C.5.31
TB-#	C-Band Design Study, Verification & Validation Planning	SP C.5.40, SP C.5.41
TB-#	Terrestrial C2 Radio Evaluation System Development and Test and Evaluation	SP C.6.10 SP C.6.11



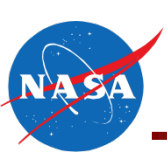
Research: Ku-Band Spectrum Interference Evaluation System Development

- <Technical Baseline Element number>; SP C.5.10
- **Objective:** Develop the Ku-Band interference evaluation system
- **Approach:**
 - The UAS-NAS Project C2 Technical Challenge includes several Technical Baseline Elements to transfer Ku-Band technology and interference research data for C2 links between the UAS and the Ground Control System that support the required performance of the unmanned aircraft in the NAS, ensures that the pilot maintains a threshold level of control of the aircraft, and is robust to both environmental or technological issues ultimately contributing to the development and validation of standards for Satcom C2 Links
 - A Ku-band Satcom propagation evaluation system will be developed by the UAS-NAS C2 Subproject Project for research of possible interference between UAS Satcom C2 links and fixed point-to-point earth stations still operating outside the United States. The Ku-band Satcom propagation evaluation system will be capable of operation within the expected operational parameters
 - The Ku-band Satcom propagation evaluation system will be used in subsequent flight tests
- **Deliverables:**
 - Type: Papers, Briefings
 - Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office, ICAO



Research: Ku-Band Propagation Flights and Interference Analysis

- <Technical Baseline Element number>; SP C.5.11
- **Objective:** Transfer technology and interference research data for the development and validation of standards for Ku-Band Satcom C2 data link
- **Approach:**
 - The UAS-NAS Project C2 Technical Challenge includes several Technical Baseline Elements to transfer Ku-Band technology and interference research data for C2 links between the UAS and the GCS that support the required performance of the unmanned aircraft in the NAS, ensures that the pilot maintains a threshold level of control of the aircraft, and is robust to both environmental or technological issues ultimately contributing to the development and validation of standards for Satcom C2 Links
 - Flight tests of a Project developed Ku-band Satcom propagation evaluation system will be conducted to research possible interference between UAS Satcom C2 links and fixed point-to-point earth stations still operating outside the United States. Research data will be acquired within expected operational parameters according to approved test plans and procedures
 - Results will be made available for the definition, development, and validation of a civil UAS Beyond Line of Sight (BLOS) satellite-based C2 system and the establishment of necessary performance parameters for the Ku-Band satellite spectrum bands
- **Deliverables:**
 - Type: Papers, Briefings
 - Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office, ICAO



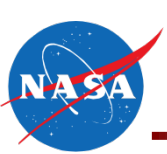
Research: Ka-Band Evaluation System Development and Test and Evaluation

- <Technical Baseline Element number>; SP C.5.20, SP C.5.21
- **Objective:** Develop the Ka-Band interference evaluation system and transfer technology and research data for the development and validation of standards for Ka-Band Satcom C2 data link
- **Approach:**
 - The UAS-NAS Project C2 Technical Challenge includes several Technical Baseline Elements to transfer Ka-Band technology research data for C2 links between the UAS and the GCS that support the required performance of the unmanned aircraft in the NAS, ensures that the pilot maintains a threshold level of control of the aircraft, and is robust to both environmental or technological issues ultimately contributing to the development and validation of standards for Satcom C2 Links
 - A commercial off-the-shelf Ka-band Satcom evaluation system comprising flight/ground elements, interfaces, and representative C2 messages will be used for laboratory and flight tests. Performance variables may be limited to trade-offs between Committed Information Rate (Quality of Service) Customer Service Plans although other non-consumer variables may be possible through the NASA/Industry partnership agreement. Research data will be acquired according to approved test plans and procedures
 - Results will be made available for the definition, development, and validation of a civil UAS Beyond Line of Sight (BLOS) satellite-based C2 system and the establishment of necessary performance parameters for the Ka-Band satellite spectrum bands
- **Deliverables:**
 - Type: Papers, Briefings
 - Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office, ICAO



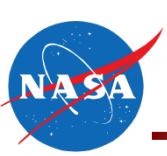
Research: Ku-Band Evaluation System Development

- <Technical Baseline Element number>; SP C.5.30
- Objective: Develop the Ku-Band evaluation system
- Approach:
 - The UAS-NAS Project C2 Technical Challenge includes several Technical Baseline Elements to transfer Ka-Band technology research data for C2 links between the UAS and the GCS that support the required performance of the unmanned aircraft in the NAS, ensures that the pilot maintains a threshold level of control of the aircraft, and is robust to both environmental or technological issues ultimately contributing to the development and validation of standards for Satcom C2 Links
 - A Ku-band Satcom evaluation system will be developed by the UAS-NAS Subproject within the proposed Ka spectrum bands comprising flight/ground elements, interfaces, and representative C2 messages. Development of a “flexible” prototype unit and C2 test support environment will allow key performance parameters to be varied enabling verification and validation of the UAS Satcom MOPS being developed by RTCA SC-228. The Ku-band Satcom evaluation system will be capable of operation within the expected operational parameters
 - The Ku-band Satcom evaluation system will be used in subsequent flight tests
- Deliverables:
 - Type: Papers, Briefings
 - Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office, ICAO



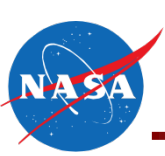
Research: Ku-Band Test and Evaluation

- <Technical Baseline Element number>; SP C.5.31
- **Objective:** Transfer technology and research data for the development and validation of standards for Ku-Band Satcom C2 data link
- **Approach:**
 - The UAS-NAS Project C2 Technical Challenge includes several Technical Baseline Elements to transfer Ka-Band technology research data for C2 links between the UAS and the GCS that support the required performance of the unmanned aircraft in the NAS, ensures that the pilot maintains a threshold level of control of the aircraft, and is robust to both environmental or technological issues ultimately contributing to the development and validation of standards for Satcom C2 Links
 - Laboratory and flight tests will be conducted using a Project developed Ku-Band Satcom system. Key performance parameters will be varied enabling verification and validation over a range of operating conditions. Research data will be acquired within expected operational parameters according to approved test plans and procedures
 - Results will be made available for the definition, development, and validation of a civil UAS Beyond Line of Sight (BLOS) satellite-based C2 system and the establishment of necessary performance parameters for the Ku-Band satellite spectrum bands
- **Deliverables:**
 - Type: Papers, Briefings
 - Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office, ICAO



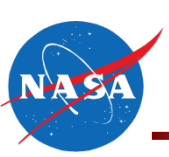
Research: C-Band Design Study, Verification & Validation Planning

- <Technical Baseline Element number>; SP C.5.40, SP C.5.41
- **Objective:** Transfer research data for the development and validation of standards for C-Band Satcom C2 data link
- **Approach:**
 - The UAS-NAS Project C2 Technical Challenge includes several Technical Baseline Elements to transfer C-Band research data for C2 links between the UAS and the GCS that support the required performance of the unmanned aircraft in the NAS, ensures that the pilot maintains a threshold level of control of the aircraft, and is robust to both environmental or technological issues ultimately contributing to the development and validation of standards for Satcom C2 Links
 - A C-Band C2 paper study will be conducted with results leading to the development of design parameters within the C-Band AMS(R)S frequency allocation and the broader determination of operational feasibility of a C-Band satellite-based C2 system
 - Study results will be made available for the development and validation of C2 standards
- **Deliverables:**
 - Type: Papers, Briefings
 - Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office, ICAO



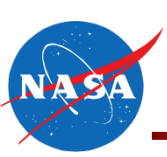
Research: Terrestrial C2 Radio Evaluation System Development

- <Technical Baseline Element number>; SP C.6.10, SP C.6.11
- **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
- **Approach:**
 - The UAS-NAS Project C2 Technical Challenge includes several Technical Baseline Elements to transfer Terrestrial C2 technology research data for C2 links between the UAS and the GCS that support the required performance of the unmanned aircraft in the NAS, ensures that the pilot maintains a threshold level of control of the aircraft, and is robust to both environmental or technological issues ultimately contributing to the development and validation of standards for Satcom C2 Links
 - Multiple generations of a Terrestrial C2 evaluation system will be developed through a NASA/industry cooperative agreement. The Terrestrial C2 evaluation system will be developed within the proposed Terrestrial spectrum bands comprising flight/ground elements, interfaces, and representative C2 messages. The Terrestrial C2 evaluation system will be capable of operation within the expected operational parameters. Laboratory and flight tests will be conducted using a Terrestrial C2 system. Research data will be acquired within expected operational parameters according to approved test plans and procedures
 - Results will be made available for the definition, development, and validation of a civil UAS Terrestrial C2 system and the establishment of necessary performance parameters for the Terrestrial C2 spectrum bands
- **Deliverables:**
 - Type: Papers, Briefings
 - Recipients: RTCA SC-228 C2 Working Group, FAA Spectrum Office, ICAO



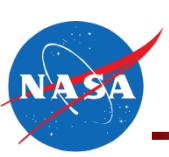
C2 Risk

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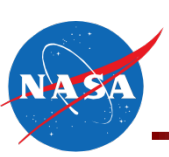


C2 risk

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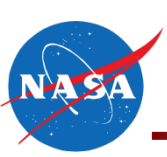


ETC-SIO: Backup Slides

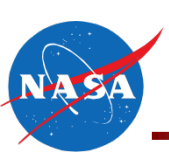


SIO Risk

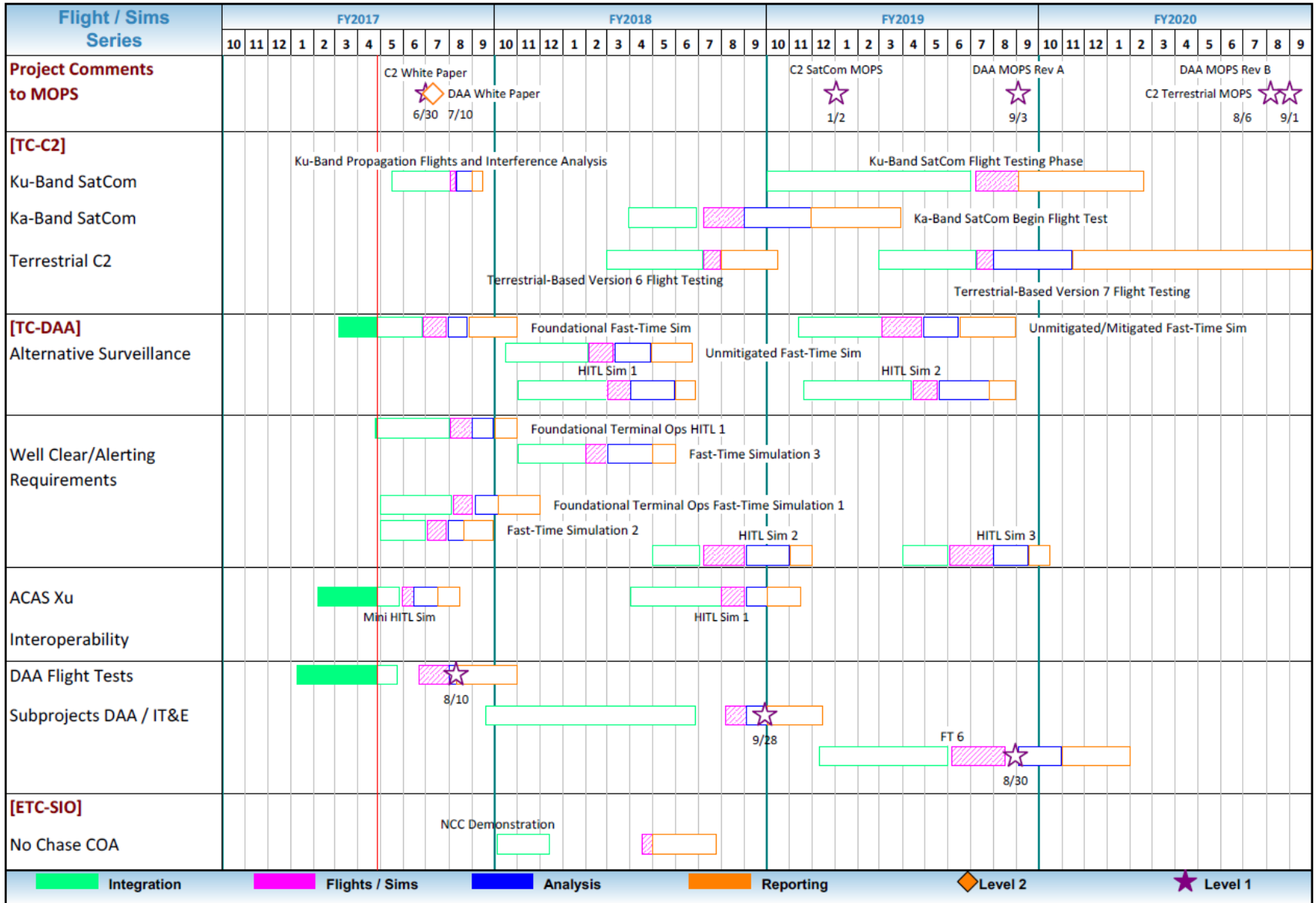
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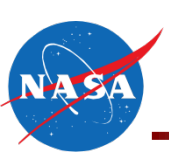
Project Summary Backup Slides



Phase 2 Flight and Simulation Overview

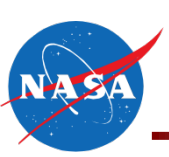


Red Status Line Date 4/26/17



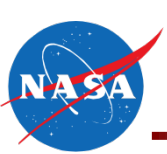
External Influences on Technical Objectives defined at PPBE18

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Reserve Strategy

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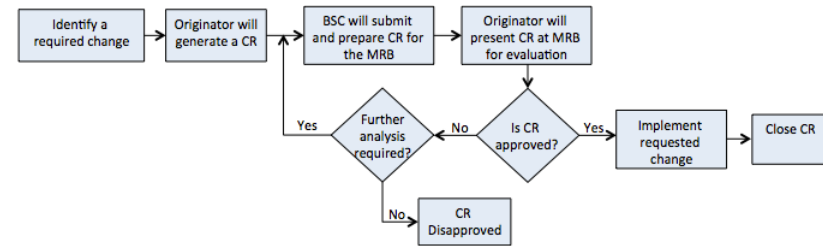


Project Processes

• Change Management

- Standard process utilizing Change Requests (CR) to manage changes to the following elements:

- L1 and L2 Milestones
- Project Goals, Objectives, and Technical Challenges
- Technical Baseline, i.e. SP objective, approach, deliverables
- Budget



• Risk Management

- Utilizes a Continuous Risk Management (CRM) process to identify, analyze, plan, track, and control risks

- Risk Workshops and Risk Review meetings conducted monthly
- Risks are communicated in IASP UAS-NAS Risk Review Board, AFRC & Partner C

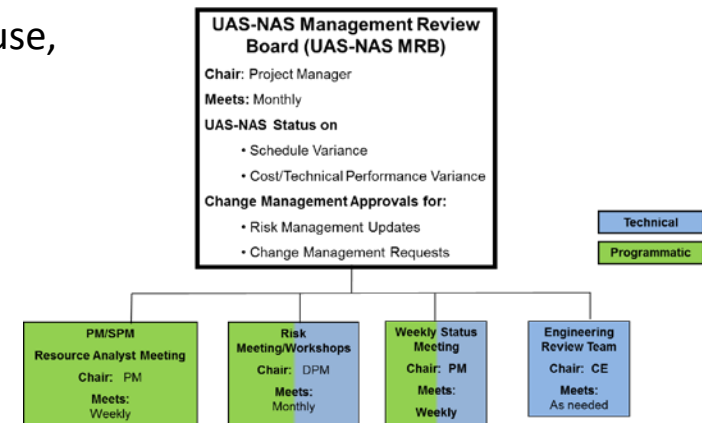


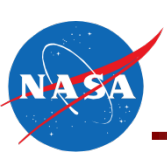
• Resource Management

- TWP, Budget roll up, and travel spreadsheets used in conjunction with standard tools (PMT, Business Warehouse, and SAP) to generate phasing plans and monitor status

• Management Review Board (MRB)

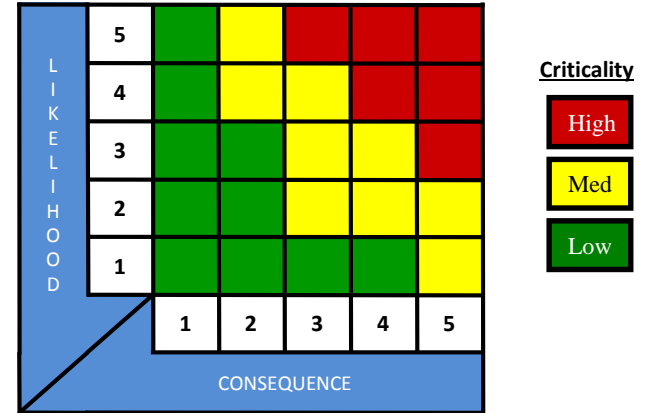
- Monthly meeting where CRs and Risks are assessed/ approved and resource status and schedule status are presented





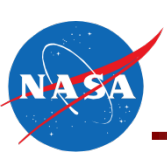
UAS-NAS Risk Summary Card

LIKELIHOOD		
5	Very High	Qualitative: Nearly certain to occur. Controls have little or no effect.
4	High	Qualitative: Highly likely to occur. Controls have significant uncertainties.
3	Moderate	Qualitative: May occur. Controls exist with some uncertainties.
2	Low	Qualitative: Not likely to occur. Controls have minor limitations /uncertainties.
1	Very Low	Qualitative: Very unlikely to occur. Strong Controls in Place



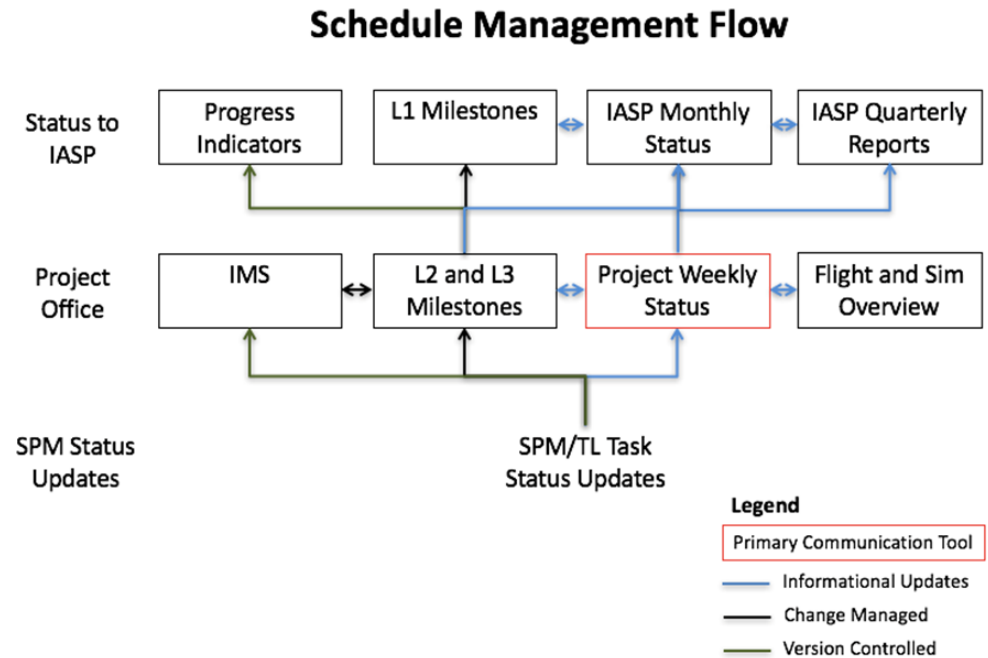
CONSEQUENCE	1	2	3	4	5
Technical	Negligible Impact to Objective, Technical Challenge, Technology Maturation	Minor Impact to Objective, Technical Challenge, Technology Maturation	Some Impact to Objective, Technical Challenge, Technology Maturation	Moderate Impact to Objective, Technical Challenge, Technology Maturation	Major Impact/Cannot Complete to Objective, Technical Challenge, Technology Maturation
Cost	≤ 1% Total Project Yearly Budget (≤ \$300K)	1% - 5% Total Project Yearly Budget (\$300K - \$1.5M)	5% - 10% Total Project Yearly Budget (\$1.5M - \$3M)	10% - 15% Total Project Yearly Budget (\$3M - \$4.5M)	>15% Total Project Yearly Budget (> \$4.5M)
Schedule *	Level 2 Milestone(s): < 1 month impact	Level 2 Milestone(s): ≥ 1 month impact	Level 1 Milestone(s): ≤1 month impact Level 2 Milestone(s): ≤ 2 month impact	Level 1 Milestone(s): > 1 month impact Level 2 Milestone(s): > 2 month impact	Level 1 Milestone(s): > 2 month impact Level 2 Milestone(s): ≥ 3 month impact

Note: L1 = IASP L2 = Project



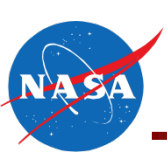
Project Processes Schedule Management Flow

- Project weekly status is the primary means of information flow, schedule status, and updates
- Schedule Packages and Milestones are the primary means of reporting at the project weekly status
- The version controlled IMS contains change managed Milestones



Representative TC Task	M/S Level	Begin Date	End Date	Status/Progress /Concerns
Schedule Package N				Technical, Schedule, Accomplishments, and Issues and Concerns Status
Active Task1		01/01/14	02/15/14	complete
Active Task2		01/20/14	02/28/14	ongoing
Active Task3		02/01/14	03/31/14	ongoing
Deliverable		03/15/14	03/15/14	Date slipped 03/21/14
Milestone	L2	04/01/14	04/01/14	On track

- Schedule management process is formally documented in the SMP



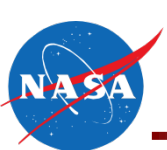
Milestone Definitions

- L1 Milestones
 - Associated with end of execution of major research activities (simulations & flight tests) of significant complexity
 - Consolidated comments/FRAC period comments to final SC-228 (White Papers & MOPS)
- L2 Milestones New Criteria
 - Start of test execution
 - Final reviews supporting simulations or flight tests associated with a L1 milestone, e.g. Test Readiness Review, Flight Test Tech Brief
 - Test plans associated with L1 execution milestones
 - Subproject FRAC comments to MOPS
 - Technology Transfer (Briefings, Reports, Papers, etc)
 - Note: Completion date is not change managed
 - System Design/Delivery Complete (in house activities; not partner activities)
 - Partnership Contract Award
- L3 Milestones
 - At the discretion of the SPM (used by the SPM to manage their schedules)
 - Potential Criteria for SPM consideration
 - Some previous L2s no longer captured by the new L2 criteria, e.g. FRR, SRR, Stakeholder Feedback reports, Configuration Freezes, Independent Reviews, Non-L1 Test Plans
- Implementation Guidance
 - Notionally should not exceed 3 L1s per TC per FY
 - L3 Milestones are not change managed at the PO level, i.e. MRB
 - IASP may elevate a L2 to L1 and the Project may elevate a L3 to L2



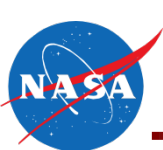
Phase 2 Technical Management Process Updates

- Addition of Project Chief Engineer (CE) introduces additional technical oversight of technical plan and execution
 - Project Concept of Operations establishes baseline description of UAS operations for Phase 2 Operational Environments within NASA Project scope and serves as key message for community outreach
 - IT&E Subproject Software Management Plan expands to address multi-center common DAA simulation architecture
 - For multi-center integration activities, the CE will coordinate with Safety & Mission Assurance authorities across the participant centers to achieve the project objectives
 - Each Flight Test will have a designated Principal Investigator (PI) from the research Subproject (DAA and/or C2) who jointly owns the Flight Test with the Flight Test Subproject (IT&E or C2)
 - Periodic technical discussions scheduled between CE and Technical Leads
 - All technical activities will require an internal brief out of the results to the CE



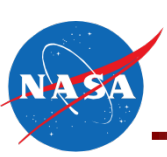
Phase 2 Technical Management Process Updates (cont.)

- Technical Review Process Changes
 - Establishes a baseline minimum set of technical reviews that are required by the Project for all test activities
 - Technical reviews are established based on the test type
 - Test types include
 - Modeling Analysis/Simulations without Human participants
 - Human-in-the-Loop Simulations
 - Flight Test
 - The CE will also assess the risks for each test to determine if the standard reviews are sufficient
 - In some limited cases, more or less reviews may be required
 - After determining the required reviews for a test, the CE will assess planned review processes at each participant center to determine which of the project's technical reviews can be satisfied by the centers' own reviews in order to reduce the duplication of reviews
 - Leadership of Reviews:
 - When a center review is deemed sufficient to replace a project review, the center shall lead the review per standard center processes and the CE, or their designee, will be a required participant in the center review
 - If the CE determines that a review must be called by the Project because a center does not plan to conduct their own relevant review, then the CE, or their designee, will chair the review



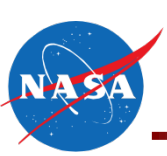
Current Active Collaborations/Partnerships Status

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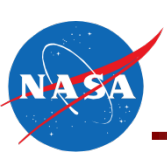
FAA ACAS Xu PO Collaborations/Partnerships Status

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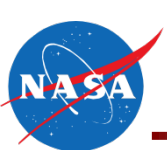
Grants and Agreements - Current

- Data Removed



Grants and Agreements - Current

- Data Removed



Governing Project Documents

Controlled Documents	Document Number	Document Date	Status
Project Plan Phase 1	UAS-PRO-1.1-001-003	07-29-13	Baselined
Phase 2 (FY17-FY20)Technology Development Project Plan [Includes Risk Management Process]	UAS-PRO-1.1-012-001	TBD	Revision in process
Technical Baseline Document	UAS-PRO-1.1-013-001	TBD	Being drafted
Systems Engineering Management Plan (SEMP)	UAS-PRO-1.1-007-002	TBD	Revision in process
Change Management Plan (CMP)	UAS-PRO-1.1-002-005	02-21-17	Signed
Schedule Management Plan (SMP)	UAS-PRO-1.1-008-001	TBD	Revision in process
Technology Transfer Plan (TTP)	UAS-PRO-1.1-006-002	02-21-17	Ready to be signed
Records Retention Schedule	UAS-PRO-1.1-003-006	01-25-17	Signed
Public Outreach Plan	UAS-OR-7.1-001-001	05-08-14	Signed
DAA Subproject Implementation Plan	UAS-DAA-4.7-001-001	TBD	Revision in process
C2 Subproject Implementation Plan	UAS-C2-4.8-001-001	TBD	Revision in process
IT&E Subproject Implementation Plan	UAS-ITE-5.2-001-001	TBD	Revision in process



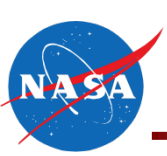
Acronyms

AA	Associate Administrator
AAVP	Advanced Air Vehicles Program
ABDAA	Airborne Detect and Avoid
AC	Aircraft
ACAS	Airborne Collision Avoidance System
ACAS Xu	Airborne Collision Avoidance System for Unmanned Aircraft Systems
ACSS	Aviation Communication & Surveillance Systems
ADD	Architecture Description Document
ADS-B	Automatic Dependent Surveillance - Broadcast
AFRC	Armstrong Flight Research Center
AFRL	Air Force Research Lab
AFSR	Airworthiness and Safety Flight Review
AGL	Above Ground Level
AI	Airspace Integration
Alt	Altitude
AMS(R)S	Aeronautical Mobile-Satellite (R) Service
ANG	Air National Guard
AOL	Airspace Operation Laboratory at NASA Ames
AOSP	Airspace Operations and Safety Program
ARC	Ames Research Center or Aviation Rule-Making Committee
ARD	Aeronautics Research Director



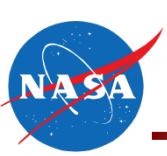
Acronyms

ARMD	Aeronautics Research Mission Directorate
ATC	Air Traffic Controller
ATO	Air Traffic Organization-FAA Organization
ATOL	Air Traffic Operations Lab
AUVSI	Association for Unmanned Vehicle Systems International
BLOS	Beyond Line of Sight
BRLOS	Beyond Radio Line of Sight
BVLOS	Beyond Visual Line of Sight
C-UAS	Center for UAS
C2	Command and Control
CAN	Cooperative Agreement Notice
CAS	Collision Avoidance System
CE	Chief Engineer
CMC	Center Management Council
CMP	Change Management Plan
CNPC	Control and Non-Payload Communications
CNS	Communication, Navigation, and Surveillance
COA	Certificate of Authorization or Waiver
CONOPS	Concept of Operations
CR	Change Request or Continuing Resolution
CRDA	Cooperative Research and Development Agreement



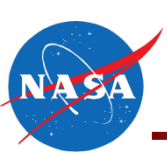
Acronyms

CRM	Continuous Risk Management
CSE	Chief Systems Engineer
DAA	Detect and Avoid
DATR	Dryden Aeronautical Test Range
DHS	Department of Homeland Security
EIP	Early Implementation Plan
ETC	Emerging Technical Challenge
EUROCAE	European Organization for Civil Aviation Equipment
ExCom	Executive Committee
FAA	Federal Aviation Administration
FFRDC	Federally Funded Research and Development Center
FRAC	Final Review and Comment
FT	Flight Test
FTE	Full Time Equivalent
FTP	Flight Test Plan
FTRD	Flight Test Requirements Document
FY	Fiscal Year
GA	General Aviation or General Atomics
GA-ASI	General Atomics Aeronautical Systems Inc.
GBDAA	Ground Based Detect and Avoid
GBSAA	Ground Based Sense and Avoid



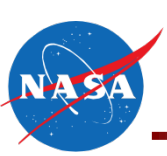
Acronyms

GCS	Ground Control Station
GRC	Glenn Research Center
HALE	High Altitude Long Endurance
HAT	Human Autonomy Testing
HF	Human Factors
HITL	Human in the loop
HW	Hardware or Honeywell
HSI	Human Systems Integration
IAA	Inter-Agency Agreement
IASP	Integrated Aviation Systems Program
IAW	In accordance with
ICAO	International Civil Aviation Organization
IDIQ	Indefinite-Delivery, Indefinite-Quantity
IFR	Instrument Flight Rules
IHITL	Integrated Human in the loop
IMS	Integrated Master Schedule
IOC	Initial Operating Capability
IRT	Independent Review Team
IT&E	Integrated Test and Evaluation
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union-Radiocommunication



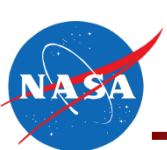
Acronyms

JADEM	Java Architecture for Detect and Avoid Extensibility and Modeling
JARUS	Joint Authorities for Rule Making on Unmanned Systems
JMP	Joint Management Plan
KDP	Key Decision Point
L1	Level 1
L2	Level 2
LaRC	Langley Research Center
LOS	Line of Sight or Loss of Separation
LTE	Long Term Evolution
LVC	Live Virtual Constructive
LVC-DE	Live Virtual Constructive- Distributed Environment
M&S	Modeling & Simulation
MS&A	Modeling, Simulation and Analysis
MASPS	Minimum Aviation System Performance Standards
MIT-LL	Massachusetts Institute of Technology Lincoln Labs
MITRE	MITRE Corporation
MOA	Memorandum of Agreement
MOPS	Minimum Operational Performance Standards
MRB	Management Review Board
MSL	Mean Sea Level
NAS	National Airspace System



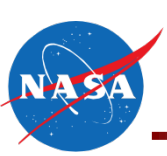
Acronyms

NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCC	No Chase COA
NextGen	Next Generation
NGC	Northrop Grumman Corporation
NLT	No later than
NSF	National Science Foundation
OBE	Overcome by Events
ODM	On Demand Mobility
OE	Operational Environment
ORD	Objectives and Requirements Document
ORF	Norfolk International Airport
P1	Phase 1
P2	Phase 2
PI	Progress Indicator or Principal Investigator
PM	Project or Program Manager
PMT	Project Management Tool
PO	Project Office
PPBE	Planning, Programming, Budgeting, and Execution
PTO	Permit to Operate
RF	Radio Frequency



Acronyms

RFI	Request for Information
RFP	Request for Proposal
RGCS	Research Ground Control Station
RMP	Risk Management Plan
RPAS	Remotely Piloted Aircraft Systems
RTP	Research Transition Product
RTT	Research Transition Team
RVLT	Revolutionary Vertical Lift Technology
SAA	Space Act Agreement or Sense and Avoid or See and Avoid
SAAP	Sense and Avoid Processor
SAF	Standalone Facility
SAP	Systems Applications and Products
SARP	Science and Research Panel
Satcom	Satellite Communication
SC	Special Committee
SD	System Development
SDD	Software Design Document
SEMP	Systems Engineering Management Plan
SIO	System Integration and Operationalization
SME	Subject Matter Expert
SMP	Schedule Management Plan



Acronyms

SOA	State of Art
SP	Schedule Package
SPM	Subproject Manager
SPMR	Strategic Portfolio Management Review
SRD	System Requirements Document
SRR	System Requirements Review
STANAG	Standard Agreement
STM	Surveillance Tracking Module
STP	Software Test Plan
SW	Software
SWaP	Size, Weight and Power
SWRD	Software Requirements Document
TACAN	Tactical Air Navigation System
TB	Technical Baseline
TBD	To Be Determined
TC	Test Conductor/Technical Challenge
TCAS	Traffic Alert and Collision Avoidance System
TL	Technical Lead
ToR	Terms of Reference
TRL	Technology Readiness Level
TRM	Technical Reference Manual



Acronyms

TSO	Technical Standard Order
TTP	Technology Transfer Plan
TWP	Technical Work Package
UAS	Unmanned Aircraft Systems
UAS-NAS	UAS Integration in the NAS
USAF	United States Air Force
UTM	Unmanned Aerial System (UAS) Traffic Management
V&V	Verification and Validation
VDD	Version Description Document
VFR	Visual Flight Rules
VLL	Very Low Level
VSCS	Vigilant Spirit Control Station
WG	Working Group
WRC	World Radio Conference
WYE	Work Year Equivalent