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# Implementing an Open-Access UTM Framework for the UK



**CATAPULT**  
Connected Places

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# Executive Summary

The adoption of Unmanned Aerial Systems (UAS), can deliver substantial economic benefits through a range of new applications and business models. Unmanned Traffic Management (UTM) will be required to unlock these benefits and provide safe and routine coordination of UAS as we move to increasingly automated and Beyond Visual Line of Sight (BVLOS) operations

The Department for Transport (DfT) commissioned the Connected Places Catapult (CPC) to develop and trial an open-access UTM framework to demonstrate an option for the UK's expanding drone sector to co-exist with other forms of aircraft. The project is designed to inform further research and demonstration activity within the Future Flight Challenge.

CPC, in collaboration with the DfT, Civil Aviation Authority (CAA) and industry stakeholders have developed a national UTM framework called Open-Access UTM. This programme has successfully progressed Open-Access UTM from concept through to live field trials, demonstrating how UTM could deliver air traffic management services in the future.

Through this programme, the UK is at the forefront of UTM innovation and a step closer to enabling commercial UTM operations within UK airspace. Adopting the Open-Access UTM Framework as the starting point for future UTM initiatives will enable projects including those funded via the Future Flight Challenge to build upon the development to date and accelerate future advances in UTM. CPC is actively engaging with the Future Flight Challenge to share the report and recommendations.

This report provides an overview of the Open-Access UTM architecture, an outline of the live field trials and the recommendations generated by CPC and industry partners. We would ask that these recommendations are considered by the relevant parties to further develop UTM in the UK.

## Key takeaways from the programme

- The live field trials were a world first, demonstrating multiple UTM Service Providers (UTMSPs) delivering traffic management services to multiple drone flights in a real-world environment with all UTMSP services and support provided remotely
- CPC and collaboration partners are well positioned to exploit the research and development investment in Open-Access UTM by supporting the Future Flight Programme, and working with Government and the CAA to help embed the principles in policy, legislation and regulation
- The programme proved the concept of a federated UTM architecture and interoperability of UTM service providers and initial set of services. The interoperability was delivered through a set of open application programming interfaces (APIs)
- The proof of concept was developed based upon ASTM International standards that are a mix of published and draft standards close to finalisation. These standards were designed to be international, and the programme demonstrated the availability of existing technology capable of implementing these standards
- The live field trials demonstrated the concept of interoperability between UTM service providers (UTMSPs). As policy, regulation, standards and technology mature, the industry will require an approach for testing and certifying new service providers and services within the Open-Access UTM ecosystem
- Whilst the programme focused on technical architecture and interoperability, the live trials have created an evidence base to inform the development of policy and regulatory frameworks required to facilitate commercial UTM operations
- CPC has the proven capability to manage large scale, complex field trials positioning the UK and CPC as the centre of excellence for future UTM collaborative research and development programmes

Recommendations are provided throughout the report and also summarised in the next section. Publishing these recommendations is intended to provide clarity and transparency on the next steps required to progress the development of UTM towards an operational system that enables advanced UAS operations in the UK.



## 2

# Summary of recommendations

## 2.1



## Policy

Implementing UTM requires cooperation between government and industry on multiple levels including technical, regulatory, and policy. Currently with UTM there is a “chicken and egg” problem of inter-dependencies amongst UTM technologies, standards, and regulations, preventing any one level from fully maturing. This cycle of dependencies hampers industry growth and the potential public benefits of UTM.

To break out of this set of inter-dependencies, one or more of these areas need to be “fixed”. The Open-Access UTM Programme has proven the feasibility of the initial set of standards and technologies associated with UTM services. The recommended next step in the UK is to define the UTM policy and regulatory frameworks to enable the other layers to mature and progress to commercial operations.

These recommendations outline the proposed next steps to develop the policy framework for the UK. Future Flight Challenge will enable further research and evidence to be collated to inform policy development.

**Recommendation:** Develop a policy to ensure equity and fairness of airspace access for regions and times where a first-reserved policy is not tenable. (7.4.5 *In-Flight Replanning*)

**Recommendation:** Create policy as to which governmental, non-governmental, or commercial entities can create dynamic restrictions and the types of dynamic restrictions to be used in the UK. (7.4.6 *Dynamic Restriction Management/Ingestion*)

**Recommendation:** Develop a policy to enable multiple UTMSPs to manage dynamic constraints on behalf of authorised entities. (7.4.6 *Dynamic Restriction Management/Ingestion*)

**Recommendation:** Consult and engage with all stakeholders to establish necessary policies to enable UTM services in the UK. (9 *UTM Policy Framework*)

**Recommendation:** Conduct a stakeholder engagement process on electronic conspicuity privacy, primarily focused on when and how additional, private information is made available to public authorities. (9 *UTM Policy Framework*)

**Recommendation:** Sponsor research on the legal and privacy concerns associated with UTM in order to develop sound government policy in these areas. (12 *UTM Legal Framework*)

**Recommendation:** Develop a policy that enables a sustainable commercial model for UTM. (13 *UTM Commercial Framework*)

## 2.2

## Regulation

The ASTM International *Standard Specification for UAS Service Supplier Interoperability* used the concept of a “regulatory overlay” that enabled localisation of the standards and implemented the necessary oversight and enforcement mechanisms. This allows international standards to be developed that can be applied to any country with the expectation that each country’s regulator would establish the specifics, such as which service providers are granted which roles and responsibilities, where each service is implemented and how the service provider approval process would be conducted.

These recommendations outline the proposed next steps to develop the regulatory framework for the UK. Future Flight Challenge will enable further research and evidence to be collated to inform regulatory development.



**Recommendation:** Develop further evidence to determine the level of federation of UTM services and definition of interfaces between regions. (7 *UTM Architecture and Scope of Services*)

**Recommendation:** Establish regulations and guidance to facilitate a UK-wide interoperability framework region with multiple DSS instances hosted by UTMSPs or other actors. (7.4.1 *Discovery and Synchronisation Service (DSS)*)

**Recommendation:** Implement APIs to the CAA registration database to facilitate UTMSP authentication of pilots and operators. (7.4.2 *Registration*)

**Recommendation:** Establish processes for granting and removing UTMSP privileges through the Interoperability Token Service. (7.4.2 *Registration*)

**Recommendation:** Develop methods and approaches to address bad actors within the UTM ecosystem. (7.4.4 *Monitoring and Alerting*)

**Recommendation:** Consider Network Remote ID (RID) as an acceptable method for implementing electronic conspicuity as the technology was proven to work during these trials. (7.4.7 *Network Remote ID*)

**Recommendation:** Establish a regulatory overlay for UTM services and the associated governance and oversight structure. (10 *UTM Regulatory Framework*)

These recommendations outline the proposed next steps to develop the regulatory framework for the UK

## 2.3 Industry

The programme proved the concept of a federated UTM architecture and interoperability of UTM service providers and initial set of services. These recommendations outline the suggested priorities for future service development and the need for a certification and testing regime for UTM. Future Flight Challenge includes a number of projects progressing the development of UTM which may be able to incorporate the scope of these recommendations.



**Recommendation:** Develop services that enable negotiation and prioritisation of operational intent between different UTMSPs. (7.4.4 Monitoring and Alerting)

**Recommendation:** Develop more sophisticated automatic routing/rerouting services. (7.4.5 In-Flight Replanning)

**Recommendation:** Establish a certification process for UTM architecture and services that is commensurate with the safety criticality of the service provided. It is

recommended that certification processes are appropriately developed based on performance and risk criteria and drawing upon relevant standards from manned aviation such as *RTCA DO-178C/ED-12C and DO-278A/ED-109A*. (11 UTM Assurance Framework)

**Recommendation:** Establish automated UTMSP testing capabilities to support initial and recurring automated testing of UTMSPs. (11 UTM Assurance Framework)

## 2.4

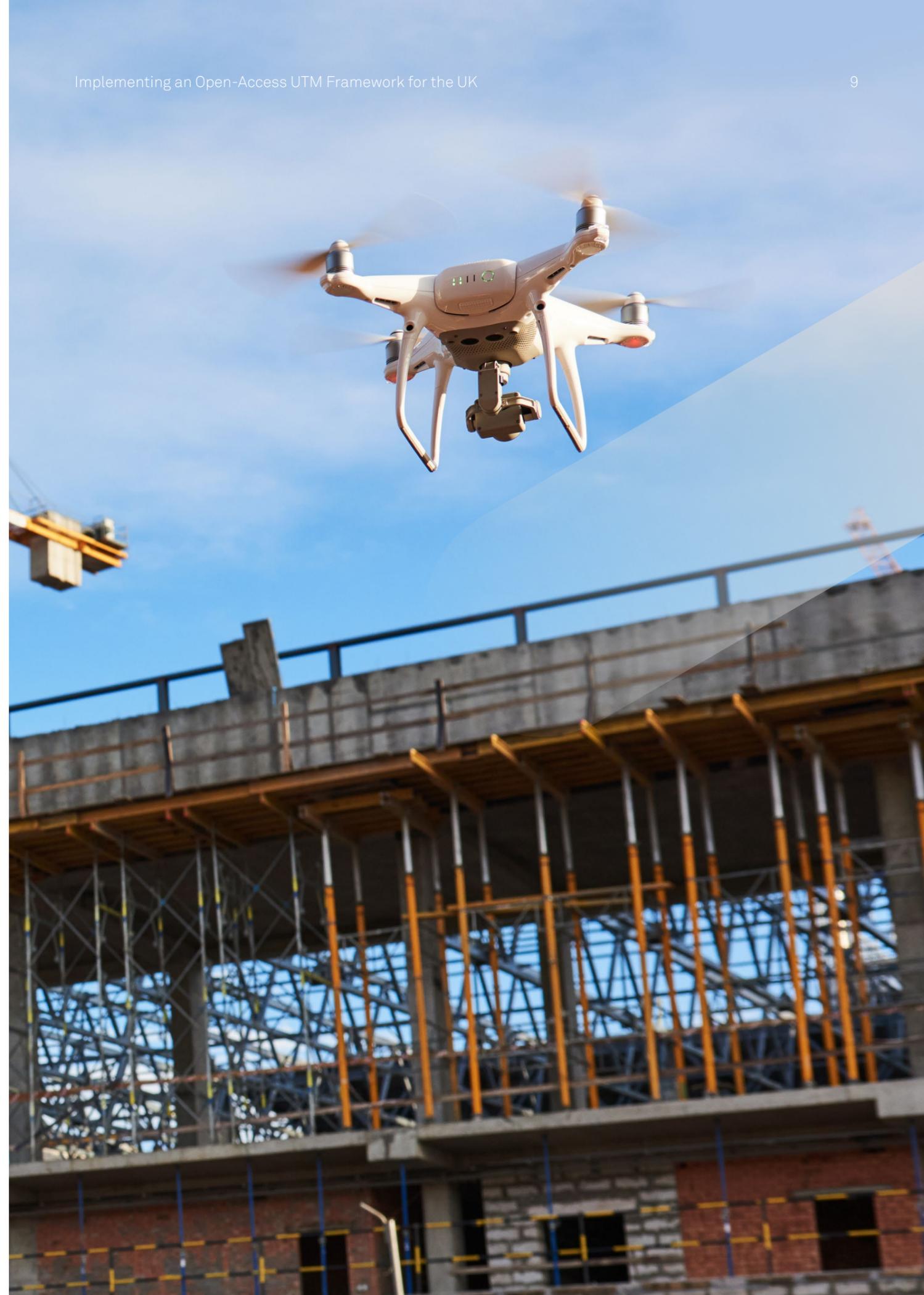
### UTM Stakeholders

The standards for UTM are evolving at pace. There is greater opportunity for the UK to actively engage to shape the future of standards and share the knowledge and experience gained through developing the Open-Access UTM.



**Recommendation:** Increase UK participation in the standards development process for international UTM standards. Where standards are needed but not available,

a neutral convener such as CPC should act to address gaps as soon as possible. (7.1 UTM Standards)



## 3

# Introduction

Since the dawn of aviation over 100 years ago, aviation capability and capacity has scaled at an incredible pace whilst keeping safety at the forefront of every development. We are now witnessing the next phase in aviation development, which will lead to a significant increase in the volume of remotely piloted and automated aircraft.

This will include small drones for surveying and inspection through to large aircraft for transporting freight and people and uses that we have yet to imagine. Over the next decade, *due to the forecast growth*, the number of unmanned flights is predicted to be several orders of magnitude greater than manned aviation.

Advances in technology such as battery capacity, communications, sensors and onboard processing technology have enabled the development of new types of inexpensive unmanned aircraft which our current airspace was not designed to handle. This offers opportunities for new aviation services including away from airports and integrated with existing modes of transport such as delivery vans.

This will place increasing demands on airspace access and traditional approaches to airspace management will become progressively unmanageable, costly and a risk to safety. We will need a new way of working.

In the UK regulation has evolved rapidly over recent years to enable drones to fly. Most drone flights are currently operated within visual line of sight (VLOS) of the remote pilot. This enables the remote pilot to “see and



avoid” any ground-based obstacles and other airspace users. This is practical for many uses such as asset inspections and surveying. However, to unlock the maximum potential of unmanned aviation, we need to enable aircraft to fly BVLOS of the remote pilot.

Operating an unmanned aircraft BVLOS is not explicitly prohibited by regulation in the UK. However, currently it requires additional considerations, such as provisioning a Temporary Danger Area (TDA) where there is minimal risk to other airspace users. This approach isn't sustainable as the requirements for BVLOS operations develop and the volume of requests to the CAA increases. In addition, TDAs inhibit access to airspace by other air users such as those in General Aviation (GA).

The challenge is, therefore, to develop a solution that is equivalent or superior to “see and avoid” without the need to segregate unmanned aviation and so allow operations within airspace that is shared with other aircraft. This requires further development of policy, regulation, standards and technology.

There is already a growing market of services around the world aiming to provide elements of an ecosystem that manages unmanned aircraft. Whilst onboard drone technology, such as ‘detect and avoid’ (DAA), will go some way to enabling flight BVLOS, Unmanned Traffic Management (UTM) is the key element of the ecosystem that is required to provide accurate visibility and situational awareness to enable strategic deconfliction of airspace users.

## 4

# What is UTM?

As the volume of drone traffic increases, we need to move to a more scalable, digital air traffic management system that can enable these new types of operations and keep aircraft safely separated. This system is referred to as Unmanned Traffic Management, or UTM.

Inevitably, unmanned aircraft and UTM will also be required to integrate with existing air traffic management services to provide a unified approach to airspace management. In the future, we may even explore how UTM can accommodate traditional airspace users as their operations become increasingly more automated and digitalised.

Traditional air traffic management systems have tended to be centralised within countries or regions. Due to the forecast volume of UAS traffic, the UK along with the majority of the world is exploring a framework that enables a market-based, federated network of UTM service providers. Each provider can deliver a range of services enabling them to adapt as new requirements surface and the market evolves. Whilst the majority of services are decentralised to UTMSPs to enable market growth and flexibility, others may be centralised for efficiency and the Government

and the CAA as the UK regulator will maintain key roles ensuring continued safety and equity of the UK's airspace.

Mobile phone networks provide a helpful analogy. The consumer has a choice of providers that offer a range of services for an agreed cost. It is envisaged that geographic areas may have multiple UTMSPs and the operator will be able to choose the provider that most closely matches their requirements. The regulator will ensure that the relevant safety, security, and performance standards are complied with and also ensure interoperability, real-time communication between UTMSPs, and any necessary centralised services are in place.

The UTM services demonstrated during the live trials are summarised below and a more detailed explanation of the services are provided in subsequent sections of the report.

1. **Registration** - validate the vehicle, the pilot, the operator, and the service supplier against a national registration system prior to flight planning and take-off
2. **Strategic Deconfliction** - provide pre-flight and in-flight planning services to ensure that unmanned aircraft maintain safe distances from other airspace users
3. **Monitoring and alerting** - live monitoring of individual flights and alerting the flight owner and other airspace users if the flight deviates from the agreed plan
4. **Inflight Replanning** - modifying the flight plan after takeoff in response to dynamic airspace information
5. **Dynamic Restriction Management/Ingestion** - Disseminating information about airspace restrictions to enable priority manned, unmanned, or ground operations
6. **Remote identification** - identify an aircraft and provide additional information such as its position, direction of travel and speed

Whilst the decentralised approach to UTM has benefits, it creates the challenge of ensuring that all UTMSPs have a complete picture of other operations in their geographic area. For example, one flight may be operating with services from UTM provider X, whilst another flight in the same geographic area may be operating with services from UTM provider Y. There needs to be reliable, secure and timely interoperability and data exchange between UTMSPs.

Demonstrating the concept of interoperability between UTMSPs has been the primary focus of the project. ASTM International working group WK63418 is developing a set of standards for UTM services and interoperability. These draft standards provide the foundations for the architecture and open API used by this project to develop and prove the concept of interoperability.



# 5

## Policy Framework

There are many technology challenges to still be addressed, as with many emerging markets, it is an enabling policy rather than technology that will truly unlock the potential opportunity of the unmanned aviation sector.

There are many technology challenges to still be addressed, as with many emerging markets, it is an enabling policy rather than technology that will truly unlock the potential opportunity of the unmanned aviation sector.

Given the emergent nature of the unmanned aviation sector, technology is evolving rapidly whilst regulation and standards development need to progress in parallel.

Proving the concept of interoperability between UTMSPs was an essential step on the technology roadmap to facilitate implementation of UTM services. Defining policies and timelines for regulations, centralised services, and roles and responsibilities will enable UTM implementation to accelerate. Government policy can break the complex cycle of interdependencies amongst UTM technologies, standards, and regulations.

Continuing the analogy with the mobile phone networks - the UK market is one of the most open and competitive in the world. Early and effective government policy enabled the mobile phone sector to innovate, creating new services and setting international standards that facilitated rapid growth and adoption within the UK.

The introduction of UTM will require a holistic policy, regulatory and legal framework for traffic management, encompassing both unmanned and manned traffic systems. This will ensure the continued safety for all airspace users and address the equity of airspace access. UTM has the potential to provide benefits to other airspace users including GA. Achieving these benefits will require active participation with UTM services and adoption of principles such as electronic conspicuity.

The Government's *Aviation Strategy 2050* and the *CAA's Airspace Modernisation Strategy (AMS)* provide the foundations but additional work is required to develop a policy framework that enables the UK to lead the growth of the nascent unmanned aviation sector. This work has demonstrated the fundamental capability of the technology and the suitability of the architecture. To continue to support the growth of this sector, policy action is required.

# 6

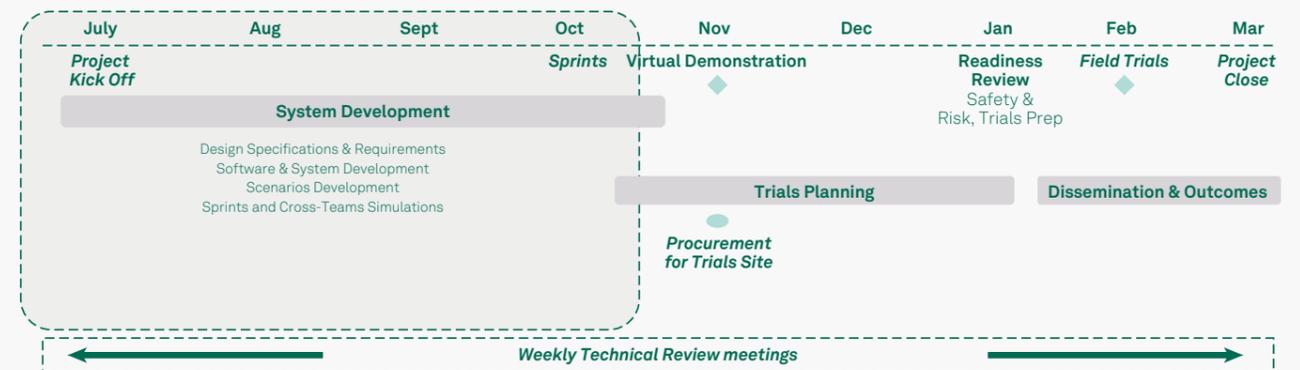
## Overview of the Project

The project was delivered working with partners selected through an open and competitive procurement process. This project is part of a larger Open-Access UTM programme, building upon the previous phase of developing the Open-Access UTM architecture.

The aim of the project was to create a proof of concept to explore UTM and drone operations with the emphasis on demonstrating interoperability between UTMSPs and necessary supporting services such as registration. The outcomes are detailed later in the report and support the recommendations and next phases of research required.

**Figure 1** shows an overview of the project approach and timescales spanning 2020 and 2021. This fast-paced project used an agile-like development process to quickly implement, integrate, and develop a proof of concept to demonstrate UTM services across multiple UTMSPs, both with simulations and live flights..

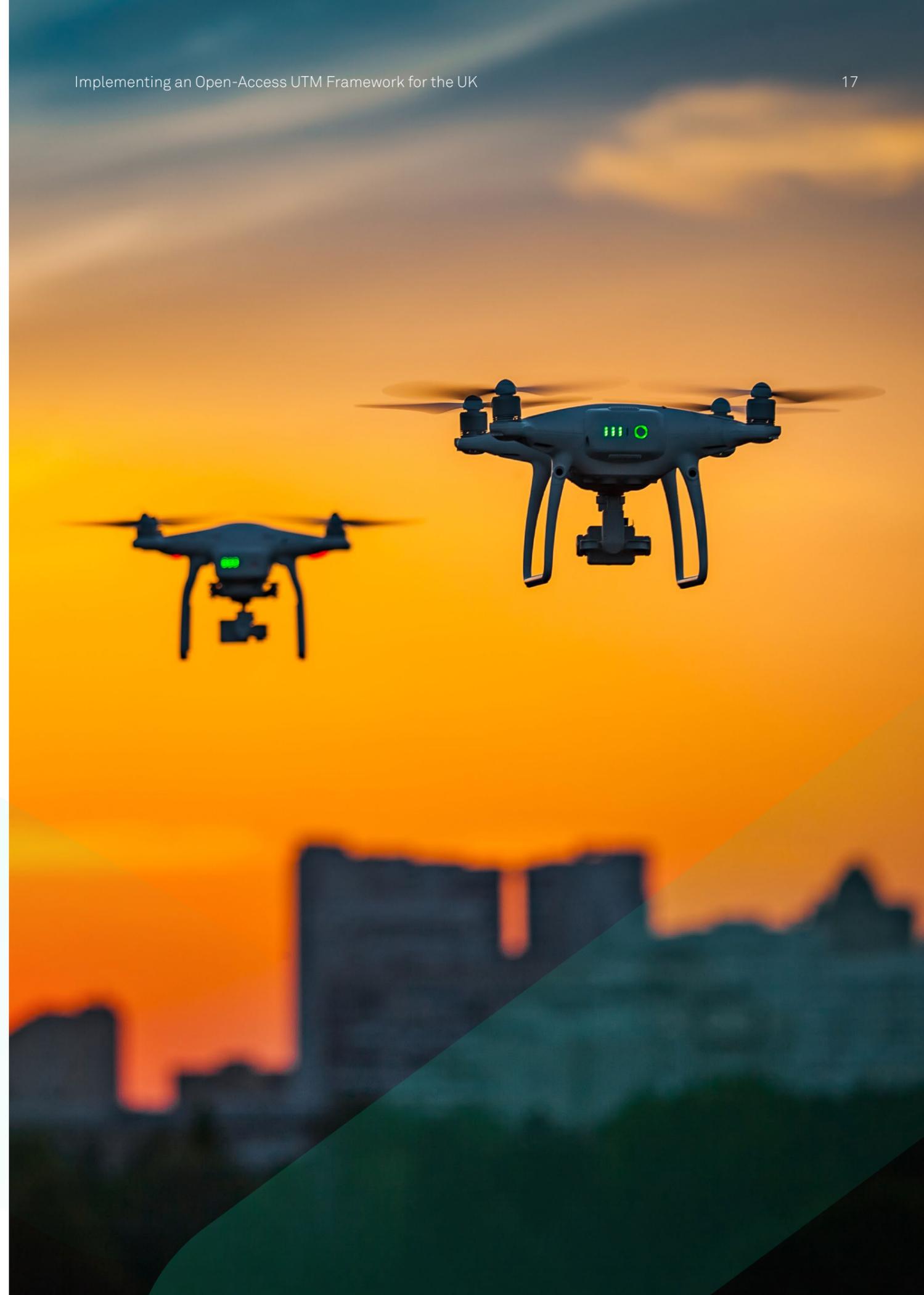
Figure 1: Programme approach and timescale



The roles of the collaboration partners are outlined in **Table 1**. CPC acknowledges their support and dedication required to successfully deliver this project.

Table 1: Collaboration partners

Role	Organisation	Description
UTM Service Provider		Altitude Angel is an aviation technology company who create global-scale solutions that enable the safe integration and use of fully autonomous UASs into global airspace. Altitude Angel have developed a purpose-built cloud platform that supports both U-Space and UTM, and delivers market-leading services to UAS Operators, manufacturers and software developers. In this project, the primary role of Altitude Angel is to support the development UTM regulatory framework.
		ANRA provide a low-cost cloud-based platform used for enabling sensor data acquisition, dissemination, simultaneous ground/air command and control functionality as well as communications for Line-Of-Sight (LOS) and BVLOS operations. ANRA has taken part in multiple R&D campaigns to test BVLOS and LOS UTM operations and concepts at various test locations around the USA and internationally.
		Collins Aerospace Systems is a leader in technologically advanced and intelligent solutions for the global aerospace and defense industry. Drawing upon their avionics expertise, they bring enhanced situational awareness, surveillance, navigation and communications to unmanned systems in some of the world's toughest environments.
		AiRXOS, a wholly owned GE venture specialises in unmanned air systems and UTM systems. Its mission is accelerating the safe, efficient, and scalable growth of unmanned vehicles, delivering services and solutions for UTM. The company supports municipalities, regional aviation authorities and private sector operators to manage and meet the increasing demand for sophisticated and safe UAS operations..
InterUSS Platform		Wing, a subsidiary of Alphabet, has built a small, lightweight aircraft and navigation system that can deliver small packages – including food, medicine, and household items – directly to homes in minutes. Created in 2012, Wing has conducted more than 100,000+ flights across three continents. They believe drone delivery will improve the way our cities operate by reducing road congestion and creating new economic opportunities for local businesses.
Drone Operator		SkyLift designs, develops and operates specialist commercial drones for a variety of specialist roles in hostile and rugged environments. Their focus is on heavy lift, security and maintenance tasks. Drones are changing the way we aviate and they are at the forefront of that innovation.



7

# UTM Architecture and Scope of Services

The concept and architectures for UTM have been evolving over the last few years since the initial conceptual work and flight trials by NASA's Ames Research Center in 2015. UTM is maturing and countries around the world are adopting regulations and policies to use UTM to integrate UAS into their airspaces.

The International Civil Aviation Organisation (ICAO) has published a common framework for UTM<sup>1</sup> based on a series of annual international workshops to begin harmonisation of UTM concepts and terminology world-wide. The CAA has outlined their latest position on *a unified approach to the safe integration of unmanned aircraft systems (UAS) outlined in CAP 1868*. The European Union developed a UTM concept for Europe, called U-Space,

under a SESAR Joint Undertaking. This has led to a pending (European Union Aviation Safety Agency) EASA high-level regulatory framework for U-space.<sup>2</sup>

The Open-Access UTM architecture aligns with the ICAO UTM principles and is one piece of implementing the *UK's Airspace Modernisation Strategy of integrating drones seamlessly into the UK airspace as described in CAP 1711 (December 2018)*. The shared CAA and DfT objective for airspace modernisation is to:

“Deliver quicker, quieter and cleaner journeys and more capacity for the benefit of those who use and are affected by UK airspace.”

The digitalisation, automation, and data-sharing UTM attributes demonstrated during this programme will help to integrate drones into the airspace which can perform missions in a safe, efficient, and environmentally-friendly manner. The role of airspace constraints managed by UTM

can also help enhance defence and security, one of the additional objectives of airspace modernisation.

For the UK, a tailored UTM concept and architecture has been developed by Connected Places Catapult's collaborative Open-Access UTM programme. The scope

1 <https://www.icao.int/safety/UA/Pages/UTM-Guidance.aspx>  
 2 <https://www.easa.europa.eu/document-library/opinions/opinion-012020>

of the Open-Access UTM system, as described in the *Enabling UTM in the UK* white paper is as follows:

1. Initial UTM assumes Very Low-Level (VLL) Operations (<400ft)
2. UTM applies to unmanned aircraft in the *Open and Specific categories*
3. All participating drones will be electronically conspicuous
4. Traffic services are digital and automated
5. UTM to enable the spectrum of nominal and emergency scenarios foreseen for UAS operations

6. UTM does not require the establishment of new airspace classes although there is a need for greater awareness and adjustment in the aviation community that operates below 400ft. This is likely to require active participation with UTM and adoption of principles such as electronic conspicuity

Based upon this scope, a target architecture was developed during earlier phases of the CPC Open-Access UTM programme. This architecture was implemented to develop the proof of concept and demonstrate real-world scenarios through simulations and live field trials. This architecture, shown in **Figure 2**, identifies the primary UTM actors and their connections.

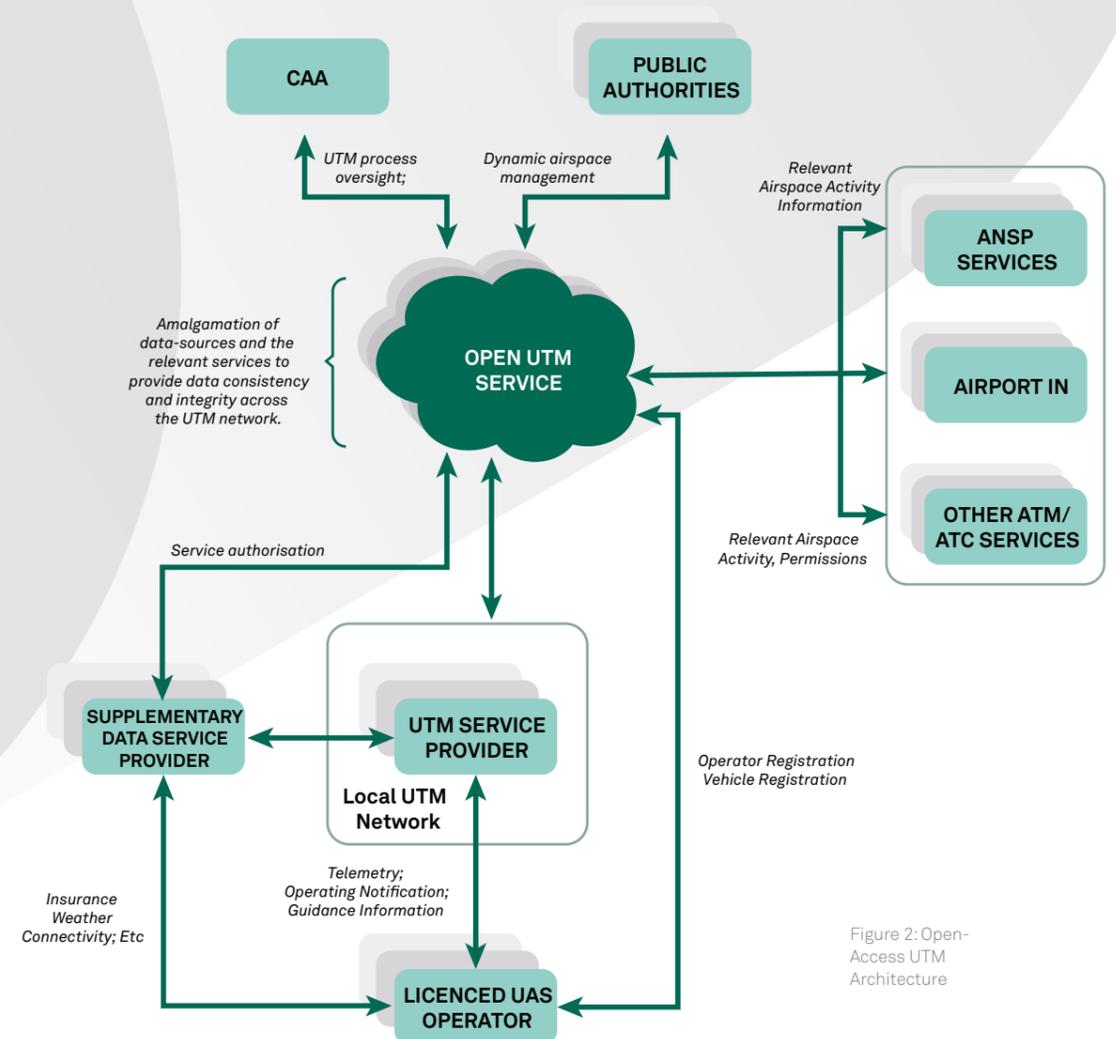


Figure 2: Open-Access UTM Architecture

This architecture is underpinned by the following key design principles:

- The architecture is federated, in that there are multiple UTMSPs serving UAS operators in a given region
- The architecture contains a Local UTM Network (LUN) which facilitates inter-UTMSP communications in a standardised manner
- The architecture enables integration with existing airspace users through integration with ATC and air navigation service providers (ANSP) services, along with surveillance feeds from Supplementary Data Service Providers (SDSPs) to provide airspace situational awareness

- Public authorities are connected to the UTM system to facilitate dynamic airspace management during emergencies and special events
- The Open UTM provides centralised services and connections and is depicted as a cloud as these are still maturing
- The CAA is included in the architecture providing regulations and oversight of the entire system

**Recommendation:** Develop further evidence to determine the level of federation of UTM services and definition of interfaces between regions.



## 7.1

### UTM Standards

The Open-Access UTM system depends on interoperability of services based upon defined interface standards. These standards come in different forms including regulatory standards, industry consensus standards, APIs, and commercial service-level agreements (SLAs). International standards enable service providers to provide services in multiple countries, reducing development costs and pricing to customers.

The Open-Access UTM architecture was developed to deliver live field trials, utilising published and draft standards including:

- ASTM WK63418, *Standard Specification for UAS Service Supplier Interoperability*, (commonly called the ASTM UTM Standard). Currently in draft and includes the specification for strategic deconfliction and constraint management services. It also includes the UTMSP-UTMSP API and Discovery and Synchronisation Service (DSS) API for strategic deconfliction and constraint management
- ASTM F3411-19, *Remote ID and Tracking* (Published). This includes the Network Remote ID API and DSS API for remote ID
- Registration API (Mock-up). Developed for this project based upon a specification developed in conjunction with the CAA

Whilst significant progress has been made to define standards for UTM architecture and services, the following areas identified by this project require definition or further development:

- Specification for the Registration APIs require finalising with the CAA
- Interfaces with Air Traffic Control (ATC) and Air Navigation Service Providers (ANSP) for controlled airspace access (not explored during this project)
- UK-specific constraint data format. It is recommended that this should be based on the EUROCAE ED-269 Geographical Zone Data Model, which is being incorporated into the ASTM WK63418 UTM standard API

- Certification process for UTM architecture and services that is commensurate with the safety criticality of the service provided. It is recommended that certification processes are appropriately developed based on performance and risk criteria and drawing upon relevant standards from manned aviation such as *RTCA DO-178C/ED-12C and DO-278A/ED-109A*. (*U1 UTM Assurance Framework*)
- Human factors standards for pilot interfaces for UTM services to ensure consistency of safety critical services such specification of flight plans and pilot alerts and notifications. There is also a need for common language and representation for key concepts such as altitudes, flight volumes and operation start times

**Recommendation:** Increase UK participation in the standards development process for international UTM standards. Where standards are needed but not available, a neutral convener such as CPC should act to address gaps as soon as possible.

## 7.2 Actors

**Table 2** lists the complete set of UTM actors identified for the Open-Access UTM architecture.

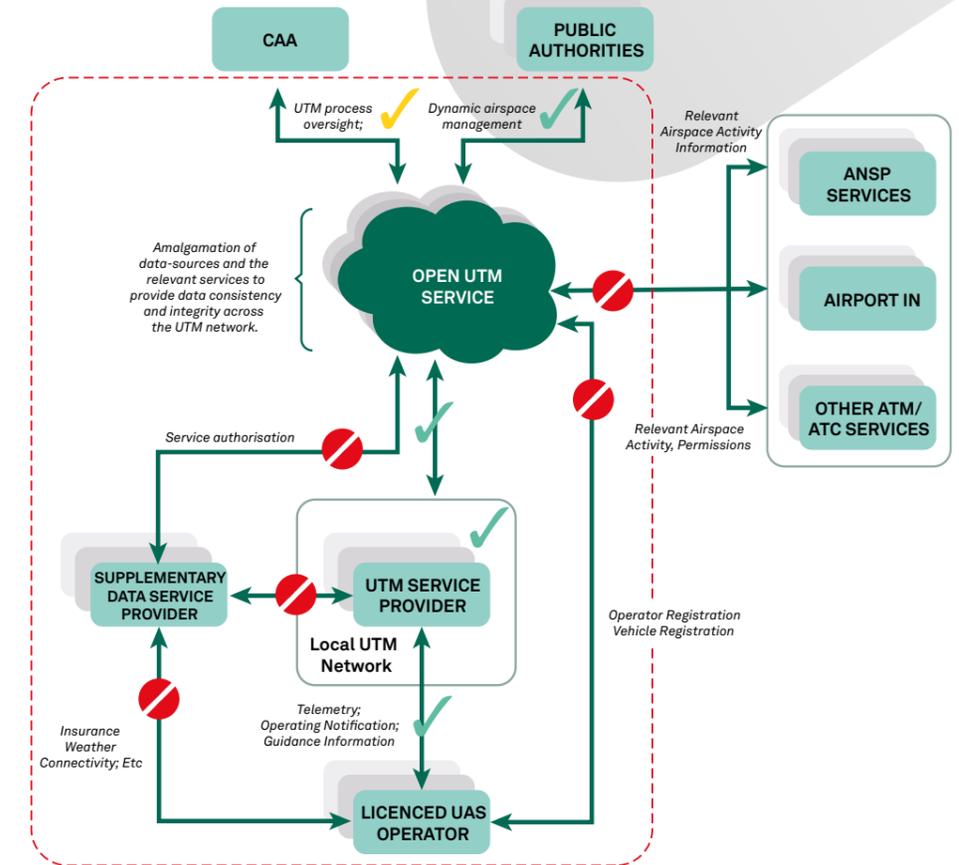
Table 2: Open-Access UTM Actors

Actor	Description
CAA	The CAA is responsible for the regulation of aviation safety in the UK, and determining policy for the use of airspace. In the context of UTM, they will look to ensure the industry meets the appropriate levels of safety and that airspace is utilised efficiently. As a result, the regulator can be expected to maintain the role of overseeing the UTM system and UTM-related activities, interface with the UTM system to ensure all participating actors behave appropriately, and perform services in accordance with defined regulations. This will include guidance about the appropriate levels of safety, development of approvals, licences and registration for UTM participants.
Public Authorities	Public authorities include government departments, aviation authorities, local authorities, the police, the military, and other agencies that are expected to play necessary roles to coordinate access to airspace or potentially impact operations. Public authorities specifically the UK Emergency Services have a joint operational model for the use of an aerial service. This service is distributed across the country and is able to coordinate emergency operations with the local and national air traffic services. The Open-Access UTM programme has taken this into consideration when considering the use of dynamic restrictions to support emergency operations.
Open UTM Service	The Open UTM Service (OUTMS) is an entity, managed by service providers, which sits at the intersection of many service interactions between UTMSPs and others to facilitate the exchange of data. It has several roles including the interface for the CAA to access regulatory data for oversight and audit, provide UTMSP digital authorisations to operate, and provide a discovery function if not provided by UTMSPs. Authorisations for UTMSPs to participate in the Local UTM Network are provided through the Interoperability Token Service portion of the OUTMS.
UTMSPs	UTMSPs enable UAS Operators to safely and efficiently operate in the national airspace through implementing the majority of the UTM services. There is a need to consider different categories of UTM service providers to cater for the breadth of airspace stakeholders who need to engage with UTM e.g. law enforcement, fire services, town and city councils, military and commercial organisations.
UAS Operators	The UAS operator is the individual or enterprise responsible for the safe control and operation of their vehicle. Future drone operations are likely to become increasingly complex in nature, and as the number of drone operations increases and the sector matures, the UAS operator may become subject to additional requirements and responsibilities that reflect the nature of their operations, and the vehicle performance. The operator's role in the UTM ecosystem will also have to account for issues of accountability and legal considerations of responsibility. There are two types of UAS Operators considered: the individual drone pilot and the operating organisation.
UAS	Unmanned aircraft will have to be made to regulatory requirements e.g. equipment standards prior to being operated in a UTM environment. UAS aircraft will have to support electronic conspicuity and geofence technologies in addition to typical health information about Command & Control (C2) link, GNSS link status and battery health to name a few.
ATMSPs	ATM services are required to interface with UTMSPs to assure safety – particularly within the vicinity of airports, as well as throughout controlled airspace. ATM services are considered separate though complimentary to the services provided by UTM service providers. Air Traffic Management Service Providers (ATMSPs) will have the responsibility to manage manned aviation of all types in designated classes of airspace and will have the power to approve or deny any UTM activities that are deemed to interact with the ATM activities. The ATMSP might consist of the ATC provider and/or authorised service providers, such as ANSP, UTMSP, SDSPs, depending on the capabilities (i.e., specific services and functions) of the given Controlled traffic zone (CTR).
SDSPs	Supplementary Data Services Providers (SDSPs) offer additional information services that will typically support a UTM actor to plan, validate and verify information, or inform a decision-making process.
Public Users	Members of the general public, are included as actors as nearby UAS operations will provide services to them (e.g. delivery) but may also provide environmental concerns (e.g. noise). Generally the public will influence the UTM system through public authorities, but may also have a direct connection through services such as electronic conspicuity displays.

## 7.3 Proof of Concept - Actors

The proof of concept explored and demonstrated the OUTMS, UTMSP, UAS Operator, UAS, and Public Authority actors' roles, responsibilities, and interfaces as shown in **Figure 3**. There were multiple UTMSPs providing services in the same region forming a Local UTM Network and sharing information to perform the strategic deconfliction and monitoring and alerting services. Each UTMSP provided a proprietary connection to the UAS Operators and their UAS. The project did not explore the ATMSP, SDSP, or Public User actors.

Figure 3: Project Scope



The OUTMS, hosted by Wing, provided registration services, DSS, and the Interoperability Token Service. While the CAA participated in planning discussions during the project, no CAA systems were integrated. The Wing OUTMS provided a notional registration service playing the role of the CAA. Likewise, the OUTMS provided authorisation tokens to all UTMSPs without any CAA approval process, which would be needed in an operational system (see the section below on Governance).

Dynamic Constraints, that is airspace volume restrictions, were published by UTMSPs on behalf of simulated public authorities. These dynamic restrictions were ingested by the UTMSPs serving operators and made available to the UAS Operators who could then adjust planned flight paths through dynamic replanning.

SDSPs were not integrated during the project, primarily due to the lack of available, standardised, or approved services. Currently in the UK there is no guidance or policy on which SDSPs need to be approved or regulated for use in UTM and which, if any, need to be based on "official" data sources. This lack of certainty likely has inhibited commercial entities entering the SDSP market.

**Recommendation:** Develop a policy for Supplementary Data Service Providers (SDSPs) including definitions of official data sources and the process for approving data sources and providers.

## 7.4 Proof of Concept – Services

Six services were implemented and demonstrated through the proof of concept:

- 1. Registration** - validate the vehicle, the pilot, the operator, and the service supplier against a national registration system prior to flight planning and take-off; includes the Interoperability Token Service
- 2. Strategic Deconfliction** - provide pre-flight and in-flight planning services to ensure that unmanned aircraft maintain safe distances from other airspace users
- 3. Monitoring and Alerting** - live monitoring of individual flights and alerting the flight owner and other airspace users if the flight deviates from the agreed plan
- 4. Inflight Replanning** - modifying the flight plan after take-off in response to dynamic airspace information
- 5. Dynamic Restriction Management/Ingestion** - Disseminating information about airspace restrictions to enable priority manned, unmanned, or ground operations
- 6. Network Remote ID** - identify an aircraft and provide additional information such as its position, direction of travel and speed

In addition to those six UTM services, an enabling service, the DSS, for remote ID and strategic deconfliction was used for this project..

### 7.4.1 Discovery and Synchronisation Service (DSS)

The DSS is an enabling service that is necessary to establish the LUN to support transfer of information amongst UTMSPs and with the OUTMS. The DSS is part of the interoperability paradigm established as part of the ASTM Remote ID and UTM Interoperability standards. It enables discovery and sharing of information, and ensures consistency of the data. An open-source implementation of the DSS, which was used for this project, is available through the InterUSS Linux Foundation project.<sup>3</sup>

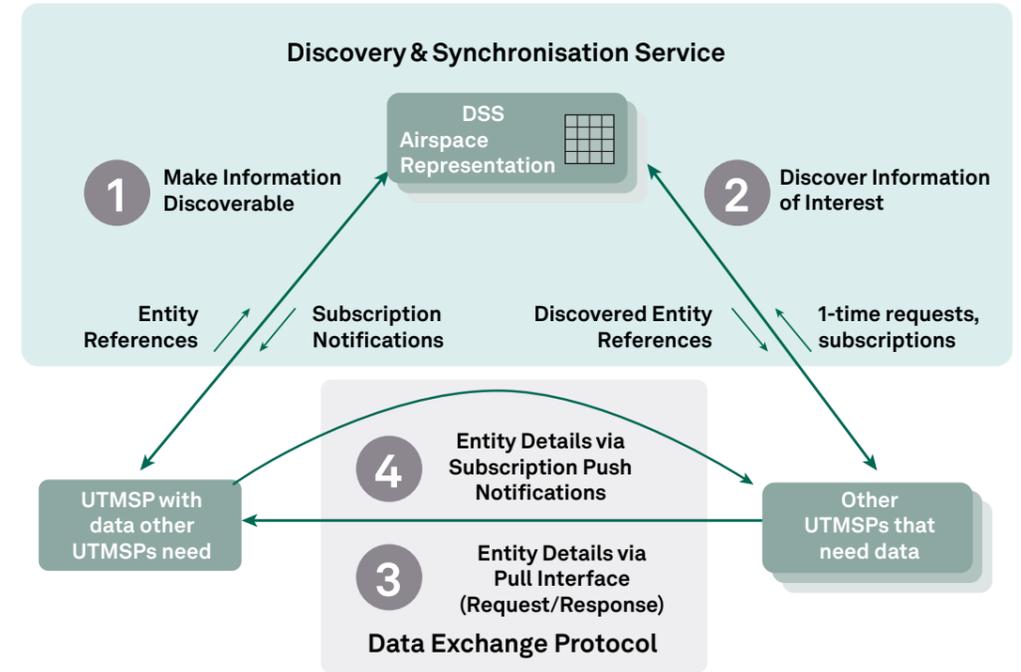
The interoperability paradigm consists of two parts:

1. A standardised discovery mechanism, the primary functions of which are to **(1)** identify UTMSPs with which data exchange is required and **(2)** verify that a UTMSP considered relevant entities owned by other relevant UTMSPs
2. Service-specific data exchange protocols used to obtain the details of entities discovered via the DSS from the owning UTMSP

While the interoperability paradigm is currently used across multiple specifications (Remote ID and UTM Interoperability), the service-specific aspects are detailed in each applicable ASTM specification. **Figure 4** illustrates this paradigm's data exchanges in a service-independent manner. DSS related interactions are shown at the top in the blue-shaded area; data exchange protocols between UTMSPs are shown in the bottom in the green-shaded area.

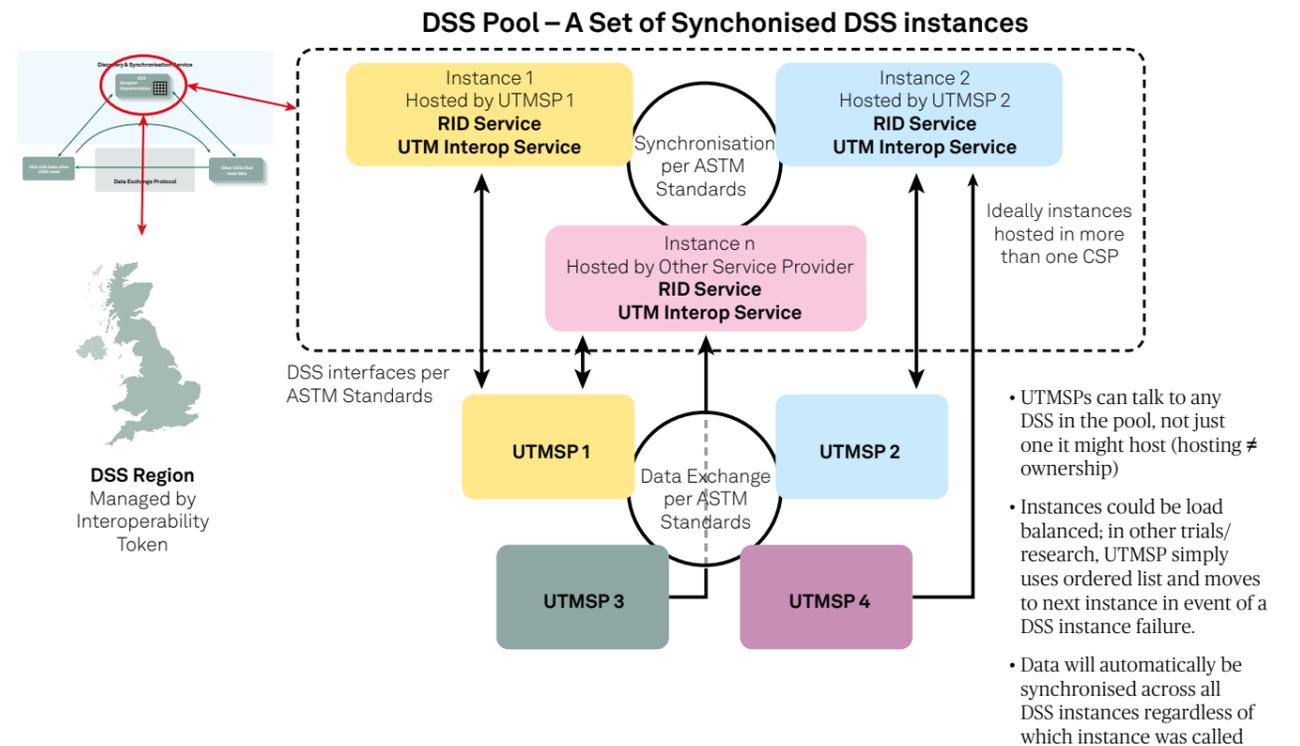
<sup>3</sup> <https://interussplatform.org/>

Figure 4: Interoperability Paradigm



For safety and availability purposes, the DSS is a redundant service as indicated in **Figure 5**. Instances of the DSS in a region (a DSS Pool) synchronise with each other in a standardised manner. A DSS Region is the geographic area supported by a set of DSS instances.

Figure 5: DSS Regions and Pools



For this project and for future operational implementation, we recommended that a single region be used corresponding to the UK. While smaller regions are possible, they offer no benefit and increase the complexity for UTMSPs in instances where an operation traverses more than one DSS region.

While the DSS instance for this project was associated with the Open UTM Service Provider (OUTMSP), in a live operational environment, we recommend that DSS instances be hosted by UTMSPs or other actors. By allocating responsibility for the DSS instances to the UTMSPs, it reduces the scope for the OUTMSP and allows for

enhancements to the DSS to be done quickly based on industry needs and evolving standards. DSS implementations can be authorised for operational deployment as part of the onboarding process for the associated UTMSP, as discussed in [Section 10 UTM Regulatory Framework](#).

**Recommendation:** Establish regulations and guidance to facilitate a UK-wide interoperability framework region with multiple DSS instances hosted by UTMSPs or other actors.

## 7.4.2 Registration

There are potentially four types of registrations required to enable authentication with UTM services:

1. Unmanned aircraft (when necessary)
2. Remote Pilot in Command
3. Operator (where necessary separate to Pilot registration)
4. Service Providers namely UTMSPs, ATMSPs and SDSPs

In an operational environment it is envisioned that one or more national registration systems will exist and the OUTMSP provides a conduit to those systems. The registration of operators, flyers, and potentially aircraft in the future is outside the scope of the OUTMSP and would be handled by direct interaction with the CAA's national registration system. In discussions with the CAA for this project, they indicated their intention to support direct interaction with the national registration system, either through an interactive website and/or through APIs that would be made available to UTMSPs to use on behalf of their customers.

However, a CAA national registration system was not available for use in this project, so the OUTMSP provided a registration system that simulated the CAA service based

upon a draft API containing data elements identified through discussions with the CAA and UTMSP stakeholders. This simple API provided to the UTMSPs for interacting with the OUTMSP registration service is essentially the same as one that would eventually be provided by the national registration system for direct interaction. There is a need to build global and regional consensus on the delivery of registration services which ensures data protection and harmonisation.

**Recommendation:** Implement APIs to the CAA registration database to facilitate UTMSP authentication of pilots and operators.

The registration service also encompasses registering approved UTMSPs and granting them access to the Local UTM Network (LUN). After approval/certification processes are completed by the CAA, the CAA would communicate to the OUTMSP details of which UTMSPs should be granted which roles for the Interoperability Token Service. The Interoperability Token Service then provides access tokens with associated privileges to

UTMSPs. These tokens have limited durations and allow for the removal of privileges upon request of the CAA, consistent with industry-standard cybersecurity practices.

**Recommendation:** Establish processes for granting and removing UTMSP privileges through the Interoperability Token Service.

## 7.4.3

### Strategic Deconfliction

This aerial conflict management layer is provided in the pre-flight planning phase to ensure that the planned flight volumes are unique to each operation, have considered known hazards and enable UAS to be strategically separated. This service is facilitated through the DSS and the LUN and enables the flight plan approval process. Strategic Deconfliction can be provided for trajectory based and area-based operations conducted under both VLOS and BVLOS. These operations are represented by a series of overlapping 4-dimensional volumes.

The ASTM UTM specification allows each UTMSP a high degree of flexibility in achieving this 4D volume creation, supporting a wide range of operations from highly specific, many-volume operations, all the way to general, single-volume operations. In some cases, a single volume for the duration of the entire operation extending from the ground up to the maximum altitude of the operation may suffice, especially when planning in an area with low airspace density. In contrast, an operation could be defined to convey a high level of specificity of where exactly a vehicle will be in space at each specific moment in time. As operational density increases, additional requirements will be needed to ensure fairness and equitable access to the airspace.

## 7.4.4

### Monitoring and Alerting

Each UTMSP is responsible for monitoring the performance of their client operations and alerting flight owners and other airspace users when off-nominal conditions (i.e. off-plan) are detected. Monitoring and alerting has the following functions:

- When higher priority operations are detected, the service should alert client UAS Operators of the change
- Monitor airspace conformance (e.g., when UAS is out of planned volumes such as the conformance geography)
- Inform UAS Operator when a UAS leaves its planned volume
- To inform/alert other airspace users and other UTMSPs when flights violate planned volumes

Prioritisation was not addressed in this project but expected to be needed to accommodate the variety of airspace participants. The ASTM UTM Draft standard offers the mechanisms and information for sharing operational states, but purposely does not impose detailed requirements for how/when operators are notified of all changes in their own UAS or other UAS's operational states. As this implementation has safety implications, it will need to be considered by regulators either through imposed notification requirements or through marked consideration in performance authorisation assessments.

For an operational UTM capability, there will have to be a regulatory overlay devoted to prioritisation and operator notification requirements (see *Section 10 UTM Regulatory Framework*).

**Recommendation:** Develop services that enable negotiation and prioritisation of operational intent between different UTMSPs.

**Recommendation:** Develop methods and approaches to address bad actors within the UTM ecosystem.

## 7.4.5

### In-Flight Replanning

Dynamic re-routing is the primary strategic conflict resolution strategy when operational volume intersections are identified by the monitoring service. The service functions in all situations while the conflict does not present an immediate risk and should be able to:

- Propose alternative routes or landing areas
- Apply priority rules to affected operations

The issue with re-routing is the need for systems to collaborate in building consensus on new routes when conflicts exist in order to maintain airspace fairness and equity. While this may not be necessary when densities are low, as airspace densities increase the need for some form of negotiation might become necessary.

During the proof of concept, replanning was a manual process that took time. Additional

refinement is needed to make this process easier and faster. Since the interface between the UTMSP and the UAS operator is controlled by the UTMSP, it is up to each UTMSP to refine this process. It will likely require tighter coupling between the UTMSP systems and the Ground Control Station (GCS) systems used by most operators to plan and execute their flight plans.

**Recommendation:** Develop a policy to ensure equity and fairness of airspace access for regions and times where a first-reserved policy is not tenable.

**Recommendation:** Develop more sophisticated automatic routing/rerouting services.

## 7.4.6

### Dynamic Restriction Management/Ingestion

A dynamic restriction is a type of airspace constraint<sup>4</sup> that can be used to identify relatively small pockets of airspace at low altitudes as having special rules for UAS, such that priority operations of manned aircraft, unmanned aircraft, or ground-based entities can be performed without the potential for interruption by nearby UAS that are not participating in the priority operation. Which entities can publish and manage these dynamic restrictions is a policy decision, while how the dynamic restrictions are published is a technical decision.

**Recommendation:** Create policy as to which governmental, non-governmental, or commercial entities can create dynamic restrictions and the types of dynamic restrictions to be used in the UK.

The entity responsible for a dynamic restriction must use a UTMSP with appropriate privileges to disseminate information about the dynamic restriction to other UTMSPs and their operators. This project explored two methods for dissemination:

1. A central UTMSP combined with the OUTMS which provides all dynamic restrictions
2. Multiple UTMSPs working directly with dynamic restriction providing entities to provide dynamic restrictions to other UTMSPs directly.

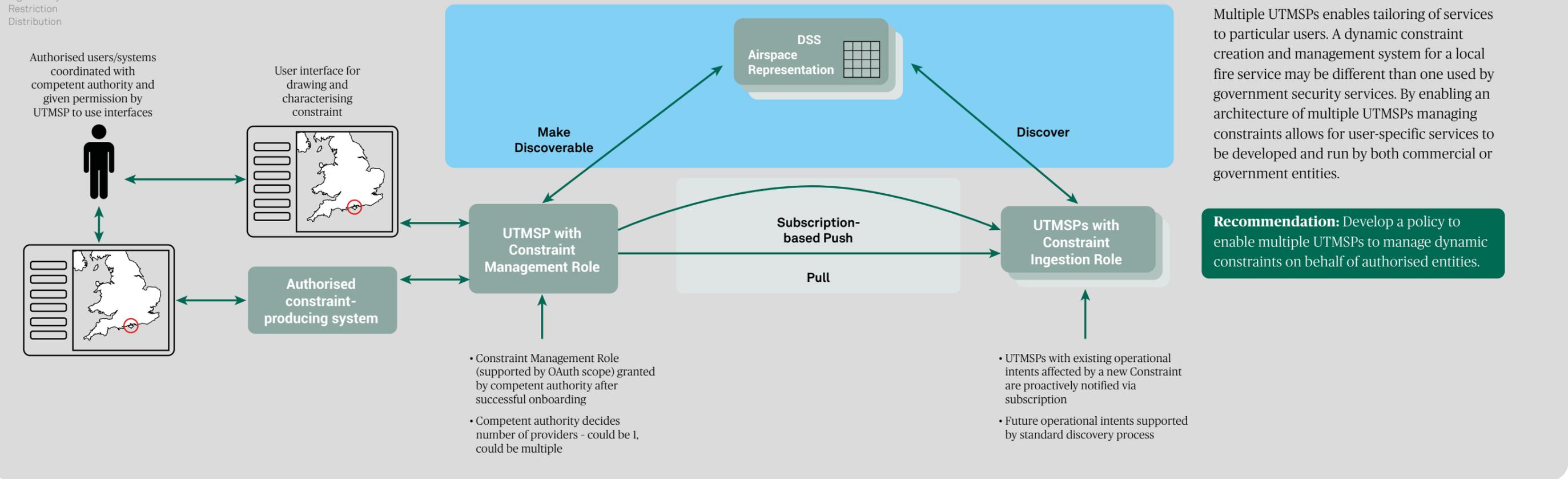
This enabled the proof of concept to explore the alternative of a single provider (the OUTMSP) versus potential multiple market providers. Wing integrated its RPAS Platform OUTMS constraint capability with the DSS to effectively become a UTMSP relative to dynamic restrictions. Additionally, ANRA and AiRXOS provided dynamic restrictions as UTMSPs.

It is important to note that the constraint ingestion role of UTMSPs and the associated pilot alerting is unaffected by the choice of one or multiple constraint manager UTMSPs as shown in **Figure 6**. Dynamic restrictions are all discovered in exactly the same manner, and retrieval of the associated data automatically is routed to the correct constraint manager by data provided from the DSS. In other words, whether there are one or multiple constraint managers, it is transparent to a UTMSP.

<sup>4</sup> The draft ASTM UTM standard uses the term "constraint" as a generic term that can cover all types of dynamic airspace information internationally. A dynamic restriction in the Open-Access UTM framework is a type of constraint, but in project documentation the two terms are used interchangeably.



Figure 6: Dynamic Restriction Distribution

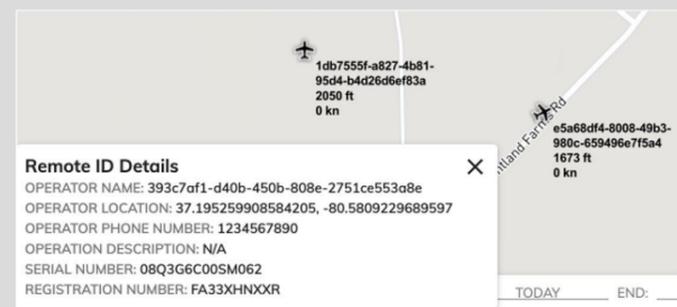


### 7.4.7 Network Remote ID

Electronic conspicuity is critical to enabling UAS operations in airspace. It is a broad term covering a range of technologies which at the basic level provide electronic identification and positional information to help create a known environment for the users. Electronic identification will make it possible to identify aircraft, the flight status and the operator/pilot by relating digital markers with the registration data.

This project used Network Remote ID (RID), as defined in the *ASTM F3411-19 Remote ID and Tracking* standard, to provide electronic conspicuity of all operations. The remote ID information is available to anyone with a smartphone or other internet-connected device.

Figure 7 Example Remote ID Display



**Recommendation:** Consider Network Remote ID (RID) as an acceptable method for implementing electronic conspicuity as the technology was proven to work during these trials.



## 8

# UTM Field Trials

To demonstrate the proof of concept, field trials were conducted at the end of February 2021. This section details activities and results of the actual flight trials. One of the main objectives of the trials was to test the interoperability between UTMSPs and their services in a live flight setting.

A consensus on the scope of services to be developed and tested was agreed by all partners at the start of the project and defined in the previous section of the report. Some of the services are covered by already published standards (e.g. Remote ID) and others are part of currently in-development standards activity described above. Given standards are evolving, UTMSPs are at different stages of development of services and capabilities.

These trials were conducted in the context of a very challenging environment of COVID-19

which led to its own set of issues around travel and co-ordination and required the trials to be delivered within a COVID-safe environment. Whilst challenging to manage, the remote support provided by UTMSPs created a more realistic environment for how UTM would be used by an operator in the real-world without on-site UTMSP personnel. The secondary objective of the trials was to demonstrate interoperability between stakeholders and demonstrate this capability within the Open-Access UTM framework in the UK.

## 8.1

## Overview of field trials

The field trial was a physical UAS flight exercise to demonstrate and validate the functionality of the Open-Access UTM system in “real-world” conditions. Prior to the trials, several simulation exercises were carried out online to develop and integrate a core set of services and demonstrate interoperability between UTM service providers. The simulation activities culminated in a virtual demonstration in November 2020 with all UTMSPs and the OUTMS participating in simulating three scenarios exercising all the UTM services within the proof of concept.

The field trials demonstrated three different scenarios highlighting the core value proposition of a federated set of UTMSPs safely supporting simultaneous operations in a region. Each scenario demonstrated a different set of UTM services and the interoperability across the different UTM service providers. Metrics were collected for each scenario and are included in **Appendix A**.

Skylift, a commercial UAS operator and their operational site in Leicestershire was chosen as the location for the field trials. While the scenarios had BVLOS operations, during the field trials, this was simulated and all flights operated within visual line of sight VLOS of the remote pilot. There was a detailed preparation programme for the trials including training the pilots on the different UTMSP platforms and testing integration, telemetry, and access/authorisation for the UTM services. The preparation culminated in simulation exercises to sign off the scenarios and test cards in advance of the field trials.

A comprehensive safety and operations trials plan was developed and reviewed by

all partners in advance of the trials. One of the main objectives of the trials was to demonstrate a working implementation of the proposed federated traffic management architecture with multiple UTMSPs operating in the same airspace. This is fundamentally different from the ATM system currently in place, one that is centralised around a single ANSP for a given airspace. By demonstrating this architecture, it proved the concept of interoperability between UTMSPs and the ability of a broad range of stakeholders to collaborate to develop an integrated environment.

Due to COVID-19 restrictions, onsite participation was restricted to a minimal Skylift crew and minimum staff from CPC. The rest of the UTMSP partners and project support joined via a Zoom conference call, used to co-ordinate the exercise. VHF radios were used for onsite crew coordination and safety management. The pilots and the crews were linked to the test-director via the Zoom call in addition to the local inter-crew communication system. A safety director, responsible for overall safety of the trials was also present on the site.

For the field trials, DJI F550 hexacopter drones were operated using Mission Planner Ground Control Station (GCS) software. Integration with the UTMSP software was also made using standard MAVlink protocol to pass the flight telemetry data to the UTMSP software. Each drone crew had a pilot and pilot-buddy, the pilot buddy was assigned to oversee the GCS software screen and the UTMSP screen whilst the pilot maintained VLOS with the aircraft and responsibility for the safety of the flight.

## 8.2 UTM Services Tested

Table 3 provides a breakdown of the services demonstrated by each UTMSp across the three scenarios:

- **Scenario A** - Delivery
- **Scenario B** - Fire response
- **Scenario C** - Wind farm inspection

Table 3: Services, Scenarios and Partner Allocation

Service	Description	ANRA	Altitude Angel	Collins	Wing
<b>Demonstration Scenario</b>					
<b>Strategic Deconfliction - No Conflict</b>	When flight plans are submitted, the Open-UTM architecture ensures that there are no prior flights that will conflict.	A,B	B,C	A,C	
<b>Strategic Deconfliction - Replan after Conflict</b>	If an airspace volume is reserved for an operation, then a second operation over that same volume is rejected and the operator has to replan.	A	B		
<b>Strategic Deconfliction - BVLOS-VLOS intersection allowed</b>	As per the latest draft of the <i>ASTM Standard Specification for UAS Service Supplier Interoperability</i> , a BVLOS flight is allowed to fly through volumes reserved for VLOS flight, the VLOS operator is expected to see the BVLOS volume and move their flight away from it.	A,B			
<b>Consume Constraints (Dynamic Restrictions)</b>	All UTMSPs can read constraint information and display it to the operator.	A	B	B	
<b>Constraints Provider</b>	Authorities and other stakeholders in the network can establish constraints and restrict activity for that airspace.	B			A,B
<b>Display Constraints</b>	Like the consumption of constraints, constraint information can be displayed by the different UTMSPs in the network.	A,B	B	B	A,B
<b>Registration - Check and Revocations List</b>	Registration is a foundational pillar of the UTM ecosystem and run by the Civil Aviation Authority. Before every operation, the UTM services have to interact with the registration service to ensure that the operator registration is valid.	A,B	B,C	A,B,C	
<b>Registration - Incorrect Details resulting in rejection</b>	As above			B	
<b>Network RID Display Provider</b>	Remote ID is in the context of UTM has been specified in a standard and enables participants to query flights in the local airspace and display their ID and other telemetry information for a short time on a screen.	B,C			
<b>Network RID Service Provider</b>	There is instrumentation / software capability required to ensure that remote-id data can be queried.	B,C	B,C	B,C	
<b>Monitoring and Alerting - Notify user of Conflict</b>	There are provisions in the Open-UTMSp architecture to ensure alerts around the airspace are sent to the participants.	A,B,C	B,C	A,B,C	
<b>Monitoring and Alerting - Notify user of Off-Nominal</b>	If a flight deviates from its declared course (for whatever reason), the participants in the airspace must be notified of the changes.	B,C	C	B,C	

<b>Declare Off-Nominal</b>	The UTMSp can declare a flight as off-nominal as the situation evolves.	C	C	B	
<b>In-Flight Replanning - Land due to Conflict</b>	In case of an emergency or "off-nominal" behaviour, the other participants can land safely on time.		B	B,C	
<b>In-Flight Replanning - Replanning/Rerouting due to Conflict</b>	If a flight changes its planned course during flight, the other participants in the network are notified and can take appropriate action.	A,B,C	C		
<b>In-Flight Replanning - VLOS accept Conflict and manage visually</b>	A VLOS operator has their eyes on the drone at all times and they must move away from BVLOS flights if they intersect.			A	

The services above were identified as crucial capability that needed to test, developed, and demonstrated to ensure a long-term success of the UTM ecosystem. The scenario narratives are tailored to demonstrate a combination of these services and in turn showcase the value of UTM in enabling a safe, secure, and efficient airspace.

## 8.3 Field trial scenarios

Three realistic scenarios were developed to incorporate the range of UTM services to be demonstrated.

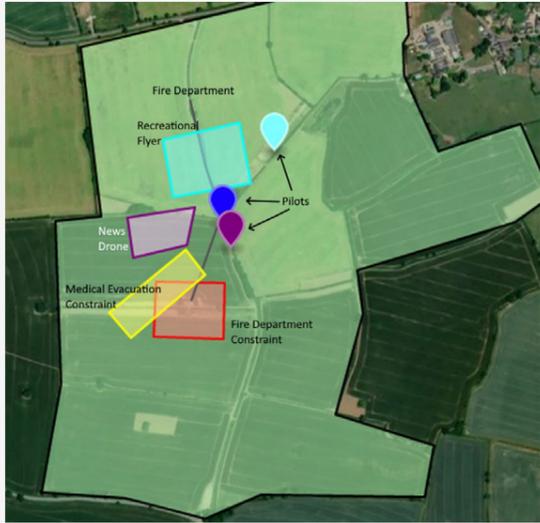
### 8.3.1 Scenario A - Delivery

**Demonstration Goal:** Strategic deconfliction and in-flight replanning enables multiple complex proximate operations.

Details	Map
<ul style="list-style-type: none"> <li>• An agricultural inspection is being conducted at a farm with one VLOS flight when the inspection team discovers they need an aircraft part and orders one for immediate delivery</li> <li>• Before the delivery operation is planned the Police service requests a constraint is applied to an area where a Police helicopter is monitoring traffic around roadworks</li> <li>• The delivery drone attempts to fly a direct route, but a conflict is detected with the Traffic Monitoring Dynamic Restriction Constraint</li> <li>• Following a replan the delivery operator follows a route around the constraint through the VLOS area</li> <li>• The VLOS operator is notified and avoids the incoming BVLOS delivery by moving away from the delivery flight's area</li> </ul>	

### 8.3.2 Scenario B - Fire Response

**Demonstration Goals:** UTM services allow a diverse set of users to appropriately coordinate their responses to an emergency.

Details	Map
<ul style="list-style-type: none"> <li>• A new recreational flyer launches a VLOS flight for the first time in a park.</li> <li>• The fire department is alerted to a possible fire and sends out a drone to quickly assess the scale of the fire. The recreational flyer is notified of the fire department drone and decides to begin landing.</li> <li>• While landing, the recreational flyer briefly leaves the operation area triggering a notification to the fire department UTMSP but quickly returns to his area once notified and completes landing. Following the notification, the Fire Department uses RID to identify the recreational operator and following landing a member of the fire department can interact with the pilot advising him on other locations he might be able to fly in further from the fire.</li> <li>• When the fire is verified, the fire department informs all operators nearby of the fire via dynamic restrictions. A news organisation comes to cover the fire and is informed of the fire area via the dynamic restriction. After seeing the dynamic restriction constraint, the news operator plans their operation around it to avoid a conflict.</li> <li>• Seeing a nearby drone, the fire department is quickly able to determine that it belongs to a news organisation (with previously established processes with the fire department).</li> <li>• In response to a Fire Department request an air ambulance is dispatched to site and the news operator in the area makes accommodations for the helicopter after being informed of its imminent arrival via a dynamic restriction.</li> </ul>	



### 8.3.3 Scenario C - Wind farm inspection

**Demonstration Goals:** Operators are able to efficiently communicate relevant information to relevant recipients even when a supporting dispatcher is not on site. UTMSPs are able to respond to another operation's contingency situation in different ways.

Narrative	Map
<ul style="list-style-type: none"> <li>• Two operations far apart are launched to inspect a wind farm and the power lines running along a railway track. Meanwhile, another operation to transition between the two inspections is launched to deliver a defibrillator following a 111 call.</li> <li>• As a member of the company is driving near the wind farm, he sees a drone and phones headquarters to make sure it's authorised to be there. The Headquarters dispatcher can use network Remote ID to confirm the purpose of the second drone.</li> <li>• During the operation there is a sudden wind gust and all drones operating in the area are blown out of their volumes temporarily. As all operations are operating near each other the UTMSPs/Operators are notified.</li> <li>• Immediately after the wind gust the railway inspection operator declares a contingency (following loss of control but not telemetry) and updates the plan to reflect the predefined contingency action (return to base) which takes it through the other operations' volume.</li> <li>• The VLOS inspection operator receives a notification for the contingent operation and decides to move the operation to another part of the volume to avoid the new contingent operation after locating the drone using Network Remote-ID.</li> <li>• The defibrillator delivery operator also receives a notification for the contingent operation and decides to replan the route to avoid the contingent operation. All operations complete and land.</li> </ul>	



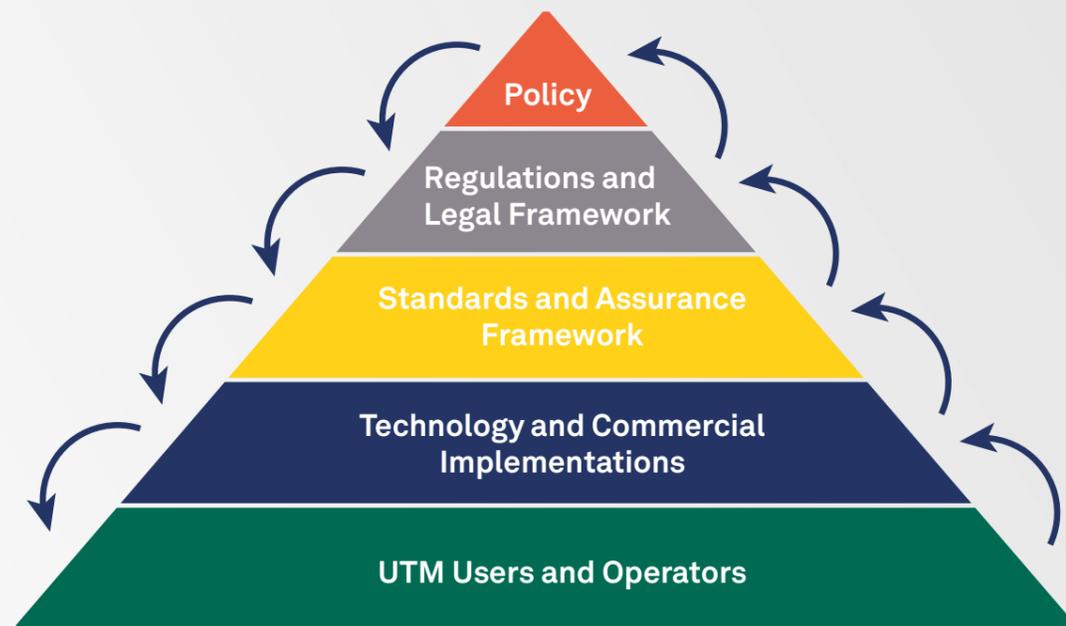
## 9

# UTM Policy Framework

Implementing UTM requires cooperation between government and industry on multiple levels including technical, regulatory, and policy. A higher-level set of policies must be put in place to enable the ecosystem and infrastructure for UTM to progress to commercial operations. These policies fall under the jurisdiction of the DfT.

Currently with UTM there is a “chicken and egg” problem of inter-dependencies between different levels of UTM implementation, preventing any one level from fully maturing. This cycle of dependencies hampers industry growth and the potential public benefits of UTM and is illustrated in **Figure 8**.

Figure 8: Dependencies between levels of UTM implementation



To break out of this set of inter-dependencies, one or more of these levels need to be “fixed” for the initial implementation. For example, in Europe the focus is on fixing the regulatory level through UTM rulemaking. In Switzerland, the Swiss U-Space Implementation (SUSI) is focused on fixing the standards, technology, and commercial pieces of Network Remote ID as a first step in breaking the cycle of UTM dependencies.

The Open-Access UTM Programme has proven the feasibility of the standards and technologies associated with UTM services. The next step in the UK is to define UTM policy and the regulatory framework to enable the other layers to mature and progress to commercial operations.

Specifically, we recommend the DfT establish policies to:

1. Establish the roadmap with a specific timeline for government investment, regulatory framework, and establishment of centralised UTM services. This will enable industry to invest in parallel with confidence that the necessary supporting infrastructure will be in place.
2. Establish formalised roles and responsibilities for all actors. By defining roles and responsibilities, technical integration and regulatory oversight can follow. This report, along with other conceptual documents such as *CAP1868*, provide inputs to shape the final definition for actors.
3. Provide frameworks for the integration of stakeholders. Specifically identified in this document is the need for policy on minimum airspace equipage requirements, the integration of ATM, police and fire services, international entities for cross-border flights, electronic conspicuity, and equitable airspace access rules.

Development of these policies will require broad stakeholder consensus including UAS operators, UTMSPs, the CAA, manned aircraft operators, and local governmental entities. As recommended in *CAP1868*, legislative changes such as an amendment of the Air Navigation Order 2016, may be necessary to produce new airspace structures for UTM and/or to mandate minimum equipage requirements for airspace participants.

**Recommendation:** Consult and engage with all stakeholders to establish necessary policies to enable UTM services in the UK.

One particular policy topic rose to the forefront during these trials, but was out of scope, that of role-based information access for network remote ID. To make network remote ID a viable component of electronic conspicuity, policy needs to be set around several questions, including:

- How do you properly credential public authority users and display clients?
- How do you manage PII exchanges/uses among the various entities involved in a remote ID exchange?
- How do you ensure integrity of the extended RID details and compliance information?

**Recommendation:** Conduct a stakeholder engagement process on electronic conspicuity privacy, primarily focused on when and how additional, private information is made available to public authorities.

## 10

# UTM Regulatory Framework

The CAA plays a key role in governance of the Open-Access UTM system. The CAA is primarily tasked with ensuring safety of the airspace while also promoting efficient use of the airspace by operators. The UTM system provides functions to support both the safety and efficiency goals.

The CAA plays a key role in governance of the Open-Access UTM system. The CAA is primarily tasked with ensuring safety of the airspace while also promoting efficient use of the airspace by operators. The UTM system provides functions to support both the safety and efficiency goals.

The federated approach in the Open-Access UTM system, with multiple UTMSPs competing for UAS operator customers, provides the opportunity for the UK government to promote UK industry growth and engagement, much like the mobile phone market. The marketplace for UTMSPs will enable them to compete on additional features, pricing, and service, while the CAA ensures all UTMSPs meet a minimum acceptable level of safety and interoperability.

The collective authors of the ASTM Remote ID and UTM standards used the concept of a “regulatory overlay” to apply to these regulations that would tailor the standard to the local jurisdiction where it is used and implement oversight and enforcement mechanisms. This allows the standards to be developed in an international fashion that can apply to any country with the expectation that each country’s regulator would establish

the specifics, such as where each service is implemented and how the service provider approval process would be conducted. It enables international providers to provide similar services in multiple countries and also enables cross-border UTM flights with interoperability at the border.

As observed in the trials, different UTMSPs implemented different approaches to 4D conflict management and operator notification - all of which followed the standard. To extrapolate this enterprise behaviour into an operational environment, lack of a regulatory overlay on these topics will create a UTM environment wherein an operator may be denied to plan an operation with one UTMSP but permitted to plan the exact same operation with another UTMSP. While not inherently detrimental to UTM functions, this observation does serve to highlight the role of regulatory overlay required in addition to the adherence to standards.

The regulatory overlay would also specify which actors are allowed to provide which services. For example, in some countries a centralised entity may manage all constraints while in other countries, multiple entities would be approved to provide constraints.

For the UK a regulatory overlay for UTM needs to be put in place that specifies:

- Establishment of UTM airspace where all air vehicles are required to participate similar to the concept of U-Space airspace in Europe
- The process for approving UTM service providers and verifying that they meet the required standards
- Ongoing oversight and auditing of service providers
- Identifying and addressing system or service provider defects across the federated network of service providers
- Which overlaps are allowed with strategic deconfliction, for example two VLOS operations and/or a VLOS with a BVLOS operation

- What safety credit can be taken for strategic deconfliction as a layer in managing collision risk
- How to handle highly congested airspace safely and efficient, whilst also ensuring equity of airspace access

This regulatory overlay would add additional requirements beyond the ASTM standard as well as set forth policies for onboarding testing, auditing, and record retention.

**Recommendation:** Establish a regulatory overlay for UTM services and the associated governance and oversight structure.



## 11

## UTM Assurance Framework

For the simulated and live trials, UTMSP interoperability was largely a manual process. While this was well managed by the CPC programme and effective, it is not a scalable approach to validating UTMSPs for operational deployments. The next major step is to incorporate automation in the interoperability testing process.

While there are many challenges associated with this, exploration of automated UTMSP interoperability tests will not only enable more rapid iterations on the checkout process, but establish a strong foundation for future operational UTM validation/verification processes.

Cloud-based software used for UTM will be constantly changing, so there is an additional need for routine automated testing to ensure continued interoperability. Ideally this automated testing would consist of a 24/7 test capability where at least one UTMSP or pseudo-UTMSP is always running simulated operations in a region, subscribing to operations, RID display client, etc. This would allow for testing and regression testing of all functionality without scheduling with a peer UTMSP or the OUTMSP.

**Recommendation:** Establish a certification process for UTM architecture and services that is commensurate with the safety criticality of the service provided. It is recommended that certification processes are appropriately developed based on performance and risk criteria and drawing upon relevant standards from manned aviation such as *RTCA DO-178C/ED-12C and DO-278A/ED-109A*. (*II UTM Assurance Framework*)

**Recommendation:** Establish automated UTMSP testing capabilities to support initial and recurring automated testing of UTMSPs.

## 12

## UTM Legal Framework

Developing the Open-Access UTM proof of concept identified a number of legal and privacy concerns. Whilst these were not in scope for this project nor did they impact the implementation of the proof of concept, they are areas that will need to be addressed for commercial UTM operations.

The legal and privacy concerns include:

- The legal framework to address interfaces between commercial entities such as between UTMSPs on the LUN and between UTMSPs and SDSPs
- SLAs between UAS operators and UTMSPs agreed through commercial arrangements between a UAS operator and their chosen UTMSP
- SLAs between dynamic restriction providers and UTMSPs performing the constraint management role on their behalf
- The liability for 3rd party data shared between entities across the UTM network and used as the basis for safety critical decisions
- Privacy of UAS operators conducting operations in the UTM system. While the registration system and LUN are designed to protect personally identifiable data, they do not protect commercially sensitive data such as flight routes and launch and recovery point

- Display of operations managed by other UTMSPs - there is the need to balance privacy with the ability to efficiently plan and replan deconflicted routes
- Abuse of the UTM system especially related to blocking other airspace uses through overly large or unused strategic deconfliction operational volumes (this may be covered by policies associated with equitable use of the airspace)

**Recommendation:** Sponsor research on the legal and privacy concerns associated with UTM in order to develop sound government policy in these areas.

13

# UTM Commercial Framework

Associated with policy is the need to establish a sustainable funding model for UTM. UTM development costs to date have been primarily borne by private UTMSP operators, but there have also been some projects funded by public research organisations including, CPC, NASA and SESAR. Government regulators from multiple nations have been participating in community-based standards development organisations on behalf of their governments.



The commercial viability of BVLOS UAS operations depends on the availability of UTM with cost-effective services provided by UTMSPs. Burdening UTMSPs, and by extension UAS operators, with excessive costs will hinder the expansion of UAS economic benefits to the UK.

Because airspace safety benefits the general public as well as airspace users, in many countries costs are shared between taxpayers and industry. However, in the UK the CAA is funded entirely by charges to those who are provided services or regulated. In addition to determining the funding mechanism for CAA oversight of UTM, the mechanism for funding any centralised services must be established.

In many cases, industry can provide those services directly through a federated model. For example, multiple DSS instances can be run simultaneously in a “pool.” One or more industry UTMSPs can host a DSS instance and let other UTMSPs use it, possibly charging for the service, while other UTMSPs may use their own DSS instance without external users. Because the interoperability standards are in place, it doesn’t matter which model industry adopts and none of them require government intervention in the funding mechanism. The competitive price pressure on these services will keep costs low.

Given the federated marketplace, it is expected that UTMSPs will charge their customers for UTM services provided and pricing will be one of the competitive differentiators, much like in the mobile phone market. However, it is likely there will be common fees and costs associated with regulatory oversight that all UTMSPs must pay and will pass along to the UAS operators either directly or indirectly. Given the nascent state of the industry, initial fees and charges should be kept low until the market evolves and more participants are available to share the costs. Funding mechanisms should consider differences between near-term funding structures and long-term funding structures once the industry is mature.

Funding mechanisms were not part of this project, so additional work is required to establish the details of such a structure. This structure would include which services are directly funded by UAS pilots and operators, which ones are centrally funded by the CAA (possibly based on user charges), and which ones are funded by the Government. An example of a proposed funding structure is detailed in **Table 4**.

Table 4: Example UTM Funding Structure

Directly User Funded	Centrally Funded (by CAA)	Government Funded (by DfT or local government)
UAS Operations, Flight Planning	Interoperability Token Services	Dynamic Restriction Management
UTMSP Services	Registration Service	Electronic Conspicuity Receivers/ Display
DSS (through UTMSPs)	UTMSP Oversight	Policy Development
Electronic Conspicuity	Regulation Development	
	ATMSP Interfaces	

**Recommendation:** Develop a policy that enables a sustainable commercial model for UTM.

14

# Glossary of Terms

<b>ANSP</b>	Air Navigation Service Providers
<b>API</b>	Application Programming Interface
<b>ATC</b>	Air Traffic Control
<b>ATM</b>	Air Traffic Management
<b>ATMSP</b>	Air Traffic Management Service Provider
<b>BVLOS</b>	Beyond Visual Line of Sight
<b>CAA</b>	Civil Aviation Authority
<b>CPC</b>	Connected Places Catapult
<b>DAA</b>	Detect and Avoid
<b>DfT</b>	Department for Transport
<b>DSS</b>	Discovery and Synchronization Service
<b>EASA</b>	European Union Aviation Safety Agency
<b>EU</b>	European Union
<b>GA</b>	General Aviation
<b>GCS</b>	Ground Control System
<b>ICAO</b>	International Civil Aviation Organisation
<b>LUN</b>	Local UTM Network
<b>OUTMS</b>	Open UTM Service
<b>OUTMSP</b>	Open UTM Service Provider
<b>RID</b>	Remote ID
<b>SDSP</b>	Supplementary Data Service Provider
<b>SESAR</b>	Single European Sky ATM Research
<b>SLA</b>	Service Level Agreement
<b>UAS</b>	Unmanned Aerial System
<b>UTM</b>	Unmanned Traffic Management
<b>UTMSP</b>	UTM Service Provider
<b>VLL</b>	Very Low Level
<b>VLOS</b>	Visual Line of Sight

15

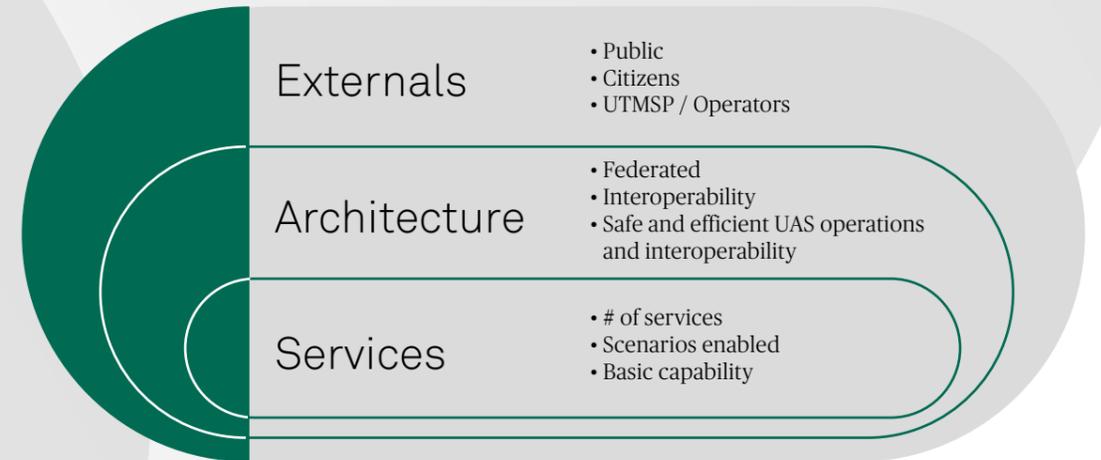
# Appendix A – Metrics

## 15.1

### Field trial scenarios

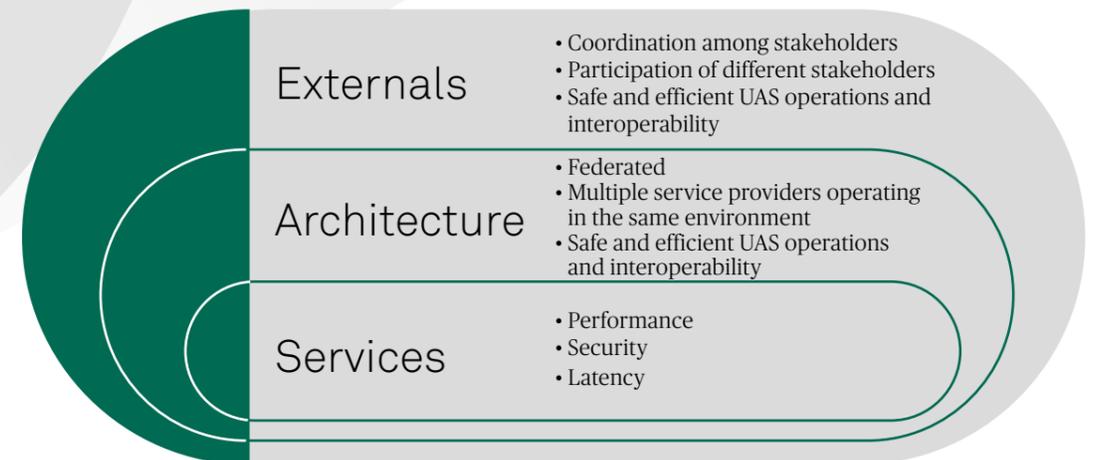
The UTM system has multiple stakeholders and we classify measuring performance in three broad categories: External, Architecture and Services. These three categories serve different stakeholders in the UTM system. The purpose of this appendix is to capture metrics from the February 2021 flight trials across these categories to develop a critical understanding of the performance and capabilities of the Open UTM system demonstrated during the proof of concept.

Figure 9: Performance measures



These performance measures can be made specific by developing specific aspects of these categories so that data collection activities can be performed. It is summarised below.

Figure 10. What is being measured?



## 15.2 Basic Trial details

**Goal:** Develop an objective understanding of the scenario so that different scenarios can be compared across to understand key operation parameters.

A, B, and C represent the three scenarios described in **Section 7**.

Table 5: Basic Trial Details

ID	Metric	What does it give us?	A	B	C
1	Total number operations	An overall assessment of how busy the scenario is	2	3	3
2	Vertical and lateral buffers for each UTM-SP, per phase of flight	How the airspace is structured. This could be in m3 or any other metric showing how much of airspace is used, perhaps add a time dimension as well	~15m	~20 m	~20 m
3	Total off-nominal notifications (e.g., total non-conforming and contingent notifications SENT)	That UTMSP can handle emergencies and the system can report it	0	3	2
4	Duration of conflict	The duration of the conflict is a good measure to ensure that USSes and DSS can manage long and short term deconfliction	2 min. 13 sec	~ 1 min (first time) ~ 40 seconds (second time)	
6	Response time to constraint notification after constraint applied in the DSS	This can give an indication of how operators can remove their active plans and replan. A spotter / second person might have to time this by staying beside the operator	NA	NA	23 seconds
7	Messages sent in a scenario	An understanding of network load and requirements. It could through be a detailed review of the logs perhaps or some other mechanism to see how busy a scenario can be	5	10	14
8	Average Altitude	An average altitude of the operations including maximum and minimum altitude and units across all the operations	50m – 100m AGL 20m – 120m for Constraint	90 m -100m AGL 10m -100m Constraint	50m – 100m AGL

## 15.3 Scenario details

**Goal:** Capture the activity within the UTM system in the context of the scenario to understand the scope of scenario operations and activities.

Table 6: Scenario Details

ID	Metric	What does it give us?	A	B	C
9	Number of submitted operation plans [1] * constraint is also classified as an operation	Density of operations, A comparison between scenarios	4	7	5
10	Number of rejected operations [1]	A view into constraints / overlapping constraints. Perhaps a ratio of accepted to rejected might be useful	1	1	0
11	Number of accepted operations [1]	The scale of the test / scenarios	2	3	4
12	Time and distance flown by UTM system, via field trial setup measurements [1]	We can cut the scenario by vehicle type and can show operational planning scope	1.2 km – BVLOS .8 km - VLOS 8 mins 26 seconds	~ 1km BVLOS flight ~ .2 km VLOS ~ .17 km VLOS flight ~ 14 mins	0.42 km BVLOS .38 km BVLOS ~ 500 m by VLOS ~ 13 mins
13	Number of non-conforming operations [1]	Ability of UTM operator to plan operations and ability of aircraft to stay within the plan	0	1	1
14	Tempo of Operations [1]	Pace / “busyness” of the scenario. A timeline of operations is necessary to estimate this	4 operation submission	7 operation submission	4 operation plans

## 15.4 Communications and Navigation

**Goal:** The goal of collecting this metric is to understand how long it takes to query and identify performance of communication in the network.

Table 7: Communications and Navigation

ID	Metric	What does it give us?	A	B	C
18	Response time to emergency procedure.	The time from notification of conflict to response / changing. This can be measured for all operators	NA	NA	43 seconds
19	Remote ID query performance	The time needed to make a network remote ID query and get the appropriate data	NA	24 seconds	46 seconds

## 15.5 Deconfliction

Table 8: Deconfliction

ID	Metric	What does it give us?	A	B	C
20	Strategic deconfliction rate – Ratio of operations that need to be deconflicted vs that do not need to be deconflicted. [2]	Intersections are not necessarily “Bad” but this tests how the USSes understand each other’s data and messages. UTM-MOP-01 (Share data about each other’s operations and use that information to separate)	0.5	0.66	0.66
21	Deconfliction rate for priority operation [2]	This is directly from UTM-MOP-20	0	0.66	0.66
22	Time to replan around a constraint	How well does the replanning function perform	34 seconds * alternative route already provided	NA	50 seconds * alternative route already provided

## 15.6 References for Metrics

1. Unmanned Aircraft Systems (UAS) Traffic Management (UTM) National Campaign II [https://utm.arc.nasa.gov/docs/2018-Aweiss\_SciTech\_1727.pdf]
2. Strategic Deconfliction Performance [https://utm.arc.nasa.gov/docs/2020-Rios-NASA-TM-20205006337.pdf]
3. Flight Demonstration of Unmanned Aircraft System (UAS) Traffic Management (UTM) at Technical Capability Level 4 [https://utm.arc.nasa.gov/docs/2020-Rios-Aviation2020-TCL4.pdf]
4. USS Specification [https://core.ac.uk/reader/141519137]
5. UAS Service Supplier Checkout [https://utm.arc.nasa.gov/docs/2019-Smith-USS-Checkout-NASA-TM-220456.pdf]
6. UTM UAS Service Supplier Development [https://utm.arc.nasa.gov/docs/UTM\_UAS\_TCL4\_Sprint1\_Report.pdf]
7. TCL4 UTM (UAS Traffic Management) Texas 2019 Flight Tests, Airspace Operations Laboratory (AOL) Report [https://hsi.arc.nasa.gov/publications/TCL4-UTM-testing-TexasE-200505.pdf]

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