Evolution of the NAS

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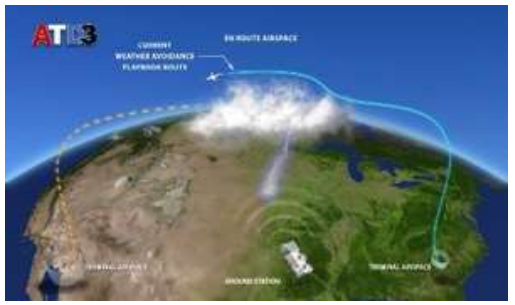
Success Stories: ARMD Research Technology Transfers to FAA

- **Terminal Sequencing and Spacing (TSAS) and Flight Deck Interval Management (FIM) (FY 2011-2017, $102M)**
  - Forecast $500 million national fuel savings
  - FAA national deployment in Time Based Flow Management (TBFM) starting with Denver in 2020
- **Integrated Arrival, Departure, Surface Operations (FY 2015-2021, $128M)**
  - 462,211 gal of fuel saved and 9,552,417 lbs CO_2 emissions reduction, 2,448 hours reduced engine runtime (as of Sept 30, 2019 CLT trials)
  - FAA's Terminal Flight Data Manager (TFDM) Program will deploy IADS capabilities to 27 airports beginning in 2021
- **Efficient Re-routes Around Weather (FY 2015-2019, $57.8M)**
  - Demonstrated re-routes are more direct, fuel-efficient, wind optimal, conflict free, and avoid congested airspace (2018)
  - Multi-flight Common Routes and Dynamic Routing Around Weather informing FAA Traffic Flow Management System (TFMS)

Source: Boeing



Success Stories: ARMD Research Technology Transfers to FAA

- **UAS Traffic Management Low-altitude Small UAS Operations in Dense Urban Environments (FY2015-2021, $107M)**
  - Reno, NV, June 17-28, 2019 and Corpus Christi, TX, August 12-23, 2019
  - Enable FAA's UTM Pilot Program and UAS Integration Pilot Program and Low Altitude Authorization and Notification Capability (LAANC)
- **UAS Integration in the NAS (FY2011-2021, $297M)**
  - Recommendations based on research findings for Detect and Avoid, Command and Control and Human Performance leading to RTCA and FAA Standards (2020)
- **Deliver to Six Commercial Aviation Safety Team (CAST) Safety Enhancements (FY 2015-2019, $ 32M)**
  - Stall prevention and recovery, aircraft state awareness (2019)
  - In response to CAST SE recommendations following accidents
  - Technology transfer algorithms to FAA and airlines to assist in enhanced simulator training for aircraft stall and upset recovery.

Four UAS autonomously flying over Reno managed by UTM

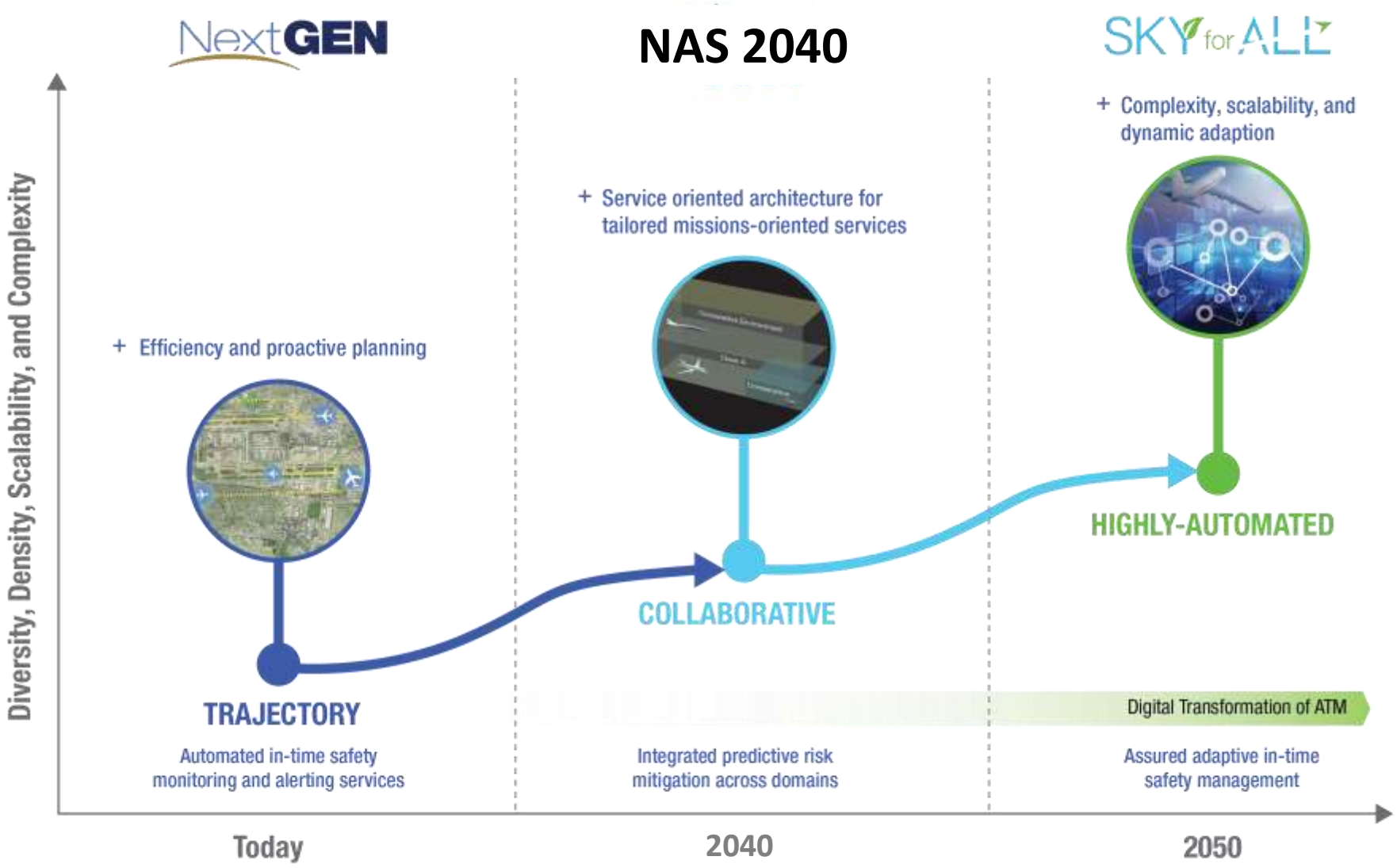
CAST | The Commercial Aviation Safety Team

Airspace Vision Drivers

- Diversity
  - Vehicles, Performance and Missions
  - Takeoff and landing locations
- Density
  - Operations increase from 10's K to millions
  - Emergent aviation lower altitude operations
- Complexity
  - New operations, airspace
  - Interoperability
- Human-centric approach for provision of airspace and safety services limits scalability

Transformation is Needed to Accommodate Future Operations

Airspace Vision and Strategy



ICN provides data to power the Sky for All transformation

The Future of the NAS

- **Evolving NAS beyond NextGen**
  - ✓ Will build on the NextGen foundational infrastructure
  - ✓ Will leverage NextGen and industry investments to provide additional capabilities to users beyond the Core-30.
  - ✓ Will address the key drivers of change in a manner that respects our principles of aviation while taking advantage of opportunities brought on by innovation and societal change.
  - ✓ Will provide real-time safety analytics across all operations means safer skies for everyone.
  - ✓ Users will be more connected and information is readily available to support decision making.
    - Information is made available based on each participant's needs and access level

Diverse Operations

ICN ConOps (2022)

Operational View

- In the future the FAA will operate an integrated National Airspace System, from the earth's surface to the lower stratosphere, shared by a diverse set of users with different operational capabilities
- Piloted, remotely-piloted, and fully autonomous - in air and space vehicles with a variety of commercial and non-commercial missions requiring various types and levels of air traffic services
- These services are all governed by the FAA with some provided directly by the FAA and others from third-party service suppliers.
- All enabled by extensive data sharing and advanced automation platforms, operating from airports, spaceports, heliports, and an expanded network of vertiports across the United States and its territories.

Transit to Space

Higher Airspace Services

ETM ConOps 1.0 (2020)

Air Traffic Separation Services

Concept of Use for Service-Based Reference Architecture (2022)

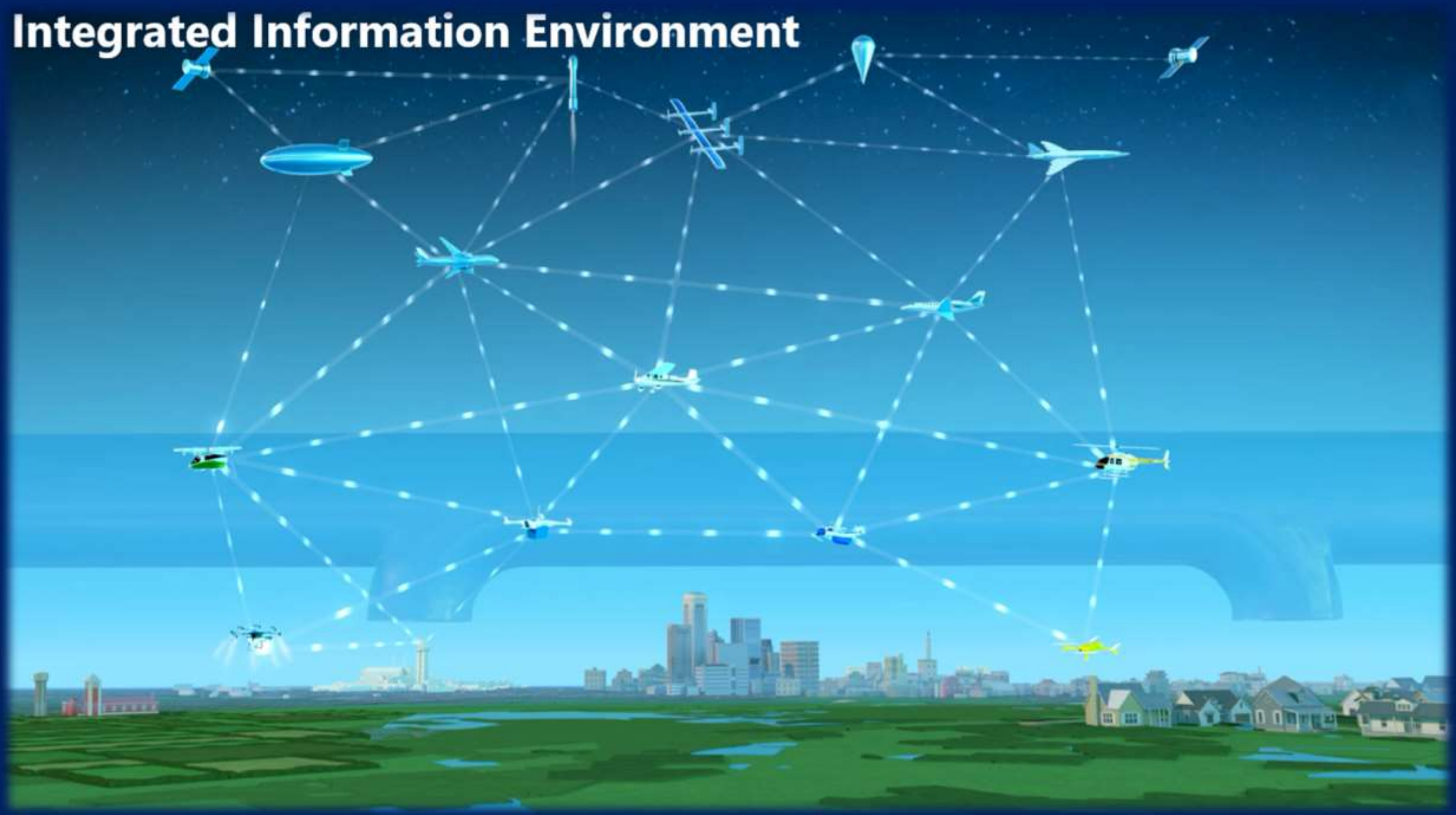
Urban Air Traffic Services

UAM ConOps 2.0 (2023)

Unmanned Traffic Services

UTM ConOps 2.0 (2022)

Integrated Information Environment

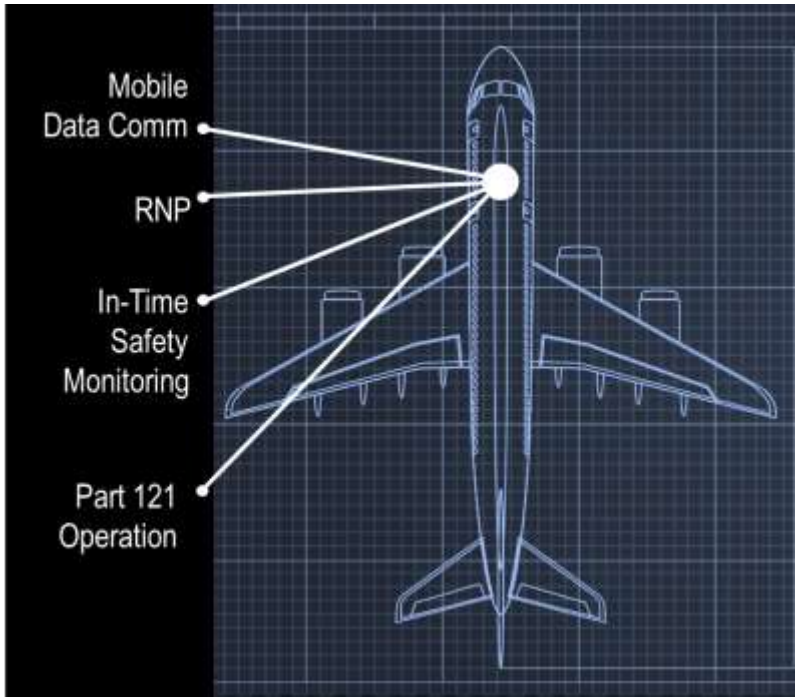


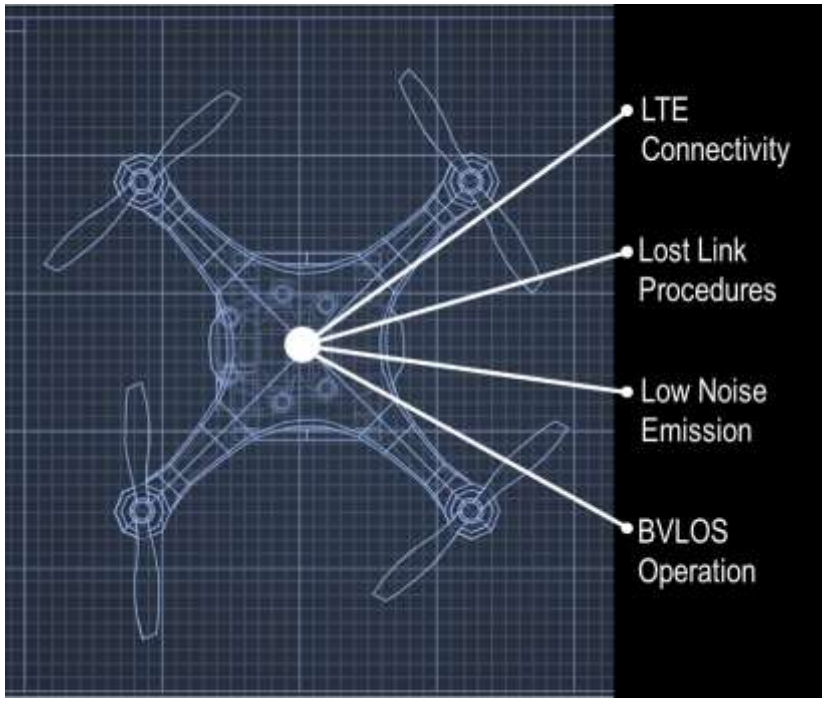
Tailored Operations and Flight Rules

TAILORED SERVICES
MEET THE NEEDS OF OPERATIONS IN ALL AIRSPACE

FLIGHT RULES
ACCEPTABLE RISK TO ALL PARTIES

JOINT USE AIRSPACE
WHERE POSSIBLE





In-Time Safety Risk Management

CONTINUOUS DATA EXCHANGE

MACHINE LEARNING

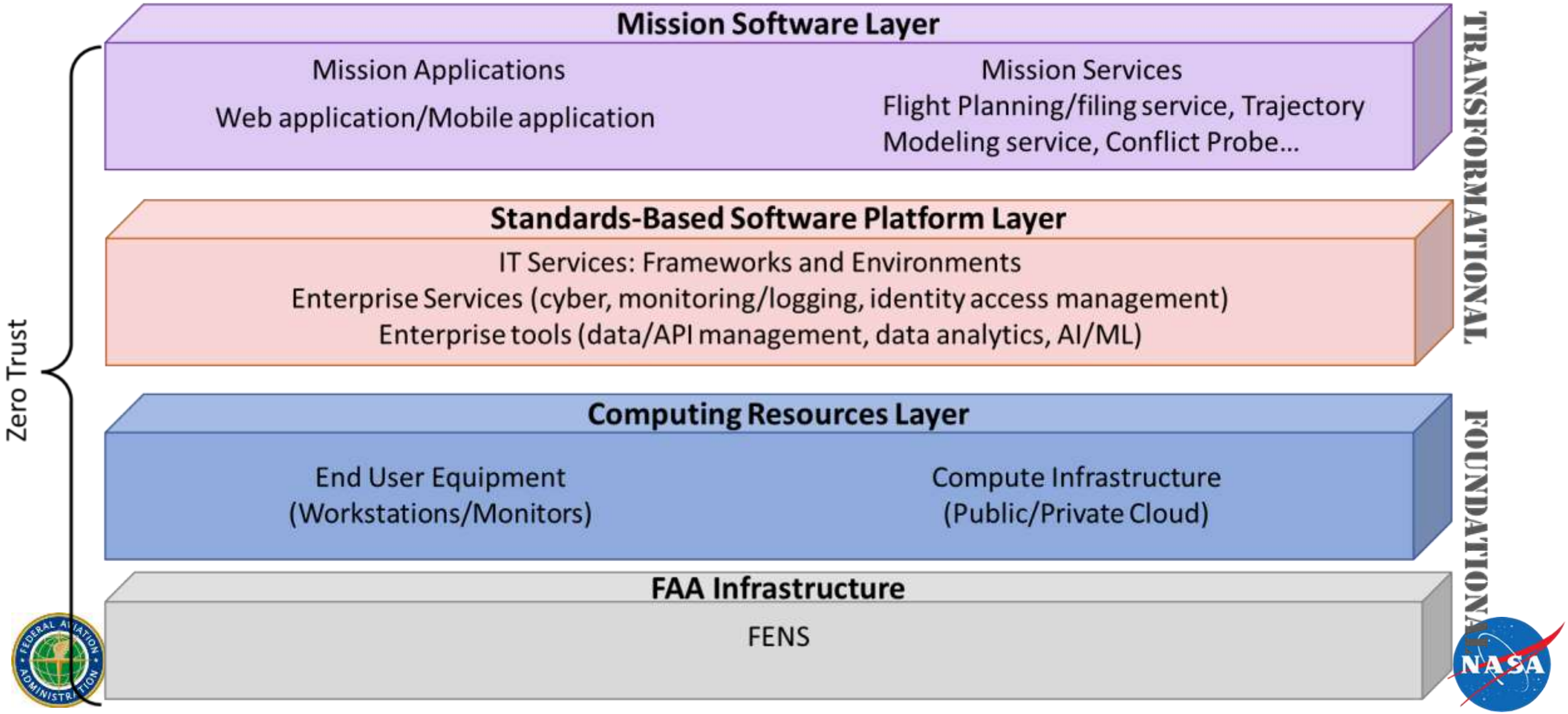
AUTOMATED MONITORING

PROGNOSTIC RISK MODELING

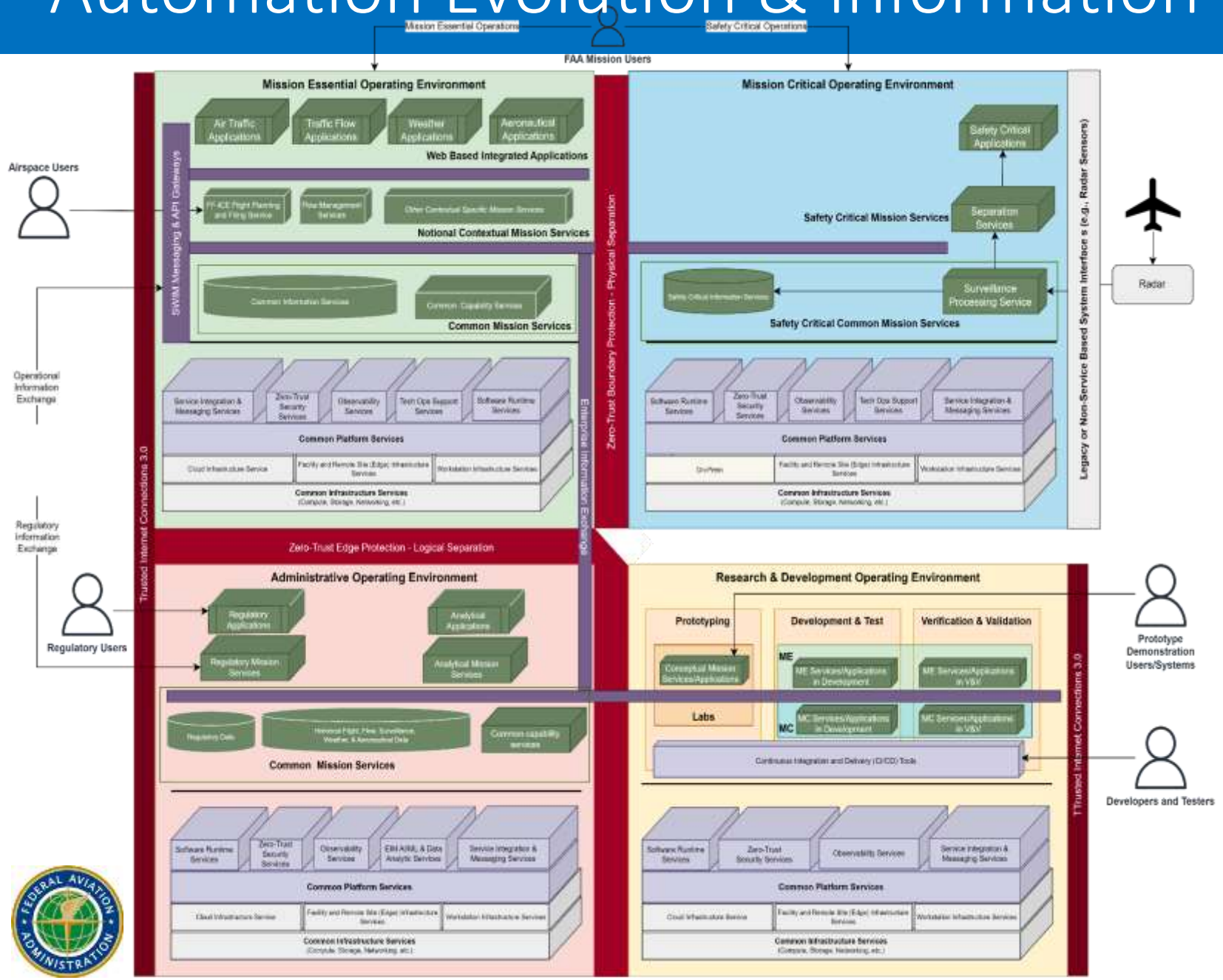
ALERTING AND RESPONSE

AES Architecture

Scalable, Flexible, Secure, and Resilient Applications and Common AT Automation Services - Supports Multiple Levels of Criticality.



Automation Evolution & Information Key Characteristics



- Distinct and segregated Operating Environments ensure protection based on criticality.
- Layered architecture provides separation of responsibility & and standardization across the FAA.
- Integrated Zero trust to ensure secure and resilient architecture.
- Distributed, Service-based architecture ensures agile services and faster delivery of capabilities.
- Common mission services enable reusability.
- Modern API-driven interfaces for standardized information exchange.
- Common Information services for Information management and Information sharing with diverse operations.

Airspace Vision and Strategy

- Seamless Integration of Future Diverse Operations
  - Federated Architecture
  - Mission and Service-Oriented
  - Increasingly Autonomous
  - Prognostic Safety
- Technical Approach
  - Validate xTM Concept
    - Define Architecture and Interoperability
  - Evolution of NAS Operations
    - Data-driven ATM Technology for the Existing NAS
    - Disruptive Capabilities for the Future NAS
  - In-Time Safety Assurance
    - Leverage data analytics toward predictive and prognostic safety services
    - Validate IASMS concept and architecture

Digitized, ML and AI-Enabled, Highly Automated & Increasingly Autonomous

AOSP Contributions Toward Airspace Transformation

Evolve Toward Federated, Service-Oriented NAS

DIP – Data fusion, ML/AI, Agile deployment, ATC and airline services, Sustainable ops demos

PAAV – Integration of remotely piloted/supervised ops in the NAS, Infrastructure as a service

IASMS – In time safety assurance services and SMS

Validate xTM Concept

ETM – 2nd xTM, Cooperative operating practices for diverse ops, Conflict Mgmt

UTM BVLOS – Pathfinding for rulemaking Interoperability of services, Validation of services

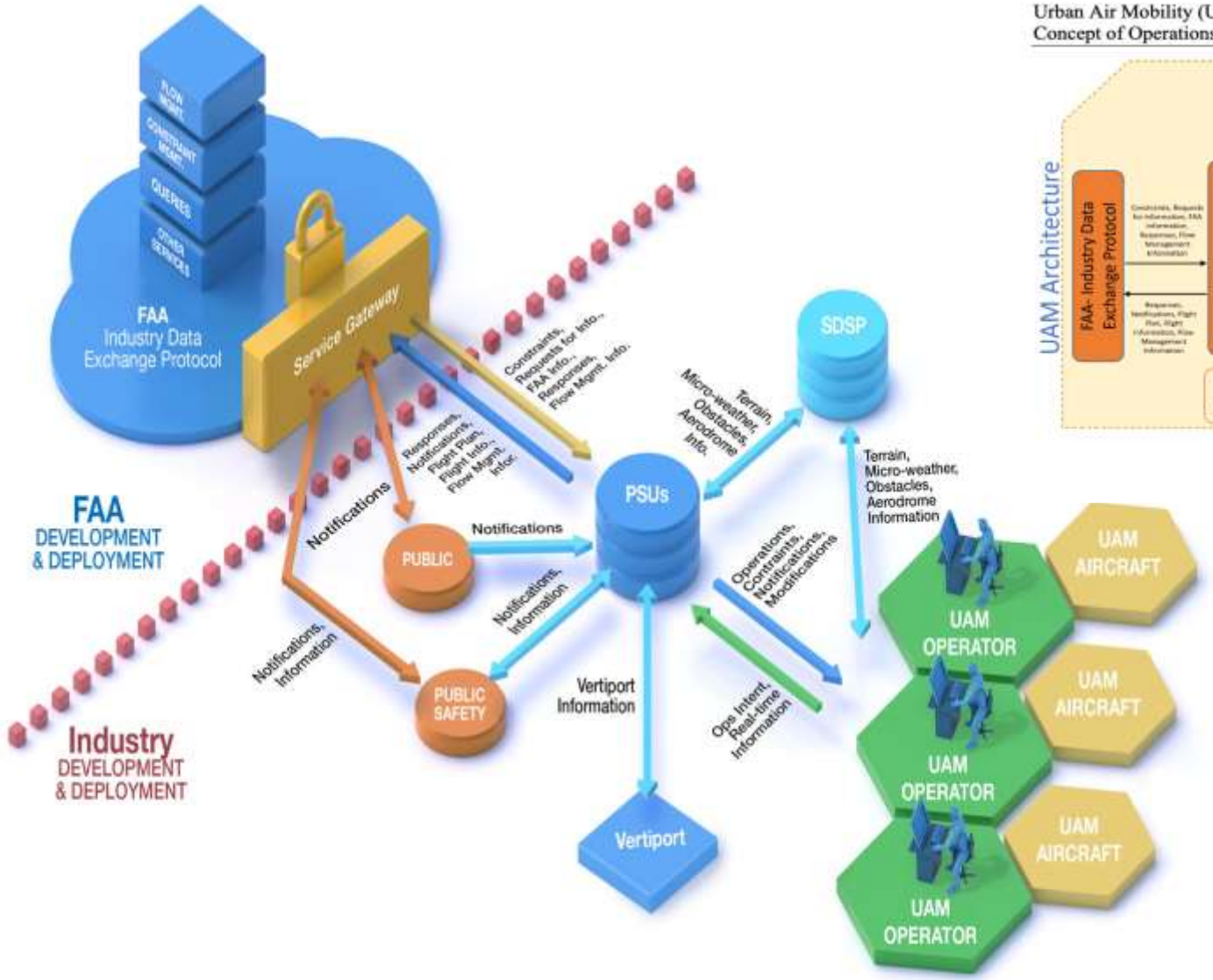
AAM – Architecture, Cooperative operating practices, Interoperability of services, XTM-ATS Interoperability, Requirements for passenger ops, Vehicle, Safety

IASMS – In time safety assurance services and architecture

Leveraging NASA/FAA Research Transition Teams

- Advanced Air Mobility RTT
  - Architecture for the xTM Concept
  - Integration of Autonomous Vehicles into the NAS
- Digital Mesh Technology and Applications RTT
  - Digital Information Platform for Commercial Transports Enabling Service-oriented Architecture
  - ML/AI Digital and Intelligent ATM Services
- Upper E Traffic Management
  - xTM Concept and Mission-oriented Architecture
- UAS Traffic Management RTTs
  - BVLOS for UAS
  - Interoperability
- System Wide Safety RTT
  - In-Time Aviation Safety Management
  - Data Analytics
  - V&V of Complex Systems/Assurance of Autonomy
- Wildfire Management RTT
  - Airspace Access
  - Traffic Management

AAM as Pathfinder for FAA NAS Modernization and Sky For All



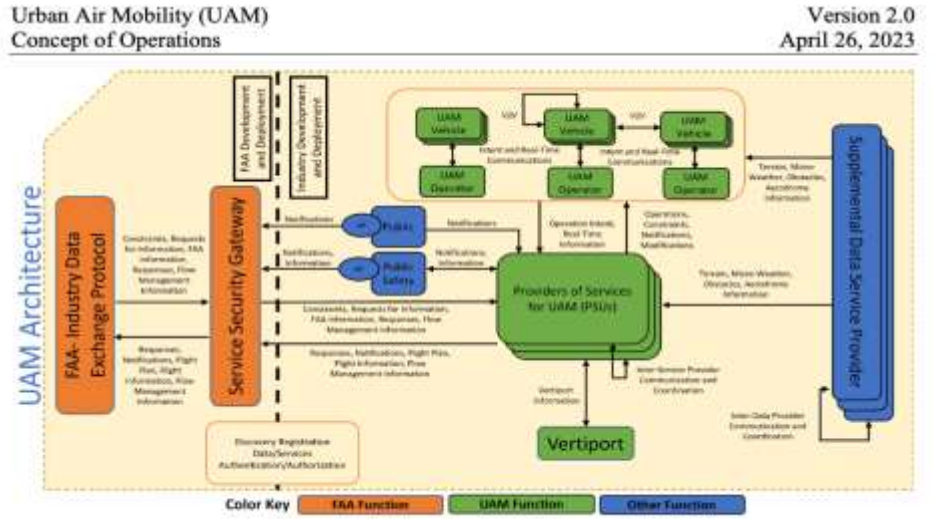
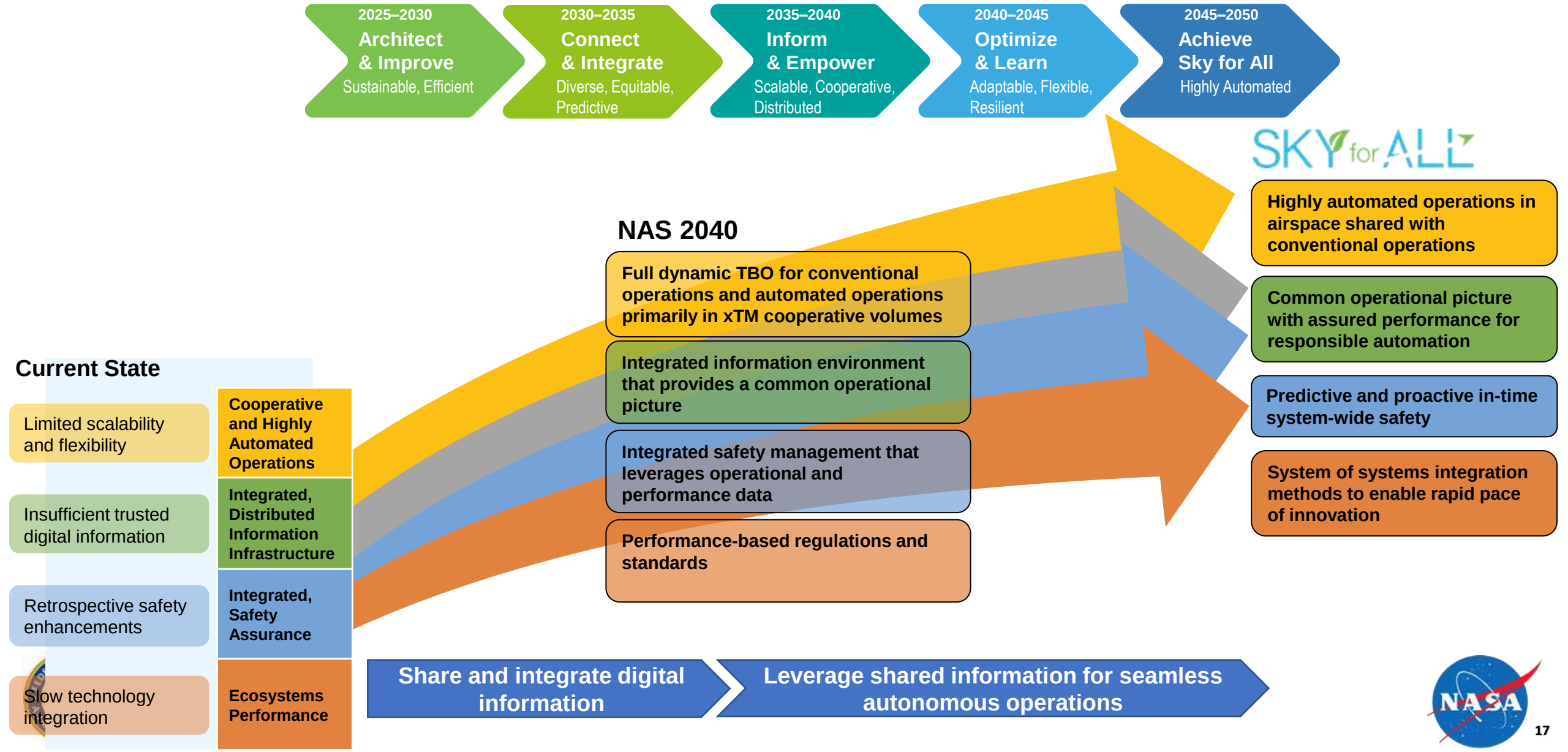


Figure 8: Notional UAM Architecture

Architecture will evolve and is a major contribution of NASA's effort

Sky for All Aviation Ecosystem Transformation



Summary

- Great progress made on alignment and joint evolution of Sky For All
  - FAA, CANSO, SESAR Joint Undertaking, ATCA, NATCA, Flight Safety Foundation
- AOSP portfolio well aligned to deliver key NAS 2040 capabilities
  - xTM, DIP, IASMS
- AAM, ETM, UTM excellent initial pathfinding for NAS 2040 and Sky For All
- Further refinement of Sky For All in FY24-25
  - Functional Reference Architecture, Initial ConOps, R&D Roadmap
- Key Questions/Studies
  - Autonomy and Future Flight Deck Roadmap
  - CNSS Requirements Roadmap
  - V&V and Assurance of Autonomy