
FLYING

G HIGH

The FAA and NASA have distributed a concept of operations for civil air traffic in the stratosphere for the first time

By David Hughes

Managing air traffic above 60,000ft is becoming more challenging as civil aviation long endurance balloons, high altitude fixed-wing aircraft, high altitude airships and supersonic transports enter operational service and join US military aircraft in the stratosphere. Upper Class E Traffic Management also has to account for commercial space and other launch activities which transit the stratosphere on ascent and descent.

The cooperative air traffic management approach the FAA and NASA are proposing for high altitude operations is very similar to their approach to Unmanned Aircraft System Traffic Management (UTM) below an altitude of 400ft. The Version 1 conops (concept of operations) for Upper Class E Traffic Management (ETM) they have developed envisions industry providing separation services under FAA regulatory authority where "ANSP separation services are not desired, appropriate or available."

The first draft of the conops captures what the FAA, NASA and industry participants discussed in a series of meetings and exercises during 2019 at NASA's Ames Research Center in California. The document, which was co-authored by FAA NextGen's chief scientist Steve Bradford and Parimal Kopardekar, the director of the NASA Aeronautics Research Institute has been distributed to participants in the ETM initiative.

The conops states "It [the ETM] 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 deconflict when necessary. ATC accesses cooperative and National Airspace System (NAS) data to safely separate operations under their control".

Both the FAA and NASA are starting new ETM initiatives that will involve additional research. ETM is what ICAO calls "higher airspace management" in the Global Air Navigation Plan. Research transition teams are being formed at the FAA and NASA. The FAA work will be managed by Biruk Abraham, a NextGen advanced concepts manager, and at NASA by Jaewoo Jung, the space agency's UTM deputy program manager.

The research will tackle infrastructure issues in addition to conops and explore how navigation and communications will be conducted. The FAA does not expect to provide communications infrastructure for ETM but instead will rely on participants' communications capabilities. Once an air vehicle arrives on station at those altitudes the operators will cooperate in order to ensure separation rather than being routinely directed by ground-based air traffic control.

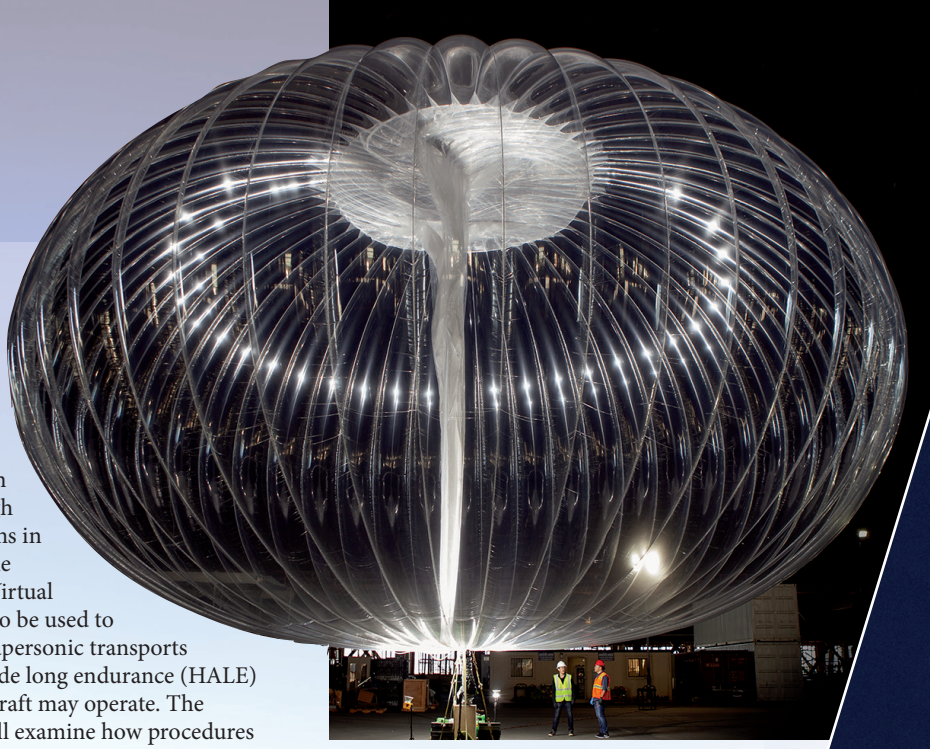
Operators will coordinate with each other while sharing flight intent information. Operators, third party services and the FAA, if needed, are notified of any non-conformance whether it is intentional or not. Cooperative separation relies on shared intent, shared awareness, deconfliction of operations, conformance monitoring and right-of-way rules. Operators will have to archive flight data as specified by the FAA for its use in analysis, regulatory activities and for holding operators to account.

International efforts

Only the USA and Canada have a defined airspace designated upper class E for altitudes at 60,000ft and above. In the US, upper Class E is above airspace designated Class A (18,000ft to FL 600). New and innovative air vehicles will transit airspace controlled by the FAA using traditional air traffic management procedures during ascent to the stratosphere, and for descent and landing.

Air vehicles on IFR operations above FL 600 currently receive radar if available and

ANDREY ARMYAGOV @ STOCK.ADOBE.COM



non-radar separation services. Traffic advisories are provided and ATC separates air vehicles from special airspace including Temporary Flight Restrictions (TFRs), altitude reservations and space transition corridors. Bradford says that some innovative air vehicle operators want to have a flexible floor, so they can fly as low as 55,000ft in conjunction with ETM. Many high performance business jets can operate as high as FL 510.

The conops envisions the operators of air vehicles using self-provided air traffic services or ones provided by a network of third-party service providers. ETM services may include flight planning, vehicle deconfliction, conformance monitoring and information on airspace constraints.

"We wanted to create a document that shows where we are together and how we can move forward. Part of this is that ICAO doesn't have the wherewithal to have a whole study group," says Bradford.

ICAO is participating in the FAA / NASA discussions with industry. Yuri Fattah, program manager of multidisciplinary priorities at ICAO's Air Navigation Bureau is acting as a liaison. In the next phase of development, the FAA and NASA will engage in ETM joint activities with Europe's SESAR. There are several organisations active in Europe which want access to high altitude airspace including Thales, Airbus and the French space agency CNES (the National Centre for Space Studies).

Kopardekar says NASA started working on UTM in 2013 and began considering similar concepts for high altitude in 2017. Upper UTM became ETM as NASA and the FAA began addressing the issue. However, the diversity of operations presents some challenges. Supersonic passenger transports may be operating in the same airspace as long-endurance unmanned balloons, which might be adversely affected by the high-speed aircraft's shock wave depending on how close they get.

Loon data to feed simulations

The next step at NASA Ames is to work with industry on several slow time and fast time simulations. These may include real flight data from Loon, a company which is owned by the parent firm of Google, called Alphabet. Loon already has high altitude balloons in operation in the stratosphere. Virtual models will also be used to capture how supersonic transports and high altitude long endurance (HALE) fixed wing aircraft may operate. The simulations will examine how procedures will work.

There will be several NASA Technical Capability Level (TCL) demonstrations, but not as many as is being conducted for UTM. Eventually there will be a TCL with data on flights by Loon balloons being fed into the simulation along with virtual vehicles where people run targets and constructed types where both the vehicle and people operating them are simulated.

As well as Loon, other participants in the ETM developments include Aerion, AeroVironment, Boeing's Aurora Flight Sciences, General Atomics, Leidos, Lockheed Martin, Northrop Grumman, Sceye, Swift Engineering and Virgin Galactic-owned the Spaceship Company.

Loon started to deliver internet services with balloons to Kenya during July 2020 in partnership with Telekom Kenya. The company is providing a 4G LTE network connection for people living in an 80,000km^2 swathe of central and western Kenya, including the capital Nairobi, using a fleet of 35 high altitude balloons. Several balloons provide internet coverage simultaneously in 11,000km^2 increments. The balloons are launched from Winnemucca, Nevada and the former Roosevelt Roads US Navy airbase in Puerto Rico. The balloons use solar-powered mobile networking equipment and are lifted by helium with an air pump to add ballast when needed to control altitude. Thanks to continuous design improvements the balloons can now stay aloft for nearly a year and are recovered after they descend.

The Loon balloons are controlled by a satellite communications link and a backup link via the mesh communications network that supports internet service in the areas the balloons are flying over. The balloons move with the wind flow in varied and complicated patterns managed by algorithms as they pass over Kenya. They function very much like ground-based cell towers. When a balloon goes out of sight of the coverage area it is manoeuvred back to join the constantly changing formation.

Leo Bouygues, head of aviation strategy at Loon, and David Hansell, global head of aviation regulation, both participated in the FAA / NASA conops discussion and development.

Loon's Kenyan operations put the company way ahead of other high-altitude air vehicle operators, who have mostly only conducted initial flights. "We cannot operate on the assumption that we will be the only ones flying at high altitude," says Bouygues.

"There are a few other operators and you have military operations going on across the world. Some of them are very cooperative and some aren't and

"There are a few other operators and military operations, some of them are cooperative and some won't disclose their position"

Left: Loon's balloons use solar-powered mobile networking equipment, are lifted by helium and use an air pump to add ballast for altitude control

Left: The balloons stay aloft for a year and are recovered after they safely descend to the ground

Zephyr

Pioneering the stratosphere

What is it?

Runs on sunshine in the **stratosphere**

Ozone layer

Weighs **75 kg**

Supports up to **5 times** its own weight

Manufactured from fibres no thicker than **a human hair**

Powered by **the sun**

Zephyr uses **solar energy, with secondary batteries** charged in daylight to power overnight flight

25 m wingspan

Zephyr flies for longer than any other aircraft during its successful maiden flight:

25 days, 23 hours, 57 minutes

What will it do?

Zephyr:

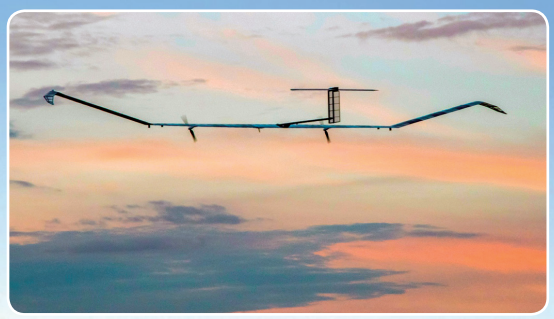
- See clearly
- Sense efficiently
- Connect precisely

Zephyr is able to **revolutionise missions** all over the world:

- Defence
- Humanitarian
- Security
- Environmental

AIRBUS

Zephyr has a 25m wingspan and is designed for use in maritime surveillance, border patrol, communications; it operates at an average altitude of 70,000ft



won't disclose their position." There are other current operations that require deconfliction today. "Our balloons actually navigate down all the way to 50,000ft and so do have some occasional interaction with high-performance business jets, mainly in the United States and Australia, where more Falcons and Learjets operate," Bouygues says. "And we do have other balloons operating up there."

Zephyr

According to Bouygues the Airbus Zephyr High Altitude Pseudo Satellite (HAPS) doesn't fly very often, but when it does Loon has to have a way to share the airspace safely. Airbus is developing two models of its unmanned air vehicle. Zephyr S has a wingspan of 25m and weighs less than 75kg, while the Zephyr T has a longer wingspan and can carry a heavier payload.

In August, 2018, the Zephyr S completed a 25 day maiden flight, the longest duration flight ever made by a Zephyr prototype, breaking a previous record of 14 days. The Zephyr is being flight tested at Wyndham in Western Australia, a site chosen for its unrestricted airspace and reliable weather. The aircraft is designed to be used in maritime surveillance, border patrol, communications and wildfire detection and monitoring. It operates at an average altitude of 70,000ft. Previously this was the exclusive realm of aircraft like the U2, SR-71, WB-57 and Concorde.

Bouygues notes that the Loon service in Africa, which will be launched in Mozambique next, is not in competition with cell phone towers, but can provide internet connection capabilities in difficult mountainous terrain where ground-based infrastructure is impractical.

Global harmonisation

The FAA and NASA's work over the next two to three years will complete a second version of ETM conops which could become the basis of international action on the management of high-altitude airspace around the world. Some of the challenges are that these new entrant air vehicles cross national boundaries on their way to keeping station in a region to deliver a service. There are concerns about how the ETM will integrate with airspace below 60,000ft, with existing ATM techniques and with the approaches being developed below 400ft. Some ANSPs are interested in providing traffic management services in the stratosphere for a fee, unlike the FAA.

Mitch Fox, who served in the ICAO Secretariat for two decades, is keeping a close eye on how airspace conops for new entrants are being developed in Montreal. Fox is the senior director of strategy for the international coordinating council of the aerospace industries associations (ICCAIA). He notes that an Airbus and Boeing presentation titled "A New Digital Era for Aviation: The Path Forward for Airspace and Traffic Management" was given to the ICAO Air Navigation Commission during June which outlined the need to harmonise the various ATM approaches being taken in different airspace strata. The two major OEMs asserted that a holistic approach is needed, not separate treatments for each different type of airspace.

Mildred Troegeler, director of global airspace integration at Boeing NeXt and Isabel Del Pozo, vice president head of Airbus UTM gave the talk about the innovation wave being led by unmanned aircraft systems. They also discussed how to manage this traffic at low and high altitudes along with urban air mobility electric vertical takeoff and landing vehicles and other innovative air vehicles.

A white paper on this topic issued by Airbus and Boeing repeats the statement of the chief technology officers for seven leading aviation manufacturers, who said at the Paris Air Show in 2019 "aviation is at the dawn of a third major era." This third era follows on the ones started by the Wright Brothers in 1903 and the jet age of the 1950s and is being driven by several new technologies.

The speed of technology is outpacing the speed at which regulations can be written, and thus ICAO is looking at innovative ways in which to work with industry to ensure they keep pace. For example, drones have increased the speed of innovation in aerospace, according to Fox. Rather than rely solely on the traditional method of developing new standards and recommended practices at ICAO, Fox believes a more agile global aerospace industry can develop guidance and best practices.

The pressure to provide harmonised standards and recommended practices is particularly acute in the low altitudes structure where drone operations are seeing explosive growth as the FAA and NASA and similar organizations around the world try to cope with how to manage

Thales and the French defence procurement agency DGA are developing a platform to operate in the stratosphere to meet the French Army's operational needs for communications

this traffic. ICAO member states are seeking guidance from Montreal on how to deal with drones that isn't available yet. Some unmanned air traffic management innovations are expected to affect how commercial airliners and business jets are handled in traditional airspace in the future so the need for a comprehensive approach to airspace is imperative.

The two OEMs believe a single integrated airspace management system is needed for global implementation that will embrace all airspace users. The performance-based system needs to be safe, scalable, interoperable and feasible. However we have been here before. Shortly after Boeing formed its air traffic management organization in 2000 and after the 9/11 terrorist attacks in 2001, the company called for a new air transportation system to be developed with global interoperability. In 2020 the hunt is still on for this holy grail.

Other experts believe the airspace problems in the stratosphere, the traditional airspace and below 400ft can't be redesigned one at a time. John Walker, a former senior official at the FAA who is involved with international regulatory bodies working on UTM, says a panel needs to look at the problem holistically. Airspace needs to be used more efficiently and new entrants can't be accommodated effectively if airlines have to stick to the status quo in procedures, air traffic facilities stay put due to politics, and airspace responsibilities and sectors remain frozen in amber. A project is needed to break this logjam. Time is short and so is the money required to finance such an effort.

Guidance to new companies

Nancy Graham, who led the ICAO Air Navigation Bureau, is now assisting new entrants who are interested in using high-altitude airspace. New entrants in the stratosphere are currently relying on best practices, because the traffic is light and this is sufficient. Operators have been sharing best practices in recent years at the ICAO Drone Zone meeting.

Graham says that innovation is happening very quickly and that these nontraditional players "are creating a very new world." Automation will assist in these operations which ICAO will have to review and endorse. "The old way won't work," says Graham about the systems and structure of traditional aviation. Graham is a veteran of several senior positions in the FAA and believes the agency has embraced the notion of innovation while working with new entrants. The FAA and European authorities have been collaborating informally with ICCAIA so far, rather than a formal ICAO group. "I'm interested in how the opportunity of having new talent and new money can help aviation and aerospace evolve. This will never happen again in my life, so I am trying to give stick and rudder advice to help these companies," he adds.

There is a delicate balance needed between industry and government in these joint efforts. "Industry input is important, but the FAA needs to provide expertise as well," says Ruth Stilwell, a senior non-resident scholar at George Washington University, who has her own consulting company Aerospace Policy Solutions. "Operators think they know what they want but they don't know what flexibility they already have to achieve their goals."

It would be good to know more about what the industry is looking for, Stillwell adds. She notes that class E airspace (below 18,000ft) has a lot of techniques that could be useful in high altitude E, such as VFR on top and that the controller handbook has lots of seldom used procedures that could be useful. "We don't need to get to fancy," she says. "Things that could be helpful already exist."

Bradford agrees that there are a lot of little used procedures that could be useful, but also notes that the FAA hasn't surrendered any of its authority. "Anything the industry comes up with has to be approved by the FAA," he says. "Rules on how to behave with each other will have to be approved by the FAA."

Andy Thurling, a UAS expert and principal at Thurling Aero Consulting, notes that Europe has its own concept of higher airspace. "The FAA conops should spur the European community into action," he says. "I would bet they don't want to yield leadership to the FAA and NASA." ❖