A joint collaboration in thought leadership

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AFRICAN INSTITUTE
for Entrepreneurship

SA INNOVATION SUMMIT

2022 South Africa UTM
The Future Drone Tech Evolution

A South African UTM Position Paper Perspective

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Messages from the thought leadership partners – AIfE and SAIS

This publication came about through collaboration and partnership between two associates in the thought leadership space: AIfE (the African Institute for Entrepreneurship) and SAIS (the South African Innovation Summit).

AIfE launched its inaugural publication, *2021/2022 Drone Industry in South Africa: The Potential of the Unmanned Aviation Industry*, at the 15th annual SAIS summit at the Mount Nelson Hotel in Cape Town, South Africa. The publication has been noted as one of the most comprehensive documents on the drone industry and its ecosystem on the African continent, and the launch initiated a collaboration discussion between the two organisations.

It was a great pleasure to share this ground-breaking publication at the 2022 SAIS annual event.

The SA Innovation Summit (SAIS) is Africa's largest tech innovation and start-up conference. SAIS believes that entrepreneurs with scalable business models build the African continent and exists to support these tech start-ups by working with development agencies as well as corporates to connect them to resources and opportunities.

According to Statista, African GDP per capita has been projected to be relatively stagnant in the last 10 years. After dropping 15% in 2020, compared to its high in 2012, it is only projected to climb another 15% by 2026. We believe that there are new and transformative technology verticals that pose a huge positive delta for African innovators, its economies, and people where there is a relatively level global playing field and shorter catch-up distance. The drone, and autonomous aerial industry is one of those. We partnered with AIfE to shed light on the ecosystem at the 15th annual SA Innovation Summit (SAIS 2022).

SAIS proactively seeks out collaborations, forming partnerships with organisations such as AIfE to leverage ecosystem strengths and amplify impact and scale. We look forward to seeing how collaborative publications in thought leadership will inspire tech entrepreneurs, investors, industry titans and the African innovation.

Buntu Majaja
CEO, SAIS

At AIfE, we are tremendously excited to launch the *2022 South Africa UTM – The Future Drone Tech Evolution* at the 2022 SAIS summit and to share the final publication. Following the launch of our inaugural publication in 2021, we recognised the need to create evidence-based research in new technology. With the speed of the tech evolution, finding appropriate information to make data-driven decisions remains a challenge for business decision makers, entrepreneurs and policy makers all over the world.

We would like to recognise the drone and aviation expert team members who came to this project and volunteered their time and expertise for this publication. At times, a difference is only made when those who are in the industry see its potential and come together. In new technology, when the combined power of industry experts, government, policy makers and others work together for industries to grow, the evolution of new technology can be harnessed to develop the South African economy, create jobs, businesses and new opportunities for future generations.

We welcome all to read this position paper and begin the dialogue that will take the drone industry forward. This industry is rapidly digitising the aviation world to the next level – UTM – towards the realisation of the future drone tech evolution.

Tamiko Sher
Executive Director, AIFE

Contents

Watch our short drone video

This team supports the following UN-SDGs

01

Background, objectives and scope

Background

At the 2021 South African Innovation Summit (SAIS), AfFE (the African Institute for Entrepreneurship) launched its inaugural publication, *2021/2022 Drone Industry in South Africa: The Potential of the Unmanned Aviation Industry*. Since that time, the AfFE and SAIS have engaged in various discussions in the thought leadership space.

Thought leadership can take many forms – it can happen through discussions, webinars, workshops, publications, essays, blogs, podcasts, speaking engagements and critical social media posts. What is crucial is that the engagement, whatever form it takes, leads to shifts in thinking, policy, strategy and eventually actions. This collaboration, and subsequent position paper, seeks to stimulate dialogue towards harnessing the power of the next level of the future drone tech evolution.

The key concept is understanding what is next for UTM in South Africa – and what this means to the aviation, entrepreneur and tech community.

Objective

To deliver a position paper on the RPAS or drone UTM potential in South Africa that highlights key enablers and barriers for the industry, and indicates opportunities for aviation, entrepreneurs and the tech industry in the country.

Scope

This publication is a collaboration between AfFE and SAIS, with a team of private and public sector aviation and drone experts, that seeks to develop a high-level UTM position paper highlighting the latest developments in UTM as well as opportunities for aviation, entrepreneurs and the tech industry in South Africa.

The publication is the culmination of several months of desktop research and interviews with key stakeholders in the drone and UTM space, and was developed from July to November, with the concept presented at the 2022 Annual South Africa Innovation Summit at the Old Biscuit Mill in Cape Town, South Africa.

About the contributors

The 2022 UTM Position Paper Working Committee and team of authors consists of 10 individuals, led by Tamiko Sher from AfFE, and includes Caine Mainganya, Christo Craill, Dean Condé, Dean Polley, Jimmy Ricaut, Keith Maleho, Kim James, Louise Jupp, Sharlin Perumal and Sam Twala.

Each individual gave time in their private capacity to support this initiative, offered desktop research, introductions to interview candidates, and provided their own expertise and input to the final document. This collaboration is exemplary of what is needed to take the drone tech industry forward, to stimulate dialogue, foster ecosystems, and create opportunities, new jobs and businesses that will contribute to South Africa's economic growth.

The UTM Working Group (UTM-WG) seeks to be gender-neutral. The current terminology in aviation uses 'manned' for piloted aircraft and 'unmanned' for drones. This publication uses gender-neutral terminology; respectively 'crewed' and 'uncrewed'.

For more definitions and acronyms, see the glossary on page 48-49.

02

Introduction – what UTM means to the drone industry

One day, we could arrive at an international airport, be collected by an uncrewed air taxi and taken through the skies to our hotel.

Drones will deliver medical supplies and blood to hospitals and rural areas. People will order food and receive deliveries by drone. Farmers will use drones to survey their crops and ensure they are maximising their land for better environmental protection. Conservation activities will be conducted via drone, people will be saved during humanitarian crises or when lost, and police surveillance and crime prevention will be done by drone.

While this may seem futuristic, this will be happening in China, Australia and specific countries in Europe in the next few years. What will it take to make this vision a reality?

Uncrewed aircraft traffic management systems, or UTM, also known as 'U-Space' in the European Union (EU), or UAS, uncrewed aircraft systems are a key ingredient to what is needed to grow the drone industry in South Africa.

What is a UTM system?

A UTM system is a digitally integrated environment with a set of regulatory, operational and technological tools used to coordinate the integration of both manned and unmanned air traffic in the same airspace in the most automated and safe way possible.

Source: Implementing Regulation 2021/664 on the U-Space Regulatory Framework (10 May 2021) sUAS News - The Business of Drones.

The drone industry is the digital disruptor of the aviation industry. Aviation has existed since the Wright Brothers launched the infamous Kitty Hawk on 17 December 1903. According to the International Air Transport Association (IATA) as of 20 June 2022, aviation is a well-established, powerful industry with revenues expected to reach US$782 billion and double the 3.5 billion scheduled passenger numbers of 2019, with thousands of aircraft in the skies by 2030.

How could something as small as a drone, which could fit into someone's hand, possibly disrupt such a powerful industry as aviation?

The quandary lies in the fact that the airspace occupied by the traditional aviation industry needs to be shared by the up-and-coming drone industry, and the management of that airspace is a key factor in the future development of this industry. Crucial to its development is the strategic application and understanding of how the technology, the industry and its ecosystem will evolve and grow into the future. How do we imagine air taxis integrating with crewed jets and aviation? How do we balance the needs of the existing aviation industry with those of the emerging innovators?

A different approach is critical going forward. In recent years, an unimagined level of digisation has been achieved, accelerated by the impact of COVID-19. This kind of accelerated digisation can, in the future, be expected in aviation.

> "An industry like drones is so innovative and has so much potential in terms of technology, you cannot regulate that with old-fashioned rules."
>
> **Tom Verbruggen, Co-founder and CEO of Aviatize, Belgium**

What the drone industry is doing is shaking up how an industry evolves – which is as much technology-led as taking into account the regulatory environment, the established ways of thinking about and approaching industry development.

Drones are forcing the aviation industry – known for its adherence to standard operating procedures, rules, safety regulations and strict compliance elements – to re-examine the digitisation of aviation.

Imagine a mega-liner taking off at South Africa's largest airport, OR Tambo International Airport. As Craig Poultney, a Tower Controller, says, "We can't have a situation where we say, 'Turn to your right, but watch out for that drone.'" Poultney continues, "I think one of our biggest challenges is the fact that [the drone industry] is growing so fast."

Drones are here to stay and how they integrate into the airspace – safely, securely and effectively – will be decisive going forward.

An important consideration in the integration of drones into crewed airspaces, regulated and unregulated, is the framework against which this development needs to take place.

According to www.globenewswire.com, on 15 August 2022, the global market for UTM is estimated at

US$791.2 MILLION IN 2022 AND IS PROJECTED TO GROW TO US$1.6 BILLION BY 2026.

An exciting opportunity exists to build a new industry in South Africa – one that can create new businesses, revitalise the aviation industry, and create jobs and opportunities for entrepreneurs to develop new solutions in this tech space. Managing this space will require sophisticated interventions – in terms of the strategic alignment of the airspace, both on the ground and in the air, as well as in the drones themselves and the ancillary systems to support the integration of commercial, regular and automated BVLOS operations.

New UTM software developments offer a multitude of opportunities for software developers to create platforms to support multiple systems that can perform a variety of tasks for both crewed and uncrewed traffic, real-time tracking of drones flying in the air, new ways to illustrate different types of airspace that allow for pilots, drone flight managers and others to better manage the aircraft in this airspace.

Taking advantage of these opportunities and building an integrated aviation landscape in South Africa means understanding the UTM landscape and ecosystem, which are imperative next steps in developing the potential of the drone industry.

03

About the UTM landscape in South Africa

The UTM landscape begins first in the aviation space. Aviation being a highly technical, legislative and complex industry, when it comes to UTM the aviation challenges are the most critical element to address. Safety and security are tantamount in this industry – the risk of drones running into jets is real, and the ability to safely manage the airspace in which both will operate is important.

Following are the aviation challenges that are of interest in South Africa, the first being the monitoring and management of Remote Piloted Aircraft Systems (RPAS), and the second being the deployment of an enabling Uncrewed Traffic Management System, otherwise known as a UTM, in South Africa's airspace.

Monitoring and management of Remotely Piloted Aircraft Systems (RPAS)

The major challenge for the South African Civil Aviation Authority (SACAA) is that UAS/RPAS flown in the South African airspace are not all registered to their owners.

When an RPAS is involved in an incident, it becomes impossible for the regulator to identify, monitor and record the incident, as most of these aircraft are not equipped with electronics, such as transponders, which can track them and provide their locations.

Most RPAS are a challenge to detect using the conventional primary surveillance radar systems, and this difficulty poses a colossal flight safety risk.

From the air traffic controller (ATC) viewpoint, the most significant problem is the collision of RPAS devices with each other and with other crewed aircraft.

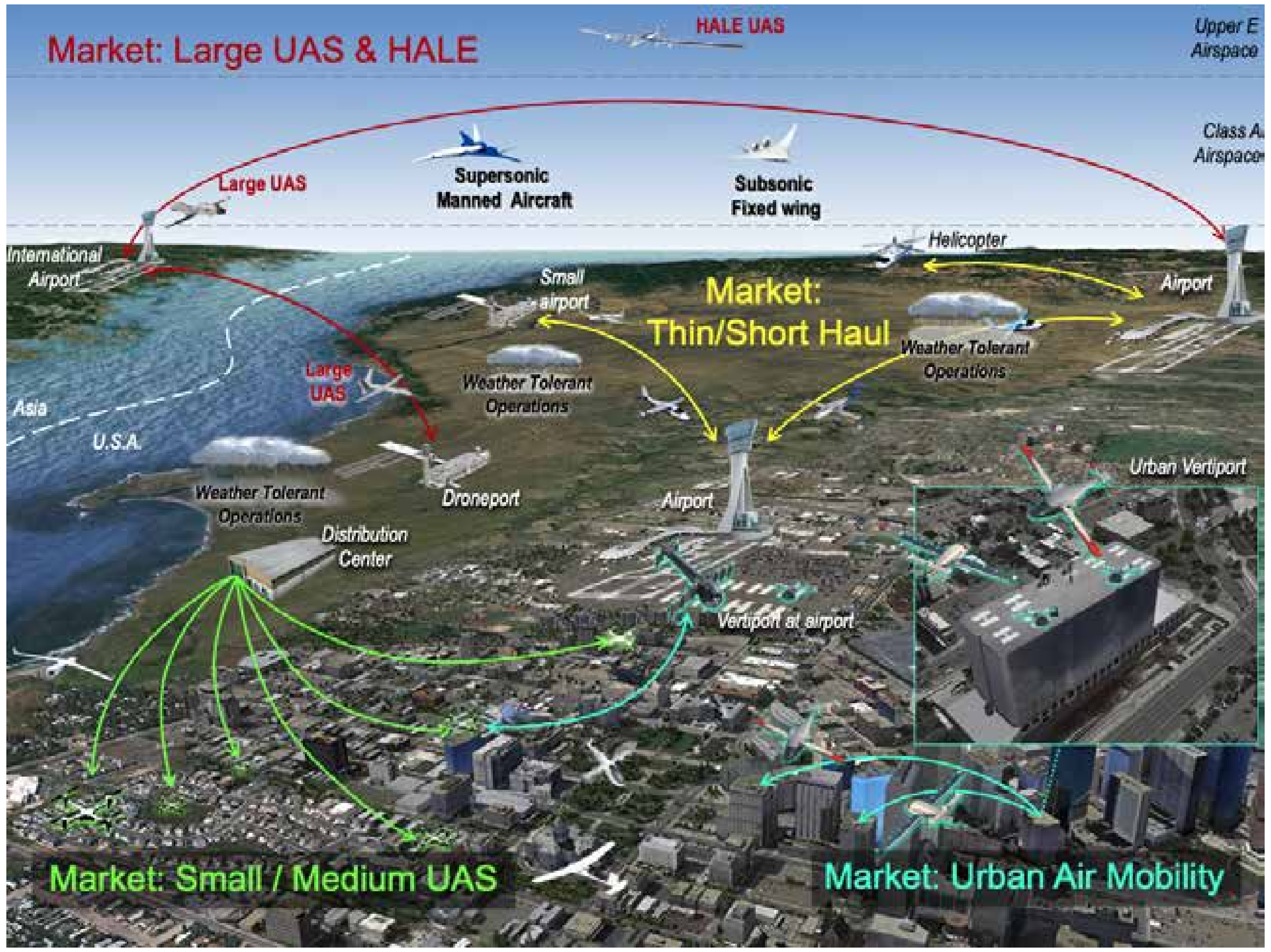
This is mainly an aviation safety risk because the speed at which these aircrafts fly is very high, and this in addition to the weight plus payload of aircrafts results in a significant threat. The mitigation of this would be to harmonise air traffic management (ATM) operations of both crewed and uncrewed aircraft.

What is required is a system that will ensure that RPAS/UAS and regular aviation are monitored and guided at all times to adhere to regulations set by the SACAA.

To achieve this, a new segment – uncrewed air traffic management (UTM) – is emerging within the airspace management industry. UTM is similar to the currently existing ATM, and it covers several areas connected to aviation airspace users, offering standard ATM services alongside UAS services related to airspace management and, flight planning.

With the increase in the number of RPAS, a highly heterogeneous community is emerging, which includes users that range from hobby operators to professionals. As Sandor has pointed out, in an article dealing with the challenges posed by integrating uncrewed aircraft into air traffic management, a UTM system should be prepared to cater for this diverse user community, accommodating low- to high-risk instrument devices, and everything in between.

The figure below serves as an example and illustration from the United States of how an approach to integration of uncrewed aircraft into the airspace might look.



Source: Gipson, L. (2020) UTM 101, NASA. Available at: http://www.nasa.gov/aeroresearch/utm-101

Deployment of an enabling system in South Africa's airspace

Forward-thinking and planning will allow South Africa's aviation industry to be diverse by eventually integrating RPAS into mainstream aviation, moving away from the concept of UTM in opposition to, or separate from, ATM.

With the evident growth rate of RPAS in the world, it is foreseeable that the UTM vs ATM concept would limit and stifle RPAS capabilities and South Africa's economic prospect. Hence, integration of RPAS into mainstream aviation is necessary, without compromising safety and security.

RPAS would be treated like any other aircraft in aviation once integration into ATM has taken place, and the SACAA automation will help a great deal, adding impetus in achieving this end goal. Inter-operability between the SACAA automation and ATC systems is of paramount importance.

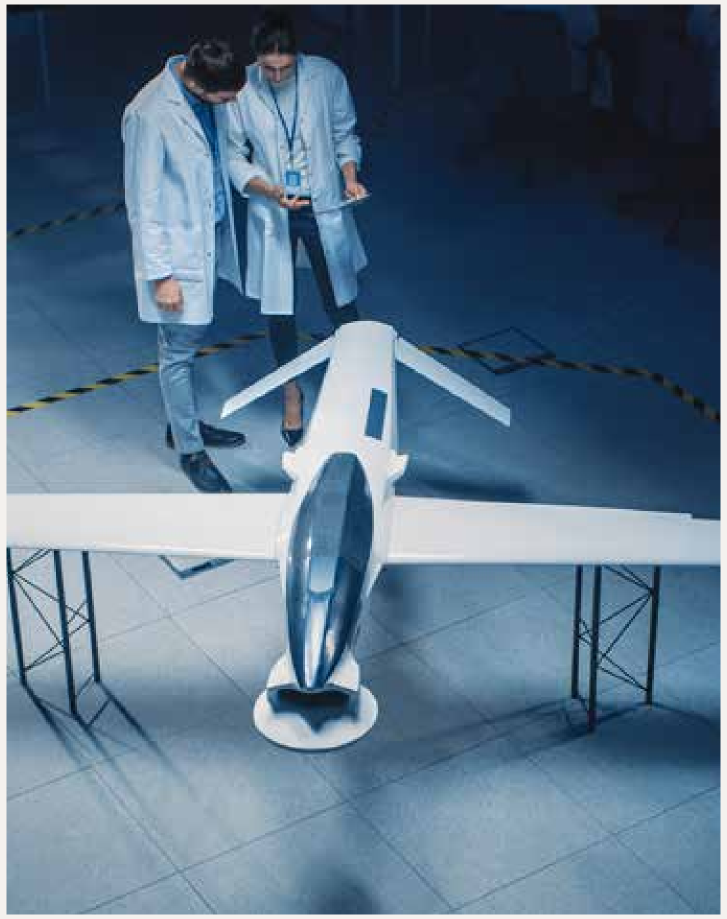
> "UTM comprises not just the unmanned traffic market. One could almost argue that UTM is going to be merged within the ATM, so we talk about "U" standing for "Unified" traffic management. That is going to happen eventually."
>
> **Simon Johnson, acting Secretary General of the Global UTM Association (GUTMA)**

The following serve as guidelines for such an integration to occur:

1. UTM must be able to accommodate the diversity of air traffic and be flexible enough to adapt to the growing number of airspace users
2. Design of the UTM must follow the state's aviation regulations
3. UTM must safeguard the Republic's sovereignty
4. Privacy and safety of the citizens must be guaranteed
5. Innovation and technology should be encouraged when building and developing a UTM

In the South African context UTM can provide the following usages:

- Tracking and monitoring of uncrewed operations;
- Provide real time data to aviation, security and safety clusters, and other key stakeholders;
- Flexible Use of Airspace (FUA) authorisation automation capabilities;
- Ensure Civil Aviation Regulations compliance and adherence;
- Provide a safe and secure platform for wider uncrewed operations, such as drone deliveries, air taxis, medical supply transportation, and other applications; and
- Integrate aviation systems – Air Traffic Navigation Services (ATNS), Airports Company South Africa (ACSA), SACAA, Department of Defence (DoD) and the South African Police Service (SAPS) – enabling a smoother and harmonious transition of uncrewed integration into crewed/ conventional operations.



While the success of UTM and the drone industry lies within the aviation industry, the stakeholders reach far beyond aviation.

In the following section the current management of airspace, and the implications of UTM for the management of airspace are explored.

04

Understanding the airspace implications

There is no greater challenge to the development of UTM and the drone industry than the management of the airspace. Traditionally in aviation, strict protocols exist around the management and monitoring of airspace. This is an established part of the aviation world that is well-understood by those within the industry.

When drones and UTM are introduced, the conventional control of airspace is turned on its head. How does the industry safely and securely monitor both crewed and uncrewed vehicles in the same space?

It can take commercial pilots years to fully understand the implications of managed airspace, classifications, aerodrome, terminal, en route and uncontrolled flight information service (FIS) airspace and corridors. How can those who might be flying a drone for pleasure purposes understand the intricacies of this tightly managed space?

Questions that arise include how UTM and airspace might work together, and what this could look like in the future. What are the barriers and enablers on an operational basis and how can they be addressed? How will spectrum influence these issues?

How the airspace is currently managed

The National Airspace Master Plan (NAMP) is compiled in accordance with the National Civil Aviation Policy, as amended, which mandates the construction of the NAMP through the National Airspace Committee (NASCOM). The Civil Aviation Regulations (CARS) provide the regulatory framework for NASCOM, as well as the designation and classification of the various types of airspace.

NASCOM has a number of stakeholders (Department of Transport (DoT), South African Civil Aviation Authority (SACAA), Air Traffic Navigation Services (ATNS), Airports Company South Africa (ACSA), airlines, the South African Weather Service (SAWS), aviation bodies and the public) and is concerned primarily with safety and security. It is also the platform where airspace changes and enhancements are proposed.

The national airspace is a resource that the air traffic management (ATM) system is responsible for managing within its borders. The flexible distribution and use of airspace based on the principles of access and equity is the responsibility of the ATM service provider, in collaboration with the South African National Defence Force (SANDF).

All present and possible future uses of airspace need to be taken into account while organising and managing the airspace.

Airspace classifications

Controlled Airspace aircraft operating in these airspaces are provided with full air traffic control service in accordance with airspace classification.

The two types of Uncontrolled Airspace in the national airspace are Advisory Airspace and Information Airspace. In Advisory Airspace, all participating Instrument Flight Rules (IFR) flights receive an air traffic advisory service and all flights receive flight information service if requested. In Information Airspace, air traffic control service is not provided, as only the provision of information useful to the safe and efficient conduct of flights is necessary.

The following are the different types of classes of airspaces recognised internationally:

International Airspace Classifications	
Class A	All controlled airspace FL200 and above, prohibited for Visual Flight Rules (VFR) flights
Class B	All controlled airspace below FL200. In case of a CTR.
Class C	All controlled airspace below FL200. In case of an ATZ, aerodrome separation will be applied
Class D	All controlled airspace below FL200. In case of an ATZ.
Class E	Not in use in South Africa
Class F	All advisory airspace
Class G	All information airspace

The provision of standard vertical (1000 feet) or horizontal (5 NM) separation shall be provided in the above classes of airspace between Instrument Flight Rules (IFR) and Visual Flight Rules (VFR), unless otherwise specified, in the following manner:

Classes of Airspace between Instrument Flight Rules and Visual Flight Rules

- All flights in Class A and B airspace
- IFR flights in Class C, D and E airspace
- IFR flights and VFR flights in Class C airspace
- IFR flights and special VFR flights in Class C airspace
- Special VFR flights in Class C airspace
- IFR flights in Class F as far as Practical
- IFR flights in Class A and C airspace and known IFR flights operating up to 10 NM outside of the boundaries of such airspace

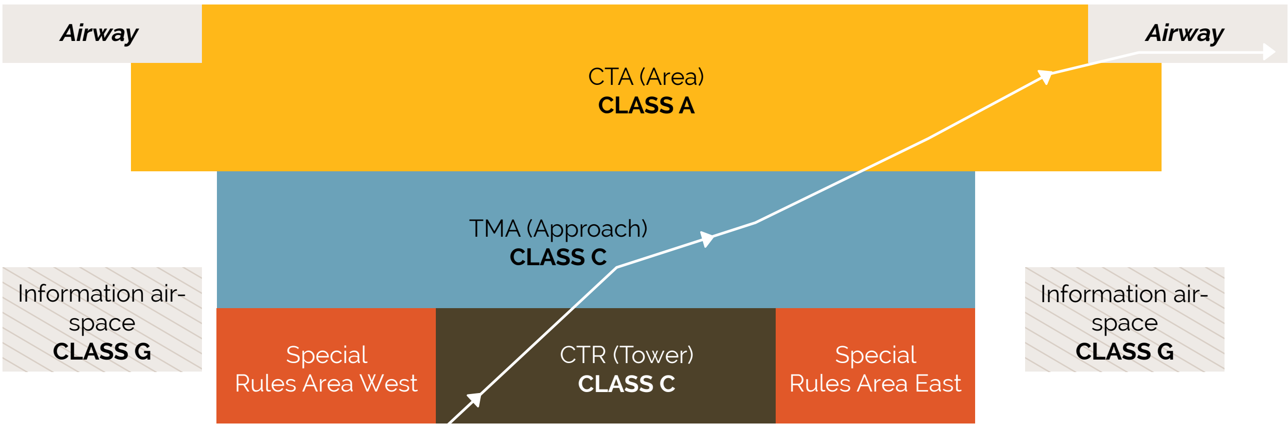
As much as these airspace classes were created for crewed aviation, they can equally accommodate uncrewed aviation, and this has been proven through accommodation that the FUA process provides.

South African airspace classes

South Africa's airspace classes, have the following types associated with them:

Aerodrome Traffic Zone (ATZ)	This airspace is associated with classes B, C, D or E. This airspace is generally from ground to 2000 feet above ground level (AGL). This airspace provides aerodromes services. It accommodates IFR and VFR, separated according to the class type.
Control Zone (CTR)	This airspace is associated with classes B, C, D or E. This airspace is generally from ground and can go higher than 2000 feet AGL. This airspace provides aerodromes services, and usually has terminal and en route services above it. It accommodates IFR and VFR, separated according to the class type.
Terminal Control Area (TMA)	This airspace is associated with classes B or C. This airspace generally starts from the CTR upper limits to Flight Level (FL) 150. This airspace provides approach control services, and has en route services above it. It accommodates IFR and VFR, separated according to the class type.
Control Area (CTA)	This airspace is associated with classes B, C, D or E. However, no VFR flights are permitted above FL195. This airspace is above the TMA upper limits, with an upper limit of FL410. This airspace provides area control services, and accommodates Reduced Vertical Separation Minima (RVSM) airspace, between FL290 and FL410. It accommodates IFR and VFR, separated according to the class type.
Air Traffic Service (ATS)	Routes are associated with airspace classes B, C, D or E, and no VFR flights are permitted above FL195.
Oceanic airspace	Is only associated with class A, which only accommodates IFR above FL245.
Uncontrolled airspace	Consists of advisory airspace, which is class F, and information airspace, which is class G. This is typically where UTM can be tested for integration.

The following graphic illustrates the different airspace classes in South Africa.



Source: Webmaster, X.Z. '2.3 Classification of Airspace', IVAO XZ - Southern Africa MCD. Available at: https://xz.ivao.aero/aviation-handbook/2-general/2-3-classification-of-airspace/

Challenges in the South African context

The current airspace and ATM system makes no provision for uncrewed aviation. Only accommodation currently exists, with no integration into the ATM system. Uncrewed aviation is currently accommodated in the national airspace through SA-CAR Part 101. At present, no published procedures exist on the separation of crewed aviation from uncrewed aviation.

Another challenge seems to reside in the understanding and definition of UTM throughout the world, to a point that the International Civil Aviation Organisation (ICAO), a United Nations (UN) aviation body, still has no official definition for UTM. ICAO leaves it to individual signatory states to define UTM, indicating that UTM is a domestic product.

Education and training around UTM needs to be spearheaded by all aviation agencies (ACSA, ATNS SACAA and the DoT in order to sensitise the public to this aviation innovation, which has the potential to unlock a whole new economic landscape, not only within aviation, but also for many other sectors within the economy.

UTM is yet to establish a funding model, unlike the ATM system for which the users, being airlines, are funding the system, its improvements and advancements.

The introduction of UTM is likely to pose a challenge to these ATM system funders, as the monopolistic market share may be skewed with new players introduced to propel UTM forward.

UTM and ATM

UTM has no official meaning, but several countries are describing the airspace up to 400 feet as UTM, where uncrewed activities and operations can take place. Therefore, UTM is state- or country-specific, and South Africa can define UTM in whichever way best defines uncrewed operations within the country. It is envisioned as a system that is similar to an ATM system, but accommodates uncrewed operations.

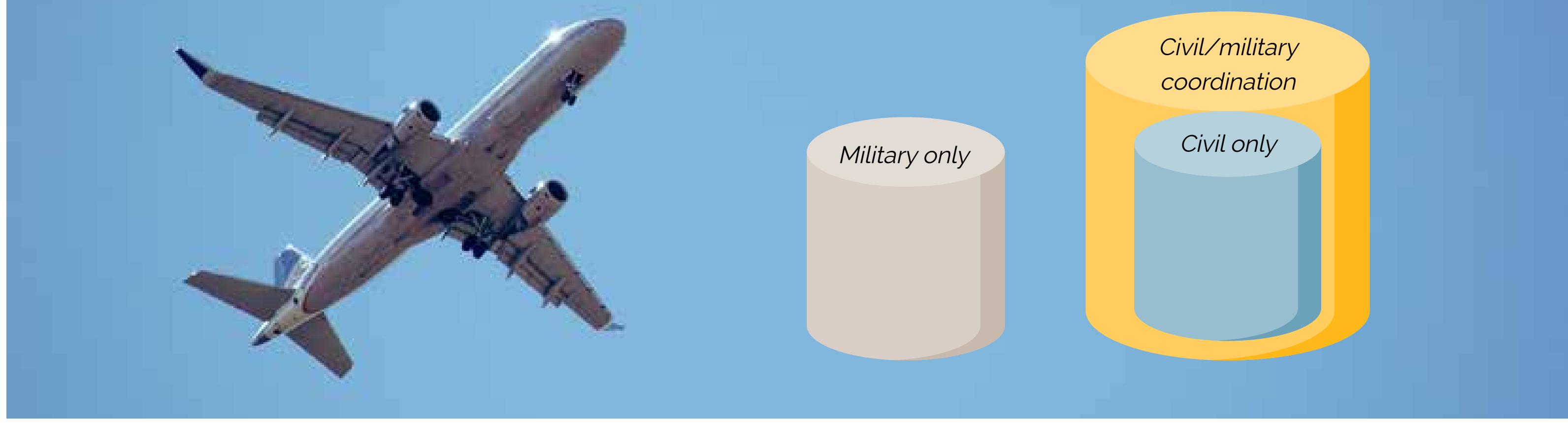
ICAO defines air traffic management as the dynamic, integrated management of air traffic and airspace — safely, economically and efficiently — through the provision of facilities and seamless services in collaboration with all parties.

The ATM is operated by a system that provides air traffic management through the collaborative integration of various elements, including people, information, technology, facilities and services, which are supported by both ground and air/space-based communications, navigation and surveillance.

Currently the ATM system accommodates conventional crewed aviation activities, including other aviation activities, such as paragliding and para-jumping, through Flexible Use of Airspace (FUA).

Flexible Use of Airspace

Flexible use of airspace (FUA) is an airspace management concept based on the principle that airspace should not be designated as purely civil or military, but rather as a continuum in which all user requirements are accommodated to the greatest possible extent.



Source: Mohammed, R. (2016) 'Flexible Use of Airspace'.

Through FUA uncrewed aviation can be accommodated and integrated into the airspace. However, lessons need to be drawn before any integration takes place.

A UTM, however it is defined in South Africa, will enable lessons to be gained as it can be used as a test bed, where corridors, uncrewed routes and slot times are introduced, as well as any other innovation and technology around uncrewed aviation. UTM will be used as a trial, and therefore it will be possible to draw conclusions on how uncrewed technology works and behaves, enabling the setting of standards, and the creation of a necessary regulatory framework.

This approach must be a multi-stakeholder approach, steered and mandated by the highest responsible office in the nation. The experience gained from this approach has the capacity to teach us how uncrewed aviation functions in confined airspace, alongside all other related innovations tested and trialled.

Once the implications of UTM are understood, and authorities have developed the necessary standards and regulatory framework, UTM can safely integrate into the ATM system. Eventually, South Africa will have an airspace with an ATM system that encompasses any aviation activity, be it crewed or uncrewed, as well as unforeseen aviation innovation.

Going forward – a need for a flexible mindset

For any advancement to occur in airspace and aviation, the industry must adopt a flexible mindset. In South Africa, flexibility of that degree already exists through Flexible Use of Airspace (FUA).

FUA in simple terms denotes that if there are no existing activities in any given airspace, that airspace can be utilised for any other aviation activities, such as recreational aviation activities. This is where uncrewed activities can be accommodated with rigorous testing and acceptance from interested and affected stakeholders.

An example of how this can play out in any airspace is for the aviation and security cluster, including the business sector, to co-operate and form private-public partnerships. In this case, air routes and flight procedures are designed to assist in specifying altitudes to fly and times to fly, noting the best periods through the Central Airspace Management Unit that co-ordinates FUA. Compliance to given conditions would need to be strictly observed in order to gain industry trust and advance it further.

A key element in the future will be the influence of spectrum in airspace. The following section reviews how the development of spectrum in the South Africa n context will influence UTM in the future.

05

Drones, UTM and spectrum

Spectrum will be a critical element for the development of the drone industry in the future. By providing positioning through various satellite-based systems, such as Galileo, GLONASS, and GPS, it contributes to sense and avoid capability, vehicle control and traffic management.

What is spectrum?

Spectrum refers to the invisible radio frequencies that wireless signals travel over. The radio spectrum is part of the electromagnetic spectrum, with frequencies between 0 Hz and 3 000 GHz. Electromagnetic waves in this frequency range are called radio waves and are widely used in modern technology, particularly in telecommunications. It is a fixed resource which is highly in demand for today's technology needs. Without spectrum, individuals cannot make cell phone calls, visit social media on their devices or use GPS services.

Source: 'Radio spectrum' (2022) Wikipedia. Available at: https://en.wikipedia.org/w/index.php?title=Radio_spectrum&oldid=1114271462

Currently there is a shortage of and limitations on spectrum in South Africa, in particular, spectrum for mobile services. To handle capacity constraints, telecommunication companies must deploy and densify networks, which is a capital-intensive exercise. The Department of Communication and Digital Technologies (DCDT) can only license spectrum to 400 ECNS and ECS licence holders. This controls which companies have access to spectrum, making it highly competitive.

Access to spectrum for drones will be critical to their usage and development. Drones are driving the adoption of digital technologies, and sense and avoid capability, alongside areas such as electronic conspicuity (to be described in Section 7), will ensure the ability of drones to operate in the airspace together with manned aviation.

When spectrum is licensed to ensure widespread, high-quality connectivity, this enables drones to have sufficient capacity to support competitive services and rising usage levels. Ultimately, drones are a digital tool in the sky, and their ability to harness data is the area in which they offer the greatest value.

In aviation, the field of communication is a highly regulated, well-evolved industry with specific rules of engagement to ensure the safety of aircraft and their passengers, which is essential to the industry. In South Africa, spectrum will be the radio term for the connection between the operator – potentially an individual managing a control station of drones – and the overall UTM system or chain of communication.

The South African Civil Aviation Authority (SACAA) has engaged a frequency spectrum management specialist, Thomas Matabane, who will be managing spectrum relating to UTM in the future, and whose role will be critically important for drones. His job is to "ensure there is availability of a bank that is specifically being utilised by the function of unmanned aviation systems (UAS). Usually, we take those recommendations from the international organisations, such as the International Telecommunication Union (ITU) and the International Civil Aviation Organisation (ICAO), and [take these] recommendations to the national framework through the DCDT and the Independent Communications Authority of South Africa (ICASA)."

This, in turn, becomes one of the most significant elements of the ecosystem of UTM.

The adoption of spectrum is normally done via international recommended practice. In the United Kingdom, as indicated in Section 4 on international drone systems, aerial super highways such as Project Skyway are being developed as a collaboration between the government and the private sector, which is important for the future development of UTM.

> Matabane sees the future of UTM being driven by a proactive government and business sector collaborating with each other, ensuring that the spectrum is being utilised to its greatest capability.

He says, "Currently there are studies underway, and there are a number of deliberations on the frequency that perhaps we can use…Within that whole spectrum, we have the traditionally identified bands of aviation. So when you find that there is functionality within certain bands, say the ILSs are in place in the 900s to 1.2 MHz, why can't we use that functionality since it's within a vision of how critical the spectrum is?"

A key element of spectrum within UTM is that it cannot be a standalone system – it must be integrated with air traffic management (ATM). Systems such as Automatic Dependent Surveillance Broadcast (ADS-B) and remote ID will become increasingly important.

ADS-B is a surveillance technology and form of electronic conspicuity which tracks an aircraft or vehicle via satellite or other sensors and broadcasts its position, which will be essential to determine drone positioning, thereby ensuring that the skies between crewed and uncrewed aviation remain safe.

The greater need for relevant equipment also means a need for the skills to support it. "Software developers are one of the key skills," says Matabane. "We don't have enough of these skills in the country, or we cannot sustain them, because the whole world is looking for them."

The technology and the skills to support this new world are key. In the following sections, this paper explores UTM development around the world, the evolution of drones, and the technical implications of these upcoming changes.

06

UTM Evolution around the world

"The integration of drones in the airspace is one of the most revolutionary events for air traffic management since the beginning of its implementation."

Single European Sky Air Traffic Management Research Joint Undertaking (SESAR-JU)

The short history of UTM has already seen exponential acceleration, and many players have joined the race to capture the value of the sky above us, democratising the airspace for drones and making it available to the masses. Registering an average compound annual growth rate (CAGR) of 12%, which is expected to double within the next few years, increased research and development activities, technological development, and rapid adoption by key players globally is the result of producing reliable, precise, and efficient UTM initiatives.

Based on Unmanned Aviation's Global UTM Readiness Index, the following countries were featured in their top 20 list, on the basis of having made the most progress in UTM systems (in order of rank): Switzerland, Belgium, Canada, Poland, Croatia, Australia, Austria, Israel, Germany, Norway, Dubai, Denmark, Finland, Spain, India, Japan, Singapore, USA, Netherlands and France, Italy and Ireland in joint 20th position.

Source: UTM Global Readiness Guide, Unmanned Airspace's Market for UAV Traffic Management Services, edition 5.1. (2022). Available at: https://www.unmannedairspace.info/uav-traffic-management-services/

This chapter provides a snapshot of the evolution of UTM outside South Africa, comprising a review of the policy and regulatory frameworks that provide the foundations for future undertakings by public and private organisations that will be involved in researching, designing, operating and managing the integration of uncrewed aircraft into both society and the surrounding airspace. A special focus on approaches developed in Australia, the European Union (EU), the United Kingdom (UK) and the United States of America (USA) gives insight into how this has been done elsewhere in the world, including reference to recent key activities being undertaken to experiment with and implement viable UTM systems at national or regional levels.

Varying rates of adoption and development

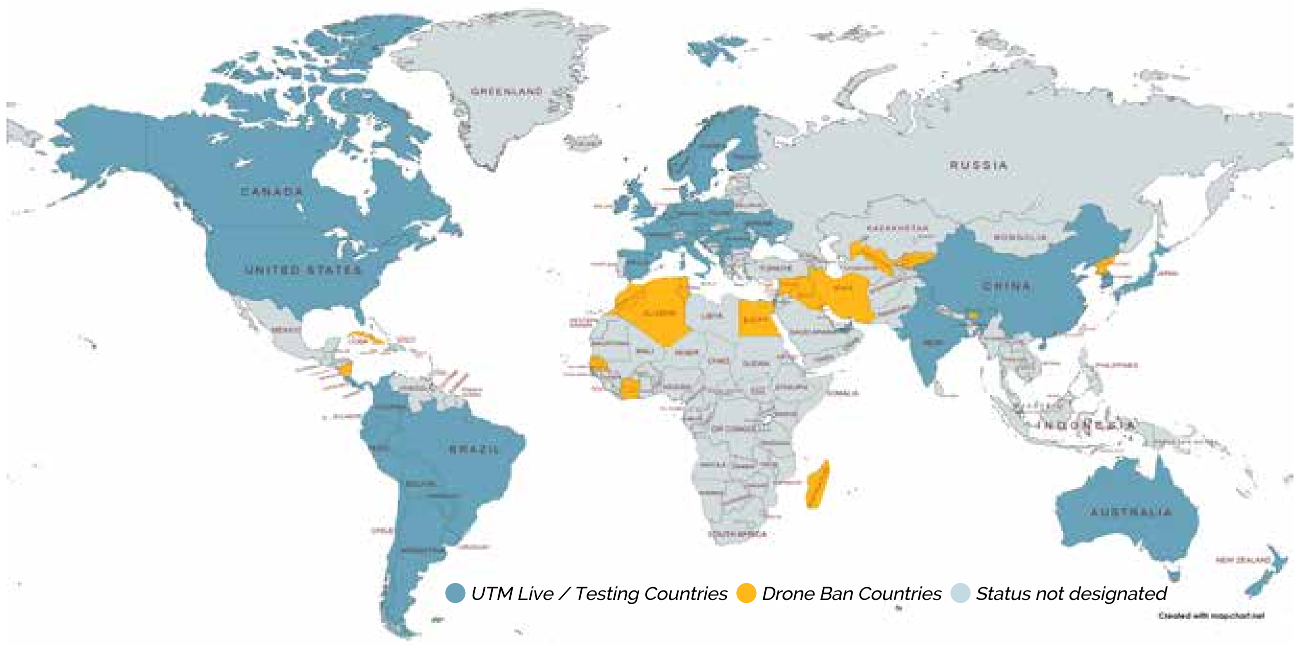
The explosion of drone applications and ease of access to drone technology is driving the demand for future delivery mechanisms. Current approaches to UTM in various countries around the world vary considerably. The development of UTM and emerging aviation technologies is underpinned by policy and regulatory frameworks in individual countries, and the levels and timeframes in which these are being developed across the globe are diverse.

Some countries are already finding ways to manage uncrewed aircraft based on industry standards and services, while the approach in other regions is based on more traditional models of government regulation and centralised service delivery.

While some countries have already published detailed concepts of operations for proposed systems related to UTM, other countries, particularly developing countries such as South Africa, lag behind, with legislation, policy and enforcement often hindering the growth rate substantially.

The following map provides a snapshot of Countries that have implemented UTM testing.

2022 Global Perspective: Countries that have implemented UTM



Source: Dean Condé, UTM-WG member

First World countries are at the forefront of UTM development, enabling them to accelerate their economies to new heights, cement their supply chains and ultimately meet human transport needs way into the future. Switzerland is currently the most advanced in terms of UTM worldwide, according to the new UTM Global Readiness Guide, a new feature in the June 2022 edition of *Unmanned Airspace's Market for UAV Traffic Management Services*, edition 5.1.

In Africa, Kenya has been the first country to express interest in implementing a UTM system for the Kenya Civil Aviation Authority through a public tender process. In other countries, as seen in the map, drones are not being used, or are banned altogether.

In these early stages of the development of the sector globally, there is no clear consensus on international best practice. However, what has emerged in countries where UTM systems are further ahead, relationships between regulators, research agencies, operators, UTM system suppliers, and other drone ecosystem stakeholders are open and collaborative.

On the other hand, where divisions exist between stakeholder groups, progress is much slower. UTM stems from ATM, but the applications far outweigh commercial crewed aviation. This factor and the sheer number of drones that could occupy the sky is staggering, and will drive UTM growth to a point where most airspaces will require some type of monitoring in place.

ICAO's Approach to UTM

The activities of the International Civil Aviation Organisation (ICAO) set the scene for the development of UTM systems from an international perspective.

ICAO is a specialised agency of the United Nations that coordinates the policies, principles, standards and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe, sustainable and orderly growth.

Although ICAO is not an international aviation regulator, as national regulatory requirements of each region take primacy, ICAO's policies, principles, standards and practices are typically informed by industry experts, safety organisations and multiple stakeholders through research, workshops, task groups, conferences and seminars. In this way, ICAO is able to provide governments with robust advice and results.

ICAO views UTM "as a subset of ATM that is aimed at the safe, economical and efficient management of UAS operations." ICAO's publication of the *Unmanned Aircraft Systems Traffic Management (UTM) – A Common Framework with Core Principles for Global*

Harmonization (Edition 3), provides guidelines for the development of UTM systems on a global scale, which would "enable industry, including manufacturers, service providers and end users, to grow safely and efficiently without disrupting the existing manned aviation system."

ICAO further provides guidance on how such a system could be developed "through the collaborative integration of humans, information, technology, facilities and services supported by air, ground and/or space-based communications, navigation and surveillance." In ICAO's view, such a system would also achieve "'continued safety of all air traffic, manned and unmanned; safety of persons on the ground; complex low-level UA operations; ongoing support of technological advancements; evaluation of security and environmental risks; and provision for a global, harmonised framework for low-level UTM."

However, it is noteworthy that for the time being ICAO guidance focuses on developing UTM as a separate system to the traditional ATM although it is acknowledged that the UTM system should still be "potentially complementary" to traditional ATM systems. Ongoing interoperability with existing ATM systems, ATC frameworks and hardware and the ultimate global harmonisation of UTM are critical overriding features of ICAO's Common Framework.

The Australian Approach to UTM

Unmanned Aviation list Australia sixth in its recent list of countries making the most progress in UTM systems, and most prepared for drone regulation and applications, as a result of its national UTM flight information management system announced at the start of 2022.

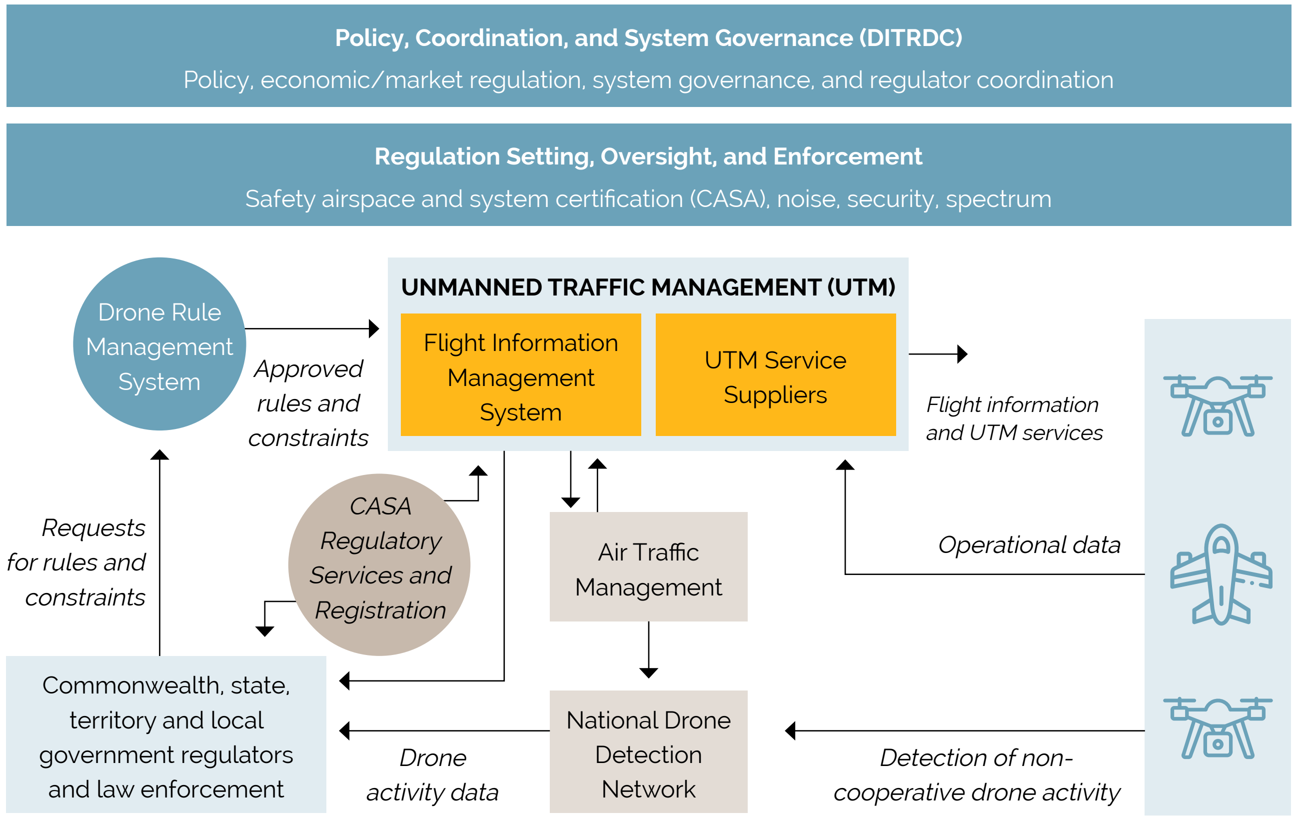
Recent developments in Australia include:

- A National Emerging Aviation Technologies (NEAT) Policy Statement in May 2021, which sets out "how Government will support individuals, businesses and industry to adopt new and emerging digital aviation technology…and create an efficient and adaptable operational ecosystem for emerging aviation technologies."
- The Economic Benefit Analysis of Drones to Australia, published in October 2020, qualifying the "potential economic benefits and savings emerging aviation technologies could have on the Australian economy over the next five, 10- and 20-year periods."
- The National Aviation Policy Issues Paper on Emerging Aviation Technologies, published in September 2020. This was produced by an Industry Advisory Group convened for the purpose, and which allowed for broader stakeholder consultation. This document informed the NEAT Policy Statement.

Features of National Emerging Aviation Technologies Ecosystem envisioned in the NEAT Policy Statement and/or under development include:

- National drone detection network "to support an increase in drone use incorporating a network of drone detection sensors, linked to a central database, which will filter and produce appropriate data to a wide range of users."
- Drone rule management system "to coordinate and manage operating rules."
- Unmanned Traffic Management which "will support the management of a range of risks and impacts associated with emerging aviation technologies, including safety, security, noise, privacy and environmental issues."
- NEAT Infrastructure Planning Framework comprising "clear principles and processes to ensure effective and efficient coordination of planning decisions related to construction and operation of eVTOL and drone take-off, delivery and landing sites…in preparation for the future uses of large-scale drones, eVTOL aircraft and AAM services such as air taxis."

2022 Australian National Emerging Aviation Technologies



Source: Australian Government (May 2021) 'National Emerging Aviation Technologies'.

The European Approach to UTM

Of the top 20 countries listed in the Unmanned Aviation report, 12 countries are members of the EU, including Belgium, Poland, Croatia, Austria, Germany, Denmark, Finland, Spain, Netherlands, France, Italy and Ireland.

Most noticeable for the European region, has been the provision for 'U-Space' across the member states of the EU under the auspices of the Single European Sky Air Traffic Management Research Joint Undertaking (SESAR-JU).

What is U-Space?

The U-Space refers to a set of services relying on digital services and automation of functions designed to support safe, secure and efficient access to U-space airspace for a large number of uncrewed aircraft systems (UAS).

U-Space provides a framework to facilitate the implementation of more complex UAS operations in all classes of airspace, while ensuring an orderly coexistence with crewed aviation and Air Traffic Management (ATM).

U-Space also allows for a set of agreements, protocols, means of communication and standards that together must ensure that the growth of uncrewed air traffic will proceed in an orderly manner in the future including more complex operations.

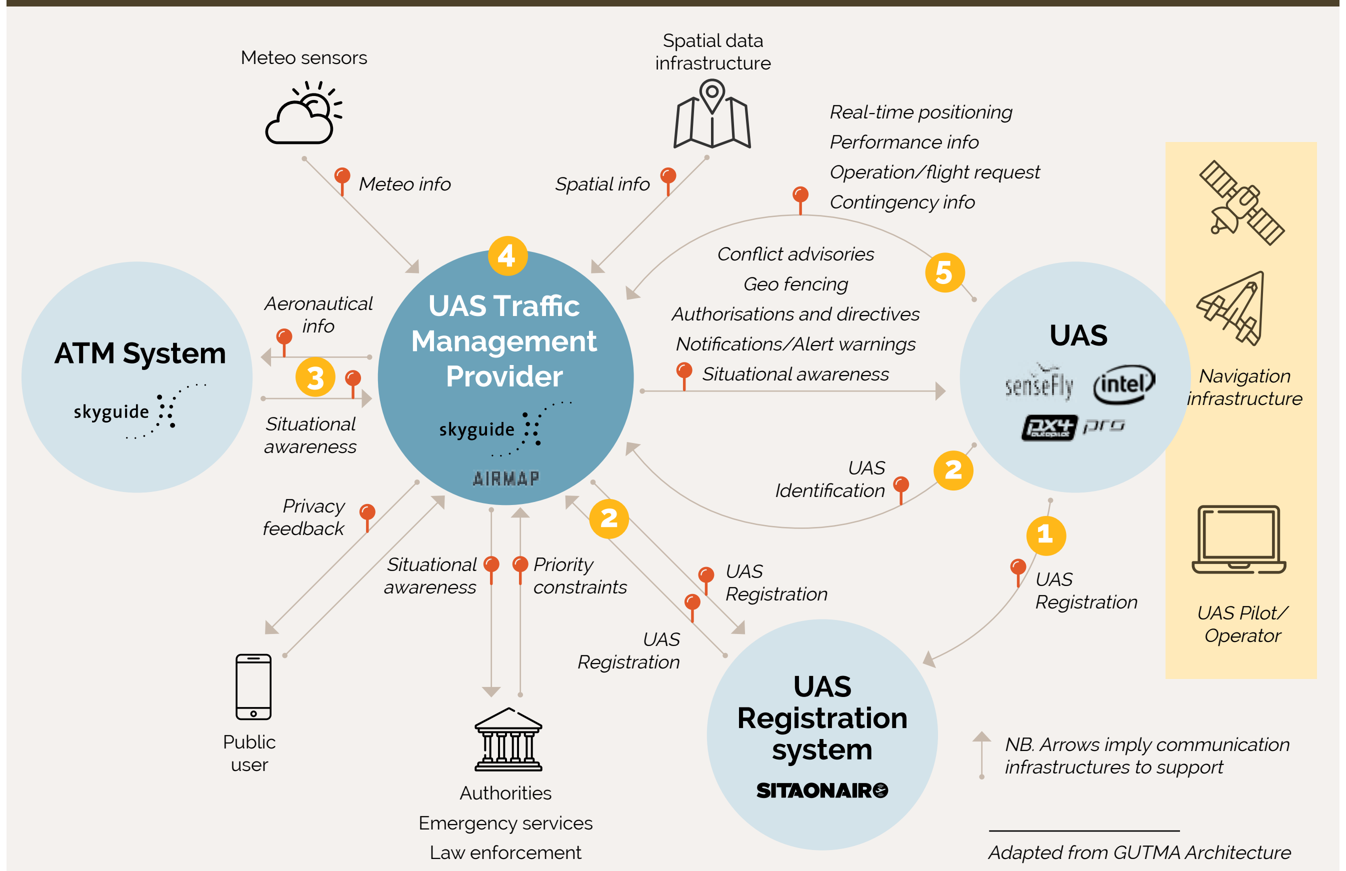
Through a clearly documented staged process, U-space will ultimately be capable of ensuring the smooth operation of drones in all operating environments, and in all types of airspace (in particular, but not limited to, very low level airspace.) It addresses the needs to support all types of missions and may concern all drone users and categories of drones.

Fundamental building blocks for U-Space include: network identification; geo-awareness; air traffic information; and flight authorisation; and is underpinned by a common information service, called the CIS.

Other aspects of U-Space will include:

- States being allowed to designate areas where U-Space will apply
- Provision for U-Space Service Providers (such as Altitude Angel or Unifly)
- Provision for operators to pay subscription fees to fly within designated U-Space areas
- Restrictions for crewed aircraft that enter areas of U-Space

2022 EU UTM TRAFFIC MANAGEMENT SYSTEM



U-space in action

Skyguide and its project partners will demonstrate U1 & U2 capabilities including:

1. **Drone registration** – with a blockchain based database managed by SITAONAIR
2. **Authentication of the drone's identity** – against the SITAONAIR registration database using AirMap technology
3. **Integration with ATC & digital airspace authorisation** – from skyguide through through the AirMap platform
4. **Dynamic flight plans and live telemetry** – visualised on AirMap U-space dashboard
5. **Real-time drone telemetry data** – sent by senseFly

Source: SESAR Joint Undertaking (2017) U-Space Blueprint. Available at: https://www.sesarju.eu/sites/default/files/documents/reports/U-space%20Blueprint%20brochure%20final.PDF

As of July 2022, SESAR-JU is sponsoring the new project, U-Space SEParation in Europe (USEPE), which aims to research and test concepts that will harness, develop and accelerate the adoption of cutting-edge technology to solve the safe and effective management of conventional aircraft, drones, eVTOL and similar vehicles flying at very low level (VLL), as well as at higher altitudes.

The UK Approach to UTM

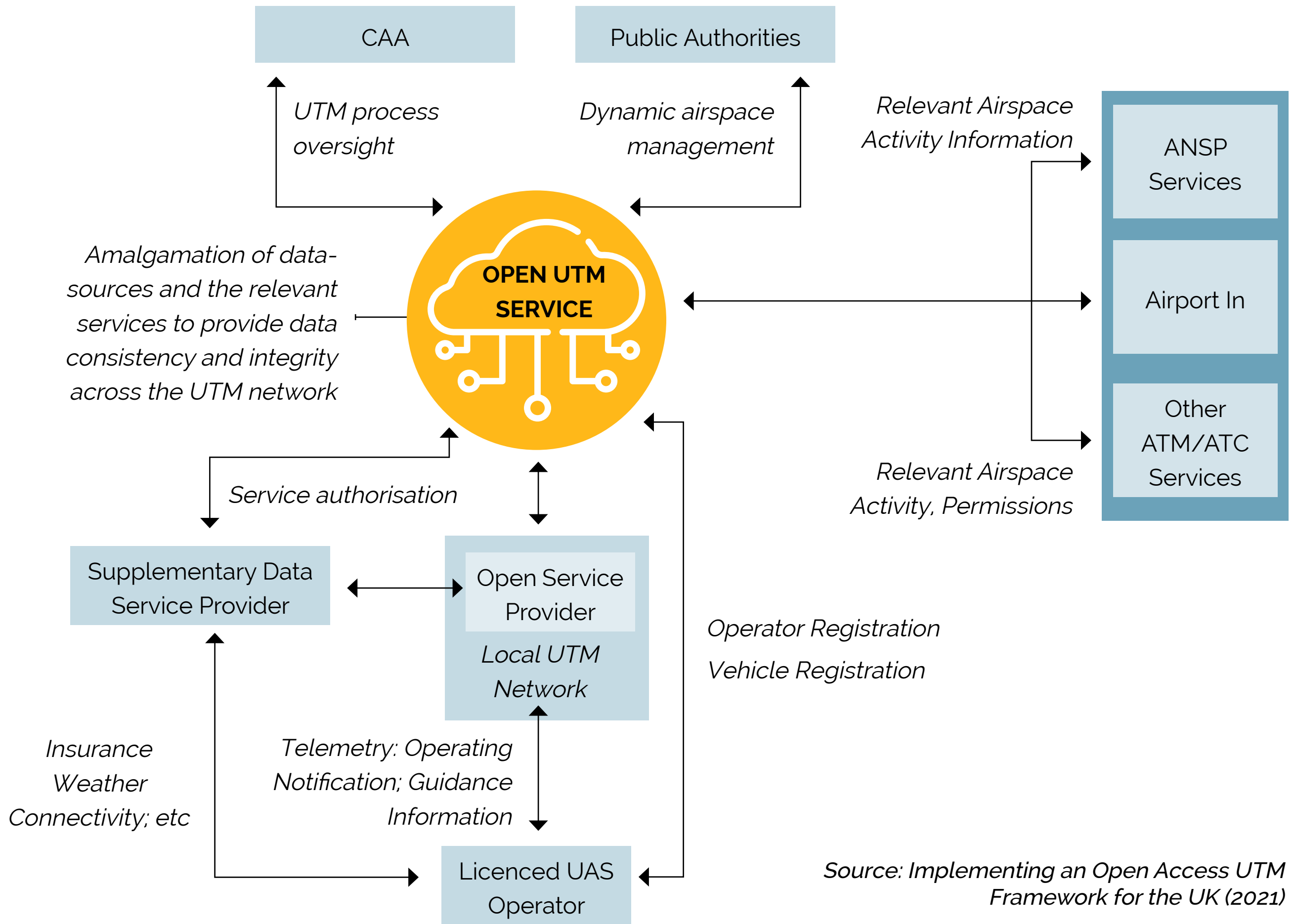
Although the UK does not feature in the list of top 20 countries identified as making the most progress with UTM architecture and implementation in the Unmanned Aviation Report on global UTM readiness, the report does acknowledge that the UK has more drone/UAM research programmes per head of population than anywhere else. Which of these will deliver the rules and procedures to directly allow imminent automated UTM drone operations in complex airspace has yet to be determined.

Also of note is the UK's participation in the EU-lead Air Mobility Urban – Large Experimental Demonstrations (supported by SESAR-JU), providing demonstrations at Cranfield University (June and September 2022). During these demonstrations, multiple services were tested, such as 'sat-comm' capabilities for on-board internet connection, USSP structures and the testing of contingency management and action plans.

The UK has led the way in terms of using UTM to create the first autonomous corridor of over 265km long, and The Airspace of the Future project has started live trials with the UK National Experimentation Corridor (NBEC), with a view to enable drones to transition from VLOS to BVLOS operations by 2030.

The UK has also been developing and testing an Open Access UTM framework, described in a publication produced for the Department of Transport in 2021, to bring the UK a step closer to enabling commercial UTM operations within its airspace, and function as the starting point for future UTM initiatives that will enable projects including those funded via the Future Flight Challenge.

2022 UK Approach to UTM



Source: Implementing an Open Access UTM Framework for the UK (2021)

2022 UK Project Skyway

Most notable among key UTM related projects and initiatives funded through the UK's Research and Innovation's Future Flight Challenge initiative is Project Skyway.

Project Skyway, which is enabled by a consortium led by UTM solution provider Altitude Angel, alongside telecommunications group BT and various UK tech start-ups, was given the go-ahead by the UK Government in July 2022. It comprises the world's largest and longest network of drone superhighways in the UK. The 165-mile drone highway will connect Reading, Oxford, Milton Keynes, Cambridge, Coventry, and Rugby, with the option for future expansion to other towns, cities and regions in the UK.

Through Project Skyway, any drone manufacturer will be able to connect a drone's guidance and communication systems into a virtual superhighway system which takes care of guiding drones safely through 'corridors', onward to their destinations, using only a software integration. The Skyway will provide ground sensors to provide real time guidance, which means drones will not be required to carry on board sensors to detect and avoid other air traffic. This in turn means improved payload capacity, range and better guidance and safety.

According to Richard Parker, Altitude Angel CEO and founder, "This system will ensure any company can safely get airborne and build a scalable drone solution to benefit society, businesses, and industry, on level and fair terms, accessible to everyone."

Source: Altitude Angel (18 July 2022) 'UK Government gives the green light for World's longest drone 'superhighway''.

The Approach to UTM in the USA

The USA currently holds 18th position in the Unmanned Aviation ranking of UTM readiness. The report specifically notes the final recommendations issued in March 2022 by the Federal Aviation Administration's UAS BVLOS Aviation Rulemaking Committee (UAS-BVLOS ARC), which included the need to set up risk targets for all types of drone operations.

The report also notes that, in collaboration with industry and stakeholders, the Federal Aviation Administration (FAA) is planning field tests for new entrants later this year to test UTM safety standards and data exchanges. Although commercial daily BVLOS operations remain constrained in the USA, extensive trials are underway throughout the country, including the highly successful Low Altitude Authorization and Notification Capability (LAANC), and UTM area "bubbles" are emerging, which concentrate complex drone flights in core research areas. However, owing to questions over the revenue potential for UTM service suppliers, key and pioneering UTM services suppliers AirMap and Skyward have exited the market.

According to the FAA website, the current focus of the US approach to UTM, is to collaborate and explore options and concepts with the National Aeronautics and Space Administration (NASA), other federal agencies, academia and industry stakeholders, for managing BVLOS operations below 400 feet above ground in uncontrolled airspace.

In these discussions, the emphasis is on identifying "concepts for operation services, roles and responsibilities, information architecture, data exchange protocols, software functions, infrastructure, and performance requirements for enabling the management of low-altitude uncontrolled drone operations."

Activities have been underway since 2017, most notably the release of the Concept of Operations (ConOps) for UTM within national airspace, Version 2, in March 2020. This document is an update of the original version published in 2018, and describes foundational principles and components, operations, roles and responsibilities, and operational scenarios. According to the document, the objective of the ConOps is not to "prescribe solutions" but rather to "inform development of solutions across the many actors and stakeholders involved in implementing UTM."

NASA is also advancing the concept of Advanced Air Mobility (AAM) to enable a "safe, accessible, automated and affordable air transportation system for passengers and cargo capable of serving previously hard-to-reach urban and rural locations." A National Campaign for AAM was announced by NASA in May 2022, with a view to promoting "public confidence and accelerating the realization of emerging aviation markets for passenger and cargo transportation in urban, suburban, rural, and regional environments."

Challenges and opportunities for international UTM

What is evident from the picture of the evolution of UTM internationally, as well as from general feedback received from the international professionals interviewed for this paper, is that a number of key challenges and opportunities exist around the development and implementation of international UTM systems.

Risk, uncertainty and paradigm shifts

The paradigm shift from traditional aviation is commonly stated, in one form or another, and is vital to achieving the level of safety, security and efficiency of crewed, uncrewed and automated air traffic management required.

The scale (and impact) of the activities required to adopt and integrate UAS into the existing ATM framework is undoubtedly daunting from multiple perspectives and no easy task given the different pace at which traditional establishments operate, in relation to the rapidly evolving UAS and emerging technologies industry. This is especially the case for the development of the UAM and AAM business case and marketplace.

The degree of uncertainty and risk associated with the scope of innovation required for this new emerging technology driven industry is high. Some concerns that have emerged include uncertainty about the business case for UAS/UTM/UAM and other associated activities, especially in light of safety, budgets, security and public acceptance.

There is also, for example, uncertainty about the capability, robustness and resilience of the technology for achieving the key components of UTM, including communications, detect-and-avoid and counter-UAS.

In addition to these concerns, there is also an inherent irony, as identified by ICAO, that to meet demand, states and regulators are encouraged to be innovative. However, this is leading to a lack of harmonisation that may impact safety, security, the environment, system reliability and economic efficiency. This irony alone creates an uncertainty about being an early adopter (often at considerable expense in time and money) compared to waiting until a final harmonised UTM system has been proven by others.

The broad applications and value of the UAS industry

In contrast to the challenges facing the development of UTM internationally, perhaps the most overriding opportunities, enablers or drivers for establishing a UTM system and supporting emerging aviation technologies lie in recognising the broad applications and value of the UAS industry.

> By actively supporting the demand for drone services of all types and scales, nations can achieve a number of things, not least among them being a boost to economic growth in many other industries that may benefit from the application of UAS (including eVTOL) through improved efficiency, better productivity and associated cost and safety conditions.

As evidenced by the Australian approach to UTM, such integration can attract greater investment, create employment, stimulate new business models, foster research and innovation in emerging aviation technologies, create new services for society, and promote economic growth within the aviation sector and across other industries.

The prestige gained from early adoption, innovation and implementation of successful UTM systems may also set a precedent for revolutionising aviation and harmonisation for global air traffic management (crewed and uncrewed).

07

Technology status: the evolution of drones and technical implications

This section explores the evolution of drones and their technical implications within the UTM context. There are five key elements identified, which will influence the success of uncrewed traffic integration: the regulatory ecosystem, the importance of separation and integration, the technology ecosystem and the platform/UAS/inherent technologies.

In the words of economist Adam Thierer, drones were "born in captivity". Drones are entering skies as newcomers to a world in which crewed aircraft have evolved to become extremely safe. A matured industry with little tolerance for risk can present a challenge for the new entrants.

Drones have distinct features that are fundamentally different from crewed aircraft. Their current and projected future uptake by industry and technical developments are fast, disruptive and almost intimidating. While these technologies are challenging the digital nature and speed of innovation of crewed aviation, they also provide the solution for the incorporation of UTM into the world of traditional air traffic management (ATM).

Within the platform/UAS/inherent technologies are the elements of design, body/airframe (aerodynamics, airframe materials and structure), power supply (energy) and fuel systems, propulsion (propeller, turbine/jet, ramjet, rocket), actuators (servos and flight controllers), software and sensors.

Next are the airspace and traffic ancillary technologies, including spectrum and remote real-time identification and tracking, addressing the current use of ADS-B transponders. Last is the ground footprint and management of ancillary technologies, including ADS-B receivers, data storage/cloud computing services, AI/computational modelling and simulation, surveillance systems, airspace security and cyber security.

The adoption and integration of drone technology into the crewed aircraft world will only happen through a process of testing existing and developing technologies in a safe environment cloned as drone hubs and drone corridors. These proof of concept endeavours must support all possible drone applications and use cases, and the development of a roadmap applying a risk-based approach to identify the location of future drone hubs and corridors is required.

There are two critical areas where drones impacts aviation, namely the regulatory ecosystem and the technical ecosystem, both equally informing the UTM domain, which is a requirement to unlock the power of drones.

5 Key Components for Successful Uncrewed Traffic Integration

	Status	Stakeholders	Key Challenges
Remote ID	Currently under development	Drone Manufacturers; Regulators	Standardisation; practical adoption barriers
Stakeholder Buy-In	In an early phase	Drone Operators, Regulators, Civil Aviation	Diverse needs in the ecosystem and differing levels of drone knowledge
Regulations	Under development	SACAA, Int'l Standards Bodies	Catching up to rapidly evolving technologies
Communication	Early adoption phase	Network Providers, Drone Manufacturers	Network coverage, potential high usage, ensuring connectivity
Software	Under development with partial adoption	Software developers and ecosystem members	Regulatory approval, connectivity; widespread adoption, evolving technologies

Source: McNabb, M. (20 May 2020) 'DRONEII: The 5 Key Components of Successful Unmanned Traffic Integration', DRONELIFE.

The regulatory ecosystem

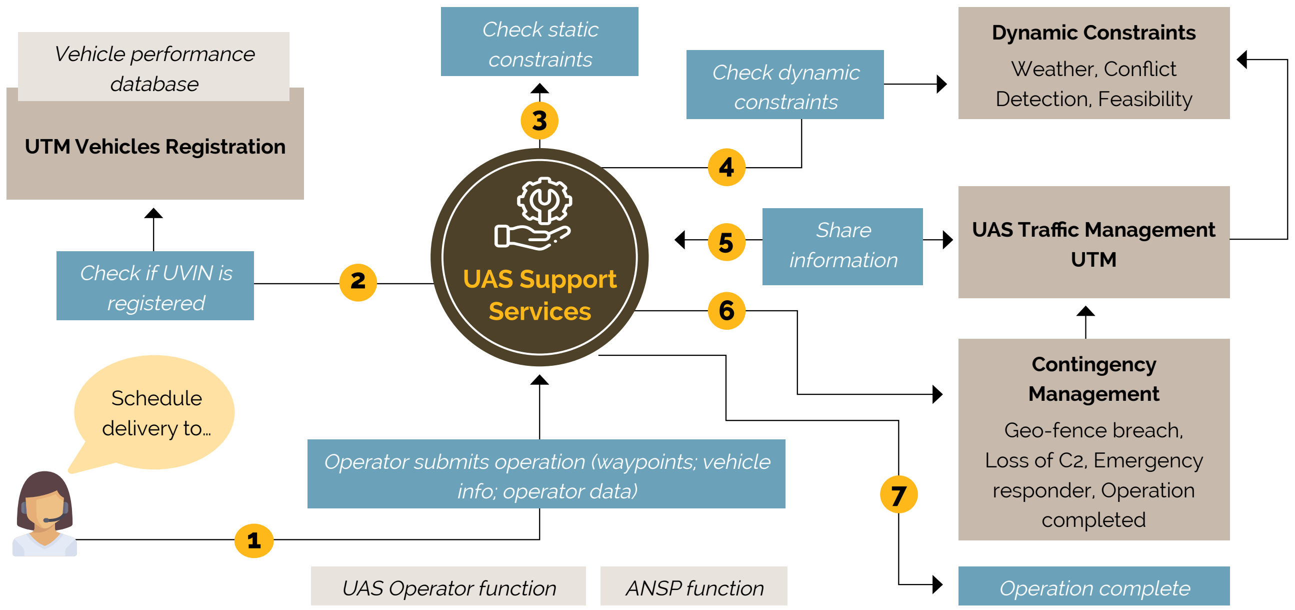
A new model will be required to allow for integration with existing ATM with a delegation of responsibility for traditional air navigation services, from a single supplier to multiple operators operating in a distributed fashion.

What will be needed are new systems with high levels of digital technology (automation and connectivity) that will allow for and raise new challenges related to:

- Data links – frequency spectrum, allocation and usage, resilience and cybersecurity.
- Cloud-based networking of information – using System Wide Information Management (SWIM) technology, allowing for data collection, processing and sharing.

The graphical presentation of a generic UTM value chain, below, highlights the interaction of the various events:

A proposed seven step UTM value chain (breakdown of support services)



Source: Parimal Kopardekar et al. (June 2016) 'Unmanned Aircraft System Traffic Management (UTM) Concept of Operations'.

> With the objectives of **safety, simplicity and adaptability**, the integration of UTM into ATM will be a playoff between the tools of Separation and Integration.

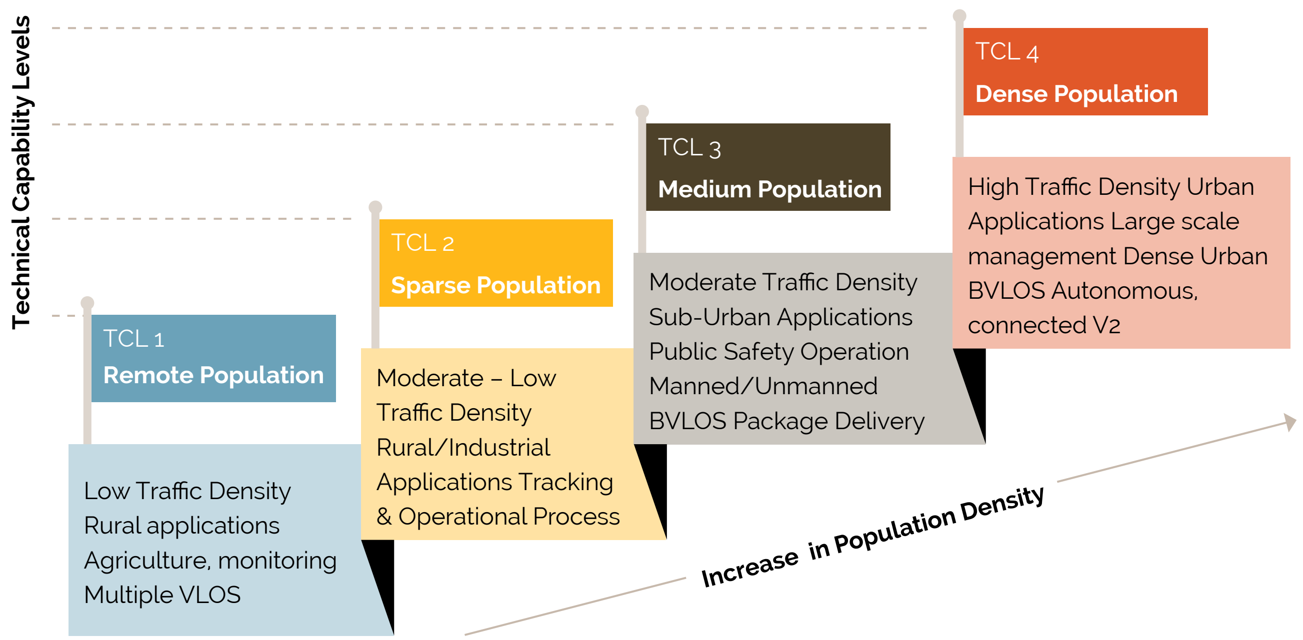
Why separation is important

As it stands, separation covers both the components of flight and environment.

- **Flight classes** – applies the principles of height, envelope and safe distance. For more information on South African flight classes, see Section 4: Understanding the Airspace Implications
- **Environment** – is classified in terms of Technical Capability Levels (TCLs) and, in a nutshell, are distinguished as follows:

  - **TCL1** – scheduling and geo-fencing
  - **TCL2** – BVLOS, integration of crewed aircraft
  - **TCL3** – drone sense and avoid, vehicle-to-vehicle communications, drone control interfacing (managing operations, communication, navigation, surveillance, human factor, data exchange, network solutions) + BVLOS, human and technology interface
  - **TCL4** – drones integrated into urban areas

Technical Capability Levels Required Relative to Population Density Risk



Source:Rakesh Shrestha, Inseon Oh, and Shiho Kim (2021) 'A Survey on Operation Concept, Advancements, and Challenging Issues of Urban Air Traffic Management'.

This graphic illustrates that Technical Capability Levels can be combined to devise a Risk Calculation Matrix, thereby opening opportunities for regulatory authorities to earmark future drone hubs, corridors and UTM spaces.

Why integration is important

One of the most critical elements of UTM will be the integration of the different technologies, capabilities, hardware and software. This will be influenced by the adaptability, especially in relation to connectivity and data sharing.

Adaptability

Enabled by technology allowing for connectivity, communication, data sharing, and virtualisation/digital twin, and covers both ground and air operations.

Connectivity

Cockpit evolution	• Multilink management • Broadband satellite comm. (ESA-Iris) • Broadband airport comm. (Aeromacs) • Broadband ground comm. (LDACS) • Cellular link for GA/RC	Command & control Tracking & telemetry Vehicle-to-vehicle Vehicle-to-infrastructure
U-space	• Command & control • Tracking & telemetry • Vehicle-to-vehicle • Vehicle-to-infrastructure	

Simplicity

Enabled by digitisation allowing for automation will affect all interfaces – self, inter-air and inter-ground.

Automation

Is multi-dimensional, covering man, machine and environment and can be classified accordingly:

- Man vs Machine – no automation, partial automation, conditional automation, high automation, full automation
- Machine vs Environment – evolving from simple to more complex scenarios

Vehicle-to-vehicle	Detect and Avoid (DAA); Remotely Guided, Real Time Health/Diagnosis, Adapt to Failures & Flight Conditions, Select path, Decide to turn around.
Vehicle-to-service	Requiring data quality (e.g. on accuracy, resolution, integrity, timeliness, completeness, traceability, format) of the system which need to be compatible and interoperable.
Service-to-service	Forecasting and dissemination of localised weather patterns that may impact low altitude UA operations (e.g. urban canyon phenomenon, windshear, diurnal effects caused by urban structures, etc.).

Group – coordination, mission/tactical re-planning, mission/tactical goals, distributed control, group strategic goals

Swarms – fully autonomous swarms

Aircraft participating in the UTM system must be separated physically, but integrated technically, utilising digital communication technologies dealing with data and information. Regulation will be challenged by technology and many new and diverse opportunities for software and electronic engineering will develop as a result.

Increasingly, regulation will be challenged by increasing numbers of drone flights requiring decreased acceptable risk levels by providing safety guidance, but lacking amnesty through technological means.

The technology ecosystem

The technological disciplines of physics, coding, aerospace, programming, automation and robotics enable and drive drone capabilities such as VTOL, BVLOS and autonomous operations driving the development of UTM to accommodate joint drone and crewed operations.

Drone technology is challenging the technology ecosystem. As Ken Treloar, General Manager, Aerobotics, has observed, in the current technology matrix, "hardware is not keeping up with the software" at this point in time.

These technological enablers typically serve critical controlling parameters in the UTM space, and will be classified and discussed as follows:

Collision Avoidance	• Abrupt evasive manoeuvre after previous levels fail	Air Space, e.g. vehicle-to-service	Traffic
Mission Scheduling	• Flight plan to flight deconfliction • Geofencing • Airspace design • ATM deconfliction	Terrestrial, e.g. service-to-service	Management
Remaining "well – clear"	• Ensures separation • Differs between hazards: persons, animals, UAVs, structures, crewed aircraft	Platforms, e.g. vehicle-to-vehicle	UAS

Platform/UAS/drone inherent technologies

The components comprising the landscape of inherent platform/drone technologies are as follows:

Design

Human-machine systems deal with the allocation of functions and tasks informing automation.

Human performance factors of system design take into consideration the decision-making processes relying on high speed information exchange.

Manufacturing and design considerations are seeking low-cost fabrication, such as reducing vehicle size and modular design and construction and low-cost product realisation, including new approaches to product design and low-cost manufacturing processes involving advanced composite and multifunctional materials and 3D printing. Drones may also be manufactured to fit regulation classes and requirements.

Body/airframe - aerodynamics, airframe materials and structures

Each class of UAVs is driven by aerodynamic considerations that are either unique or very important for the future development of the specific class and will consider the following:

- The design environment in which future UAVs will operate – load definition, reliability requirements, and aero elasticity.
- On-board health monitoring, health management, fault detection and isolation (FDI) systems.

Power supply (energy)/fuel system

Without the ability to keep drones in the skies longer, areas such as last mile delivery become challenging. This is enabled by rapidly developing lithium-polymer battery technology, gallium arsenide (GaAs) solar cell, hydrogen fuel cells, hybrid, radioisotope thermoelectric generator and in-flight charging allowing for increased endurance and payload.

Propulsion - propeller, turbine/jet, ramjet, rocket

The focus is on low-cost, high-temperature materials and coatings, cooling schemes to reduce the need for costly air-cooled parts, bearing and lubrication systems and small, low-cost accessories (e.g. fuel pumps, engine controls, and electrical generators).

Actuators

Actuators will open a large range of new services and use cases such as cleaning solar panels, extinguishing fires or dropping seeds in forestry activities.

Software

The drone software comprises of firmware, middleware and an operating system that manages flight control, navigation, and decision-making, dealing with requirements of autopilot, autonomous, improved computer vision, motion planning and algorithms to avoid obstacles and planned network configuration. Cloud processing and AI enable intelligent UAV swarms.

Sensors

There are internal and external sensors. Internal sensors address the appropriate functioning of UAV, navigational capabilities and collision detection. External sensors/remote sensing provide accurate data about the environment, such as RGB, Lidar, multispectral cameras, and gas sensors.

Opportunities for robotics, software and electronic engineering are inherent and widespread.

Air space/traffic ancillary technologies

Air space technology is mostly communication-driven and the key enablers of registration and identification, communications and geo-awareness/geo-fencing, deal with the challenges of:

- Interface between UTM and ATM – technology architecture to ensure the real-time sharing of information, the interoperability of the two systems, and to identify roles, responsibilities and limitations.
- Data recording – to support accident/incident reporting and investigative requirements.
- Communications – with the UTM system, ATC and pilots of crewed aircraft, sharing registration and identification systems.
- Alerting systems – securing the safety and integrity of the UTM system.
- Contingency management protocols – operating protocols that account for contingencies.
- Safety, efficiency and cybersecurity.

Spectrum

The International Telecommunication Union (ITU) plays a decisive role in allocating protected frequency spectrum to UAS operations, which may be necessary for safety-critical functions.

Spectrum is an essential input to and enabler of the drone industry, providing positioning through Galileo, GLONASS, SBAS, GNSS, GPS, wireless/cellular communications and other satellite-based systems making available licensed and license-exempt spectrum bands. The selection of the frequency spectrum is subject to availability, suitability and security.

The communication bands must allow for detect and avoid capability, vehicle control and traffic management supporting strategic deconfliction services, tactical separation, conflict advisory and alert service, dynamic reroute service and geo-awareness/geofencing-like systems, and on-board diagnostics.

Concerns regarding frequency availability and suitability will need to be addressed and closely coordinated with ITU and the Independent Communications Authority of South Africa (ICASA).

Remote real-time identification and tracking

The ability to identify and track an uncrewed aircraft flying in the airspace is a critical requirement while enabling high-density, complex uncrewed aircraft operations.

Real-time Identification and Tracking (RIT) of the uncrewed aircraft would enable sharing of the identity of the UAS and its location to other airspace owners and people on the ground. This would provide stakeholders situational awareness and allow law enforcement and security agencies to track uncrewed aircraft, where required.

International regulatory trends shows that drone manufactured in the near future will be equipped with remote identification.

Communications technology

Currently, three types of communications technology are the focus of research, these being ADS-B, ADS-B-like communication, and Remote ID.

In crewed aviation, ADS-B systems are in use and have been required since 2020. ADS-B-like systems work similarly to ADS-B systems, but use alternative technologies, such as 4G, XBee, and automatic packet reporting systems (APRS).

Remote ID, however, represents the up and coming technology, utilising Bluetooth and WiFi, and has the potential to open new avenues for UTM development.

As the legacy system ADS-B, which stands for automatic dependent surveillance broadcast, is most widely used for consolidating the communication technology required to operate UTM systems, and an explanation of the technology follows.

ADS-B Transponders

ADS-B transponders are able to both transmit and receive information in real time enabling RIT implementation.

The ADS-B abbreviation means:

- Automatic – requires no pilot input or external interrogation.
- Dependant – depends on accurate position and velocity data from the aircraft's navigation system (e.g. GPS).
- Surveillance – provides aircraft position, altitude, velocity, and other surveillance data to facilities that require the information.
- Broadcast – information is continually broadcast for monitoring by appropriately equipped ground stations or aircraft.

ADS-B ground stations receive the broadcast data and relay the information to air traffic control centres for precise tracking of the aircraft.

Relatively low cost and low SWaP (Size, Weight and Power) ADS-B transponders with integrated GPS and barometer, weighing a mere 20 grams, are currently available in the market.

ADS-B Receivers

ADS-B receivers are both integrated into ADS-B transponders, and dedicated ADS-B ground receivers known as ADS-B In. Both systems receive all broadcasts from any ADS-B out source. Onboard ADS-B receivers will typically display other air traffic on the drone operator's ground control station and provide the necessary alarms and potential air conflict warnings.

The ADS-B receiver is a permanent outdoor installation, which transmits information to a computer via a standard IP network and displays real-time air traffic within a 200 nautical mile radius of the ADS-B receiver.

Ground (foot print)/management ancillary technologies

Ground space technology is mostly data-driven and informs aviation data such as activity reporting, aeronautical information, airspace authorisation, discovery service, mapping service, flight planning service, tracking and location service and meteorological services.

Data storage/cloud computing services

The enormous amount of data collected by each and every drone makes the storage, transfer, availability and safety of data a major challenge for UTM development. Newer approaches and technologies including hyperconverged storage, flash transmission technologies and dedicated data centres are under development.

AI /computational modelling and simulation

AI and Machine Learning are critical innovative components. From advanced computer vision, object detection, collision avoidance, space simulation, model validation and automation. AI will push navigation capabilities beyond the limits.

Surveillance systems

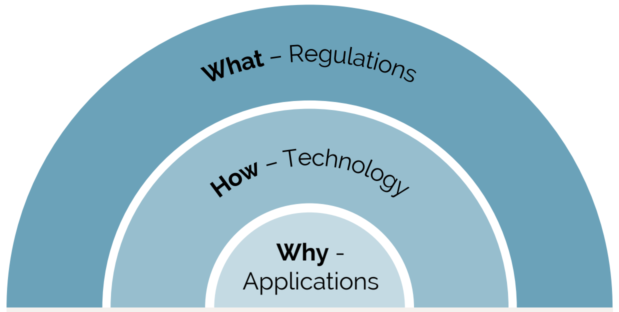
Managing magnetic interferences will become a consideration in dealing with natural sun flares (K-index) and the screening of its effect.

Airspace security systems/cyber security

There are significant cybersecurity risks and vulnerabilities related to UTM operations. A robust security framework must be established to address potentially malicious attacks to communications systems, avoiding erroneous advisories, unwanted changes in flight paths and increased risk of collision.

Technical implications summary

The challenge moving forward will be multidisciplinary:



Where - Drone hubs and corridors, enabling the joint development journey of regulation, technology and applications.

Public entities responsible for regulation adoption, development and implementation, such as Department of Transport (DoT), the South African Civil Aviation Authority (SACAA) and Air Traffic Navigation Services (ATNS), spectrum management and allocation (via ICASA) will be challenged whether being enablers or barriers for UTM development.

Academia and curriculum development should produce human resources capable of embracing the fusion of electronics, ICT and robotics.

Private entities and entrepreneurs, supported by government incentives, should be allowed to challenge the convention and put South Africa back into its leading African position in drone aviation.

A roadmap including experimental flying incubator zones as test beds for hubs and corridors, will allow both regulators and operators to implement those technologies safely into the future.

08

Entrepreneurship opportunities and skill sets required for UTM

The case with any industry, but particularly in the drone industry, is that to be an entrepreneur requires a deep passion and dedication to growing one's knowledge base about the industry and its evolution. UTM is not for beginners – it is a complex area of the drone industry and goes beyond passion, requiring a deeper skillset and commitment.

Managing UTM relies on the effective combination of technologies and expertise in the airspace, aviation, and information technology sectors. To begin with, entrants into this space should possess skills applicable to these key fields.

To be successful in UTM, new participants should be digitally enabled, as the disruptive drone industry owes much of its rapid rise to transformative digital technologies that make performance advancements almost every day.

5 Core skillsets required for UTM

1. Expertise in aviation and aeronautical industries
2. Knowledge of airspace and how it impacts on the integration of uncrewed and crewed traffic
3. Understanding of the drone industry and its technical implications
4. Commitment to digital technologies and their evolution, knowledge of their development
5. Capability in stakeholder engagement and building collaborative partnerships

Many of the skills required to work in the UTM space are built into the operating infrastructure, where the most common applications are known. Drones are integral in making jobs such as autonomous inspection, delivery, and mapping possible. These applications rely on supporting frameworks and technologies related to drone corridors, drone traffic coordination, and radio spectrum. Skills that enable entrepreneurs to thrive in these industries include software engineering, computer science, and information systems, among many others.

"You're going to have to have people that understand both the technical and operational side, because it involves solving problems on both sides. So, you need people that really understand how air space works and just how the current airspace models in the country work."

Andre Meredith, Senior Staff Officer Air Certification, South African Air Force (SAAF)

In UTM, operating the drone is only part of creating value for a client or business. The data collected by the drone needs to be uploaded, processed, analysed and presented. The range of required skills necessarily broadens to include these elements. Whether the use case is agricultural, security, mining, telecommunications or government work, after the drone performs its function, there is still a lot of downstream work required to complete the job.

"Obviously, you need engineers. You need traffic management skills, air traffic management skills, the understanding and the knowledge. Aerodynamic skills are needed there. You will need data analysts. You will need IT skills, robotics. Those types of skills are going to be critical in the future."

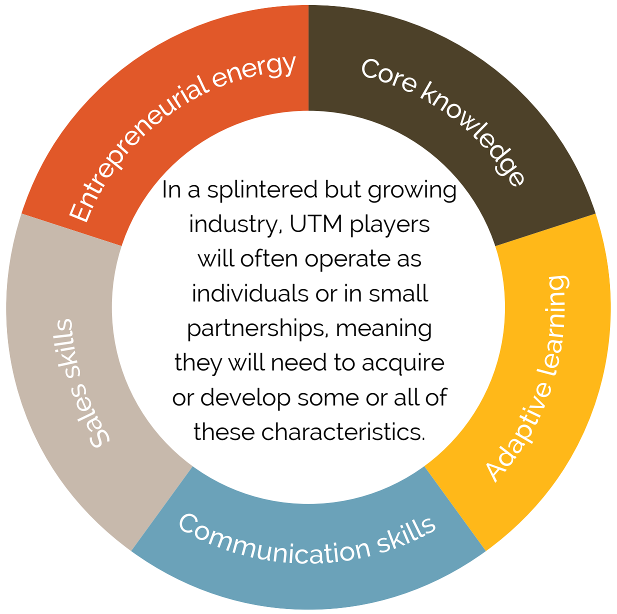
Brigadier Simon Buti Mahlangu, Section Head for Airwing, South African Police Service (SAPS)

As drone use cases develop and competition to produce more advanced products and features increases, platforms and apps will mushroom. Skills that will enable this now and into the future include coding and software development for making increasingly powerful drone-dependent apps. What's more, to thrive in this space, drone operators will become drone application salespeople and marketers for typical UTM use cases, such as mapping, inspection, and data collection.

As the number of drone applications increase and more people with entrepreneurial mindsets enter the field, so will the demand for these services and the size and value of the industry. This will give rise to the drone role player who possesses more than simply a deep technical skill, but a range of complementary skills that will allow them to survive in this industry.

Tom Verbruggen, founder of Aviatize says, "People who don't come from this industry will equally be able to disrupt this industry and they will come with insights and skill sets that were not traditional aviation skillsets."

Therefore, in addition to their foundational knowledge in science, aviation, or engineering, new entrants will need to combine this with new skills to push their business plans forward.



The UTM space continues to develop. As it grows, it will require more recruits from the information technology, engineering, science, and aviation industries. Already, some skills that feed into these industries are in short supply. The following table shows a non-exhaustive listing of the areas of expertise currently required in UTM:

Information security	Devops	Application development
Big data design	Blockchain	Quality assurance
Big data analytics	Performance testing	Systems analysis
Artificial intelligence	Data science	Business analysis
Machine learning	Process management	Project management
UX design and implementation	Business intelligence	Systems design
Systems architecture	Internet of things	Cloud management
Manual testing	Drone piloting	Robotics
Drone maintenance		

It is easy to identify that skills are already at a premium as the UTM industry competes for skills in established big industries such as technology, banking, and manufacturing. In addition, the UTM space will need all the usual skills that complement all industries, such as insurance, regulation, law, security, financing, and other support functions, further heightening the skills crunch.

Regardless of the challenges it faces as an emerging sector, UTM is a dynamic space. Some applications are only being developed today that are bringing previously unthinkable career paths together in interesting ways. Commenting on the pace of change, Ian Kiely, Chief Executive of Drone Consultants Ireland says, "I have been called an expert, and yet I choose never to use that word because how can you be an expert in something that is happening so quickly?"

Some technologies will only develop years from now and will call upon contributions from even more diverse industries.

For example, consider the skills required to perform drone-enabled rewilding. This process involves remotely introducing new plant seeds into deforested areas through pellets that are ejected from a drone-mounted gun.

To imagine the scenario of rewilding via drones, entrepreneurs would need to achieve a number of things to realise the idea, including developing chemical compounds to make the remote seeding process effective, and creating the technology that shoots the projectiles into the ground with the correct amount of force and accuracy. Such a situation would necessarily bring together experts from sectors as diverse as plant science and weaponry that we could have hardly imagined would cross paths for a commercial drone-facilitated venture.

The example of rewilding is just one of the many potentially hazardous jobs that drones have taken out of the hands of people because they are better equipped to do it at scale and with speed and accuracy. Use cases like these demonstrate that individuals entering the drone industry space will need to arrive in the sector with an applicable base skill, but they must also be prepared to quickly learn complementary skills to pitch and sell their ideas as a start-up would. Afterwards, they must specialise in their niche to offer the best product and ward off competition.

> "You need vision and tenacity. If you're going to get into this industry, you need to be tenacious, and equally have the vision, but make sure that you're thinking about a solution to somebody's problems, rather than just thinking you can put this out there, and it's going to be adopted."
>
> **Louise Jupp, Owner of Terreco Aviation**

Entrants into UTM will need to be fuelled by an entrepreneurial spirit that makes them provide services that are not yet conceptualised or even required. Sharon Rossmark, founder and Chief Executive of Women And Drones comments, "Many in the industry call them new collar jobs, jobs that didn't exist before. They're not blue collar and white collar, they're new collar; they're going to be developed as we go. So, in addition to the whole STEM-related skill sets, I really think critical thinking skills are going to be vital to really evolving."

Overall, new entrants will need curiosity, perseverance and innovation. To thrive in the UTM space, individuals must above all have passion, drive, and a continuous desire to learn. There is no exhaustive set of skills that can be advertised ahead of time. However, the more skills new entrants have and the more they are willing to augment these skills, the better.

Drone Start Ups – An Insider's Perspective

In this section two drone industry insiders sat together to chat about the ingredients to start and build a thriving drone business in South Africa.

Collectively they have been on both sides of the industry: one is a regulator turned entrepreneur aviation consultant, and the other is a commercial drone operator thrust into an entrepreneurial environment after decades of working in large corporates.

Meet Sam Twala and Kim James

KJ: Sam, before we talk drones, let's start with the basics. What do you think it takes to start a business in the drone industry?

SAM: Starting a drone business is like starting any other business. All entrepreneurial skill and principles of starting a business are applicable, including capital.

The drone industry is getting more competitive and, as a service provider, you need to have a unique business proposition and solve real problems.

KJ: You were part of the drone industry from the get-go as a regulator and then left to start your own aviation consultancy. Could you share your personal experience of how you solved a particular problem?

SAM: In short, "What is the problem to be solved?" and "How do we solve it"?

Since drone regulations were promulgated in July 2015, commercial drone operators are required to be licensed by the Civil Aviation Authority. This means any person intending to operate a drone in South Africa will be treated as an aviator by the Civil Aviation Authority.

The problem: Almost everyone entering the drone industry had very little understanding of aviation, let alone drone regulations. Non-aviators (most drone users) were frustrated by the regulations and "how" to obtain the licence from the regulator.

As a former Civil Aviation Authority employee with relevant experience and knowledge of drone regulations, I could solve most of the industry's number one problem – obtaining a licence from the Civil Aviation Authority. That's how Ntsu Aviation Solutions was born.

SAM: Kim, you work in the drone security industry. What problem did you set out to solve?

KJ: We set out to combine our Managing Director's knowledge and experience as an aviator and his software and engineering background with something that was new and upcoming at the time and that was going to make a real difference to our society. In 2016, the industry was new, and crime was on the rise.

All this led to the idea of using drones in security surveillance to assist private security companies and law enforcement fight crime more effectively by giving them an air force – putting eyes in the sky.

Add in our now Operations Director, who has 25 years of South African Air Force experience (also an aviator) and my heavily regulated banking industry experience. A winning formula to address the crime problem by using drones and being able to operate at the highest levels given our aviation and compliance backgrounds.

KJ: So, that's only the starting point. Sam, so many young people are encouraged to start a business in the drone industry. What's the next step after identifying a problem to solve?

SAM: It is equally important to conceptualise a solution to a problem that has been understood and defined. Some of the guiding parameters may include one or a combination of the following:

Is the solution cheaper? Is it efficient? Is it more accurate and precise? Is it safer? Does it save the planet, meaning is it "green"?

One of the biggest pitfalls in the drone industry is that most people rush and spend money and time obtaining all licences without a compelling business plan. A few months or years after obtaining a licence, they put up a "for sale" board at the business entrance.

KJ: Sam, what do you think is required to execute on the solution?

SAM: After the correct identification of a problem and/or pain points of the potential client, a key consideration is having the required skill and knowledge to solve the problem. You must know that a drone is the "tool" used to solve a problem. The drone is not necessarily the solution.

KJ: On that same point, I believe the hunger and drive for entrepreneurship in our country is driven by the lack of full-time employment opportunities. This does not necessarily mean that everyone has the natural entrepreneurial abilities needed to work in this highly technical, regulated, competitive and costly environment as a business owner.

It is important to understand that licences and equipment will no longer be the differentiator. That only gets you to the starting line. It is the competitive advantage of how you are solving for the identified problem at hand, that will be the winning formula.

Concluding Thoughts:

SAM: With the drone industry expanding, there will be problems to solve and opportunities to build a thriving and successful drone business in South Africa. Find that true competitive advantage.

KJ: A start up in the drone industry in South Africa is not for the fainthearted. It requires will and skill and of course capital. If you have the right problem to solve and have knowledge, experience, and access to market, you may just have a winning formula.

The drone is simply a tool in the toolbox.

09

Key learnings and implications

The UTM position paper presents key learnings and implications based on the study of various desktop resources and links, and extractions of codified and iterated insights from the recorded transcripts of interviews with experts in the sector, which have been presented to and vetted by the group of 10 experts in the UTM Working Group (UTM-WG).

These key learnings and implications form the best insights and observations of this UTM-WG on the status of UTM in South Africa and general observations regarding UTM and its implications for South Africa at this point in time.

The following barriers and enablers are compiled from the 13 interviews conducted in the preparation for this document, as well as the insights from the 10 experts in the aviation and drone industry.

2022 Barriers and Enablers to UTM

Barriers	Enablers
• Current restrictions in drone legislation • Slow change in the implementation of policy and legislation changes • Outdated air traffic systems • Lack of skilled people with industry knowledge • Lack of resources to implement required updates in digital infrastructure • Public resistance • Too many private systems with lack of integration between systems • Shortage of skills required to implement UTM, including a consolidated focus needed to grow the industry – not UTM-specific, but including AI, ML, aerospace, engineering, IT, robotics, data analytics, air traffic management • Low government intervention and lack of awareness outside of aviation.	• Potential to develop a new industry that creates economic growth and jobs • New investment opportunities for the country to bring on board domestic and international investment • A body of experienced operators who are keen to grow the industry • The level of and keenness for tech adoption in South Africa, and attention and funds going to the development of the country's tech sector • Low congestion of airspace and significant tracts of 'sterile' airspace suitable for pilot sites • The air traffic systems already need a massive overhaul – the potential exists to digitise and modernise South Africa's air traffic control • Developing ecosystem with key stakeholders investing in building a knowledge base within the industry

Given the highly flexible nature and rapidly changing technological landscape of the drone industry, these key learnings and observations hold for the period of time during the study up to October 2022.

1 **UTM is a highly complex infrastructure and transport network, reaching far beyond the drones themselves.** There are those who believe that UTM is a matter of carving out a corridor for drones – i.e., 400 feet above ground level (AGL), yet the complexity of UTM lies in the integration of existing systems in aviation with new technology and capabilities into a much broader transport ecosystem.

At its heart, UTM is transport infrastructure. There will be a day when drones will replace planes, trucks and other existing traditional transport methods, through the digitisation of the landscape.

Industry experts see that the policy must be driven by the Department of Transport (DoT), bringing Air Traffic Navigation System (ATNS), the South African Civil Aviation Authority (SACAA), Airports Company South Africa (ACSA) and others into the fold. There is a role for leadership in government to bring transport companies and logistics under one umbrella, recognising the future role for the drone industry and UTM.

2 **There are no fully functional UTM systems in the world.** Ian Kiely, CEO of Drone Consultant Ireland, says, "If anybody tells you they have a fully functional UTM system, they are talking out their rear end."

The headline in 2022 is that there are no perfect, fully functional UTM systems out – there are parts of UTM systems, and there are a few "experts". As seen from Section 6: UTM evolution around the world, there has been tremendous progress in several countries, and excellent space for learnings, but each country, each organisation, needs to develop their own systems. It is important to ensure that South Africa learns from others' successes and mistakes, but also is unafraid to develop its own solutions and recommendations.

3 **UTM cannot be executed in a bubble.** As an essential new level of integrated transport, it must be built into and integrated with South Africa's transport landscape. A new world of digital technologies is evolving, and the drone industry and UTM demand a new level of expertise and thinking. Only those who embrace a new digital world will succeed in implementing UTM. Old ways of thinking and traditional approaches will not work in this new world.

4 **UTM will demand new and multiple skillsets and an in-depth understanding of different industries.** While there are many opportunities within the drone industry that do not demand intensive background in the industry, the level of complexity and extensive requirements in UTM make it a space that requires deep expertise.

UTM is not for beginners – like the space industry, it poses a need for in-depth understanding of aviation and aerospace, of the intricacies of airspace, a strong technical appreciation for how digital technologies will impact the infrastructure and the integration of technologies.

Critical skills to implement UTM will cross over IT, aviation, aerospace, engineering and other skills, as highlighted in Section 8: Entrepreneurship opportunities and skill sets required for UTM. This is both a challenge and a prospect in terms of developing frameworks to cultivate new skills in the "new collar" industries, as highlighted by Sharon Rossmark, CEO of Women And Drones.

5 **The technologies exist to implement UTM – yet there are opportunities to integrate the components together and test in the uncrewed environment.** While technology continues to advance, infrastructure, legislation, and most importantly, the mindset, have not kept pace. As it currently stands, the drone industry is being treated as an adjunct to the aviation industry, with the same requirements as an airline to set up a business.

These are all being considered for change. There still exist opportunities for entrepreneurs in the UTM tech space to develop new solutions. UTM can also assist in relaxing and reshaping the legislation, as well as making drones more financially viable. This is needed in order that South Africa can take advantage of the job creation, inclusion and economic growth potential that the drone industry holds.

6 **UTM is a system that allows for risk mitigation and anti-collision avoidance that can be integrated into air traffic management.** One of the greatest areas of concern in traditional aviation is the integration of crewed and uncrewed aviation vehicles in the same space. In terms of challenges, "One of the greatest challenges is that the fact that the drone industry is growing so fast," says Craig Poultney, Tower Controller at OR Tambo International Airport.

Poultney indicates that the goal ultimately is, "safety, safety, safety, safety. We're not trying to curb an industry that is growing, but we need to protect the lives that we are responsible for as controllers."

The most critical time in aviation is during take-off and landing – this is when planes, their crew and passengers are at the greatest risk, both from a performance point of view and ability to manoeuvre. Aircraft potentially face difficulties in executing complex and expensive procedures when dealing with a drone that does not have the ability to communicate. This can also significantly increase the workload of air traffic controllers.

7 **One of the greatest risks in UTM is not the licensed industry, but the illegal, unlicensed drone operators.** There are many private operators working outside of regulatory compliance. This is where the greatest risk lies for the industry, both from a potential accident point of view and also in terms of its impact on legal operators, as it essentially negates their current business models that comply with SACAA requirements.

Risk mitigation lies in the ability for both crewed and uncrewed aviation vehicles to detect and avoid one another, and the introduction of electronic conspicuity discussed in Section 7: Technology status: the evolution of drones and technical implications is an essential element

8 **The gap between the drone industry and traditional aviation needs to be addressed.** Currently there are limitations between those who understand the traditional aviation industry, which has deep roots, and those who understand the drone industry. Many drone operators come from non-aviation and tech backgrounds – after all, the drone industry is and will increasingly be a tech space.

Ensuring onboarding and understanding of both sides will assist in developing UTM and new protocols going forward. Information sharing will be key to development and understanding, and will assist in risk mitigation.

9 **South Africa's geographic and spatial landscape offers opportunities.** South Africa has far less congested airspace than many other regions, in particular the EU. The development of rules, regulations and requirements should take into account these differences, and also seek to leverage the country's natural advantages, such as those for test pilot areas, with extensive sterile and relatively unpopulated airspaces.

This also means that the U-Space technology and approach cannot be applied as is in South Africa – a tailored approach will be required. Given one of the critical elements of UTM will be the transmission of data, South Africa has its own challenges in terms of spectrum and the current cost of data.

10 **UTM requires new business models.** The current funding of aviation and airspace is done via the contributions of the traditional aviation industry. The fees charged for the use of airspace, aerodromes, spectrum and flights are well regulated and ensure the workings of the industry. By bringing drones and UTM into this space, new business models will be needed.

The drone industry will need to be structured to pay for its usage, and ensure that organisations such as SACAA and ATNS can balance the needs of traditional aviation with the emerging needs of the drone industry. Funding models need to be developed, and there is an important role for the finance, insurance and legal sectors to develop expertise in the industry and assist in building viable business models that ensure the industry's sustainability.

Ultimately, UTM will be a necessary element in enabling the future Categorisation Model, which will in turn expand the drone industry through the envisaged Open Category. Currently, under the Certification Model, one-person operations are prohibitive and unobtainable, so the future will be brighter for those interested in offering drone services or solving local problems for their communities.

This list of key learnings and implications is not intended to be comprehensive. There are many more, important findings in the UTM industry, yet these, together with the following conclusions and recommendations, are intended to generate thought, debate and dialogue to further grow the drone industry and UTM for the future.

10

Conclusions and recommendations

Conclusions

The drone industry is one of the most dynamic in the world. Against a backdrop of the threat of world-wide recession, the implications of the conflict in Ukraine and accelerating prices and inflation, an industry with the exponential ability to promote economic growth, create jobs and develop a new, dynamic world is inspiring.

And yet, as with any complex undertaking, the development of UTM and the drone industry is for the brave, for those who are committed to creating a new, previously unknown world. What is critical for its future growth is that the drone industry is seen as a tech industry, and not purely an aviation industry.

UTM will require an understanding of how the drone industry will evolve and the needs of its digitised nature. Traditionally, aviation legislators and operators do not possess a deep understanding of digital technologies. This will need to change, so that legislation is able to take into account the potential future landscape of UTM and how it can impact the economy.

Drone legislation and its complexity, which combines aviation and technology, has a deep impact on the success of UTM. The legislative nature of aviation and the slow pace of its changes have serious implications for the drone industry and its potential growth. As seen from the *2021/2021 Drone Industry in South Africa: The Potential of the Unmanned Aviation Industry*, no country has it "just right."

While South Africa's drone legislation was ground-breaking in 2015, it has not kept pace with the changes in the industry. The current legislation makes running a drone business prohibitively expensive, compliance-driven on the level of an airline company and hard to scale. Without the ability to scale relatively inexpensively and quickly, companies – especially smaller businesses – will struggle.

This is set to change, yet aviation legislation changes slowly. Expediting this change – albeit with awareness of the changing landscape – will be critical to grow this industry. Legislation and respective systems need to be built around opportunities rather than restrictions.

Growth and success in UTM will be determined by scalable solutions. The return on investment (ROI) of future systems will determine the viability of UTM and the drone industry. UTM will require unified traffic management, including increased automation of airspace, automated BVLOS and safe and transparent management of the airspace.

UTM has the potential to embrace socio-economic impact and bring greater economic benefits to South Africa. Incorporating socio-economic and community impact into the thinking from the beginning will ensure the integration of benefits for those in disadvantaged communities.

In a country such as South Africa, facing official 33.9% unemployment and 63.9% youth unemployment

NEW INDUSTRIES THAT CAN PROVIDE SOLUTIONS FOR POTENTIAL ECONOMIC GROWTH AND NEW JOBS ARE ESSENTIAL.

Recommendations

1 UTM will need to be purpose-built in South Africa to accommodate innovation and potential technological advances and applications.

There are models in the world – as indicated in Section 6: UTM evolution around the world – that can be adapted to South Africa's landscape. Yet, each country has its own specific geography and special needs. Integration cannot be done by external experts – it requires deep local knowledge.

While the EU has excellent models and strategy in UTM, what it doesn't possess is large tracts of 'sterile landscape'. Much of South Africa's airspace is known as Class 'G' airspace, which has little traffic, interference or radio waves. Unlike the UK and many parts of Europe, which are heavily congested, having large sections of non-urban settings with limited aviation traffic or radio interference allows for a different approach to UTM and the related airspace.

This also opens up South Africa to the potential of the creation of drone corridors – linking airspace that could create wide avenues of UTM airspace in more impacted zones. These drone corridors in turn pose an opportunity for testing and pilot sites for UTM and other drone innovations, which could be leveraged to create new economic zones in rural and peri-urban areas.

UTM cannot be developed in a vacuum. Linking to drone corridors and taking into account South Africa's landscape, people dynamics on the ground, and the potential to develop economic development possibilities will be critical going forward.

2 A successful UTM system requires a digital traffic system.

UTM demands a commitment to the digitilisation of aviation – the investment by government, together with the private sector, into new 4IR/5IR traffic management systems.

3 UTM systems need to be technology agnostic, software neutral and allow for integration.

An ideal UTM system should be able to work with any drone that will be manufactured and not married to any specific manufacturer or technology. UTM platforms should be enabled with open Application Programming Interfaces (API) to communicate with other UTM platforms. One UTM system nationally may not be ideal or conform to procurement regulations in South Africa. Today there are companies developing technology that would allow drones to operate under these types of systems.

It is critical that UTM development is built around integration, as highlighted in Section 7: Technology status: the evolution of drones and technical implications. Any system that is embedded in one company's software or one supplier's capability, which brings limitations, does not allow for changes in technology, capabilities and needs over time.

4 UTM requires active test pilot sites to ensure its operational effectiveness and safety.

UTM cannot be implemented into existing congested airspace. It requires testing zones that allow for the piloting and trialling of new systems and equipment. The designation of these potential sites represents an economic opportunity.

South Africa offers various sterile airspace environments, often in economically depressed and rural areas. These would be ideal testing grounds to pilot and test new UTM systems before any level of implementation is allowed. In addition, the Department of Defence owns various currently unused military airbases throughout the country. and is well underway in proposing the development of test sites for its own, government and SOE use.

5 UTM requires the appropriate response to and management of spectrum.

Digital technologies require the platforms on which to operate. Spectrum is a limited and finite resource that is highly contested. Cellular companies could offer 4G and 5G data capability to drone and UTM operators at a premium, but this would prevent the industry from creating the necessary financial models that will make this digital space viable.

The management of spectrum and assignment of frequencies will create a space where UTM, the aviation and aerospace industries, and small businesses could flourish. According to Thomas Matabane, spectrum specialist at the SACAA, "Spectrum is the ecosystem of UTM," and its management to ensure that it does not pose a barrier to the industry will be critical.

6 The complexity of UTM will require a phased approach. The best approach is one of "crawl, walk, run." Learnings from other countries, such those in the top 20 in UTM development, will be of value to South Africa.

One suggestion from an expert was that a ring-fenced, smaller UTM may be a good first step. Ensuring the right stakeholder engagement and parties are involved at different phases will be an essential part of the planning.

Clearly a phase that incorporates the piloting and testing of UTM technology will be important. Financing sources for integrated systems could start with small test corridors, BVLOS and cell phone systems.

7 Collaboration and stakeholder engagement will be critical elements of the success of implementing the complexities of UTM.

Given the complexities of UTM and its requirements, no one person, organisation or company possesses all the skill sets or expertise required.

Collaboration will be an important element of UTM's success. This UTM-WG is an example of how this can happen – bringing together people each with deep levels of expertise and finding working methods for integrating that expertise will be key.

Stakeholder engagement will be another significant factor. According to Sonya Betschart, co-founder and co-CEO of WeRobotics, which founded Flying Labs in 37 countries, their analysis identified that 45% of their Flying Labs' time was spent in stakeholder engagement. Getting key government bodies, communities, members of the drone and flying communities, to participate in and accept UTM systems will be a critical skill set going forward.

Given the newness of the industry, the greatest depth of knowledge lies in the business people who are actively operating in the sector. It is important that the operators are an integral part of the collaboration going forward, and not added in as an afterthought to the development of the technological elements of UTM.

8 The integration of UTM with the crewed aviation industry will be critical to the uncrewed industry's success.

As part of the collaboration, the existing aviation industry partners, which are well organised and highly capable, need to be onboarded to the drone industry and UTM development. The legislation, policy, financial business models and other framework elements need to incorporate the existing aviation industry, or they could pose a roadblock to UTM's future development.

Integration is about harnessing local knowledge and empowering local stakeholders. There is an inherent knowledge base and expertise in the traditional aviation sector that can assist the tech operators to ensure operational viability of new developments.

9 The success of the drone industry and UTM requires creating drone operations as scalable commodities.

When the cost of drone flights progressively decreases, this will determine the cost-effectiveness of the industry and its viability long-term.

Countries such as the US employ 'discovery and synchronisation' (DSS) services, which could be an option. Potential for collision could be met with strategic deconfliction services, and integrating services into operating systems with the police services. This would also require the police services to embrace digisation as part of the elements of growing their capabilities.

10 UTM will require an investment into innovation, critical skills and technological development.

There are currently a number of different resources available for new technical development, but the funding is not well known, the sources are disparate and many entrepreneurs struggle to identify where to seek assistance. A critical element to this development will be the source of funds and government's willingness to endorse the industry and the importance of UTM.

Areas such as equipment that seamlessly operate with multiple networks simultaneously will be important. While existing sources are valuable, there is a need to consolidate the funding models, create broader engagement between existing stakeholders in the industry and capture the early learnings of the existing drone operators.

New venues and avenues for innovation, critical skills development and technological development will be required to develop the workforce and leadership that can take UTM and the drone industry forward. At the same time the tech requires investment, and grassroots development in basic STEM skill sets will help provide a funnel for the workplace and skills for tomorrow.

11 UTM will require new models of leadership.

The traditional, hierarchical nature of business and government leadership is seniority- and experience-led and top-down. These models will not work in today's digital world. UTM and new digital technologies require a flexible mindset, an openness to new ideas, innovation and ways of working.

There is no deep pool of UTM expertise to call upon – the skill sets, capabilities and know-how must be developed. It is likely that UTM leaders will be young people leading groups of highly experienced experts in their fields.

Those creating the framework for the UTM systems of tomorrow must recognise the need to identify a new cadre of leadership skills, where collaboration, openness, innovation and the passion for and embracing of new technologies will be far more critical than seniority and experience.

12 Integration with International Civil Aviation Organisation (ICAO) standards and practices will be essential long-term for UTM.

The ICAO UTM Framework document highlights the complexity of establishing UTM systems, and much can be drawn from the guidelines.

The conditions that complicate the successful development of UTM internationally, but can also be used to its advantage, include:

- the wide range of stakeholders that should be involved in researching, developing, implementing and maintaining a UTM system.
- effectively 'shoe-horning' UTM into a long-established ATM system and aviation regulatory environment, which is not always compatible with the demands of uncrewed aviation.
- incorporating a capacity to evolve with the rapid and varied growth of the UAS industry, as well as being compatible with existing ATM.
- allowing for innovation (in terms of technology and approaches), but needing homogeneity.
- ultimately being harmonised within regions and across international borders in due time for greater efficiency and safety and for the mutual benefit of crewed and uncrewed aviation.

Internationally, advances in developing the UTM architecture (in terms of policy, frameworks, regulations, infrastructure and software, for example) appear to be best achieved where there is a clear governmental recognition of the value of the UAS industry.

Other emerging aviation technologies, such as eVTOL and electric aircraft, may be typically captured in clear national or regional policy statements, as seen with Australia and the European U-Space policies.

Also crucial is a willingness to engage with other jurisdictions to learn from, to share knowledge or to align policy and regulatory procedures or to develop consensus around international regulatory harmonisation and implementation of regulatory frameworks.

Alongside this, clear steps or phases of development and implementation for the evolution of UTM systems are needed to accommodate growth, demand and continued innovation and investment in unmanned aviation.

Early adoption plays a large role, and this goes hand-in-hand with creating initiatives to engage, partner and work with a wide group of stakeholders within the ecosystem, including government, regulators, industry leaders, manufacturers, operators and the general public from concept to field demonstrations to full implementation.

The common skill sets required to achieve the level of interoperability, safety, security and growth require coordination, collaboration and communication in equal measures. There is also a requirement for ongoing and continuous "plan, do, check and review" to maintain relevancy.

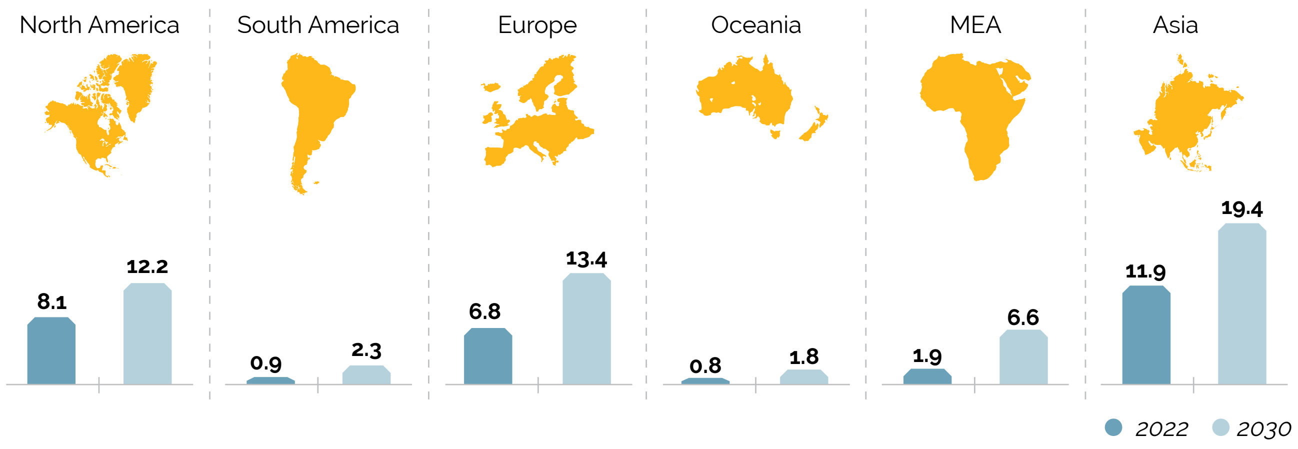
Not least of all, there is a need for a certain amount of collective tenacity, daring and vision to turn what might still be regarded as a futuristic concept into a viable global reality.

Summary

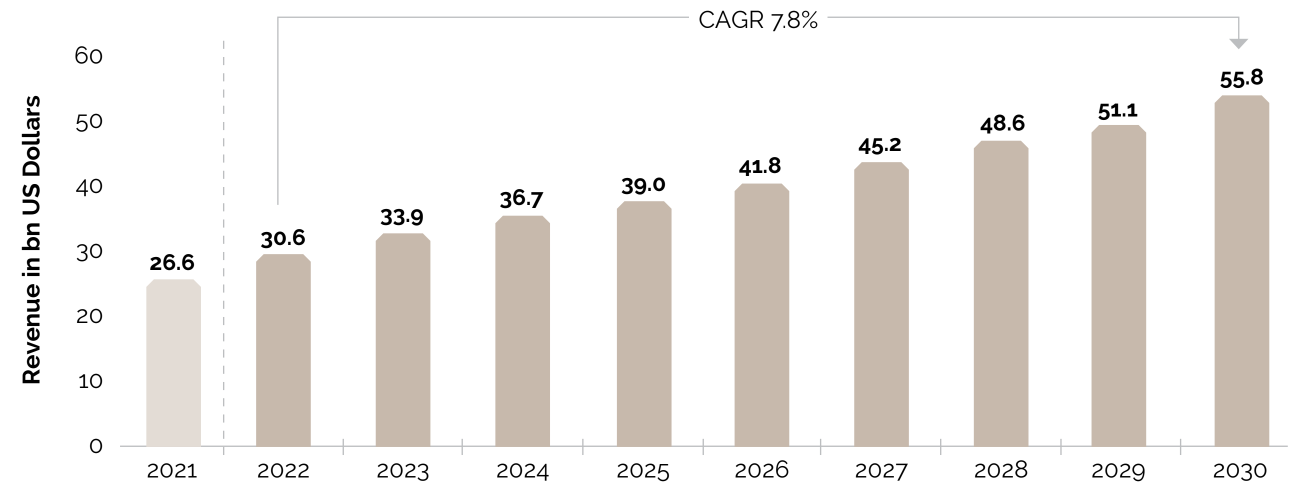
There are few industries that offer as great a potential as the drone industry and UTM in the world. According to DRONEII's 2022 Drone Market Report, the global drone market is worth an estimated US$30.6 billion in 2022. It's a stunning number – one poised for steady growth. DRONEII forecasts that the commercial drone market will experience a compound annual growth rate (CAGR) of 7.8% until 2030.

> "Overall, our drone market analysis shows that the market as a whole (commercial + recreational) will be worth US$55.8 billion by the year 2030."
>
> **Ed Alvarado, DRONEII**

Drone market growth by region



Total Drone Market 2022 - 2030



Source: 2022 Drone Industry Insights, droneii.com

> While Africa is not seen as a primary driver of growth in this industry, South Africa has the depth of aviation expertise, leadership on the continent, one of the most sophisticated and advanced transportation systems in Africa and capability to make the drone industry and UTM a key economic driver.

The key questions to take further past this position paper include:

- Will the next key steps be the creation of drone corridors or test sites under the flexible airspace use?
- What are the new financial models and ROI required in the near-, medium- and long-term future for UTM and the drone industry?
- Who are the key stakeholders to take UTM forward in South Africa and how will the new models of collaboration operate and remain effective?
- What will be required to elevate the economic importance and job creation of the drone industry and UTM at an executive political level in South Africa, and ensure buy-in nationally, in the provinces and the municipalities?
- What are the most important skill sets and best modes of grassroots development to ensure that UTM and the drone industry will have a steady pipeline of skilled employees and entrepreneurs for the future?
- How much of the UK, EU, Australian and US UTM model development is applicable to South Africa, what can be incorporated, what needs to be put aside?
- Where will the economic potential for drones be driven – through the country's Department of Economic Development, Department of Transport or the Department of Telecommunications and Technology?
- How will the new models in collaboration be measured and ensured they remain on track, and that stakeholders are being sufficiently engaged?
- Will there be consideration given to strategically positioning UTM as an opportunity for economic stimulation, particularly with drone pilot sites in rural and peri-urban areas?
- Are the SACAA, ATNS, ACSA and the Independent Communications Authority of South Africa (ICASA) prepared to embrace the development of drones and UTM strategically and are they allocating and preparing in-house resources to assist in the development of the industry?
- What is the level of spectrum required to build an effective and economically viable drone industry and UTM framework for the short-, medium- and long-term? What will be required to make this happen?
- Who will be the new leaders in this space, what systems, processes, culture, and personnel will they need to engage to ensure a successful future for UTM?

The members of the UTM-WG are exceptionally passionate about the growth and development of the drone industry and UTM. This group of highly motivated and capable individuals recognises the need for collaboration, the creation of new models and innovative ways of working. It is this group's commitment to this industry and its development that led to the creation of this position paper.

We believe in the drone industry and the power of UTM to change the world – and how we live, work, and fly – for the future.

Appendices

Appendix I – Interview List and Research Methodology

Interview List

	Name	Job title	Company	Country	Date interviewed
1	Tom Verbruggen	CEO	Aviatise	Belgium	04.08.22
2	Andre P Meredith	Senior Staff Officer Air Certification	South African Airforce	South Africa	08.08.22
3	Craig Poultney	Tower Controller at OR Tambo International	Aviation Transport Navigation Services (ATNS)	South Africa	15.08.22
4	Gary Vermaak	Advisor, consultant and ecosystem developer	Drone Logistics Ecosystem	South Africa	16.08.22
5	Patrick Sethole	OR Tambo International Airport (FAOR) Tower Pool Manager	ATNS	South Africa	18.08.22
6	Sharon Rossmark and Louise Jupp	CEO, Women And Drones Advisor, Women And Drones Africa	Women And Drones; Women And Drones Africa	USA & South Africa	19.08.22
7	Guido Schwartz	Director	NewSpace & Stem Foundation of Space Development Africa	Germany	22.08.22
8	Ian Kiely	CEO	Drone Consultants Ireland	Ireland	22.08.22
9	Philip Binks	Head of ATM	Altitude Angel	United Kingdom	22.08.22
10	Mercia Maans	Helicopter pilot	South African Police Services (SAPS)	South Africa	23.08.22
11	Brigadier Mahlangu	Section Head for Airwing	SAPS	South Africa	24.08.22
12	Thomas Matabane	Frequency Spectrum Specialist	South Africa Civil Aviation (SACAA)	South Africa	25.08.22
13	Alan Ball	Founder	Flying Robot (Pty) Ltd	South Africa	20.09.22

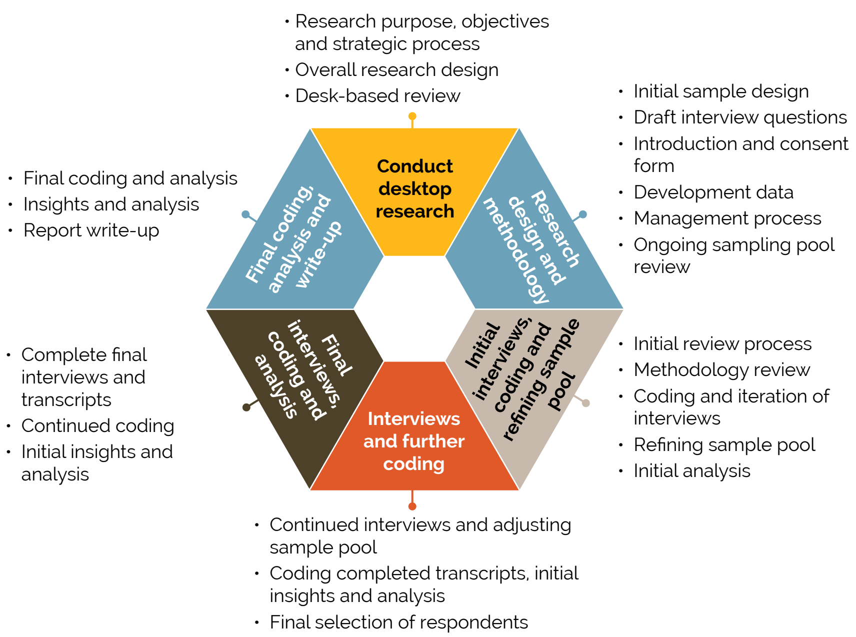
Research Methodology

AIfE employs a qualitative methodology consisting of a six-step process, which began with the overall research purpose where objective and strategic processes were determined.

This was followed by a desktop review of existing documents on UTM in the drone industry, focusing on the most recent documents. Following this process, draft interview questions were prepared while introduction letters and consent forms were finalised.

The third step involved the initial review process, coding and iteration of interviews. AIfE's research methodology encompasses a three-step codification process for the full extraction of key insights, which in turn, feed into the final analysis, key learnings and insights, recommendations and conclusions.

AIfE Research Methodology Process



Appendix II – 2022 UTM Publication Glossary and Acronyms

ADS-B	A surveillance technology in which an aircraft determines its position via satellite navigation or other sensors and periodically broadcasts it, enabling tracking.
ADSP	Airbus Drone Services Platform
Air taxis	A small aircraft for passengers, cargo, and mail, operated either on a scheduled or nonscheduled basis.
APRS	Automatic Packet Reporting Systems
ANSP	Air Navigation Service Providers
ATC/ATM	Air Traffic Control or Management
ATNS	Air Traffic Navigation Services (South Africa)
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority (South Africa)
CAR/CATS	Civil Aviation Regulations/Civil Aviation Technical Standards
Computation	Computation is any type of calculation that includes both arithmetical and non-arithmetical steps.
Computer vision	A field of AI that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs.
CSIR	Council for Scientific and Industrial Research
CUAASA	Commercial Unmanned Aircraft Association Southern Africa
Detect & Avoid	Onboard collision avoidance system on a UAS.
DoT	Department of Transport
DTI	Detect, Track and Identify
EVLOS	Extended Visual Line of Sight
EASA	European Union Aviation Safety Agency
Edge Computing	A distributed computing paradigm that brings computation and data storage closer to the sources of data.
Electronic conspicuity	An umbrella term for technology that helps pilots, uncrewed aircraft users and air traffic services be more aware of what is operating in surrounding airspace.
EMA	Electro-mechanical Actuators
FAA	Federal Aviation Administration (United States)
FDI	Fault Detection and Isolation
Fixed-Wing	Drones which comprise of a rigid wing and predetermined airfoil.
FUA	Flexible Use of Airspace
Geofencing	Software feature using GPS to define geographical boundaries.
Geospatial data	Data that includes a direct or indirect reference to a location on Earth.
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite Systems
GUTMA	General UTM Association
Hybrid drones	Hybrid drones operate on multiple sources of energy and can stay in flight for longer durations.
ICASA	Independent Communications Authority, South Africa
IFR	Instrument Flight Rules
ITU	International Telecommunication Union
LiDAR	Light detection and ranging scanner
Machine Learning	A method of data analysis that automates analytical model building.
Multilateration	A technique to determine a position of a node by measuring the distances through distance bounding protocols.
NASA	National Aeronautics and Space Administration (United States)
NASCOM/NAMP	National Airspace Committee/ National Airspace Master Plan
NQF	National Qualifications Framework
Payload	The payload is the weight a drone or UAV can carry.
POPI Act	The Protection of Personal Information Act (South Africa)
QIS	Quantum Interference Switching
Quadcopters	A quadcopter or quadrotor is a type of helicopter with four rotors.
Quantum internet	A network that will let quantum devices exchange information within an environment that harnesses the odd laws of quantum mechanics.
Quantum Key Distributions	A secure communication method which implements a cryptographic protocol involving components of quantum mechanics.

Restricted airspace	An area of airspace that air traffic must be restricted for safety or security concerns.
RIT	Real-time Identification Tracking
ROC	Remotely Piloted System (RPAS) Operators Certificate
RPAS	Remotely Piloted Aircraft Systems
RPL	Remote Pilot License (South Africa)
SACAA	South African Civil Aviation Authority
SACAR/SA-CATS	South African Civil Aircraft Register/South Africa Civil Aviation Technical Standards
SUAS	Small Unmanned Aerial System (<25kg)
Surveillance & Monitoring	This includes commercial drones used to capture video and still images to gather information about specific targets, including environments, groups, or individuals.
SWaP	Size, Weight and Power
SWIM	System Wide Information Management
TCAS	Traffic Alert and Collison Avoidance System.
TCL	Technical Capability Levels
TIA	Technical Innovation Agency (International)
Transponder	An avionic system located on board the aircraft that provides information about the aircraft identification and barometric altitude to the ATC system.
UAM	Unmanned Aerial Mobility
UAS	Refers to the whole system that includes a human-operated control base and a command and control system linking vehicle and controller.
UAV	An aircraft with no human pilot on board which can be flown remotely from the ground, or autonomously through a pre-programmed flight plan.
VLOS	Visual Line Of Sight Operations
VTOL	A vertical take-off and landing (VTOL) aircraft is one that can hover, take off, and land vertically.

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Appendix IV – UTM-WG Team profiles

The UTM Working Group (UTM-WG) consists of members from AIfE, SAIS and the UTM-WG project members who all contributed to the publication. Each individual in the UTM-WG is committed to the development of the drone industry and volunteered their time to write a section in the publication, attend UTM-WG meetings, the webinar, and provide feedback to the overall publication.

It is through the efforts of private individuals that this position paper came into being, and the immense cooperation of those in the private, public and government sectors who come together to make a difference in the future development of UTM in South Africa.

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