Roadmap to Cooperative Operating Practices for Strategic Conflict Detection and Resolution in the Upper Class E Traffic Management Concept

Connie L. Brasil
San José State University Research Foundation

Hyo-Sang Yoo
Universities Space Research Association

Paul U. Lee
NASA Ames Research Center

Deborah L. Bakowski
San José State University Research Foundation

Mark Evans
ASRC Federal Data Solutions

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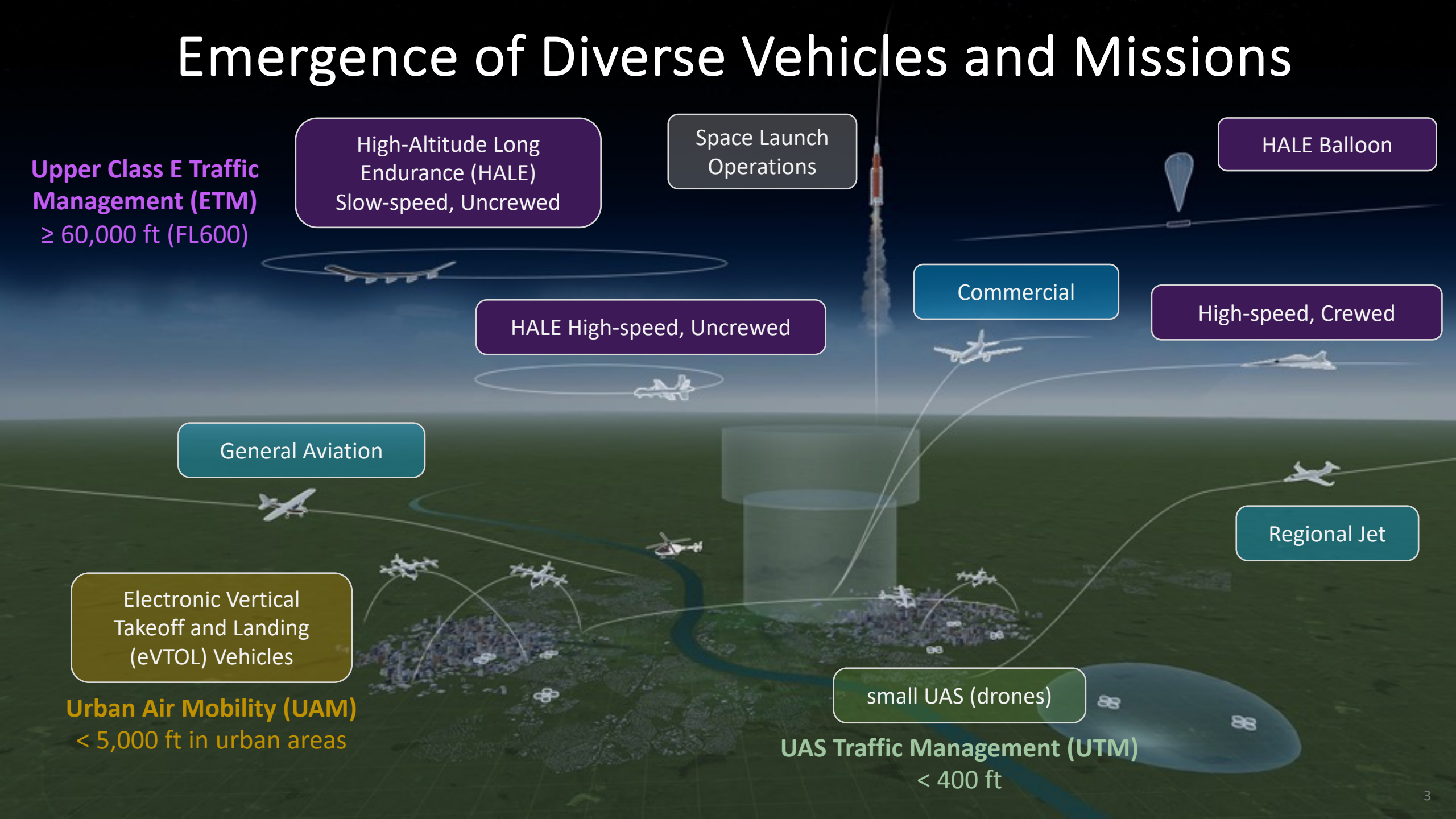
Agenda

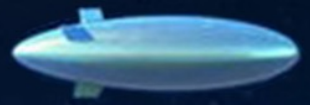
- **Upper Class E Traffic Management (ETM)**
  - Diverse Vehicles and Mission Types
  - Background
  - Concept Development
- **NASA ETM Industry Tabletop**
  - Defining Cooperative Operating Practices (COPs) for Strategic Deconfliction
  - ETM System Proposed for Conflict Separation Management
  - Overview and Objectives
  - Roadmap Following 3 Rounds of the ETM System Process
    - Round 1: Submit Operation Plan with Operational Intent (OI)
    - Round 2: Strategic Conflict Detection: Intersecting OI
    - Round 3: COPs for Strategic De-confliction and Mitigation
- **Conclusions and Next Steps**

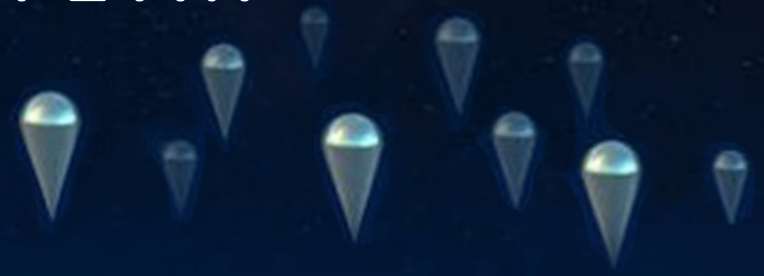
Emergence of Diverse Vehicles and Missions



Diverse Set of Vehicles in ETM

High-Altitude Long Endurance (HALE)





HALE Airship, Uncrewed

Communications and research capabilities

- More propulsion control than balloons, but maneuverability may still be limited
- Energy dependent
- Susceptible to wind

HALE Balloon, Uncrewed

Internet and telecommunications services; connectivity in unserved areas

- Limited vertical control to ascend, descend or hold altitude
- No real lateral position control
- Wind dependent
- Can provide an *estimated flight path*

HALE Slow-Speed, Fixed-Wing, Uncrewed Vehicle

Telecommunications base/platform, high-resolution observation

- Slow Spiral ascent / descent patterns.
- Have propulsion control
- Dependent on battery power
- Susceptible to wind

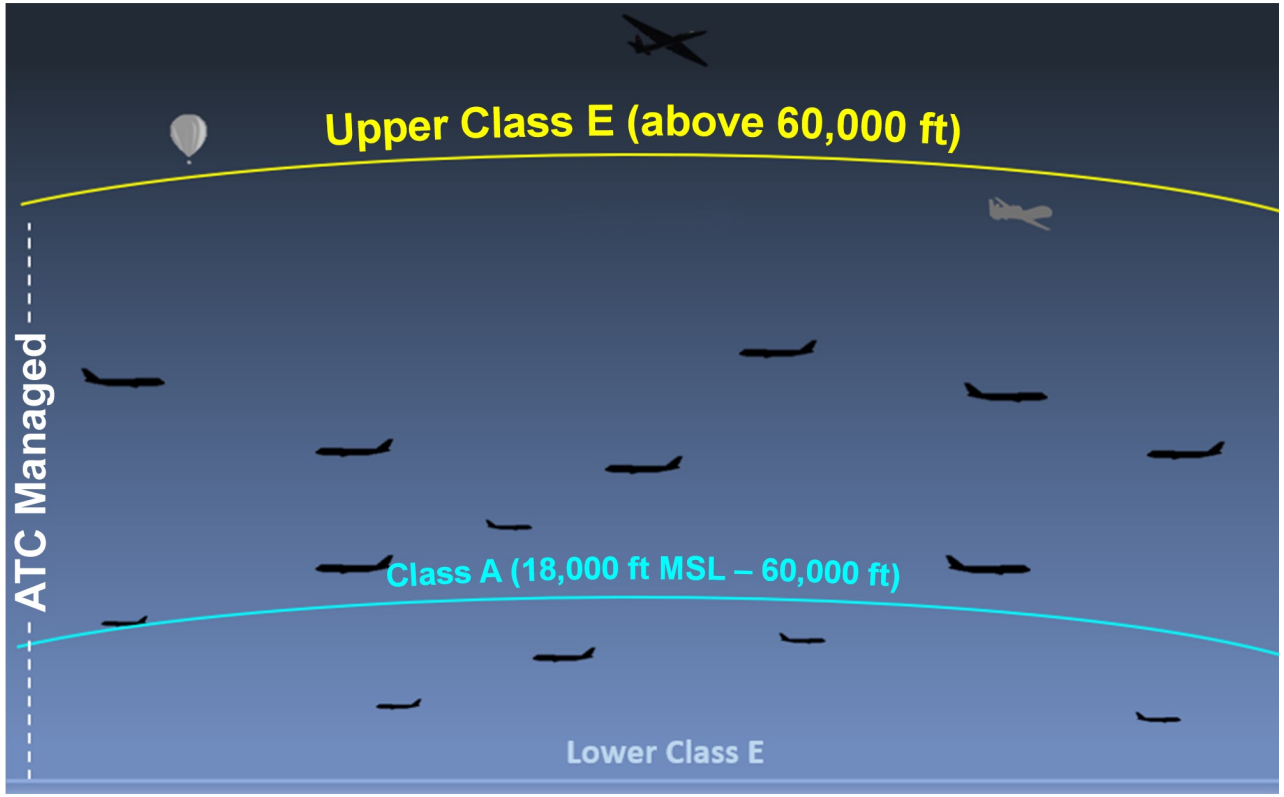
High-Speed, Fixed-Wing, Uncrewed
High-Speed, Fixed-Wing, Crewed Vehicles

Global Hawk for research/surveillance; Passenger transportation

- High-performance capabilities, expected to operate like conventional, piloted aircraft

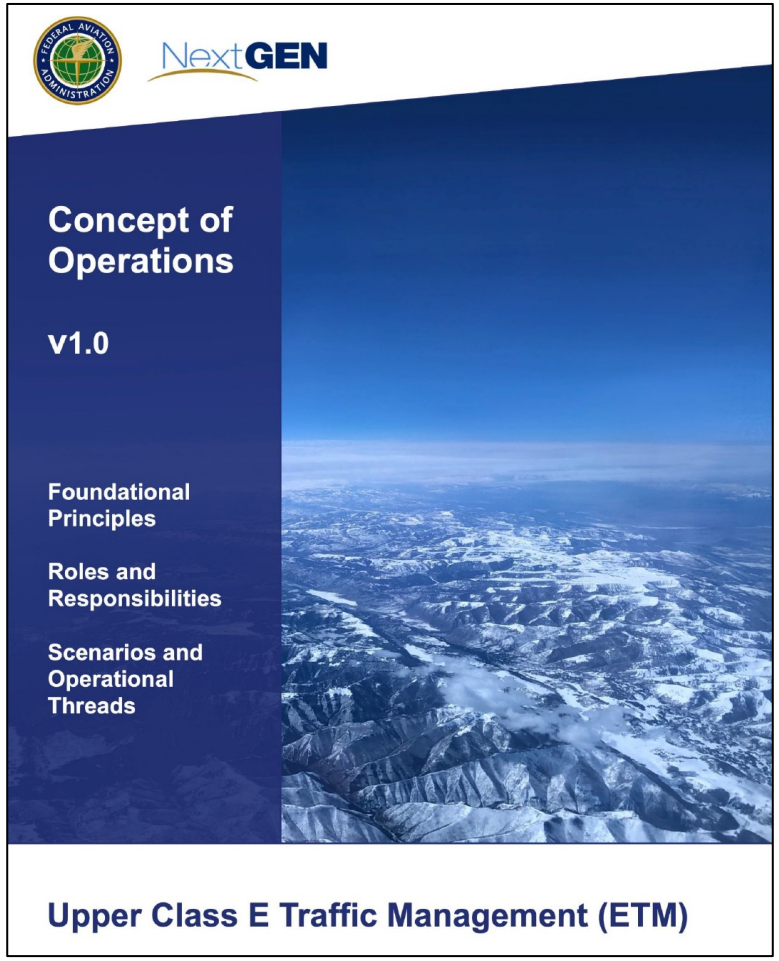
Upper Class E Background

- Upper Class E Airspace $\geq$ 60,000 ft
  - Currently for military/science operations
  - Infrequently used for civil aircraft
- No provisions for scalability of traffic management infrastructure
- New generation of high-altitude aircraft expected to increase
  - Research enterprises
  - Surveillance missions
  - Communications services
  - Space Tourism (~balloons)



Upper Class E Traffic Management (ETM) Concept

- FAA is developing ETM as an approach to traffic management in Upper Class E
- Like the UTM and UAM environments, ETM relies on:
  - Community-based, cooperative traffic management concept
  - Highly automated information exchange infrastructure
- FAA, NASA, and the ETM community are working together to advance the concept
- NASA is conducting research and simulations to help develop, evaluate, and mature the ETM concept to meet the expected demand



FAA, Upper E Traffic Management (ETM) Concept of Operations v1.0, https://nari.arc.nasa.gov/sites/default/files/attachments/ETM_ConOps_V1.0.pdf

ETM Industry: Tabletop

Defining Notions of Cooperative Operating Practices

January 10-11, 2023

Upper Class E Traffic Management (ETM)

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Cooperative Operating Practices (COPs) Defined

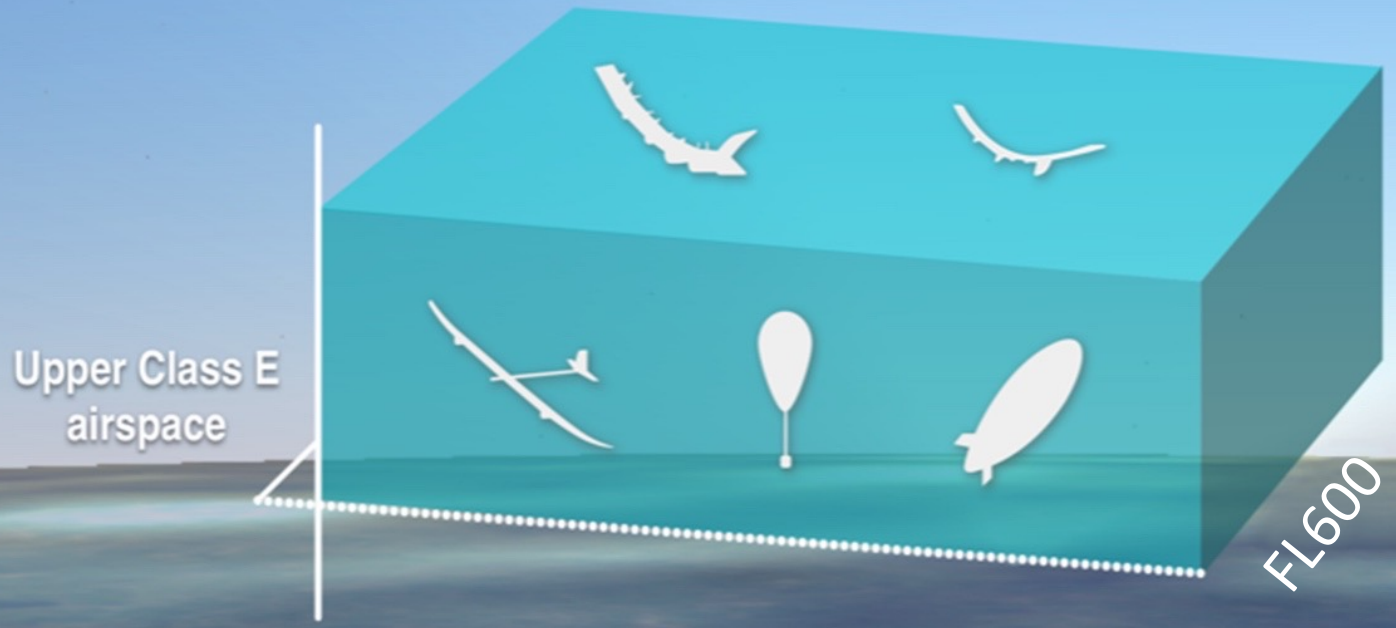
COPs are operator-defined, FAA-approved practices that define how airspace users will conduct their operations in concert with all stakeholders

COPs are a set of pre-agreed operating rules and procedures to maintain separation while promoting safety, cooperatively, fairly and equitably

Industry Areas of Focus

- Rules for the Establishment and Enforcement of COPs
- Equity and Airspace Usage
- Information Exchange
- Demand and Capacity Balancing
- Conflict Management (NASA Tabletop Focus)
  - Operational Intent Volumes
  - Intent Update Rate
  - Intent Lookahead Horizon
  - Strategic Conflict Detection
  - Strategic Conflict De-Confliction & Resolution
- Off-Nominal and Emergency Situations

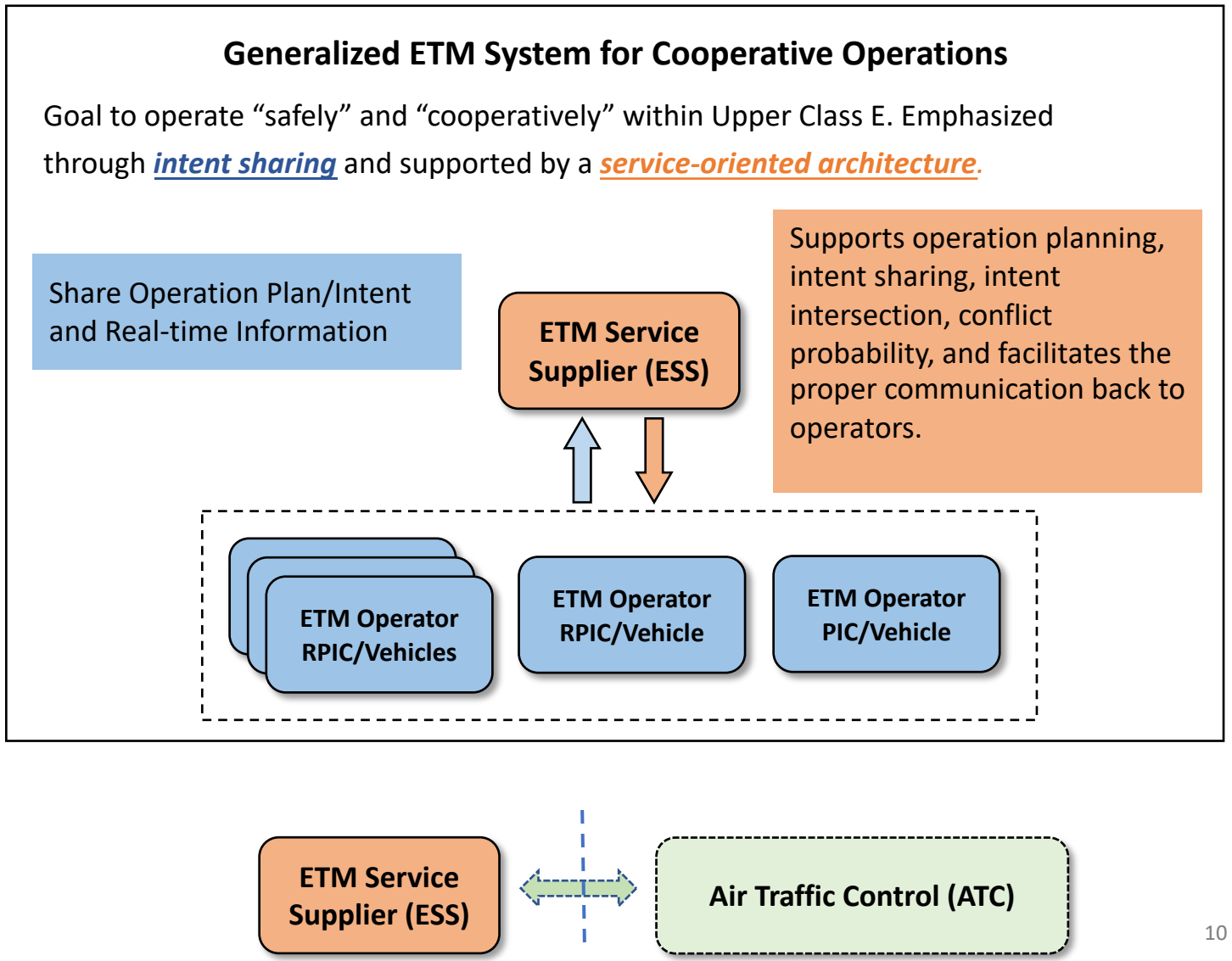
ETM Cooperative ‘Separation’ Management



- Air Traffic Control does not provide separation services – not responsible for separating, managing, or communicating with the ETM operations
- Cooperative Traffic Management requires *Cooperative Separation* based on shared flight intent and data exchanges between ETM Operators
- Shared situation awareness provisioned through a service-oriented architecture

ETM System for Cooperative Operations

- Automated information exchange infrastructure
- ETM operators will use a set of tools, automation, and services to support cooperative operations
- Ensuring cooperative Situation Awareness
- **ETM Service Supplier (ESS)**
  - An operator tool that supports operations planning, intent sharing, coordinating, monitoring and de-confliction protocols.
  - Share information not only to connect operators but to facilitate information exchange between ETM and ATC.



Tabletop Overview

- 7-8 Participants each day
- Representing 7 different companies
  - **Balloon**
  - **Balloon/Airship (or Hybrid)**
  - **Slow Fixed-wing HALE**
- Goal was to *leverage industry expertise* and *come to consensus* on various aspects of ETM cooperative operations for strategic conflict mediation
- Assume *nominal* conditions within ETM when discussing each event
- Introduction of the *system process* for each of the three round
- Training for the *technical components* needed to build incite into COPs
- A guided discussion with some directed questions was then followed by online survey for any further thoughts and specifics for each concept

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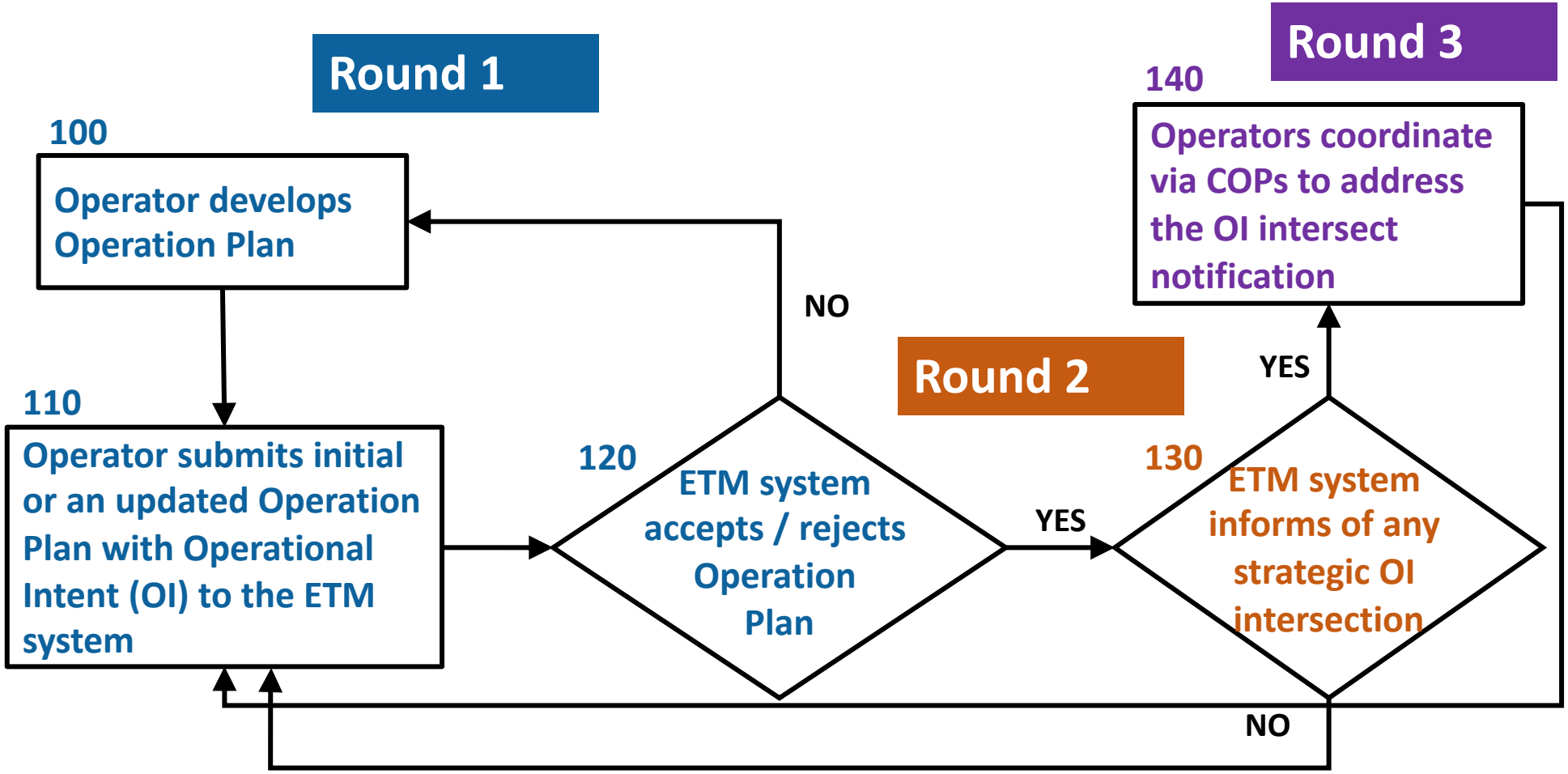
Tabletop Training Objectives

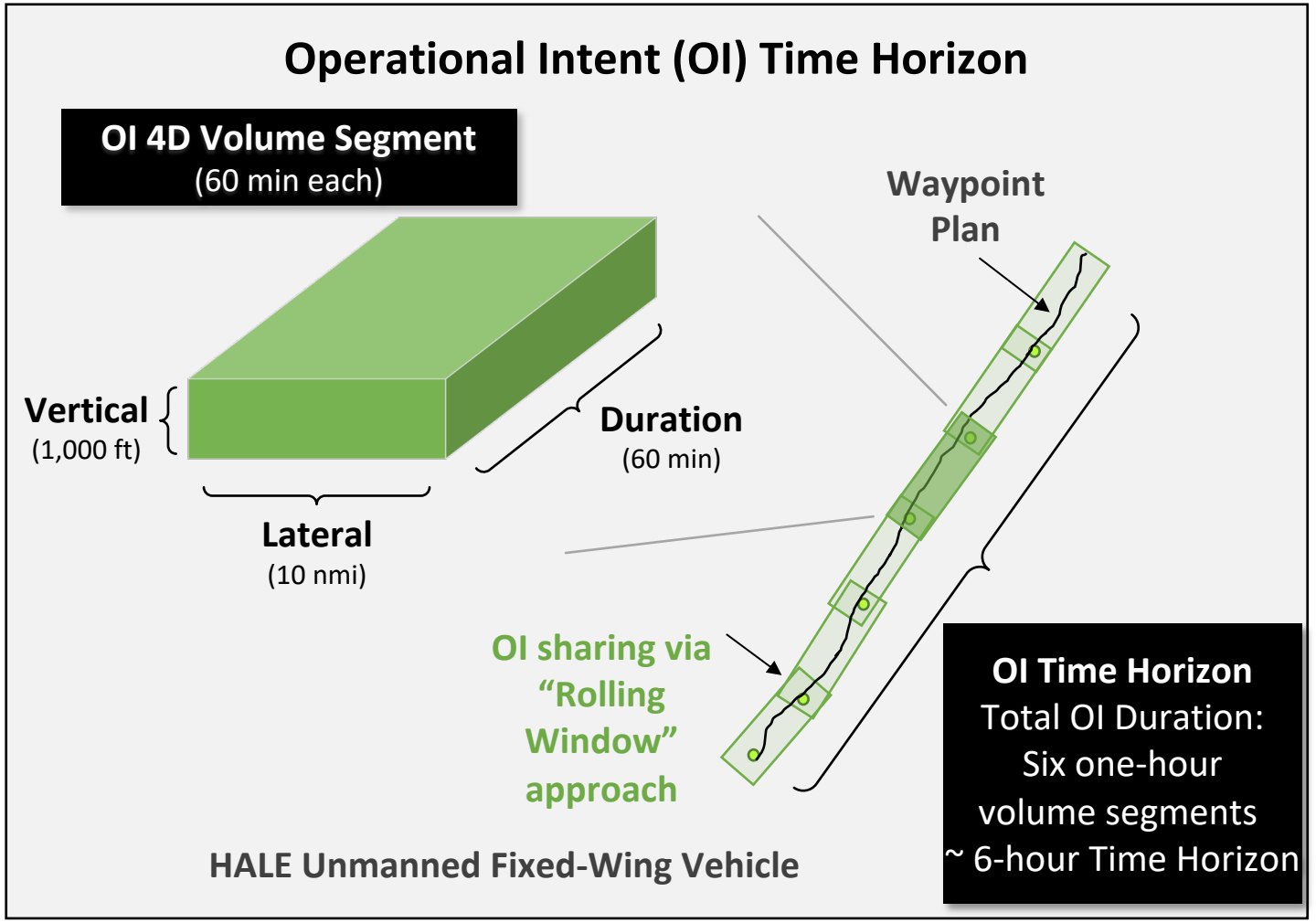
- **Be familiar with the path to COPs for strategic deconfliction focusing on 3 main 'rounds'**
  - *Round 1*: Submit Operation Plan with Operational Intent (OI)
    - OI Characteristics and NASA research on OI Generation options/services
    - NASA research on OI Containment Confidence Levels (CCL)
  - *Round 2*: Strategic Conflict Detection: Intersecting OI
    - Impact of the OI size, update cycle and CCL
    - NASA research on Conflict Probability (CP) and corresponding threshold criteria
    - Define Decision Point (wait or take-action)
  - *Round 3*: COPs for Strategic De-confliction and Mediation
    - Process
    - Agreements
    - Actions

Roadmap to COPs for Cooperative Separation



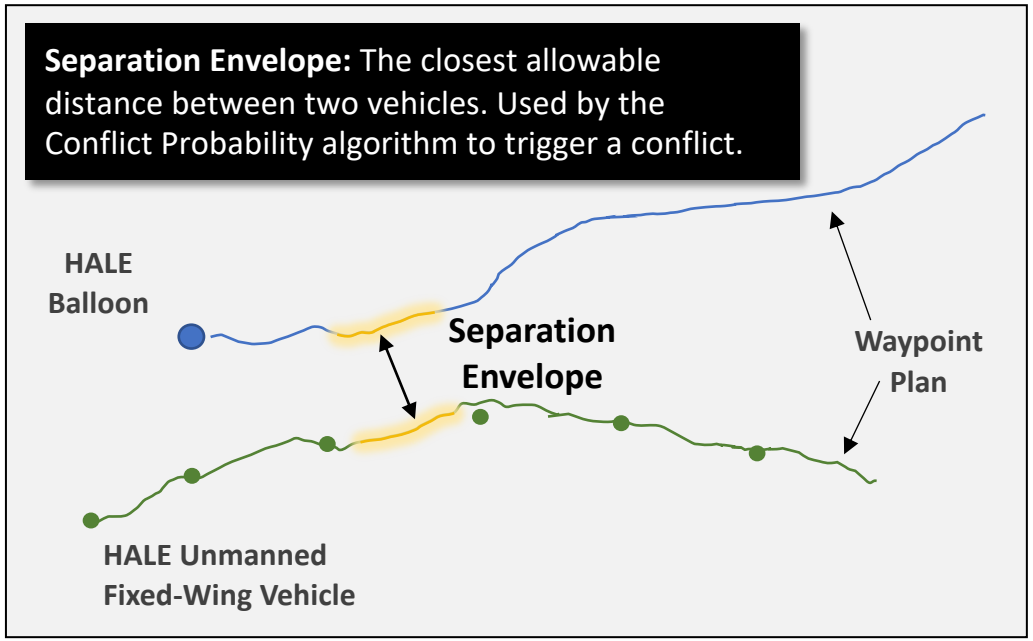
Round 1: Submit Operation Plan with Operational Intent

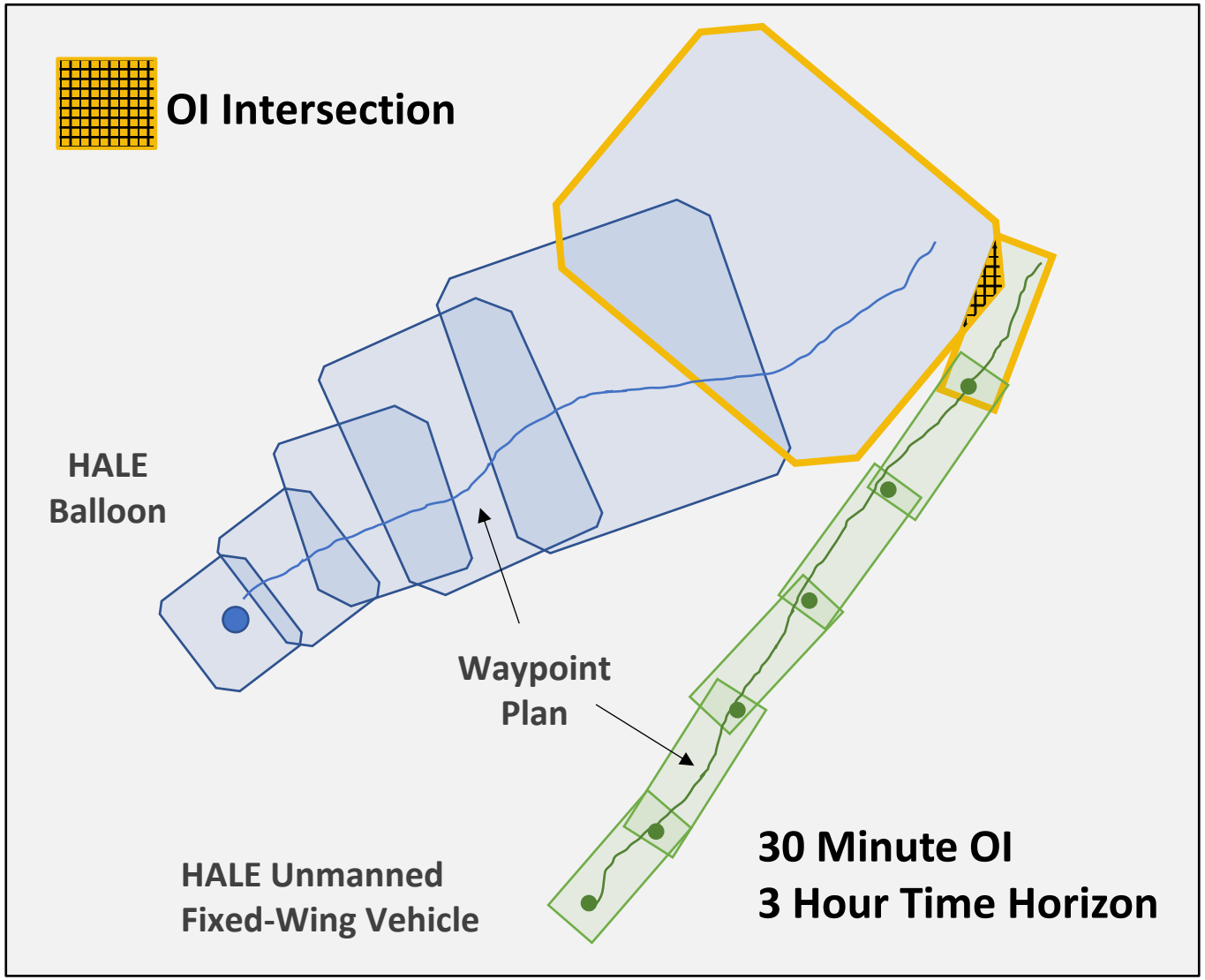
- **Operation Plan (OP)**
  - Operator Information
  - Vehicle Information
  - Mission Information
- **Operational Intent (OI)**
  - OI 4D Volumes
  - OI Time Horizon
  - OI Containment Confidence Level
  - OI Update Rates (*rolling window*)
- **ETM System (ESS) Accepts / Rejects Operation Plan/Intent**



Round 2: Strategic Conflict Detection

- **Operational Intent (OI) Intersect**
  - Trigger point
  - Parameters to assess situation
  - Conflict probability/likelihood
  - Decision points
    - Wait-and-See
    - Take-action





Round 3: Strategic Conflict De-confliction

https://www.freeimages.com/

- **Proposed COPs for Strategic De-confliction Mediation**
  - Process
    - System notification with 'Minimum Lookahead' time
  - Negotiation
    - Ad-hoc
    - Pre-Agreed
    - Dynamic
  - COP Agreements
    - Immediate and frequent update of OI with more accurate position information
    - Both parties participate in maneuver action
    - Develop pair-wise maneuver matrix
  - Actions
    - What *can* you do and what do you *want* to do?
    - Balloon Maneuvers: Ascend, descend, temporary altitude hold, or terminate flight
    - Airship Maneuvers: Increase speed, decrease speed, change course, ascend, descend, or hold altitude
    - Slow Fixed-Wing Maneuvers: Increase speed, decrease speed, change course, ascend, or descend

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Conclusions for Round 1

Round 1: Submit Operation Plan with Operational Intent

- COPs for Operational Intent Volume (2 proposed stages)

1. Informational Volumes: Provide situation awareness of the *mission plan*
    1. Long duration, with low CCL, and no size constraint
    2. No action needed for OI intersection detected past the defined ***minimum*** **lookahead time** threshold
    3. No set OI update rate, but participants agreed that a *minimum* update rate is needed ('heartbeat' in system)

2. Conflict Intersect Volumes: Provide situation awareness for *strategic conflict detection*
    1. Shorter duration, with a *high* CCL (95–99%), smallest size to ensure conformance
    2. Action taken based on the *minimum negotiation and maneuver time* (***minimum*** **lookahead time)**
    3. Users agree to then update OI frequently, believing that frequent updates will strategically resolve most OI intersections.

Conclusions for Round 2

Round 2: Strategic Conflict Detection

- COPs for Operational Intent Intersect

1. Consensus on trigger for strategic conflict detection being *OI intersect*
   - *Minimum* lookahead time – which includes the time for negotiation and the time to make a maneuver
   - Based on >95% CCL of position in OI
2. Participants expressed concern that *standardized* separation thresholds would be too conservative
   - Prefer to set their own conflict alert notification thresholds (Risk tolerance)
   - Agreed to some basic collaborative rules to form COPs (i.e., if one operator decides that they think an action should be taken, then both operators should engage)
3. A common wind source was not deemed critical to the strategic conflict detection process
   - OI and CCL will be built from their best models and interpretations
   - 'Trust in the process' (Auditor function)
4. Embedding the CP calculation within their OI is preferred
   - OIs reflect the best vehicle performance, environmental factors, and likelihood based on the separation envelope then OI intersection and conflict probabilities/likelihood provide the same function

Conclusions for Round 3

Round 3: Strategic Conflict De-confliction

- COPs for Strategic De-confliction Mediation
  1. Consensus was to go through the *ad hoc, free negotiation* stage first and learn from that process
  2. COPs should be more about procedures rather than requirements or standardization
     - Both parties participate in a maneuver action
     - Multiple operators in one area may develop a set of COPs procedures amongst themselves
  3. Become more comfortable with flying vehicles closer to one another and minimizing the separation envelope, thus, decreasing the incidence of conflict detection and the subsequent need for resolution.
  4. Potential for predefined agreements included the following strategies or actions:
     - a wait-and-watch strategy
     - the most performant operator moves
     - both operators move
     - vehicle-to-vehicle agreements
     - company-to-company agreements
     - shrink the OI for x amount of time
     - stop and hover / loiter for x amount of time

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Next Steps for ETM

- ETM tabletop provided great insight to the NASA research team by the industry partners
- Main goal of tabletop was to drive the research and prototyping requirements to conduct a collaborative evaluation with a set of partners early next year
- Future Research:
  - Define the ***minimum*** **lookahead time** (time to negotiate and time to make a maneuver) for each vehicle type
  - Development of an algorithm to help negotiate and / or decide who should make the maneuver to deconflict and what type of maneuver that should be (*Dynamic Negotiation*)
  - Addition of an *auditing service* to ensure that users properly and accurately share OIs that their vehicle can, indeed, conform to at a 95% or greater level of confidence
  - Extra testing and technical exchange regarding assessing the ***conflict probability*** / likelihood calculations

ETM Research at NASA Ames

Airspace Operations Laboratory (AOL)

- NASA, along with FAA and Industry, is planning a series of collaborative research activities to validate ETM operations and mature the ETM concept
- Collaborative Evaluation #1 (2024)
  - Explore NASA functionality developed for ETM Cooperative Operations
  - Build COPs specific to Strategic Conflict Management
  - Invite ETM community partners for evaluation and exploration of a prototype research ETM system

Thank You!

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