Concept of Operations

v1.0

Foundational Principles

Roles and Responsibilities

Scenarios and Operational Threads

Upper Class E Traffic Management (ETM)

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U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of NextGen

800 Independence Ave., SW.
Washington, DC 20591

May 26, 2020

Dear Reader:

We are pleased to share Version 1.0 of the Upper Class E Traffic Management (ETM) Concept of Operations with our FAA, NASA, and Industry partners who were in attendance at the ETM Tabletop sessions at NASA Ames Research Center last year. This ConOps documents the outcomes of the Tabletop discussions and the joint concept development efforts we have thus far undertaken.

ConOps Version 1.0 is the first stage of work in progress and will be matured and modified in conjunction with Upper E Operator efforts to further develop an Industry-supported cooperative traffic management approach for their high altitude operations. The results of those Industry efforts will be integrated into a Version 2.0 of an ETM ConOps, which will provide a broader and more comprehensive vision of our shared partnership for ETM operations.

Sincerely,

Steve Bradford

Steve Bradford
Chief Scientist, Architecture & NextGen Development
Office of the Chief Scientist, ANG-3

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Version History

Date	Revision	Version
04/22/2020	Initial Draft	1.0

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Table of Contents

Table of Figures

List of Tables

1 Introduction

Upper Class E airspace operations have historically been limited due to the challenges conventional fixed wing aircraft face in reduced atmospheric density in the upper stratosphere and mesosphere. Recent advances in technologies, however, relating to power and propulsion, aircraft structures, flight automation, and aerodynamics have led to an increase in the number of vehicles that can operate in low atmospheric density airspace. Sophisticated high altitude, long endurance (HALE) vehicles, unmanned free balloons, airships, and supersonic/hypersonic aircraft can efficiently and economically satisfy research objectives, demands for broad coverage services (earth sensing, telecommunications) and supersonic passenger flight. This increase in demand for upper Class E operations, combined with disparate vehicle performance characteristics and unconventional operational needs, present novel challenges for the current communications, navigation, and surveillance (CNS) infrastructure and airspace management model. The future use of this airspace creates a common desire to re-evaluate the current traffic management approach and realize innovative solutions through public-private partnerships to support this burgeoning market in meeting their objectives, while maintaining the safety, security, efficiency, and equity of the National Airspace System (NAS).

1.1 Need for ETM

In the United States, there are no airspace management provisions specific to civil aircraft operations above FL600. The regulations for operations in Class E airspace at lower altitudes apply equally to the airspace above FL600. While the FAA has established separation standards for both surveillance (radar) and procedural (non-radar) separation, most references are specific to military operations. Some operations conducted by State entities include flight without separation provided by air traffic control (ATC) (e.g., Military Authority Assumes Responsibility for Separation of Aircraft [MARSA], restricted airspace). These procedures met the needs of the NAS as no civil aircraft operated above FL600 when they were adopted (see Figure 1-1 for current airspace management model). However, that is no longer the case.[1]

New vehicles designed to operate at high altitudes have proved to be attractive investments to commercial entities. High altitude platforms enable broad service area coverage at ground level, innovations in solar power and unmanned vehicles support long endurance flights that have historically been impractical for manned Operators, and powerful cameras/sensors and emerging technologies enable precise, sophisticated data collection capabilities. These innovations, among others, have created civil market demand for high altitude airspace. This demand will likely continue to grow with the advent of new technology and business markets, placing a strain on Class E service provision capabilities, resources, infrastructure, and regulatory structure.

[1] Stilwell, R. (2016). Unmanned Aircraft and Balloons in Class E Airspace above FL600, Challenges and Opportunities. *Space Traffic Management Conference*, 13. https://commons.erau.edu/stm/2016/presentations/13

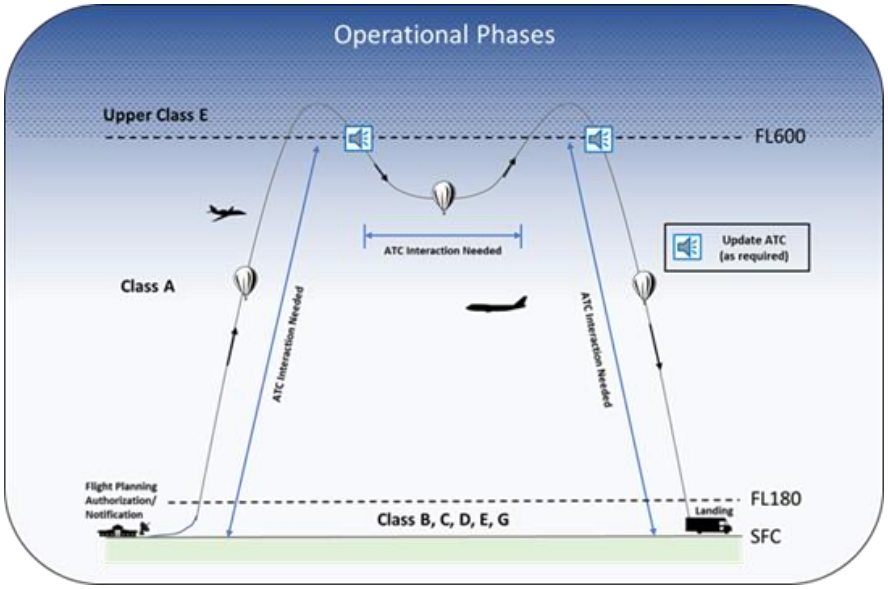

Figure 1-1. Current airspace management model

The future of upper Class E airspace operations presents opportunities for an alternative traffic management approach. To ensure safe and efficient service provision for current, and expanded operations, the Federal Aviation Administration (FAA) is exploring an upper Class E Traffic Management (ETM) concept. Development of this concept must account for the following:

- For some operations, technological components, capabilities, and CNS needs may differ from conventional operations, creating new operational and technical requirements and opening the door for novel management solutions.

- Some vehicles have vastly different performance characteristics and maneuverability profiles. Supersonic and hypersonic flights, slow moving (or stationary) unmanned balloons, very slow (or stationary) long endurance fixed wing vehicles, and high speed, long endurance fixed wing vehicles must safely interact in upper Class E airspace – all without interfering with current operations, which are expected to continue.

- The duration of anticipated operations ranges from hours to months to up to one year, during which time they can span across multiple Flight Information Regions (FIRs), or even nations. This operational model presents two important considerations for ETM: 1) it must support long endurance missions, and 2) it must give due consideration to international application.

- Characteristics of projected upper Class E operations create unique challenges for equitable airspace management. While some operational profiles will be point-to-point operations, many operations will loiter in a pattern, move very slowly, or even remain stationary for extended periods of time. In addition, many vehicles are vulnerable to wake turbulence and/or environmental conditions, which means they will require considerable amounts of airspace buffer in which to separate and/or operate. The needs for large volumes of airspace for long periods of time, the limited ability for some vehicles to maneuver, along with increased operational tempo

of upper Class E operations, will increase the potential for airspace competition. Equitable airspace management is imperative to ensure fair, safe access for these operations.

- The current manner of air traffic management (ATM) service delivery cannot cost-effectively scale to meet the needs of the envisioned upper Class E airspace environment. It is not feasible for the FAA to provide air traffic services to an unlimited altitude.[2] Furthermore, ATC-provided separation services are not necessarily desirable for upper Class E airspace Operators.

An ETM construct must:

- Scale beyond current NAS infrastructure and manpower resources to meet the needs of market forces
- Support the management of operations where no air navigation service provider (ANSP) separation services are desired, appropriate, or available
- Promote shared situation awareness among Operators

An ETM regulatory framework, operating rules, performance-based standards and procedures, and roles and responsibilities to ensure accountability of Operators must be developed. As the federal authority over operations in all airspace, and the regulator and oversight authority over commercial operations, the FAA will ensure that the ETM cooperative vision aligns with agency goals and meets the requirements for safe and efficient operations.

1.2 ConOps Scope

The primary focus of this V1.0 of the ETM Concept of Operations (ConOps) is on ATC interactions with Operators transiting to/from upper Class E airspace and operating just below FL600 in upper Class A airspace. Foundational operating principles for ETM operations above FL600 are also presented; however, subsequent versions of the ConOps will more comprehensively address a cooperative traffic management approach for this airspace, as industry stakeholders are currently collaborating on cooperative separation strategies and solutions, to include airspace equity and access rules.

1.3 ConOps Objectives

The objective of V1.0 is to establish an initial version of an ETM Concept of Operations, focusing first on how Operators plan their operations to upper Class E airspace, interact with ATC and the ATM system during transit phases of flight, and manage contingency events. The ConOps describes the roles and responsibilities of the Operator and ATC/ATM, and presents high-level use cases and operational threads that demonstrate the conduct of these operations.

[2] Booz Allen Hamilton (2018). *Conceptual Strategy for Cooperatively Managed Upper E Airspace Operations Report*. McLean, VA.

V1.0 presents the foundational operating principles of cooperative upper Class E traffic management – ETM, as well as a flexible floor concept, leveraging cooperative separation principles, for vehicles that need to operate just below FL600.

This ConOps does not prescribe solutions or specific implementation methods, unless for example purposes. Rather, it describes the essential conceptual and operational elements associated with upper Class E operations that will serve to inform development of solutions that will ultimately enable ETM. Moving forward, ETM concepts will continue to be developed with due consideration to global interoperability.

2 ETM Operational Concept

ETM is the manner in which the FAA will support the expected expansion and introduction of novel operations, including but not limited to, commercial, State/government, and research entities operating both manned and unmanned vehicles in upper Class E airspace. The ETM environment is notionally defined as upper Class E airspace above FL600 (depicted in Figure 2-1). ETM consists of both cooperatively managed operations by Operators themselves, and ATC-managed operations where required. The ETM environment includes the participants (their accompanying roles and responsibilities), supporting services, information flows, and architecture elements supporting operations above (and approved operations below) FL600.

ETM solutions extend beyond the current paradigm to those that promote shared situational awareness among upper Class E Operators, through cooperative traffic management, while accommodating government operational needs and securing national security interests. ETM utilizes industry's ability to supply services under FAA's regulatory authority where ANSP separation services are not desired, appropriate, or available. It is largely a community-based, cooperative traffic management system, where the Operators are responsible for the coordination, execution, and management of operations, with rules of the road established by FAA. Operators share awareness of proximate operations, and de-conflict when necessary. ATC accesses cooperative and NAS system data to safely separate operations under their control. Safe separation and demand capacity balancing of all operations are enabled through harmonized ETM airspace user interactions, established procedures, and compatible technologies. On transition to and from operating altitude, and when in ATC managed airspace, ETM Operators coordinate with ATC, receive ATC services (as required), and satisfy FAA requirements for operation.

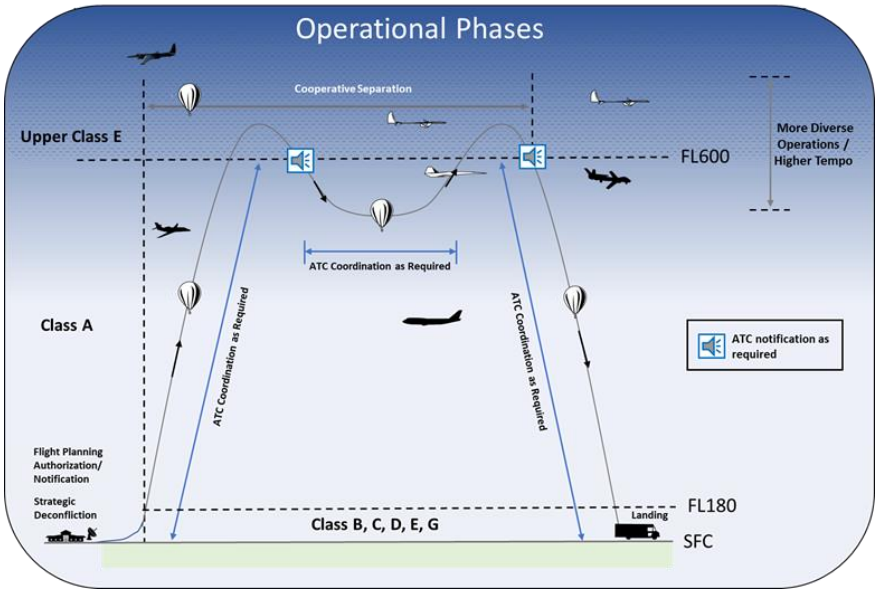

Figure 2-1. ETM airspace management model

Due to long duration flights and other upper Class E mission characteristics, operations can move across multiple FIRs, and even nations, making procedural and system(s) harmonization key considerations. Practical, compatible, and where possible, universal ETM solutions are desired. While the FAA's ETM concept focuses on operations within its NAS, the principles and operating practices described herein are designed to be flexible and scalable so that they may extend to global applications.

2.1 Participants

Upper Class E airspace participants include Operators, third party service suppliers (if utilized for cooperative operations) and ATC. The FAA regulator is also a participant, as it exercises authority over the airspace.

2.1.1 Operator

An Operator is the person or entity responsible for the overall management of an operation. The Operator meets regulatory responsibilities, plans flights/operations, shares operation intent information, and safely conducts operations using all available information. Operators are responsible for ensuring the Pilot in command (PIC) and/or remote pilots in command (RPIC) have access to all information required to maintain safe flight. An individual may serve as both the Operator and the PIC.

Upper Class E Operators include those representing commercial and State (e.g., Department of Defense [DoD]) interests. They operate a range of vehicles including manned fixed wing, supersonic aircraft, unmanned fixed wing high-speed vehicles, HALE unmanned fixed wing vehicles, unmanned balloons, and airships.

2.1.2 Third Party Service Suppliers

If an upper Class E Operator chooses not to self-provision services, third party service suppliers can assist the Operator in meeting ETM operational requirements above FL600 that enable safe and efficient use of airspace without direct FAA involvement. Third party service suppliers can (1) act as a communications bridge between ETM participants to support Operators' abilities to meet the regulatory and operational requirements for upper Class E operations, (2) provide Operators with information about planned operations in and around a volume of airspace so that they can ascertain the ability to safely and efficiently conduct their mission, and (3) archive operations data in historical databases for analytics, regulatory, and Operator accountability purposes. Third party services can support operations planning, intent sharing, vehicle de-confliction, conformance monitoring, and other airspace management functions.

2.1.3 Air Traffic Control

ATC is a service provided by ground-based air traffic controllers who direct aircraft on the ground and coordinate and expedite air traffic flow through controlled airspace using NAS data systems, radar, radio communications, and other sources. In upper Class E airspace, ATC provides separation services to operations that elect to use them, as well as operations transiting to and from operating altitude.

2.1.4 FAA

The FAA is the federal authority over aircraft operations in all airspace, including upper Class E airspace, and the regulator and oversight authority for civil aircraft operations in the NAS. The FAA maintains an operating environment that ensures airspace users have access to the resources needed to meet their specific operational objectives and that shared use of airspace can be achieved safely and equitably. The FAA develops rules, regulations, policy and procedures as required to support these objectives.

2.2 Airspace Management Services

ETM is an airspace management concept for NAS operations over FL600. It leverages novel approaches to ensuring separation between vehicles, maintaining equity of access to airspace, and sharing information among Operators in an environment where ATC infrastructure and services are limited. ETM encompasses all infrastructure, policies, procedures, services, and personnel required to support upper Class E operations. It requires the establishment of regulatory frameworks, development of operating rules and performance requirements commensurate with demands of the operation, and a data exchange and information architecture that supports shared situational awareness among participants.

ETM consists of the following methods of separation management:

- **Cooperative Separation** – community-based separation, where the Operators are responsible for the coordination, execution, and management of operations, with rules of the road established by FAA[3]

- **ATC Separation** – provision of separation services by ATC

Safe, efficient ETM operations are dependent upon Operator and FAA (when required) access to accurate, timely information. Information exchange between the FAA and Operators ensures responsible parties have access to all the information necessary to maintain safe, equitable operations. ATM systems are interoperable with Operator systems used for cooperative separation, ensuring data access and management is in place to satisfy ATC needs when separating vehicles under their control from those that are managed cooperatively.

A novel information architecture is in place to support cooperative operations. This architecture enables, at a minimum, sharing intent information, access to up-to-date flight information, provision of FAA airspace constraint data, and storage and dissemination of historical data. NAS data systems continue to support ATC-managed operations. The FAA/ATC has on demand access to all cooperative flight information necessary to support safe separation and fulfill regulatory obligations.

[3] UAS Traffic Management (UTM) is a cooperative UAS traffic management concept designed to enable high-density UAS operations at low altitudes. Where possible, UTM foundational principles, architecture, and concept elements are leveraged for ETM.

2.2.1 Cooperative Separation Services

ETM cooperative operations above FL600 are organized, coordinated, and managed by a federated set of participants. Operators use a complementary set of services to air traffic-provided services that support the safe execution of flight. These services can be self-provisioned services or provided by a network of third-party service suppliers. ETM services can support Operator planning of flight operations, vehicle de-confliction, conformance monitoring, dissemination and receipt of airspace constraints (e.g., Temporary Flight Restrictions [TFR]) and emergency information. If services support Operators in meeting applicable regulations and policies, the party providing them may require qualification by the Government.

Operators conducting cooperative operations are ultimately responsible for maintaining separation from other vehicles, and avoiding unsafe conditions (e.g., atmospheric conditions, solar flares) throughout an operation. Information exchange between Operators, and between the FAA and Operators, ensures responsible parties have access to timely flight data, environmental data (e.g., atmospheric, weather), airspace constraints, and advisory/hazard information required to support safe, efficient, and equitable operations. Information exchange protocols provide the means for Operators to share information and access FAA information - for common situational awareness among all stakeholders (Operators, other government agencies, and the FAA). The FAA and other airspace users have on-demand access to ETM operational information.

2.2.2 ATC Separation Services

Upper Class E airspace is controlled airspace. As such, Instrument Flight Rule (IFR) operations above FL600 receive ATC radar (if surveillance data is available) and non-radar separation services. Traffic advisories are provided, workload permitting. ATC also is responsible for separating vehicles from special use airspace above FL600 (e.g., TFR, altitude reservations, space transition corridors) and providing emergency services when required.

Today, State/military operations make up the majority of upper Class E airspace operations. These vehicles file and fly an approved IFR flight plan, or equivalent FAA/DoD authorization. They often elect to discontinue IFR services while operating above FL600 (e.g., operate in restricted airspace, MARSA). These vehicles maintain communications with ATC when able, allowing for flexibility to return to Class A airspace at their discretion.

Under ETM, today's ATC services remain available to operations above FL600 upon request. ATC-managed operations are subject to the ATC restrictions and limitations imposed due to airspace constraints and other participating traffic (cooperative and ATC-managed).

Vehicles transiting to/from operating altitude are provided ATC services commensurate with the airspace in which they are operating, as they are today. Operators comply with applicable FAA rules and regulations for the operation and airspace in which they are operating.

2.3 Operator Participation

Operators either cooperatively separate or receive ATC services to maintain separation in the ETM environment.

- **Cooperative Separation**: Cooperative services are available to all ETM operations. Cooperative services provide optimal operational flexibility and are, therefore, encouraged for operations that wish to fly with few restrictions (e.g., something other than a filed route). Cooperative Operators utilize services to meet performance requirements associated with cooperative separation and other flight activities. The services utilized may vary based on the performance characteristics of the vehicle and associated operational requirements (e.g., CNS requirements).

- **ATC-Managed Separation**: ATC services are available to all ETM operations. ATC-managed operations receive less operational flexibility than cooperative operations (e.g., fly filed route) as they are subject to the limitations imposed by airspace separation constraints and cooperative/ATC-managed traffic.

Sensitive operations (e.g., State operations that require anonymity) conducted above FL600 may engage in cooperative separation, participating at a level commensurate with the data they can share. ATC services are also available to sensitive operations, but would likely limit operational flexibility (e.g., fly according to a fixed flight plan).

2.4 Operations

ETM operations above FL600 are predominantly cooperative; that is, they are coordinated and managed by the Operators themselves. ATC manages operations above FL600 upon request. All Operators plan their flights and transit to/from other controlled airspace classes to reach upper Class E airspace.

Prior to take-off, Operators plan their flight, meeting applicable requirements for flight plan filing, notification to ATC, and/or obtaining authorization from ATC. Cooperative ETM Operators coordinate with other cooperative Operators through sharing of flight intent information (e.g., entry point to the ETM environment) and resolve conflicts when identified.

At take-off, Operators communicate with ATC as required. While an Operator's vehicle is ascending through controlled airspace (Classes A, B, C, D, and surface of E) to its operating altitude, ATC personnel provide separation services to the Operator and other aircraft (e.g., other high altitude vehicles, commercial airliners, business jets). Vehicles are equipped, as required, per applicable operating rules (e.g., Automatic Dependent Surveillance – Broadcast [ADS-B]), to fly within controlled airspace among conventional aircraft. While ascending, Operators may adjust their flight intent (e.g., upper Class E entry point, projected flight path at operating altitude) due to factors such as weather. Intent changes that may impact other cooperative ETM Operators are shared (e.g., changes relevant to separation and operational safety) to support situational awareness needs and de-confliction.

Upon reaching, and while operating at altitude, cooperative Operators' vehicles, control systems, supporting infrastructure, and supporting services perform at levels sufficient to maintain separation from other operations and avoid hazards in a fully accountable manner. Operators continue sharing of accurate, timely flight information. When conflicts are detected, Operators de-conflict to ensure separation is maintained. The FAA accesses information as required for regulatory and operational purposes, including to ensure separation is maintained between cooperative operations and vehicles receiving ATC separation services.

ETM Operators are expected to abide by the appropriate operating rules, regulations, and policies for their operations.

2.4.1 Pre-Flight and Transition to Upper Class E Airspace

Operators perform necessary pre-flight activities, which may include operation planning, flight plan filing, requesting authorization, submitting applicable notifications, and sharing flight intent with other ETM Operators for conflict detection/resolution needs.

2.4.1.1 Pre-Flight Planning and Intent Sharing for Cooperative Separation

For Operators participating in cooperative separation, planning and coordination with other Operators is conducted prior to flight. During pre-flight planning, Operators obtain the flight intent of other Operators that are, or will be, in the vicinity of their projected flight path at operating altitude[4]. Operators also obtain information on airspace constraints (e.g., airspace restrictions, special use airspace [SUA], Notices to Airmen [NOTAMs]), weather and atmospheric events relevant to high altitude operations (e.g., solar flares), and other factors relevant to flight planning; the Operator may utilize third party services to support obtainment of this information.

Using information obtained from other Operators participating in cooperative separation, Operators develop their initial flight intent, ensuring they will be de-conflicted from the other operations. This may be done by adjusting their nominal flight path/flight times to ensure their intent does not conflict with another operation, or through negotiation/coordination with another Operator. Once flight intent is finalized, the Operator shares it with other cooperative Operators to support situational awareness and enable de-confliction services.

2.4.1.2 Pre-Flight Coordination with ATC/ATM

In addition to flight intent development and coordination with others in the cooperative separation environment, ETM Operators meet applicable regulatory requirements regarding flight plan filing, authorization and notification - a summary of which is provided in Table 2-1 below.

[4] Some operations will have a projected flight path from take-off to landing (e.g., fixed wing supersonic transport) while other operations projections will be limited in timeframe (e.g., 2 hours out) due dependencies on factors such as environmental uncertainties, limited maneuverability, and unpredictable business needs (e.g., HALE and balloon operations).

Flight Plans – Manned and unmanned high-speed fixed wing operations file an IFR flight plan and receive ATC separation services during the transit to upper E airspace. More specifically, manned supersonic aircraft are required to file six to 24 hours prior to expected departure.

HALE airship and some HALE fixed wing vehicle Operators also file flight plans; however, these vehicles have limited ability to comply with ATC instructions or adhere closely to a specified flight path due to performance limitations. Operators of free balloons do not file conventional flight plans; they meet requirements for notification and authorizations as detailed below, which support ATC in separating other IFR aircraft from these less maneuverable vehicles.

Notification & Authorization – Notification and authorization requirements vary by vehicle type. Manned fixed wing aircraft Operators must contact ATC prior to departure and are provided full-route clearance by ATC. Unmanned high-speed fixed wing vehicle Operators contact the ATC facility nearest to their launch point and are provided route clearance in the same manner as manned aircraft.

HALE fixed wing Operators file NOTAMs prior to launch and are authorized in accordance with Letters of Agreements (LOAs). Free balloons and HALE airship Operators provide notification to ATC and other airspace users in accordance with 14 Code of Federal Regulations (CFR) Part 101.37 and applicable waiver/Certificate of Authorization [COA] requirements. In certain areas, balloons and airships are also required to obtain ATC authorization per 14 CFR Part 101.33.

Table 2-1. Current Flight Planning, Notification, & Authorization Requirements by Vehicle Type

	Manned Fixed Wing (Super/Subsonic)	High Speed Unmanned Fixed Wing	HALE Unmanned Fixed Wing	Balloon (HALE & Short Endurance)	HALE Airship
Flight Plan	IFR Flight Plan Filed (6 - 24 hours*) in advance (per 7110.65 9-2-15a) ***supersonic only**	IFR Flight Plan filed 1 to 2 hours in advance. Covers route between airport and SUA	Filed as required based on national regulation	Unable due to trajectory uncertainty	IFR Flight Plan 24 hours prior
Notification Required	N/A	To the nearest ATC facility	NOTAMs requested 24 hours prior to launch	As required per 14 CFR Part 101.37 Nearest ATC facility 6-24 hours prior to operation and time of launch	Adapted from 14 CFR Part 101.37
Authorization Required	After filing flight plan, Operator receives a full route clearance and a squawk code	ATC Clearance is provided or amended real-time (same as manned aircraft)	In accordance with LOA with ANSP	Authorization as required per 14 CFR Part 101.33	Adapted from 14 CFR Part 101.33

2.4.1.3 Launch/Transit to Operating Altitude (through Class A airspace)

During launch and transit to/from the ETM environment, Operators comply with applicable regulations governing operations within the ATC service environment, including any LOAs that have been established or COAs that have been granted. Operators maintain communications with ATC as required.

ATC separates aircraft from one another in accordance with policy/regulations and established separation criteria using available surveillance information for the vehicle (e.g., radar, ADS-B) and information provided by the Operator (e.g., projected trajectory). Separation criteria are based on vehicle performance, maneuverability, and ability to withstand wake from other aircraft. ATC takes these

limitations into account when providing separation services and issuing instructions. ATC may issue control instructions consistent with the vehicle's ascent capabilities. Specific ATC clearance will depend on conflict geometry and the vehicle's performance capabilities (e.g., vector, reroute, interim level off, speed adjustment, change in vertical rate, or some combination thereof). ATC must issue a clearance to enter upper Class E airspace.

Each vehicle has an ascent pattern that is dictated by various operating characteristics which may include maneuverability, available power, flight control and structural limitations of the vehicle. NAS efficiency is also a consideration if the vehicle's ideal descent pattern is disruptive to NAS operations (see Figure 2-2).

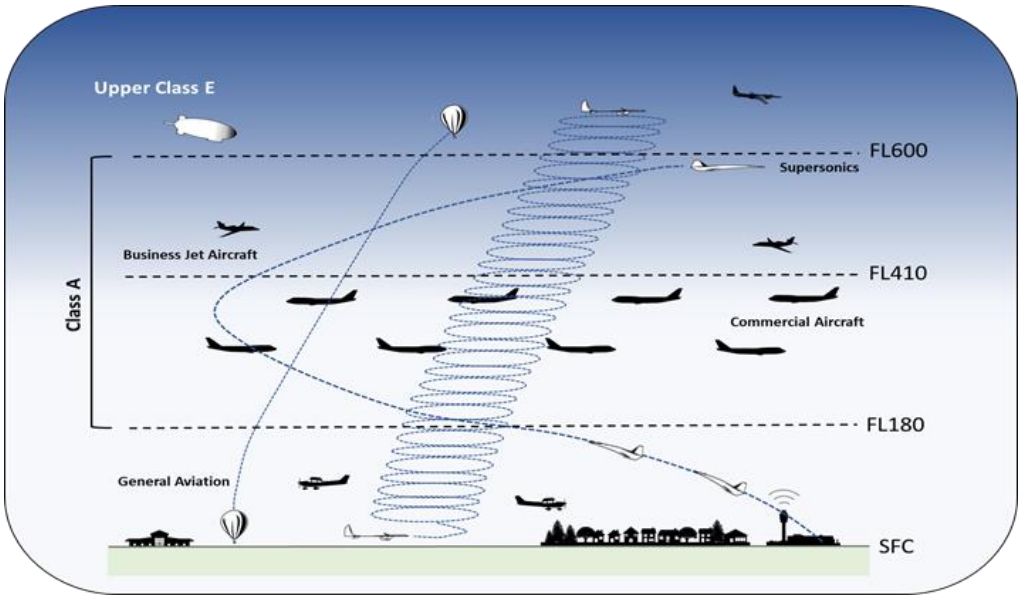

Figure 2-2. Launch and transit to upper Class E airspace

Balloons and High-Altitude Airships – These vehicles ascend freely with little to no maneuvering ability. Operators provide ATC with an estimated flight path (not a conventional flight plan) and notify ATC prior to launch. Position reports are provided to ATC throughout the ascent. Neither lateral positioning nor rate of ascent can be controlled. The vehicles have limited ability to respond to unforeseen events due to lack of maneuverability; therefore, ATC segregates other traffic from them.

HALE Fixed-Wing – Operators transiting to upper Class E file a flight plan based on forecasted winds for their ascent through controlled airspace. Ascent is performed via a spiral pattern climb. Since the vehicle is susceptible to winds, route flexibility is often an important aspect of transit. ATC segregates the HALE from other traffic during transit since the vehicle has limited ability to hold altitude and maneuver. ATC may terminate radar services and revert to non-radar procedures should surveillance capability becomes inadequate (e.g., radar contact lost).

Supersonic – Supersonic aircraft are expected to operate like conventional manned aircraft through Class A airspace (similar to current subsonic operations), however, climb rates are expected to be much greater

as fuel efficiency is a much larger concern. These aircraft also require greater separation distances from other aircraft due to climb and maneuverability differences from conventional aircraft.

***Scenario 1* – ETM HALE Balloon Operation Planning and Transit to Upper Class E Airspace**

A HALE balloon Operator, Helium Eagle Communications, is planning to send a vehicle into upper Class E airspace to provide broadband Fourth Generation (4G) Long Term Evolution (LTE) internet service as part of an emergency response effort for a region with an earthquake damaged ground-based communications infrastructure. To control the vehicle's trajectory, pressurization controls enable operating altitude adjustments that take advantage of prevailing winds. The vehicle is equipped with ADS-B, a transponder, and primary/redundant communications equipment for connection to the Operator's control station.

The Operator subscribes to third party services for support with flight planning, weather/atmospheric data, and other information pertinent to the operation. Initial planning information, including current weather forecasts for the launch and ascent, atmospheric forecasts for high altitude airspace, and available cooperative intent and flight information for other Operators that may be in proximity to the balloon at operating altitude and upon initial phase of flight are obtained. The Operator plans the initial portion of the flight, focusing on the launch and ascent phase, and identifying the optimal altitude for the initial operating phase. Adjustments are made to the plan to ensure no operational conflicts exist with other cooperative Operators.

Once planning is complete, the Operator for Helium Eagle shares relevant intent information with other Operators that are participating in cooperative separation. The Operator also notifies ATC in accordance with 14 CFR Part 101.37(a) requirements, providing required information (e.g., balloon identification, estimate launch date/time, launch location, trajectory/ascent time to operating altitude). ATC utilizes this notification information to evaluate the feasibility of managing the operation at the requested time and, if necessary, notifies the Operator to alter launch time.

Upon launch of the balloon, the Operator notifies ATC in accordance with 14 CFR Part 107.37(d). The balloon transmits via ADS-B and/or transponder, in accordance with applicable operating requirements. Once the balloon is in controlled airspace, ATC manages any traffic that is in proximity of it during its ascent and ensures separation is maintained. The balloon eventually reaches its operating altitude, levels off, and begins its initial operating phase.

***Scenario 2* – HALE Vehicle Changes to Flight Path/Intent While in Transit to Class E**

StratoWing Communications is operating a HALE fixed wing vehicle, which is ascending through Class A airspace on its way to upper Class E airspace. StratoWing operates 4G-LTE communications platforms at high altitude to provide widespread internet services to remote and rural customers. Prior to launch, the Operator has met all requirements relevant to flight planning, notification/authorization, and cooperative information sharing. The vehicle executes a spiral ascent pattern on transit to Class A airspace. ATC has access to flight/surveillance information for the HALE vehicle, which may come from ATC systems (e.g.,

radar) or may be provided by the StratoWing Operator. ATC manages any nearby traffic, ensuring separation from the HALE vehicle is maintained.

During ascent, ATC reroutes a commercial airline traffic around storm activity (see Figure 2-3). As a result, ATC instructs the StratoWing Operator to temporarily halt the ascent of the HALE vehicle. The Operator commands the vehicle to temporarily hold altitude while maintaining a circular flight path around a specified waypoint. Once the rerouted traffic has passed, ATC instructs the Operator to continue the ascent. The Operator resumes ascent, and then performs in-flight re-planning to determine when the vehicle will reach its operating altitude in upper Class E and begin its initial operating phase. As part of this re-planning, the Operator obtains any updated information on other Operators participating in cooperative separation and de-conflicts the operation if any issues are detected. Once re-planning is complete, updated intent is shared with other Operators in the cooperative separation ecosystem; ATC has access to this information if needed.

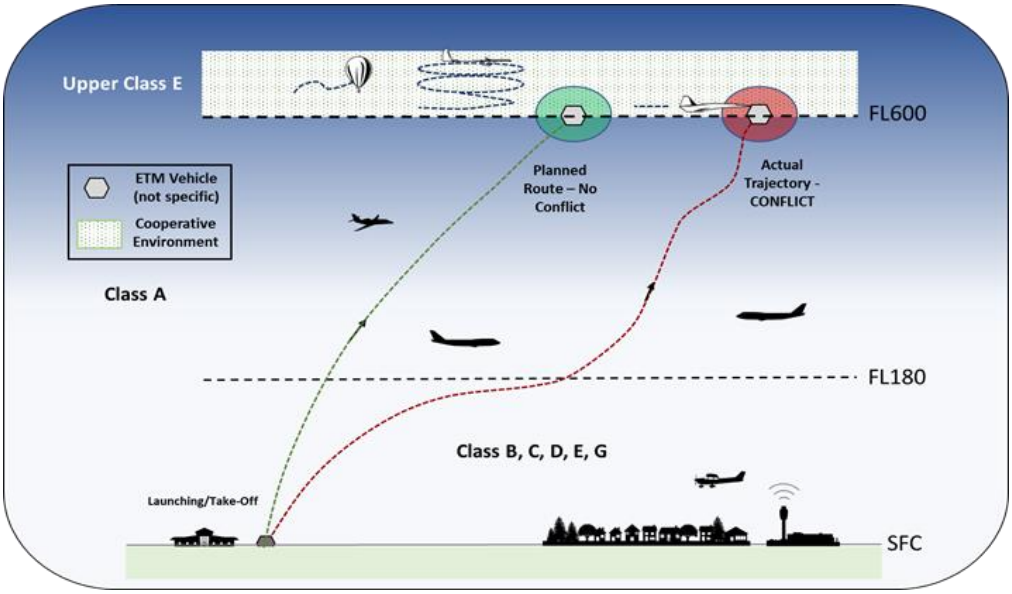

Figure 2-3. Launch and transit to upper Class E airspace

2.4.2 Operating Altitude WITHIN Upper Class E Airspace

Upper Class E industry stakeholders are working together to propose recommendations and solutions for a cooperative traffic management architecture, leveraging UTM principles and current ATM rules to the extent practical, that will support management of operations in upper Class E airspace. This includes establishing rules of the road (e.g., right of way rules) that take into consideration vehicle capabilities and performance/separation envelopes[5]. Industry stakeholders are also developing equity and airspace access rules and guidelines to address normal and emergency or priority operations.

[5] ETM cooperative separation will be predicated on performance-based criteria (referred to here as separation envelopes) rather than separation minima.

The following sections describe some of the key components of separation assurance in a cooperatively managed environment, and present some of challenges high altitude vehicles pose to cooperative solutions due to performance disparities.

2.4.2.1 Cooperative Separation

Cooperative separation is achieved via shared intent, shared awareness, de-confliction of operations, conformance monitoring, technologies supporting de-confliction, and the establishment of procedural rules of the road (e.g., right-of-way rules). Operators share their flight intent with each other and coordinate to de-conflict and safely separate trajectories. Conformance monitoring is engaged to ensure that operations stay safely within the bounds of their intent. Operators, third party services, and if need be, the FAA, are notified of non-conformance (intentional or unintentional) so that appropriate action can be taken. Vehicle de-confliction (e.g., Operator to Operator, vehicle-to-vehicle [V2V]) ensures safe separation while procedures and clear rules-of-the-road ensure harmonized user interactions. Systems supporting cooperative operations are interoperable where necessary to support data format and exchange protocols, equipment requirements, procedures/response protocols, and other ETM needs.

- **Intent Information**: Intent information consists of the spatial and temporal elements of a planned operation (e.g., intended trajectory and time). Intent information enables Operators (and ATC when appropriate) to gain situation awareness of proximate operations, and supports demand/capacity balancing, de-confliction, and distribution of constraints, advisories, and flight operations data to affected airspace users.

- **Flight Information Updates:** Inflight information supports real-time separation management functions. It is comprised of active flight data, including, but not limited to, vehicle tracking and conformance data, position data, and V2V data. Active flight information supports de-confliction/ATC separation functions in the cooperative environment, advisory generation and distribution (e.g., identification of non-conforming flight and distribution of advisories to proximate operations), and contingency management.

- **Airspace Constraint Information**: The FAA makes NAS airspace constraint data available to cooperative Operators so they can respond to flight restrictions (e.g., TFRs), Special Activity Airspace (SAA)/ SUA activity, and other NAS constraints.

- **Supplemental Information:** Supplemental information designed to support safety of flight on transit, or at operating altitude, can be self-provisioned or obtained through third party service suppliers. Supplemental data can include, but is not limited to, atmospheric data, weather, surveillance, and advisory/hazard information related to transit (e.g., terrain and obstacle data).

- **Historical Cooperative information**: Cooperative Operators, or third party service suppliers, archive operations data according to FAA stipulations. The FAA has access to this historical data as needed for FAA analytics, regulatory, and Operator accountability purposes.

De-confliction is the resolution of a potential conflict between two or more operations, primarily via advanced planning and information exchange. Flight intent is a type of information that is exchanged between Operators that can be used to identify conflicts. It is four-dimensional (4D) (time and space) information that indicates, with a known level of confidence, where an aircraft will be at some given point in the future. Examples of flight intent include flight trajectories and volumes. The known level of confidence regarding adherence of the vehicle to the Operator's shared flight intent may vary significantly between different types of vehicle (e.g., supersonic transport vs. HALE balloon), due to characteristics unique to each vehicle type. Examples include:

- A supersonic transport vehicle can maintain position along a pre-defined flight path from take-off to landing under nominal circumstances. The confidence level of adhering to the nominal flight path is impacted by factors such as navigation performance or tolerance to weather/atmospheric events.

- HALE balloons are generally able to vary their altitude, which enables them to take advantage of prevailing winds to control the vehicle's flight path. However, this level of control is not as predictable as other vehicles. The balloon's path can be projected based on available data, with increasing uncertainty the further out the projection.

To account for these varying levels of confidence, Operators update their flight intent at some regular interval and share it with other Operators. Operators flying vehicles with increasing uncertainty over time may have to update their intent and share it more often than those that have a high confidence over time.

If de-confliction is not pre-planned or fails, Operators enact collision avoidance procedures. Standardized procedures exist and are known by all Operators within the cooperative separation environment. Collision avoidance procedures vary by the type of vehicle being operated, due to the differences in maneuverability, performance, and other factors.

Each vehicle type has specific capabilities that may limit its ability to abide to certain de-confliction procedures based on its structure, maneuverability, performance, and separation required from other vehicles. Unique cooperative separation considerations for projected high altitude vehicle types are presented in the following paragraphs.

Balloons and High-Altitude Airships – Balloons and high-altitude airships, by virtue of being lighter-than-air aircraft, are comprised of less rigid structures, with minimal control capabilities. They may have susceptibilities to atmospheric disturbances associated with higher-speed large aircraft, such as rapid pressure changes due to passing shock waves from aircraft in supersonic flight. As cooperative separation relies on strategic de-confliction between Operators, the predictability of vehicle positions over time should be accounted for when considering separation between vehicles. Separation envelopes for balloons/airships should be established to account for their increasing uncertainty of projected position over time.

HALE Fixed-Wing – Compared to balloons, HALE Fixed-Wing vehicles are powered and have directional and altitude control. However, they are very lightweight and have limited propulsion, so they are still susceptible to changing wind conditions. They also have susceptibilities to atmospheric disturbances associated with higher-speed large aircraft, such as rapid pressure changes due to passing shock waves from aircraft in supersonic flight. As cooperative separation relies on strategic de-confliction between Operators, the predictability of vehicle positions over time should be accounted for when considering separation between vehicles. Separation criteria for HALE fixed-wing vehicles should account for increasing uncertainty of projected position over time.

Supersonic – As with all aircraft, weather conditions can affect planned trajectories, however supersonic vehicles have high-performance capabilities, and thus have a high confidence in the planned trajectory. When flying at supersonic speeds their ability to maneuver for unplanned reasons (e.g., large heading changes) is limited reducing speed requires a large amount of distance. In addition, the shock wave produced by these aircraft at supersonic speeds can affect lighter vehicles (e.g., balloons, HALE fixed wing) - cooperative separation criteria needs to account for potential disruption, or possible damage, to other vehicles.

2.4.2.2 ATC-Provided Separation

Radar and non-radar ATC services remain available to IFR aircraft above FL600 in ETM. ATC separates IFR from IFR and cooperative vehicles using NAS data sources and cooperative operations data. ATC separates IFR aircraft from SUA above FL600 according to prescribed separation criteria. Traffic advisories are issued when workload permits.

If ATC-managed aircraft require emergency services, or have the potential to be impacted by an emergency, ATC services are provided. ATC does not provide services to cooperative operations.

2.4.3 Operating Altitude BELOW Upper Class E Airspace: Flexible Floor of Cooperative Environment

Airspace below FL600 is used regularly by HALE balloons and fixed wing Operators. HALE balloon Operators utilize prevailing winds at changing altitudes to control their vehicle's direction of flight, while solar-powered HALE fixed wing Operators ascend and maintain a specified operating altitude during the day while charging batteries and descend at night to minimize battery drain. Airspace usage below upper Class E airspace typically ranges from FL500 and FL600 for these operations. Supersonic transport operations, once reintroduced into the NAS, will primarily operate their cruise phase between FL500 and FL600.

Today, conventional (i.e., high speed/fixed wing) aircraft operations traversing airspace between FL500 and FL600 are sparse, relative to commercial traffic below FL500, and are generally limited to high-performance business jets and State aircraft. Business class aircraft operate at altitudes as high as FL510 (when equipped/certified) and generally receive a block of airspace in which to operate with vertical separation standards of 2000 ft. State aircraft operations, both manned and unmanned, consist primarily

of research and surveillance missions. Operational tempo for conventional aircraft is not expected to significantly increase as HALE and supersonic transport operational tempo increases. Table 2-2 provides an overview of these aircraft types. Figure 2-4 provides a visualization of airspace usage below FL600.

Table 2-2. Operations below FL600

Type of Operation	Operational Description
Subsonic Transport	May conduct cruise phase of flight at or below FL510
State Aircraft	May operate at various altitudes, up to and above FL600, based on mission needs and aircraft capabilities. May operate at subsonic and/or supersonic speeds, and may be manned or unmanned/remotely piloted
Supersonic Transport	Will initiate supersonic cruise above FL500. As fuel is consumed, altitude increases, which may include some portion of flight above FL600
HALE Balloons	May ascend/descend between ~FL500 and FL700 (+) to take advantage of different prevailing winds (primary method of controlling geographical position)
HALE Fixed-Wing	Will ascend during the day using solar energy (charging batteries) - primarily above FL600. Will descend during night (battery only); the vehicle may drop below FL600
HALE Airship	Has equipment to control lateral trajectory (motor/propeller and rudder). Vehicle may ascend/descend above/below FL600 to take advantage of prevailing winds and possibly to balance pressure differentials

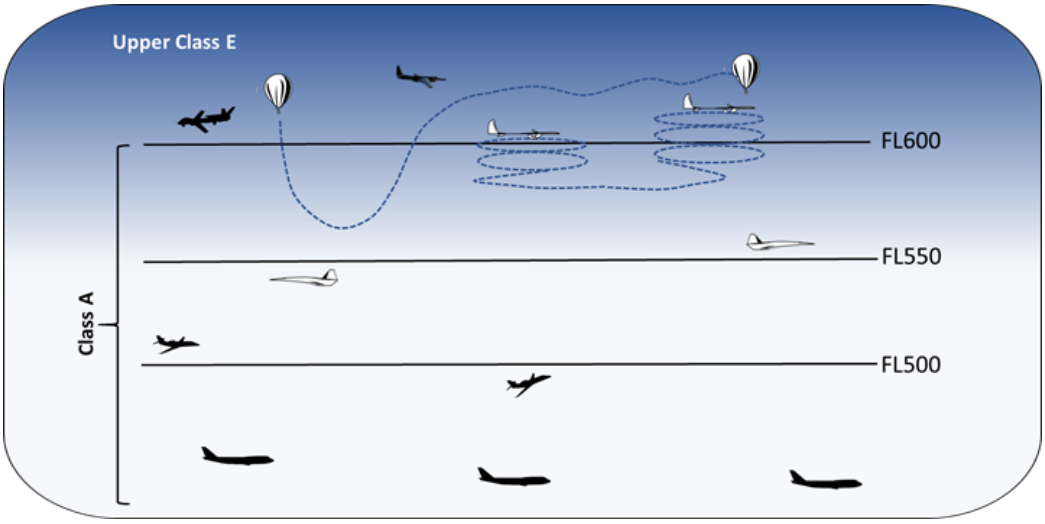

Figure 2-4. High altitude operations straddling FL600

Operational tempo of HALE vehicles is projected to increase significantly, as development enables new use cases and capabilities, vehicle production capabilities improve, and new Operators move from their test/development phases to routine operations - which will include operating regularly in the FL500 to FL600 altitude strata.

2.4.3.1 Flexible Floor of Cooperative Separation Environment

Due to relatively low-density conventional aircraft operations between FL500 and FL600, it is feasible, in areas deemed appropriate by ATC/FAA, to extend the conduct of cooperative operations within this altitude range. This would enable ETM Operators to continue to cooperatively separate their vehicles from one another without ATC coordination. The areas where the floor is extended are referred to in this document as flexible floor areas. A depiction of a notional flexible floor area is shown in Figure 2-5.

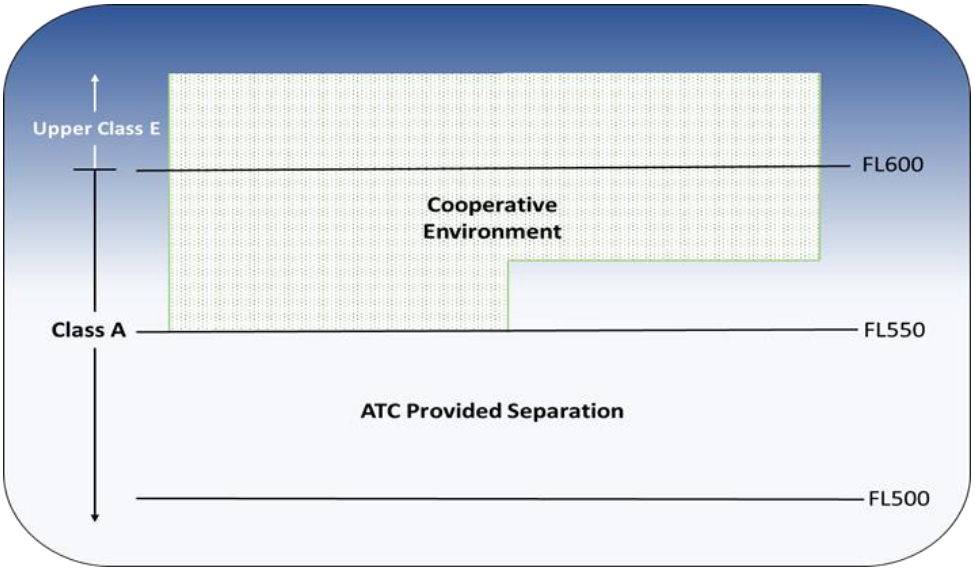

Figure 2-5. Cooperative separation below FL600

Flexible floor areas are designated by the FAA and communicated to airspace users through some means (e.g., digitally published). Floors are flexible, not dynamic or static, so they require lead-time to establish, and change according to a reliable schedule that accommodates user needs (e.g., change day to night, seasonally). Operators wishing to separate cooperatively in a flexible floor area are required to notify and/or request authorization from ATC prior to entry (e.g., ascent if on transit to flexible floor area or descent if descending from upper Class E)[6]. An Operator can 1) manually coordinate with ATC, or 2) provide notification, and receive authorization, via an automated means. An automated notification/authorization capability provides a similar level of ATC coordination/situational awareness that exists today, while leveraging digital information exchanges to maximize efficiency and decrease

[6] Operators notify and/or request authorization in accordance with applicable regulations.

workload. ATC does not provide separation services to vehicles cooperatively operating within an approved flexible floor area.

2.4.3.2 Aircraft receiving ATC Separation Services through Flexible Floor Areas

While flexible floor areas will primarily be used by vehicles participating in cooperative separation, they are not exclusive-use areas. Some aircraft operate in Class A airspace above FL500 while receiving ATC separation services, including supersonic and subsonic transport, and State aircraft.

A flight operating on an IFR flight plan, referred to here as an ATC-managed operation, has the option of flying a route that avoids flexible floor areas or one that traverses through a flexible floor area (see Figure 2-6). Operators that opt to fly through flexible floor areas are responsible for strategically de-conflicting their operations from cooperatively-managed operations and filing an IFR flight plan that that includes a conflict-free trajectory. Due to the performance limitations of HALE vehicles, which require a significant amount of time to maneuver/adjust their position compared to high speed transport aircraft (e.g., subsonic/supersonic transport or State aircraft), tactical maneuvers to avoid conflicts between the vehicles are not practical and, thus, avoided under nominal operating circumstances. Cooperative Operators begin to maneuver their vehicles in timeframe that ensures appropriate pair-wise separation envelopes (e.g., supersonic to balloon pair-wise separation buffer) are attainable.

When the ATC-managed flight approaches flexible floors along the route, ATC clears the aircraft to enter a conflict free corridor/volume as filed; ATC does not provide separation services to aircraft or vehicles in flexible floor areas. ATC does have access to notification/authorization and intent/flight data for operations within flexible floor areas, should it be required. Intent/flight data includes real-time position reports, forecasted trajectories, and other information exchanged between cooperative Operators as part of de-confliction processes.

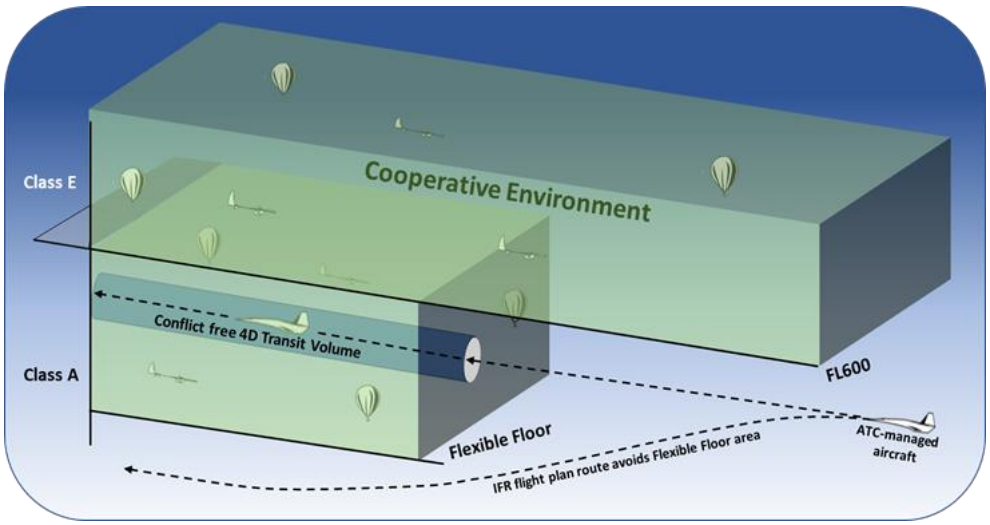

Figure 2-6. ATC-managed flight through flexible floor area

***Scenario* – Supersonic Transport Flight through Class A Flexible Floor Area**

Quiet Boom Charter is planning a chartered supersonic transport flight from IAD to LAX, with the intent to depart from IAD in 12 hours[7]. Quiet Boom operations personnel (QB-Ops) compare their nominal flight path against known flexible floor areas to identify locations along the flight path where their aircraft will overlap cooperative separation environments in Class A airspace (see Figure 2-7); two are identified. For each area identified, QB-Ops utilizes services to identify cooperative Operators that will be operating within either area during the time of the supersonic aircraft's transit. HALE Operators A and B are identified for one of the flexible floor areas; the other flexible floor area has no active cooperative operations during the specified time.

QB-Ops initiate data exchanges with Operators A and B, requesting information on their projected 4D flight trajectories for times of interest; each Operator responds with the requested information. QB-Ops compares their nominal 4D flight path against the set of cooperative vehicles' projected trajectories and determines that separation envelopes of the supersonic and Operator A's and B's vehicles will be violated if adjustments are not made.

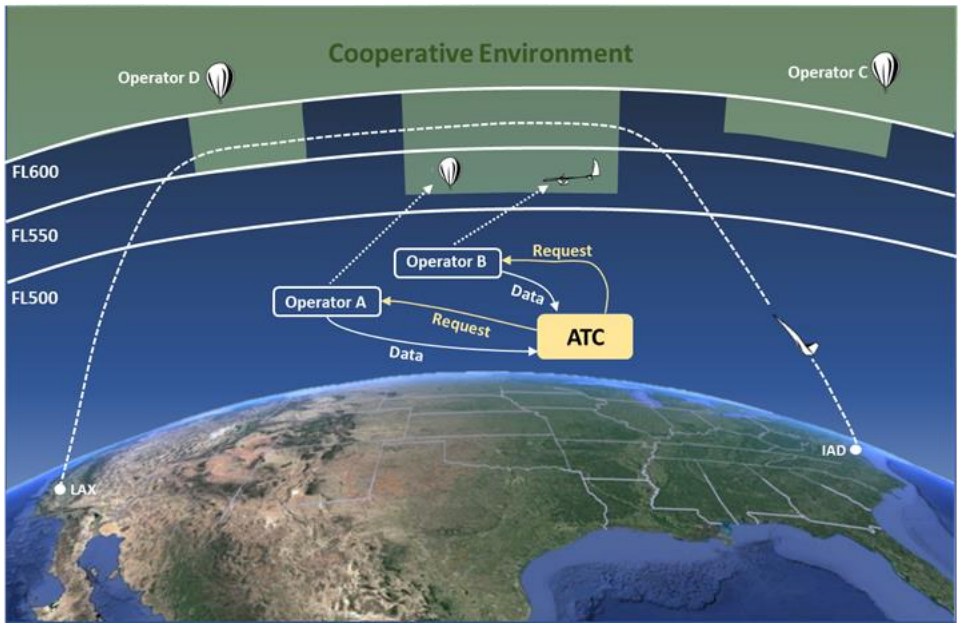

Figure 2-7. ATC information exchanges with cooperative operators

QB-Ops coordinates with Operators A and B to adjust elements of the 4D trajectories and resolve the conflicts. Operator B indicates the vehicle can move in time to resolve the conflict, while Operator A indicates an additional 20 minutes would be required to ensure the HALE vehicle's separation envelope will not conflict with the supersonic transit volume. QB-Ops adjusts elements of their 4D flight path to account for the time needed for the Operator B HALE vehicle to move. QB-Ops finalizes their flight plan, and sends the update to Operators A and B; both Operators acknowledge they have received the update

[7] This scenario assumes that aircraft with quiet boom capabilities are permitted to operate supersonic over land.

and will separate from the volume. QB-Ops also generates a transit volume for the other identified flexible floor area; details on this volume are made available to cooperative Operators as needed. QB-Ops generates an IFR flight plan and files it via appropriate services. ATC approves the flight plan.

Prior to the supersonic aircraft's takeoff, Operator D, whose vehicle is currently in Upper Class E airspace, begins in-flight planning for entry into the other flexible floor area (the one not used by Operators A and B). Operator D obtains relevant planning information from other Operators, which includes the transit volume from QB-Ops; the Operator accounts for this constraint while planning the descent time and profile, ensuring the vehicle will not conflict with the supersonic operation during its transit. Once planning is complete, Operator D submits a request to ATC systems for authorization to enter the flexible floor area. ATC sends an approval message in response to the request.

The supersonic aircraft takes off per the approved flight plan and conducts flight using ATC separation services. ATC clears the aircraft to enter the 4D transit volumes for each flexible floor area. The supersonic aircraft flies through each flexible floor area without issue and safely lands at LAX.

2.4.4 Descent from Upper Class E Airspace to Landing (into/through Class A airspace)

ATC provides clearance to Operators to enter into Class A airspace from Upper Class E prior to descent. Upon entry into Class A, ATC separates aircraft from one another in accordance with applicable policy/regulations and established separation criteria using available surveillance information for the vehicle (e.g., radar, ADS-B) and information provided by the Operator (e.g., projected trajectory).

ATC may issue control instructions consistent with the vehicle's descent abilities to maintain separation. Specific ATC clearance depends on conflict geometry and the vehicle's performance capabilities (e.g., vector, reroute, interim level off, speed adjustment, change in vertical rate, or some combination thereof).

Each vehicle has a descent pattern that is dictated by various operating characteristics which may include maneuverability, available power, flight control, and structural limitations of the vehicle. NAS efficiency is also a consideration if the vehicle's ideal descent pattern is disruptive to NAS operations (refer to Figure 2-8).

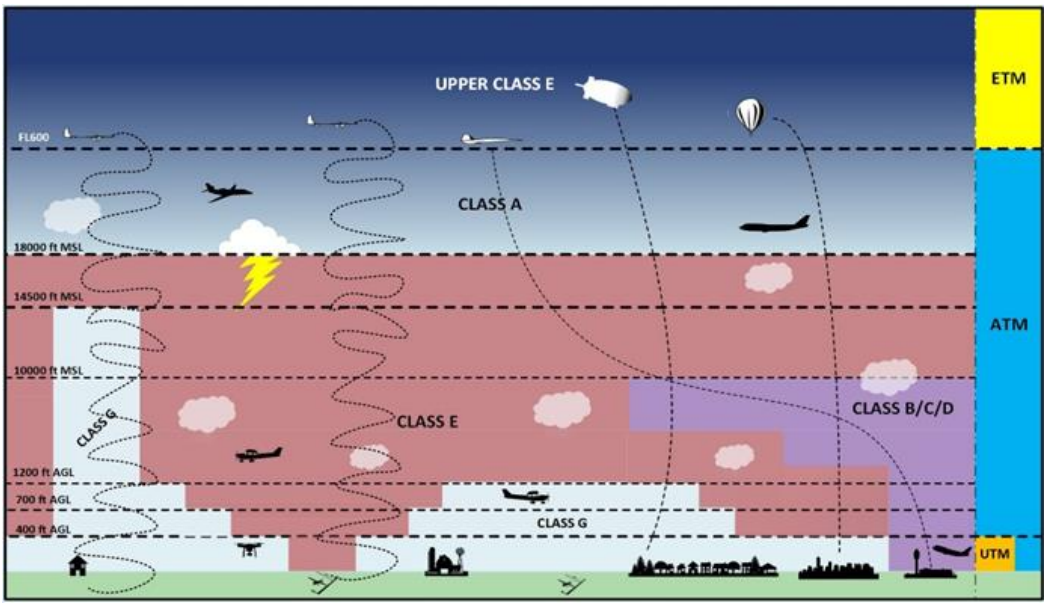

Figure 2-8. Operating altitude to landing

Balloons and High-Altitude Airships – Prior to descent for landing, Operators notify ATC, providing information such as intended descent time, estimated exit point, and predicted trajectory from upper Class E through Class A. ATC may delay the requested descent due other traffic or restrictions within the block of airspace. ATC provides clearance for the vehicle to descend, and segregates traffic from the vehicle during descent. Once the Operator initiates the descent, the vehicles have limited to no ability to respond to unforeseen events due to maneuverability limitations. Parachutes are deployed to slow the rate of the balloon's descent.

HALE Fixed-Wing – On descent, Operators provide notification to ATC with an intended descent time and estimated exit point from upper Class E to Class A airspace. The Operator provides ATC with the intended descent trajectory, much like a flight plan. ATC provides the Operator with a clearance to descend into Class A airspace and segregates traffic from the vehicle. On descent, the vehicle has the ability to hold altitude, if necessary. Therefore, ATC may provide the Operator with a stepped clearance on descent allowing ATC to efficiently route traffic. It is possible a case may arise where the vehicle is low on energy and may not be able hold altitude prior to a clearance, thus requiring ATC to make special accommodations.

Supersonic – Supersonic aircraft Operators interact with ATC similar to conventional aircraft when at subsonic speeds; though maneuverability characteristics may require ATC handle them differently as different portions of descent. Operators are on IFR flight plans that contain all of the information required by ATC, including specified routes and aircraft performance-related data. Prior to descent from operating altitude, ATC provides the Operator with a clearance to descend via the filed route for a specific window. ATC provides separation and may provide an updated route that vectors the aircraft around potential conflicts.

***Scenario 1* – Unmanned HALE Fixed Wing Descent through Controlled Airspace to Landing**

StratoWing Communications, a HALE fixed wing Operator, has a vehicle orbiting on station providing commercial high-speed internet communications services to a remote/rural area for several months that must land for scheduled maintenance. Due to the vehicle's descent characteristics, and to minimize airspace usage, the Operator coordinates with ATC to arrange a spiral descent over the course of 10-12 hours. Since the vehicle requires segregation from other traffic during descent, ATC requests a nighttime descent to minimize disruption to the NAS.

At the arranged time, ATC issues the Operator a clearance to descend to FL450 and hold at a waypoint close to the aircraft's destination until midnight, at which time they should request further clearance. The initial hold accounts for the higher tempo of air traffic at/below FL430 that occurs during the day and evening (e.g., commercial en route, lower altitude general aviation). The Operator tracks the descent and remains in communication with ATC as required, which may include supplementing ATC surveillance data via digital means and/or maintaining voice communication.

Around 11:45 p.m., ATC issues a clearance for a spiral descent to FL240 and the vehicle is handed off to the low altitude sector responsible for the non-towered destination airport. With traffic being light, the low altitude controller immediately clears the HALE vehicle for approach.

As the HALE vehicle passes through 10,000 feet, a general aviation (GA) aircraft flying via Visual Flight Rules (VFR) enters the airspace managed by the low altitude controller. The low altitude controller advises the GA aircraft over radio of the IFR HALE UAS with limited maneuverability. The GA aircraft responds that the vehicle has been detected using ADS-B IN and Traffic Alert and Collision Avoidance System (TCAS) and will maneuver around it. Once the HALE vehicle is sufficiently close to the airfield, radar service is terminated and its flight concludes without further incident.

***Scenario 2* – Unmanned Balloon Descent through Controlled Airspace to Landing**

A Helium Eagle Communications balloon, on station for several months to support ground communication infrastructure repair after an earthquake, must descend for required maintenance. In accordance with 14 CFR Part 101 requirements, the Operator notifies ATC with descent information (e.g., current position/altitude, planned trajectory). ATC acknowledges the notification and approves the request. At the agreed upon time, the Operator initiates descent, monitoring the vehicle, re-calculating the trajectory and location of landing as regular intervals as it descends, and providing updates to ATC as appropriate. The Front Line Manager (FLM) responsible for the Air Route Traffic Control Center (ARTCC) area where the balloon will land and balloon Operator communicate periodically via telephone, as necessary. The Operator is able to provide the estimated latitude and longitude, along with a radius from the identified point, within which the balloon will land. The FLM shares this information with the sector where the balloon is descending. The controller notes the approximate region of the balloon's descent on radar and determines it is projected to descend through one of the sector's major traffic flows. As the balloon descends through FL450, the controller begins to proactively vector aircraft around the descent area. The FLM, noting the operational impact, advises the ARTCC Traffic Management Unit to reroute any aircraft departing within the center around the affected region. As the balloon descends below FL200, it becomes

less of a factor for the center and normal operations resume. The balloon envelope and payload separate at a predetermined altitude and each section deploys a parachute for soft landing.

2.4.5 Contingency Management

ETM Operators have established contingency procedures for events that can impact their ability to fly or land their vehicle safely (e.g., UAS loss of command and control [C2] link, uncontrolled descent). Known, predictable response protocols support the Operator and ATC management of situations that have potential for injury to people on the ground and in the air and/or damage to property.

Contingency responses can vary based on the event, vehicle capabilities, operational characteristics, phase of flight (e.g., take-off, transit, operating altitude), location (e.g., over populated areas vs over the ocean), the airspace management system under which ETM Operators are operating (e.g., ATC or cooperative), and other factors.

Operators must be capable of identifying contingency conditions and enacting protocols designed to correct or mitigate them. If the situation cannot be corrected or presents a hazard to others, Operators must notify potentially impacted entities as soon as practical of the condition, providing operational information sufficient for them to take action.

Cooperatively-managed ETM Operators notify other potentially impacted cooperative airspace users (e.g., airspace users along the projected trajectory) according to common notification standards and messaging protocols, using their own or third party services, to facilitate de-confliction of affected flights. If the event requires FAA attention and/or intervention, or could potentially impact ATC-managed flights, ATC is notified. ATC-managed ETM Operators notify ATC as soon as practical. Known, relevant information (e.g., last know location, projected flight path) is supplied to impacted parties (e.g., ATC, impacted cooperative Operators) and used to directly enact necessary measures to respond to and/or mitigate outcomes. Response/emergency personnel (e.g., fire department), public/private entities (alternate landing site), and/or other impacted parties (e.g., citizens on the ground) are also notified, as applicable.

There is an assumption of priority in ETM, vehicles along the trajectory of the affected vehicle give way to the extent practical, according to agreed-upon rules.

Operators are responsible for collecting and retaining FAA specified data about an accident/incident for an indicated period of time. Third party services may help Operators in meeting these responsibilities by retaining records and other data (e.g., telemetry data).

Scenario 1 **– Emergency Descent of an Unmanned Balloon**

A HALE balloon, operated by Helium Eagle, is operating at FL610 providing internet and telecommunications services to remote and rural areas. At 3:00 a.m., monitoring equipment alerts the Operator that the balloon is slowly losing altitude, and automated controls are unable to return it to its programmed position (see Figure 2-9). The Operator performs troubleshooting procedures and

determines that the equipment issue cannot be fixed remotely and contingency procedures must be enacted.

The balloon is operating cooperatively, therefore, its Operator coordinates with other cooperative Operators to identify potential conflicts resulting from the situation. Since the balloons intends to descend straight into Class A (there is no flexible floor area below FL600) without laterally deviating from its intent, no conflicts are identified. The Operator continues to monitor cooperative intent conflicts as the situation progresses.

The balloon is set to squawk 7700 and ATC coordination begins. The Operator uses available traffic information sources (e.g., FlightAware) to identify actions that could minimize impacts to other traffic in Class A airspace and below. While the airspace below the balloon's current position has light air traffic and is in a remote area, it is heading toward a more heavily populated area with higher air traffic densities. Circumstances indicate that a rapid descent via deflation would minimize impacts to NAS operations and optimize the safety of air traffic and people/structures on the ground.

The balloon Operator requests ATC approval to initiate a rapid descent via deflation and advises ATC of the circumstances surrounding the event. All operational information required for ATC to manage the balloon's descent is provided, including the balloon's current location, altitude, projected descent trajectory, and procedures (e.g., rapid deflation, parachute deployment).

ATC evaluates the information provided, approves the request, and prepares for the descent. The balloon Operator acknowledges and provides updated trajectory information to ATC that accounts for the new descent rate. The Operator commands the balloon to execute the deflation/descent procedure. During descent, ATC vectors aircraft under its control based on the Operator's projected trajectory and current position.

The Operator works with ATC to send notifications relating to the balloon's descent to other airspace users as quickly as possible (e.g, NOTAMs, advisories). Upon reaching a pre-determined low altitude, the balloon deploys its recovery parachute. The vehicle makes a soft landing, and the Operator completes recovery procedures using the balloon's location data.

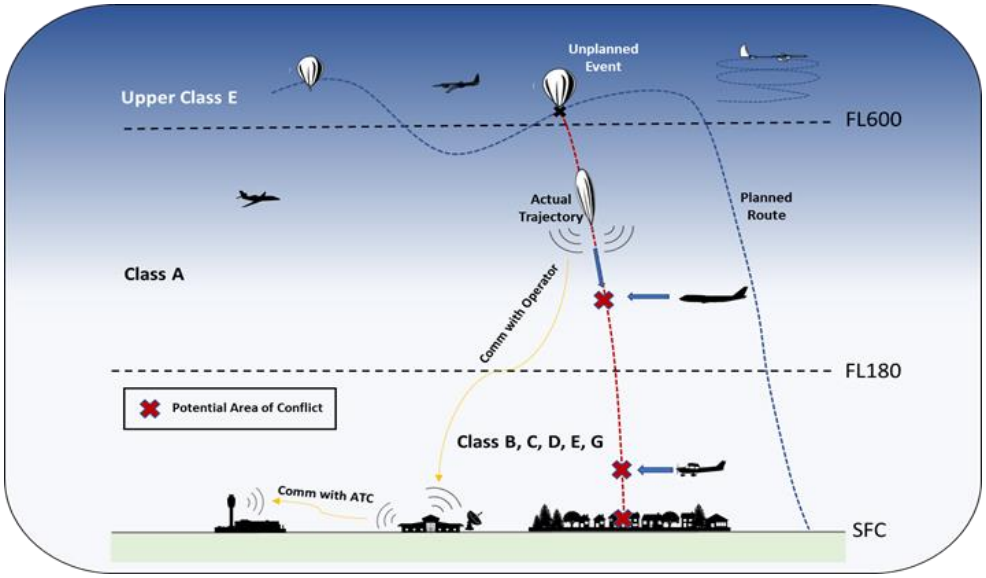

Figure 2-9. Uncontrolled descent

2.5 Equity of Airspace Usage

ETM needs to ensure Operators share airspace in an equitable manner so they can each meet their specific operational objectives. Due to the nontraditional performance of high altitude vehicles - equity rules, operating rules of the road, and priority access guidelines must be developed. Industry stakeholders are currently addressing these equity of access rules, as well as enforcement of those rules through agreed upon guidelines, for the ETM cooperative environment. This development may be evolutionary in nature, increasing in complexity as density increases, challenges arise, and the ETM environment matures. The process by which rules are modified or adapted shall be transparent with established policy and processes. If industry developed business rules or actions are determined to adversely impact FAA expectations such as equity, access, or the competitive environment, the FAA may require changes to resolve.

2.5.1 Airspace Access

Access to airspace must be equitable for vehicles transiting airspace and operating at altitude. Operators cannot optimize their own operations at the expense of sub-optimizing the ETM environment as a whole (or the ATC-managed environment).

For operations transiting to and from operating altitude (controlled and uncontrolled airspace), use of airspace must be equitable regardless of the performance restrictions of vehicles on climb or descent. Operators minimize the impacts their operations may pose to others to the greatest extent possible. For example, Operators can modify climb profile (e.g., spiral climb), launch and land in areas with sparse traffic, and invest in capabilities that will minimize the impacts of their operations and/or decrease required separation to the greatest extent possible.

For cooperative operations above FL600, Operators adhere to a common set of rules that foster equity of access for all Operators. In the event of airspace competition, equitable access is achieved through clear,

industry-established airspace rules, efficient airspace design, and FAA rules. Civil/commercial operations do not infringe on the ability of federal security/public aircraft to carry out their missions in the ETM environment. Operators de-conflict operations according to agreed-upon business rules – via Operator-to-Operator coordination or through automated processes with built in rulesets – that resolve competition for airspace when Operator intent information is shared.

Operators and third party services (if utilized) ensure that airspace volume configuration/design is as efficient as possible during the intent development/sharing process to optimize airspace capacity and minimize the impacts their operations may pose to others to the greatest extent possible.

2.5.2 Priority Operations

In the event of an emergency, the operation is assumed a priority regardless of whether the Operator is receiving ATC provisioned (transit and/or operating altitude) or cooperative services. Priority rules for the cooperative environment will be agreed upon and established by industry stakeholders. As far as practical, there will be a common set of standardized terminology and procedures for managing off-nominal events.

2.6 Security

Security is a priority of ETM and is an expectation of the public. Security refers to the protection against threats that stem from intentional acts (e.g., terrorism) or unintentional acts (e.g., human error), affecting people and/or property in the air or on the ground. ETM contributes to security, while ETM systems and information are protected from external and internal security threats. Security risk management goals include balancing the needs of the members of the ETM community that require access to the airspace with the need to protect stakeholder interests and assets, including the FAA, public entities, NAS participants, and the general public. In the event of threats to aircraft or threats using aircraft, ETM Operators and third party services provide relevant information and assistance to responsible authorities.

The FAA establishes requirements and response protocols to guard NAS systems and the public against associated security threats. The FAA uses ETM cooperative and ATC/ATM system data as a means of traceability to (1) ensure Operators are complying and conforming to regulatory standards, (2) identify and hold accountable those who are responsible during accident/incident investigations, and (3) inform other NAS users, if needed, of problematic activity in the vicinity of the airspace in which they are operating. The FAA can use near-real time cooperative/ATC data to address security needs with respect to ETM operations, including managing off-nominal and exigent circumstances. They use archived data as a means to analyze ETM operations and ensure NAS needs and safety objectives are being met. The FAA can also use all available ETM data (cooperative and ATC provisioned) to notify federal entities of security threats.

The ETM cooperative community supports requisite security and accountability functions. They comply with all security requirements levied by appropriate authorities (e.g., FAA, DoD) and designed to guard NAS systems and architectures against security threats. ETM systems and/or networks meet applicable

security requirements through data collection, archival, and provision protocols, ensuring operations data is available to support stakeholder needs.

2.6.1 Data Management and Access

All Operators must satisfy FAA-stipulated data archiving and sharing requirements to support safety and security regardless of service provision method (cooperative or ATC-provisioned). Stakeholders (e.g., DoD, public safety officials) may need information on active ETM operations for the purposes of aircraft separation and identification of operations that could impact air/ground assets (e.g., vehicle mechanical failure, malicious activity). Operators are required to archive certain data to support post-flight requests by authorized entities with a need to know (e.g., FAA, public entities). This data could include, but is not limited to, operation intent, 4D position tracks, reroute changes to intent, and off-nominal event records (e.g., safety violations). If using third party services, these entities also satisfy applicable data management requirements set by the FAA, such as responding to authorized requests for Operator data that must be provided in near-real time. ETM services may also support authorized historical information requests of an Operator when providing data archiving services.

2.6.2 Networked Systems

ETM introduces new security challenges due to Operator reliance on interconnectivity and integration. ETM service connections, Operators, and government assets increase overall network complexity and provide opportunities for cyber incidents and attacks – including threats to system security and unintended or malicious degradation of system performance. To protect for these system vulnerabilities, cybersecurity architectures and structures are developed and implemented to mitigate the potential for malicious activities and prevent unlawful access to third-party and FAA systems.

UAS design architectures, which vary by manufacturer and/or model, can be manipulated in ways that impact the safety and security of people on the ground and in the air. Command and control link infrastructure, cellular communications, security of Ground Control Stations (GCSs), and global positioning system signal vulnerabilities, create potential for misuse (intentional and unintentional) and malicious interference (e.g., hacking, hostile takeovers) of high altitude vehicle technologies. The FAA considers security risks and requirements proposed for an operation and evaluates the adequacy of proposed solutions (e.g., encrypted links). Operators comply with applicable with FAA rules and regulations governing operations both within ATC and cooperative service environments. Operators are required to obtain all appropriate regulatory approvals, certifications, and/or waivers per FAA policy prior to performing ETM operations. Aircraft systems, including the vehicle and GCS, are operated in accordance with applicable requirements. Operator records are subject to FAA auditing at the agency's discretion.

3 ETM Implementation

As the FAA transitions from the current low density, limited infrastructure of the upper Class E environment to an operationally diverse, technologically sophisticated environment, with increased tempo, new solutions for managing the airspace are prudent. Given the inability to scale the current air traffic management system to support expanded upper Class E operations - cooperative separation, coupled with ATC separation services, provides an ideal foundation to support new, and maintain current, service mechanisms. However, the transition to safe, secure, equitable upper Class E management requires a non-traditional implementation strategy.

ETM implementation requires FAA, National Aeronautics and Space Administration (NASA), industry, and State agency collaboration to evolve the current service mechanisms and realize solutions. Through NASA's Space Act Agreement, the FAA, NASA, and industry are working collaboratively to conceptualize, develop, and demonstrate ETM cooperative operations. While ETM development leverages UTM conceptual elements where possible, its cooperative separation environment is modified to support characteristics unique to the airspace– long duration, multinational flights, extreme deltas between vehicle speeds and performance characteristics, and high-altitude safety risk considerations, among others.

Industry is partnering to derive solutions for the cooperative environment, including the formulation of rules for fair sharing of airspace; an architecture and information sharing protocols to ensure common language and foster situation awareness; harmonized procedural and operational protocols that account for the needs of all participants (e.g., emergency protocols); and adoption of operational systems/technologies/capabilities that are compatible where necessary (e.g., vehicle to vehicle component interoperability). Industry-formulated vehicle separation measures (e.g., separation envelopes), approved by the FAA, will ultimately create a new separation paradigm for upper Class E operations.

Key to ensuring the right solutions and service mechanisms are realized for ETM, is current and aspiring industry stakeholder participation in its development. Industry will continue to work with NASA and the FAA, providing input to ensure new entrant operational needs are accounted for in the development process and to validate proposed solutions and develop performance standards through research (modeling/simulations) and operational testing.

The FAA will mature and refine the ETM concept and conduct engineering analyses to examine and evolve infrastructure, technology, policies, and rules. This includes working with air traffic subject matter experts to explore concepts and solutions for safely, securely, and efficiently co-managing upper Class E airspace with cooperative Operators. As issues are addressed and solutions developed, a complimentary regulatory framework will be constructed to support operations above FL600.

ETM must be able to adapt to new technologies and automation, both ground-based and airborne, allowing for cost-effective, adaptive solutions that can accommodate expanding demand, operations (national and international), applications, and technologies, and support safe and efficient operations that

coexist with current traffic, and impose as little disruption to the existing ATM system as possible – while maintaining fair and equitable access to airspace.

Systems supporting cooperative operations must be interoperable where necessary to support data format and exchange protocols, equipment requirements, procedures/response protocols, and other ETM needs – and should consider global application. Non-prescriptive solutions can minimize deployment and development time by utilizing industry-provided technologies (e.g., mobile communications, existing ground and air infrastructures) capable of meeting appropriate performance requirements for safety, security, and efficiency.

FAA prescribed ETM requirements will be developed with consideration to international application. Universal solutions will optimize industry investments and mitigate operational complexities. With the establishment of a sufficiently formulated, flexible ETM concept, the international community can be engaged to establish a universal framework for, and further inform, information management/sharing, strategic planning, separation standards, situational awareness and security for high altitude operations[8].

[8] Federal Aviation Administration. (2018). Promotion of a Global Framework for Operations above Flight Level 600 [Paper Presentation]. International Civil Aviation Organization: Thirteenth Air Navigation Conference, Montreal, Canada. https://www.icao.int/Meetings/anconf13/ Documents/WP/ WP/wp_162_en.pdf

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List of Acronyms

Acronym	Definition
4D	Four Dimensional
4G	Fourth Generation
ADS-B	Automatic Dependent Surveillance – Broadcast
ANSP	Air Navigation Service Provider
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATM	Air Traffic Management
C2	Command and Control
CFR	Code of Federal Regulations
CNS	Communication, Navigation, and Surveillance
COA	Certificate of Authorization
ConOps	Concept of Operations
DoD	Department of Defense
ETM	Upper Class E Traffic Management
FAA	Federal Aviation Administration
FIR	Flight Information Region
FL	Flight Level
FLM	Front Line Manager
GA	General Aviation
GCS	Ground Control Station
HALE	High Altitude Long Endurance

IFR	Instrument Flight Rules
LOA	Letter of Agreement
LTE	Long Term Evolution
MARSA	Military Authority Assumes Responsibility for Separation of Aircraft
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NOTAM	Notice to Airmen
PIC	Pilot in Command
RPIC	Remote Pilot in Command
SAA	Special Activity Airspace
SUA	Special Use Airspace
TFR	Temporary Flight Restriction
UAS	Unmanned Aircraft System
UTM	UAS Traffic Management
TCAS	Traffic Alert and Collision Avoidance System
V2V	Vehicle to Vehicle