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

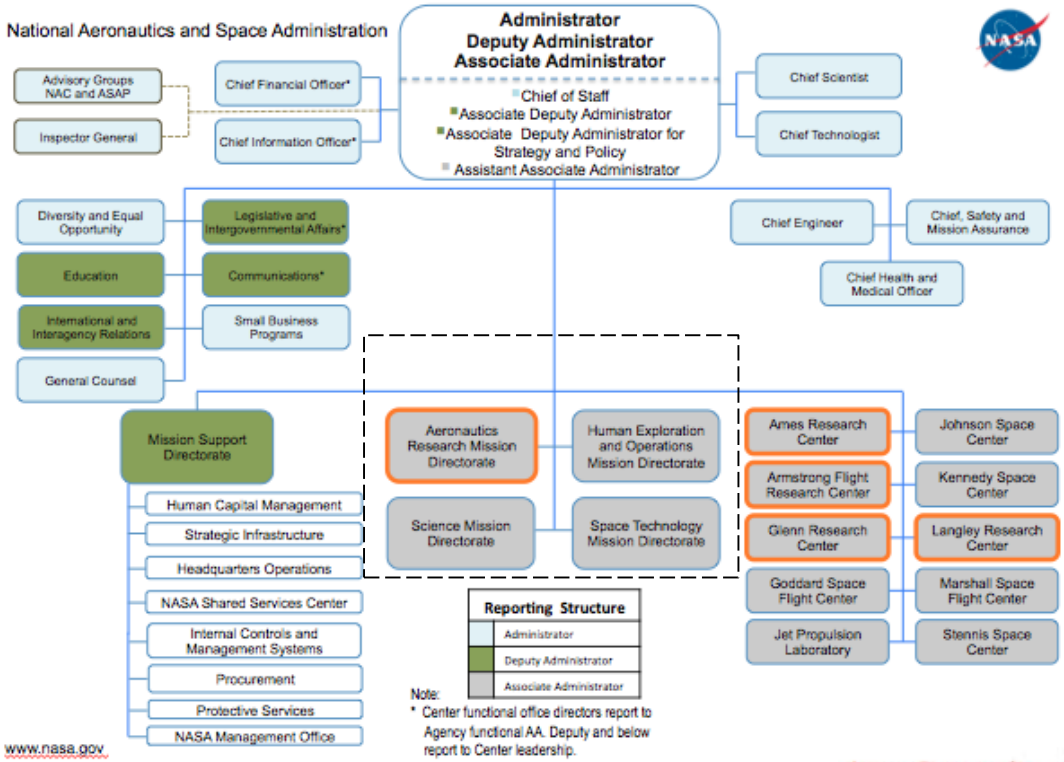
Chuck Johnson

Senior Advisor for UAS Integration

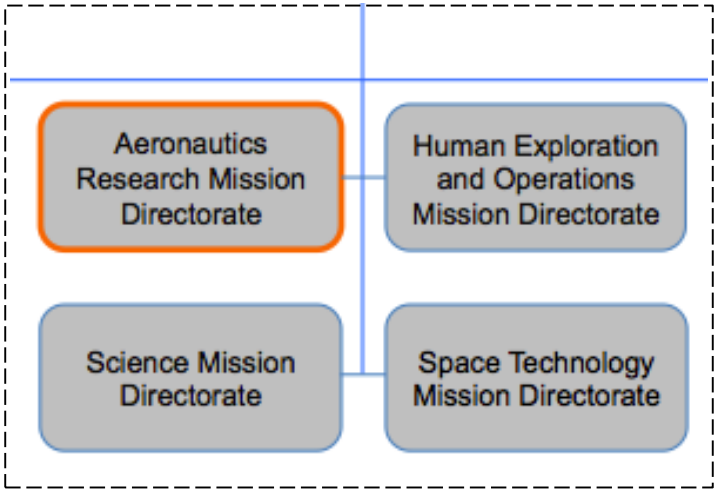
Discussion Topics

- NASA Organization
- NASA Cohesive UAS Integration Strategy
  - Scope / Outcome
  - Current Landscape and Future Vision
  - Overarching UAS Community Strategy
- UAS Integration in the NAS Project Overview
  - Project Goal
  - Detect and Avoid
  - Command and Control
  - System Integration and Operationalization Demonstration

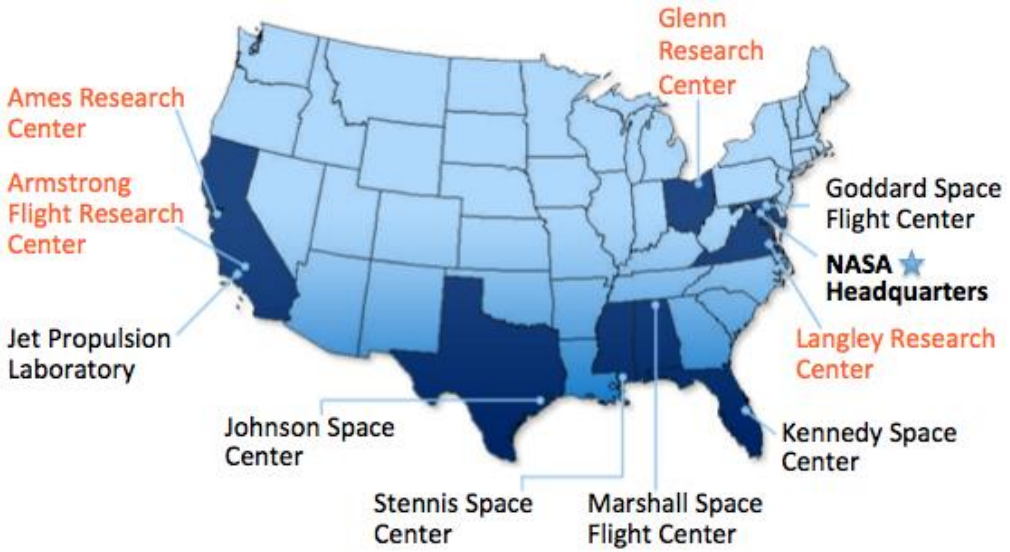
NASA Organizational Structure



Mission Directorates



Aeronautics Research Centers



ARMD Organizational Structure, Programs Overview

MISSION PROGRAMS

Airspace Operations and Safety Program

AOSP

- Safe, Efficient Growth in Global Operations
- Real-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

Advanced Air Vehicles Program

AAVP

- Ultra-Efficient Commercial Vehicles
- Innovation in Commercial Supersonic Aircraft
- Transition to Low-Carbon Propulsion
- Assured Autonomy for Aviation Transformation

Integrated Aviation Systems Program

IASP

- Flight research-oriented, integrated, system-level R&T that supports all six thrusts
- X-planes/ test environment

<u>IASP Projects</u>

- UAS-NAS
- Flight Demonstrations & Capabilities (FDC)

SEEDLING PROGRAM

Transformative Aeronautics Concepts Program

TACP

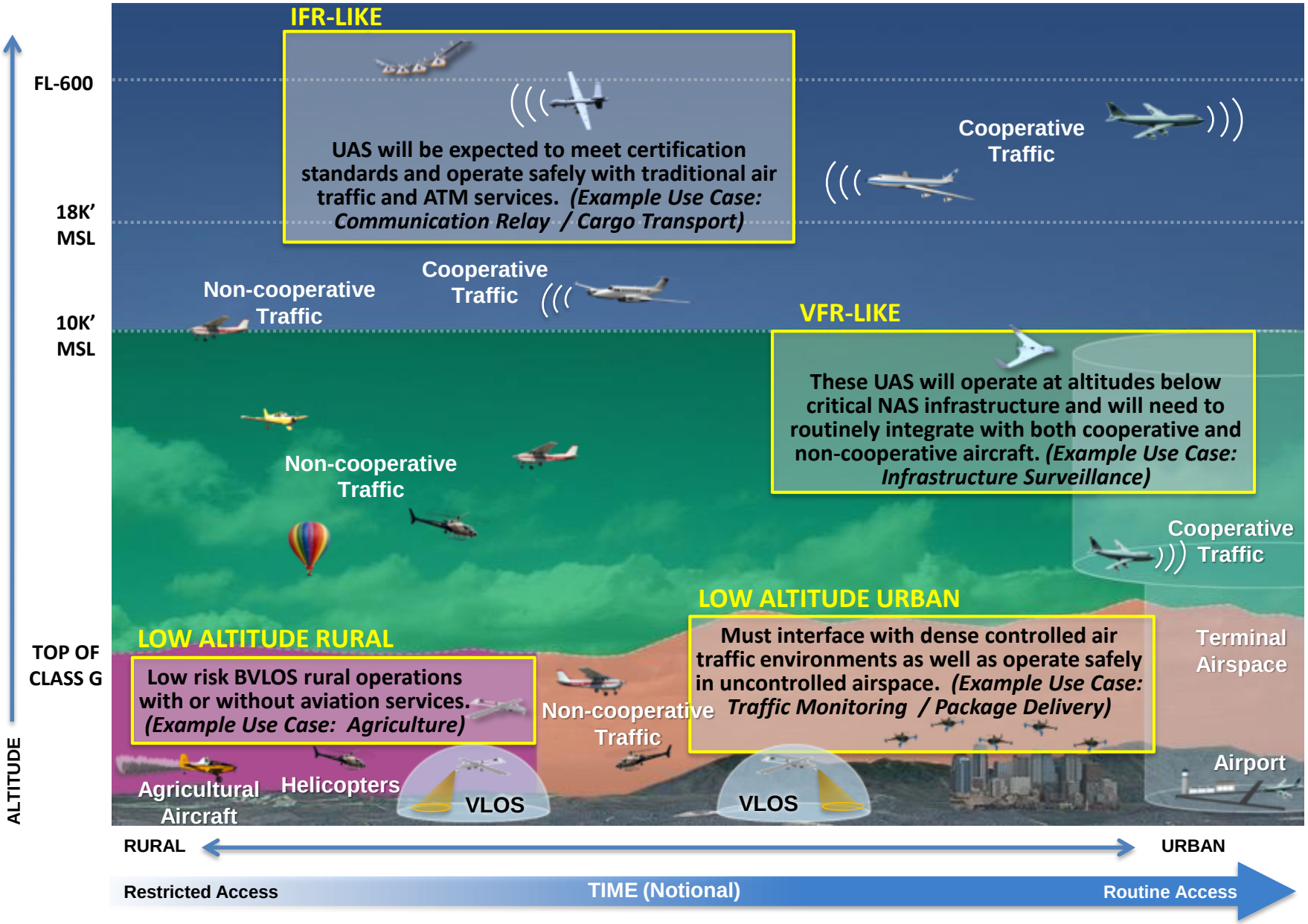
- High-risk, leap-frog ideas that support all six thrusts
- Critical cross-cutting tool development

NASA Cohesive UAS Integration Strategy

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

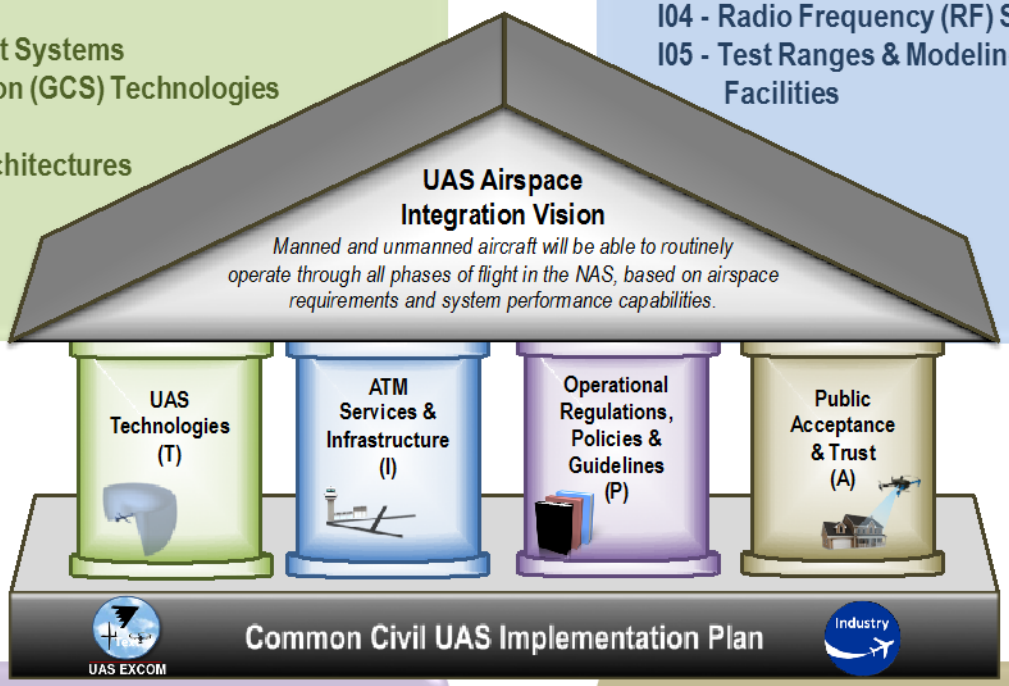
Future Civil UAS Airspace Environment



NASA 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

Overarching UAS Community Strategy

- The future civil UAS airspace environment is a complex picture with many unique considerations across the various operating environments
  - Operating environment attributes and community needs must be considered in order to provide routine access for a diverse set of UAS demand scenarios

- UAS airspace access pillars are a simple decomposition method to structure the broad needs of this diverse community
  - UAS Airspace Access Enablers provide another layer of detail to consider research elements necessary to achieve the routine access vision

- Assessing the intersections of the future civil UAS airspace environments and UAS airspace access pillars was the method chosen to develop the overarching UAS Community Strategy
  - Operating Environment Roadmaps were developed around these intersections and the community needs necessary to enable routine UAS access
  - Assessments were performed against “routine UAS access,” rather than an autonomous end state.

UAS-NAS Phase 2
Project Organization Structure

PROJECT OFFICE LEVEL

Project Leadership

Project Manager (PM)	Robert Sakahara, AFRC (A)
Deputy PM	Davis Hackenberg, AFRC (A)
Chief Engineer (CE)	William Johnson, LaRC

Project Support

Sr. Advisor	Chuck Johnsons, AFRC
Staff Engineer	Dan Roth, AFRC
Lead Resource Analyst	April Jungers, AFRC
Resource Analysts	Amber Gregory, AFRC
	Warcquel Frieson, ARC
	Julie Blackett, GRC
	Pat O'Neal, LaRC
Scheduler	Irma Ruiz, AFRC
Risk Manager/Outreach	Jamie Turner, AFRC
Change/Doc. Mgmt	Lexie Brown, AFRC
Admin Support	Sarah Strahan, AFRC

Systems Integration and Operationalization

Deputy CE / Lead Systems Engineer	TBD, AFRC
Demonstration Deputy/COR	TBD, LaRC
SIO Flight Ops Lead	TBD, AFRC
DAA TIM	TBD, ARC
C2 TIM	TBD, GRC

SUBPROJECT LEVEL

Command and Control (C2)

Subproject Manager

Mike Jarrell, GRC

Subproject Technical Lead

Jim Griner, GRC

Detect and Avoid (DAA)

Subproject Manager

Jay Shively, ARC

Subproject Technical Lead

Gilbert Wu ARC (A), Confesor Santiago, ARC; Lisa Fern; ARC; Tod Lewis, LaRC

Integrated Test and Evaluation (IT&E)

Subproject Manager

Mauricio Rivas, AFRC (A) /Jim Murphy, ARC

Subproject Technical Lead

Ty Hoang, ARC (A) ; Sam Kim, AFRC

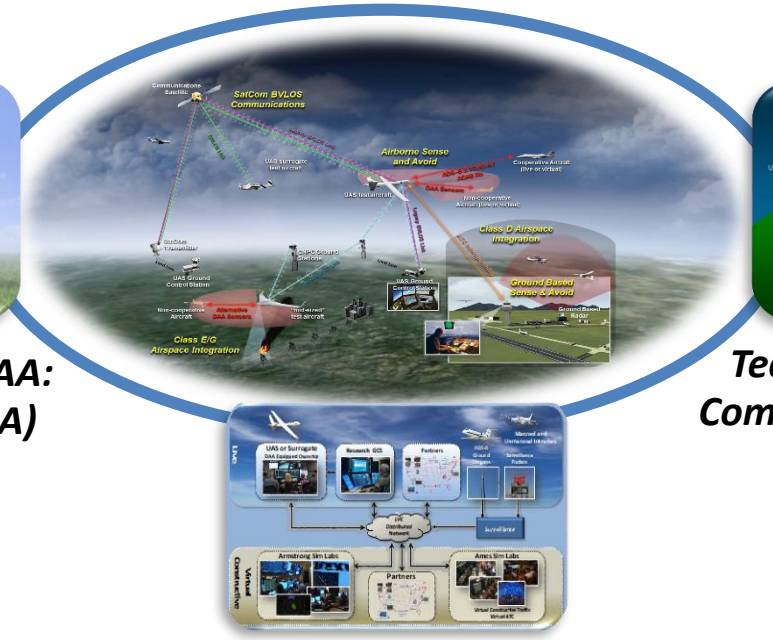
Notional

UAS Integration in the NAS Project

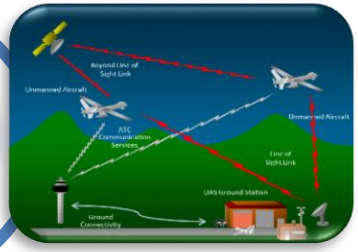
Project Goal

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)



SIO: System Integration and Operationalization for UAS (SIO)



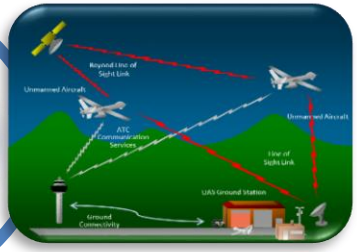
Technical Challenge-C2: Command and Control (C2)

DAA: Detect and Avoid

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)



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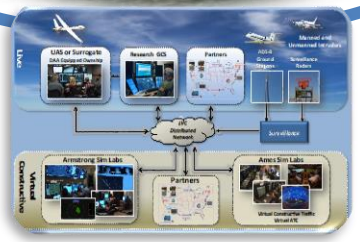
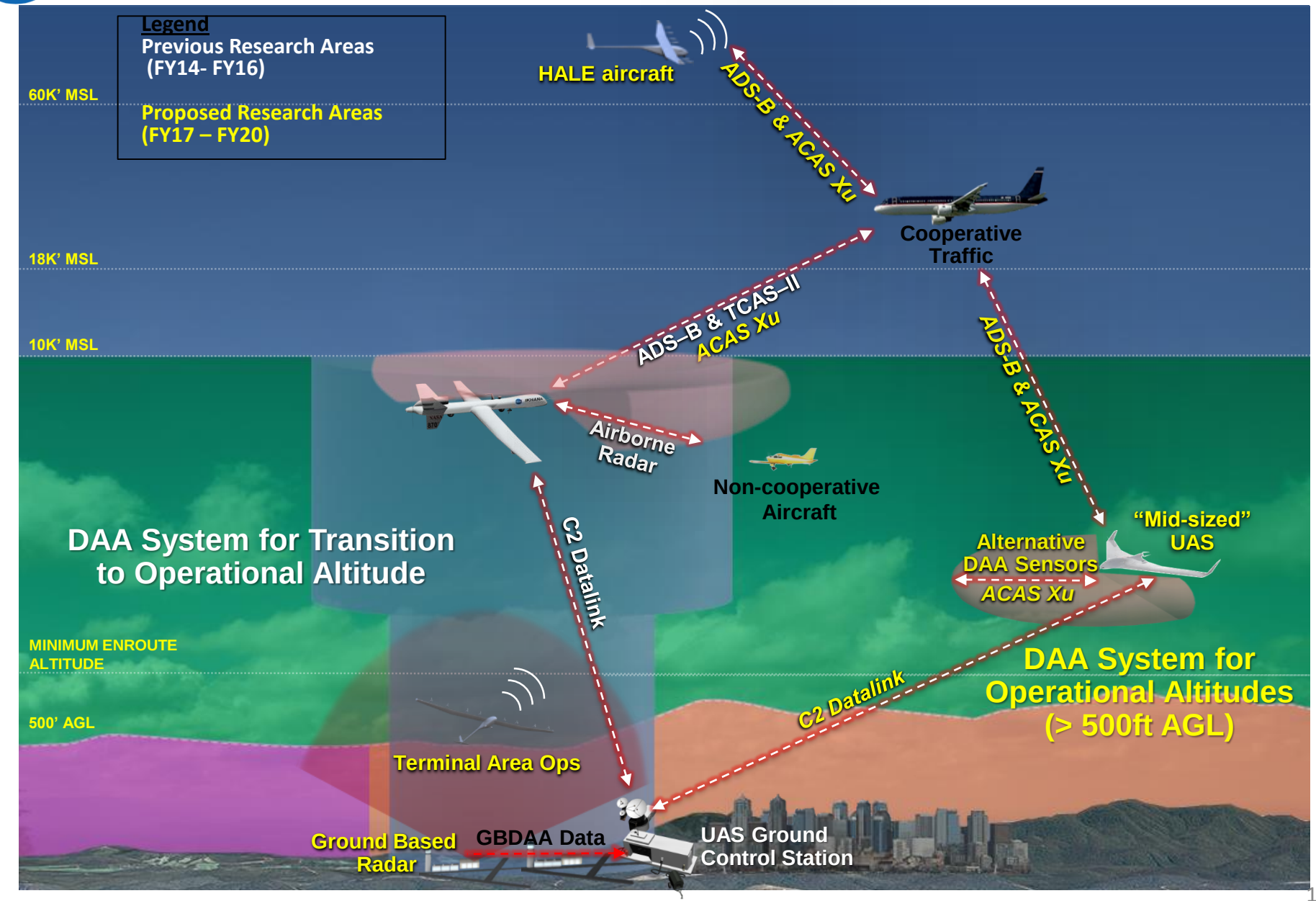


SIO: System Integration and Operationalization for UAS (SIO)

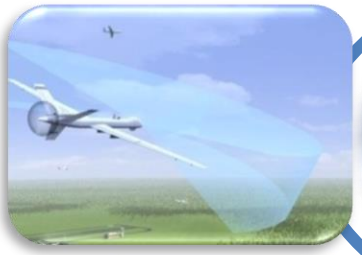
Detect and Avoid (DAA) Operational Environments



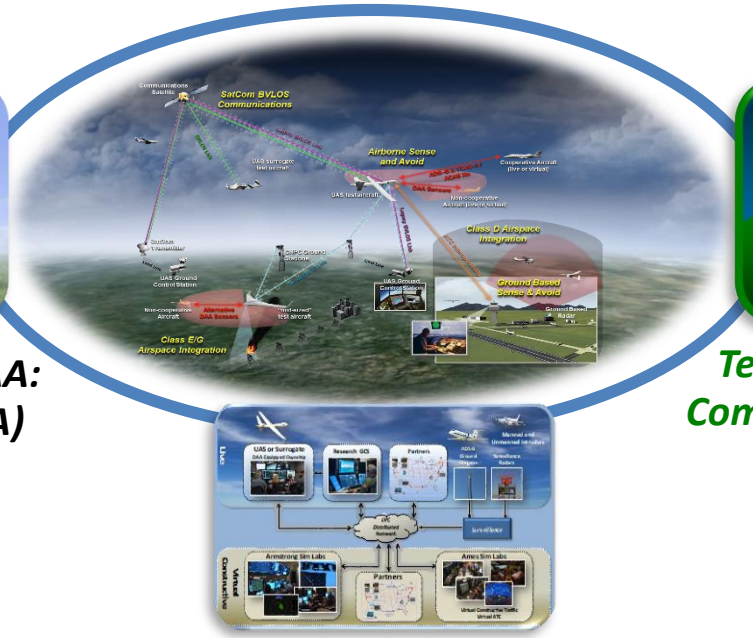
C2: Command and Control

TC-C2

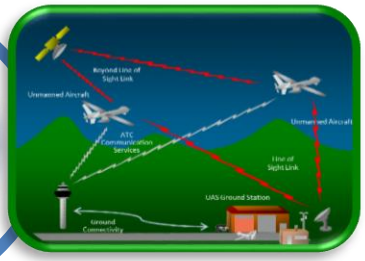
Develop Command and Control (C2) operational concepts and technologies in support of standards to enable the broad range of UAS that have Communication, Navigation, and Surveillance (CNS) capabilities consistent with IFR operations and are required to leverage allocated protected spectrum



Technical Challenge-DAA: Detect and Avoid (DAA)

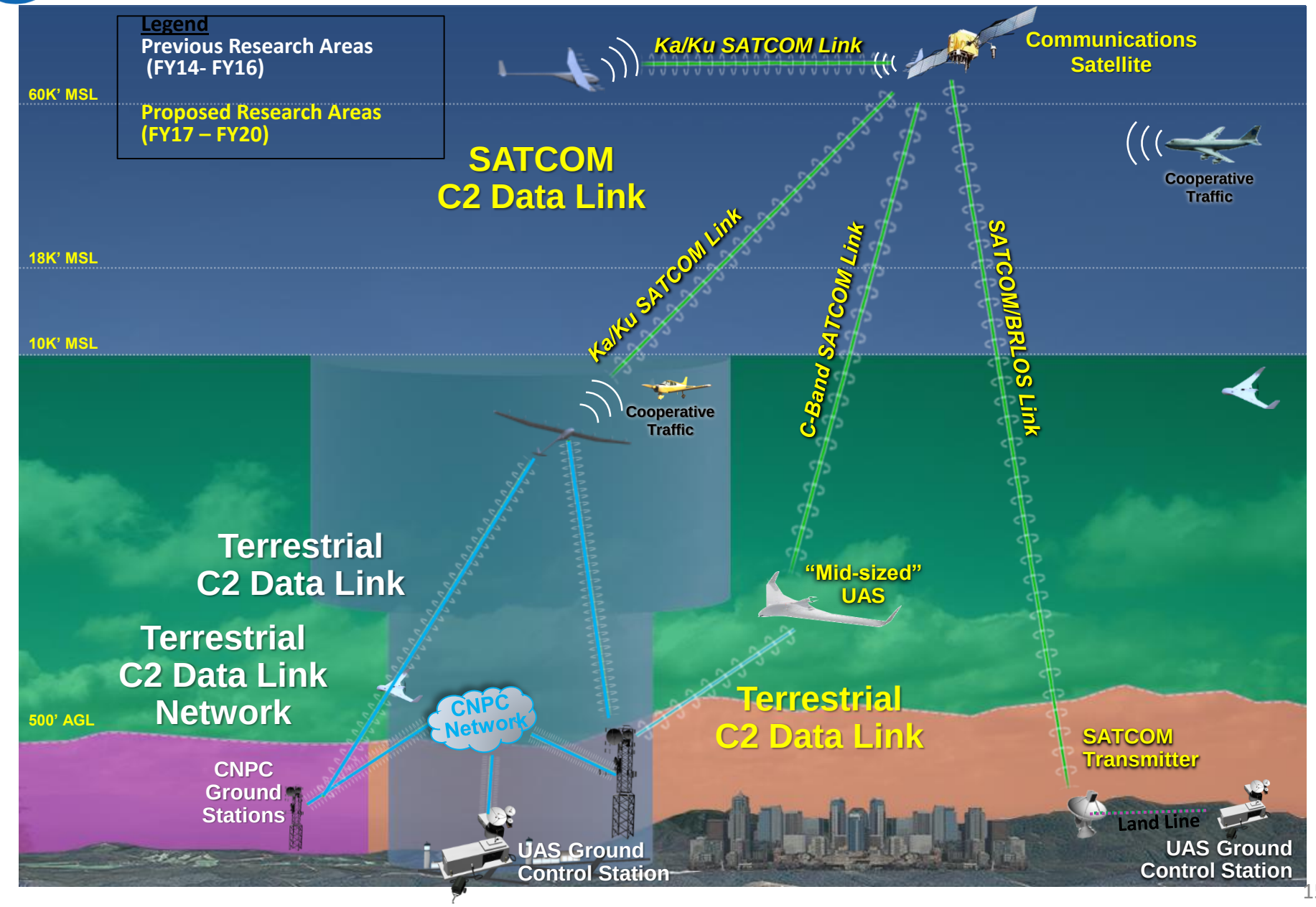


SIO: System Integration and Operationalization for UAS (SIO)



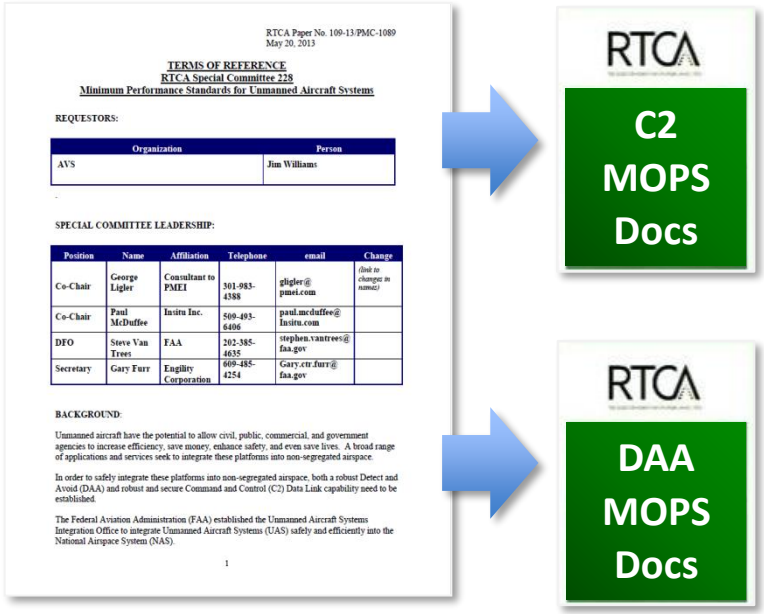
Technical Challenge-C2: Command and Control (C2)

Command and Control (C2) Operational Environments

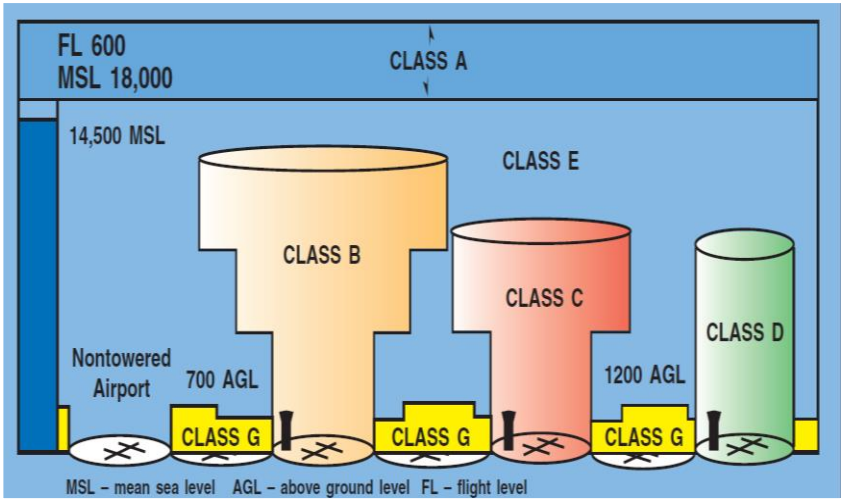


RTCA SC-228 Phase 2 MOPS Terms of Reference

- RTCA SC-228 ToR defined a path forward to develop MOPS
  - Phase 2 MOPS included in the original ToR, but had several TBDs
  - ToR development team defined Phase 2 DAA and C2 scope broad enough to fully enable the operating environments for relevant UAS (e.g., instrument flight rules [IFR] and visual flight rules [VFR]-like)
- Phase 2 MOPS ToR scope
  - C2: Use of satellite communication (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)



RTCA SC-228 ToR

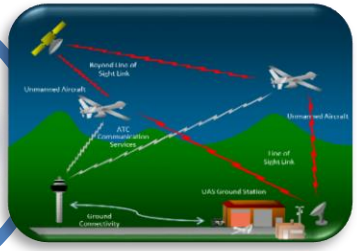


SIO: Systems Integration and Operationalization

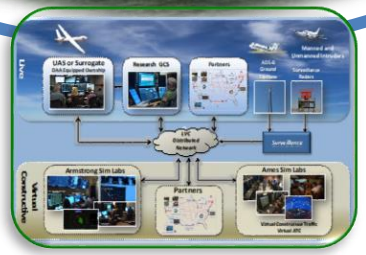
SIO

Integrate state of the art DAA and C2 technologies to ensure sufficient aircraft level functional and operational requirements, and perform demonstrations in the NAS to inform the FAA on the creation of policies for operating UAS that have Communication, Navigation, and Surveillance capabilities consistent with IFR operations

Technical Challenge-DAA: Detect and Avoid (DAA)



Technical Challenge-C2: Command and Control (C2)



SIO: System Integration and Operationalization for UAS (SIO)

Summary

- NASA has begun developing a cohesive strategy for full UAS Integration
- The strategy is based on the demand for four OEs – Low-Altitude Rural, IFR-Like, Low-Altitude Urban, and VFR-Like
- NASA has identified UAS Airspace Integration Pillars and Enablers to achieve the strategy
- The UAS-NAS Project has developed significant capabilities and infrastructure for the research of DAA, non-cooperative surveillance sensor, and C2 technologies
- The UAS-NAS Project is dedicated to driving the community toward robust and innovative solutions that apply to DAA, C2, and other necessary technologies