Upper Class E Traffic Management (ETM) NASA R&D Update

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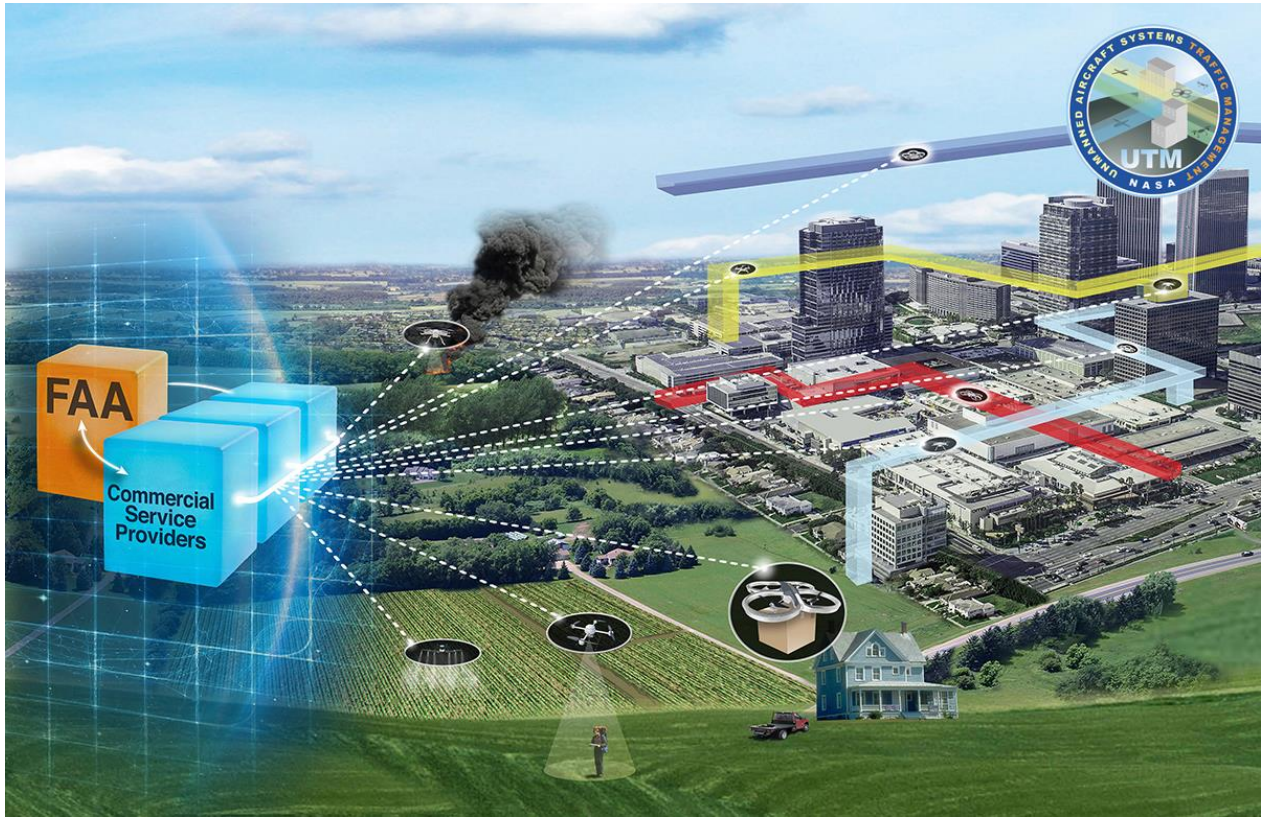
Agenda

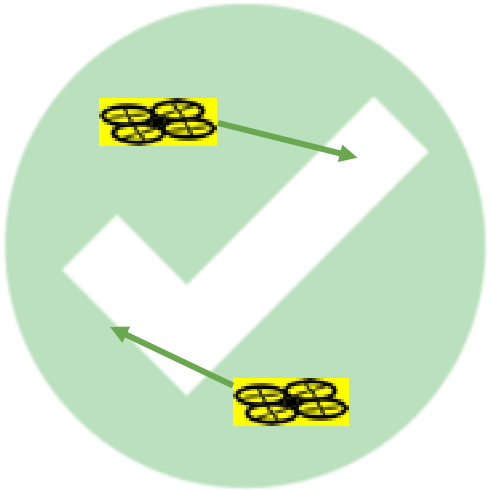
- What is Unmanned Aircraft Systems (UAS) Traffic Management (UTM), Extensible Traffic Management (xTM), and how Upper Class E Traffic Management (ETM) is related
- NASA's Upper Class E Traffic Management (ETM) R&D Overview
- Description of upcoming ETM Collaborative Evaluation
- Summary

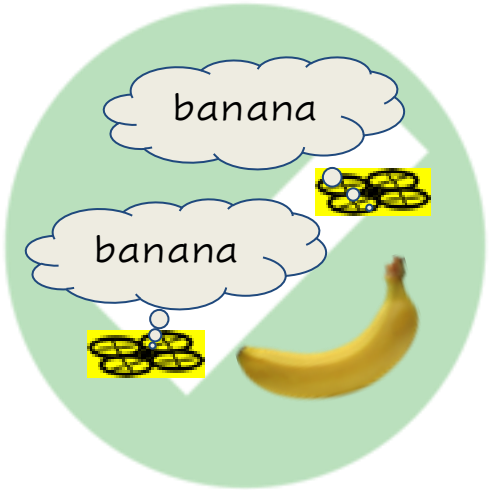
NASA Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Work

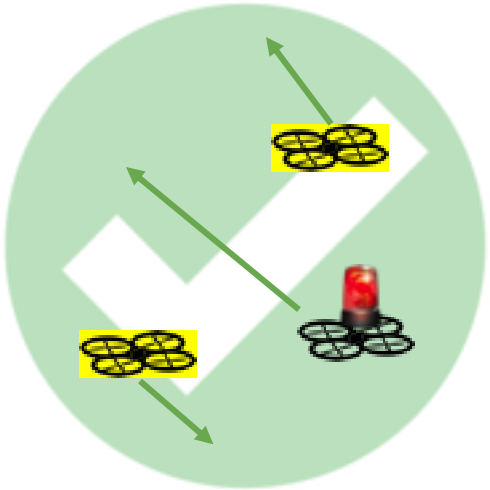


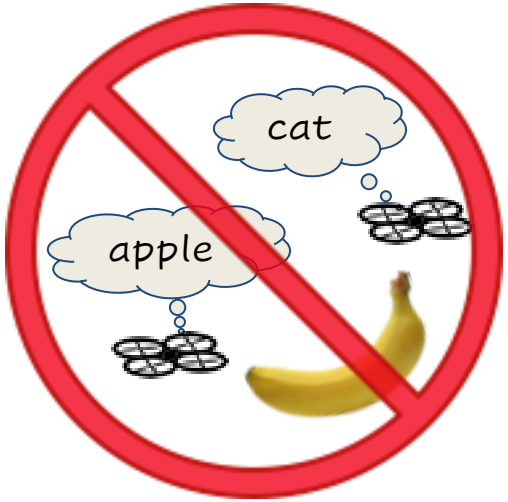
- In 2015, NASA began research on technology, performance requirements, and procedures to enable civil UAS operations in low altitude airspace
- UTM is an “air traffic management” ecosystem for uncontrolled airspace
- UTM utilizes industry’s ability to supply services under FAA’s regulatory authority where these services do not exist
- For more information: https://www.nasa.gov/utm

UTM Core Principles



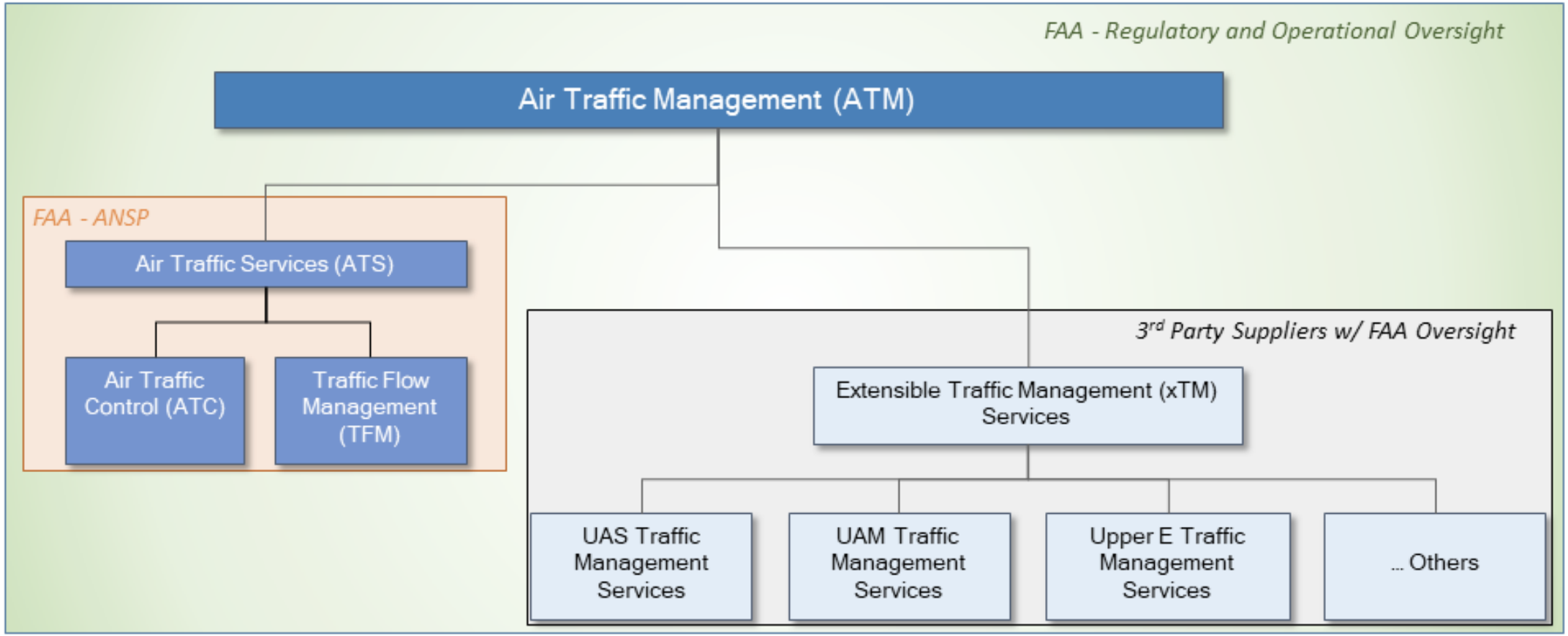






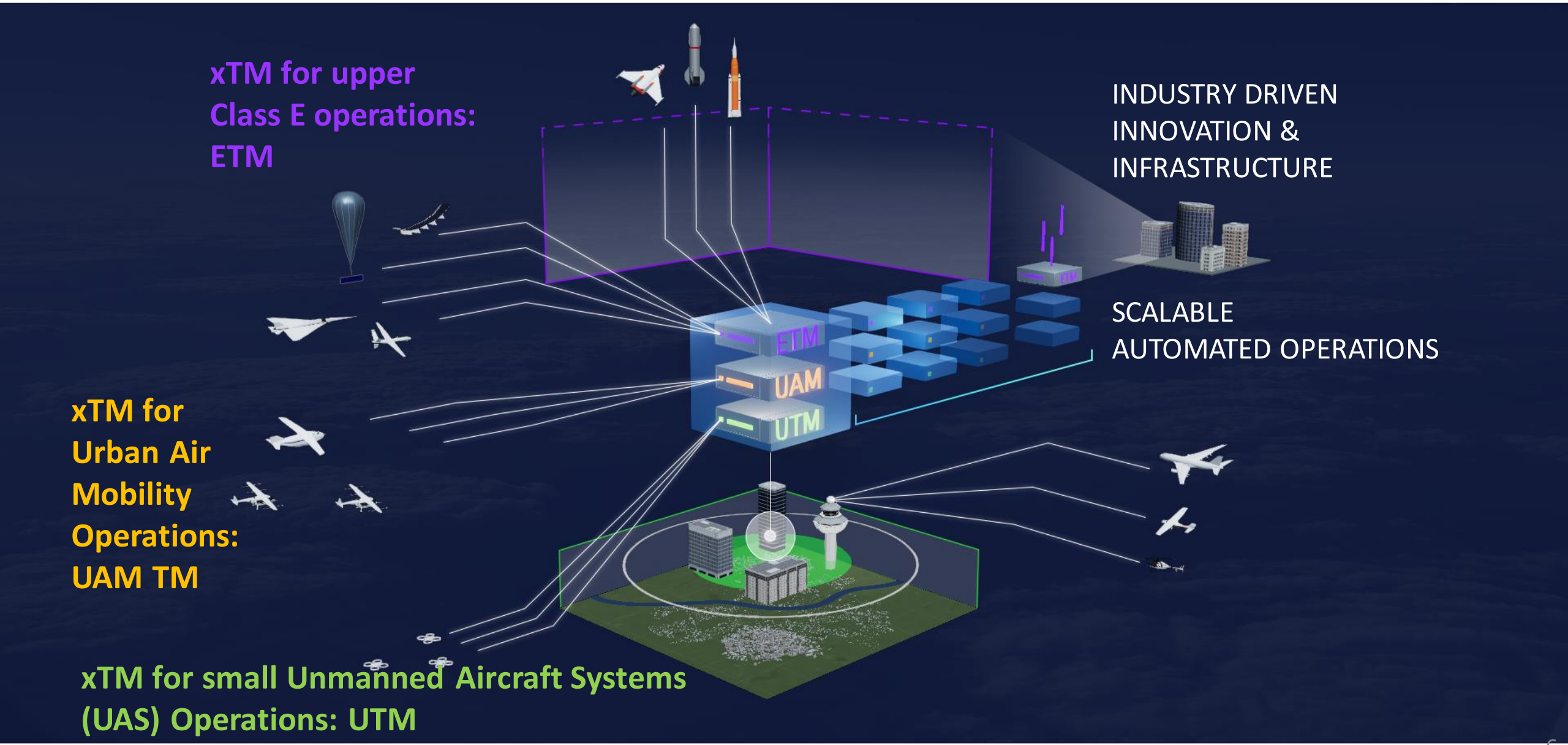
What is Extensible Traffic Management (xTM)?

- NASA and the FAA's pioneering UTM work introduced a new traffic management architecture that utilizes industry's ability to supply services with FAA regulatory and operational oversight
- UTM principles and core properties are generalized to become Extensible Traffic Management (xTM) and applied to manage new entrants beyond small UAS such as Upper Class E operations



FAA, Charting Aviation's Future: Operations in an info-centric NAS, June 2022

xTM to Enable Safe, Efficient New Entrants Operations at Scale



Upper Class-E Traffic Management (ETM) Background

- New generation of high-altitude aircraft are expected to efficiently satisfy research objectives, demands for broad coverage services, and supersonic passenger flight, and an increase in upper Class E operations is predicted
- However, there are no specific provisions for aircraft operations above 60,000 feet for civil aircraft, and most existing applications are limited to military operations
- Also, existing Air Traffic Management Systems is unable to cost-effectively accommodate upper Class E needs
- A strong need, expressed by both FAA and industry, for NASA to conduct research and simulations to help develop, evaluate, and mature the upper Class E Traffic Management (ETM) to meet the expected demand

NASA, FAA, Industry ETM Activities

- 2 NASA-hosted Tabletops in 2019
- Following the tabletops, NASA, Industry, FAA, DoD, and US Forestry Service meetings continued
- NASA/FAA ETM leads have been engaging industry members for in-depth conversations
  - AeroVironment on CNS topics of interest
  - Hermeus to bring hypersonic passenger transport into community discussions
  - Raven to understand high-altitude balloon operation and coordination with ATS
- NASA research outcomes are shared through publications and conferences, and ETM presentations are given at AUVSI, Fed UAS workshop, and other venues

ETM ConOps and Cooperative Operating Practice (COP)

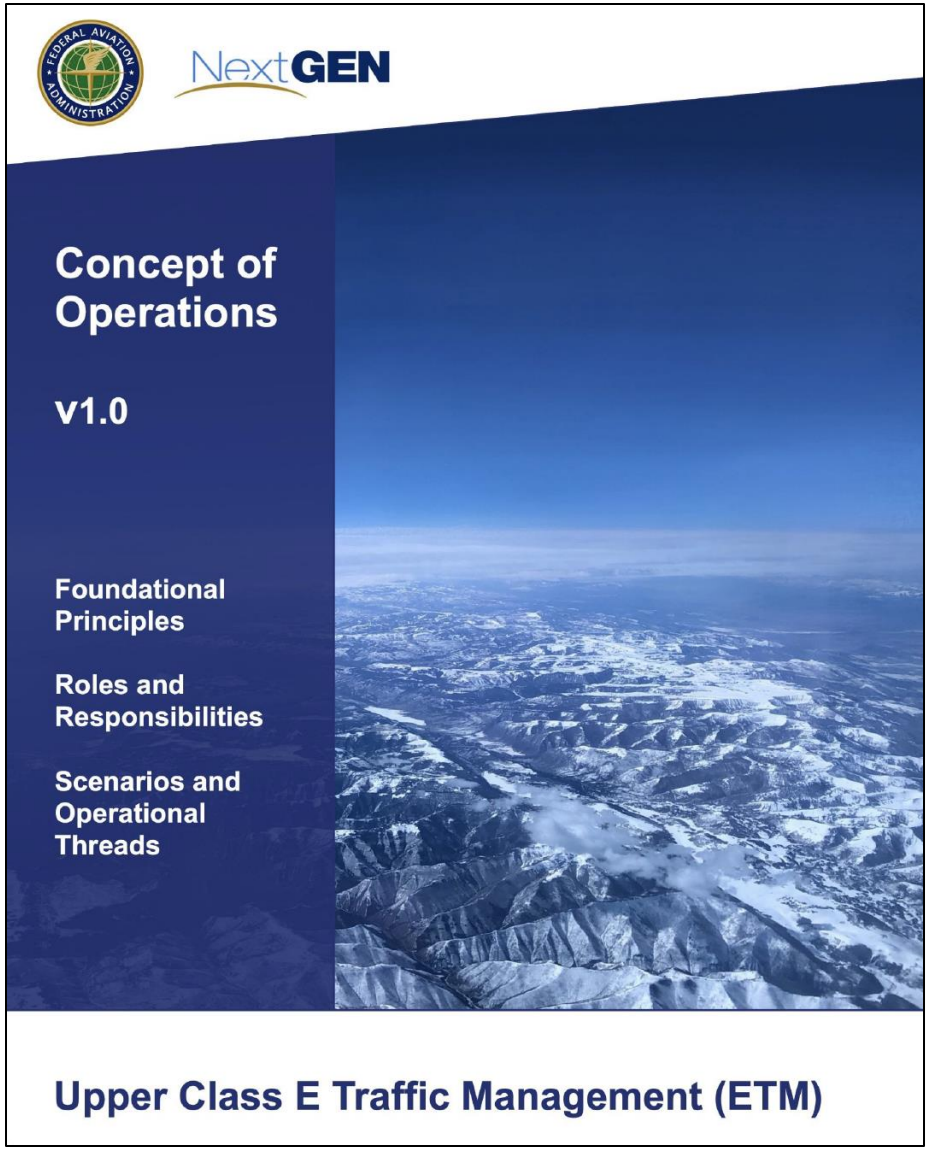
- The ETM community interest and NASA, FAA, and industry activities led to the FAA publication of the initial Concept of Operations for Upper Class E Traffic Management (ETM) in May 2020.

- In the ConOps, ETM consists of two methods of separation management
  - Cooperative Separation
  - Air Traffic Control (ATC) Separation

- For Cooperative Separation, the operators are responsible for the coordination, execution, and management of the operation; this is to be conducted through Cooperative Operating Practices (COPs)

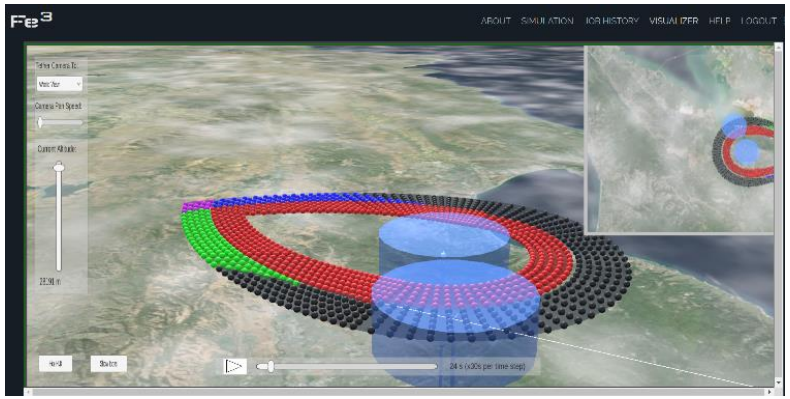
- COP: Industry-defined, FAA-approved practices that address how operators cooperatively manage their operations within an ETM domain, including conflict management, equity of airspace usage, and demand/capacity balancing.

- For example, operators under cooperative separation would exercise what was agreed upon in the COPs to maintain a safe distance from each other and avoid unsafe conditions such as severe atmospheric conditions

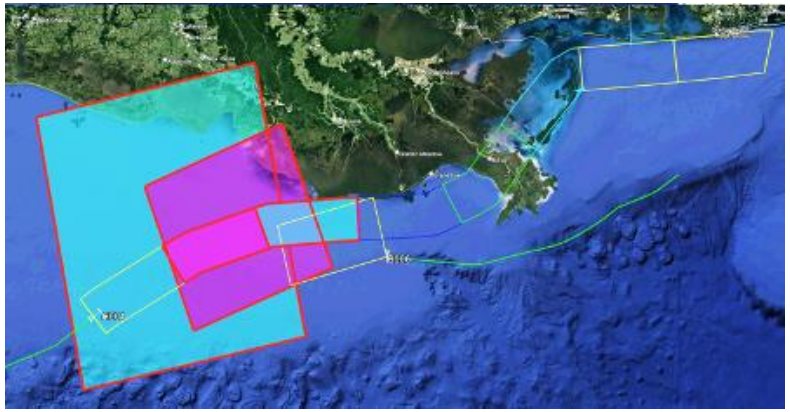


NASA ETM Collaborative Evaluation #1 (CE-1)

- The concept of Cooperative Operating Practice (COP), emphasizing cooperative operation through intent-sharing supported by a UTM-like service-oriented architecture, has been proposed and accepted by the ETM community. However, details of COPs are currently lacking



- In 2021 and 2022, several fundamental functions for cooperative operations were developed including
  - An algorithm to calculate minimum maneuver distance reflecting diverse vehicle types and performance
  - A model for formulating probabilistic operational intent
  - An algorithm to calculate the probability of flight intent intersection
  - A negotiation model for cooperative operations



- Insights gained from this work are being implemented into a prototype research ETM system that consists of an ETM Service Supplier (ESS) and a client that connects to the ESS.

- NASA plans to onboard partners for collaborative evaluation of the prototype research ETM system. The first of this event is scheduled for August 2023, designated as Collaborative Evaluation #1 (CE-1). In CE-1, a version of COP prepared by NASA will be evaluated using a prototype ETM system for enabling cooperative operations. Two additional CEs are planned.

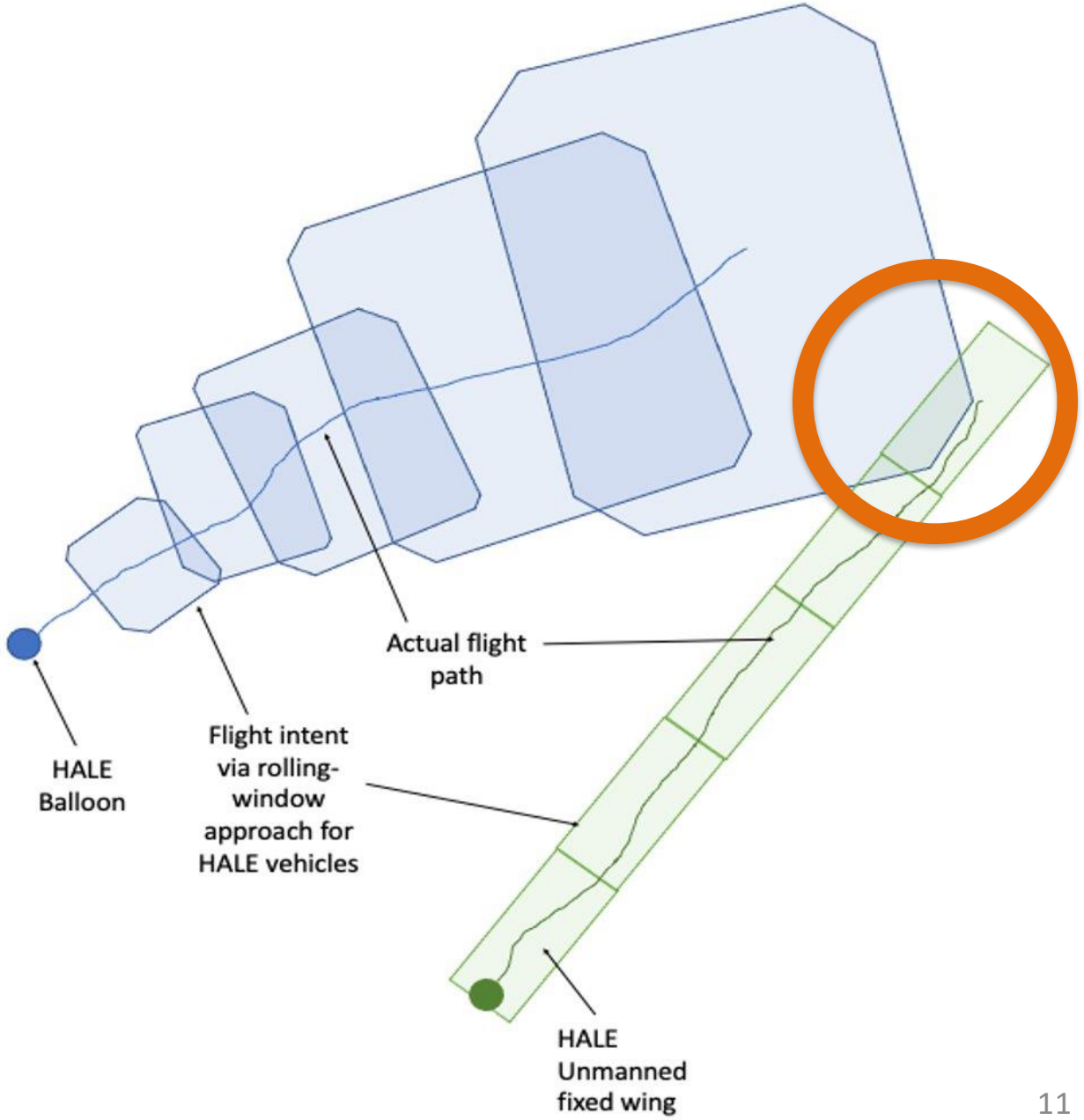
ETM CE-1 Research Question

- For high-altitude operations under Cooperative Separation management, a COP for identifying a future conflict and resolving it is needed but this COP has not yet been fully developed

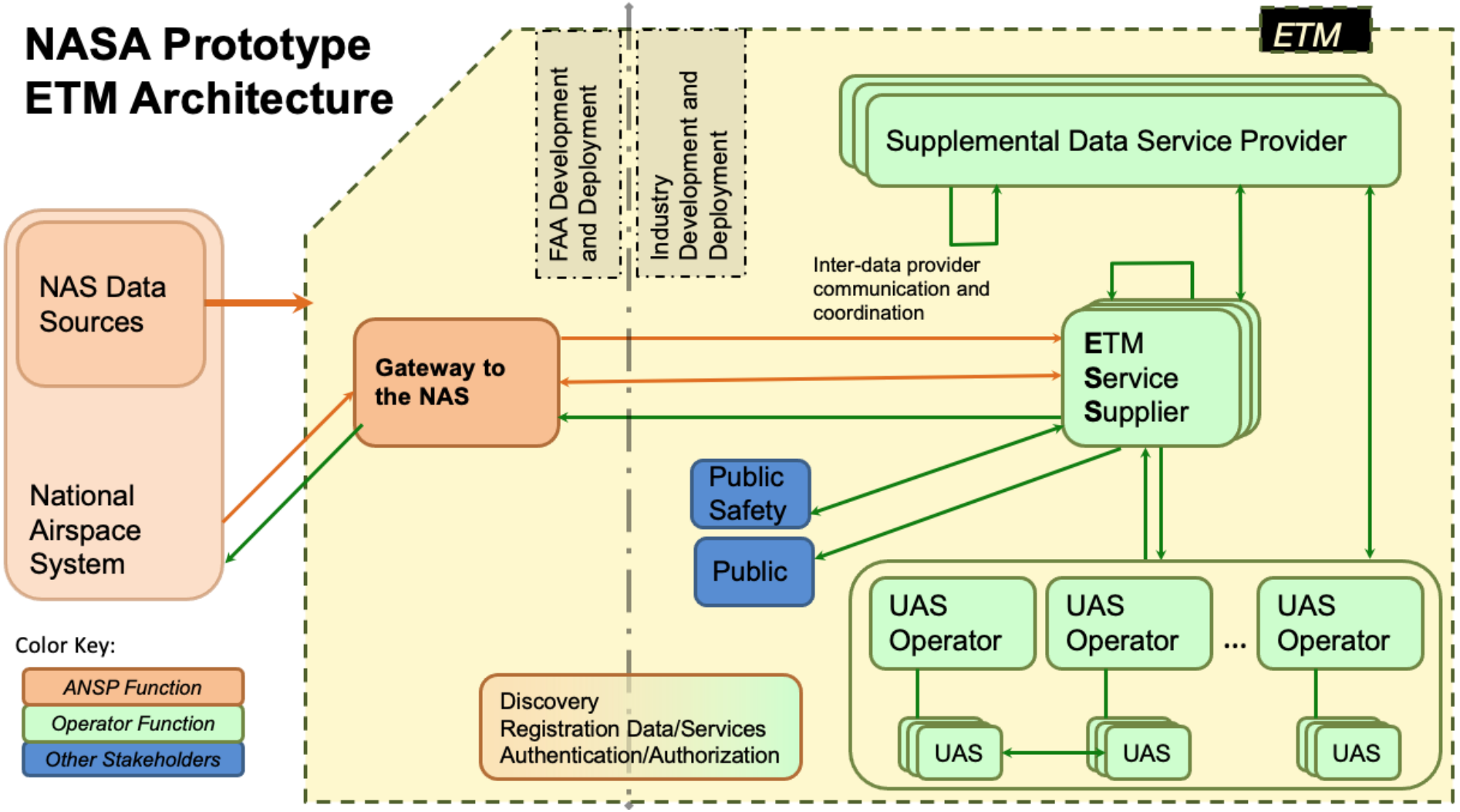
- A prototype ETM system is designed to identify a future conflict using operational intents (i.e., 4D intersection)

- However, due to the diversity of high-altitude aircraft types and performance, immediate resolution of all conflicts may not be necessary
  - Conflict is too far into the future
  - Aircraft are susceptible to changes in the wind condition

- **Research Question**: What information and procedures are needed for strategic conflict identification and resolution in ETM?

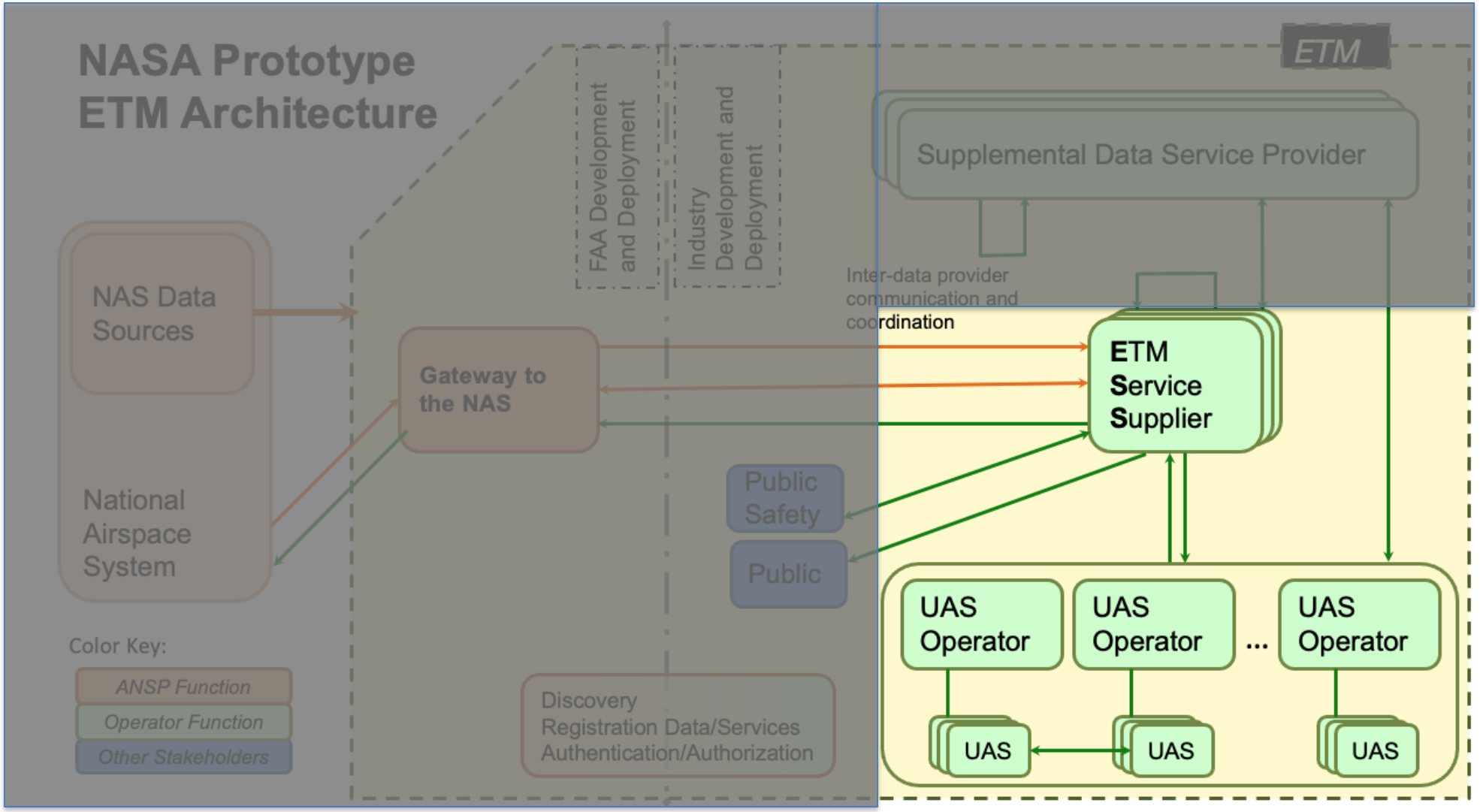


Prototype NASA Research ETM System



UTM construct is adopted for a prototype NASA Research ETM system

Prototype NASA Research ETM System for CE-1



ETM CE-1 includes single ESS and ETM clients connecting to the ESS. High-level requirements are defined, and lower-level ones are in development

Development of High-altitude Traffic Situation for Research

The reference traffic situation planned for testing is based on a use case from a commissioned ETM Market Study

TELECOMMUNICATIONS: RURAL FIXED WIRELESS INTERNET ACCESS

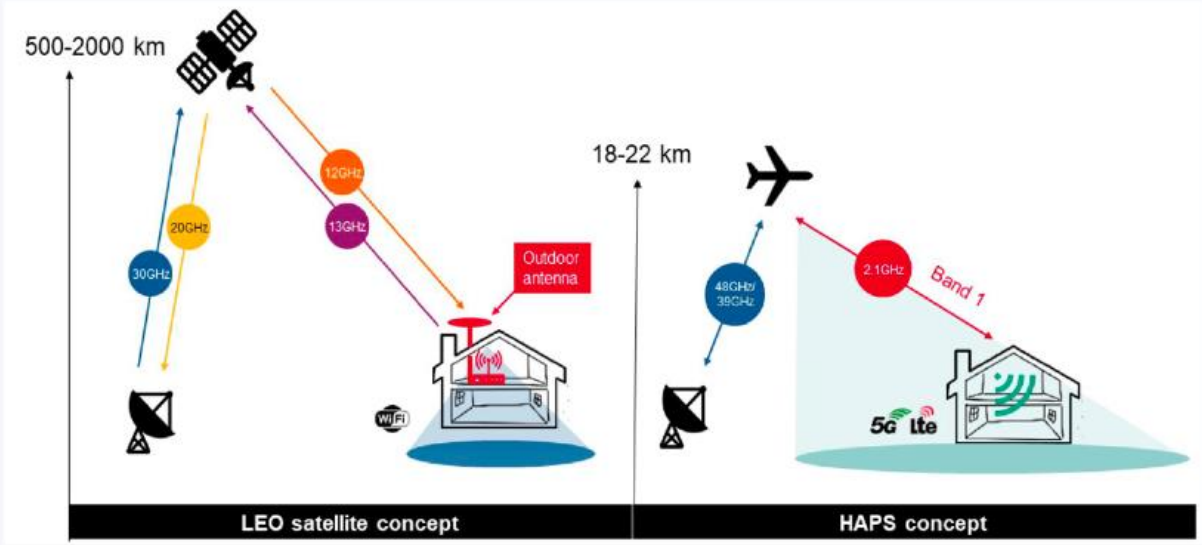
HAPS can be used to provide telecommunication services to geographic areas that would be cost prohibitive for terrestrial networks.

Fixed Broadband Connectivity

HAPS can deliver adequate fixed wireless access to households without any wired connectivity. The lower operating altitude and smaller service footprint means HAPS can provide higher capacity and lower latency than satellite-based services. Further, HAPS can provide close to 100% geographical coverage with lower latency than satellites and can ensure more reliable connectivity along traffic corridors. A HAPS system can also bring connectivity to edge-computing facilities on the ground to further reduce the latency for close-to-real-time services.[1]

Backhaul Transport

HAPS systems can be used to provide transmission links between the mobile and core networks for backhauling traffic. Traditionally, the majority of backhaul capacity has been provided by terrestrial fiber networks, but there may not be enough traffic to warrant the costly deployment of fixed-line fiber connectivity. Millimeter wave and free space optics (FSO) communications solutions could allow for a relatively lightweight payload, allowing use of smaller HAPS vehicles, which could be connected in a mesh network configuration.[2]



(Source: GSMA, "High Altitude Platform Systems: Towers in the Sky", 2021)

References:

[1] High Altitude Platform Systems: Towers in the Skies, URL: https://www.gsma.com/futurenetworks/wp-content/uploads/2021/06/GSMA-HAPS-Towers-in-the-skies-Whitepaper-2021-1.pdf

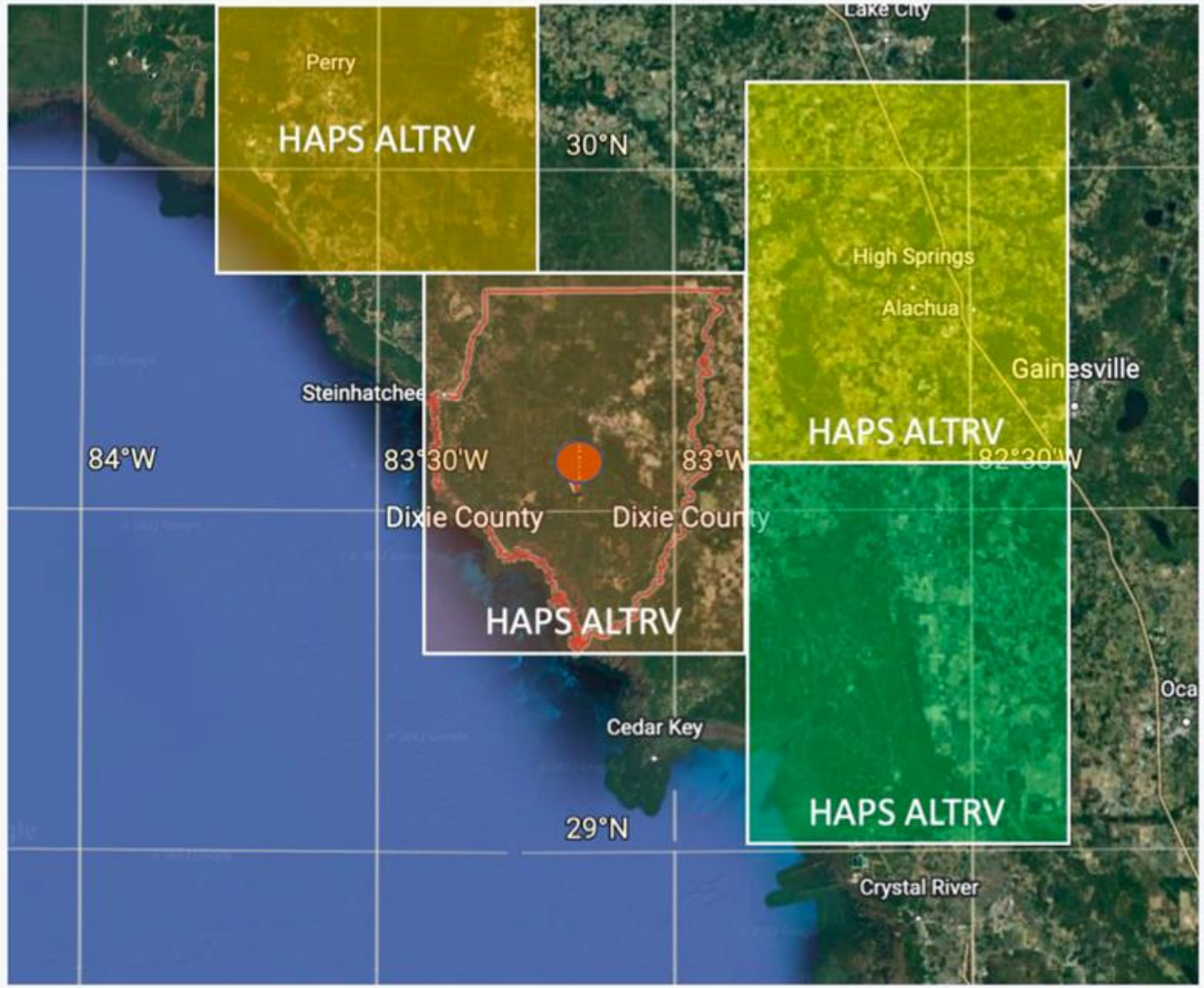
[2] HAPS – High Altitude Platform Systems, URL: https://www.itu.int/en/mediacentre/backgrounders/Pages/High-altitude-platform-systems.aspx

LMI

EXAMPLE: AIRSPACE – WITHOUT ETM

- Dixie County, FL
- 2,702 sq km
- Households without access to fixed broadband (potential market): 4,769
  - One of the most "unconnected" counties in the state
  - According to FCC:
    - 74% do not have access to broadband
    - <1% have 50Mbps or better service
- HAPS required to meet demand
  - 9.54
- Airspace capacity
  - Without ETM: 1 HAPS

An ALTRV using domestic separation standards requires 5,216 sq km of airspace; large vertical separation standards do not allow for overlapping HAPS.



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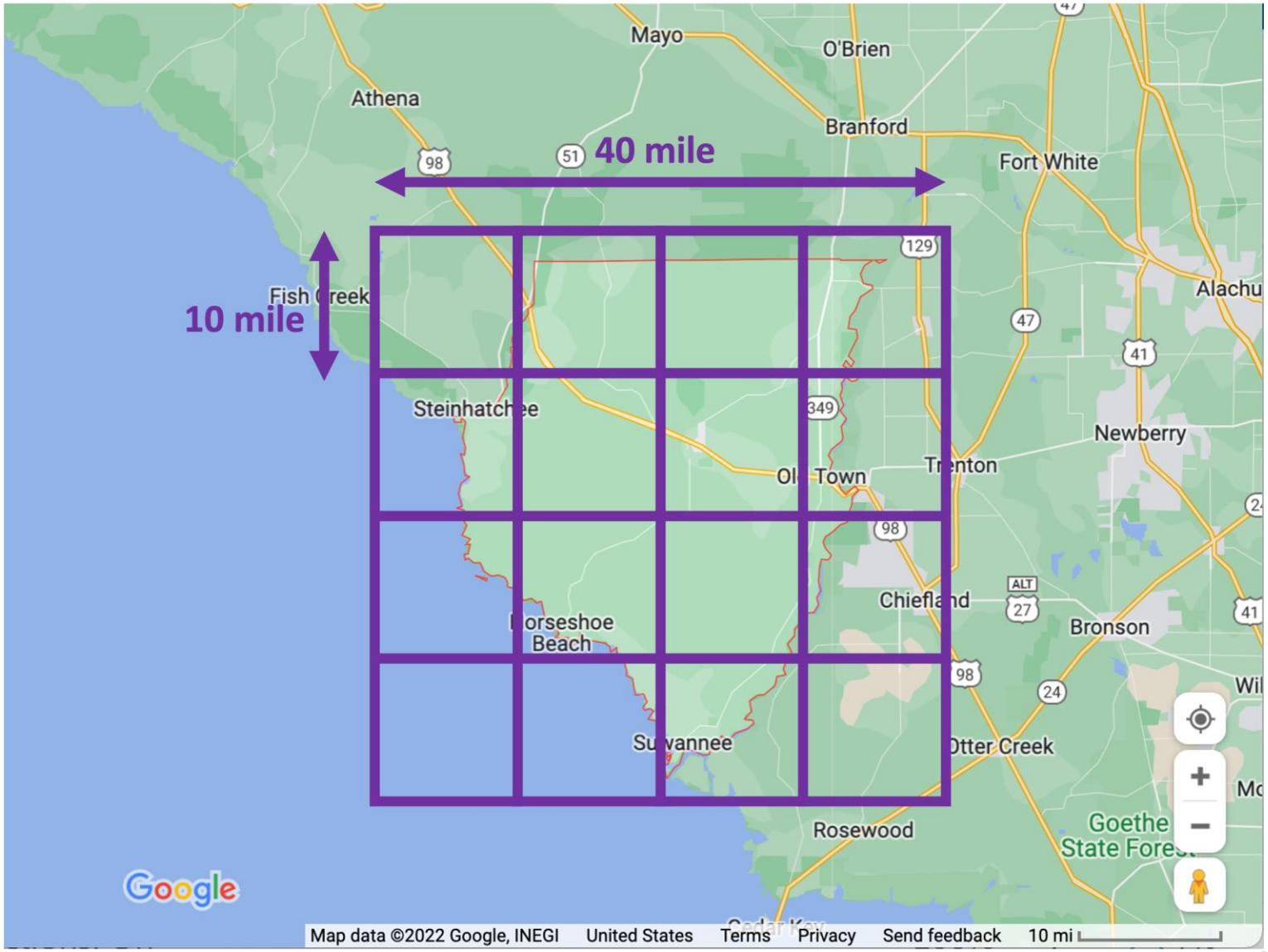
High-altitude Traffic Setup

The following simulated operations are to take place over Dixie County

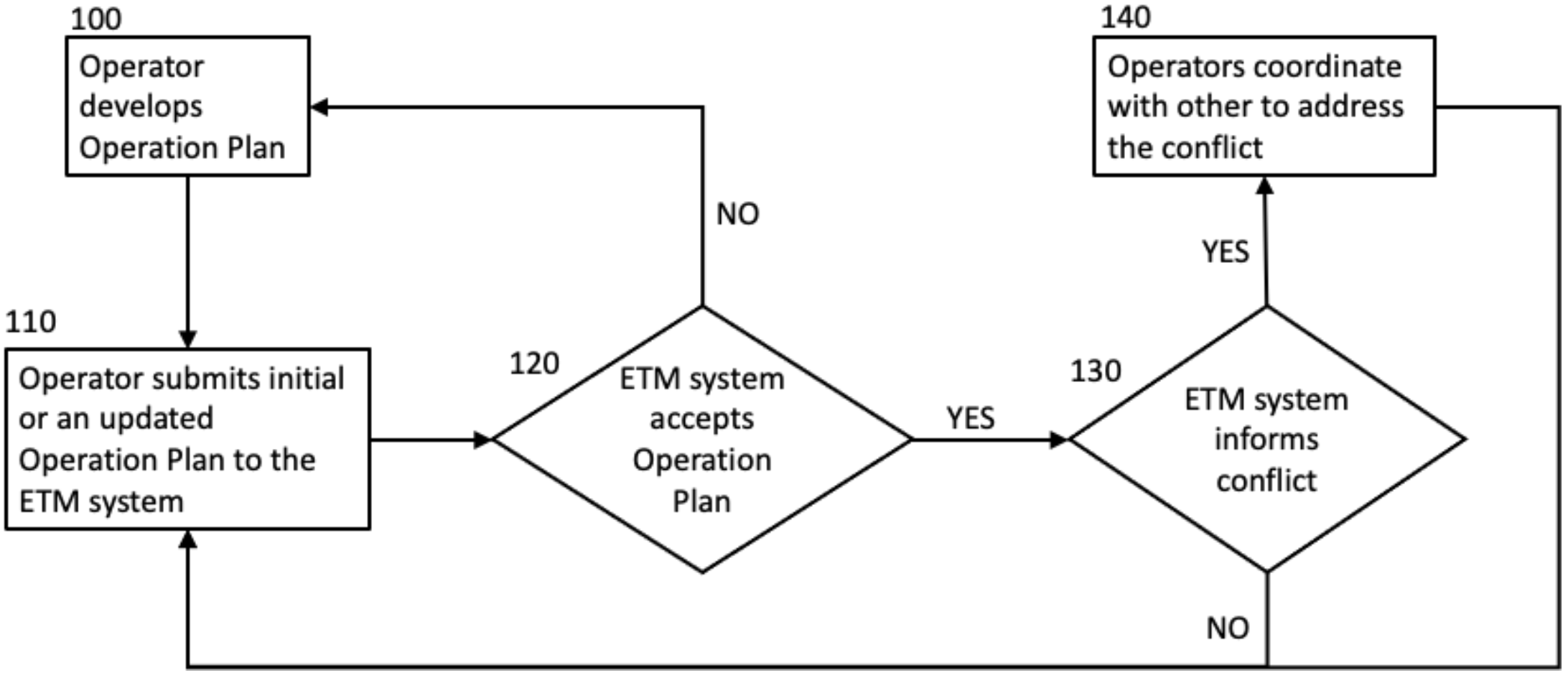
3 Internet service operations:
- 2 Solar-powered HALE aircraft
- 1 Airship

1 Earth observation operation:
- HALE balloon

1 aircraft transiting to return to its base:
- Jet-powered fixed-wing



Expected Operator Behavior Participating in CE-1



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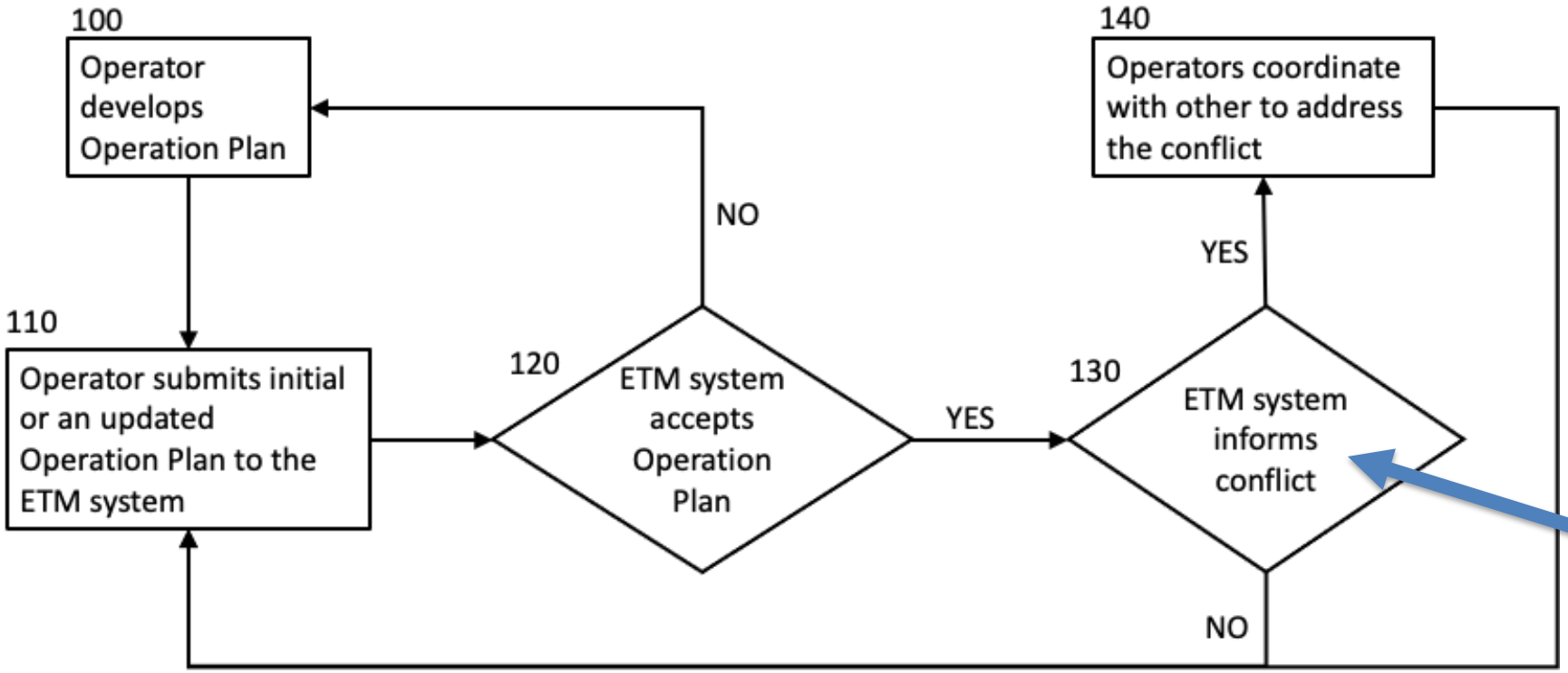
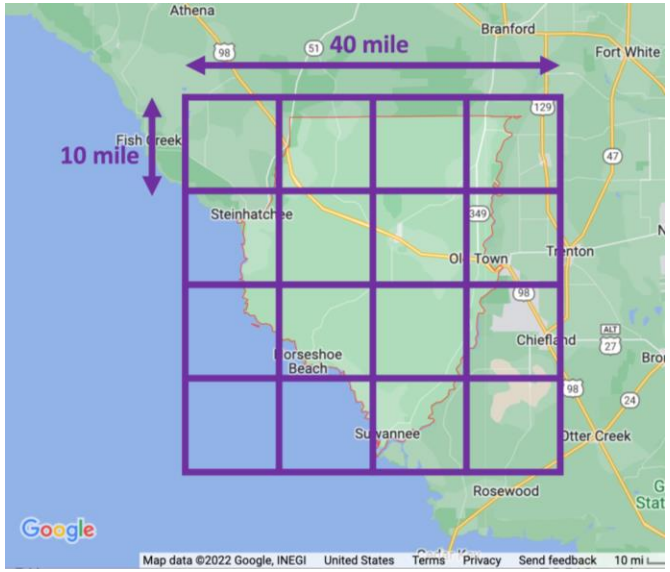
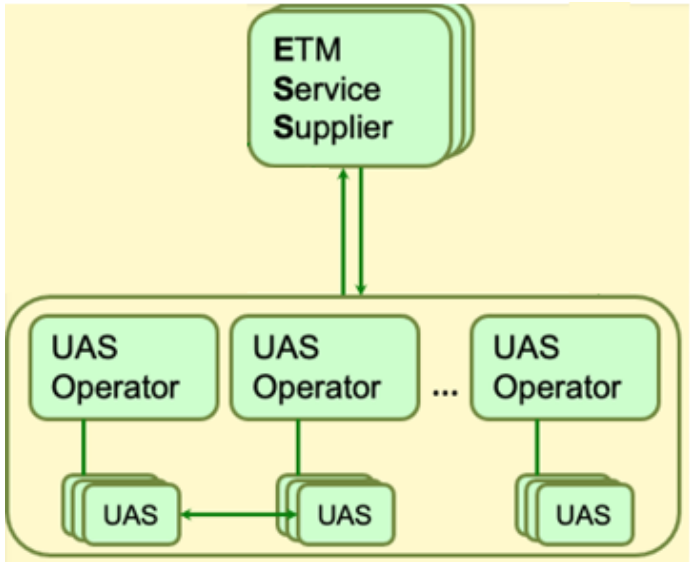


Conflict is informed with the following:

- OI intersection geometry, start and end time
- Containment confidence level for each OI
- Probability of flight intent intersection

Planned CE-1 Test Approach and Environment





- The ETM operating area for CE-1 will be defined through the scenario development process and shared with participants
- Participants develop their Operational Intents based on vehicle type and mission
- Prototype NASA Research ETM Service Supplier (ESS) deployed and accessible via Operator API
- ESS client to interface with ESS developed by participant or available for share from NASA
- Test evaluation and data collection to be conducted in real time from NASA Ames

Ongoing and Future Work

- Further development of representative traffic situations
- Continued work with the community to establish Cooperative Operating Practices and refine overall ETM concept
- Non-reimbursable Space Act Agreement with potential ETM CE-1 participants
- Tabletop exercises to reflect ETM stakeholder input to ETM CE-1
- Rapid prototyping and testing for ETM software requirements generation

Summary

- Upper Class E Traffic Management (ETM) is in development to improve access to high altitudes for current users and new entrants
- Access and ability to scale where needed depends on operators to practice Cooperative Separation: ETM is designed to support this
- NASA plans to conduct a collaborative evaluation of a prototype NASA research ETM system in 2023
- Looking forward to sharing lessons learned from the evaluation at the next Fed UxS event