Upper E Traffic Management (ETM) Tabletop Summary
NASA Ames Research Center, April 18, 2019
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1 Introduction

The Upper E Traffic Management (ETM) Tabletop meeting was hosted at National Aeronautics and Space Administration (NASA) Ames Research Center on April 18, 2019 with participants from industry, International Civil Aviation Organization (ICAO), Department of Defense (DoD), NASA, and the Federal Aviation Administration (FAA) (see Appendix A for a list of attendees). The objectives of the Tabletop meeting were:

- Gain an understanding of planned operations above Flight Level (FL) 600 and begin discussions around a concept of operations for ETM
- Introduce and gain consensus on common principles, assumptions, terms, and conceptual elements
- Discuss varying types of vehicles & profiles in operational phases of flight and their impacts on traffic management above FL600
- Explore various Scenarios and their associated operational threads
- Provide input to an initial Concept of Operations (ConOps) through scenario-driven tabletop exercises and discussions - leveraging principles of other related traffic management concepts and practices

To accomplish the objectives of the Tabletop, proposed ETM principles and assumptions, and a lexicon were presented to establish common ground and solicit feedback about foundational ETM conceptual elements. High-level scenarios/situations were also presented to stimulate discussion about particular aspects of ETM. Scenarios included:

1. Transition into ETM
2. Strategic Deconfliction between Operations (Pre-Flight)
3. Deconfliction between Pre-Flight and Active Operations
4. Planned Overlapping Areas of Supersonic & HALE Operations
5. Tactical Deconfliction
6. Off-Nominal Event

This document summarizes the major points from the resulting discussions. The goal is to ensure that all participants have a common, accurate understanding of the proceedings, areas of agreement, and actions. Major talking points surrounding vehicle characteristics, ETM principles and assumptions, equity and access, and ETM airspace management are summarized in their respective sections. Areas of agreement regarding development approach and ETM conceptual elements are summarized in the ‘Agreed upon Conceptual Elements’ section of the document. Actions are presented in the ‘Actions’ Section. Meeting slides are included in Appendix B.
2 Vehicle Characteristics and Operational Profiles

Industry participants described their different vehicle types, including respective performance characteristics and limitations, and operational profiles. Current air traffic control (ATC) handling practices to and from upper E airspace (FL600) were also discussed.

Balloons and High-Altitude Airships

On ascent, operators provide ATC an estimated flight path (not a traditional flight plan). They notify ATC prior to launch and track the balloon via web application. Neither lateral positioning nor rate of ascent can be controlled, it can only descend. The vehicles have limited ability to act or respond to unforeseen events. ATC segregates traffic from the vehicle. The balloons are equipped with transponders. Position information is provided in the event the balloon is not visible on radar. Operating altitude ranges from FL500 to above FL600.

High-Altitude Long Endurance (HALE)

In Class A airspace, operators file a typical Instrument Flight Rule (IFR) flight plan based on winds. Transit is performed via a spiral pattern or a climb/descent based on winds. Since the vehicle is susceptible to winds, flexibility is often an important aspect of transit. Climb is slow (~ 4 knots). ATC segregates traffic during transit. Like balloons, the HALE has issues with wind and cannot keep station. They rely on traffic advisories for awareness. Above a certain flight level, ATC may terminate the IFR flight plan. Operational altitude typically ranges from FL650 to FL850.

Supersonic

Supersonic aircraft are expected to operate like a typical aircraft in Class A (similar to current subsonic operations). Operating altitude will vary according to speed constraints (dip below FL600 when operating at lower speed), as a result, operating altitude will range from FL580 to above FL600. In the event of a solar flare, supersonic aircraft would need to descend quickly.

3 ETM Principles and Assumptions

To enable safe management of increased traffic and novel operations in upper E airspace, an upper E airspace management concept, ETM, is being explored. The objective of ETM is to explore solutions that scale beyond the current ATM infrastructure. Solutions that extend beyond the current paradigm to those that promote shared situational awareness among operators are needed that accommodate government operational needs and national security interests.

Major discussion points during the tabletop surrounding general ETM concept principles, assumptions, and lexicon are summarized as follows:
• Currently there is limited infrastructure in place to provide scalable separation services (positive control) in Upper E airspace. A cooperative approach to separation and situation awareness is a potential solution to this capability gap.

• The FAA has and will maintain regulatory and operational authority over all airspace including upper Class E over FL600. ‘Authority’ does not mean having direct contact with aircraft. The FAA exercises authority when it agrees to the rules that industry proposes.

• ETM must satisfy safety and security expectations and standards commensurate with air traffic management (ATM).

• The term Air Navigation Service Provider (ANSP) in the ETM context refers to the FAA in the US, but can differ according to the airspace in which one is operating (international differences).

• ETM needs to accommodate a large range of operations with vastly different performance characteristics and operational profiles (e.g., loiter vs. point to point) with limited infrastructure, including unmanned aircraft systems (UAS), military, commercial space, and commercial transport operations. Increased operational tempo will increase competition for the airspace and creates the need for strong equity rules and airspace management principles.

• Development efforts must account for the needs of state aircraft and those not operating cooperatively above FL600. Cooperative/non cooperative management is critical.

• Due consideration must be given to global interoperability while developing ETM concepts and requirements. Sensitivity must be given to geopolitical environments. Goal is to stay practical and flexible in approach to allow growth. We must also maintain awareness and be mindful of related work being done outside this forum including European Union Aviation Safety Agency (EASA), Civil Air Navigation Services Organisation (CANSO), the UAS Advisory Group, and ICAO. Industry plans to have a cooperative agreement with Single European Sky ATM Research (SESAR) by June 2019.

• There will need to be international agreement on a decentralized model - national security and other issues will need to be accommodated in ETM. Although this process is not without complications - it is doable. The goal is to present countries with proposed services and a framework with the objective of getting them to rethink traditional systems and be open minded to solutions. ICAO can support this process. There may be sovereign countries who do not want to participate, but industry should not hook their business models to an expectation that other countries will not engage.

• The current floor of ETM operations is FL600. Industry expects to operate FL500 up to FL850. Several industry attendees’ operations will straddle this ETM/ATM airspace due to the nature of their operations and would like to discuss change of Class A convention where/when possible. The FAA cannot change the FL600 threshold but is open to extending ETM operations below 600 where/when/if possible.
There is potential for the application of UAS Traffic Management (UTM) concepts in the ETM environment. Industry should read UTM documents for consideration in the ETM environment\(^1\),\(^2\).

The concept of UAS Service Suppliers (USSs) (as presented in the UTM concept) may be helpful to enable operator to operator data exchange and strategically de-conflict operations in the cooperative ETM environment. A USS network allows operators to share their intent information and de-conflict from one another (according to a set of built-in business rules). A centralized repository for situation awareness without the complexity of deconfliction rules could be an initial step in ETM. More complexity could be added gradually. The system would need to be sufficiently flexible for global application. ICAO will support adaptation at the international level once a framework is sufficiently developed. Industry intends to build the platform, potentially with NASA’s help.

Deconfliction through position reporting to a shared network (in lieu of surveillance by broadcast or interrogation) is another strategy that ETM could employ to de-conflict flights (e.g., ATM Oceanic separation model). Position reports enable trajectory model predictions to identify potential conflicts (e.g., conflict probe). An ETM version of this separation management technique could present opportunities for high fidelity technological solutions.

### 4 Equity and Access Rules for a Cooperative Environment

Equity and access rules encompassed a significant portion of the Tabletop discussion. Due to vehicle operating disparities, long range missions, potential need for large airspace blocks, and other factors, ETM will require new, complex equity rules and rules of the road. Major discussion points regarding equity and access rules are summarized:

- Industry will take on the responsibility of developing strategic and tactical equity and access rules for the cooperative environment.

- Industry will leverage ATM/Space Laws to the extent practical to develop equity rules, operating rules of the road, and priority access guidelines - but inherent differences within the ETM environment will limit application. ATM equity rules are predicated on different factors (e.g.,

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point-to-point operations, duration of flight, limited gates and runways). NASA may be able to help with this piece.

- Transparent business rules for equity of airspace access are foundational. The process by which rules are modified or adapted must also be transparent so they can evolve with flexibility.

- Business rules can be built into a decentralized (no central authority), internet connected application programming interface (API) that strategically deconflicts operations and resolves competition for airspace when operator intent information is shared.

- Industry will take a gradual approach to developing and proposing business rules for the cooperative environment – starting simple and building as density increases. If industry developed business rules or actions are determined to adversely impact expectations such as equity, access, or the competitive environment, FAA may require changes. Additionally, should industry-proposed rules and processes inadequately reconcile demand/capacity imbalances in the cooperative environment, the FAA may issue specific directives/protocols to resolve them.

- ETM needs a means for deciding how international entities will get access to the airspace. Industry will start with a review of how they get access today.

- ETM needs a means of reporting and enforcement for business rule/agreed process violations. A corporate consortium could be established to adjudicate industry developed rule violations that are not safety related (e.g., equity rule violation). Under this paradigm, operator (domestic or international) violations of consortium developed rules would result in agreed consequences. Industry will develop and enforce rules and guidelines for the cooperative environment. Safety risk violations will be managed by the FAA (e.g., violations to safety envelopes).

- Proposed considerations for equity rule development in the event of competition include: 1) compromise based on value of airspace (e.g., compensate others for priority), 2) efficient use of airspace (those that need less get priority), 3) maneuverability scale dictates terms (more maneuverable vehicle gets priority), and 4) operational profile dictates priority.

5 ETM Airspace Management

The summaries of Tabletop discussions regarding ETM airspace management are broken up into 5 categories: airspace management for ATM and ETM, transition to/from ETM, strategic deconfliction, tactical deconfliction, and off-nominal operations. Major discussion points regarding airspace management are as follows:

5.1 Airspace Management for ATM & ETM
• Performance of vehicles using the airspace will vary significantly. Performance of certain vehicles may also vary significantly as a function of external and environmental constraints.

• Industry suggests equipping with capabilities to reduce separation as much as safely possible in both the ATM and ETM environments to reduce impacts of each operation to the furthest extent possible.

• Industry needs to determine, and consistent with standard safety cases, propose safe distances for vehicles operating in both ATM and ETM environments. Industry wants performance-based separation criteria rather than specific separation minima. Industry will collectively develop a separation model and perform analyses to determine safe distances between vehicles (e.g., HALE vs supersonic). Safe distances will need to be presented to the FAA for verification and approval. NASA is prepared to work with industry in the exploration of these considerations.

• The FAA must consider new automation needs and impacts to existing ATC automation because aspects of the ETM concept may be considerably different than today’s model (e.g., industry-proposed risk envelopes and performance-based separation vs blanket separation minima).

• An analysis of Space Law and ATM rules may provide some ideas for separation approaches and rules of the road.

• Technological means for communications, navigation, and surveillance (e.g., ADS-B) must be established for transit to/from and within ETM environment.

• 4-D, not 2-D, maneuverability in the vertical and horizontal planes will be used in both strategic and tactical deconfliction.

5.2 Transition to/from Upper E Airspace

• Today, industry operators file an IFR flight plan and separation services are provided by ATC when transiting to upper E airspace. They are segregated from other traffic on climb. ATC knows vehicle limitations and provides route flexibility because environmental conditions typically necessitate adjustments (e.g., winds). A clearance is provided by ATC prior to entering upper E.

• Industry expectations for future operations are much the same: 1) Separation will be provided by ATC in the ATM environment, 2) operators will maintain communications with ATC, and 3) ATC will continue to accommodate operational limitations and performance characteristics (flexibility).

• ATM airspace must remain equitable despite performance restrictions. Airlines and commercial space entities are concerned about equity given temporal and spatial aspects of climb. Industry proposes to limit impacts on others by investing in capabilities that will minimize the impacts of their operations and decreasing separation criteria to the greatest extent possible.

• Equipage is a major industry concern. Industry would like discussion on acceptable alternative arrangements for minimal equipage to accommodate transit portion of flight (since it is a very
small portion of the operation). Industry will provide the FAA with information on desired equipage waivers (if any) for consideration.

- Vehicle maneuverability restrictions may not accommodate collision avoidance. Development efforts must take this into consideration.

### 5.3 Strategic Deconfliction

- Need to develop a means for strategic deconfliction in the event of airspace competition. Long duration missions, needs for sizable airspace volumes, and other factors make equity rules complex. Industry will work together to establish equity/access rules for strategic deconfliction.

- Industry will develop a decentralized, internet connected application programming interface that provides a means for operator to operator data exchange and strategic deconfliction. The platform enables operators to connect and share operation plans. When an airspace conflict arises, industry-developed business rules are in place to resolve the conflict. A centralized repository for situation awareness without complexity of deconfliction rules is a good place to start (as an initial step). Plan is to employ a multi-step process - business rules can be built into the model for automated deconfliction solutions in the future. NASA is prepared to work with industry in the exploration of this approach to ETM.

- Flight plan changes will be common in the ETM and ATM environments due to dependencies on environmental factors and planning constraints. ETM will have to provide the flexibility to re-plan as often as needed. Industry will need to take this into account during development.

- Strategic deconfliction in the ETM environment must accommodate short planning horizons (e.g., one hour out), otherwise a considerable amount of uncertainty will be inherent. Environmental uncertainties, considerable maneuverability limitations, and unpredictable planning needs dictate the need for flexibility.

### 5.4 Tactical Deconfliction

- Means of separation in the ATM and ETM environments will be based on risk envelopes that factor in both risk to the vehicle and risk that the vehicle imposes (e.g., fragility to wake and
vehicle wake characteristics), rather than separation minima. Industry will do the research to determine envelopes for their vehicles, then present them to the FAA for review and approval.

- These envelopes will need to be shared with the community.

- Industry developed rules of the road for the cooperative environment may consider: 1) ability to maneuver, and 2) efficiency of airspace demand.

- Tactical maneuvering does not necessarily mean strategic deconfliction failed. There may be times where operators decide, based on characteristics of the two vehicles, that they will forgo strategic separation and resolve the situation tactically.

- There will be standard rules for tactical separation. If an element of the operation changes, there will have to be a trigger for notification or reconciliation process (e.g., changes to intent trigger notification to impacted parties).

- Decision to forgo strategic deconfliction could present equity challenges. An operator could decline to strategically deconflict under the assumption that a conflicting aircraft would need to give way consistent with the known business rules, wait for the other vehicle to give way, and thus gain access to previously unavailable airspace as a result (i.e., opportunities to game the system).
5.5 Off-Nominal Operations

- Off-nominal circumstances that are not ideal but are routine (e.g., winds) are reportedly not of large concern to industry. Wind predictions can be wrong and are subject to issues, but other operators will be subject to the same issues (i.e., everyone moves with it).

- Exigent or emergency circumstances where a vehicle is compromised and its ability to keep functioning is in jeopardy are anticipated by, and being prepared for, by industry. A few examples of anticipated emergency/exigent events include:
  - Significant weather such as winds, electrical storms/discharge which can cause a need to maneuver or cause vehicle to be unable to hold position
  - Solar flare that causes quick descent
  - Equipment failure (e.g., global positioning system [GPS], engines)

- Industry expectations of interactions with other operators and ATM in the event of off-nominal emergency or exigent circumstances include:
  - Priority services
  - ATC coordination (would need frequency information/method for contact and procedures in place)
  - ETM network and ATM coordination
  - As far as practical, standardized terminology and procedures including process for unexpected descent through ATM
  - Human oversight
  - Redundant systems
  - GPS
  - Surveillance technologies are large concerns

- Where possible, industry would like to utilize existing equipment/mechanisms to signal changes or issues. For example, Loon uses squawk codes to signal issues to ATC.

- The FAA would appreciate industry sharing any information they can about anticipated off-nominal events and proposed correction/mitigation response and procedures.

6 Industry Priorities

Industry partners will collectively address numerous ETM development issues. Industry participants identified the following priorities for development:

- Maneuverability profiles and avoidance issues
- Minimum equipage
- Next steps to start operations in Class E
- Airspace management rules (performance-based operations, right-of-way rules)
- Contingency management, emergency procedures, and coordination/communications
- Framework for collaboration between government and industry
- System design that includes flexibility and responsiveness to accommodate needs for changes (e.g., re-planning)
- Industry collaboration with global focus
- International agreements
- Maneuverability envelopes
- Sovereignty rules and limitations (non-participating parties)
- Data standards for ETM/ATM
- Consult with other users (airlines)

7 Summary of Agreed Upon Conceptual Elements

Tabletop participants reached agreement on the following concept elements:

<table>
<thead>
<tr>
<th>Area of Development</th>
<th>Agreed Upon Conceptual Elements</th>
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<tbody>
<tr>
<td>ETM Principles and Assumptions</td>
<td>• The ETM concept will be developed with consideration to international application. ICAO will support international socialization of the concept once adequately matured.</td>
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<tr>
<td></td>
<td>• The ETM floor is FL600; more flexibility to the floor will be considered if/when practical.</td>
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<td></td>
<td>• In order to meet the needs of market forces, ETM systems and services must be flexible (e.g., intent change, performance characteristics limitations).</td>
</tr>
<tr>
<td>Equity and Access</td>
<td>• Access to the airspace must be equitable. Operators cannot optimize their own operations at the expense of sub-optimizing the ETM environment as a whole (or the ATM environment).</td>
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<td></td>
<td>• Operators will cooperatively manage the airspace according to a common set of industry-developed rules that foster equity of access.</td>
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<td>• Operators will minimize the impacts their operation may pose to others to the greatest extent possible.</td>
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<td></td>
<td>• In the event that Industry management of cooperative ETM airspace operations fails to ensure equity and access, the FAA may issue specific directives/protocols to resolve.</td>
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<td>• Industry-developed rules/guidelines for the cooperative environment could be established by an industry consortium:</td>
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<tr>
<td>Area of Development</td>
<td>Agreed Upon Conceptual Elements</td>
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<tr>
<td></td>
<td>o  Transparent business rules are foundational</td>
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<td></td>
<td>o  Process by which rules are modified or adapted is transparent, enabling flexible evolution of rules</td>
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|                     | o  Violations of consortium rules may result in industry established consequences  
|                     | ▪  Safety risk or regulation violations (e.g., separation standard or risk envelope violations) are investigated and enforced by the ANSP/FAA |
|                     | ▪  Non-conformance/violation of consortium-based rules (e.g., equity and access violation or other rules not pertaining to safety) could be managed through the consortium |
| Transition to/from ETM | •  Transitioning operations cannot compromise access and equity balance in airspace through which the vehicle transits. |
|                     | •  Operators prefer ATC continues to provide separation services for transit to upper E airspace. |
|                     | •  Transit operations will be performance-based (conducted with consideration to vehicle maneuverability/speed/performance limitations, etc.). |
|                     | •  Separation criteria/performance envelopes for transition will be researched by industry and provided to the regulator for verification and approval. |
| Strategic Deconfliction | •  Industry will coordinate and strategically deconflict operations (according to an established set of business rules) using a common, decentralized, internet connected API. |
| Tactical Separation | •  Risk envelopes will provide means of separation in the cooperative environment (as opposed to separation minima); industry will determine their envelopes and present them to the FAA for review and approval. |
| Off-Nominal Principles | •  In the event of an emergency, there is an assumption of priority; priority rules for the cooperative environment will be agreed upon and established by industry. |
|                     | •  As far as practical, there will be a common set of standardized terminology and procedures for off-nominal events. |
### Area of Development

<table>
<thead>
<tr>
<th>Summary of Industry Development for Cooperative Environment</th>
<th>Agreed Upon Conceptual Elements</th>
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<tbody>
<tr>
<td>• Industry (potentially in collaboration with NASA) will propose rules, solutions, and/or recommendations for:</td>
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<tr>
<td>o ETM cooperative sharing architecture (to include common, decentralized API for cooperative data sharing)</td>
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<td>o Equity and access rule development and enforcement guidelines</td>
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<td>o Rules of the road (e.g., right of way rules)</td>
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<td>o Performance envelopes</td>
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<td>o Emergency/Priority operations</td>
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<tr>
<td>• Industry (potentially in collaboration with NASA) will leverage ATM rules and ‘lessons learned’ to the extent practical as a first step.</td>
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### 8 Actions

#### 8.1 Industry Actions

- Send inputs on lexicon, assumptions, and principles to FAA/Sherri Magyarits and NASA/Jeff Homola by Friday, April 26 *(completed)*

- Discuss with each other safety considerations, vehicle maneuvering and risk envelopes, and operating “rules of the road”. Send results of the discussions to FAA and NASA to support research planning and development of a Concept of Operations (ConOps). Specific topics may include:
  - Proposed methods of separation
  - Proposed ETM system architectures
  - Expected methods and technologies for ATM/ATC and manned aircraft interaction
  - Equipage requirements industry wishes to be waived for transition through the ATM environment
  - Any other topic on which industry wishes to provide input

- Analyze ATM rules and Space Law for potential application to ETM

- Loon will coordinate with NASA about providing an API to incorporate into NASA simulation environment
8.2 NASA/FAA Actions

- Prepare ETM Tabletop summary report and distribute to participants (FAA & NASA)
- Initiate development of a ConOps for ETM operations (FAA & NASA)
- Assess resources to determine a timeline for the ConOps development (FAA)
- Coordinate with industry partners to establish areas in which they can participate in planned research (e.g., platform for industry information sharing) (NASA)
- Explore options for developing an ETM simulation environment (NASA)
  - NASA will coordinate with industry partners about use of Live, Virtual, Constructive Simulations/Demonstrations to explore the ETM concept
## Acronyms

<table>
<thead>
<tr>
<th>Acronym or Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
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<tr>
<td>ANSP</td>
<td>Air Navigation Service Provider</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<td>CANSO</td>
<td>Civil Air Navigation Services Organisation</td>
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<td>ConOps</td>
<td>Concept of Operations</td>
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<td>DoD</td>
<td>Department of Defense</td>
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<td>EASA</td>
<td>European Union Aviation Safety Agency</td>
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<td>ETM</td>
<td>Upper E Traffic Management</td>
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<td>FAA</td>
<td>Federal Aviation Administration</td>
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<tr>
<td>FL</td>
<td>Flight Level</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>ICAO</td>
<td>International Civil Aviation Organization</td>
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<td>IFR</td>
<td>Instrument Flight Rules</td>
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<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<td>SESAR</td>
<td>Single European Sky ATM Research</td>
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<td>UAS</td>
<td>Unmanned Aircraft System</td>
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<td>USS</td>
<td>Unmanned Aircraft System Service Supplier</td>
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<td>UTM</td>
<td>Unmanned Aircraft System Traffic Management</td>
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Appendix A – List of Attendees

The following participants attended the Tabletop meeting either in person or by teleconference (* signifies teleconference attendance):

**FAA**

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<tr>
<th>FAA</th>
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<tbody>
<tr>
<td>Onja Beebe (NATCA)</td>
<td>Maureen Keegan (AJV-73)*</td>
<td>Scott Rosenbloom (AJV-113)</td>
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<td>Steve Bradford (ANG-3)</td>
<td>Diana Liang (AJV-2)</td>
<td>Bonnie Schmidt (AUS)*</td>
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<td>Mark Fox (AFS-400)</td>
<td>Brandon Lint (AJV-7)</td>
<td>Bill Vogelgesang (AJT)</td>
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<td>Duane Freer (AJR-11)</td>
<td>Sherri Magyarits (ANG-C2)</td>
<td>Steve Weidner (NATCA)</td>
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<tr>
<td>Matt Haskin (AIR-6B2)</td>
<td>John Page (AJV-115)</td>
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<tr>
<td>Maurice Hoffman (AJV-1)</td>
<td>Praveen Raju (ANG-C5)</td>
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**Industry**

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<td>Peter De Baets (AeroVironment)</td>
<td>Yuri Fattah (ICAO)</td>
<td>Linda O’Brien (Loon)</td>
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<td>Brad Belcher (Liberty Works)*</td>
<td>Nancy Graham (Loon)</td>
<td>Ryan Terry (Lockheed Martin)</td>
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<td>Léonard Bouygues (Loon)</td>
<td>Miguel Iturmendi (Aurora)</td>
<td>Johnny Walker (The Padina Group)</td>
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<td>Eli Dourado (Boom)</td>
<td>Rich Kapusta (Alta Devices)</td>
<td>Caspar Wang (AeroVironment)</td>
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<td>Rob Eagles (Loon)</td>
<td>Anthony Militello (DoD)</td>
<td>Lee Weinstein (Leidos)</td>
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**NASA**

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<td>Misty Davies</td>
<td>Husni Idris</td>
<td>Faisal Omar*</td>
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<td>Tamsyn Edwards</td>
<td>Parimal Kopardekar</td>
<td>Rosa Oseguera-Lohr</td>
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# Support Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Position</th>
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<tbody>
<tr>
<td>Kim Bender</td>
<td>CSSI-FAA</td>
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<td>Rich Jehlen</td>
<td>LST-FAA</td>
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<tr>
<td>Jim Smith</td>
<td>LST-FAA</td>
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<tr>
<td>Chris Clark</td>
<td>NASA</td>
<td></td>
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<tr>
<td>Casey Nguyen</td>
<td>Digital IBiz-FAA</td>
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<tr>
<td>Michael Tsairaides</td>
<td>NASA</td>
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<tr>
<td>Duy Duong</td>
<td>P17 Solutions-FAA</td>
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<tr>
<td>Collin Roche</td>
<td>LST-FAA</td>
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Appendix B - ETM Tabletop Meeting Slides
Upper E
Traffic Management (ETM)

Tabletop Exercise

April 18, 2019

NASA Ames Research Center
Moffett Field, CA

Participants

Standards
Int’l. Civil Aviation Org.

Defense & Security
Dept. of Defense (DOD)
Dept. of Homeland
Security (DHS)

FAA
NextGen (ANG)
Aviation Safety (AVS)
Air Traffic Organization (ATO)
UAS Integration Office (AUS)
National Air Traffic Controllers
Association (NATCA)

NASA
Ames Research Center

Industry
AeroVironment
LOCKHEED MARTIN
BOEING
Aurora
GENERAL DYNAMICS
leidos
## Agenda

**NASA Ames Research Center**  
**Building N-232, Conference Room 103**  
**April 18, 2019**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Participants</th>
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<tbody>
<tr>
<td>8:30 AM – 8:45 AM</td>
<td>Check-in</td>
<td>All</td>
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<tr>
<td>8:45 AM – 9:00 AM</td>
<td>Participant Introductions</td>
<td>All</td>
</tr>
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</table>
| 9:00 AM – 9:10 AM | Tabletop Introduction  
  Objectives  
  Exercise Overview  
  Planned Outcomes | NASA           |
| 9:10 AM – 9:40 AM | ETM Concept Development  
  Operational Environment  
  Principles  
  Assumptions  
  Lexicon | FAA            |
| 9:40 AM – 10:25 AM | Scenario 1: Transition into ETM                                           | All           |
|               | Break                                                                     |               |
| 10:35 AM – 11:20 AM | Scenario 2: Strategic Deconfliction between Operations (Pre-Flight)     | All           |
| 11:20 AM – 12:00 PM | Scenario 3: Deconfliction between Pre-Flight and Active Operations     |               |
|               | Lunch                                                                     |               |
| 1:00 PM – 1:45 PM | Scenario 4: Planned Overlapping Areas of Supersonic and HALE Operations |               |
| 1:45 PM – 2:30 PM | Scenario 5: Tactical Deconfliction                                       | All           |
| 2:30 PM – 3:15 PM | Scenario 6: Off-Nominal Event                                            |               |
|               | Break                                                                     | Facilitator   |
| 3:45 PM – 4:15 PM | Discussion Recap                                                          |               |
| 4:15 PM – 4:30 PM | Next Steps                                                                | FAA/NASA      |

### Welcome!
Tabletop Introduction

Objectives
Exercise Overview
Planned Outcomes

Tabletop Exercise Objectives

- Explore and develop a concept for operations above Flight Level (FL) 600 - leveraging principles of other related traffic management concepts and practices
- Introduce and agree upon common principles, assumptions, terms, and conceptual elements
- Discuss varying types of vehicles & profiles in operational phases of flight and their impacts on traffic management above FL600
- Explore various Scenarios and their associated operational threads
- Provide input to initial Concept of Operations (ConOps) through scenario-driven tabletop exercises and discussions
Tabletop Exercise *Overview*

- **Format**
  - Set of Participatory Exercises
    - Introduction of high level scenarios / situations
  - Audience Participation
    - “Around the Room” discussion with participants being called upon to collaborate

- **Capturing Participant Inputs**
  - Two individuals will record major decisions, actions, and overall discussion
  - A review of the discussions will be presented at the end of the day

Tabletop Exercise *Planned Outcomes*

- Gain insight into industry’s operational needs above FL600
- Gain common understanding regarding principles & assumptions around a future concept for managing operations above FL600
- Gather inputs for developing an Upper E Traffic Management (ETM) Concept of Operations that
  - Describes a future operating environment above FL600
  - Includes representative use cases
  - Presents a clear delineation of roles & responsibilities among stakeholders
- Identify areas requiring further discussion and/or exploration
ETM Concept Development

Operational Environment
Principles
Assumptions
Lexicon

Current Operational Environment

• Historically, Class E above FL600 has not been a congested airspace environment with ATM services provided to civilian operators

• Today, operations in Upper E include military (e.g., reconnaissance), experimental/research (e.g., hypersonic), and civilian (e.g., high-altitude balloons, space transit)

• ATM services are provided to those transiting through Class A into Upper E and to those transiting back through Class A from Upper E
Future Operational Environment

• Increased operational tempo

• New types of operations
  – Hypersonic flight, reintroduction of supersonic passenger flights, and very slow (or on-station) long endurance flights

• ATM scalability
  – Current manner of ATM service delivery cannot cost-effectively scale to meet the needs of the envisioned ETM environment
  – Current ATM services may not be desired in the ETM environment

• Solutions are needed that
  – Scale beyond current ATM infrastructure and manpower resources
  – Promote shared situation awareness among Operators
  – Support the management of operations where no ANSP separation services are desired, appropriate, or available

ETM Concept Principles

• Operations must be
  – Safe, efficient, & scalable
  – Interoperable – Operators/systems exchange information/intent and are aware of each other’s existence

• Access to the airspace must be equitable

• The State maintains regulatory authority

• The ANSP maintains operational authority

• Regarding
  – Operations: Integration where possible, accommodation/segregation where necessary
  – Airspace: Flexibility where possible, structure where necessary
ETM Concept Assumptions

- Upper E is defined as FL600 & above (undefined upper limit)
- Operations may move across multiple Flight Information Regions (FIRs)
- Policies and regulatory framework to support operations in the ETM environment may differ from those in place today
- Supporting infrastructure, systems and services will differ from that in the current ATM environment
- Communication, navigation, surveillance (CNS), automation, and information requirements may differ from those in place today to satisfy operational requirements
- State entities (e.g., military) conducting certain operations take responsibility for maintaining separation from all other aircraft (e.g., due regard, VFR)
- Separation methodologies within the ETM environment may include
  - Cooperative Separation
  - Provided Separation

Lexicon (1)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Cooperative Separation</td>
<td>Separation based on shared trajectory intent/expanded data exchanges between operators, stakeholders and service providers, and is supported by the appropriate rules, regulations and policies for the planned operations.</td>
</tr>
<tr>
<td>Provided Separation</td>
<td>The provision of separation services by an ANSP.</td>
</tr>
<tr>
<td>Due Regard</td>
<td>A phase of flight wherein an aircraft commander of a State-operated aircraft assumes responsibility to separate his/her aircraft from all other aircraft.</td>
</tr>
<tr>
<td>High Altitude Long Endurance (HALE) Operation</td>
<td>Unmanned aircraft flight conducted at slow speeds and capable of lasting considerable periods of time (days, weeks, months) without recourse to landing.</td>
</tr>
<tr>
<td>Supersonic Operation</td>
<td>Aircraft flight speeds above Mach 1 (speed of sound). Includes both manned and unmanned operations.</td>
</tr>
<tr>
<td>Hypersonic Operation</td>
<td>Aircraft flight at significantly high Mach speeds, typically defined as above Mach 5. Typically performed as unmanned operations.</td>
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## Lexicon (2)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Intent Information</td>
<td>Information exchanged for the purposes of strategic planning and cooperative separation between stakeholders for the purpose of managing the airspace. Examples of such information may include trajectories (of defined fidelity), volumes, etc.</td>
</tr>
<tr>
<td>Conflict</td>
<td>A point in time in which the predicted separation of two aircraft is less than the defined separation minima.</td>
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<tr>
<td>Strategic Deconfliction</td>
<td>Deconfliction between trajectories via advanced planning and information exchange, including intent.</td>
</tr>
<tr>
<td>Tactical Deconfliction</td>
<td>Timely response to avoid a conflict after strategic deconfliction has failed, or was not executed.</td>
</tr>
<tr>
<td>Constraint</td>
<td>Anything that interferes with the normal flow of air traffic. Constraints can be natural (e.g., weather), circumstantial (e.g., runway construction), or intentional (e.g., TFR).</td>
</tr>
<tr>
<td>Unmanned Traffic Management (UTM)</td>
<td>A traffic management environment in which UAS operators cooperatively separate from one another, enabled by the open exchange of relevant intent information for the purposes of strategic and tactical deconfliction.</td>
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## Lexicon (3)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Oceanic</td>
<td>Oceanic operating environment refers to the offshore, international airspace for which the US is the designated service provider. It is characterized by large volumes of airspace and less legacy infrastructure than domestic US airspace. Separation procedures are based on surveillance, in most cases, predicated on automated position reporting by individual aircraft.</td>
</tr>
<tr>
<td>Maneuverability</td>
<td>The ability of an aircraft to adjust its trajectory over a period of time, which is determined by various performance characteristics.</td>
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Cooperative Separation Example

- **Unmanned Traffic Management (UTM)**
  - Cooperative separation model for UAS operations under 400 ft above ground level (AGL)
  - Information exchanges and protocols provide the means for Operators to cooperatively share information and access FAA information - for common situational awareness among all UTM stakeholders (Operators, other government agencies, and the FAA)
  - Network of third party UAS Service Suppliers (USSs) provides services to support the safe and efficient use of airspace and assists Operators in meeting UTM operational requirements
  - USS services support operations planning, aircraft de-confliction, conformance monitoring, and emergency information dissemination

Provided Separation Example

- **Oceanic**
  - Limited infrastructure (relative to CONUS) supporting separation of Oceanic operations
  - Surveillance is based on position reporting of the aircraft conducting Oceanic operations
  - Systems predict separation and find conflicts so controllers can resolve
Other Operational Considerations

- **Public Operators (e.g., DOD, DHS)**
  - Some operations conducted by State entities include flight without separation provided by ATC (e.g., due regard, VFR).
  - While there is no standard global definition of due regard, the “Convention on International Civil Aviation” declares contracting States, when issuing regulations for their State aircraft will have due regard for the safety of navigation of civil aircraft. ICAO Doc. 7300/9 defines State aircraft as those “used in military, customs, and public services.”

Scenarios

1) Transition into ETM
2) Strategic Deconfliction between Operations (Pre-Flight)
3) Deconfliction between Pre-Flight and Active Operations
4) Planned Overlapping Areas of Supersonic & HALE Operations
5) Tactical Deconfliction
6) Off-Nominal Event
Scenario 1: Transition into ETM

- A look into the transit of the various types of aircraft from the ground up into Class E.
- Some aircraft types will be able to comply with the regulatory framework for ATM operations (e.g., supersonic), while some may not (e.g., fixed-wing unmanned HALE).
- Transit into ETM may require varying approaches to move through the ATM environment safely.

Scenario 2: Strategic Deconfliction between Operations (Pre-Flight)

- Two HALE operators are planning operations in overlapping areas with overlapping time windows. The operators strategically deconflict within the Cooperative environment during the planning phase.
- During the flight phase, coordination between the operators occurs as necessary to maintain separation.
Scenario 3: Deconfliction between Pre-Flight and Active Operations

- Two long duration operations within the Cooperative environment have been strategically deconflicted and are currently in flight.
- An additional operation is being planned such that it overlaps in time and space with the two current operations. This additional operation is acting within the Cooperative environment as well.

Scenario 4: Planned Overlapping Areas of Supersonic and HALE Operations

- Relatively dense HALE operations are in progress across a large volume of airspace.
- A supersonic flight seeks to transit the volume currently occupied by the HALE aircraft.
  - 4(a) The supersonic aircraft is engaged in Cooperative Separation.
  - 4(b) The supersonic aircraft is operating under Provided Separation.
**Scenario 5: Tactical Deconfliction**

- An anomalous event occurs in which strategic deconfliction between two aircraft fails (e.g., environmental event, performance issue of one of the aircraft).
- When strategic deconfliction has failed, tactical deconfliction is enacted such that the aircraft maintain well clear of each other.

**Scenario 6: Off-Nominal Event**

- An aircraft operating in ETM must quickly descend due to an off-nominal event or an exigent circumstance.
- The descent is going to cross into ATM airspace.
Discussion Recap

Agreed upon conceptual elements
Topics requiring further discussion/exploration

Next Steps
Moving forward...

• Proceed with development of Concept of Operations to mature and refine the concept through use cases, roles and responsibilities allocation, and high-level operational and technical requirements

• Perform engineering analyses to highlight opportunities and challenges in the current infrastructure, technology, policies, and rules with regard to their applicability to support future operations

• Build simulation environment and conduct simulations to derive and validate requirements