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# Managing the evolving skies

Unmanned aircraft system traffic management (UTM), the key enabler

Deloitte recently published a study on ***Elevating the future of mobility*** which examines six challenges associated with achieving a scaled commercial deployment of "passenger drones." The key among those challenges is the current gap associated with managing the passenger drone airspace. Any approach to doing so would need to be integrated with the existing airspace management systems in place or under development, as well as the growing commercial drone market. This study provides an approach for the path forward in meeting that challenge.

# Introduction

The technology of flight is changing our skies and evolving the way we think about aviation. Passenger and delivery drones, and other elevated vehicles have the potential to address today's urban congestion, improve logistics, and create new products, services, and markets. As the skies get busier, it will be an ongoing challenge to manage and maintain an increasingly diverse airspace, while keeping all air traffic moving safely and efficiently.

Drones are being used across a range of areas, for research, public safety, in agriculture, transportation management, and surveillance. These new and emerging users of airspace deliver tremendous value, whether transporting people and/or goods, responding to an emergency, or gathering site data.

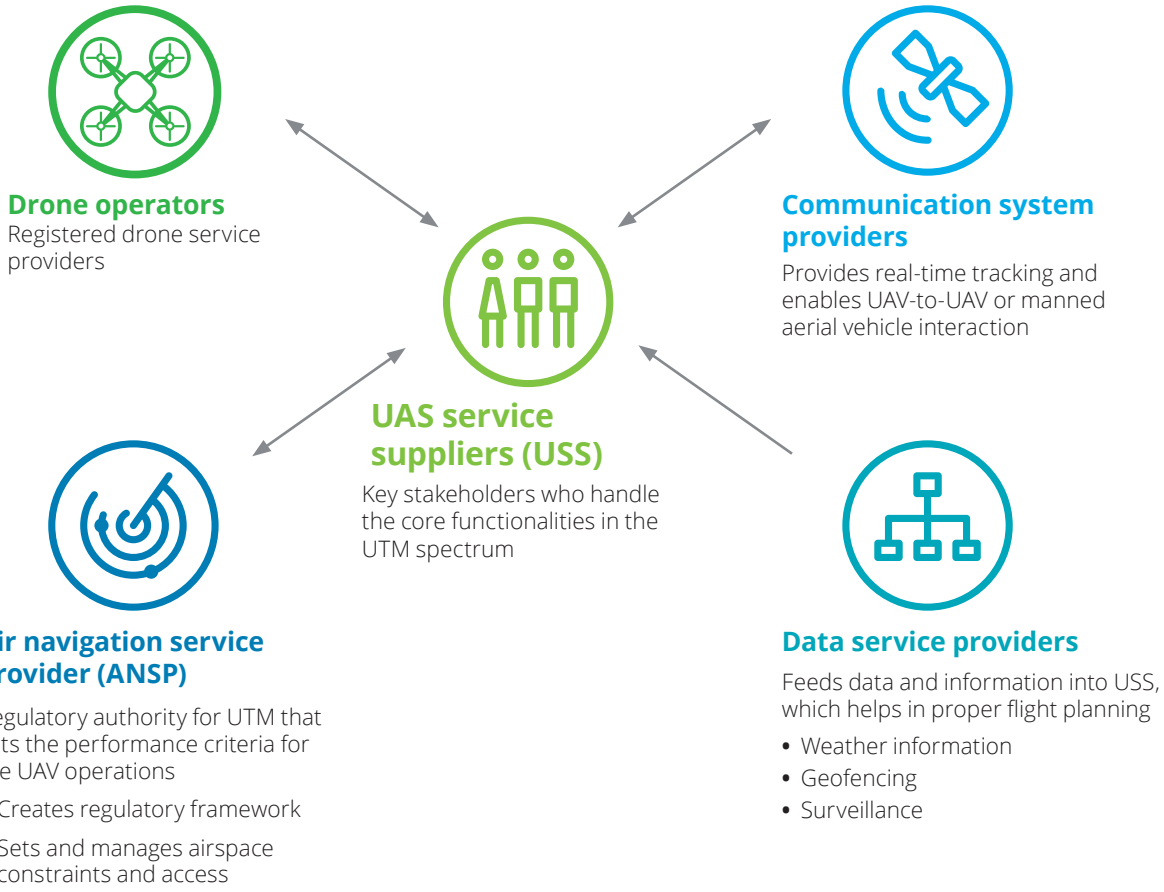
As the use of unmanned drones continues to rise, and passenger-carrying elevated vehicles are on the horizon, there is a need to establish who will manage the airspace and how. Air Navigation Service Providers (ANSPs) have been the primary source of oversight for safe and secure airplane travel for decades, but how will the flight paths of thousands—possibly millions—of daily manned and unmanned drone flights be managed? A safe and sustainable system, one that supports growth and expansion while protecting life and property, is a must.

Defining the problem, exploring solutions, and assigning responsibility are critical to the success of all unmanned aerial vehicles (UAV) ecosystem stakeholders. This study explores those key elements and invites stakeholder dialogue to resolve the concerns associated with an air traffic management system that serves the needs of today's aircraft, including unmanned vehicle systems, and establishes a foundation for the future of elevated travel associated with passenger drones.



# **Managing a system of systems:** Unmanned aircraft system traffic management (UTM)

**Figure 1. Key stakeholders in the unmanned aircraft system traffic management (UTM) ecosystem**




Unmanned aircraft system traffic management (UTM) is a key enabler for the future of unmanned aircraft systems (UAS)/remotely piloted aircraft systems (RPAS), autonomous passenger drones, and vertical takeoff and landing (VTOL) air systems. For years, industry leaders have been discussing the challenge of managing this system of systems. The stakeholders and operators represent a diverse set of industries, geographic areas, and purposes. While every autonomous vehicle operator has specific needs, all operators require a UTM solution to fully realize the potential of elevated mobility.

Effective air traffic management (ATM) has been the hallmark of the safe and efficient global aviation enjoyed for at least the last decade. It is a risk-averse community, and therefore, any progress with UAS deployment will have to protect, enhance, and expand that operation. Success depends upon having trust in the essential elements of the ATM system: reliable and available communication, predictable and consistent navigation, and accessible and trusted surveillance—Communication, Navigation, Surveillance (CNS). These elements, coupled with tried-and-tested procedures, coordinated teams, redundancy, and continuous training allow the system to operate reliably and safely.

# The drone market is soaring

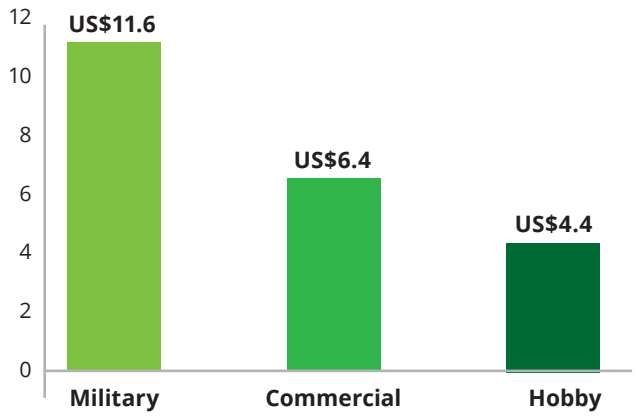
To grasp the sense of urgency surrounding the establishment of a comprehensive UTM, it is essential to understand the growth of the drone industry.

Drones have proven to be an important tool for numerous applications across both commercial and noncommercial operators. In the past, UAVs were limited to defense applications. However, in the last decade, technology has improved significantly, and, as their size has reduced, their numbers and capabilities have increased. Today, UAVs have emerged as an economical solution for commercial applications such as surveying, mapping, and aerial photography, among others. The growing importance of "drone-as-a-service," as well as the exemptions provided by government and regulatory authorities to operate commercial UAVs, has been a driving force for applications in agriculture, construction, and oil rig inspections.

The initial introduction of UAV aircraft to airspace, especially in the commercial world, has been limited to visual line of sight (VLOS) operations. Australia, Canada, China, Denmark, New Zealand, Poland, South Africa, Switzerland, and some states in the US have taken measures to incorporate UAVs into the airspace far beyond visual line of sight (BVLOS) operations, opening opportunities for ever more innovative applications and expansion (see Figure 3).

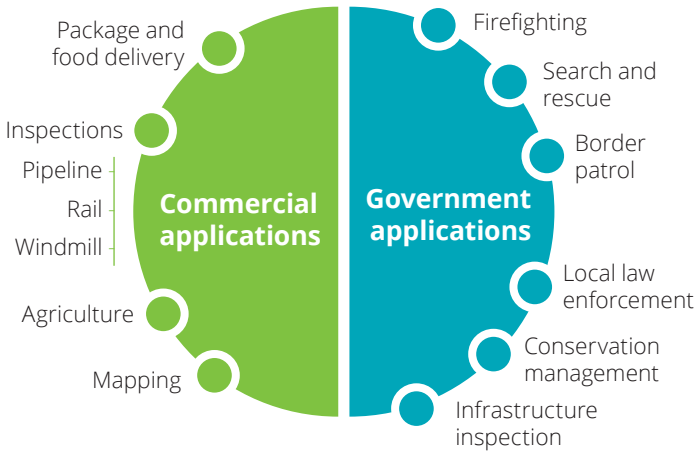
The UAV market continues to grow, and consumer-centric innovation is one of the most prominent factors in that growth. One of the most vibrant areas—the global vertical takeoff and landing vehicle (VTOL) or the passenger drone market—is likely to be worth US$21 billion by 2035. Automotive and aerospace manufacturers have been experimenting with concepts in recent years, and it is not unreasonable to expect autonomous flying taxis in the skies within the next ten years.[1]

**Figure 2. Global unmanned aerial vehicle (UAV) market: 2020** (By area of application (in US$ billion)



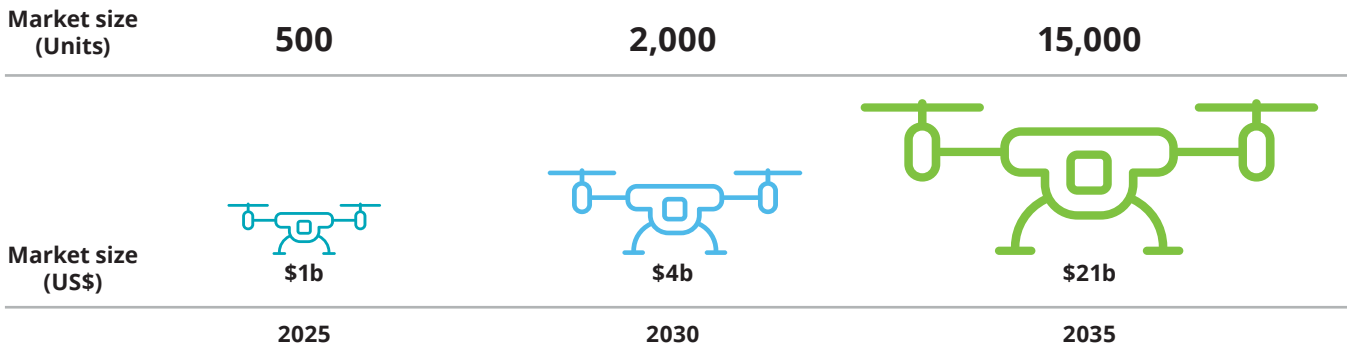

Source: Statista 2018.

**Figure 3. Drone technology: Beyond visual line of sight (BVLOS) operations and applications**




Source: Deloitte analytics.

**Figure 4. Growth of the vertical takeoff and landing (VTOL) market**



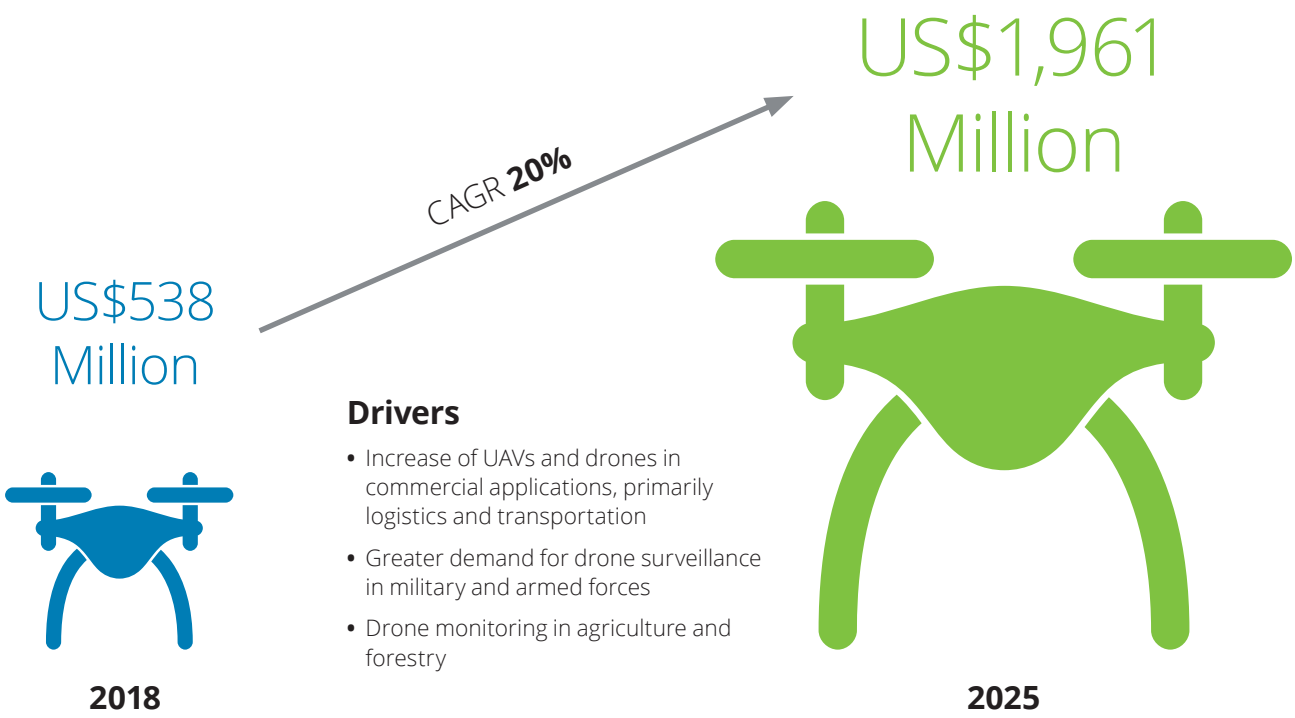

Source: The future of vertical mobility. Porsche Consulting 2018.

# Why the urgency?

Innovative applications for UAV are being introduced almost daily by companies around the world. The global UTM market, valued at about US$538 million in 2018, is expected to grow at a compounded annual growth rate (CAGR) of over 20 percent during the period 2019–2025.[2] Most of this growth is expected to come from commercial applications, as companies find ever more innovative ways to gather information, improve logistics, and move people and goods using drone technology.

With this growth comes tremendous responsibility to put a globally harmonized traffic management system in place. As the skies become the next frontier, a successful UTM will facilitate growth in the elevated mobility market, streamline operations, and ensure public safety and security. One potential solution may be a system of subsystems that will work together to offer an end-to-end service that includes oversight, standards, and protocols common to all operators. Every stakeholder has a responsibility to participate in the conversation and play a role in its deployment and ongoing operation.

**Figure 5. Growth of unmanned aircraft system traffic management (UTM) market**




Source: Research and Markets 2018.

# Who is keeping an eye on the airspace?

Managing the airspace and establishing standards for all stakeholders is critical to the long-term success of UAV. UTM development will ultimately identify services, roles and responsibilities, information architecture, data exchange protocols, software functions, infrastructure, and performance requirements for enabling the management of UAS operations.

Integrating UAS into existing air traffic management operations will present a variety of issues and challenges. It will require bringing together a diverse system of stakeholders that includes operators, communication system service providers, and data service providers, as well as regulating authorities. In recognition of this bottleneck, the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA) in the United States, European Aviation Safety Agency (EASA), Civil Administration of China (CCAC), and many similar organizations around the world have initiatives underway to identify, respond to, and ensure the safety and integrity of the current ATM operation.

NASA's research and development approach includes methodology for integrating UAS into the airspace in the near-term and pioneering transformative changes towards autonomous aviation systems over the mid- to long-term. The FAA's focus expands that to include operational UAS implementation and the potential impact on operations. Integrating NASA's research with ongoing activities to deploy new technologies will assist the FAA and other stakeholders in realizing benefits in the near term.



# Building a foundation for UTM

Developing and putting into practice a widespread UTM is complex and its many stakeholders have varied expectations and anticipated outcomes. There are a number of areas where a concentrated effort is needed to facilitate a smooth transition into a safe, efficient unmanned aircraft system traffic management system:

**Figure 6: Pillars of UTM foundation**




Source: Deloitte analytics.

### Delegated authority

UTM will likely need to utilize the commercial market's ability to supply services under regulatory agencies where ATM services are currently limited or do not exist, such as low-altitude operations associated with small UAS (less than 55 pounds or 25 kilograms). The existing regulatory agencies will maintain operational authority for the airspace and for legacy air traffic operations, while possibly offering "delegated or designated authority" certification to an industry or to a market-derived solution. Who will assume this leadership?

This UTM construct will likely require ANSP governance reform, much like what was required in the US when the FAA transitioned to contract towers in the early 2000s. They will need to develop directives, procedures, incident protocols, constraints, and possibly airspace classification changes that will include UAS operations (e.g., drone-required coordination zone, drone-required notification zone, no-drone zone, and drone right of way).

## Security

Public safety and manned airspace traffic are of utmost importance. Commercial drone operators will be charged with ensuring the safety and security of drones in "beyond visual line of sight" (BVLOS) operation and tracking drones in the airspace to make sure that they do not fly into restricted airspace. Dan Elwell, acting FAA Administrator, underscored this by pointing out that drone integration should to be done in a way as to maintain the current low accident rate of today or improve upon it, and notes zero tolerance for the introduction of safety risk. He asked the community assembled at the 2018 Uber Elevate conference to not simply bring ideas and plans related to UAS deployment that will work, but those that will work safely.[3]

## Infrastructure

For UTM to be successful, three key infrastructure considerations—communication, navigation, and surveillance, commonly referred to as CNS—need to be resolved. For the regulating authority or its delegated authority, these are the essential tools required to provide these services effectively.

- ***Communication:*** Of all the elements of an effective air traffic control community, communication is the most essential. Direct, controller-to-pilot (resident on the aircraft) interaction/interface is a hallmark of air traffic control (ATC). In the absence of every other tool, communication can save the day. UAVs add complexity by remoting the pilot. Special communication consideration should be applied to serve emerging needs in real-time, providing the sufficient broadband and procedures for two-way communication (control data must be uploaded and telemetry must be transmitted back to the ground station). Currently, for short-range missions, Wi-Fi and similar low-performance communication methods are efficient in the vicinity of the remote station. As flight length increases through BVLOS, so will the need for reliable transmission over longer distances. As voice communication transitions to digital messaging for legacy aircraft, will digital communication work effectively with UAV traffic?

  In addition, the communication and submission of flight plan information (airspace requests) connected to UAV operations are not compulsory. As a result, air traffic service providers do not have situational awareness of mission-affected areas. Some solutions are available to process this information, but they are currently (for the most part) working in isolation and are not yet integrated with ATM systems.[4]

- ***Navigation:*** From the viewpoint of aviation safety, avoiding possible conflicts and collisions between other airspace users is an important consideration. Currently, UAV instrumentation may not be capable of detecting and avoiding other aircraft, and they are usually not equipped with anti-collision systems. Designing vehicles with these systems could help prevent conflicts by modifying the flight path based on predefined rules. Another significant concern may be the loss of remote control capability or applicable protocol in case of technical malfunctions, and the lack of appropriate procedures to follow under such circumstances.

  The air traffic control community cannot operate with ambiguity. Even as the industry evolves, airspace and procedures need clarity. Very low and ultra-high (upper) altitude operations, as well as the airspace over high density populations, will continue to require attention and definition, laying the groundwork for setting appropriate control-related expectations.

  In the case of conventional aircraft, flight data processing systems used by the ATC can identify aircraft in the airspace based on flight plan information and surveillance data. Coupled with established procedures and effective training, the air traffic service provider has all the necessary data to support their missions. This level of information provision is not likely realistic for UAVs, so alternative navigation-related solutions need to be identified. Currently an "applied surveillance system" might identify only the type of the UAV,[5] not facilitating a resolution to this concern. Equipping drones and other elevated vehicles with sensors to detect other flying objects in their airspace, or restricting travel to only pre-determined flight paths, could help prevent mid-air collisions.

- ***Surveillance:*** One of the most effective tools in broadening the efficiency and the safety of air traffic operations is surveillance. Automation platforms display surveillance data to the air traffic operation, but its effectiveness is limited to those aircraft providing flight information, those large enough and in coverage locations capable of being detected or properly equipped and functioning in a cooperative manner. However, in the case of drones or small unmanned aerial vehicles, their size (a flying object as small as 10 centimeters, for example) and construction materials (plastic, composite, etc.) may not reflect the signals.

  Adequate surveillance will require a resolution, or several possible solutions to the issue of aircraft tracking. Surveillance technology will need to be capable of fusing all potential tracking methods.

  Another complication to surveillance is the lack of the mandatory transponders and the fact that these vehicles use low-level airspace (10 meters or 33 feet to a maximum of 200 meters or 656 feet in altitude) where conventional surveillance radars are not able to detect them. New technologies such as holographic radar are available that can establish a complete picture of airspace volume and detect small flying objects, but they are totally independent from current ATM systems. Integration is necessary to provide surveillance data for integration with current operations.[6]

These foundational elements of a UTM infrastructure are closely interrelated and apply specifically to the needs of the UAV market. Standards and protocols for this system of systems should be developed so a UTM operates independently, yet concurrently, with current ATM systems. For existing ATMs to support drone traffic management, ATCs would require an electronic system that could access flight information as well as constraint notifications in lower altitudes or uncontrolled airspace.

### Financing

Funding for a long-term UTM is likely to come from a variety of sources, including seed money from the public sector, investors, and companies with significant cash reserves that are committed to the market and willing to invest in its future. Today, digital platform companies such as Amazon, Google, Facebook, and Uber are driving some of the UAS activity; their investments are helping drone and other elevated mobility technology to gain widespread consumer support. For the most part, they are focusing their efforts on hardware, support services, or operations. Niche companies such as Blue Innovation from Canada, Colibrex from Germany, and Aerodyne from France are also offering support and incorporating operations-oriented innovations (operations broadly covers software and services related to navigation, UTM, and security, as well as the construction and maintenance of infrastructure such as vertiports). Companies specializing in navigation and UTM have received approximately US$371 million in funding from venture capitalists, private equity, and private angel investors in 2017.[7]

The following are some examples of the investments being made in the UTM space. The challenge lies in coordinating and unifying these worthwhile endeavors, while not allowing the deliberate and specialized investments to outpace the regulatory and infrastructure layout needed to support these advances.

- Unifly, an unmanned aircraft systems UTM software company in Belgium, has secured a total of €6.3 million; €5 million of this funding comes from Terra Drone, a Japanese drone manufacturer and system integrator.[8]
- Analytical Graphics, Inc. (AGI), software developer for aerospace, defense, and intelligence companies, has signed an agreement with the Air Traffic Management Research Institute (ATMRI) of Nanyang Technological University, Singapore (NTU) to assist in the development of a UTM solution. AGI project, SKYVUE, will support ATMRI with software, training, and subject matter expertise to understand key sensitivities of UAS flight systems.[9]
- AirMap, the world's top supplier of ATM software for UAS completed US$26 million of Series B financing in 2017 that included a number of investors, including Microsoft Ventures, Airbus Ventures, and Qualcomm Ventures. The company will be using Microsoft's resources, software, and artificial intelligence tools.[10]

## Rise of vertiports

The advent of vertical takeoff and landing (VTOL) aircrafts, flying cars, drones and other future of mobility carriers press the need for a new infrastructure. Vertiport, a new form of airport, emerges as a potential solution enabling all the above. Unlike conventional airports, vertiports do not require vast land to build airfields and need not be limited to just one or two for a metropolitan city. In fact, these can be built in small pockets of areas at multiple places in a city to facilitate intermodalism—the flexibility to take any of the many routes available from a vertiport, for instance, VTOL, helicopter, train, or road. Vertiports currently face certain infrastructure challenges related to site criticality, area, architecture, and noise/community acceptance. However, the industry has been making steady progress both in terms of technology (developing advanced unmanned traffic management systems) and infrastructure (using harbor sites and adoption of drilling rig technology) to make vertiports a reality.

### Technology

The evolution of aircraft tracking, software apps, and drone technologies have far outpaced current ATM technologies. Leading organizations and market innovators are developing solutions that apply emerging technologies and provide practical—and future-ready—solutions. ATM technologies are challenged, not only to play catch up, but also to prepare for the introduction of autonomous vehicles. Safety and security will be of utmost concern. It is inevitable that regulatory processes lag the pace of advancement in technology, so a UTM must be designed to address these complexities.

NASA is leading the way with a UTM system designed to enable commercial use of UAS within lower-altitude airspace and airspace that does not interfere with regular National Airspace System (NAS) operations. The system is designed to support accelerated drone applications ranging from simple to sophisticated, strategic to tactical.

Through its technology transfer program, NASA is looking to transfer the technology to benefit US industry and it is available through licensing from commercial applications. Uber is currently working with NASA on an initiative to improve air traffic management for UAV, as well as flying cars, and plans to launch a pilot program testing flying taxis by 2020.[11]

Emerging technologies such as artificial intelligence and blockchain promise to play a critical role in the development of UTM. Deep Aero is developing an autonomous, AI-powered drone system using blockchain that will act as an on-demand logistics system and later, a fully functioning UTM platform. Their solution includes universal drone registration standards, open identification systems, 3D mapping data, and more.[12]

Meanwhile, the FAA has stepped into the arena with the expansion of its Low Altitude Authorization and Notification Capability (LAANC). The system will be deployed at nearly 300 air traffic facilities covering approximately 500 airports and is expected to be finished in September 2018.[13]

### Analytics and optimization

Digital by design, drones and other flying vehicles will generate an extraordinary amount of data about their locations, flight paths, and speeds, in addition to the data their mission requires. Using this data, analytics will provide valuable insight to help optimize travel and route planning, both in planning and in real-time. Automation and artificial intelligence also promise opportunities to improve efficiency, accuracy, and safety. For example, at Kennesaw State University, an approximation algorithm is being developed to determine how to best deliver a set of packages using multiple drones. This solution will help courier companies coordinate their efforts, saving time and money when operating multiple drone-assisted truck delivery systems.[14]

### People

Every stakeholder needs to recognize their place and clearly understand their role in UTM. Like the parable of the blind man and the elephant, every stakeholder involved is touching a different part of the ecosystem; it is critical that all see the whole and recognize the necessity of collaboration. Regardless of their operation—whether inspecting crop conditions, delivering medical supplies, or relaying traffic information—every flying vehicle operator has multiple responsibilities to fulfill to their organization and to the broader environment. Public concerns may also surface about loss of employment, as drones may replace human workers in some situations. While some jobs may be automated, others will likely be created. Throughout the evolution of UTM, change management is essential and must include ongoing communications and training.

## Government regulations supporting usage of drones in airspace

- **European Union (EU)** – The European Aviation Safety Agency (EASA) is working on finalizing the first EU rules for all types of unmanned aircraft. At present, EASA only has regulations for unmanned aircraft above 150 kilograms.
- **Germany** – The country has come up with new regulations permitting the usage of BVLOS flights when the operator is able to verify a safe flight record. The drones can fly below 100 meters heights and their weight should not exceed 25 kilograms.
- **Australia** – The Civil Aviation Safety Authority (CASA) has allowed the employment of drones, and the operators do not need any permit for VLOS operations, if a drone weighs less than 2 kilograms and flies within 400 feet above ground over unpopulated areas.



# Taking safely to the skies

Today, UAS, drones, and aerial vehicles are taking to the skies at an accelerating rate, even without an established infrastructure to safely manage the low-altitude airspace and UAS flight. As the skies grow more crowded, the future growth and sustainability of the UAS marketplace depend upon the emergence of a UTM system to ensure safe and efficient operations. This air traffic management system should provide services such as airspace design, corridors, dynamic geofencing, and guidance for severe weather and wind avoidance, congestion management, terrain avoidance, route planning and re-routing, separation management, sequencing and spacing, and contingency management. It must be designed to meet the needs of today's drones while anticipating a future that includes passenger drones, flying taxis, and even inventions not yet imagined.

UTM represents a critical requirement for the future of elevated mobility and presents significant business opportunities for key stakeholders:

- UAS Service Supplier (USS): These companies will need to collaborate with elevated vehicle manufacturers, communications providers, and regulating authorities to develop pilot programs, regulations, and standards, and determine the hardware and software adaption necessary to develop a safe traffic management system. By handling the core functionality of the UTM spectrum, they have the opportunity to capture the largest revenue share in the UAS traffic management system market. USS will be able to generate revenue by charging operators a subscription fee. This can be a one-time fee or on yearly basis. Along with the subscription fee, the USS might also charge a fee from the flying vehicle operators on per flight basis.

- Drone operators: Several business opportunities such as package delivery, railroad inspection, and forest research are expected to flourish rapidly. Drone operators benefit greatly from a system that will allow flight beyond visual line of sight (BVLOS) over densely populated areas. To protect their investments, drone operators should be proactive in helping to establish and support a universal traffic management system. They are likely testing route planning, air corridors, navigation technology, and robust contingency management systems, as well as installing sensors and navigation software on their equipment to ensure the safety of their drones. In the process, they may discover solutions that can be applied to the broader UTM network. Drone operators also have much to gain from having access to a safe UTM, and should be participating in conversations with other stakeholders.

- Communication Service Provider: Communication companies have an opportunity to assume a primary role in establishing a traffic management system, as they hold the technology for tracking and interacting with drones and can ensure compliance with regulation. Once the system comes into play, communication companies will have the opportunity to charge drone operators as well as USS for their services. Communication companies currently collaborating with the regulating authorities will have the first mover advantage when the UTM system is launched commercially.

Resolving these issues and creating the foundation for a solid, sustainable UTM will then open the door to the next phase in this evolution, allowing this industry to look beyond unmanned air traffic management towards "Unified Air Traffic Management." In this phase, Unified TM will need to support legacy traffic, unmanned aircraft operations, and piloted and/or autonomous manned vertical takeoff and landing (VTOL) operations and air systems.

Establishing a unified air traffic management system that provides for safe, secure, and sustainable air travel for UAS, VTOL, and other aircrafts is mission critical. Companies are investing billions in their development with the expectation that a system will be in place to ensure efficient and streamlined travel, as well as to reduce the risk of accidents and traffic congestion. The time is now for establishing the foundation of an air traffic management system. Laying the blueprint and managing this ecosystem of players is the next big challenge for the future of elevated mobility. What role will you play?



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