Strategic Insights for Thriving in the Unmanned Traffic Management Ecosystem

PwC Drone Powered Solutions

Global Center of Excellence in Drone and Satellite Technologies

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Introduction

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Director
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It is with great enthusiasm that I unveil our latest endeavor into the evolving world of Unmanned Traffic Management. Launched at the renowned Airspace World 2024 conference in Geneva, this report is a testament to our dedication to advancing drone integration across various industries. By covering the forefront of UTM technology, we aim to illuminate the path toward an integrated drone ecosystem. This report not only addresses the challenges we face but also underscores the vast opportunities for growth and innovation within the UTM sector. Providing a comprehensive overview and forward-looking insights, our goal is to empower stakeholders worldwide to navigate the complexities of future airspace and air traffic management. Within its pages, you will discover an in-depth exploration of the current state of UTM ecosystem, detailed analyses of key market players, and a visionary outlook on the future of drone operations. We delve into the essential components and challenges of the UTM market, striving to equip policymakers, Air Navigation Service Providers, and industry innovators with the knowledge needed to foster a safe, efficient, and sustainable drone future. Together, we can unlock the full potential of drones, contributing to an era of aerial innovation and efficiency.

Executive Summary *(highlights with figures)*

The Unmanned Traffic Management sector is at a critical juncture, poised for significant expansion as the drone industry continues to ascend. Our predictions indicate that the **market will double in size by 2029**, with an annual **growth rate of 14.4%**.

This growth is expected to propel the number of **drone operations to an estimated 28 million**, underscoring the urgent need for robust UTM systems to ensure the safe, efficient, and sustainable integration of unmanned aircraft into the global airspace and air traffic.

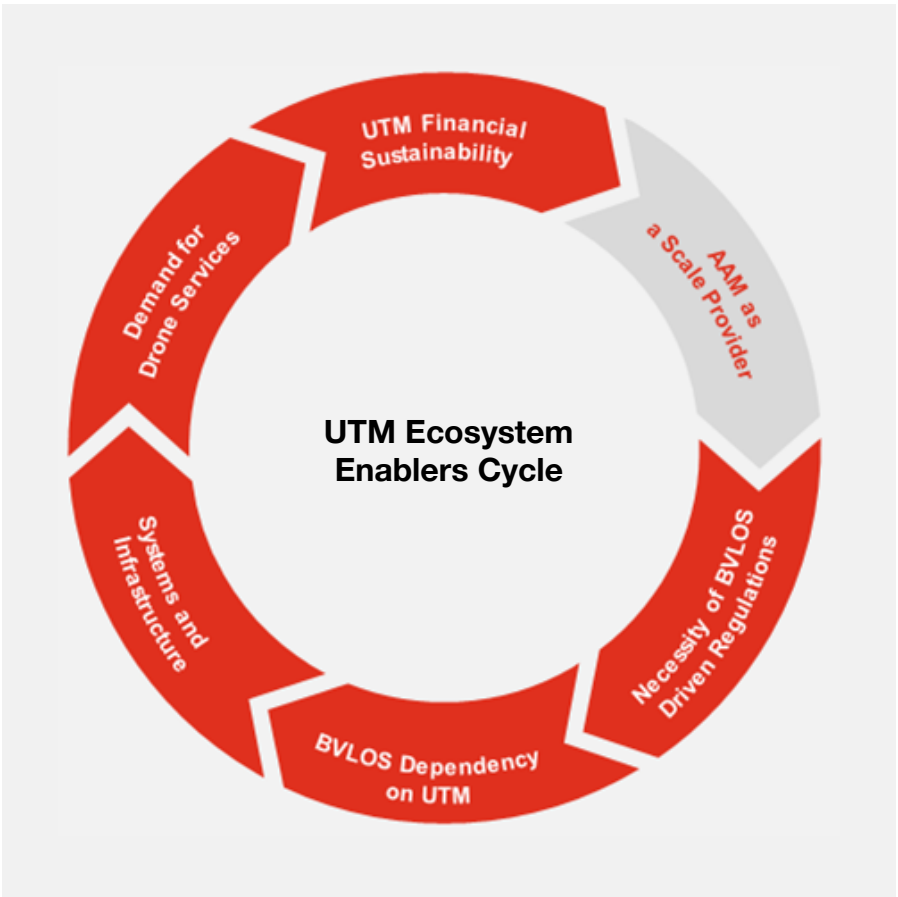
28mln
Drone operations by 2029

2 times
Market growth by 2029

14.4%
CAGR

This report delves into the evolving landscape of UTM ecosystem, underscoring its pivotal role in enabling the drone sector. It highlights the challenges and opportunities within the industry, providing insights into **how public authorities, service providers, and industry stakeholders** can collaborate to shape a future where drones contribute significantly to a variety of industries, enhance service delivery, and open new avenues for innovation and growth.

The UTM market's evolution is intricately tied to the synergy between regulatory frameworks, technological advancements, and market demand, with a robust demand for drone services at its core. Advanced Air Mobility (AAM), **particularly drone delivery, stands as a key driver**, fostering this demand and establishing the financial bedrock of the ecosystem. This interplay creates a **self-sustaining cycle** where the success of each element supports the collective growth and viability of the UTM market, ensuring a harmonious and scalable future for unmanned aviation. In our report we focus on crucial enablers for the UTM.



- Each UTM ecosystem enabler and its realisation can be clearly associated with a specific UTM stakeholder
- In most countries, an initial kick-off or an additional motivator should be public financing of UTM systems and infrastructure, being a bottleneck for BVLOS and regulations enablers
- The report analyses the roles and interdependencies of stakeholders within the UTM ecosystem

11 Quotes

Agnieszka Gajewska

Partner, Global Leader
Government and Public Services
PwC Poland

As PwC Global Leader for government and public services, I recognize the transformative power of drone technology and I'm passionately aware of its role in reshaping our world today. Far beyond mere process optimization and digitization, it opens new markets and enhances public sector availability and efficiency. Drones promise not only to support agencies in fulfilling their mandates but also to contribute to life-saving and humanitarian efforts worldwide. Their potential in environmental protection and energy transition is immense. It is critical for public stakeholders to focus on orchestrating unmanned traffic to ensure safe integration of drones into our skies. Together, we can establish a sustainable, safe future for drone operations, unlocking their full potential to revolutionize how we meet critical global challenges and enhance societal well-being.

Michael Burns

Partner
Aviation Transport & Infrastructure
PwC Australia

On my professional road I stand at the forefront of an era where the aviation sector is witnessing a pivotal transformation. Drones represent not just an addition to our skies but a fundamental shift in the fabric of aviation infrastructure. The escalating necessity for Unmanned Traffic Management systems across the globe underscores a critical juncture for Civil Aviation Authorities and Air Navigation Service Providers. As these entities navigate the complexities introduced by drones occupying an ever-increasing expanse of our airspace, the adaptation and forward-thinking in managing the skies become paramount. This report emerges as a crucial milestone, catalyzing stakeholder engagement and fostering dialogue essential for addressing the multifaceted challenges UTM presents. The collective endeavor to integrate drones into the airspace at scale demands a concerted effort—a synergy of expertise, innovation, and strategic foresight. Public stakeholders are called upon to re-envision their mandates, preparing for a future where unmanned and manned aviation coexist harmoniously. It is through collaborative and open discussions, as advocated in this report, that we can unlock effective solutions to the UTM challenges that lie ahead. The integration of drones into global airspace is not merely a technical evolution; it's a redefinition of aviation’s future, promising enhanced efficiency, safety, and a new horizon of possibilities for the sector.

Dr. Jan H. Wille

Partner, Leader
EMEA Aerospace & Defence
PwC Germany

The importance of a coordinated approach to the integration of drones across both civil and military sectors cannot be overstated. The complexity of safely integrating unmanned systems into our airspace demands a collaborative effort from all stakeholders, including aviation regulators, airspace managers, defence agencies, technology providers, and industry innovators. Establishing clear protocols and frameworks is crucial to enable seamless cooperation between civil and military domains, ensuring that safety and operational efficiency remain paramount. The collective responsibility to develop and implement Unmanned Traffic Management systems is essential. This effort requires not only technological innovation but also a shared commitment to regulatory harmony and procedural clarity. As we progress, leveraging our collective expertise to overcome the challenges ahead is imperative. Achieving the safe and effective integration of drones into the airspace is a shared goal, attainable only through strategic collaboration and open dialogue among all parties involved.

1 What is the UTM and why does the industry need it?

UTM enables scalable drone operations in low-altitude and urban airspace

Unmanned Traffic Management (UTM) is an ecosystem that enables safe and efficient drone operations in low-altitude and urban airspace, typically below 500 feet / 150 meters above ground level (AGL). UTM aims to provide a framework and a set of services and functions for informing, coordinating and managing the access and use of the airspace by drones (UAS – Unmanned Aerial Systems or UAV – Unmanned Aerial Vehicles), as well as ensuring the safety, efficiency, security and sustainability of drone operations and air traffic in general.

UTM is often perceived by industry professionals and experts as a pivotal enabler, a force that propels the entire drone ecosystem towards advancement and prosperity. Drones, in this context, are seen as essential tools, instrumental in delivering services and deploying cutting-edge technologies. However, the true essence of value in this industry lies in drone services – the endgame where tangible value is created. To unlock this potential and reap the benefits, a foundational support ecosystem is essential, with UTM being a critical component. It's UTM's role in orchestrating and facilitating drone operations that transforms the mere utility of drones into a significant value generation within and across industries. In essence, UTM is not just a part of the ecosystem; it's the catalyst that enables the industry to flourish, ensuring that drones transcend their tool status to become forerunners of valuable, innovative services.

UTM is not a single system, but rather a system of systems, modules or applications. It involves various stakeholders, services and technologies which can be described as follows. The stakeholders landscape includes drone operators and pilots, UTM technology and service providers (USP), UAS service suppliers (USS), UTM supplementary data service providers (SDSP) , Air Navigation Service Providers (ANSPs), Civil Aviation Authorities (CAAs), Ministries of Transportation or Digital Affairs, Local Administration Units (LAUs), as well as other service providers and airspace users. Services can be categorized into various types, each addressing specific aspects of operations. Starting from foundational services (e.g. registration and electronic identification), flight management services (e.g. flight planning and monitoring), advanced support services (e.g. complex situations, conflict resolution), and comprehensive services focusing on automation and interconnectivity. These services are expected to collectively ensure safe, efficient, and integrated drone operations. UTM also leverages various technologies and innovations, such as communication and connectivity, navigation, surveillance, identification, automation, artificial intelligence, etc. These are required to build capabilities and deliver the aforementioned services.

UTM is primarily needed by aviation and public safety stakeholders because of the necessity of safe, efficient and secure unmanned and manned air traffic integration. Nevertheless the drone industry is growing rapidly and poses new business opportunities for new players to join and build this industry from scratch, for example, telecom infrastructure operators and service providers. According to our estimations, the number of drone operations is expected to increase significantly, from 15 million today up to 30 million in 2029. The growing number of drones in the air, followed by the number of operations will drive the growth of the UTM market. There is a variety of use cases and purposes for flying drones, but it is expected that beyond visual line of sight (BVLOS) drone operations in the form of advanced air mobility (AAM) services like drone deliveries and air taxis implemented at scale will drive the number of operations in the future.

UTM enhances safety, efficiency, security and sustainability of drone operations and air traffic in general

However, the current air traffic and airspace management systems, which are mainly designed for manned aviation, are not sufficient and suitable for accommodating the increasing number and diversity of drone operations, especially in low-altitude and/or near urban airspace, where most drones operate or advanced air mobility services will operate in the future. The low-altitude and urban airspace is complex and dynamic, with multiple and heterogeneous airspace users, such as general aviation, helicopters, gliders, etc. Among these, the increasing number of drones flying in the airspace brings another challenge to deconflict and integrate the unmanned traffic itself. The low-altitude and urban airspace is also subject to various environmental, operational and regulatory constraints, such as weather, terrain, obstacles, restricted or prohibited zones etc.

Infobox 1

Localized implementation of UTM: an optimal strategy for tailored airspace management and local needs fulfillment

The concept of UTM can be perceived both as a localized UTM regions, as well as a blanket system covering an entire country.

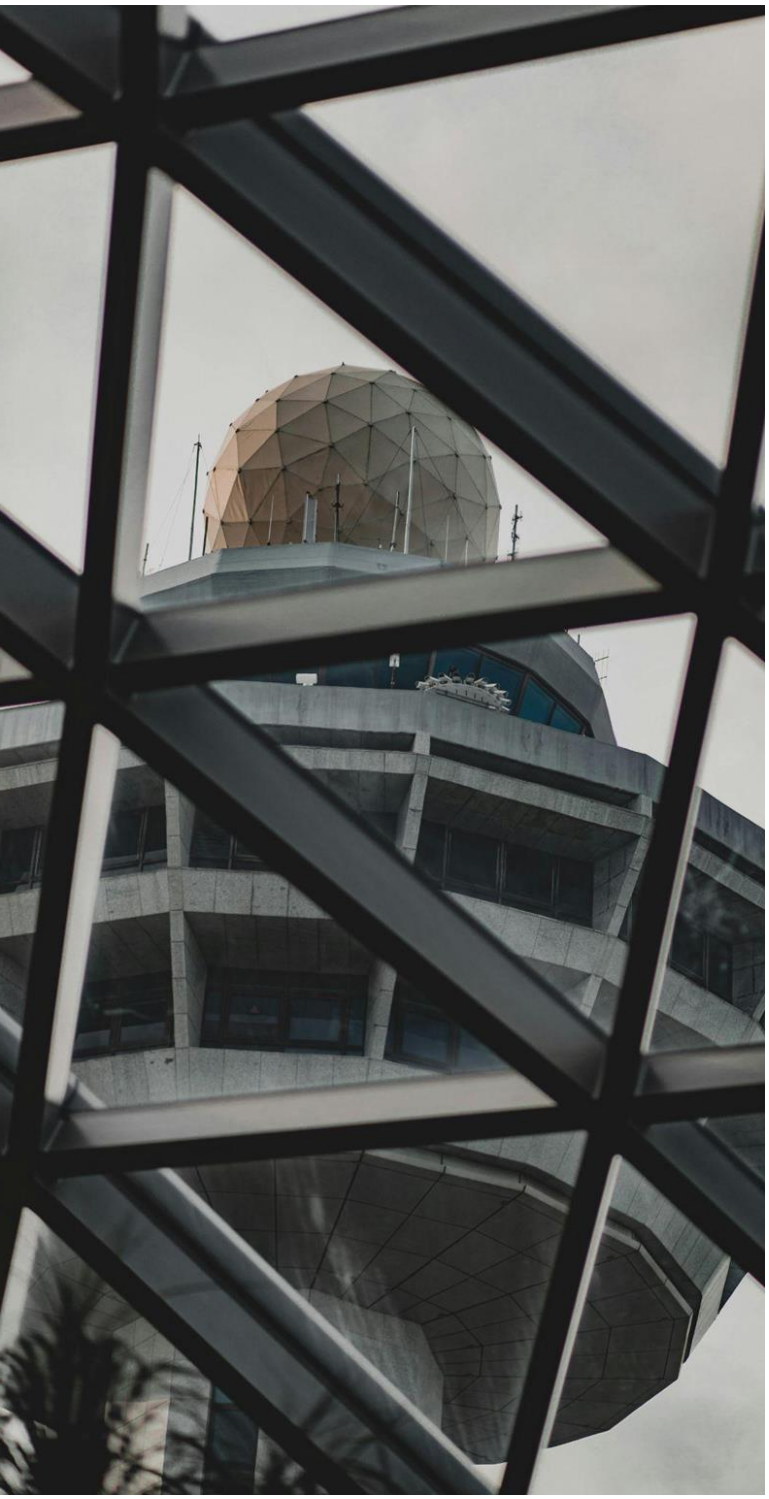
It’s important to understand that UTM can be specifically applied to controlled areas with higher air traffic, airspace density or risk, such as airports vicinity, large urban agglomerations or areas with high expected air traffic congestion, be it manned or unmanned.

This targeted approach allows for a more efficient and risk-mitigated management of drone traffic where it's most needed. Additionally, it makes business sense as these areas are more likely to have users willing to pay for UTM services.

Moreover, different UTM areas within a country can be co-managed by various entities or organizations, allowing for flexible and specialized management based on their unique needs. This model underscores the adaptability of UTM systems to cater to specific regional requirements and operational contexts.

Therefore, UTM is essential for enabling safe, efficient, secure and sustainable drone operations in low-altitude and urban airspace, by providing the following benefits:

- **Safety:** UTM enhances the safety of drone operations, by preventing and mitigating the risks of accidents and incidents, among drone operators and pilots and other airspace users, as well as with the people, animals and ground objects. UTM also ensures the compliance of drone operations with the aviation rules and other regulations



- **Efficiency:** UTM enhances the efficiency of drone operations, by optimizing the use and allocation of the airspace resources, such as the airspace access, the airspace capacity, and the air navigation services. UTM also enables the automation of the drone operations, such as the communications and coordination of flight planning, the deconfliction, the geofencing, etc.
- **Security:** UTM enhances the security of drone operations, by safeguarding the information and data of drone operations, as well as the privacy and property of the people and the environment. UTM also enables the distinction between authorized and unauthorized drone activities.
- **Sustainability:** UTM enhances the sustainability of drone operations serving as a guarantee of operational repetitiveness and scalability. This aspect may be crucial for businesses, enabling them to conduct continuous and consistent operations, rather than relying on ad-hoc or irregular service provision. This reliability seems key for confident investments and stable growth of service market. UTM also supports the sustainability of drone operations, by managing the environmental and social impacts, such as the noise, the emissions, and the nuisance. These points may be of the essence for LAUs and communities. UTM also supports the innovation and development of the drone industry, by fostering the collaboration and integration of the involved stakeholders.

Analyzing these points from the perspective of various stakeholders and their respective interests, it's evident that each aspect holds significance for the balanced and equitable growth of the entire industry and its participants. However, it can be assumed that the first two elements, safety and efficiency, are particularly critical for CAAs and ANSPs. Security, on the other hand, is paramount for ensuring public safety and maintaining trust among the general populace. Efficiency and sustainability is a key factor for business and service providers, as well as for LAUs. Such perspective of priorities underscores the need for a holistic approach in UTM development, addressing the varied yet interconnected needs of all industry stakeholders.

The need for UTM is vital today as the drone industry is globally growing rapidly

The drone industry has witnessed a remarkable exponential growth over the past decade, driven by both quick technology development and drone services level increase, as well as supportive regulatory initiatives and standards, which gradually enables even advanced operations. However, this also creates new challenges and opportunities for regulators, various operators and service providers, which requires an ecosystem that can enable safe, efficient, secure and sustainable drone operations in low-altitude and urban airspace. On the one hand, the technology development has improved the capabilities and performance of drones, as well as reduced the costs and risks of drone operations. On the other hand, the regulatory initiatives and standards have established and enforced the rules and requirements for drone operations, as well as developed and implemented the best practices and guidelines. The more the market is technologically advanced, as well as regulated and standardized, the more stakeholder involvement, coordination and management is required to let it grow further.

Today we can observe a few key enablers and trailblazers when it comes to drone regulatory and UTM efforts. The United States Federal Aviation Authority (FAA) brings their own vision of the UTM with a collaborative and inclusive effort that involves various stakeholders, such as NASA, other federal agencies, industry, academia, and the public, to explore and define the UTM concepts, requirements, standards, and best practices.

Secondly there are the European Union countries with the European Union Aviation Safety Agency's (EASA) concept of U-Space, a common general regulatory and operational framework and a collective effort of the EU member states to build a standardized and interoperable UTMs. The EU countries are still able to implement specific solutions tailored to each country's specifics.

Beyond the US and Europe, important developments can be observed across the globe, with some countries presenting an outstanding level of developments or strategies for their drone sectors. Brazil with its National Civil Aviation Agency (ANAC) and Department of Airspace Control (DECEA) are both introducing innovative UTM solutions such as SISANT and SARPAS. Japan Civil Aviation Bureau (JCAB) also sets up new standards, preparing their airspace for integrated manned and unmanned operations. Japan runs a dedicated Realization of Advanced Air Mobility Project (ReAMo), where a consortium of government and commercial entities (including PwC) run advanced studies on the future shape of the AAM and UTM ecosystem. Australia seeks their own path and solutions for efficient UTM to be developed, leveraging competencies of the Airservices Australia and other relevant stakeholders. Israel leverages a cooperation of relevant authorities and the industry, developing the Israel's National Drone Initiative (INDI), piloting and testing multi-city UTM solutions for drone delivery. These examples provide a selective overview of global UTM efforts, capturing a snapshot of the dynamic and rapidly evolving UTM landscape. Numerous other initiatives are unfolding across the world, with the UTM scene characterized by continuous change and frequent updates. Developments in this field are reported regularly, reflecting the vibrant and ever-changing nature of UTM worldwide.

Besides individual countries' effort to prepare and build required systems and capabilities, there are international overarching institutions which connect the experts and support standardization and unification efforts, with International Civil Aviation Organization (ICAO) being the key one. There are global working groups and bodies which gather top aviation experts together in order to collectively solve problems and design proven solutions, with regulatory and operational Joint Authorities for Rulemaking on Unmanned Systems (JARUS) and Civil Air Navigation Services Organisation (CANSO); standardization American Society for Testing and Materials (ASTM) and European Organisation for Civil Aviation Equipment (EUROCAE), or research and development Single European Sky ATM Research (SESAR).

The developing countries also participate in this trend, foreseeing significant opportunities in drone solutions that can bring their economies to new heights, offering unprecedented services that can contribute not only to economic growth, but also to saving people's lives or improving their quality of living. At least basic UTM capabilities are preferred when it comes to medical drone deliveries, public safety surveillance, or agriculture drone operations. These countries are being supported by international organizations such as ICAO or development institutions such as the World Bank or other local development banks. Some of the developing countries have decided to be part of drone innovation, becoming home to the first drone scalable solutions, such as medical drone delivery in Rwanda or Nigeria with their Zipline delivery networks. These solutions have demonstrated the potential of drones to overcome the challenges of infrastructure, accessibility, and affordability in delivering essential goods and services to remote and rural areas.

2023 was a pivotal year in the Advanced Air Mobility arena, especially for eVTOLs commonly known as air taxis. On one hand, the industry saw positive developments with the testing of flying prototypes, moving closer to making air taxis a reality. However, challenges remain, including aircraft certification, safety regulations, and the readiness of UTM and other air traffic and airspace management systems. Key regions like the Middle Eastern Gulf countries, particularly the UAE and Saudi Arabia, are progressing in their preparation and commitment to deploy eVTOLs commercially in the next few years. Israel, through the INDI project, prepares for setting up a network of infrastructure for both cargo and passenger drones. China, with recent EHang's achievements on obtaining the world's first airworthiness certificate for their autonomous eVTOL, already performed the world's first commercial flight, though the solution is not yet scalable. Test flights and system testing happened across the world, in the US, Europe, South Korea or Singapore to name a few. However, setbacks like Paris' decision against air taxis for the 2024 Olympics signal potential delays in commercial deployment or at least more time needed to overcome the public and regulatory concerns. The year 2024 stands crucial for eVTOLs trajectory, with UTM systems playing a key role in scalability and widespread adoption, alongside the necessary development of vertiports for infrastructure support.

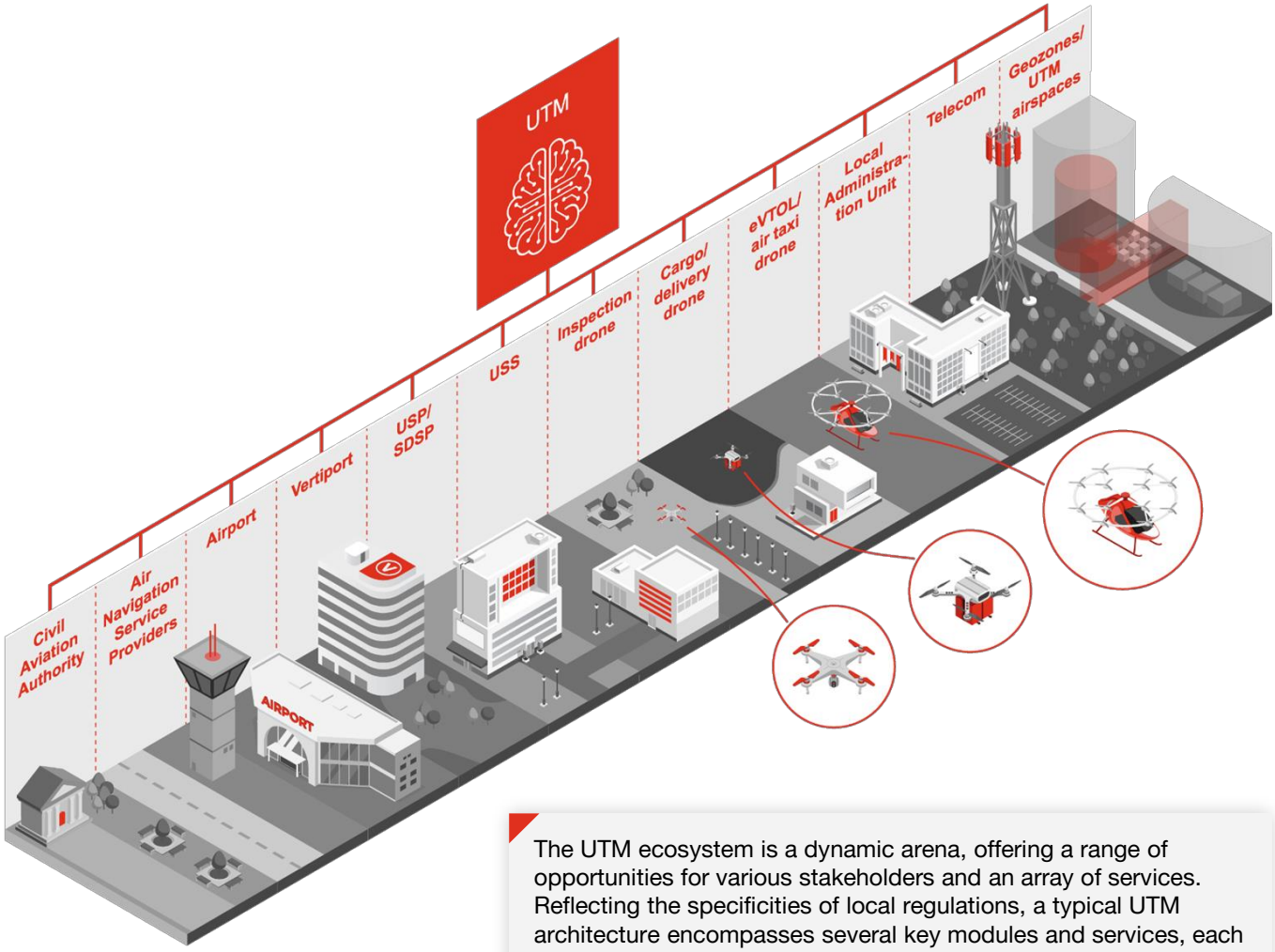
The latest regulatory developments and regulators efforts bring more optimism to the drone industry, as they pave the way for more advanced and scalable drone operations, such as the beyond visual line of sight (BVLOS) operations, which allow drones to fly farther and longer, without the limitation of the drone pilot's in person presence. For example, the Federal Aviation Administration (FAA) in the US has issued more than 3,000 waivers for BVLOS operations since 2016, and has recently proposed new rules for remote identification (RID) and BVLOS operations, including country-wide BVLOS approvals. It also allows for autonomous drone operations and multiple drones being supervised by a single remote operator. Similarly, the European Union Aviation Safety Agency (EASA) has adopted new regulations for drone operations in 2019, and has launched several projects and initiatives for BVLOS operations, such as the Concept of Operation for EuRopean UTM Systems (CORUS).

In this report, we introduce the concept of UTM to all interested parties and stakeholders, addressing their potential concerns and discussing the future of this evolving field. Our focus is not solely on technology and industrial insights, but encompasses a broader perspective, considering the diverse challenges that different stakeholders may encounter. We aim to provide insights into the future developments in UTM that are relevant to all involved parties.

2 Who are the UTM ecosystem participants and what are the key components of UTM?

Infobox 2

UTM Ecosystem: Stakeholders and Key UTM Modules and Services



The UTM ecosystem is a dynamic arena, offering a range of opportunities for various stakeholders and an array of services. Reflecting the specificities of local regulations, a typical UTM architecture encompasses several key modules and services, each contributing uniquely to the system's functionality. This architecture, while guided by general principles and regulations, can vary and extend beyond the foundational elements presented here.

UTM Modules

Drone Operators (USS/USSP) Module

Functional interface for drone operators/pilots for operations and aircraft management, mission planning, flight permissions, risk analyses, emergency communication etc.

CAA Module

Dedicated module for CAA access to the system and data exchange (e.g. on UAV operators and UAVs data), as well as approving and giving permits for registration, advanced operations, and adaptation to local conditions

ANSP (FIMS/CISP) Module

Operational ANSP module for drone flight authorization and management; master data exchange and communication; includes coordination with civilian air traffic services.
This is a crucial operational module which combines and includes all the UTM data and all the stakeholders active in the process.

Military Module

Dedicated module for flights coordination in military airspace, combined with direct communication with military air traffic services

LAUs Module

Communication and cooperation module for Local Administration Units, for the comfort of citizens and effective airspace utilization

SDSP and USP Modules

Communication and data exchange with providers of additional services and data required to provide UTM services as described below

UTM Services

Activity Reporting Service

Provides information on UTM operations like density reports and monitoring within a specified airspace and time.

AIS (Aeronautical Information Service)

Facilitates the flow of aeronautical data necessary for safe and efficient drone operations.

Airspace Authorization Service

Grants multilevel airspace authorization to drone operators.

Discovery Service

Offers information on relevant UTM services in a specific airspace volume.

Mapping Service

Provides terrain and obstacle data necessary for drone operations and UTM system needs.

Registration Service

Enables drone operators to register their drone and provides a query function for authorized stakeholders.

Restriction Management Service

Manages and disseminates directives and operational restrictions from the CAA or ANSP to drone operators.

Flight Planning Service

Arranges and optimizes operational volumes, routes, and trajectories for drone flights.

Strategic Deconfliction Service

Minimizes the likelihood of conflicts by arranging and prioritizing drone operational volumes and routes.

Tactical Separation with Manned Aircraft Service

Provides real-time information about manned aircraft to ensure drone remain clear.

Conflict Advisory and Alert Service

Offers real-time alerting on drone proximity to other airspace users and airspace violation.

Conformance Monitoring Service

Monitors and alerts on nonconformance to operational volumes, routes, or trajectories.

Dynamic Reroute Service

Provides real-time modifications to operational volumes and routes to minimize conflicts and maximize capacity.

Identification Service

Identifies individual drone with associated nationality and registration information.

Tracking and Location Service

Offers real-time location information of drone to drone operators and UTM system.

Meteorological Service

Provides meteorological information necessary for drone operators and UTM services.

Infobox 3

Key UTM archetypes: the US FAA's UTM and the EU EASA's U-Space

The drone industry has witnessed the emergence of two pioneering and fundamentally developed UTM frameworks: the FAA's Unmanned Traffic Management (UTM) concept in the United States and EASA's U-Space concept in Europe. As the first of their kind, methodically crafted from the ground up, these frameworks have established the foundational standards for the integration of drones into national airspaces. By setting these early benchmarks, both the UTM and U-Space concepts have become instrumental in shaping the global discourse on drone operations, influencing subsequent developments and regulations in the rapidly evolving UAS sector.

The FAA's Unmanned Traffic Management (UTM) concept is a collaborative effort to enable safe and efficient low-altitude airspace operations. At its core, UTM aims to integrate UAS into the National Airspace System (NAS) without negatively impacting existing manned aircraft operations. This system is built around the use of UAS Service Suppliers (USS) that provide services such as situational awareness, flight planning, and airspace authorization to drone operators. A key feature of the UTM is the implementation of Remote Identification (Remote ID), which acts like a digital license plate for drones, making it easier to identify and track UAS in flight. The UTM's phased approach to development ensures gradual integration, focusing first on establishing basic capabilities and safety measures (such as Remote ID), before moving on to more complex operations such as beyond visual line of sight (BVLOS) flights and autonomy.

EASA's U-Space concept represents the European vision for managing drone traffic in a way that ensures the safety, security, and privacy of citizens and the efficiency of drone operations across the continent. U-Space is a set of new services and specific procedures designed to support sustainable access to airspace for large numbers of drones. Unlike traditional air traffic management which is centralized, U-Space is envisioned as a decentralized framework, relying on U-Space Service Providers (USSPs) to manage drone operations. Key components of U-Space include e-Identification, which allows drones to be identified while in flight; geofencing, to prevent drones from entering restricted areas; and services that provide real-time traffic information to drone operators. U-Space is also characterized by its phased implementation, starting with basic services for drone registration and identification, and progressively integrating more advanced services as the framework evolves.

In this report, we primarily use the general UTM terminology as endorsed by the FAA (unless explicitly stated otherwise), acknowledging that the two concepts are frequently referenced interchangeably. To avoid confusion and ensure clarity, we present a selective comparison table outlining the key terminology differences between the US and EU.

Terminology equivalents

	
UTM*	U-Space
Flight Information Management System (FIMS)	Common Information Service Provider (CISP)
USS (UAS Service Supplier)	USSP (U-Space Service Provider)
Remote ID	e-Identification
Drone Zones	Geofencing / Geozones

* in Europe the 'UTM' term is mostly understood as a system rather than an ecosystem

Regardless of the terminology used, the overarching concept of Unmanned Traffic Management (UTM) should be understood as a universal framework. While individual countries may develop their own specific approaches, the inherent requirements of aviation and the evolving needs of the drone sector necessitate the development of similarly effective solutions.

Key actors and responsibilities

In the emerging landscape of the UTM ecosystem, a diverse array of stakeholders and market players play crucial roles:

Airspace Users

This category encompasses mainly drone pilots and operators, but in a wider perspective, includes both unmanned and manned aircraft, which also benefit from the UTM ecosystem. Their operations are influenced by the safety and efficiency of UTM services.

Civil Aviation Authorities and Governmental Bodies

These regulatory and strategic bodies are responsible for the oversight of aviation safety and the establishment of drone ecosystem guidelines, regulations and strategies that govern development and growth while maintaining safety.

Air Navigation Service Providers (ANSPs) and Airspace Managers

Both civil and military air traffic and airspace managers are crucial for management, ensuring that both unmanned and manned aircraft can coexist safely and efficiently.

Technology Providers

These are the innovators and developers who create the technological backbone of the UTM. They supply the necessary hardware and software that facilitate communication, connectivity, navigation, surveillance, identification and automation within the ecosystem.

Key actors

- Drone operators and pilots (service providers or internal drone units)
- Civil Aviation Authority, Ministry of Transportation, Ministry of Digital Affairs *(or their equivalents)*
- Air Navigation Service Providers, Military Air Traffic Service (or their equivalents), local airspace managers (e.g. port authorities) *(if applicable)*
- UTM technology and service providers (USP, e.g. telecoms), UAS service suppliers (USS)

Key actors

Direct and Indirect Service Providers

This group includes telecom operators, data centers, weather information suppliers, among others, that provide essential support services that enable the UTM ecosystem to function seamlessly.

UAS service suppliers (USS), UTM supplementary data service providers (SDSP, e.g. telecoms)

Local Administration Units

These local governing bodies play a significant role in integrating UTM systems within their jurisdictions, particularly in urban environments where drone activity is high.

City councils, Municipalities, County/District/Region Governments

Public Safety Users

Entities focused on community protection and crisis management, including law enforcement, emergency services, and national security organizations. Their common interest lies in ensuring public safety and responding to emergencies.

Law enforcement units, Cybersecurity agencies, Ministry of Interior, Ministry of Defense *(or their equivalents)*

Additional Stakeholders

There are other essential services and stakeholders integral to the efficient and safe management of unmanned air traffic and airspace. They contribute to various facets of the UTM, from security to environmental management

Dependencies between stakeholders and strategic decisions to be made

The effectiveness of an UTM ecosystem hinges on a diligent understanding of the interdependencies among various stakeholders. Each stakeholder plays a crucial role, similar to pieces of a puzzle that must fit together harmoniously for the ecosystem to function well. The integrity of the UTM ecosystem depends on each part performing effectively; any weak link would potentially compromise the entire ecosystem.

At the forefront of this intricate network are the Civil Aviation Authorities (CAAs), responsible for establishing forward-thinking regulations. These regulations need to address not just standards and requirements, but also operational aspects such as risk management, scalability of operations, and support for automation and further autonomy. The regulations lay the groundwork for the safe and efficient integration of drones of any kind and size into the airspace.

Following the regulatory framework, a comprehensive development strategy for the national drone ecosystem must be formulated by relevant ministries and agencies. Their involvement, overarching governance and support is important and often forgotten in the whole ecosystem planning. This strategy should provide clear direction for the industry and businesses involved, outlining the pathway for growth and innovation in the sector.

Subsequently, the selection of specific UTM technology and tools falls largely to Air Navigation Service Providers (ANSPs). Alongside technological choices, they must also consider the envisioned business models and commercial aspects. There are multiple decisions to be made in this fields, especially taking into consideration the source of UTM financing and willingness to pay for the services provided. This decision-making process involves balancing technical capabilities with market viability and financial sustainability. What makes it even more complex is the general public expectation or even requirement for the public entities to take care about airspace safety and manage the growing drone traffic accordingly.

Each of these aspects - regulatory frameworks, ecosystem strategy, and technology selection - requires a well-thought-out strategy backed by multi-variant analyses, technology development scenarios, and a profound understanding of the market. Only through such comprehensive planning can a UTM ecosystem achieve its full potential.

Infobox 4

Risk-based and performance-based risk management in drone operations

Performance-based risk assessment

An approach that focuses on the outcomes and objectives of the drone operations, rather than the prescriptive rules and requirements. It allows for flexibility and innovation, as the drone operators can choose the best methods and means to achieve the desired level of safety and performance. Examples of performance-based risk management in drone operations are the **Standard Scenarios (STS)** and the **Predefined Risk Assessment (PDRA),** which define the operational conditions and limitations for certain types of drone operations, without specifying the technical requirements of the drones.

Risk-based risk assessment

An approach that focuses on the assessment and mitigation of the risks posed by the drone operations, taking into consideration type of mission, area of flight, population density, airspace type etc. It allows for customization and adaptation, as the drone operators can tailor their operations to the specific context and environment, by identifying and reducing the potential hazards and threats. An example of risk-based risk management in drone operations is the **Specific Operations Risk Assessment (SORA),** which is a methodology for the classification of the risk and the identification of the safety objectives and mitigations for drone operations that are not covered by STS or PDRA.

For a truly effective UTM ecosystem, it is imperative that all mentioned stakeholders adhere to unified standards and integrate into a master system, typically referred to as the Flight Information Management System (FIMS)/Common Information Service Provider (CISP). Such a centralized approach is the cornerstone of automation and scalable decision-making, which are necessary for seamless air traffic and airspace management.

A particularly intricate issue is delineating the safety responsibilities and liabilities among the actors, including Flight Information Management System (FIMS)/Common Information Service Providers (CISP) and UTM Technology and Service Providers/U-Space Service Providers (USP/USSP), particularly focusing on the place and role of the Air Navigation Service Providers (ANSP). The UTM ecosystem is anticipated to incorporate greater levels of digitalization and automation compared to today's manned air traffic services, demanding clear definitions of accountability. Looking to the future, an integrated Air Traffic Management (ATM) system that combines traditional ATM with UTM is essential. UTM presents a unique opportunity to pilot, test, and validate the key principles and technologies that will underpin the digital skies of tomorrow before integrating them into the broader ATM ecosystem.

The choice of the operational model that best suits a country's specific needs and characteristics remains at the discretion of each country. While the FIMS/CISP is envisioned as the "brain" of each UTM ecosystem, the question of who should oversee its creation and operation remains open. Though it might seem like a natural progression for ANSPs to develop and manage FIMS/CISP, this may not always be practical or preferred. Such strategic decisions are pivotal for the design and subsequent evolution of an UTM framework.

Pivotal moment for ANSPs

Air Navigation Service Providers (ANSP) are at a crossroads, confronted with substantial questions and dilemmas regarding their involvement in the evolving drone industry. Recognized as natural candidates for developing and managing national UTM systems, ANSPs must navigate the complexities of this new era of airspace and air traffic management.

The questions facing them are complex, often involving significant consequences and commitments. On one hand, ANSPs are often viewed as ideal candidates for operating and managing UTM systems. This perception stems from their extensive experience in Air Traffic Management (ATM) and their deep understanding of the intricacies of airspace control. From the perspective of traditional aviation, ANSPs possess the capabilities and the institutional knowledge that seem to seamlessly translate into the area of UTM.

However, the unmanned sector and UTM present a distinct set of challenges, especially notable in highly congested, low-altitude airspace scenarios, such as those above city centers. The specific nature and requirements of drone flights differ significantly from the more uniform and structured nature of manned air traffic and high-altitude operations. This includes managing a larger volume of aerial traffic over smaller areas (e.g. urban areas, industrial zones, congested delivery paths), necessitating rapid decision-making and a higher degree of automation. While managing and operating UTM systems could potentially yield positive business outcomes for ANSPs, especially as unmanned traffic increases, it also introduces considerable uncertainty and risk. ANSPs need to develop new competencies and operational capabilities tailored to the UTM environment, which may require significant investment and a shift in their current operational ATM related paradigms.

ANSPs now need to address the growing presence of new airspace users, notably drone operators and pilots. The current and future rise of drone operations, including automated and autonomous modes such as drone deliveries, 'drone in a box' solutions for surveillance, surveying and mapping, presents a significant operational shift. These new users require dedicated attention to ensure safe and efficient integration into the airspace.

Comprehensive airspace awareness is still top priority. Maintaining operational awareness in the airspace is vital for ANSPs, aligning with their core mission of ensuring safety and collision-free skies. To achieve this, ANSPs must have complete knowledge of who operates in the airspace, their compliance with rules, their intentions, and how their plans interact with those of other users. This comprehensive awareness is fundamental for effective airspace management.

Looking ahead, the integration of ATM with UTM is an inevitable and necessary progression. This integration is essential for achieving the aforementioned comprehensive operational awareness. With the drone sector's anticipated balanced growth, including advancements in autonomy and automation (encompassing air taxis, drone delivery with a subcategory of advanced long-range cargo operations), full integration of ATM and UTM is imperative, even if no clear vision for such is available today. This integration will ensure strategic and tactical deconfliction and other key air navigation services are seamlessly aligned.

Having all these points in mind, the challenges faced by ANSPs today in the UTM context are multi-faceted and require careful consideration. These challenges center around a few considerations:

Legislation

ANSPs must navigate complex regulatory landscapes to define their role in the UTM ecosystem. Decisions must be made on whether their involvement should be limited to systems like FIMS/CISP or go an extra mile and, for instance, act as USP/USSP to key national and public services. Or should it extend to new roles like Dynamic Airspace Reconfiguration (DAR) or other alternative scenarios? On the operational side, the approach could involve building new units within ANSPs, creating dedicated UTM subsidiaries, or exploring other legal-business models. Additionally, ANSPs must develop internal drone strategies and foster well-organized, digital, and effective communication with other stakeholders, including crucial civil-military collaborations.

Technology

Another consideration are the technology choices and their implementation. The selection, development, and certification of UTM technology and related standards are critical. This encompasses the full range of UTM components such as FIMS/CISP, USP/USSP, SDSP, and USS. Testing these technologies through test sites, sandboxes, competence centers, pilot projects, and collaborations with public stakeholders and technology providers is essential. Cybersecurity and scalability is also a major concern, especially given the strict requirements in existing ATM systems and the inherently open and interconnected nature of UTM systems.

Finances

From the financial and business perspective, ANSPs face a broad spectrum of decisions and strategies related to financing the required technology, additional infrastructure, and human capital. Current and near-future focus is likely on public funding and dedicated resources such as EU funds offered to the EU Member States or public-private partnerships. However, in the longer term, ANSPs must consider commercializing infrastructure and services through subsidiaries or other channels to transition from the traditional legal-financial regime typical for ANSPs nowadays. Addressing these challenges requires ANSPs to strategically navigate legal, technological, and financial complexities, ensuring the successful integration and operation of UTM systems.

Framework

When it comes to the architecture of the UTM ecosystem and the extent of ANSP involvement, these will vary based on country-specific legislation and anticipated drone regulatory frameworks. Each ANSP faces the crucial decision of how deeply they wish to engage in the UTM sector, considering their level of responsibility and the risks involved, as well as the need of new airspace users market development. Regardless of the framework — be it the U-Space approach in the EU or a UTM framework similar to that in the US—the role of ANSPs remains vital.

Roles and Services

ANSPs also struggle with the model for implementing UTM systems. Options range from developing systems internally, which requires a long-term vision and commitment, to mixed models that blend internal capabilities with outsourced services and external solutions providers. An alternative is a more decentralized approach, where the majority of system components are delivered by third parties, with the ANSP overseeing the overarching FIMS/CISP infrastructure.

Local Administration Units (LAUs) to play a vital role in unmanned traffic orchestration

Local Administration Units (LAUs), encompassing city councils, regional authorities, and other relevant local bodies, are emerging as indispensable players in the UTM ecosystem. Their involvement in airspace management, particularly in the context of geozones - restricted or prohibited airspace, is becoming increasingly critical.

LAUs will often assume the role of airspace co-managers, wielding the authority to dictate or establish rules for unmanned traffic over specific areas. An illustrative example of this is the management of drone traffic over sensitive zones like residential areas, parks, or recreational spaces. The LAUs have the prerogative to set requirements regarding drone traffic, ensuring that activities like drone delivery or surveillance do not lead to congestion or violate privacy norms. This regulatory power directly impacts the process of flight permissions and may necessitate dynamic rerouting of drones to mitigate excess congestion.

Moreover, LAUs are expected to play a pivotal role in setting up low level flight rules and airspace restrictions using geozones within their jurisdictions. Geozones, defined areas where drone activity is restricted or prohibited, are crucial for maintaining public safety, privacy, and environmental integrity. The ability of LAUs to effectively support management of these zones is instrumental in balancing the benefits of drone technology with the rights and expectations of local communities.

Another significant aspect of the LAUs' role is their proximity and direct connection to the local population and stakeholders. Issues and concerns arising from drone operations, which are unlikely to be addressed adequately at a national level, can be more effectively managed through local governance structures.

This involves communication, discussion, and problem-solving with locals, fostering a sense of community involvement and ownership in the co-management of airspace.

The role of LAUs extends beyond the immediate domain of UTM to encompass the broader scope of Advanced Air Mobility (AAM), particularly in the context of managing emerging technologies like cargo drones or electric Vertical Take-Off and Landing (eVTOL) vehicles for air taxi function. As AAM evolves, the responsibilities of LAUs will significantly expand, underscoring their vital role in shaping the future of urban and regional airspace.

LAUs play a vital role in UTM ecosystem development by establishing and supporting test sites. These sites provide opportunities for trialing UTM and related technologies in real-life or simulated conditions. Effective sandboxes, underpinned by structured strategies with clear objectives, cater to local community needs and business interests. Recently multiple LAUs efforts can be observed globally in pioneering drone delivery networks, facilitating eVTOL test flights, and advancing UTM research and development indicates the natural and beneficial role they play in this evolving field.

Building the institutional capabilities to fulfill these responsibilities poses a substantial challenge for LAUs. It requires not only the development of specific regulatory frameworks (administrative law) and operational strategies but also an investment in technology and human resources capable of managing complex UTM modules. However, successfully navigating this challenge can confer on LAUs a more active and influential role in the airspace co-management, marking a new chapter in their history. This evolution from traditional local governance to active participants in aerial mobility underscores the transformative impact of drone technology on societal structures and governance models.

Telecom operators among potential beneficiaries of UTM revolution

The UTM market presents significant business opportunities for companies previously unassociated with the aviation or unmanned sector. Telecom infrastructure operators and service providers, for instance, are primed to play a pivotal role by leveraging their expertise in connectivity, IT solutions, data processing, and computing power. Their capabilities in handling vast amounts of data transfer and their robust infrastructure can be harnessed to bolster the backbone of the UTM's communication network, providing the high-speed, reliable low-latency connections that are essential for real-time UTM operations.

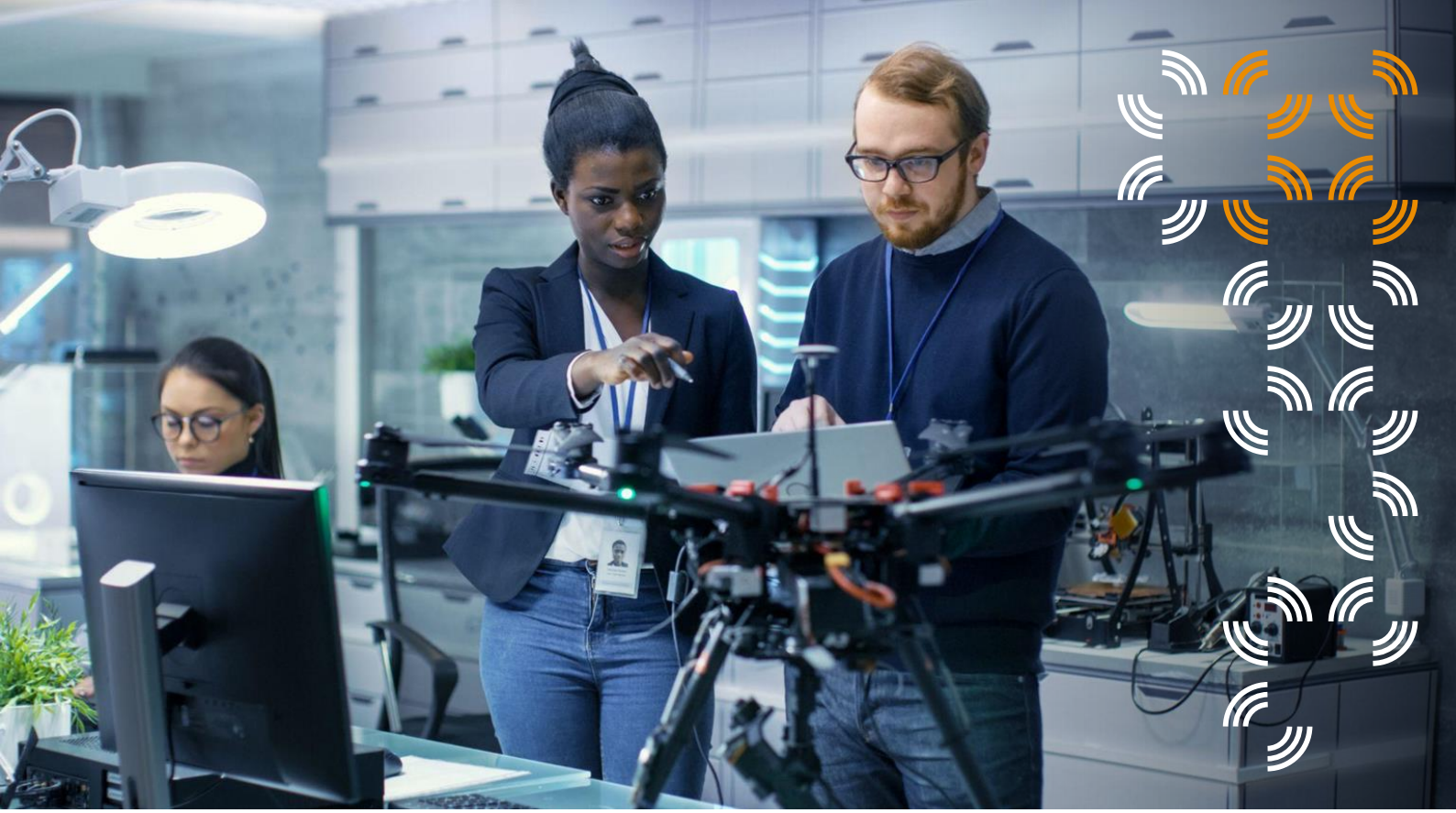
The integration of telecommunications in the drone sector, particularly in UTM, faces several challenges that demand robust and efficient solutions. Telecoms will need to extend infrastructure to provide connectivity to remote or rural areas for comprehensive drone and UTM capabilities. Additionally, as drone operations become denser and diverse devices come into play, network interference becomes a critical concern, requiring infrastructure upgrades to ensure reliable, interference-free communications.

Real-time navigation, facilitated by telecom networks, is essential for drones to navigate safely, avoid obstacles, and optimize flight paths. This capability is vital for autonomous drones in complex environments, demanding reliable algorithms and effective behavior management for safe airspace and scalable UTM systems. Moreover, high-speed edge enabled 5G networks enhance data transfer, crucial for timely decision-making in drone services delivery and optimizing resources in UTM and airspace management. BVLOS operations and advanced drone applications also heavily rely on dependable telecom networks.

Security measures are another focal point, with the need for encrypted communication protocols and anti-jamming technologies to protect drone communications from unauthorized access and interference. Lastly, telecommunications infrastructure is instrumental in enabling remote identification and tracking of drones, facilitating the exchange of identification and flight information to maintain traffic management and ensure compliance with regulations. These topics underline the significant role of telecoms in evolving the drone sector, requiring ongoing innovation and adaptation to meet the growing demands of UTM and drone technology.

In essence, the UTM is not just a system but a symphony of technological harmony, requiring the confluence of diverse capabilities and specializations. It's a fertile ground for cross-industry collaboration, inviting innovation and investment from sectors as varied as information technology, communications, data analytics, and cybersecurity. This convergence is not only a pathway to the AAM but also a catalyst for economic growth, signaling an era where technology transcends traditional industry boundaries to redefine the future of goods and people mobility.

3 What drives the UTM market and what are its development enablers?



In the evolving landscape of the drone industry, a cyclical dependency is emerging, driving market growth and shaping its development enablers. According to our estimates, over 95% of drone traffic in the near future will likely be for drone delivery services. These operations, on a larger scale, necessitate the implementation of BVLOS regulations, which are essential for scalability and enhancing drone service efficiency.

The successful scaling of drone operations, while ensuring safety, hinges on the deployment of effective UTM systems. UTM becomes a necessity as drone traffic increases, providing the infrastructure and regulatory framework needed for safe and efficient operations. In turn, the growing demand for drone services and the corresponding need for BVLOS regulations justify the business case for UTM, creating a self-sustaining cycle where one element fuels the growth of the other.

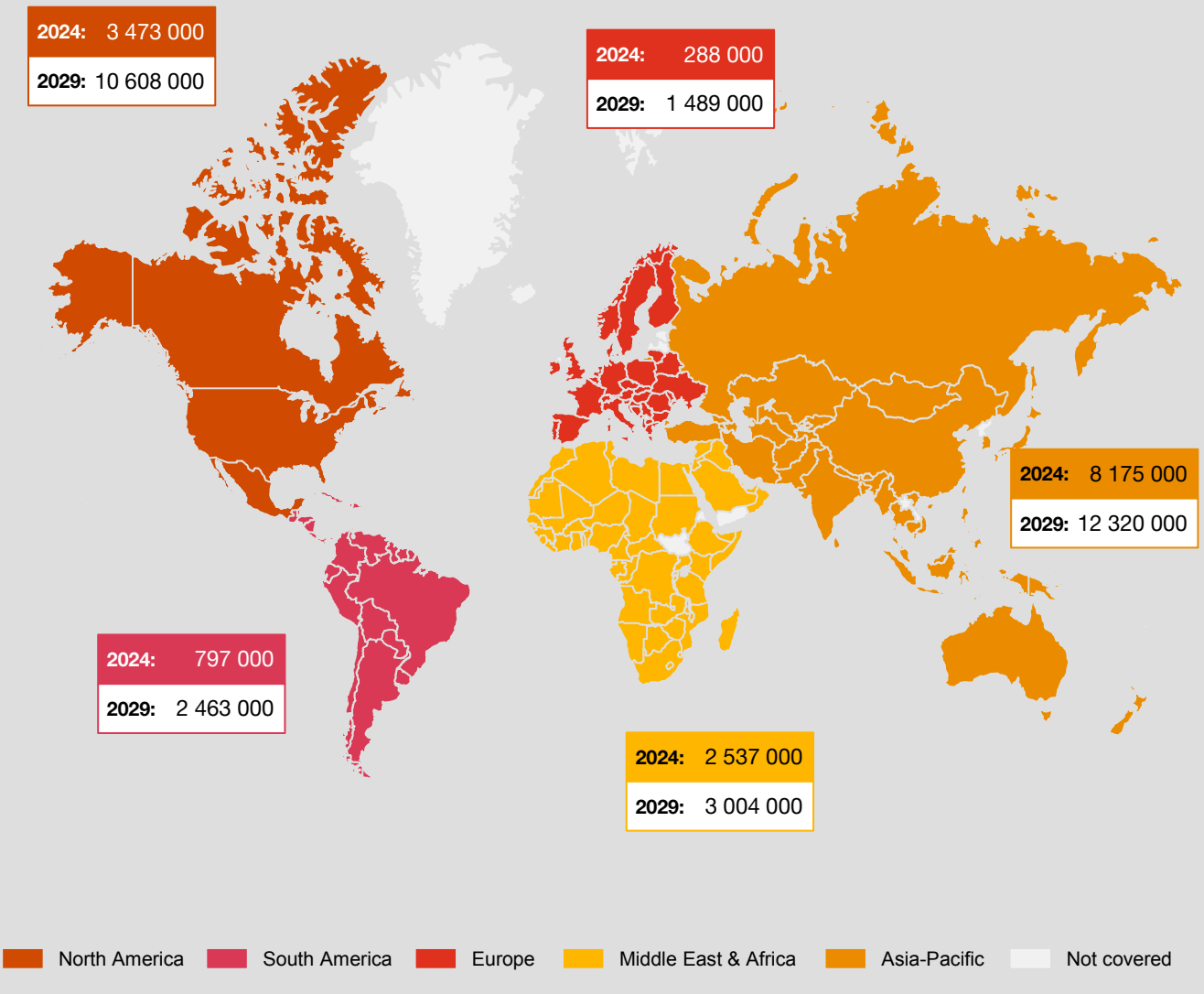
This sector, particularly drone deliveries, has the potential to significantly impact quality of life, offering solutions for medical supplies delivery, disaster relief, reaching the elderly and sick in remote areas, and operations in challenging terrains and geographical conditions. The ripple effect extends to the economy, innovation levels, and the development of businesses relying on drone deliveries. Consequently, governments are encouraged to find financial and operational means to support the development of UTM infrastructure and regulations. Today, it's widely recognized that governments bear the initial financial burden for developing UTM systems. This investment, though substantial, is essential to lay the groundwork. However, a strategic and well-thought-out approach is crucial. This involves devising a detailed plan that not only focuses on reaching a financial breakeven point but also aims to ensure the long-term financial sustainability of the UTM components. Such strategies must be carefully balanced to support the ongoing growth of the drone market and its business potential, ensuring that financial viability does not come at the cost of stifling industry innovation and expansion. This is identified as one of the key needs and prerequisites for the further advancement of UTM ecosystem globally.

The interplay of these factors – increased drone traffic, the need for effective UTM systems, and the implementation of BVLOS regulations to foster scalable drone operations – forms a foundational cycle driving the growth and sustainability of the drone industry. As such, the development of UTM infrastructure and regulatory frameworks is not just a technological advancement but a critical enabler for broader economic and societal benefits.

Expected number of drones in the air

The future landscape of our skies is set to undergo a transformative change with the expected increase in the number of drones operating globally over the next five years. The expected dynamics will differ in different geographies, but the overall trend is clearly visible. Our market model and estimations on the anticipated number of drones in the air paints a clear picture of how congested the low-altitude airspace may become. With 28 million drone operations projected to be globally in 2029, the drone traffic is expected to grow 2 times, compared to today's number of 15 Mn. This results in a market growth CAGR of 14.4%, positioning the drone industry as one of the quickest growing in the global economy.

Number of operations (rounded)



Several factors significantly influence the growth and distribution of drones. Foremost among these is the demand for drone services, propelled by a diverse range of industries from logistics to agriculture. Equally important is the supply side, which is driven by technological advancements and shaped by each country's specific priorities and needs. To illustrate with concrete examples, in Brazil, the agricultural sector is notably integrating drone technology for crop spraying, emerging as a crucial market segment.

Meanwhile, countries like the United States and Australia have achieved notable strides in the realm of last-mile drone deliveries. In Africa, pioneering efforts have been made in establishing scalable medical delivery networks, which have been successfully deployed and are instrumental in saving lives. These varied applications underscore the versatility and transformative potential of drone technology across different global contexts. Regulatory developments play a crucial role in shaping this landscape.

Notably, the increasing number of beyond visual line of sight (BVLOS) approvals and waivers, especially in the US and Europe, is a significant factor. These approvals are accelerating the growth in drone delivery operations, paving the way for more expansive and varied uses of drone technology.

With the increasing number of drones, the implications for airspace management are profound. One of the most pressing challenges is congestion. As the skies become more crowded, the need for robust collision avoidance and airspace separation mechanisms becomes critical. This rise in drone traffic also brings about a competitive scenario for airspace utilization, necessitating efficient and equitable management strategies.

Automation in flight permission issuance is another critical aspect to consider. The traditional manual methods (although subjective, dominant and very time-consuming) of managing flight permissions will likely become untenable as drone operations increase. Automated systems will be essential for handling the scale and complexity of future drone traffic, ensuring safe and timely coordination of flights. This automation will not only enhance efficiency but also play a vital role in maintaining safety standards in an increasingly crowded airspace.

Commercial drone operations and growing level of autonomy

The evolution of commercial drone operations, particularly with the emergence of automated and autonomous solutions like ‘Drone in a Box’ or ‘Drone Docks’ systems, marks a significant leap in the capabilities and potential applications of drones. These systems, primarily used for recurring tasks such as mapping, inspections, or surveillance, represent a shift towards more frequent, unsupervised drone missions. The high degree of automation or full autonomy inherent in these systems enables them to perform multiple missions at various times, day or night, thereby increasing their presence in the airspace and cost efficiency.

The recent permissions for beyond visual line of sight (BVLOS) missions in the US and Europe are a testament to the growing acceptance and popularity of such autonomous drone operations. The ability to remotely operate drones BVLOS enhances their utility and scope, particularly for industries requiring frequent and detailed monitoring, like power plants, industrial zones or mining sites.

However, this surge in autonomous drone operations presents unique challenges for UTM systems. With drones operating autonomously, often in sensitive or restricted areas, the need for robust UTM systems becomes more pronounced. This includes efficient reporting, tracking, and management of drone activities to ensure safe integration into the airspace. The rise of BVLOS operations at scale introduces complexities in airspace management, necessitating sophisticated communication and deconfliction strategies.

Moreover, the use of autonomous drone docks, particularly in regulated industries, may require specific airspace management strategies. This could involve airspace separation or restriction based on a recurring schedule, or dynamic airspace reconfiguration to accommodate the needs of first responders or law enforcement. As such, UTM systems must be equipped to handle these varying requirements, ensuring that they can adapt to the changing landscape of drone operations. These systems must be capable of not only tracking and managing these operations but also accommodating the unique requirements of various industries and emergency services. The communication and data exchange components must present the highest operational level. The challenge lies in creating UTM systems that are flexible, scalable, and robust enough to handle the increasing complexity and frequency of autonomous drone operations. Standardisation of data, algorithms and testing procedures, across various stakeholders, will play important role in a thickening airspace.

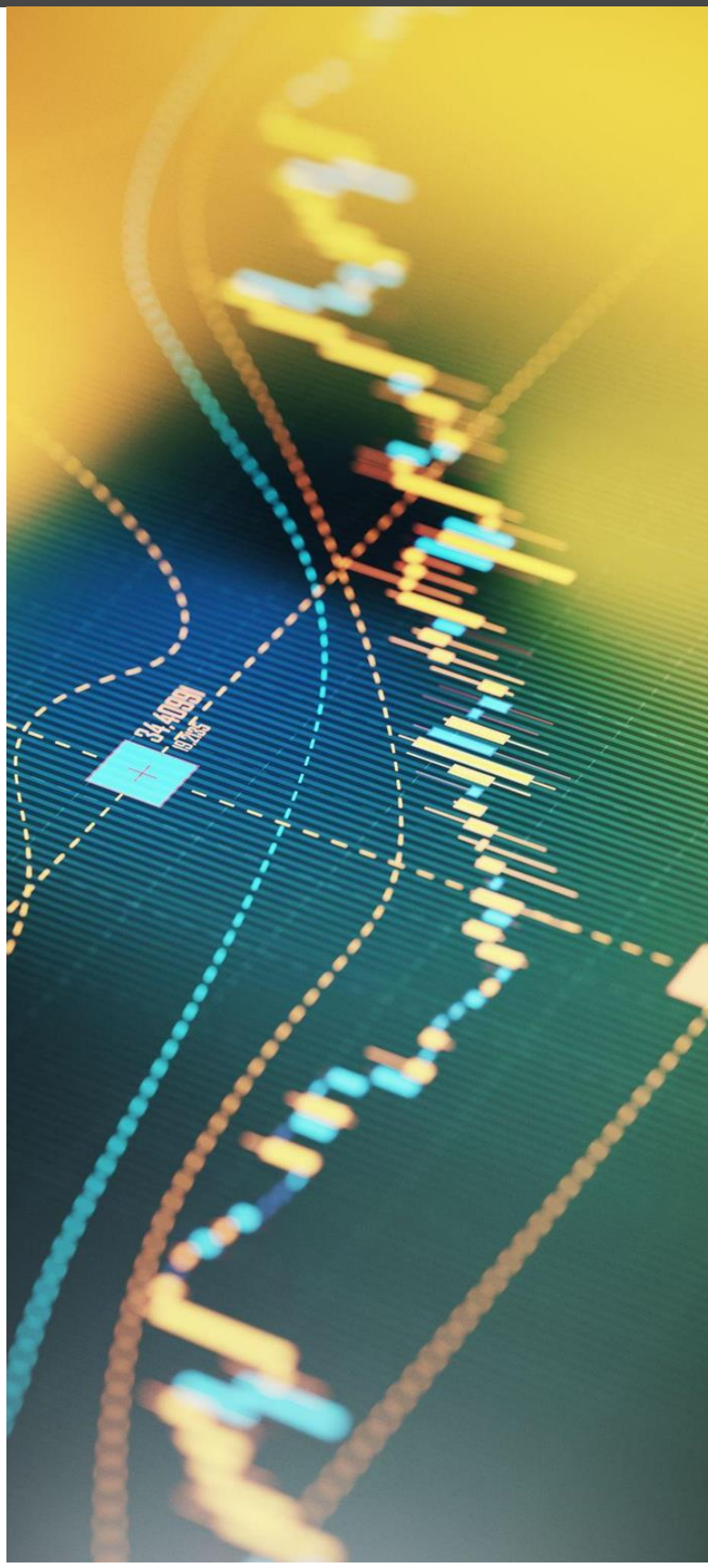
Drone delivery as key market driver

Drone delivery is anticipated to be a principal driver for the UTM market in the near future. Unlike other drone operations such as mapping or videography, drone delivery generates a significant number of operations over limited areas, leading to potential airspace conflicts and congestion. This necessitates focused attention from airspace managers and calls for automated flight permitting, along with tactical deconfliction or dynamic rerouting. Additionally, the rise in drone deliveries highlights the need for innovative solutions in collision avoidance, airspace management, and automated flight permission issuance, as manual systems may soon become obsolete.

Drone delivery has versatile applications across sectors such as e-commerce, food, and medicine. In e-commerce, it promises to revolutionize the way goods are delivered, offering a faster, more efficient alternative to traditional methods. In the food industry, drone delivery can significantly reduce delivery times, keeping food fresh. Medical drone deliveries have been life-saving in critical situations, delivering medicines and supplies to remote or hard-to-reach areas. All this will have to function in an environment that ensures competitive access to services.

More insights on the drone delivery market can be found in our report “Drone Deliveries: Taking Retail and Logistics to New Heights”.

The growth of drone deliveries is not just reshaping the logistics and transportation sectors but also compelling advancements in UTM systems. These systems must evolve to accommodate the increasing complexity and volume of drone operations, ensuring safety, efficiency, and scalability in the new era of aerial delivery.



4 How will future industry challenges influence the UTM systems?

UTM systems are poised to encounter a spectrum of future challenges that will significantly shape their evolution. These challenges include the increasing level of autonomy in drone operations, the expansion of drone cargo operations, the emergence of electric Vertical Take-Off and Landing (eVTOL) vehicles, and the broader concepts of Advanced Air Mobility (AAM), Urban Air Mobility (UAM) or Innovative Air Mobility (IAM), as recently named by the EASA.

Each of these elements will contribute to a surge in unmanned operations, necessitating a significant boost in automation for strategic and tactical deconfliction. This involves enhancing communication between airspace users (manned and unmanned) and making airspace management more efficient to accommodate the diverse and increasing number of aerial vehicles.

One of the most significant future visions for UTM, as currently perceived by aviation experts, is the full integration of airspace and complete interoperability of UTM and ATM systems. This concept of common airspace is anticipated to materialize, particularly in areas where the paths of manned and unmanned aircraft intersect. Such areas include the vicinity of airports, emerging vertiports in urban environments, over densely populated cities, and specific operational zones like those near hospitals for Helicopter Emergency Medical Services (HEMS) and medical drone deliveries, to name a few representative examples.

This integrated approach to airspace and air traffic management implies a future where both unmanned and manned aircraft coexist seamlessly, sharing the same airspace with heightened safety and efficiency. The transition towards this integrated airspace will demand sophisticated UTM solutions capable of real-time data processing, advanced algorithms for conflict resolution, and robust communication networks to ensure continuous and reliable exchange of information among all airspace users.

Addressing these challenges requires a collaborative effort from industry stakeholders - regulatory bodies, airspace managers, and technology and service providers. It involves not only technological advancements but also regulatory and operational agility to adapt to the rapidly evolving dynamics of aerial mobility. The UTM systems of the future will need to be flexible, scalable, and adaptable, capable of managing a complex and diverse range of aerial activities while maintaining the highest standards of safety and efficiency.

As public acceptance is a pivotal factor in the development of the drone industry, building awareness and trust in drone solutions and AAM is essential. It's important for the general public to recognize the personal benefits these technologies can offer – from drone deliveries bringing goods right to their doorstep to potentially life-saving medical deliveries for their families, and the prospect of enhanced urban or regional mobility.

However, communication about these technologies must be balanced and honest. While highlighting the advantages, it is equally important to acknowledge the challenges, such as operational risks, noise pollution or potential privacy concerns. The public should be reassured that these challenges are being addressed by responsible entities, with a focus on minimizing risks to the lowest possible levels. UTM systems will play a critical role in this regard, offering robust solutions for safe and efficient airspace management.

Effective education and communication strategies are crucial in ensuring public understanding and acceptance. This involves not only promoting the benefits but also openly discussing the drawbacks and the measures in place to mitigate them. The goal is to foster a sense of security and trust in these technologies, ensuring that people feel protected and their concerns are taken seriously. Without positive public sentiment towards drones and AAM, widespread deployment could face significant obstacles, as public opinion often influences government and political decisions. Building a future with these technologies starts with well-designed and clearly communicated UTM blueprints that align with safety standards and public expectations.

Financial aspects of UTM and development cost analysis

The development of a UTM system entails substantial financial investment, particularly in the initial stages where significant upfront costs are incurred to establish the foundational services and essential system modules, with FIMS/CISP being a key example. This initial phase is crucial as it lays the groundwork for a functional UTM system capable of managing drone traffic effectively.

A critical aspect of UTM ecosystem development is the balance between public and private financing. Public subsidies are indispensable in the nascent stages of UTM development. The UTM systems represent fundamentally new infrastructure within the aviation sector. Traditionally, the creation and management of infrastructure fall within the jurisdiction of the state. It highlights the critical role of the government in fostering the development of such systems. Relying solely on ANSPs, which cannot fully fund UTM from navigation charges, to finance the foundations of these services could lead to creation of another monopoly and decelerating progress. To avoid such outcomes, strategic government investment is essential to lay the groundwork for a vibrant, competitive ecosystem.

However, a thorough business analysis is essential to ensure cost-effectiveness and financial viability. Cost awareness becomes a pivotal factor in the preparation of business and financial plans, ensuring that investments are made judiciously. Government funding can indeed catalyze the development of UTM infrastructure. Yet, for a sustainable and scalable UTM system, the integration of private investment and partnerships seems necessary. The collaboration between public entities and private investors can lead to more innovative and efficient UTM solutions.

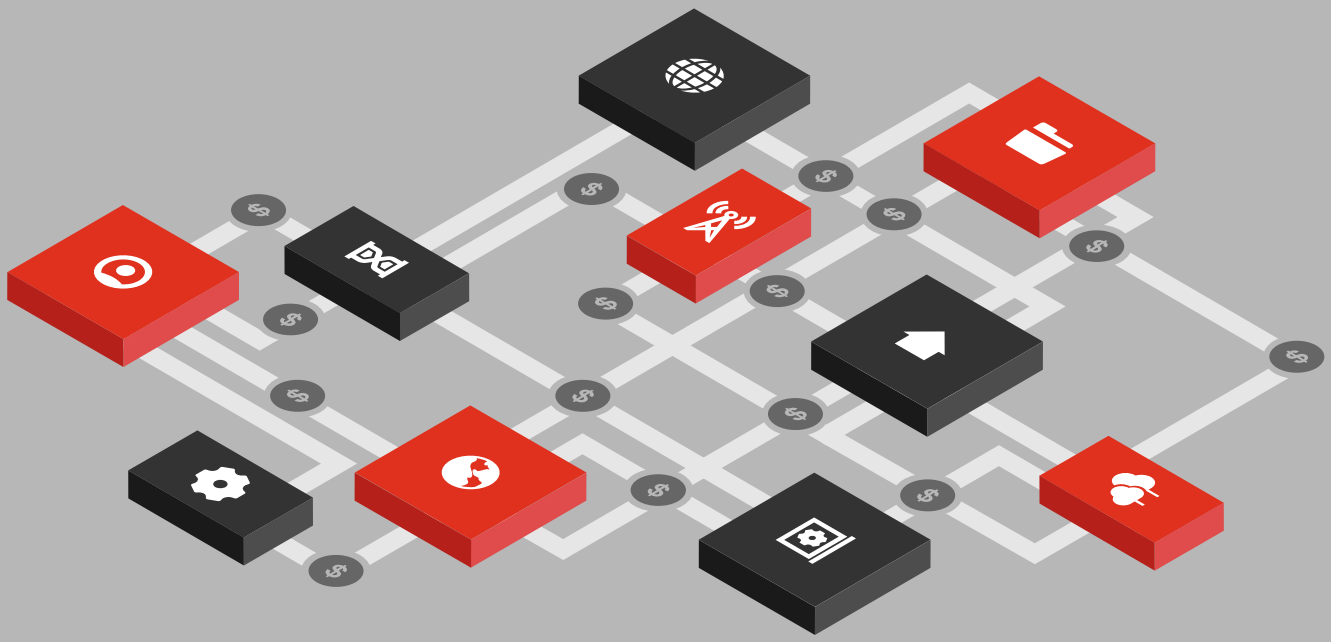
One strategy to optimize initial investments is the phased development of UTM systems. This approach entails allocating a limited portion of investment at the outset to develop and implement basic services, followed by a long-term strategy for subsequent developments and integrations. Staggering costs in this manner can aid in securing future funding, whether through public resources or public-private partnerships.

The analysis of initial investment and the projection of the breakeven point are critical components of this financial planning. This analysis must encompass the costs associated with technology development, system integration, and ongoing operational expenses. Understanding these costs and forecasting the time frame to achieve financial sustainability is fundamental to the long-term success of UTM systems.

In regions where private investment is limited, public financing is crucial, particularly in the early stages. This is even more pertinent in developing countries, where the establishment of basic UTM services and regulatory frameworks is necessary to introduce vital drone services like medical deliveries or humanitarian aid. In such scenarios, international development institutions may finance UTM development under specific funding programs or through alternative international financing partners.

Such overview of financial aspects underscores the complexity of UTM development, highlighting the need for strategic planning and a comprehensive understanding of both the initial and long-term financial implications. The ultimate goal is to create a UTM system that is not only technologically advanced but also financially sustainable and capable of adapting to the evolving needs of future integrated skies.

Money flow in UTM ecosystem



The success of the UTM hinges not only on its technological advancements but also on the sustainability of its business model and the effective flow of money within the ecosystem. Understanding where and how money circulates in the UTM ecosystem is crucial for its longevity and efficacy. Key aspects to be analyzed in the UTM ecosystem money flow are as follows:

Stakeholder Contributions and Benefits

It's essential to map out which stakeholder groups will pay for and benefit from specific actions and services. This involves identifying the stakeholders, their roles in the ecosystem, and how they contribute to or gain from the UTM.

Sources and Destinations of Money

The main financial channels in UTM, such as fees, subsidies, investments, or taxes, need to be quantified and understood. This includes analyzing service fees for airspace users, government subsidies for infrastructure development, private investments in UTM technology, and potential tax revenues.

Factors Affecting Money Flow

Several factors influence the financial dynamics in UTM, including pricing strategies, valuation of services, allocation methods, and regulatory frameworks. An open discussion and analysis of these factors are necessary to develop a robust financial model for UTM.

Cost Sharing and Pricing Analysis

Airspace users, like drone pilots and institutional operators, are expected to bear the costs of the UTM services they utilize. However, an analysis of pricing and cost structures is crucial. Overburdening airspace users with high costs could limit market growth, suggesting the need for a balanced cost-sharing approach, especially in the early stages of UTM development.

Revenue Streams and Commercialization

Identifying revenue streams in UTM is complex. While some are evident, like service fees, others are less obvious. Potential revenue streams could emerge from data commercialization, offering additional paid services.

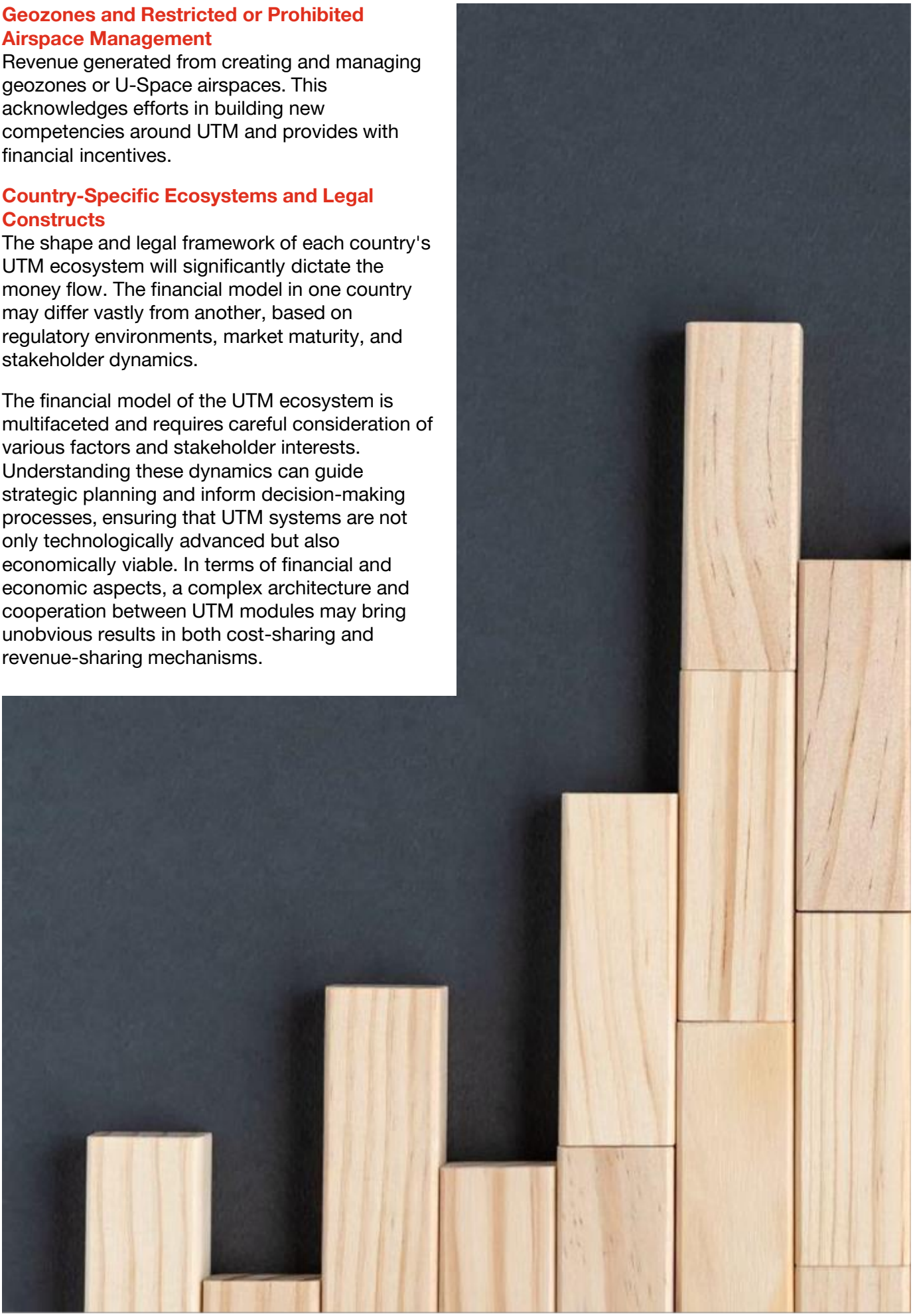
Geozones and Restricted or Prohibited Airspace Management

Revenue generated from creating and managing geozones or U-Space airspaces. This acknowledges efforts in building new competencies around UTM and provides with financial incentives.

Country-Specific Ecosystems and Legal Constructs

The shape and legal framework of each country's UTM ecosystem will significantly dictate the money flow. The financial model in one country may differ vastly from another, based on regulatory environments, market maturity, and stakeholder dynamics.

The financial model of the UTM ecosystem is multifaceted and requires careful consideration of various factors and stakeholder interests. Understanding these dynamics can guide strategic planning and inform decision-making processes, ensuring that UTM systems are not only technologically advanced but also economically viable. In terms of financial and economic aspects, a complex architecture and cooperation between UTM modules may bring unobvious results in both cost-sharing and revenue-sharing mechanisms.



Terms and Acronyms

Acronym	Full Term
AIS	Aeronautical Information Service
AAM	Advanced Air Mobility
ANSP	Air Navigation Service Provider
ASTM	American Society for Testing and Materials
ATM	Air Traffic Management
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
CAGR	Compound Annual Growth Rate
CANSO	Civil Air Navigation Services Organisation
CISP	Common Information Service Provider
CORUS	Concept of Operation for EuRopean UTM Systems
EASA	European Union Aviation Safety Agency
eVTOL	Electric Vertical Take-off and Landing
FAA	Federal Aviation Administration
FIMS	Flight Information Management System
HEMS	Helicopter Emergency Medical Services
ICAO	International Civil Aviation Organization
IAM	Innovative Air Mobility
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LAU	Local Administration Unit
PDRA	Predefined Risk Assessment
RID	Remote Identification
SDSP	Supplementary Data Service Provider
SESAR	Single European Sky ATM Research
SORA	Specific Operations Risk Assessment
STS	Standard Scenarios
UAM	Urban Air Mobility
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aircraft System
U-Space	(European Union framework for UTM)
USP	UTM Technology and Service Provider
USS	Unmanned Aircraft System Service
USSP	U-Space Service Provider
UTM	Unmanned Traffic Management

About PwC Drone Powered Solutions

PwC Drone Powered Solutions – Global Center of Excellence in Drone and Satellite Technologies is the pioneering consulting group dedicated exclusively to implementing drone and satellite technologies for commercial, international development, as well as security, defence and public safety applications.

Since 2015 we have delivered more than 150 projects on 6 continents gathering massive amounts of experience, building unique methodologies and technology solutions.

Being well recognized as global leaders in the drone and satellite industries, our team ensures:

- Strong experience in identifying and assessing disruptive and transformative growth areas, including what is needed to succeed
- Fresh perspective on drone and AAM market with our unique understanding of market needs, drivers and enablers, as well as view on potentials and barriers
- Global scale of presence and scope of activity to give strategic guidance in drone and AAM market with tailored business strategies

Areas of expertise

- Regulations & Strategies
- UTM / U-Space
- Drone Delivery
- Air Taxis
- Mapping & Inspections
- C-UAS & Defence, Security and Public Safety
- ESG & Drones for Good
- Satellites & Space

Client profiles

- National and Local Governments
- Public entities
- CAA, ANSP, Airlines and Airports
- Large Enterprises
- Private Sector Companies
- Defence and Law Enforcement
- Development Institutions
- NGOs

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