NASA UAS Integration Efforts

NASA ARMD Cohesive UAS Integration Strategy

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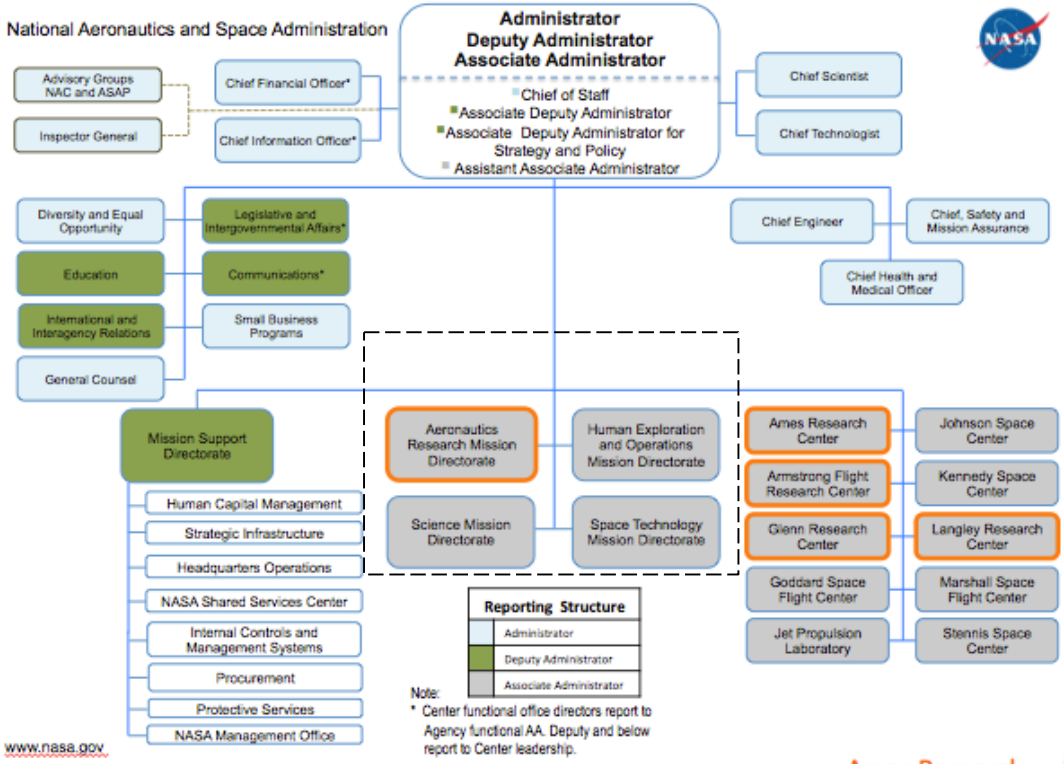
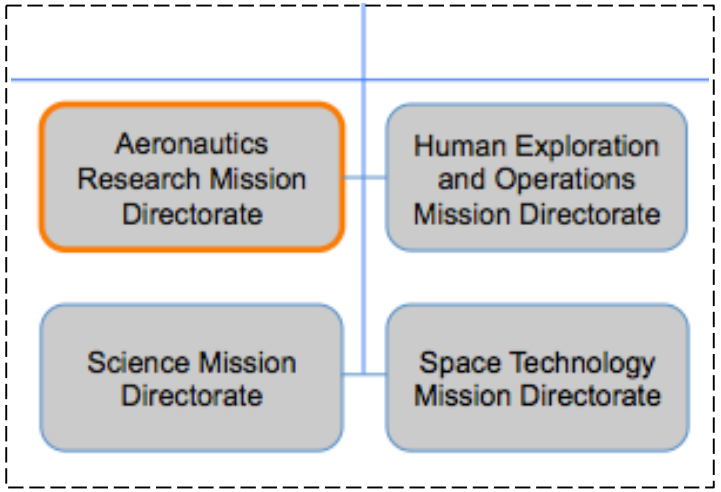
Discussion Topics

- NASA Organization
- NASA UAS Integration Strategy
  - Scope / Outcome
  - Current Landscape and Future Vision
  - UAS Demand and Key Challenges
  - Overarching UAS Community Strategy
- UAS Integration in the NAS Project Overview
- UTM Project Overview

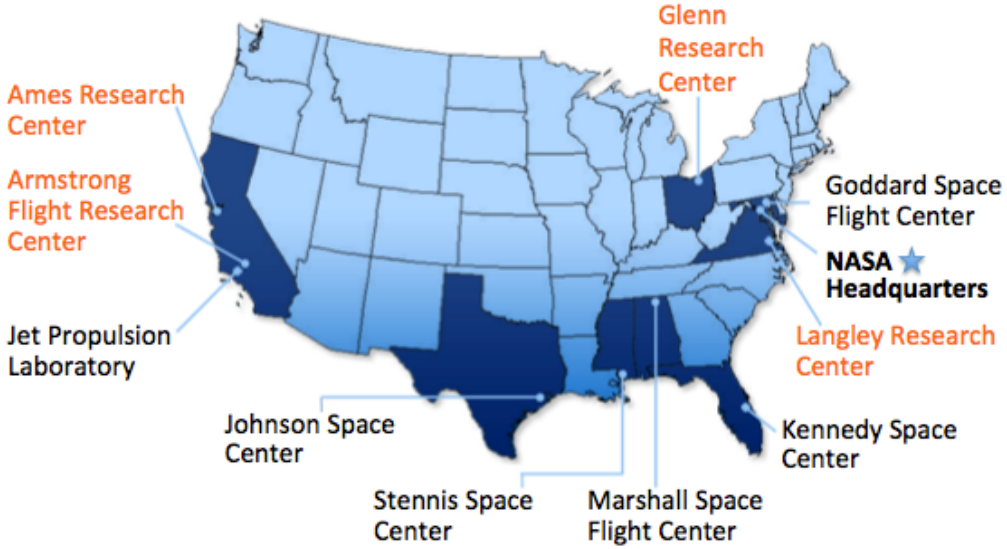
NASA Organizational Structure



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**

IASP Projects

- 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**

Scope / Outcome

Scope: Focus on what is needed to enable full integration of UAS for civil / commercial operations within the NAS by ~2025

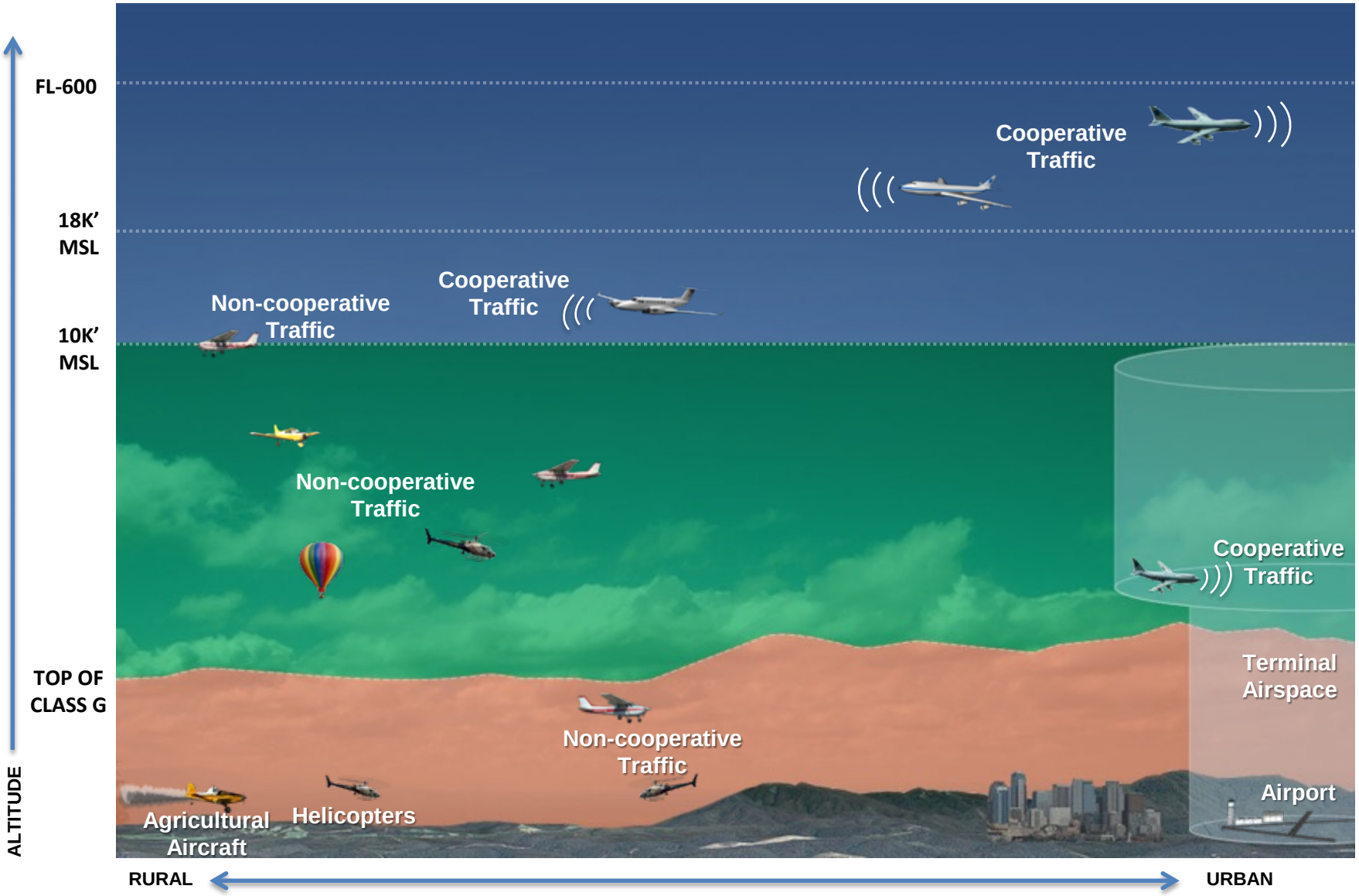
- Top level strategy that assesses stakeholder needs, FAA UAS Integration Strategy, Concept of Operations, Implementation Plans, etc.
- Leverage information from Government-wide R&D Analysis (ExCom) and FAA R&D Roadmap

Outcome: A Vision, Strategic Plan and Communication Strategy

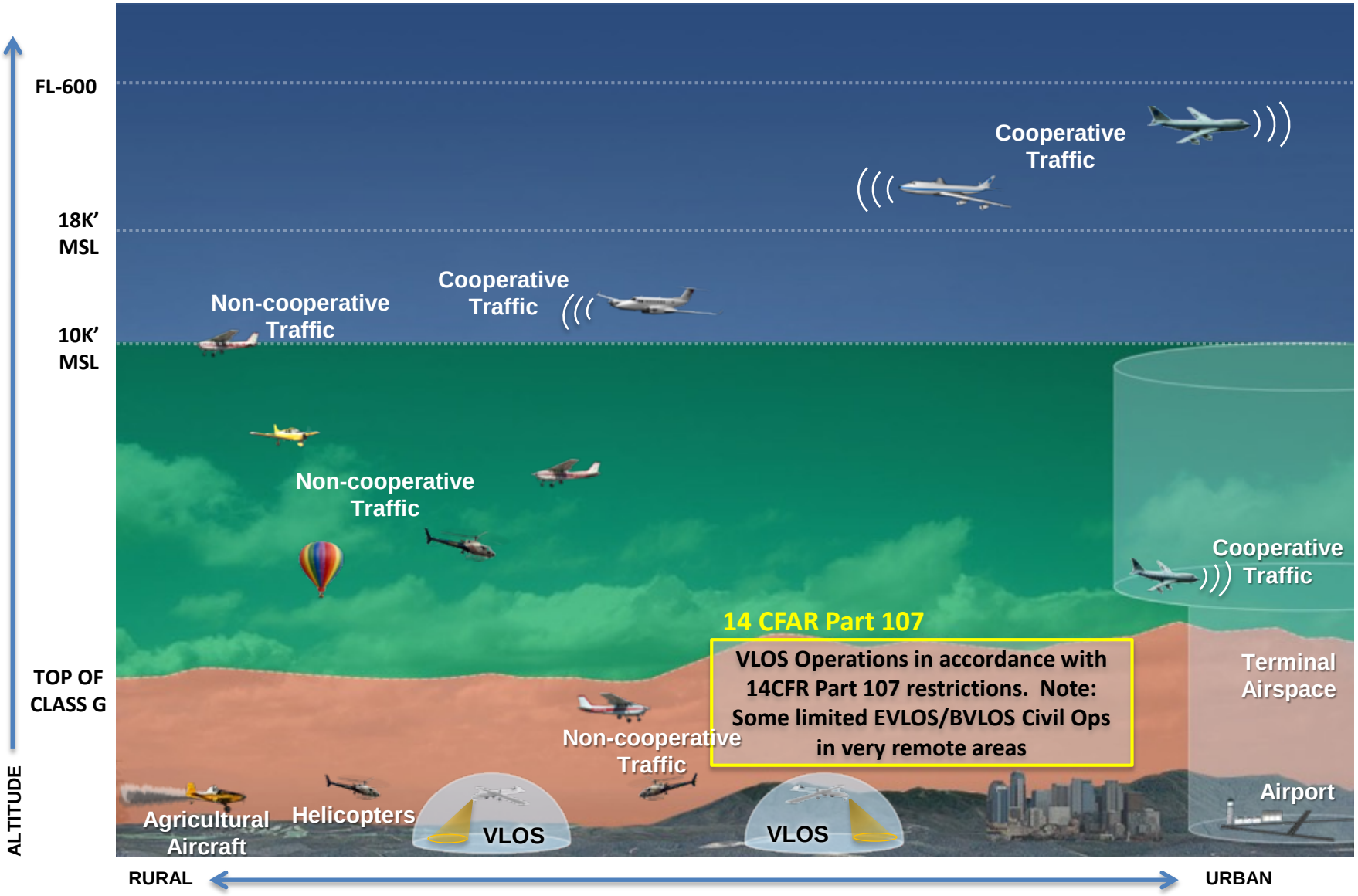
- Routine UAS access within the NAS
- Concept for transitioning UAS access advancements towards the integration of highly autonomous systems and on-demand mobility

Enabling Full Integration of UAS for civil / commercial operations within the NAS by ~2025

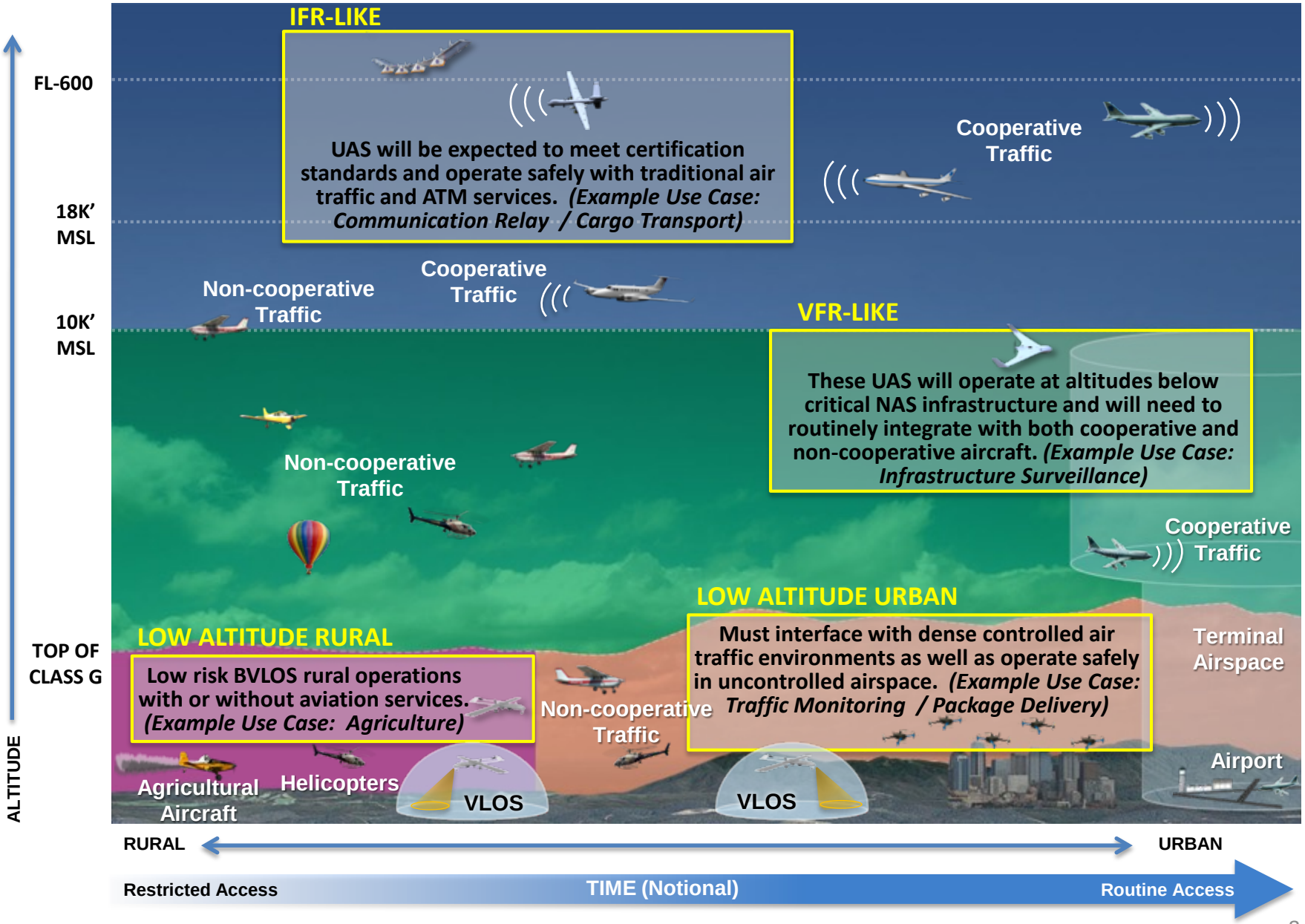
Civil Manned Airspace Environment



Current Civil UAS Airspace Environment

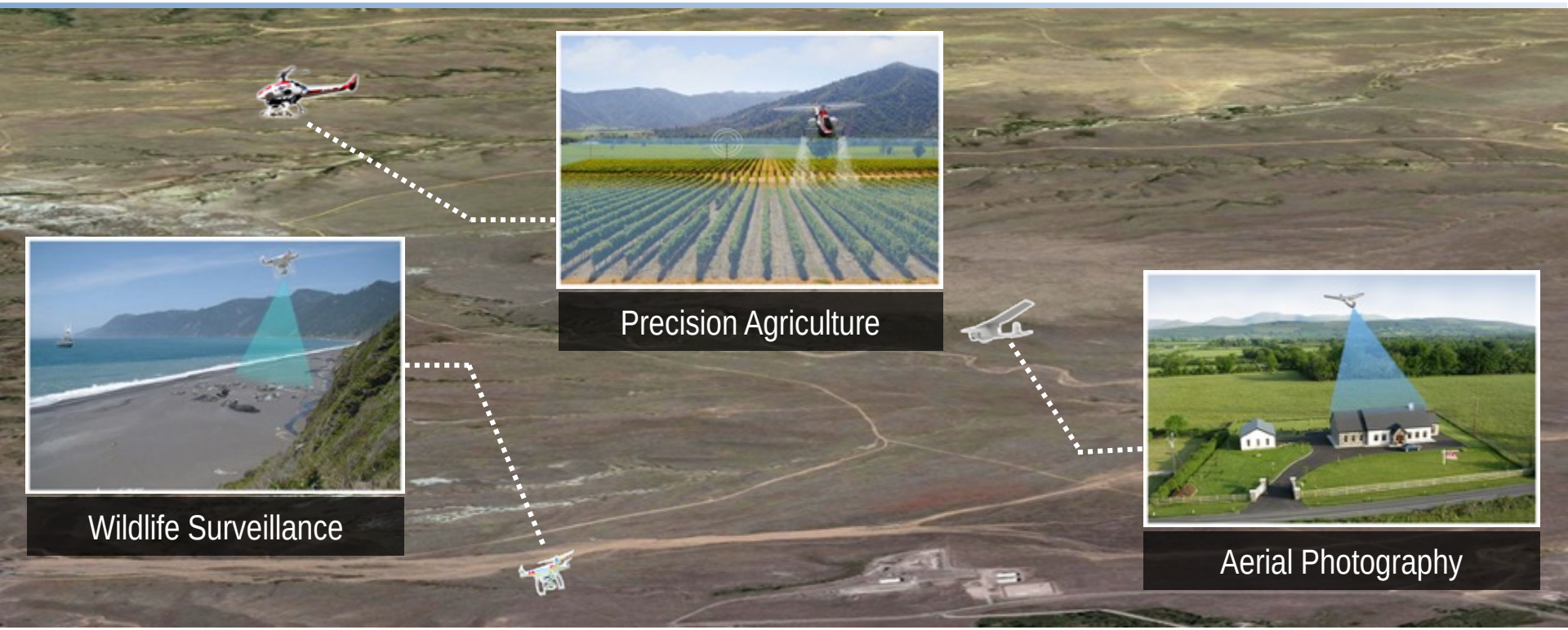


Future Civil UAS Airspace Environment



UAS Demand

Low Altitude Rural Operations



Demand Drivers:

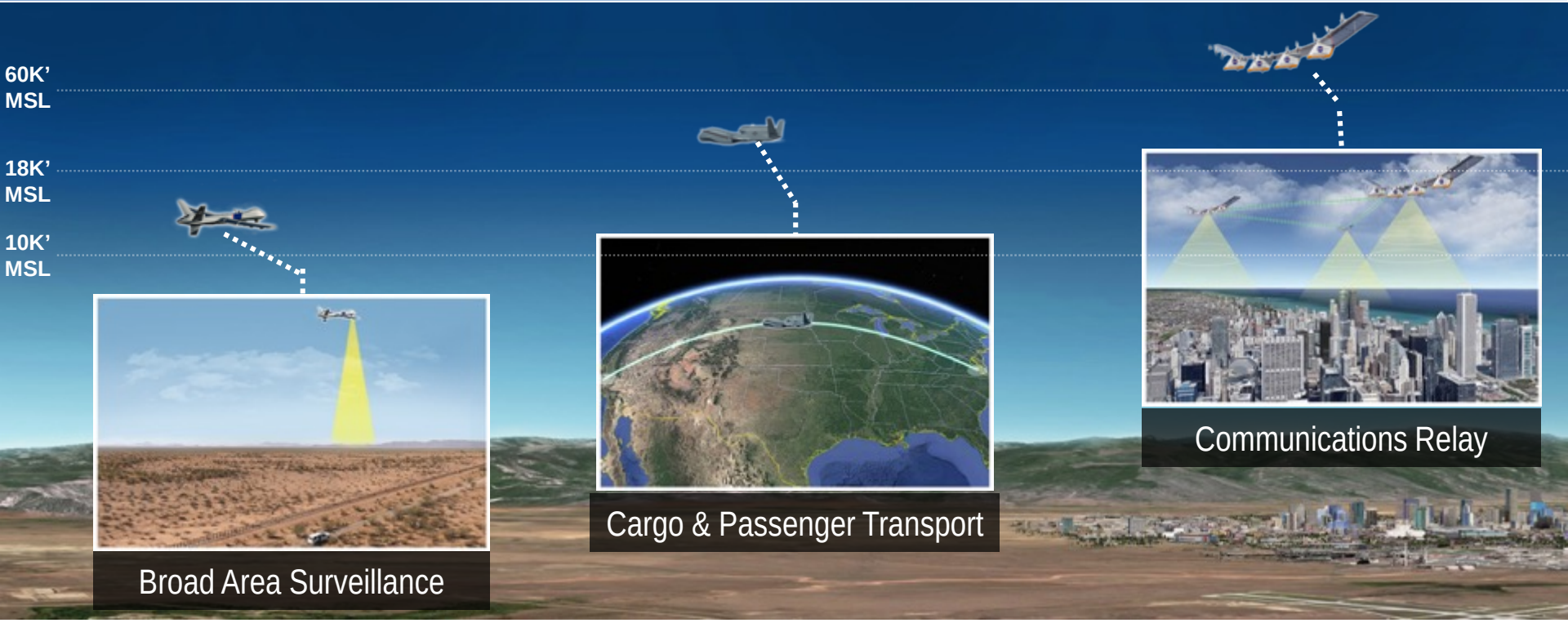
- There is a significant demand for visual line of sight flights to conduct precision agriculture, photography, and surveillance missions. This has been evident through the FAA's incremental approval process from COAs to Section 333 to 14CFR Part 107.
- The demand for these missions to expand the approval envelope to include operations beyond visual line of sight has been increasing.

Representative Markets / Companies:

- Precision Agriculture (PrecisionHawk, Elbit)
- Wildlife Surveillance (NWF, Fish & Game)
- Aerial Photography (GoPro, Roofing, Real Estate)
- Remote Surveillance (Pipelines, Railroads, Power lines, Mining)
- Vertical Infrastructure (Oil /Gas refineries, Bridges)

UAS Demand

IFR-Like Operations



Demand Drivers:

- Beyond DoD, many organizations (e.g. DOI, NOAA, NASA, FedEx, DHL) have expressed an interest in using IFR-Like operations for surveillance, science, and cargo delivery missions.
- Industry is also very interested in using HALE UAS as a more reliable option to satellite communications for remote parts of the globe.

Representative Markets / Companies:

- Communications Relay (Facebook, Google, AeroVironment)
- Cargo & Passenger Transport (FedEx, DHL, Medical Supply, Thin Haul)
- Broad Area Surveillance (DOI, DHS)
- Weather Monitoring (NOAA, NASA)
- Emergency Response & Assessment (Land Management, FEMA, Insurance)

UAS Demand

Low Altitude Urban Operations

Demand Drivers:

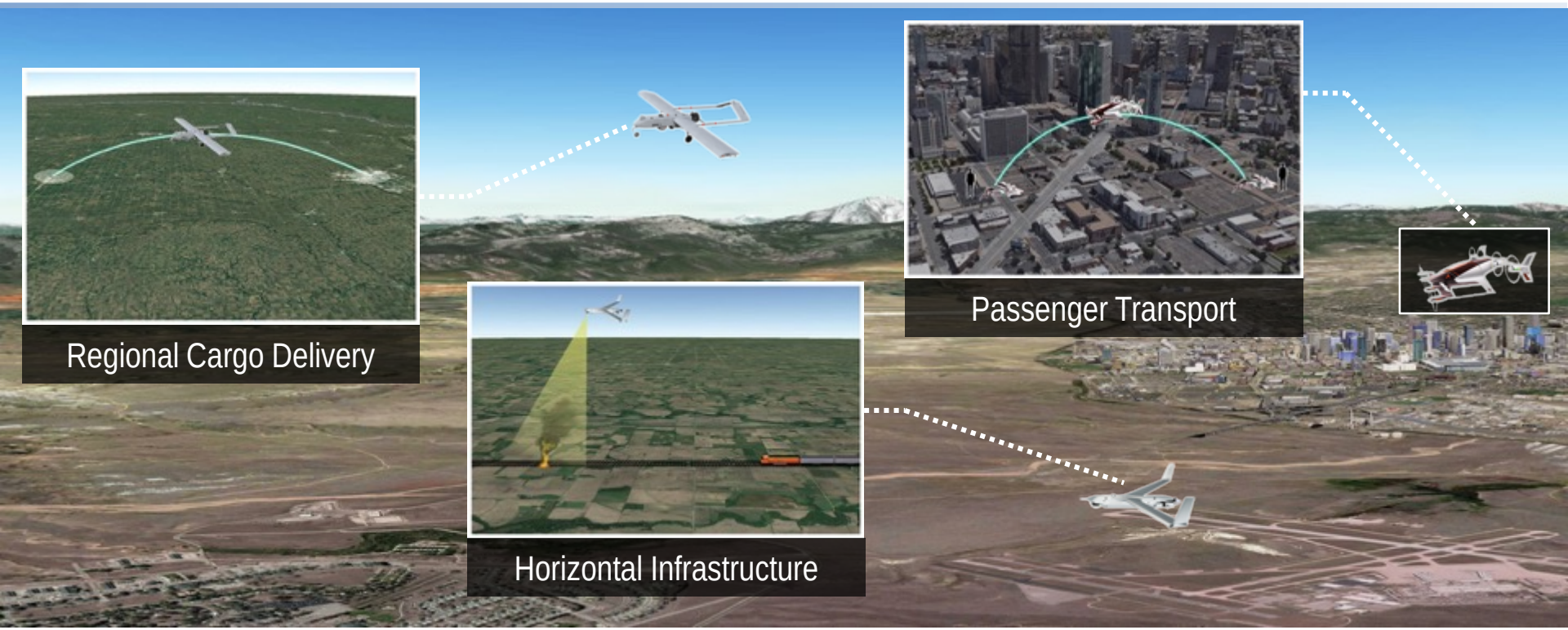
- The most prominent example of UAS demand has been in the package delivery trade space. Amazon, Google, Walmart, and others have plans to use the low altitude volume of airspace for on-demand, door-to-door delivery of goods.
- Several public service applications exist such as news gathering, traffic monitoring and photogrammetry.

Representative Markets / Companies:

- Local Package Delivery (Amazon, Walmart)
- Traffic Monitoring (Local News Stations, Waze)
- Search and Rescue (Law Enforcement, First Responders)
- Infrastructure Surveillance & Protection (Airports, Stadiums, Prisons, DHS CBP)
- Construction Site Monitoring (Land developers, Tax Assessment)

UAS Demand

VFR-Like Operations



Demand Drivers:

- Demand for VFR-Like UAS will largely depend on their ability to establish a business case that is competitive with many existing manned aircraft operations.
- Beyond Visual Line of Site (BVLOS) operations for horizontal infrastructure inspection, regional package delivery and transportation of people are current markets for this class of vehicle.

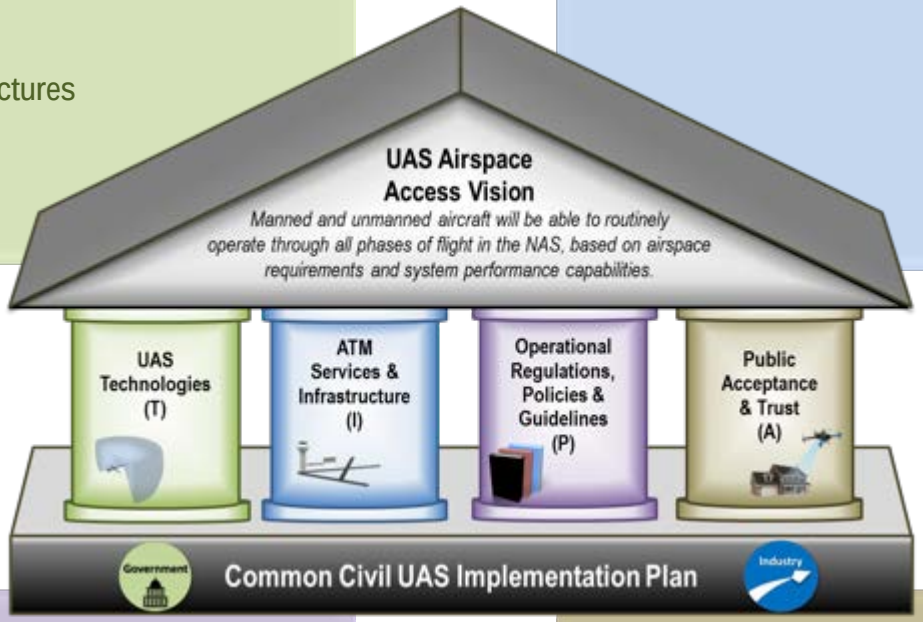
Representative Markets / Companies:

- Horizontal Infrastructure (Railways, Exxon Mobil, Duke Energy)
- Regional Cargo Delivery (Amazon, Walmart)
- Personal Transportation (Uber, AIRBUS, Ehang)
- Humanitarian Studies (Red Cross, Health Dept.)
- Wildfire Monitoring (Fire Rescue, State/Local Authorities)

UAS Airspace Access Enablers

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

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



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

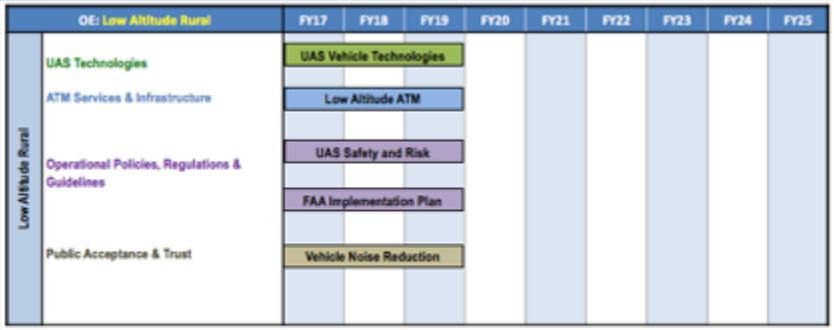
Public Acceptance & Trust:
A01 - Cybersecurity Criteria & Methods of Compliance
A02 - Legal & Privacy Rules / Guidelines
A03 – Noise Reductions
A04 - Physical Security Criteria & Methods of Compliance
A05 - Public Safety Confidence

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.**

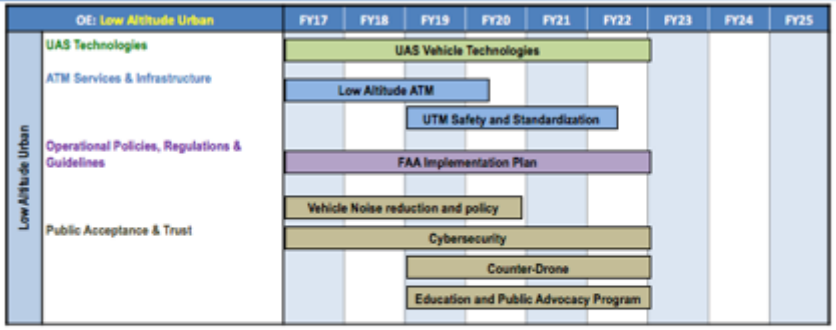
Recommended Operating Environment Roadmaps

Low Altitude Rural Path Forward



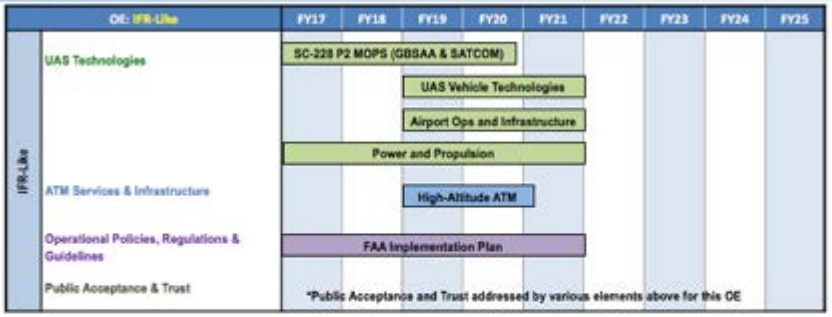
Partner	Recommended Responsibility
Industry	Industry needs to develop necessary technologies for robust geofencing, secure communications, hazard avoidance, and etc.
FAA	The FAA needs to define the methodology for risk-based safety standards which allow for trade-offs between population density and necessary vehicle performance.
NASA	NASA needs to develop integrated test results which demonstrates that the industry-developed technologies are sufficient to satisfy the risk-based safety standards.

Low Altitude Urban Path Forward



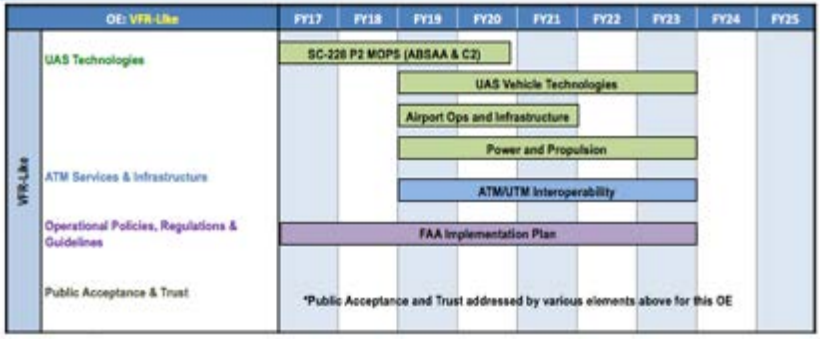
Partner	Recommended Responsibility
Industry	Industry needs to contribute vehicle technologies for addressing the unique challenges of operating in the first/last 50 feet. Theses include detecting and avoiding persons and property on the ground, and operating in and around varying weather conditions. Industry also needs to engage in the certification process for these technologies.
FAA	The FAA needs to define the safety requirements for a UAS Traffic Management System and implement necessary policies and regulations for vehicles that will operate in this operational environment by working closely with industry throughout the certification process.
NASA	NASA needs to foster development of a UAS Traffic Management System, in collaboration with both industry and the FAA, which allows for safe operations that are equitable across users within the low altitude volume of airspace. This includes developing concepts, modeling, simulation, and robust flight-testing.

IFR-Like Path Forward



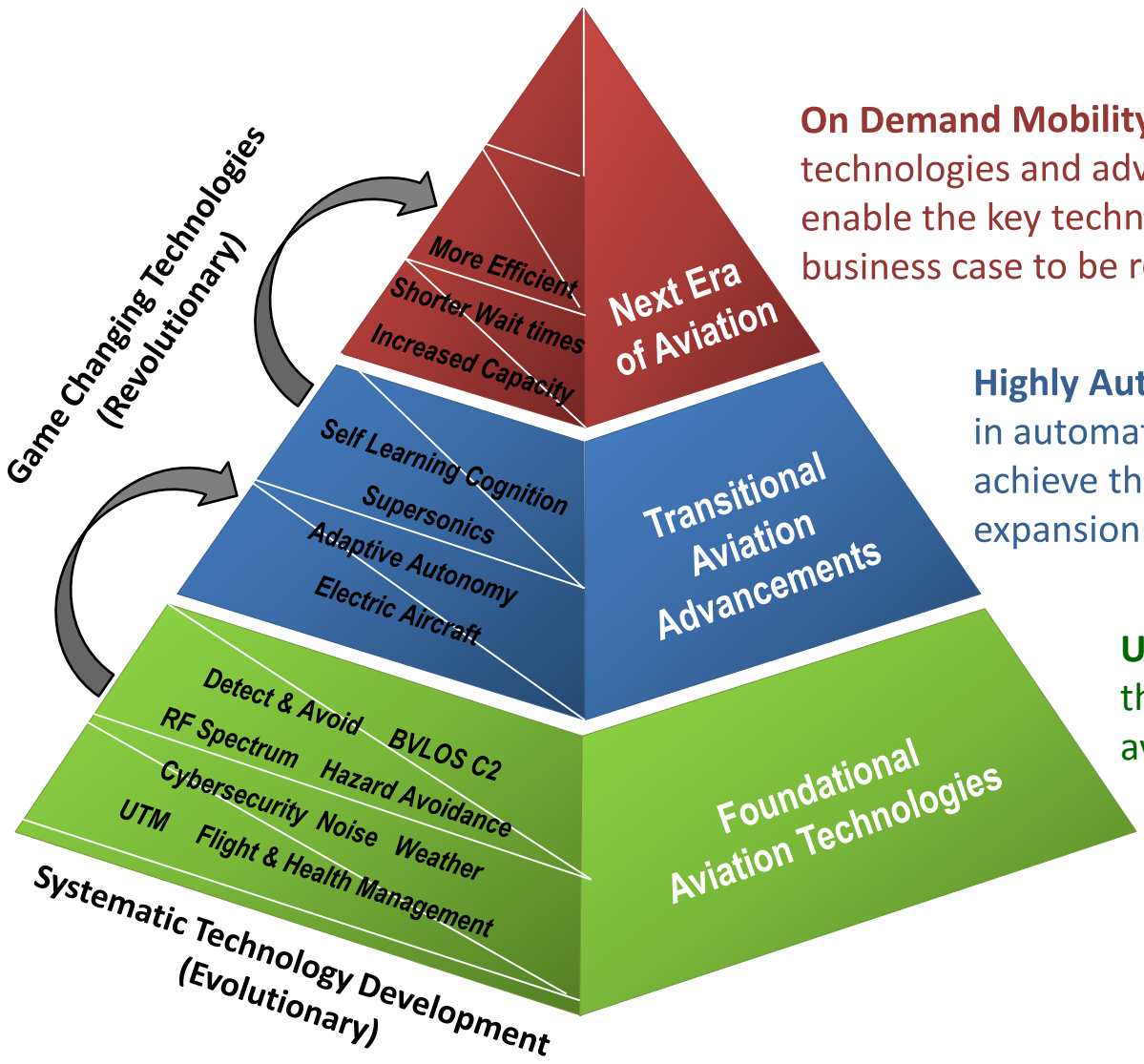
Partner	Recommended Responsibility
Industry	Industry needs to contribute technologies for DAA, C2, and flight/health management, etc. Industry also needs to engage in the certification process for these technologies.
FAA	The FAA needs to develop ATM policies and procedures for this operational environment, including Upper Class E Airspace. The FAA also needs to implement necessary policies and regulations for vehicles that will operate in this operational environment by working closely with industry throughout the certification process.
NASA	NASA needs to team with industry on high-risk technology development in areas of DAA, C2, and flight/health management, etc. NASA also needs to develop integrated test results in a relevant environment to inform both industry and the FAA on the development of safety standards and interoperability practices.

VFR-Like Path Forward



Partner	Recommended Responsibility
Industry	Industry needs to contribute technologies for DAA solutions, and the expansion of terrestrial communications, etc. Industry also needs to engage in the certification process for these technologies.
FAA	The FAA needs to develop ATM policies and procedures for this operational environment. The FAA also needs to implement necessary policies and regulations for vehicles that will operate in this operational environment by working closely with industry throughout the certification process.
NASA	NASA needs to team with industry on high-risk technology development in areas of alternative ABSAA, and expanded terrestrial communications. NASA also needs to develop integrated test results in a relevant environment to inform both industry and the FAA on the development of safety standards and interoperability practices.

Achieving the Next Era of Aviation



On Demand Mobility - ODM will leverage UAS technologies and advancements in automation to enable the key technologies needed for the ODM business case to be realized

Highly Autonomous Systems – advancements in automation will open the door for UAS to achieve their full potential and market expansion

UAS Integration - UAS Integration is the foundation for the revolution of the aviation industry

NASA Projects Overview

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

UAS Traffic Management (UTM) Project

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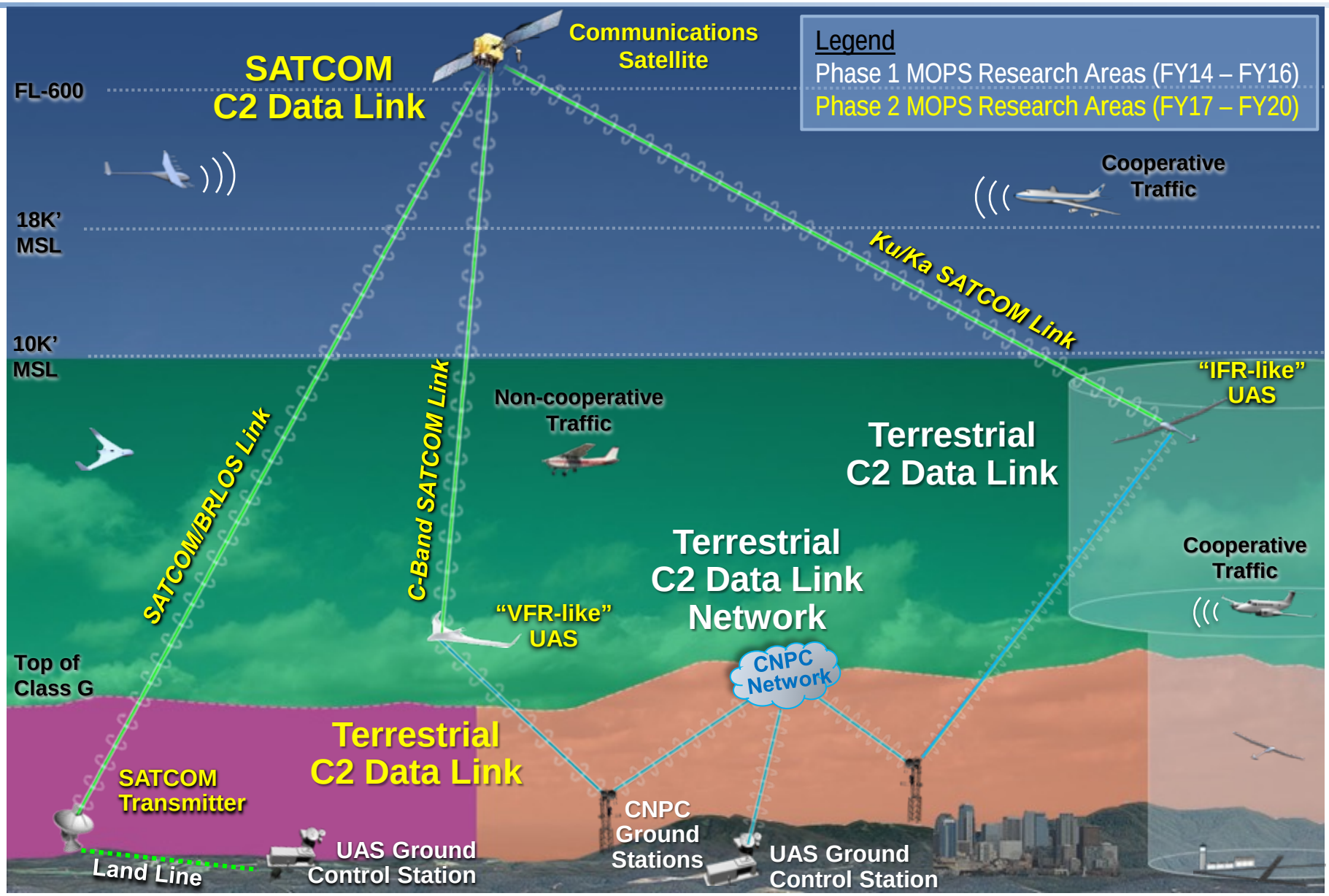
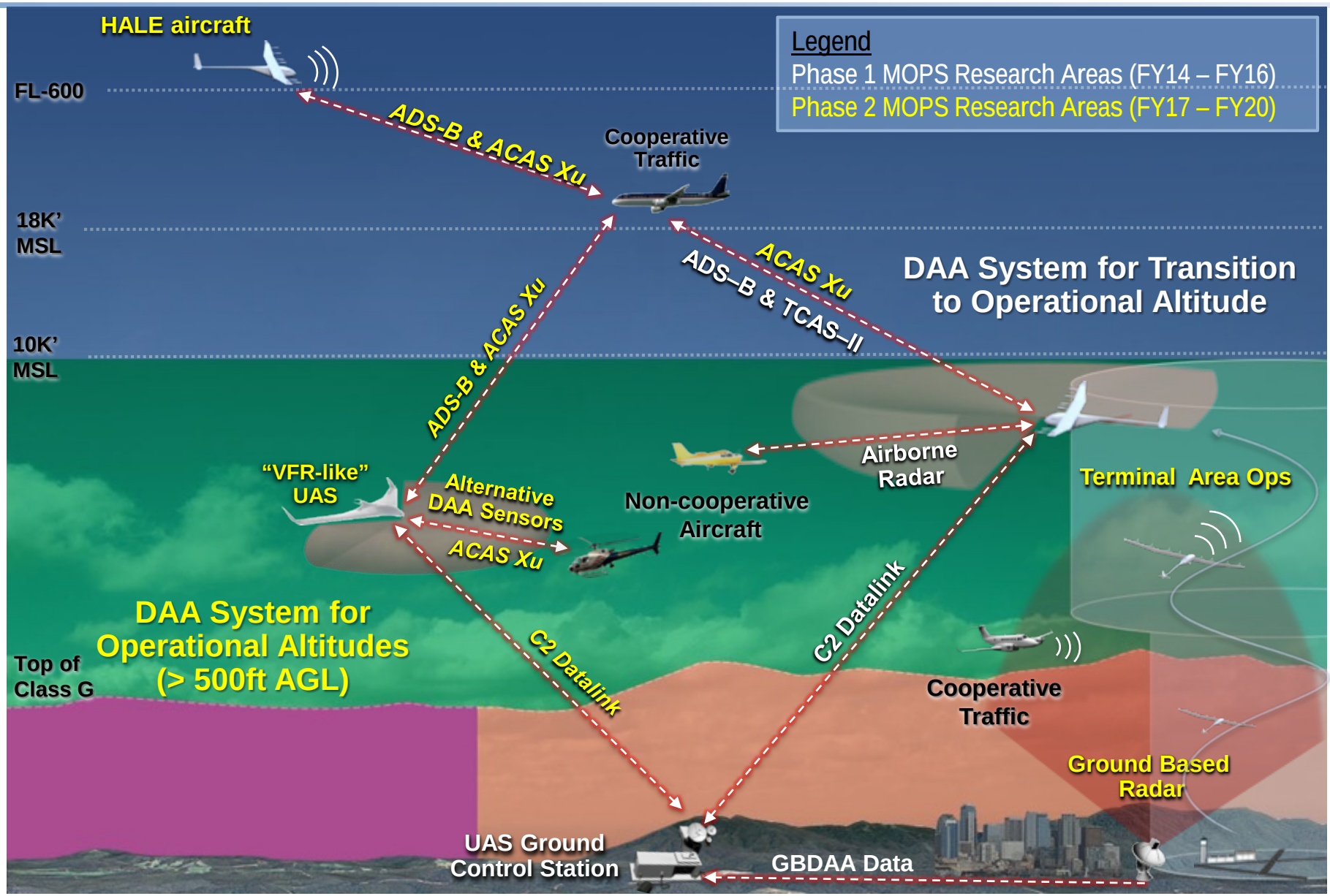
UAS-NAS Command and Control Operating Environments (OE)

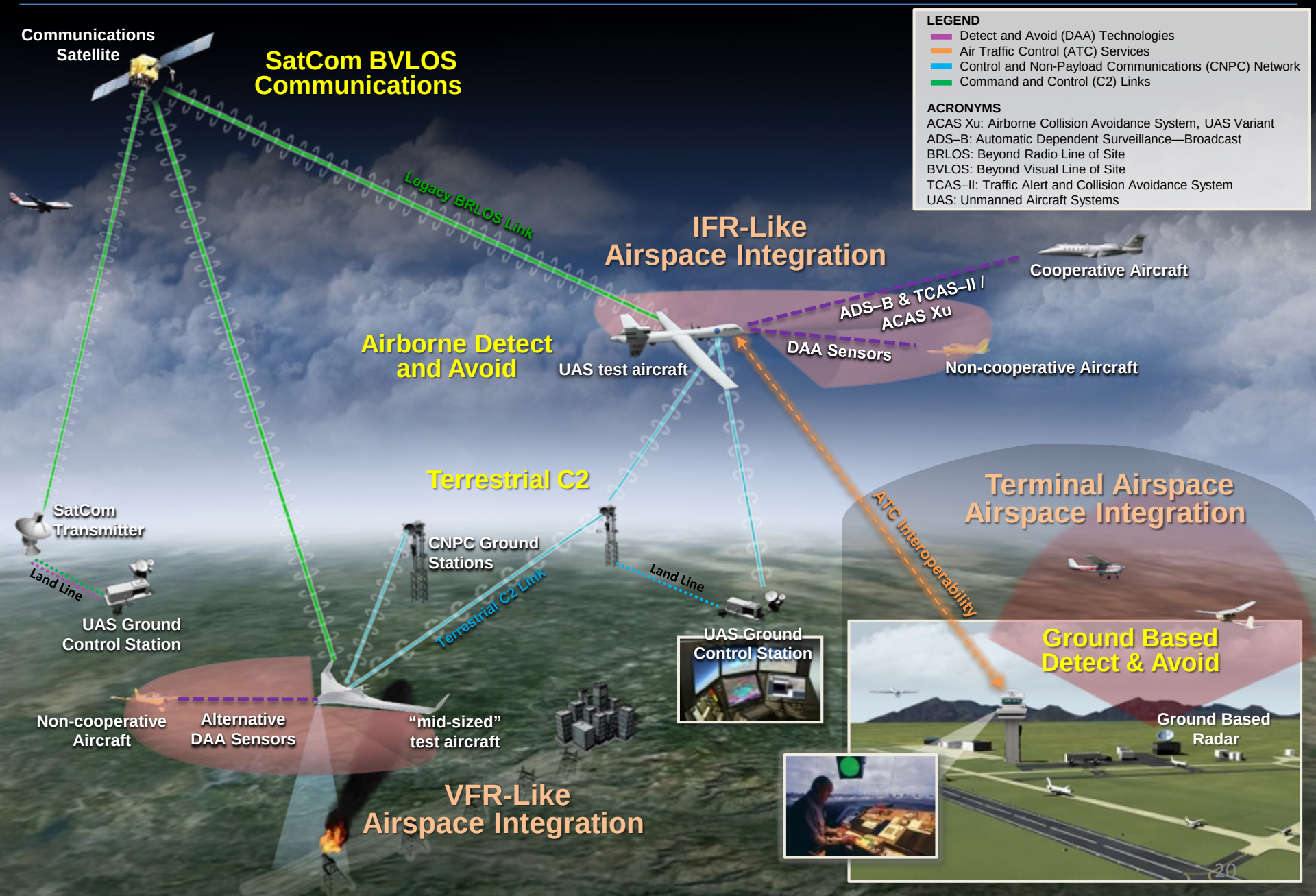


UAS-NAS Detect and Avoid (DAA) Operating Environments (OE)



UAS-NAS Project - DAA and C2 Operational View Representation

National Aeronautics and Space Administration



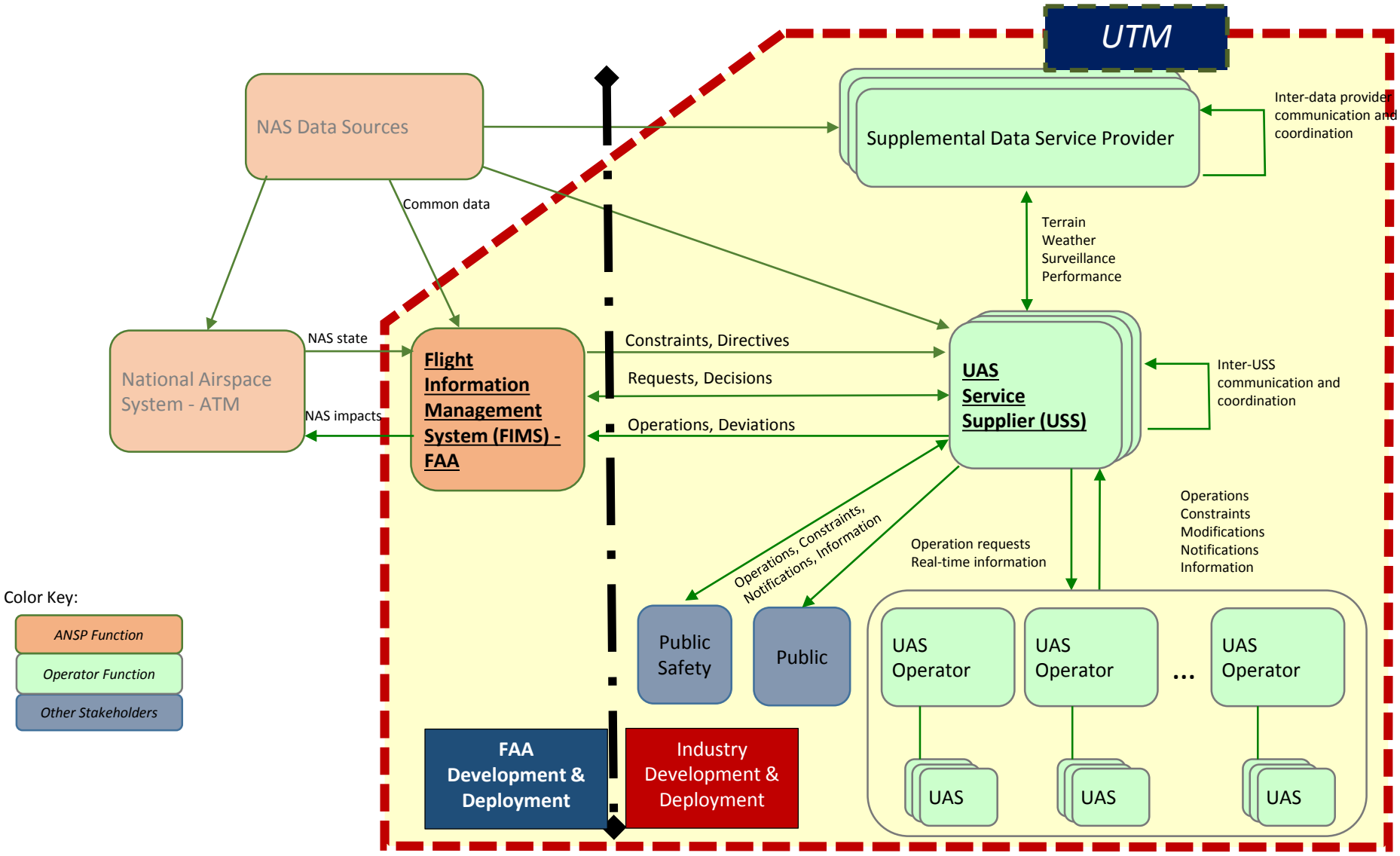
UTM Development

Goal:

Safely enabling large scale visual and beyond visual line of sight operations in the low altitude airspace

Risk-based approach along four distinct Technical Capability Levels (TCL)

UTM Architecture



UTM Technical Capability Levels (TCLs)

Capability 1: Demonstrated How To Enable Multiple Operations Under Constraints

- Notification of area of operation
- Over unpopulated land or water
- Minimal general aviation traffic in area
- Contingencies handled by UAS pilot

Product: Overall concept of operations, architecture, and roles

Capability 2: Demonstrated How to Enable Expanded Multiple Operations

- Beyond visual line-of-sight
- Tracking and low density operations
- Sparsely populated areas
- Procedures and “rules-of-the road”
- Longer range applications

Product: Requirements for multiple BVLOS operations including off-nominal dynamic changes

Capability 3: Focuses on how to Enable Multiple Heterogeneous Operations

- Beyond visual line of sight/expanded
- Over moderately populated land
- Some interaction with manned aircraft
- Tracking, V2V, V2UTM and internet connected

Product: Requirements for heterogeneous operations

Capability 4: Focuses on Enabling Multiple Heterogeneous High Density Urban Operations

- Beyond visual line of sight
- Urban environments, higher density
- Autonomous V2V, internet connected
- Large-scale contingencies mitigation
- Urban use cases

Product: Requirements to manage contingencies in high density, heterogeneous, and constrained operations

Risk-based approach: depends on application and geography

Questions?

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