Upper Class E Traffic Management: NASA's Collaborative Research and Technical Development to Enable Routine, Safe, and Scalable High Altitude Operation

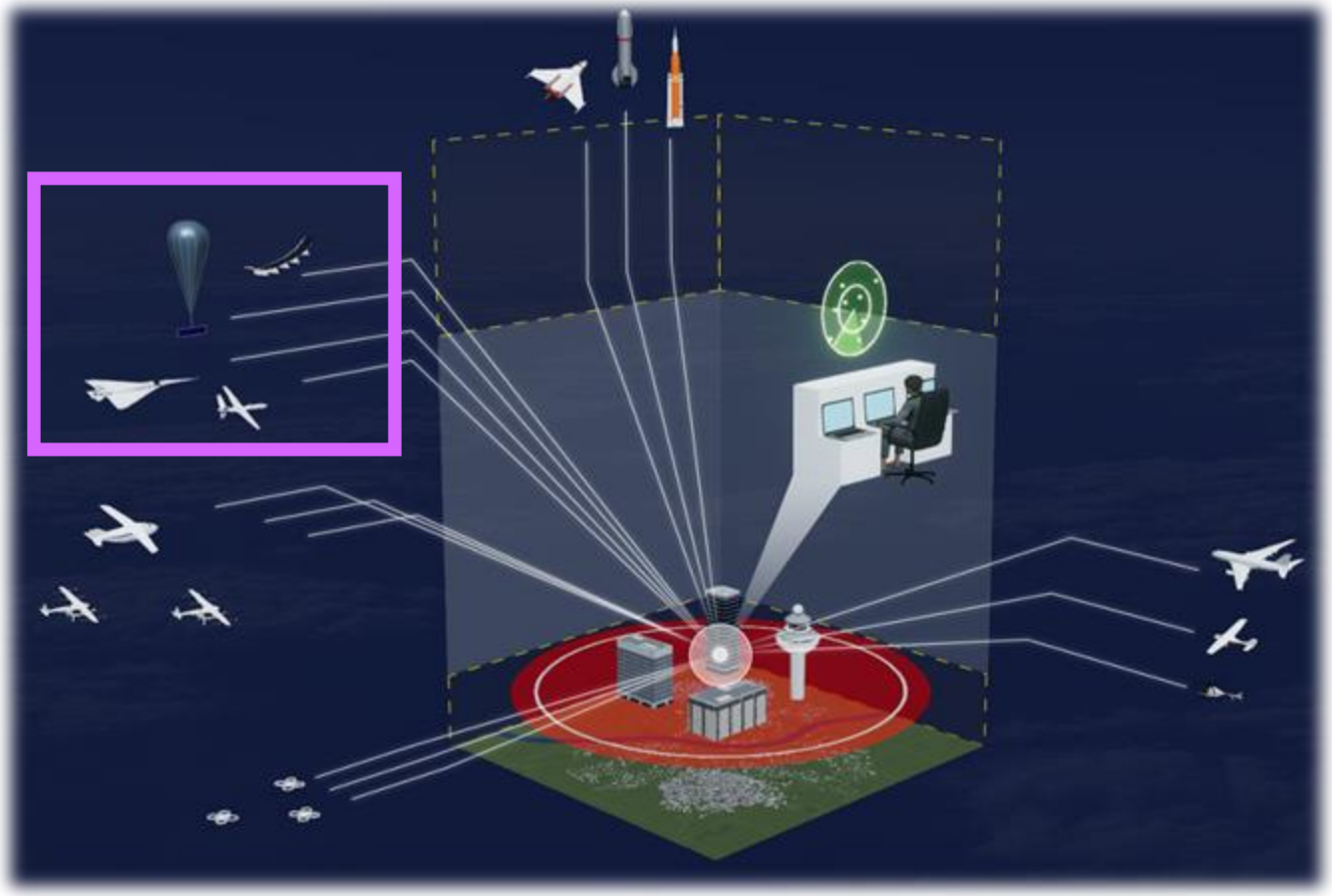
HAPS Alliance Member Meeting
Bonn, Germany
November 13, 2024

Outline

- Intro
- Background
- Upper Class E Traffic Management (ETM) Concept Development
  - NASA / FAA / Industry Engagements
  - Near-term Demonstration and Research Objectives
  - ETM Intent Sharing
  - ETM System Architecture
- ETM Collaborative Evaluation #1 (CE-1) Simulation
- CE-1 Initial Findings
- Next Steps

NAS Exploratory Concepts and Technologies (NExCT)

Catalyze airspace integration of diverse and scalable cooperative xTM operations



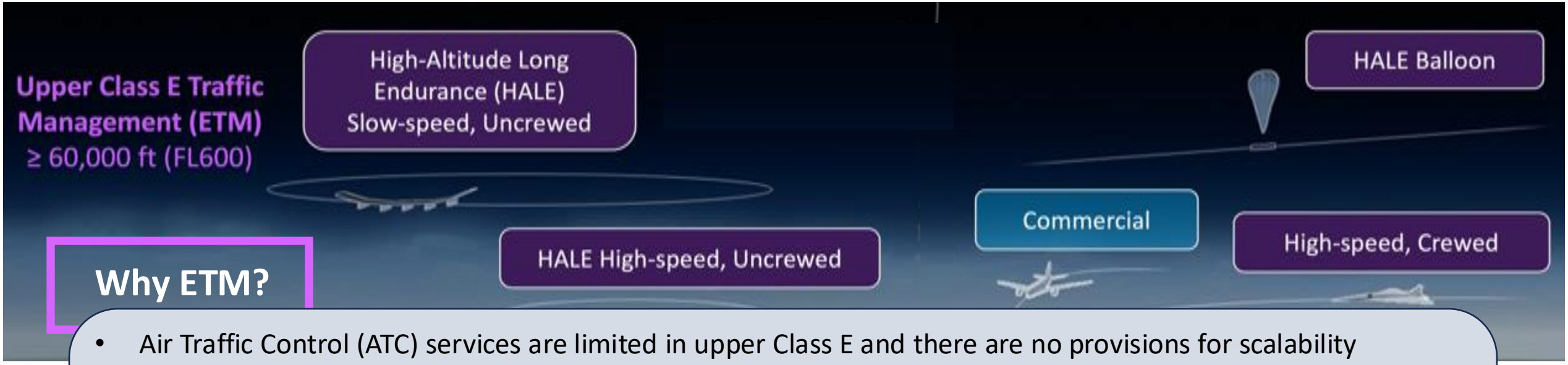
Upper Class E Traffic Management (ETM)
Develop functional requirements to support ETM operations of vehicles with unique performance characteristics and mission needs

Cooperative Operating Practices
Develop and test cooperative operating practices and automated methods of strategic and tactical conflict and flow management for diverse aircraft and operations

Integrated Operating Picture
Identify the requirements for a secure digital integrated operating picture that supports diverse and increasingly autonomous operations

Emergence of Diverse Vehicles and Missions

The Demand for Operations in the Stratosphere is Increasing



Why ETM?

- Air Traffic Control (ATC) services are limited in upper Class E and there are no provisions for scalability
- Industry needs:
  - Increased access and flexibility for their missions in this underutilized airspace
  - Fair / equitable access
- HAPS Alliance is invested in collaborative and cooperative intent sharing architecture for situation awareness

What is Upper Class E Traffic Management (ETM) and What are The Challenges?

- Like Unmanned Aircraft Systems Traffic Management (UTM) concept ETM adopts the:
  - Precedent community-based, cooperative approach to airspace integration and management
  - Provide data exchange and service-oriented information architecture for shared situational awareness
- Unique challenges in ETM:
  - Accommodate a diverse set of vehicles with a wide range of performance characteristics
  - Stratospheric conditions make communication, surveillance, and navigation challenging
  - Mission longevity and assortment of operating modes / use cases (e.g., point-to-point, loitering patterns or hovering)

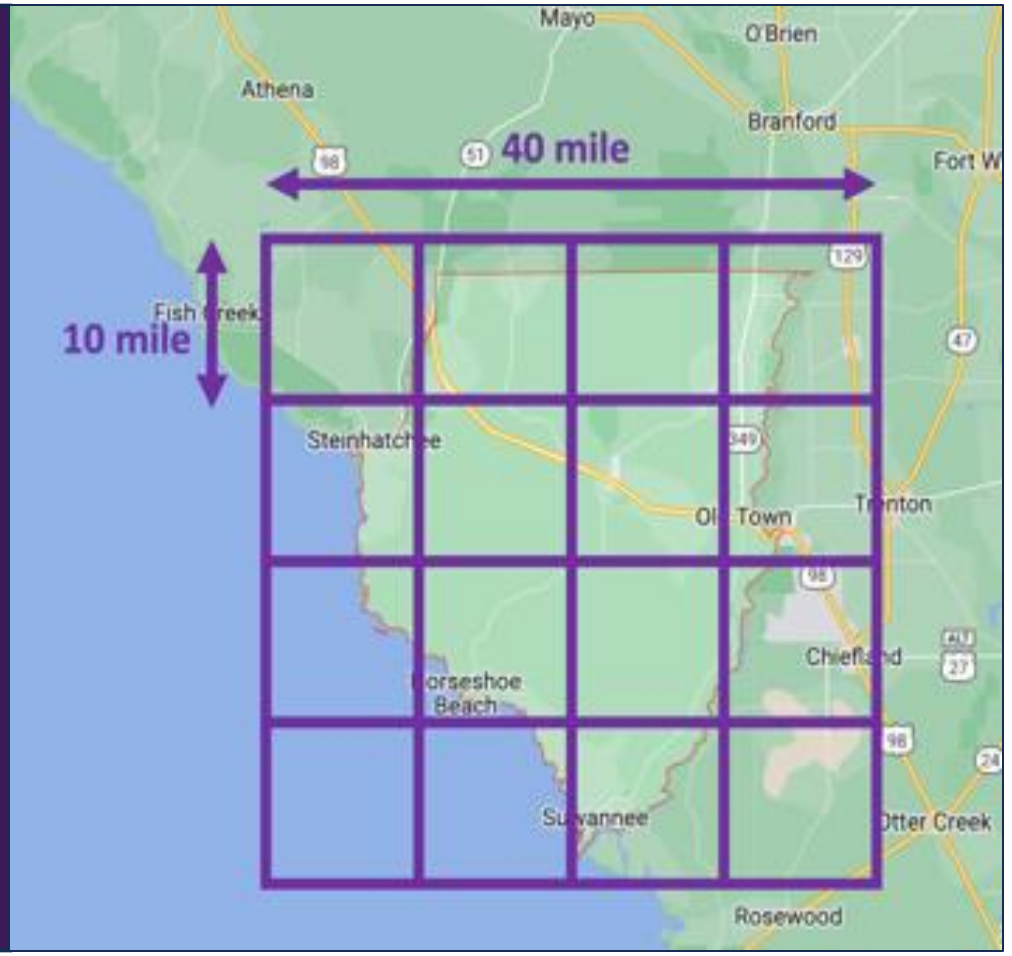
All these unique traits in ETM brought NASA / FAA / Industry partner together to discuss research and developments needed to design a fair and equitable approach to a collaborative and cooperative traffic management

Use Case for ETM

Enable ETM market viability

For High Altitude Operations to achieve commercial viability to serve the large and growing telecom, connectivity, and Earth observation markets, upper Class E airspace needs to provide:

- **Unsegregated airspace** to support collaborative operations
- Regulatory certainty to operate under **consistent fair set of cooperative operational practices**
- **Scalability** to provide intent sharing and situation awareness for cooperative separation
- **Flexibility for competition**, move away from "first-come first-served" ALTRV practices



Need to evolve towards upper Class E traffic management that is fair, while increasing efficiency

ETM Development

NASA / FAA / Industry Ongoing Collaboration			
2019-2020	**2021-2022**	**2023**	**2024**
ETM Tabletop #1 **April 18-19, 2019** **NASA Ames, CA**	**ETM Workshop** **July 21-22, 2021** **NASA/FAA Virtual**	**ETM Guided Discussion #2** **January 10-11, 2023** **NASA Ames - Virtual**	**ETM Guided Discussion #4** **March 12-13** **NASA Ames, CA**
Initial Discussions with Industry Stakeholders and FAA on Operational Needs and Principles for a Cooperative Traffic Management Concept	*Informational Briefings on ETM Concept Development and Breakout Groups for Operators to Discuss Interactions with Each Other in ETM Environment*	*Working Session with Industry Stakeholders Focusing on COPs Development for Strategic Conflict Detection*	*Working Session with Industry Stakeholders Focusing on Operational Intent Sharing*
ETM Tabletop #2 **December 12-13, 2019** **NASA Ames, CA**	**ETM Guided Discussion #1** **August 10-11, 2022** **FAA Washington, DC**	**ETM Guided Discussion #3** **August 9-10, 2023** **NASA Ames, CA**	**ETM Collaborative Evaluation CE-1** **June 2024** **NASA Ames, CA**
Concept Development Focusing on Upper Class E Operator Interactions with Air Traffic Control	*Working Session with Industry Stakeholders to Develop an Initial Set of Cooperative Operating Practices (COPs)*	*Working Session with Industry Stakeholders to Continue COPs Development*	*Invite ETM community partners to collaboratively evaluate COPs and connect to a prototype NASA research ETM System*
ETM Concept of Operations **FAA May 2020**			
An ETM construct must: Scale beyond current NAS infrastructure and promote shared situation awareness among Operators			

NASA continues to lead meetings with Industry and FAA to stay connected with latest developments

ETM Near-term Focus and Demonstration

Intent

- Demonstrate the use of ETM for cooperative conflict management between diverse aircraft in upper Class E airspace

Approach

- Evaluate a prototype NASA research ETM system
- Develop and refine ETM COPs and incorporate feedback from industry partners

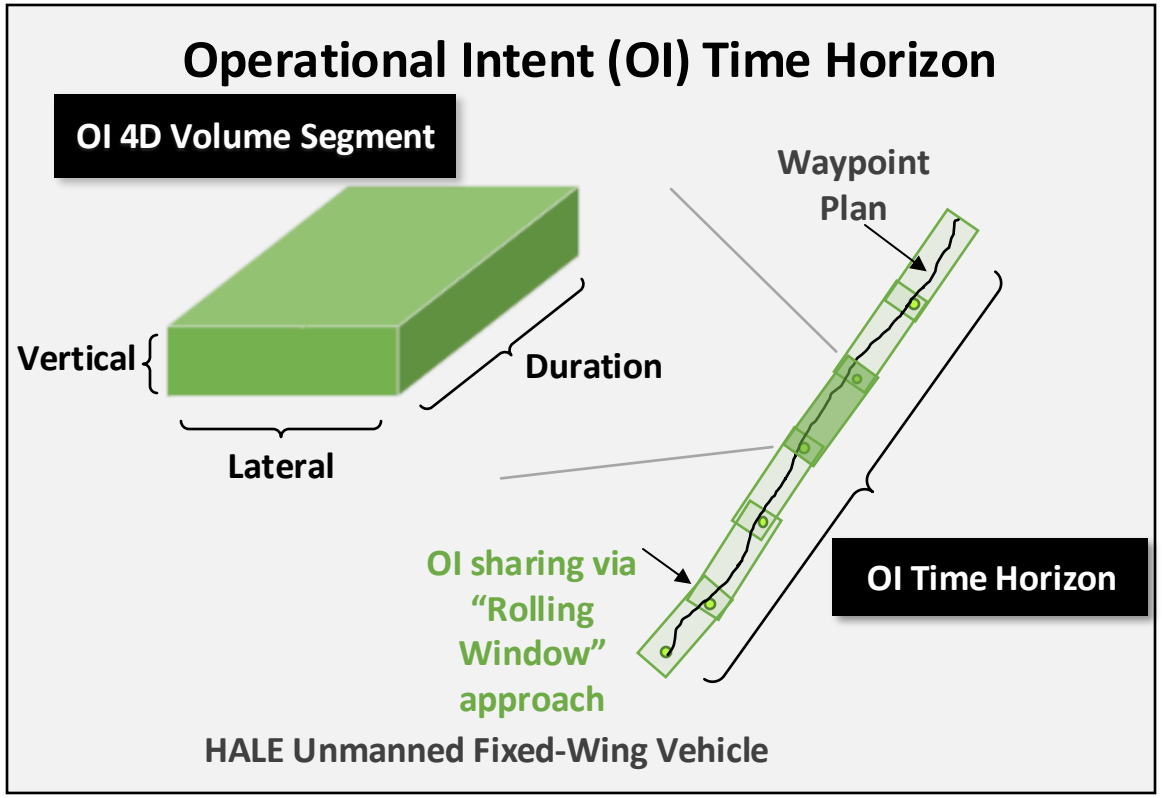
Near-term focus: ETM Collaborative Evaluation #1 (CE-1)

ETM Collaborative Evaluation #1 (CE-1) Research Objective

Invite ETM community / industry partners to connect to and collaboratively evaluate a prototyped NASA research ETM system, which allows for increased airspace access in upper Class E

- Operations to improve the effectiveness of intent sharing
- Capabilities to support cooperative interactions
- Procedures to provide more flexibility to operators

ETM Intent Sharing



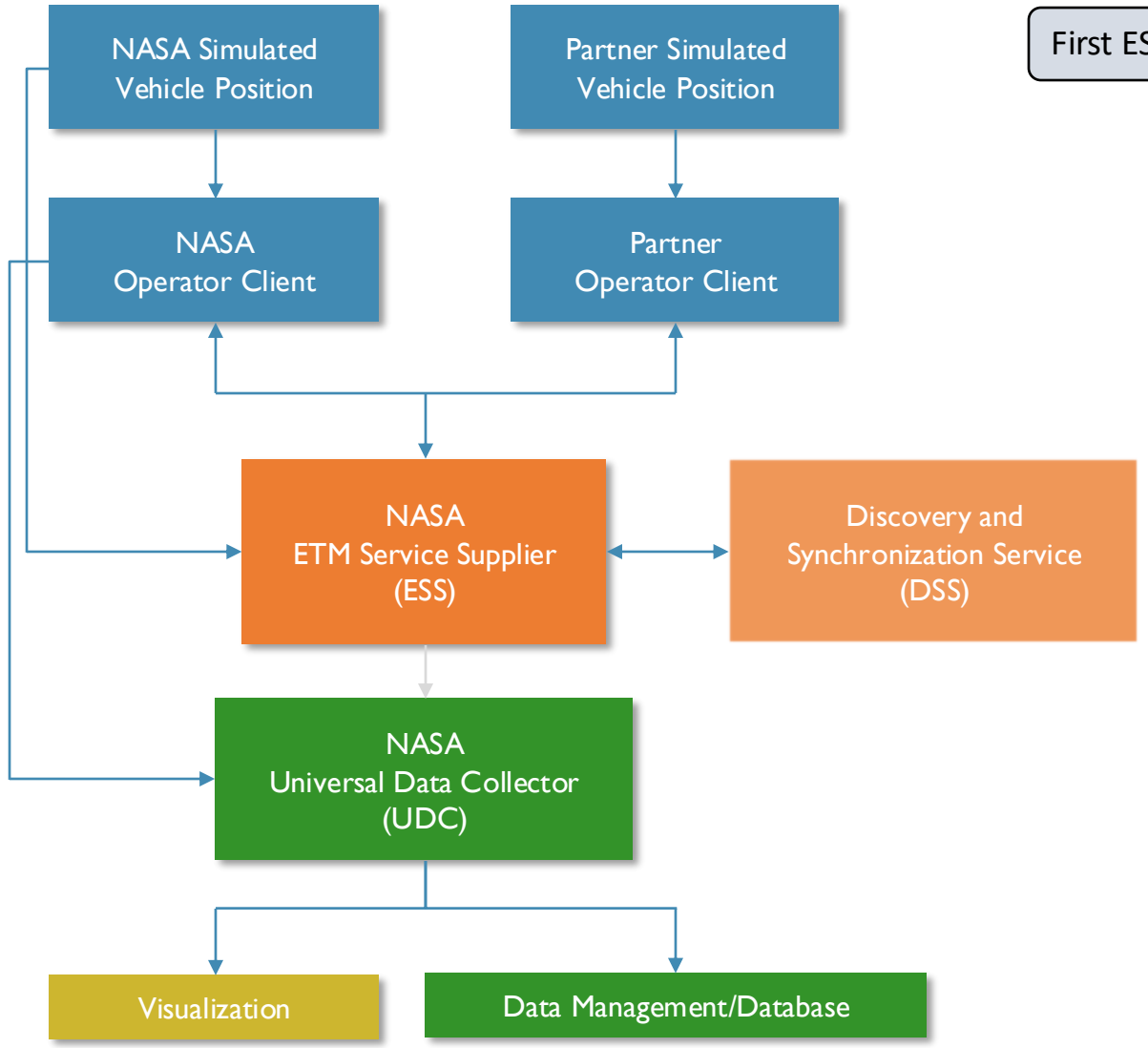
Required Parameters for Operational Intent (OI) 4D Volume for each segment

- Spatial – intended estimated trajectory of segment
- Temporal – duration of estimated trajectory of segment

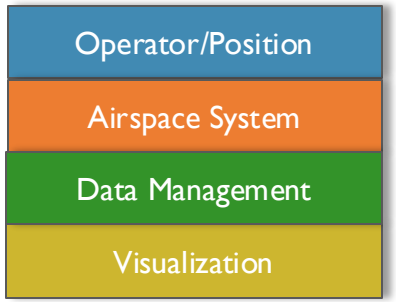
ETM CE-1 System Architecture

Automated Exchange Infrastructure

- Supports operation planning
- Operational Intent sharing
- Coordination of other operations to ensure cooperative situation awareness
- Strategic deconfliction protocols
- Conformance monitoring



First ESS Developed at NASA



ETM CE-1

- NASA hosted the first collaborative evaluation for the ETM concept
- Participants from NASA, Aerostar, and AeroVironment demonstrated the connectivity between the NASA-developed ETM Service Supplier (ESS) and the industry partners' software to explore notional procedures and information exchange requirements
  - OI (Operational Intent)
  - Cooperative Operating Practices (COPs)
- The simulation was conducted at the Airspace Operations Laboratory at NASA's Ames Research Center in connection with the two partner sites on June 25th – 27th

ETM CE-1 Key Details

- ETM community partners with Non-reimbursable Space Act Agreements (NRSAA) and Interconnect Security Agreements (ISA)
  - Aerostar
  - AeroVironment

- Partners provide and submit Operation Plans with OI 4D Volumes to NASA's prototype ESS

- Traffic setup with 4 high-altitude vehicles in / near a 40-mile by 40-mile region over Dixie County, FL

- 4 scenarios
  - OP / OI Submission
  - Strategic Conflict and Resolution: Wait-and-See
  - Strategic Conflict and Resolution: Maneuver
  - OI Conformance Monitoring
  - Loiter Scenario (Bonus)

ETM CE-1: Connectivity Tests and Demonstration

Preparation

- Establish connectivity
  - OAuth2 token
  - ETM Operator API
    - Object schema
    - Bi-directional communication
    - Post, Get, Put
    - Receive notifications and State changes from ESS
  - Verify OI sharing on prototyped NASA ETM Client (not evaluated)
- Construct scenarios and research questions on COPs

Execution

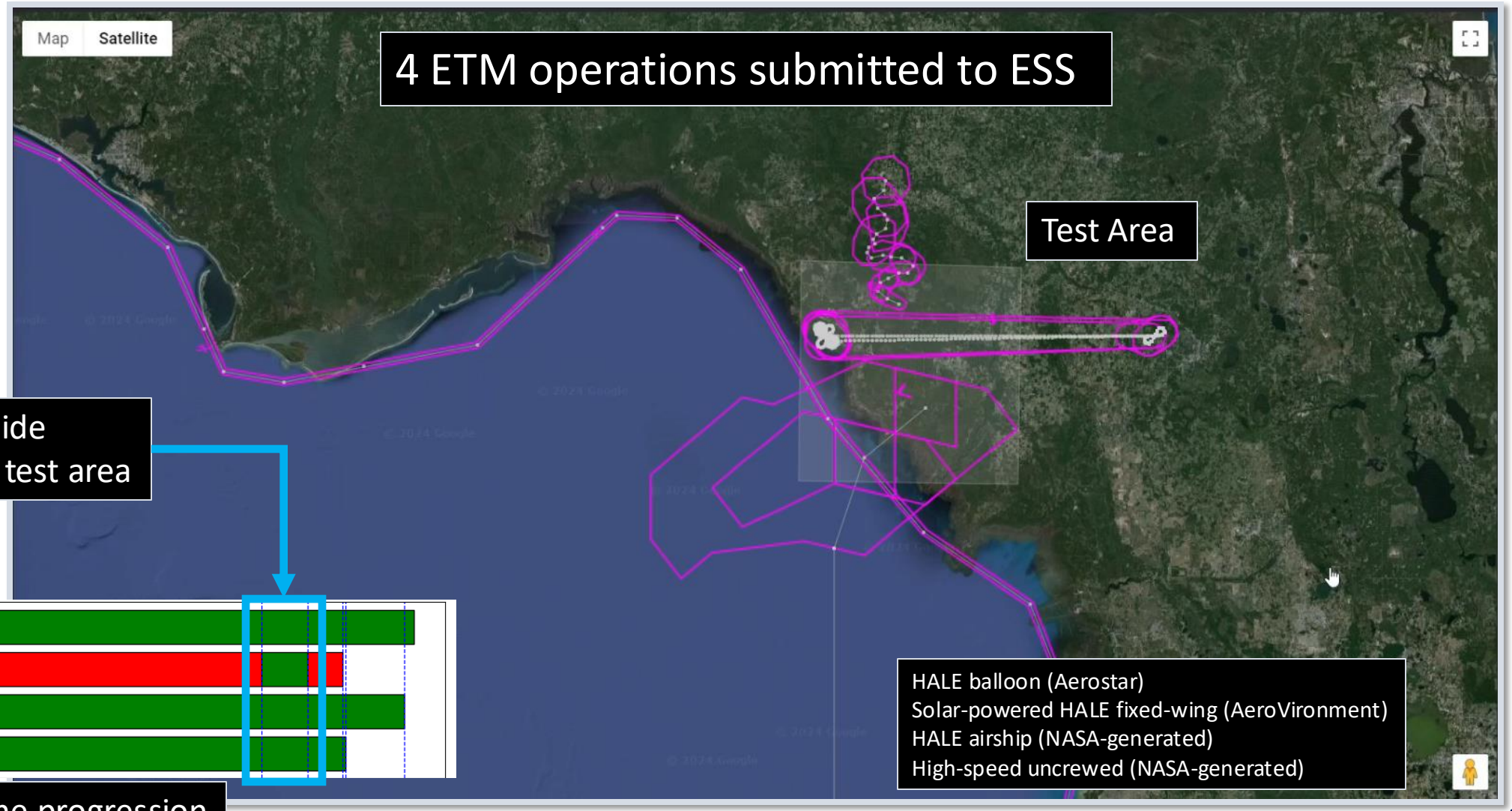
- CE-1 held June 25-27, 2024
  - 2 ½ days of simulation and data collection
  - 4 scenarios
    - 40 to 70-minute simulation runs
    - 30-minute discussions on COPs
    - 15-minute questionnaires (Engineers and Subject Matter Experts)
  - Post-simulation debrief and questionnaire

ETM CE-1 Simulation Platform

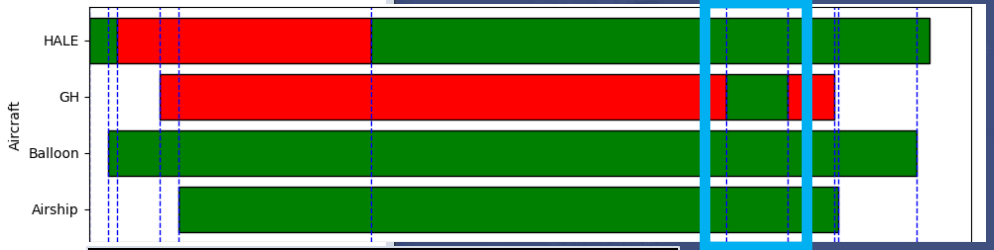
Airspace Operations Laboratory

Participants from NASA, Aerostar, and AeroVironment demonstrated the connectivity between the NASA-developed ETM Service Supplier (ESS) and the industry partners' software to explore notional procedures and information exchange requirements

ETM CE-1 Simulation



All 4 operations inside
40-mile by 40-mile test area



Simulation time progression

Preliminary Findings

- Connectivity
  - The connectivity between NASA ESS and partners' software was successful
- Operational Intent Sharing
  - APIs were used to detect and share OI intersection alerts to impacted operators and subsequent update on general Operation Plan (OP) information
  - Operators were able to increase the number of vehicles that could occupy the target airspace (40-mile by 40-mile) under ETM than would be possible under current day airspace procedures
- Cooperative Operating Practices
  - Feedback suggests that partners were comfortable with having an accurate set of OIs within a Minimum Lookahead Time Window to be used for strategic conflict detection and a more general Informational OIs for time horizon beyond that
  - Feedback suggests that partners were comfortable with the requirement to submit OIs that they could conform to within 95% conformance level
  - Feedback suggests that the procedures for detecting strategic conflicts, and the negotiation process were generally acceptable

Next Steps

Event	Date
Upper Class E Traffic Management (ETM) Collaborative Evaluation #1 (CE-1)	June 25-27, 2024
Initial rules of the road analysis and recommendations	End of 2024
ETM Industry Day (In-person Attendance Only)	February 11-12, 2025
Additional collaborative evaluation simulation	Next year
ETM transition to / from upper Class E	~2026