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# Unmanned Aircraft and Balloons in Class E Airspace above FL600, Challenges and Opportunities

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# Air Traffic Services for Unmanned Aircraft and Balloons in Class E Airspace above FL600: Challenges and Opportunities

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ABSTRACT

This paper will examine the air traffic management issues related to the introduction of both high altitude unmanned aircraft and unmanned free balloons in the National Airspace System. It will examine the challenges of providing air traffic services in Class E airspace above FL600 including high endurance operations in that stratum. The paper will consider the different challenges presented by the variability in control of different aircraft types as well as the regulatory differences between space vehicles, unmanned free balloons and unmanned aircraft. In addition, it will consider the potential need to develop or amend policies and procedures to accommodate new commercial operators in Class E airspace above FL600.

## Introduction

Unmanned aircraft have broken the civil aviation altitude barrier. The airspace above 60,000 feet (FL600), once inaccessible to civil operators, is being utilized by experimental unmanned aircraft. As these users progress from experimental to operational activities, there will be increasing competition for the airspace. The current air traffic control infrastructure is not well suited for new operational types. Limitations in communication, navigation and surveillance systems as well as air traffic policies and procedures do not easily translate to meet the demands of the emerging market. This paper will propose an alternative approach to air traffic service delivery in the US controlled airspace above FL600.

## Airspace Overview

Understanding US airspace and the obligation to provide air traffic services, requires a clear understanding of the technical and legal definitions of the airspace itself. The term "National Airspace System" is often used to refer to US airspace, however it is a much broader term. The US National Airspace System (NAS), as defined by the FAA, is the "common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military."[i] In contrast, navigable airspace, is defined in law as "airspace at and above the minimum flight altitudes prescribed by or under this chapter, including airspace needed for safe takeoff and landing."[ii] This legal definition provides the framework for a lower limit, but not an upper limit for US airspace. Airspace is further divided as controlled or uncontrolled and regulatory and non-regulator, however most of the US navigable airspace is categorized as controlled and regulatory.

Within navigable airspace, the FAA designates classifications that establish both the requirements for aircraft to operate and defines the services that are provided in the designated airspace. Part 71 of the US Federal Air Regulation includes the specific designations of airspace by category. These airspace designations align with airspace classes standardized by the UN Specialized Agency for Aviation, the International Civil Aviation Organization (ICAO). ICAO defines both the services provided in the airspace and the requirements to operate within it.

## Class E Airspace

The US aviation statute contains specific Federal Air Regulations and includes the following definition:

> Class E Airspace consists of:
>
> (a) The airspace of the United States, including that airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous states and Alaska, extending upward from 14,500 feet MSL up to, but not including 18,000 feet MSL, and the airspace above FL600, excluding—
>
> (1) The Alaska peninsula west of longitude 160°00′00″ W.; and
>
> (2) The airspace below 1,500 feet above the surface of the earth.

ICAO defines Class E airspace:

> *Class E*. IFR and VFR flights are permitted, IFR flights are provided with air traffic control service and are separated from other IFR flights. All flights receive traffic information as far as is practical. Class E shall not be used for control zones.

While the FAA provides the following specification for operations in Class E airspace:

> **Class E**: Operations may be conducted under IFR, SVFR, or VFR. Aircraft operating under IFR and SVFR are separated from each other, and are subject to ATC clearance. Flights under VFR are not subject to ATC clearance. As far as is practical, traffic information is given to all flights in respect of VFR flights.

VFR (Visual Flight Rules) operations in Class E airspace, above 10,000 feet MSL (mean sea level) requires flight visibility of 5 statute miles and to remain clear of clouds by 1,000 feet above or below and one statute mile horizontally.

These regulations are taken together to create the requirements for operation in the airspace. These requirements establish that the US airspace above FL600 in the US is controlled airspace, that aircraft operating in the space must be operating either

IFR (Instrument Flight Rules) or VFR and that air traffic control services are provided. IFR aircraft will be provided ATC separation and traffic advisory services are available about and to VFR aircraft.[iii]

### Class E Airspace above Flight Level 600

In the US, there are no specific provisions for aircraft operations above FL600 for civil aircraft, it simply designated as Class E airspace. Therefore 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. These procedures met the needs of the NAS as no civil aircraft operated above FL600 when they were adopted. However, that is no longer the case.

### New Entrants

Technological breakthroughs in unmanned aircraft, emerging civil applications for stratospheric balloons, and proposals for hypersonic suborbital flight have created new operational categories of aircraft designed to operate in this airspace. For operational types that are similar to other types of civil air transport, operations in this airspace does not pose particularly unique challenges. A manned, point-to-point IFR flight can be managed using existing rules and procedures. However, the introduction of new operational types, including high endurance operations, creates a new paradigm for air traffic control.

In addition to technologies allowing for unmanned operations, solar powered aircraft enable high endurance operations. These types of operations are different than the point-to-point model for air transportation that the system is designed to accommodate. High Altitude Pseudo Satellites (HAPS) are designed to operate for several weeks or months in quasi-stationary pattern to provide satellite like services. High altitude balloons are being developed to provide a number of services, including telecommunications, space tourism, and small satellites launch services. While current use of this airspace is sporadic with experimental types, once the operational barriers are broken, we can anticipate increasing competition.

## Operations

Currently, the Google Loon Project is utilizing this airspace for experimental operations and intends to develop a constellation of unmanned free balloons operating for 90 to 100 day periods. The Facebook Aquila project anticipates solar powered unmanned aircraft operating in a holding pattern type flight path for 90 days. The Airbus Defense and Space Zephyr has demonstrated 14 days of continuous operation and is designed to provide HAPS services including, maritime and border surveillance, environmental surveillance, earth imaging and communications links. Each type of operator has a distinct flight profile and airspace need. These types of operations do not necessarily align with conventional techniques for air traffic control.

In addition to flight profile, many of these operational types anticipate operating as unpiloted, in contrast to remotely piloted. In a remotely piloted operation, while the aircraft is unmanned, there is still a pilot exercising tactical control over the flight. In an unpiloted scenario, the aircraft may be executing a programmed flight pattern or an autonomous operation where aircraft systems use artificial intelligence to evaluate and execute course modifications, but a pilot is not actively engaged in the process.

While the US does not currently have standards that allow for VFR operation of remotely piloted unmanned aircraft beyond line of sight, that is not to say such standards cannot or will not be developed. The stratosphere is free from weather and clouds, making it possible to comply with the requirements to remain clear of clouds even for high endurance operations. However, VFR flight requires the pilot to see and avoid other air traffic, as ATC separation is not provided. There is not a concept that allows for preprogrammed or autonomous operations. In addition to the limitations on VFR flight, there is an additional requirement for aircraft to be detectable to other aircraft. In US airspace, aircraft operating above 10,000 MSL are required to have an operating transponder, which also allows for detection by airborne collision avoidance systems.

In addition being unmanned and unpiloted, stratospheric balloons have the added dimension of limited ability for the operator to control speed, altitude and trajectory. These mixed types of operations all anticipate participating in the stratosphere. While the transit to stratosphere poses certain operational challenges, the transit phase can be managed within existing separation concepts. The operational phase for these types creates a separation challenge that is unique to the environment.

## Strategic Separation

Rather than attempt to apply existing separation techniques to this new operational environment, there is value in considering a clean slate approach before the airspace becomes congested. Fundamentally, air traffic control is a service designed to prevent collisions between aircraft. How that service is delivered and the techniques used have been standardized and are divided into two categories, surveillance separation and procedural separation. The concepts in these two categories are the same, the difference lies in the separation standards used. Both are predicated on the expectation that the aircraft will progress through the airspace using a forward trajectory, with a reliable speed and the ability to maintain a constant altitude. The fact that we have two standardized paths, does not limit us to only these applications. Air traffic control is an evolutionary science, modifications are made as technology warrants and supports it. There is no reason to limit the concept of air traffic control to these two paths.

The assumptions and tools used to create the currently utilized separation concepts may not be appropriate for the types of operations anticipated in the airspace above FL600. However, unlike the evolution of air traffic control over the last century, this airspace will be populated almost exclusively with aircraft at the cutting edge of new technology, supporting high value commercial operations. This creates an opportunity to create a concept of operations tailored to the needs of the emerging market.

## Space Vehicles

In addition to traditional aircraft and aerostats, the airspace above FL600 will encounter commercial space vehicles in a variety of phases. They may be in transit through the airspace, as launch vehicles conducting airborne launch, engaged in hypersonic sub-orbital space transport, or engaged in space tourism activities. In this environment, the legal and operational distinctions between aircraft and spacecraft creates a policy challenge, although not necessarily a technical operational challenge. Strategic separation is constructed to accommodate different mission types in shared airspace, which allows for the integration of space vehicles in the concept of operations. The performance characteristic and mission needs will dictate the airspace to be allocated to the particular operation.

The policy challenge, if not addressed, may create conflict particularly with regard to airspace priority. It will be incumbent on the FAA to ensure that airspace allocation balances the needs of diverse users. Given the long duration expected from HAPS, it is important that airspace is allocated in a manner that does not preclude transit by commercial space or other operators. Using a long term planning model, coupled with an ability to confine operations during limited periods of time to allow access for other operators can resolve potential conflicts even for high endurance operations.

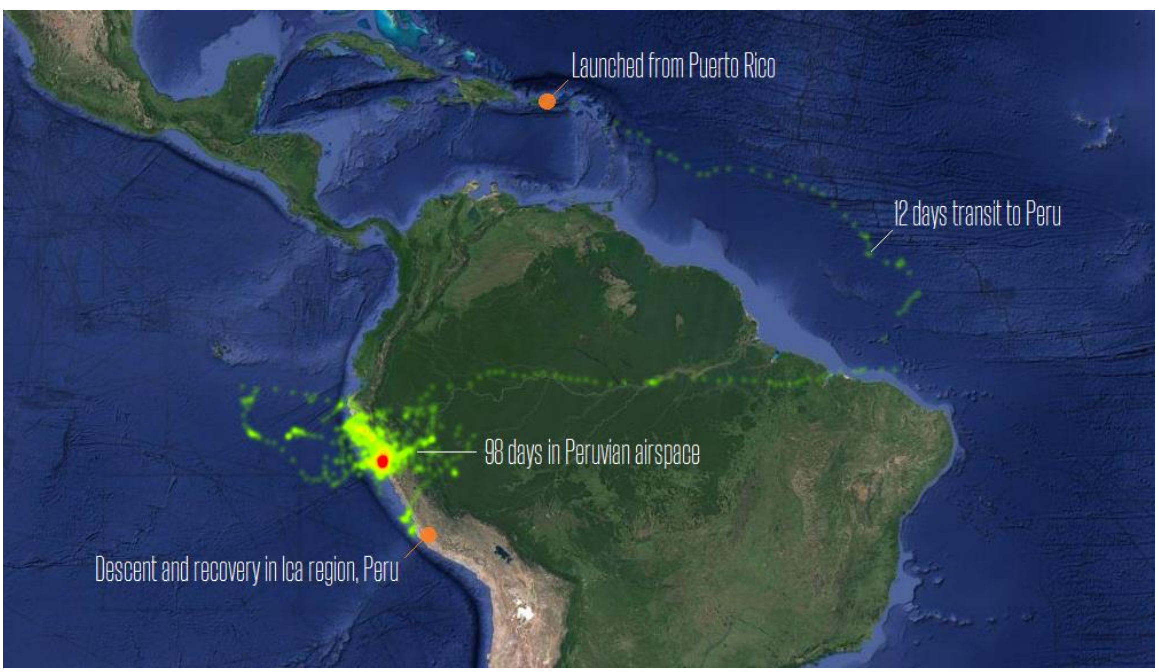
## Concept of Operations

Strategic separation is a concept that assesses the mission and airspace needs of each operation and develops an airspace management model to allow for conflict free operations. This involves a combination of mission planning, traffic management, and the ability to confine aircraft to allocated airspace. This concept builds on certain models advanced to support 4D trajectory based separation, but differs in its application. As defined by the Single European Sky ATM Research (SESAR) initiative, the 4D trajectory concept is, "based on the integration of time into the 3D aircraft trajectory. It aims to ensure flight on a practically unrestricted, optimum trajectory for as long as possible in exchange for the aircraft being obliged to meet very accurately an arrival time over a designated point."[iv] While the planning elements and decision support tools necessary to implement 4D trajectory based operations may provide resources for the development of strategic separation, the 4D trajectory concept relies on an operational model of aircraft in a point-to-point trajectory. In contrast, strategic separation will accommodate a variety of mission types, including those utilizing long-term station keeping, point-to-point, vertical transit, and low speed drift.

Currently, in this low-density airspace, experimental operations are permitted on a case-by-case basis by agreement with FAA. These agreements are a de facto waiver of the Class E operational requirements, however, as other operators seek to operate in this airspace, this approach will not be sustainable. Just as the growth in commercial aviation in the 1930's necessitated the development of air traffic control, policies will be necessary to ensure the safety of multiple operators in common airspace above FL600.

In building a concept of operations for strategic separation, it is necessary to break from the conventional design of air traffic control systems. Just as modern aircraft represent an evolution from the earliest aircraft, the air traffic control systems evolved from their earliest iterations, improving the way data is collected, tracked, presented and analyzed, but based on the same fundamental concepts. As the aircraft operating in this airspace represent fundamental changes in aircraft and their applications, the air traffic control service needs to consider a fundamental change to provide separation services that meet their needs.

This fundamental change should take advantage of technical capacity available. Unlike the 1930's, the capacity to process data is not constrained to a few inputs or sources. The first step should be to assess the data that is available, both in course planning and aircraft tracking. While certain operations may be outside the surveillance coverage of the NAS infrastructure, that does not mean that tracking data is not collected and maintained by some source. In the example of unmanned free balloons in stratospheric operations, missions follow planned routes and are tracked by the operator. In fact, tracking information is available to the public through Flightradar24.com. In the image below we see the Project Loon sought to determine how long they could maintain a balloon over a specified area, navigation is controlled by using vertical changes to capture winds. Using this technology, an unmanned free balloon is not the same as an uncontrollable balloon. As we see in the image, the balloon launched from a predetermined site navigated to the destination airspace and was confined to the area for 98 days. To the extent there is information available on the proposed trajectory and tracking, navigation reliability, and communications with the operator, separation models can be constructed.

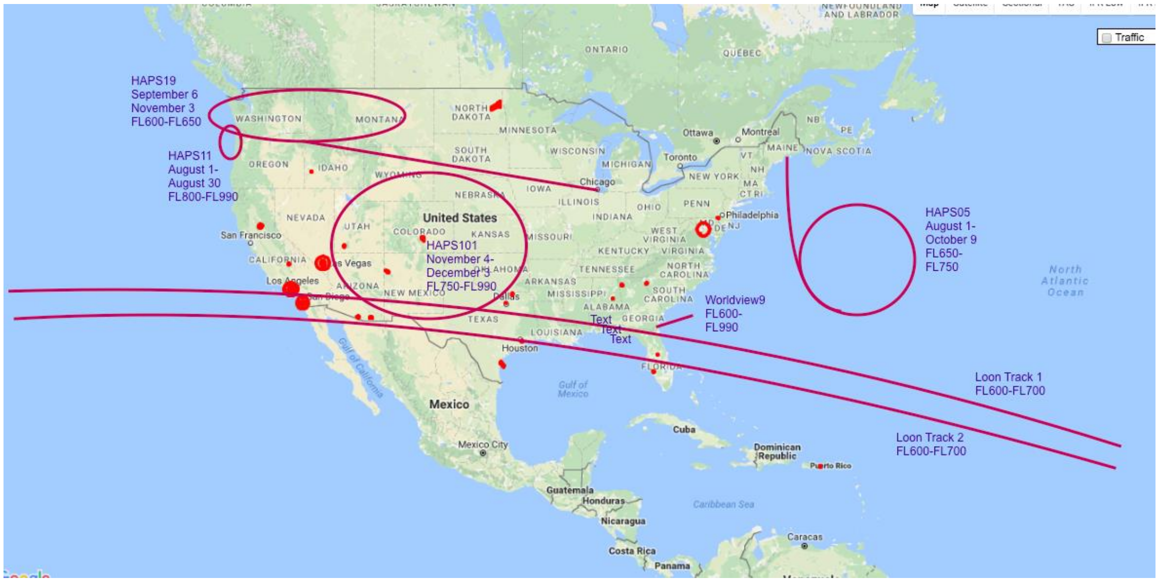



Source: Google Loon Project

Other types of operations, like HAPS have greater navigation accuracy and can provide transmitted GPS position and altitude data. Air traffic separation models are built by assessing the communication, navigation and surveillance (CNS) capabilities in the system. The less reliability in these systems, the larger the separation needs to be to ensure safety. In the development of strategic separation, there should be an anticipation of very large separation requirements, particularly for aircraft with limited maneuverability. However, given the low density of traffic in this airspace, large separation standards are not onerous. As accuracy in CNS systems improve, separation standards can be reduced.

A lack of precision in navigation is not new, celestial and inertial navigation systems were used to cross the oceans and separation standards of more than 100 miles between aircraft was common, even on congested routes. However, this distance also reflected manual tracking based on pilot reports. Enhancements in surveillance accuracy can be used to reduce separation standards, particularly for crossing traffic, even in cases where maneuverability of one aircraft is limited.

If the FAA has access to the flight path information, tracking data, and the ability to intervene in the event of conflict between aircraft, air traffic separation services can be provided. How these services are provide, creates an opportunity for innovation. For the types of operations expected above FL600, the airspace necessary to ensure separation can be allocated on a preplanned basis. Using existing airspace modeling techniques and conflict detection systems, the air traffic system could establish a conflict free clearance that accommodates the specific mission needs.




**Notional Strategic Separation Airspace**

The concept of strategic separation would not anticipate tactical air traffic control, as the routes, altitudes and operating windows would be approved based on a mission agreement between ATC and the Operator. Changes would require a reassessment and new approval. As a result, large areas of this high altitude airspace could be monitored from a single location. Rather than create additional sectors in each of the US Air Route Traffic Control Centers, the strategic separation could be monitored from the centralized Air Traffic Control System Command Center.

This approach takes in the concepts used in both satellite orbital assignment and procedural air traffic control to create a framework to serve the needs of these new entrants. By creating an IFR environment that provides sufficient flexibility to meet the unique needs of these operators, the issues related to VFR operation of unmanned aircraft are no longer consequential. In addition, using a strategic technique, the air navigation service provider need only be in contact with the operator on an as needed basis, rather than require continuous frequency monitoring. In addition to reducing demands on operators, this also allows the ultra high altitude airspace to be controlled without redirecting resources, including frequencies, scopes, and controllers, from the high-density airspace at lower altitudes.

### Opportunities

This opportunity for clean slate planning in airspace management is nearly unprecedented. In general, ATC has been reactionary, often falling behind the technical innovation in the aviation industry. For this airspace, FAA has an opportunity to implement new concepts and validate them with low traffic densities, mitigating many of the safety concerns that come with the implementation of new procedures. In addition, this airspace is not mixed mode and there are no civil legacy operators that need to be accommodated. If this approach proves to be successful, it can create a model for eventual space traffic management.

## Conclusion

The US airspace above FL600 presents an opportunity for FAA to develop an entirely new concept of operations for IFR air traffic separation for unmanned aircraft on high endurance missions, commercial space operations, and unmanned free balloons operating in shared airspace. In order to meet the needs of these new categories of civil aviation operator, innovative concepts are needed. The concept of strategic separation could provide a framework to build ultra high altitude airspace management systems tailored to the needs of this market.

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[i] FAA Pilot Controller Glossary. Airman's Information Manual. FAA (2014) . Retrieved from https://www.faa.gov/air_traffic/publications/media/pcg_4-03-14.pdf

[ii] US Code of Federal Regulations, Title 14: Aeronautics and Space, Chapter 1, subchapter A, part 1: Definitions and Abbreviations

[iii] SVFR is an acronym for Special VFR with is only permitted in below 10,000 MSL.

[iv] Skybrary. *4D Trajectory Concept.* Retrieved from http://www.skybrary.aero/index.php/4D_Trajectory_Concept