# Connected Places Catapult

## Towards a UTM System for the UK

### Preparing the UK for the Commercial Drone Industry

Catapult Connected Places

# Introduction

**There is a significant market opportunity within the United Kingdom and globally for the deployment of drone-related services, particularly at low altitudes, for a range of industrial sectors such as construction (inspection and surveying), energy (inspection), through to public safety services (search and rescue, emergency response). This is supported by many market assessments and at a practical level by a rapidly growing drone-related business sector. There is an industry-wide consensus that the technology will be impactful and  disrupt the traditional remote sensing market for surveys and inspections, emergency response, and the logistics sectors over the next decade. The potential combined societal and commercial benefits of drones are significant, and as growth in this sector accelerates the UK is keen to be the market of choice for drone operators and users, build competitive advantages internationally, attract developers and innovators, and ensure public safety and trust in drone operations.**

**Drones will be required to share the airspace with other users which creates a need to explore Unmanned Traffic Management (UTM) solutions that will enable safe and efficient drone operations in UK airspace. Inevitably, Unmanned Aircraft System (UAS) and UTM technology will also impact Air Traffic Management (ATM) services in the future – as such, we need to develop an understanding of these effects, and even look at how UTM services can accommodate future air transport beyond just UAS.**

It should be evident to the observer that the drone sector is increasing in sophistication, and that the rate at which the technology is being adopted is accelerating. Over the next decade, advances in automation combined with the maturity of commercial VLOS and BVLOS services will accelerate the scale and complexity of drone operations. Placing increasing demands on airspace access using traditional approaches to airspace management will become increasingly tasking, high-risk and costly.

Recently, a Government consultation[1] on the future of drone operations in the UK made the following statement:

> *UTM is a system designed to enable the integration of drones into airspace, including that used by other aircraft. There are numerous opinions and models of UTM, but such a system could potentially enable ubiquitous awareness for drones or drone users of permanent and dynamic airspace restrictions; awareness of other airspace users; conflict detection and resolution between drones and other aircraft; and handle requests for permission to enter or transit through controlled airspace. It is seen as an important step in realising the full potential of drones, including routinely and safely flying Beyond Visual Line of Sight.*

UTM is recognised as a key enabler to address the safe and efficient integration of unmanned vehicles into the airspace. As UTM related technologies have matured in recent years, there is a need for a coordinated approach across the community of UTM stakeholders to deliver a UTM framework that will ultimately enable the industry to capitalise on the market opportunities.

Today, numerous UTM services are developing independently of any such framework – potentially resulting in short-term fixes or uncoordinated management of drones air traffic. As a response to this, the Connected Places Catapult (CPC), on behalf of the Department for Transport (DfT) designed a research programme aimed at a future framework which brought together Government and Industry, to develop a UTM framework, to communicate the requirements and inform an implementation strategy such that safe and efficient airspace coordination can be achieved.

This work builds on the work done at the DfT that took initial steps to provide UK the context to the global race to unlock UTM. In parallel, this work has also been informed by the ongoing UTM research initiatives particularly in the USA and in Europe.

This Open Access UTM research programme was led by the CPC with the aim of engaging with UTM stakeholders and the wider UAS community to develop and formalise a functional UTM framework, and define research areas and challenges around which industry and regulators can openly engage with each other to explore how UTM may be implemented.

[1] Taking Flight: The Future of Drones in the UK

# Open-Access UTM Principles

**A set of distinct underlying principles have been developed by the consortium, against which a future UTM solution can be measured.**

The key underlying principle of the proposed UTM system is its open nature – that is, open to multiple businesses and stakeholders, between whom data can be exchanged, to foster an innovative ecosystem that encourages businesses to deliver innovative services which safely facilitates the commercial and societal exploitation of drone technology.

Open-Access UTM is strategically aligned with the Government's ambition to capitalise on the opportunities around Open Standards[2] that allow for software to inter-operate through open protocols and the adoption of automated data exchange services based on data and digital strategies set out in the Government Transformation Strategy 2017-2020[3] and the UK Digital Strategy[4]. Open Standards, as defined by Government must have:

1. Collaboration between all interested parties, not just individual suppliers.
2. A transparent and published decision-making process that is reviewed by subject matter experts.
3. A transparent and published feedback and ratification process to ensure quality.

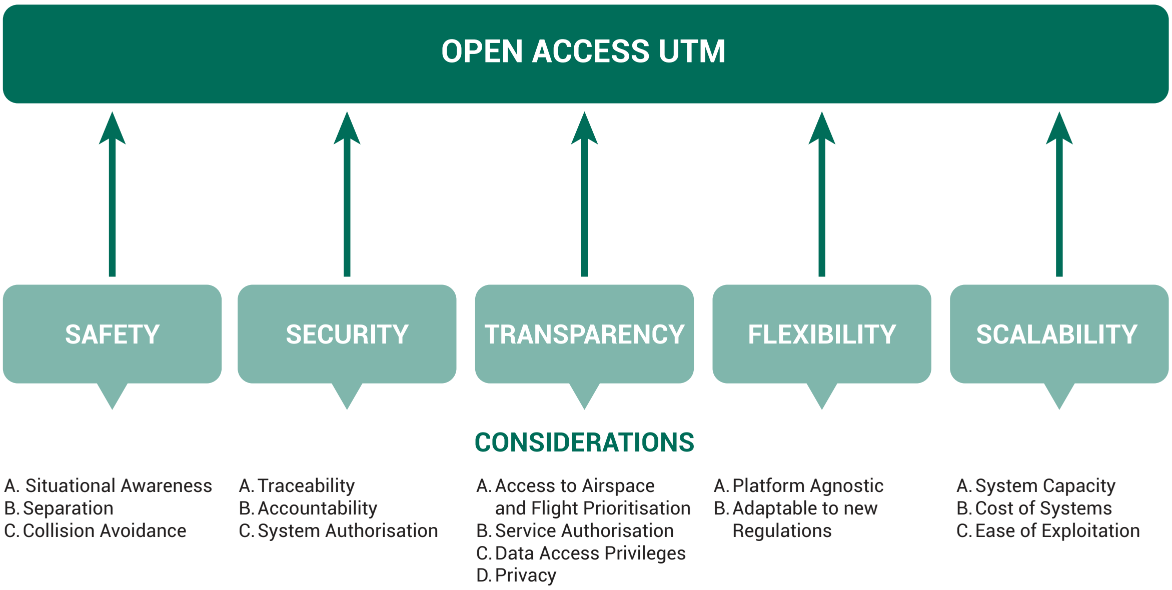



*Figure. 1 Key Open-Access UTM Principles*

The relevant authorities and regulators tasked to deliver the future UTM solution will need to carefully consider the compromises between each pillar, and how the UTM's architectural design will impact the commercial and regulatory aspects on which the system will be developed. These principles are further described in the following subsections.

[2] https://www.gov.uk/government/publications/open-standards-principles/open-standards-principles
[3] https://www.gov.uk/government/publications/government-transformation-strategy-2017-to-2020
[4] https://www.gov.uk/government/publications/uk-digital-strategy

**SAFETY** Safety is the foundational pillar of this UTM system, and its constituent sub-systems and services. Safety remains a corner-stone in the aerospace industry and will be vital to enable increasingly complex drone operations – particularly in controlled airspace or urban settings, where mitigating risk to people, vehicles, property and other airspace users will remain challenging.

**SECURITY** Security refers to the protection of a person, item, service, etc. against threats i.e. the need to protect the UTM participants, drone operations, the public and the environment. Threats can be caused by external intentional acts (e.g. terrorism, spoofing attacks, cyber-attacks), internal intentional acts (e.g. threats from disgruntled employees), and unintentional acts (e.g. human error, technical hardware or software error/failure).

**TRANSPARENCY** The term transparency refers to the information sharing attribute of this UTM framework which will enable all stakeholders access to a common understanding of the airspace in terms of operations and services. As a result, UTM users will have the right of access to the airspace when they fulfil the operating requirements, but also a right to understand why access maybe denied. Considerations around transparency are important due to the potential impact on trust, security and safety in the system. There are other key considerations around transparency, particularly around the compromise between user privacy and security.

**FLEXIBILITY** With time, new technologies will emerge and supersede existing technologies - communications technologies in particular. An established UTM technology should not need to be continuously redesigned and redeveloped to reflect the advances of technology in general. However, it should also not be limited and constrained to the technological limitations of today. Flexibility refers to the ability of the UTM architecture to evolve or adapt with respect to considerations relating to technological progress, risk and performance measures, policy and regulatory changes, and new business models.

**SCALABILITY** Scalability refers to the capacity for growth in the number of manageable drone operations, as well as the number (or density) of vehicles, or the number of actors, or services and messages that can reliably operate within the same UTM environment. Scalability is a necessary criterion to support the projected growth of the industry, and an increase in the number of drone pilots, vehicles, and operations occurring at any one-time.

*Note – Additional criteria exist that have not yet been included in the assessment table but may have a significant impact on the rankings including: operational (efficiency; timeliness (expediency to first to market); cost benefit analysis (including affordability) and societal issues (public perception). All are critical and will skew results.*

# Key Actors

For UTM to work effectively, the responsibilities of participants must be considered and how they are integrated into a communications network will need to be explored. This section summarises the general roles and responsibilities of key categories of UTM actors.

### UAS operator

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.

### UTM Service Provider

UTM Service Providers (UTMSPs) enable UAS operators to safely and efficiently integrate unmanned vehicles into the national airspace. This responsibility/capability is made up through the provision of several services that are listed below:

**A.** Provide UAS operators with an ability to plan missions considering relevant airspace and aeronautical information.
**B.** Provide UAS operators with an ability plan missions such that flights are not scheduled to conflict with other manned or unmanned flights.
**C.** Communicate relevant information to other UTM and ATM service providers as necessary (including ATM service providers) to enable the service providers and operators to strategically de-conflict, and potentially enact operating risk-mitigation procedures in-flight (i.e. tactical deconfliction).
**D.** Communicate (dynamic) operating restrictions to the operator as required.
**E.** Validate operator information and details (e.g. operating license, insurance, registration information).
**F.** Log operator flight data and archive operations data for analytics, regulatory and operator accountability purposes.

Due to the anticipated competitive nature of the UTM service market, service providers will also provide additional services on-top of the aforementioned capabilities to satisfy commercial needs.

### ATM Service Provider (ATMSP)

ATM is required to interface with UTM service providers 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.

Key capabilities and responsibilities to be maintained by ATMSPs are:
**A.** Monitor conventional manned air traffic.
**B.** Communicate air traffic information to UTM stakeholders as and when necessary (e.g. during emergencies).
**C.** Communicate received unmanned air traffic information to relevant ATM stakeholders as and when necessary.
**D.** Provide permissions to UAS operations when operating within flight restriction zones (FRZ).

## 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.

Key capabilities and responsibilities to be maintained by public authorities include the following:

**A.** Emergency services operations will be deployed and operate with a higher priority.
**B.** Local authorities will implement flight restrictions in specific areas as and when necessary.
**C.** Authorities may implement legislation and enforce regulations.
**D.** Access flight log data and other relevant information stored on the UTM systems when required.

## Supplementary Data Service Provider

Supplementary Data Services Providers (SDSPs) refer to additional information services that will typically support a UTM actor to plan, validate and verify information, or inform a decision-making process. Examples of SDSPs will include:

**A.** Weather services.
**B.** Insurance services.
**C.** Geographical information services (terrain and obstacle data).
**D.** Surveillance data.

These services are expected to be readily accessible by UTM service providers, though may also be accessible by the UAS operators and Open UTM services independently.

## Regulator

The UK Civil Aviation Authority (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, and to interface with the UTM system to ensure all participating actors behave appropriately, and perform services in accordance with defined regulations.

The CAA can be expected to provide a regulatory and operational framework, and to provide critical information required to enable UTM actors to exchange data, plan operations and deconflict airspace when necessary.

# Open UTM Service

**There is a major need for an entity or, alternatively, a collection of services which facilitate the exchange of data between relevant UTM actors to enable safe, fair and equitable access to airspace. It is therefore proposed to have a national service that facilitates the communication of flight-relevant information for actors to plan flights, deconflict traffic but also maintains a role in the validating participant service providers and users, and enable the CAA to maintain its oversight and regulatory responsibilities as the scale and complexity of drone operations continues to increase with time.**

There is a major need for an entity or, alternatively, a collection of services that enable and facilitate the exchange of data between the relevant UTM actors

This entity is referred to as the Open UTM Service, with the relevant component services referred to as Open UTM Services. The general responsibilities are listed below:

**A.** Service provider authorisations: In order to assure the integrity of the wider traffic management system, the participating services will need to be certified and approved to access the UTM network – this responsibility will likely fall to the regulator. These approved services will then be communicated and made available to the end-users (i.e. operators), but also to other service providers who require relevant information to maintain their operations.

**B.** Provide access to registration information regarding the approved or licensed UAS operators and their vehicles. This data registry will be appropriately accessible by the relevant service providers to verify and validate operator details, amongst other potential functions.

**C.** Log data-flows between actors to monitor how flight plans are approved, relevant flight information, and other important data-exchange activities. In capturing this information, data can be analysed and audited to ensure the system is appropriately managed and safeguarded, and that the actors and stakeholders involved are undertaking their responsibilities as defined by the regulator.

**D.** Provide access to static/dynamic data sources regarding flight restrictions, obstacles, and other flight-critical geographic information. These data sources are then expected to act as a reference to the relevant service providers and users.

Key services that are likely to make up the Open UTM Service are described in the following sub-chapters. These services were researched and discussed in order to provide initial points of reference and define initial requirements and potential methodologies to satisfy the defined research areas of interest as described previously. This list of services is not exhaustive, nor are the descriptions, functionalities, features and process comprehensive – as such, further research will be carried to advance our understandings of the Open UTM System.

## UTMSP Discovery

The UTMSP discovery is a service that enables operators to select an appropriate, authorised UTMSP from a maintained UTMSP registry or directory. This selection of UTMSP is likely to be subject to key market drivers, including whether the service provider provides regional or national UTM coverage, whether operators might require UTMSPs capable of managing sensitive information (e.g. relating to military or emergency services), or whether UTMSPs enable unique and beneficial operating capabilities.

The discovery service is also to enable UTMSPs to discover each other, share relevant flight data, potentially subscribe to each others flight plans, and to negotiate or deconflict operating schedules. This is immediately modelled off existing NASA documentation of their USS Discovery Service.[5]

It is likely that the CAA will be responsible, or delegate responsibility, for managing the UTMSP discovery service and the maintenance of the corresponding UTMSP directory. This may also be the case for maintaining UTMSPs approvals and licenses. This centralisation of the service will facilitate how both operators and UTMSPs can engage with the UTM network.

The UTMSP discovery will likely follow data-exchange processes as summarised below for ***service provider authorisation,*** and ***service provider discovery*** functions.

A. **UTM Discovery Submission:** Licensed and authorised UTMSP can apply/register with the UTM discovery service.

B. **UTM Discovery Submission Response:** The UTM Discovery Service responds to registration applications which are either are successful or rejected.

C. **UTM Discovery Enquiry from Operator:** The Open UTM Service is queried by UAS operators for a list of relevant authorised UTMSPs that correspond to the operator needs.

D. **UTM Discovery Enquiry Response to Operator:** The Open UTM Service responds to operator query with a list of corresponding UTMSP that match operator needs, if available.

E. **UTM Discovery Enquiry from UTMSP:** UTMSPs are required to discover other UTMSPs to formulate a direct UTM connection (Local UTMSP Network) and negotiate flight plans if necessary.

F. **UTM Discovery Enquiry Response to UTMSP:** The Open UTM Service responds to UTMSP request with a list of corresponding UTMSPs.

| # | FUTURE AREAS OF RESEARCH | DESCRIPTION |
|---|---|---|
| 1 | Procedure and Message | Agree on the procedure and message structure that can efficiently convey all the information required for the UTM discovery |
| 2 | Data Processing | The level of data processing should be estimated to ensure scalability |
| 3 | Data Storage | The data storage required for submitted UTM discovery information, data retention period and regulations need to be defined to cope with a large number of UTMSPs |
| 4 | Authorisation Requirements | Define the authorisation requirements for a UTMSP – i.e. what criteria must be met for a UTMSP to become "authorised" or "certified" |

***Table 1.*** *Open UTM Service research areas*

[5] UTM UAS Service Supplier Document: Sprint 2 Toward Technical Capability 4 – https://utm.arc.nasa.gov/docs/2018-UTM_UAS_TCL4_Sprint2_Report_v2.pdf

## UTM Flight Noticeboard

The communication of flight plans is an established practice in manned aviation, with plans typically shared with air traffic control, air traffic services (ATS), flight management systems and with the pilots. In sharing flight plans with the relevant stakeholders, flight planners and ATS can plan and coordinate operations to ensure that the aircraft can safely complete its flight in compliance with air traffic control requirements - for example, to minimise any risk of mid-air collisions.

Following conventional aviation's approach to flight planning, there is a general consensus around the need to communicate flight plans between the UTM stakeholders in order to facilitate planning, strategic deconfliction (at the planning stage), flight approvals, etc.

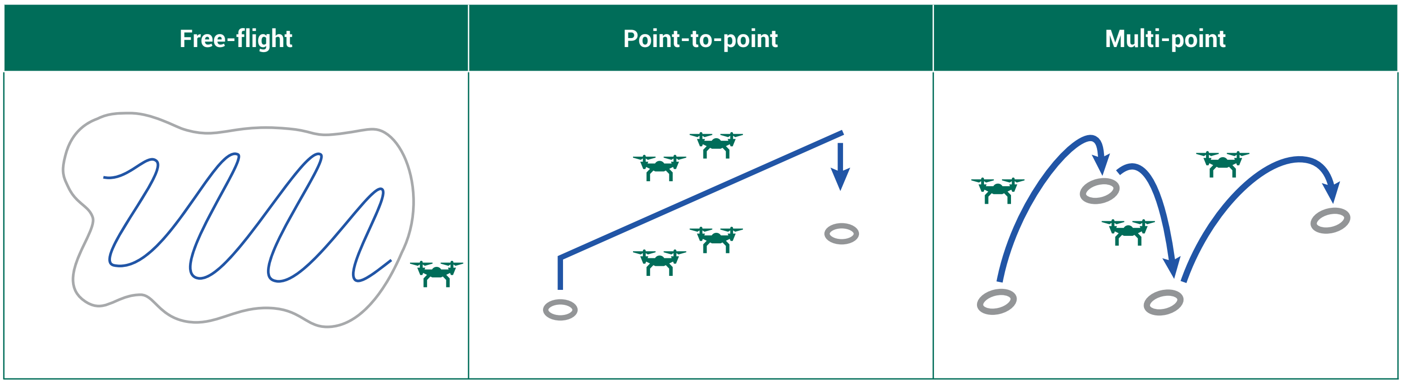



*Figure 2. Examples of drone operations*

Relevant flight details are considered below:

**A.** The identity of the Drone Operator (who is responsible for generating and submitting a proposed flight plan) which will be with the registry. The drone operator may also need to reference any training or 'certificates of competence' they might have – as may be done when submitting traditional operational safety cases.

**B.** The identification of the drone, using its designated electronic identification or call sign.

**C.** Flight category – i.e. a non-landing (surveillance) operation returning to its point of departure, or point-to-point (delivery) landing at a remote location.

**D.** Drone type, to distinguish the type of drone and its registration details.

**E.** Technical data, which may include communication, navigation and surveillance (CNS) equipage and any self-separation (detect and avoid) capability.

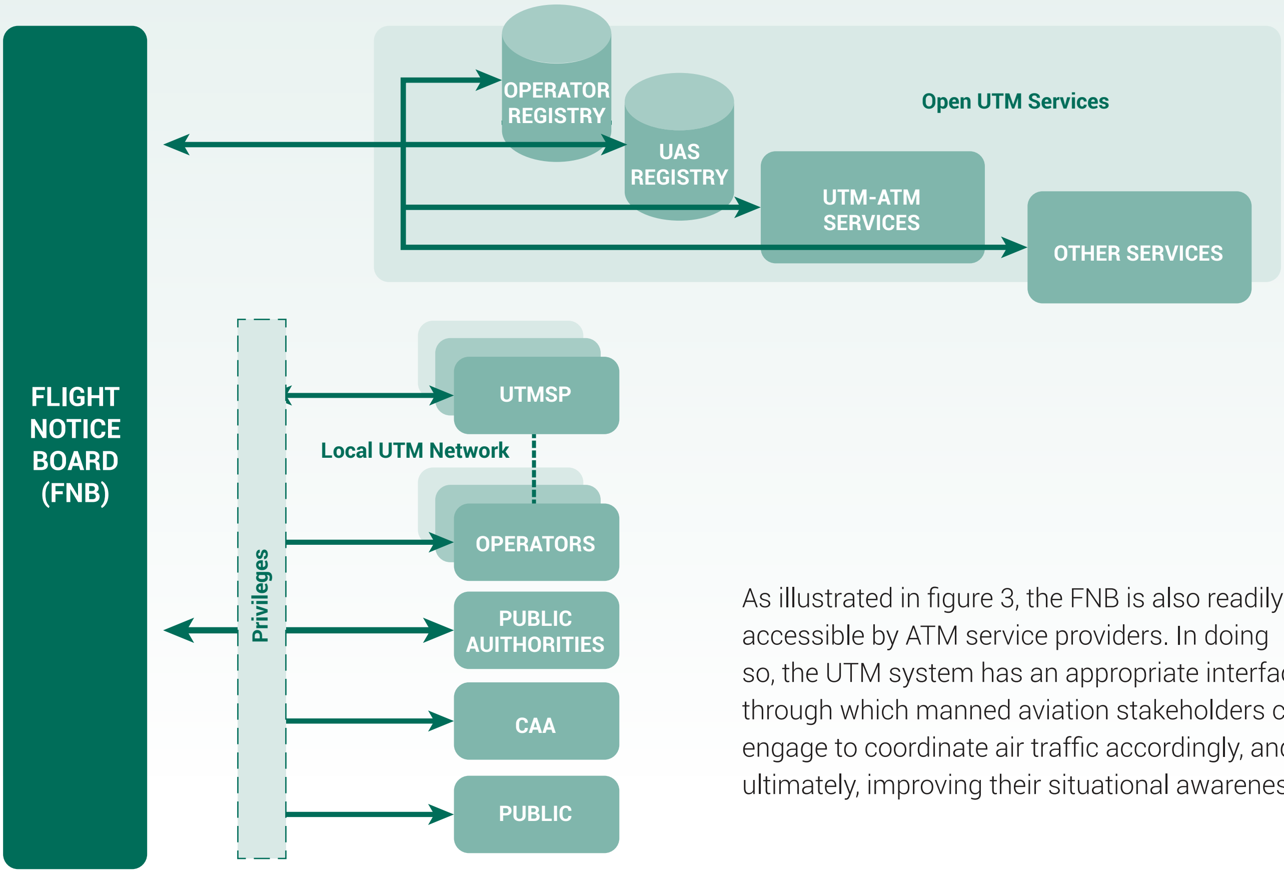
**F.** Route information, to include flight route and area of operations – (e.g. a surveillance loiter zone), planned destination, time of arrival and contingency landing points. Examples of differing drone routes are illustrated in figure 2.

**G.** Other information, such as endurance (battery type); contingency management details (such as emergency recovery points); pilot contact information and third parties.

Flight planning information will need to be communicated across the UTM network, and the level of detail available to stakeholders will depend on of the type of user and level of delegation as determined by the appropriate authority.

The Flight Notice Board (or FNB) has been generated from discussions around how this data is made accessible by the involved actors in a straightforward manner. The FNB including its principal information may be summarised as below. In this particular example, all information exchange transactions are routed back and forth through a centralised FNB service - this instantiation was used as a 'point of departure' for initial research discussions.

The stakeholders involved, as illustrated in figure 3, will have different privileges. For instance, public authorities may have access to the FNB through an online service to view where drone operations are and have been scheduled around them, allowing them to investigate potential or reported misconduct in the vicinity.




As illustrated in figure 3, the FNB is also readily accessible by ATM service providers. In doing so, the UTM system has an appropriate interface through which manned aviation stakeholders can engage to coordinate air traffic accordingly, and ultimately, improving their situational awareness.

***Figure 3.*** *Flight Notice Board concept for flight data sharing*

| FUTURE AREAS OF RESEARCH | DESCRIPTION |
|---|---|
| **Comparison of Flight Plan communication employed by NASA and U-Space initiatives with FNB Concept** | A study should compare the pros and cons of the FNB concept with that of the NASA FIMS concept, and the UTMSP Network flight plan communication strategy. Currently, it is not entirely clear how the NASA methodology functions (based on UTMSP/USS coverage) and warrants a further investigation. |
| **Flight Intersection** | The flight notice board is employed here to enable UTMSPs to determine if the proposed flight intersects or conflicts with other flight plans. There is therefore a need for the subsequent research phase to explore how these intersections can be quickly detected. It will also be appropriate to determine whether the UTMSP or a core service is responsible for this |

***Table 2.*** *Flight planning research areas*

## Strategic Deconfliction

Following the FNB concept for flight plan sharing, there is now a need to establish how flight plans, if intersecting, can be strategically de-conflicted (the term "strategic" is used here to mean "in advance of tactical"). The major objective of a UTM system will be to ensure UTM operations are free of intersections with all other known operations.

Key considerations and criteria around strategic deconfliction include:

**A.** Deconfliction procedures and rules must be well justified and well documented for the understanding of the operators. This is to provide operators with confidence that, in the competitive market, the system is performing ***fairly*** on their behalf.

**B.** The deconfliction procedures must be mandated by the airspace regulator and must be supported by all UTMSPs.

**C.** Decisions made regarding deconfliction should be transparent, and available for inspection by operators and supporting UTMSP.

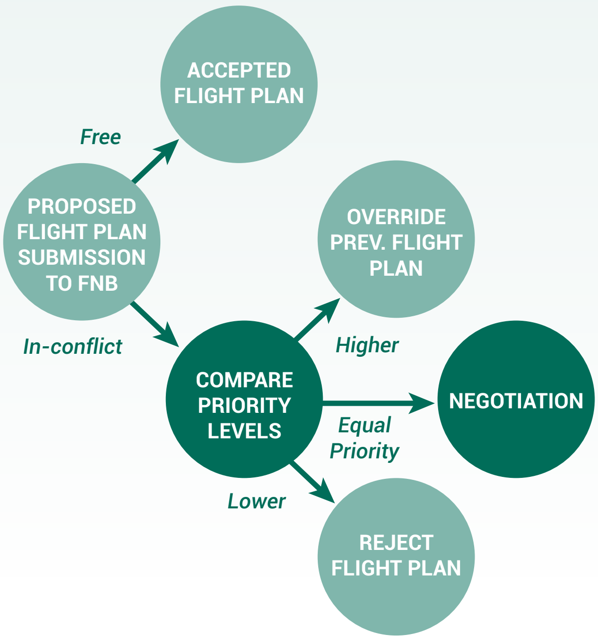



*Figure 4. Flight plan submission*

One approach for strategic deconfliction might be to implement a prioritisation scheme for UTM-engaged operations. Considerations around such a scheme are listed below.

A published prioritisation scheme must cater for pre-emption of operations with lower priority by those with higher priority. The priorities allocated to operators/operations should be bound and monitored such that the system does not become abused or "gamed" to deny access to other stakeholders competing for airspace access. For example, constant and continuous airspace reservations by one operator or organisation in an area will restrict airspace access by other operators.

An initial prioritisation scheme is proposed:

1. **Lifesaving Activities:** These are activities that involve emergency response teams who may fly conventional aircraft such as helicopters or search-and-rescue drones.
2. **National Security:** These might be manned or unmanned aircraft used for counter-terrorism applications, police, or security services operating around critical infrastructure.
3. **Life Support:** Activities such as the transport of medical cargo and equipment.
4. All other activities.

Additional parameters might also be included to consider the operator's track record, the type of operation, airspace considerations as well as other vehicle parameters.

UTM Service Providers may be expected to engage in a negotiation stage in the cases when none of the multiple conflicting flight plans are considered as a higher priority. Figure 5 illustrates the relevant example scenario: there are three UAS operators with the same priority that desire to fly their missions in the same airspace and at the same time, raising the question of whom has priority and how priority is established?

Following the prioritisation scheme, the major **inter-UTM negotiation** principles are:

**A.** Any negotiation process must minimise direct human interaction. This underlying assumption here is that human interaction must be minimised to enable operations to scale and be efficient, though, at the early stages of UTM implementation, human involvement will be necessary.

**B.** This negotiation process must be facilitated via the UTMSPs.

**C.** There must be a finite process, to ensure that negotiations between UTMSPs on behalf of their operators do not continue indefinitely and that a clear "end" is guaranteed by the automated negotiation process.

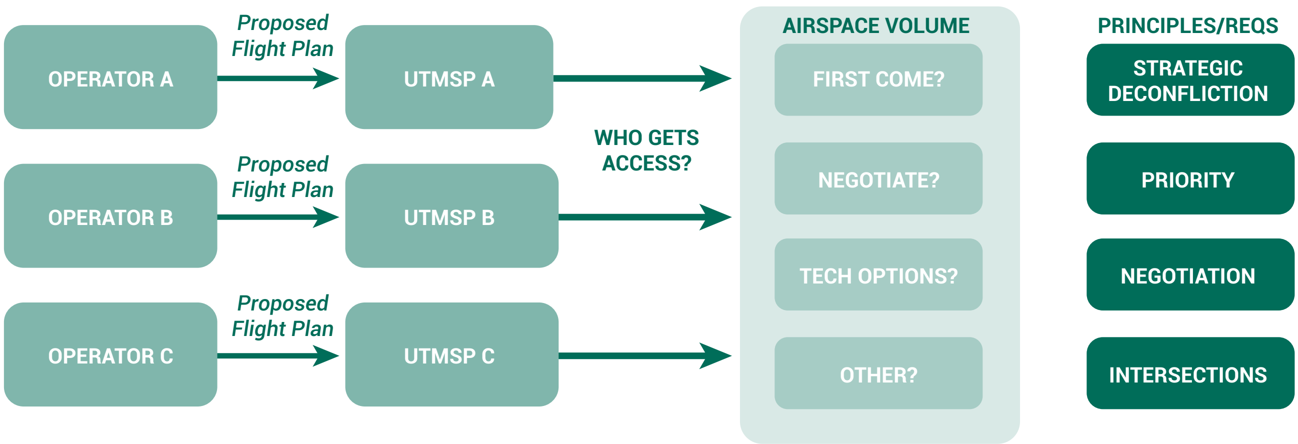



*Figure 5. Use-case for prioritisation*

Finally, there is a case to be made for allowing intersections of UTM operations to occur. There may be scenarios where intersections are reasonable, assuming that operators are aware of, and assume the risks. In these cases, there must be a means to enable operators to provide explicit acknowledgements and consent to each other of the planned intersection. The mechanism to enable this, however, has not been explored in detail, and is a research area that the programme will look to explore in the subsequent phases..

| # | FUTURE AREAS OF RESEARCH | DESCRIPTION |
|---|---|---|
| 1 | Formalise UTM operational priorities | As described, flight prioritisation is a means for strategically deconflicting operations. Coordination with the regulator will enable a formalised list of priorities to be generated |
| 2 | Inter-UTM Negotiation | A more detailed understanding of inter-UTMSP negotiation is necessary. Currently, there is no clear means around which UTMSPs can automatically coordinate flight planning activities |
| 3 | Relative Priority of Manned Air Traffic | There is a need to integrate manned air traffic into the wider operational priorities. Does unmanned traffic generally have a lesser priority than manned traffic |

*Table 3. Operations research areas*


## Flight Permissions in Controlled Airspace

The safe integration of drones into our airspace requires careful consideration of how we authorise the operator in controlled airspace. Access to controlled airspace is being developed by the United States' FAA (LAANC)[6] and the European Commission U-Space initiative, providing solutions for how UAS can request permission to access otherwise restricted airspace. The role of today's air traffic management (ATM) system, as applied to UAS, will be different from how ATC grants access to manned aviation and for UAS will be based on machine-to-machine automation. The ATM industry is looking for new ways of granting near-real-time permission for UAS, by developing new UTM interfaces that can manage the direct interactions with UAS operators, and evaluate how fair and equitable access to controlled airspace can be best enabled.

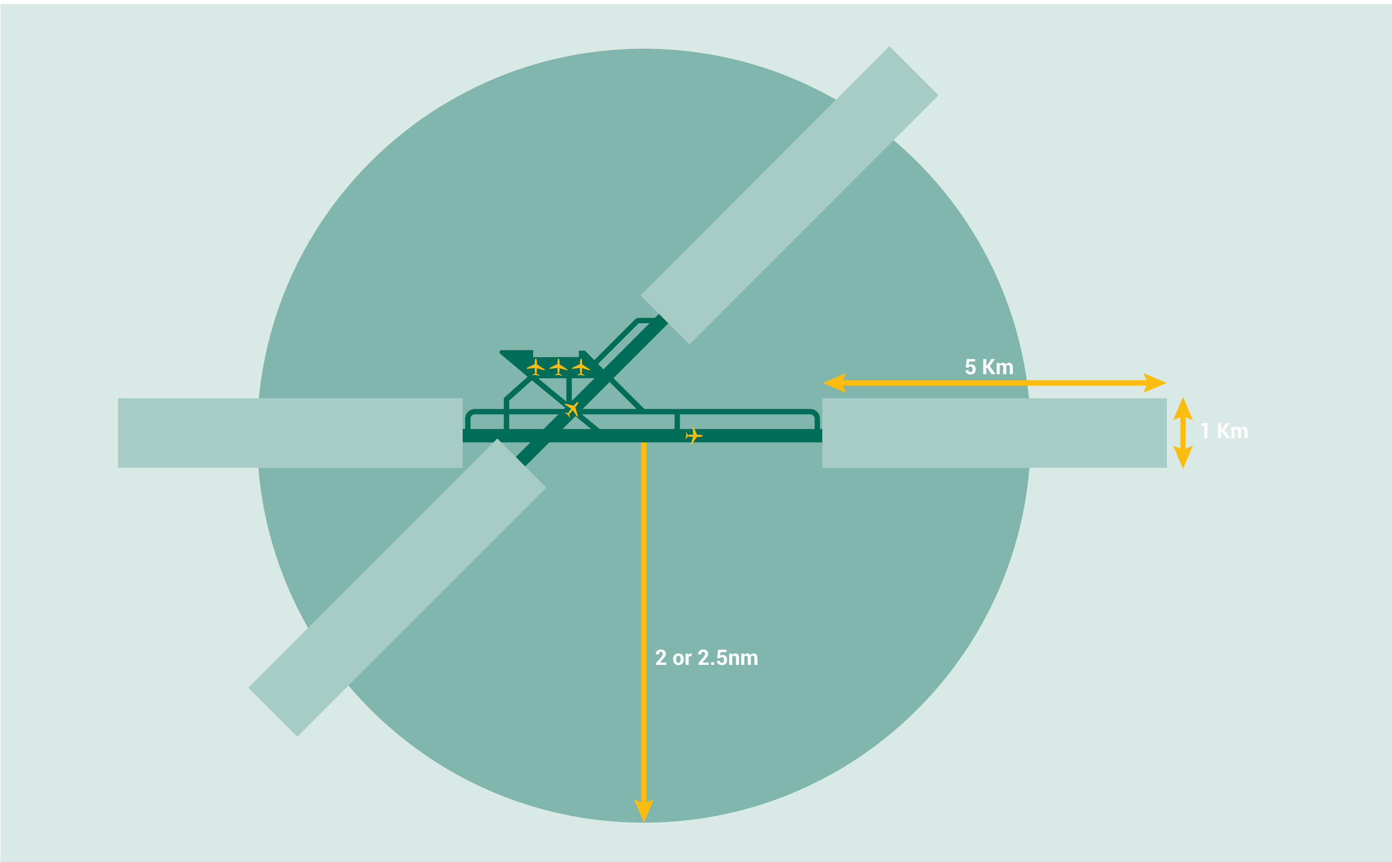



***Figure 6.*** *Flight restriction zones*

[6] UAS Data Exchange – https://www.faa.gov/uas/programs_partnerships/uas_data_exchange/

Two services are proposed here:

1. Standardised Permissions Management Interface
2. Semi-Automated Permissions Management for Drone Operations within FRZs

**Standardised Permissions Management Interface**

The UK's Air Navigation Order (ANO) of 2019[7] has established a series of Flight Restriction Zones (FRZ) around the major airports and aerodromes as a means of defining explicitly safety barriers for airports to separate unmanned operations from local manned airspace activities. Any UAS operator wanting to operate in this region requires the specific permission from that specific airport. The FRZ, is, therefore an "only by special permission" zone and for each zone there is a specific authority able to give this special permission.

In the UK market, airports are owned by independent organisations, whether private or publicly funded, and each is responsible for their own air traffic control or flight information service. This differs from the USA where such services are provided by the FAA. As such, the method to request drone access to the FRZ, and the airport's decision whether to grant or deny it, is entirely down to each airport (figure 7). This presents an inconsistent method of requesting permission that each operator must understand in the first place and an inconsistent method by which airports can assess whether to approve or deny the request, and therefore a very inconsistent level of service that the operator will receive.

This one-to-one, and case-by-case permissions request exercise presents a real challenge to UTMSPs who will look to have a single interface to consistently engage with all airports (figure 8). Similarly, airports may not have the resources or willingness to create multiple interfaces to interface with multiple UTMSPs. This potential for a large operational burden to bottleneck operations in and around FRZs will actively discourage operators and service providers, as airports might prefer simple but cumbersome phone procedures with the operators (as is typically done) or online spreadsheets to request access. Alternatively, they might deny any drone activity altogether.

For airports willing to accommodate drone operations within their respective FRZs, there are two logical options:

1. Develop a bespoke interface for all UTMSPs to engage with. This, however, is costly and time-consuming for airports, particularly small airports.
2. Create a partnership with a single UTMSP to manage FRZ permission. However, this would force all prospective. operators to utilise the designated UTMSP, counter to the open-nature of the Open UTM.

The result of both options, from both the UAS operator viewpoint and the UTMSP viewpoint, is a very poor level of customer service that will hamper the growth of drone-based services in the UK.

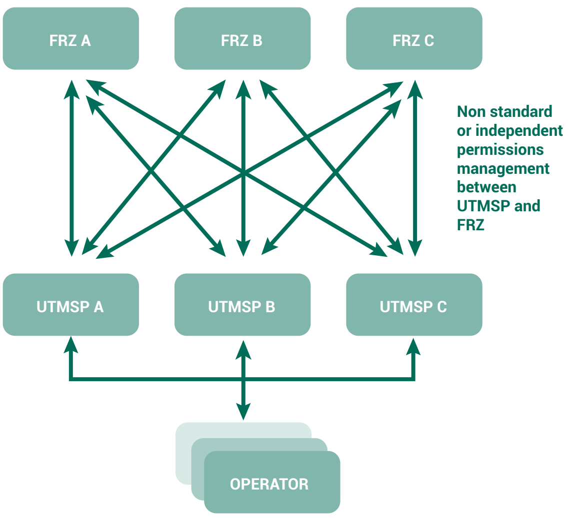



*Figure 7. Impact of non-standardised permissions management interface*

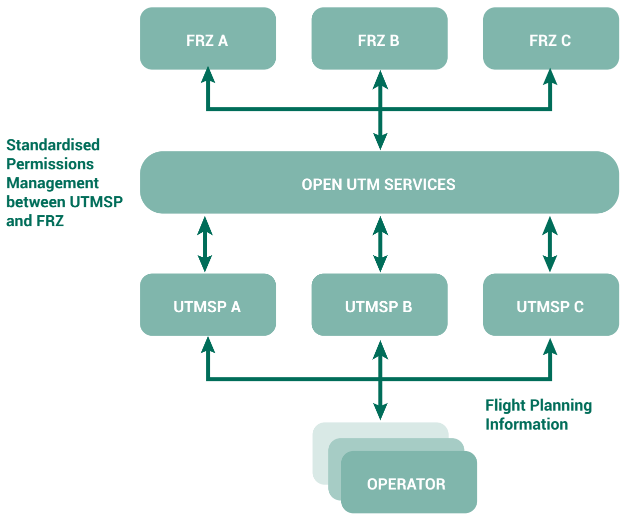



*Figure 8. Impact of standardised permissions management interface*

[7] CAP 1763 – Air Navigation Order 2018 and 2019 Amendments – Guidance for Small Unmanned Aircraft users – http://publicapps.caa.co.uk/docs/33/CAP1763%20New%20UAS%20guidance%20Feb%202019.pdf

It is instead proposed to establish an independent entity that would act as a regulated "standard" interface to each airport. Each UTM service provider would have fair access to the same data sources and authorisation procedures. This improves access to the market for drone operators and dramatically simplifies interaction with operator requests for the airports.

**Semi-Automated Permissions Management for Drone Operations within FRZs**
Part of the Open UTM function would be to help all FRZ apply a consistent assessment methodology for approving or denying flight applications and to gather national statistics of successful request rates, whilst enabling the state to have a clear picture of planned and actual airspace use throughout the UK.

As a regulated national service, this Open UTM Service could be funded through several mechanisms, such as a licence levy on USS, FRZ or UAS operators, some form of user taxation, or through interface provision costs (connection charges, annual service charges, geographic extent, etc).

| FUTURE AREAS OF RESEARCH | DESCRIPTION |
|---|---|
| Approval process | There is a need to understand and generate a standardised approval process of flight requests. This is likely similar to the LAANC process in the United States, though major considerations must be made regarding the division of airspace |

*Table 4. Drone permissions research areas*

## Dynamic Flight Restriction Management

As with the flight notice board and the management of flight permission in FRZs, there is a clear move away from time-consuming and manual processes, and towards digital, rapid-response, and automated solutions. The last major service proposed in this report is the dynamic flight restriction management service and continues to follow this trend.

The UK has a well-established system used to define and outline blocks of airspace with specific restrictions on all air operations within (manned and unmanned). Typically, these volumes have the following restriction classifications:

**A.** Prohibited Areas
**B.** Restricted Areas
**C.** Danger Areas

These permanent restrictions are marked on aviation Visual Flight Rules (VFR) flight charts used by the aviation community. Today, several UTMSPs and even drone manufacturers communicate these areas to their operators for awareness and planning purposes.

Temporary flight restrictions (TFRs) can also be imposed on blocks of airspace, used "as a result of a long-term pre-planned event, or in reaction to a short notice occurrence such as an emergency incident".[8] These restrictions are typically shared via Aeronautical Information Circulars and via the Notice to Airmen (NOTAM) system – typically requiring a long 28 day notification cycle, and are listed on the NATS' Aeronautical Information Service (AIS) website.

As the volume of air traffic increases, it will be increasingly necessary to communicate temporary flight restriction (TFR) information to relevant UTMSPs and UAS operators in order to respond to rapidly evolving circumstances and scenarios. One example of where dynamic TFRs may have a major impact is in the management of emergency response services such as a wildfire that must be contained (figure 9). In this case, the airspace must be immediately restricted to all air operations, including unmanned vehicles, with access only to permitted emergency response vehicles, and other stakeholders with relevant approvals. This concept of dynamically managing the airspace is now becoming an increasingly important component of the UTM discussion, with emerging discussions around ***Geofencing*** and ***Geo-limitations*** – both methods for restricting access to airspace.

[8] Airspace Restrictions for Unmanned Aircraft and Drones –
https://caa.co.uk/Consumers/Unmanned-aircraft/Our-role/Airspace-restrictions-for-unmanned-aircraft-and-drones/

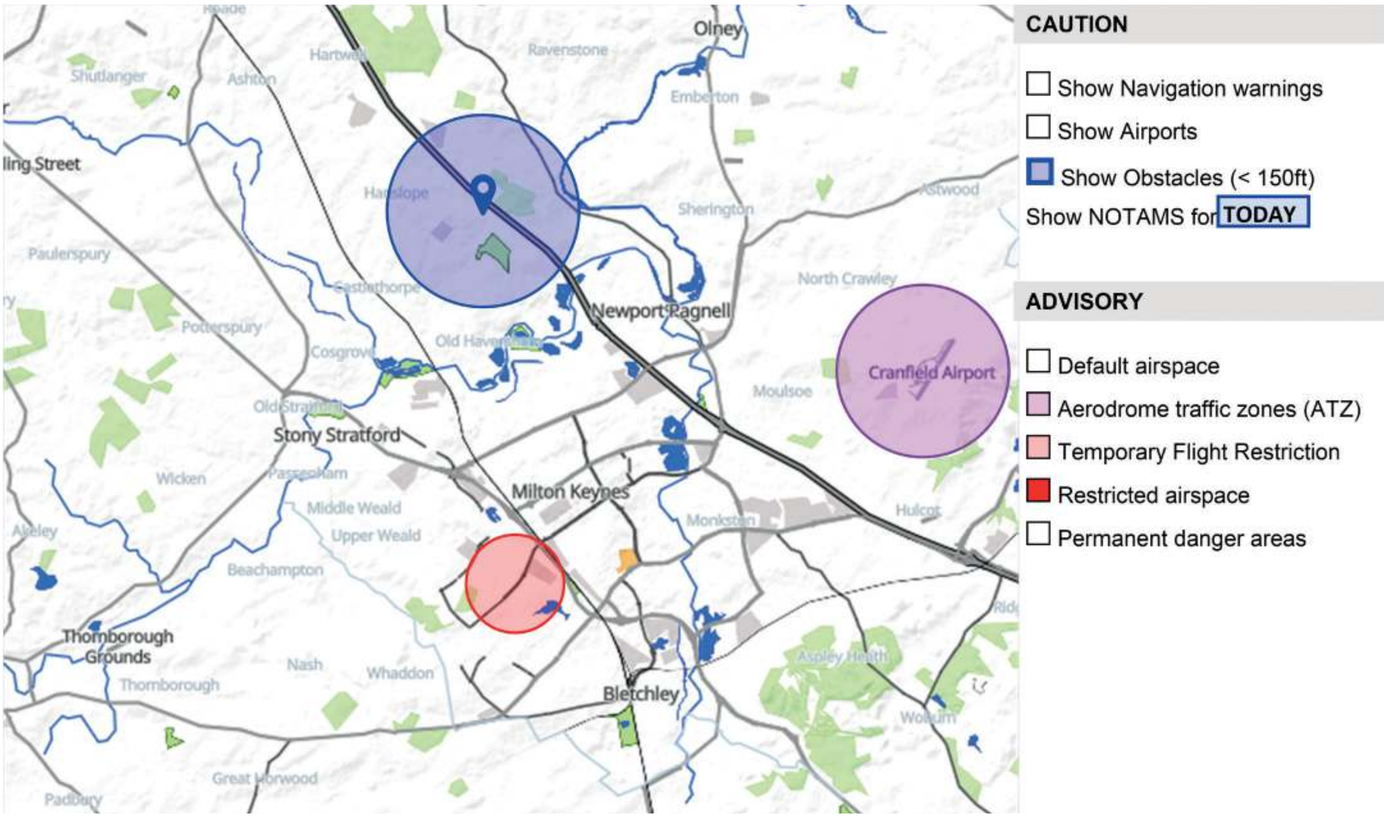



*Figure 9. Example of temporary airspace restriction*

TFRs, often as a Temporary Danger Areas (TDAs) are typically activated via Notice to Airmen (NOTAMS). NOTAMS currently have a 28 day update cycle and is typically described in a manner that is not straightforward for software to interpret. As a result, extracting relevant information from NOTAMS is a typically manual and time-consuming process.

Recommendation providers, operators and manned aviation stakeholders with a means to subscribe to airspace restriction updates, and provides visibility on planned airspace restrictions in the future. Unlike with traditional NOTAMs, this system would use standardised description formats to facilitate automated processing of the NOTAMs.

Following this, it is proposed that the recommendation is appropriately digitised and, to some degree, automated to allow for the rapid approval of TFR requests within which non-standard drone operations e.g. BVLOS can occur with prior authorisation from the CAA. This is further detailed in the following descriptions.

**Dynamically segregating drone operations with respect to critical infrastructure or areas experiencing incidents or disasters**

The need to segregate drone operations from certain infrastructure or incidents is clear with the example of the wildfires provided above and is an activity that individual UTMSPs are already implementing on their own through the geofencing of restricted areas. Following an approved TFR request, UTMSP can subsequently support operators to plan flights according to the new restrictions.

**Segregating airspace around unmanned aircraft operations**

There is an opportunity to potentially use TFRs as a means to segregate current drone operations from other air traffic. This is already an approach utilised by the CAA when providing permissions to operating companies looking to fly BVLOS operations. However, the current approach is labour intensive beyond just the requirement to develop an approved Operational Safety Case (OSC), but extends to the duration required to engage with affected stakeholders that may operate within the proposed operating area, and the necessary time required to evaluate the impact on the airspace.

Close engagement with the CAA and other stakeholders is required to best understand how to automate and streamline much of these processes and determine the most beneficial and appropriate means to accelerate the time from which a TFR can be proposed, approved and subsequently implemented.

The ambition, here, would be to enable the rapid segregation of drone operations – providing immediate situational awareness to operators and service providers engaged in UTM, including manned aviation stakeholders. When implemented, this may be similar to providing operators/UTMSPs with a means to reserve airspace access to a specific volume, with access rights provided solely to the designated operator. This is directly aligned with the concept of the UAS Volume Reservation, currently being researched under the FAA's UTM Pilot Programme (UPP)[9]

***Note** – As drone operations increase in scale, the regulator cannot be expected to appropriately manage the airspace in real-time. As such, there is a case for delegating the authority to issue localised low-level airspace restrictions to appropriate stakeholders.*

Under existing regulations, the CAA remains the sole authority able to issue and approve TFRs. However, there is a growing case for enabling local authorities such as airports, ATC, Blue Light Services to create TFRs to appropriately cope with growing volumes and manage airspace at a more local level. As drone operations increase in scale, the regulator cannot be expected to appropriately manage the airspace in real-time to respond to all airspace access requests – particularly as the number of flights grows in both volume and complexity. As such, there may be a case to delegate TFR issuance responsibilities from the CAA to enable localised control over airspace access, but further define operating requirements and the associated limitations of given airspace.

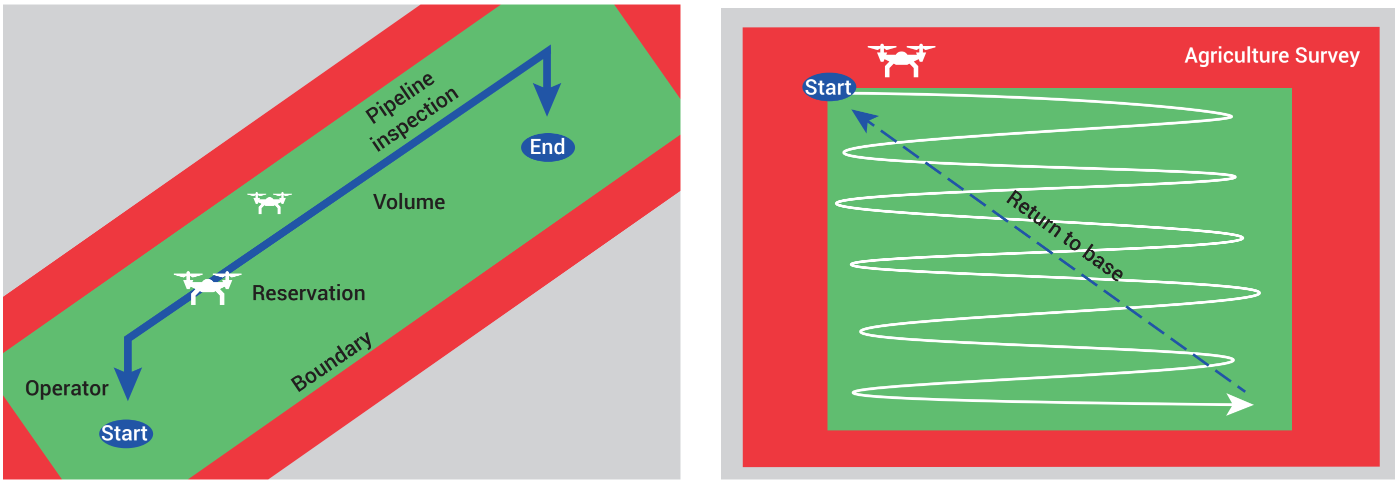



***Figure 10.** Examples of airspace volume restrictions for drone operations*

[9] https://www.faa.gov/uas/research_development/traffic_management/utm_pilot_program/

To summarise, it has been assumed that a TFR registry would be incorporated within the Open UTM Service, with full access provided to:

**A. The CAA:** is the legal authority to issue flight restrictions, it makes sense for them to continue with this responsibility.

**B. Public Authorities:** as previously described, public authorities may be required to dynamically manage low-level airspace in the case of emergencies or events.

Both the CAA and Public Authorities may opt to use UTMSP tools to manage airspace segregation, and as a mechanism to input TFRs into the dynamic TFR registry. In this case, there may be a possibility to further delegate TFR issuance responsibilities to authorised UTMSPs through which public authorities can coordinate.

To facilitate the management of the repository, two classes of TFRs are proposed:

- **Urgent:** The urgent TFR is, as the name suggests, implemented to support urgent or emergency services, including national security measures. In this case, TFR information will be disseminated to all stakeholders on a high-frequency update cycle (i.e. short time scales, or near real-time).
- **Normal:** The normal TFR is information communicated at regular intervals, not on a high-frequency basis.

This distinction between urgent and normal update cycles is a means to mitigate the risk of network overloads. The corresponding time intervals should be defined by the regulator.

| # | FUTURE AREAS OF RESEARCH | DESCRIPTION |
|---|---|---|
| 1 | TFR volume definitions, requirements, standards | There is a need to understand and generate a standardised approval process of flight requests. This is likely similar to the LAANC process in the United States, though major considerations must be made regarding the division of airspace |
| 2 | Define publication protocols | There is a need to outline and subsequently formalise the process through which TFR information is published across the UTM network to reach all stakeholders. What is the strategy to communicate TFR information to GA who may not be actively connected? |
| 3 | Delegation of TFR responsibilities | There is a need to understand how TFR issuance responsibilities might be delegated to local and public authorities, and what the oversight regiment may be for such authorities.<br>There is also a need to explore how this might be possible from a regulatory/ legislative perspective |
| 4 | TFR operating procedures | There is a need to understand what the procedures are required for operators once they are found within a TFR. The second phase of the programme will study how such processes may be formalised |
| 5 | Enforcement | What requirements exist to enforce the regulations with respect to TFRs |

*Table 5. Airspace reservation research areas*

# Architecture

**A UTM architecture is a representation of how roles and responsibilities for UTM services are distributed amongst the participating stakeholders. Building consensus about the architecture and developing the roles and responsibilities of stakeholders is an important step in the advancement of any UTM initiative**

A high-level view can be visualised in figure 11, to show how the UTM architecture might be organised to enable the relevant communications and data-exchange activities between actors.

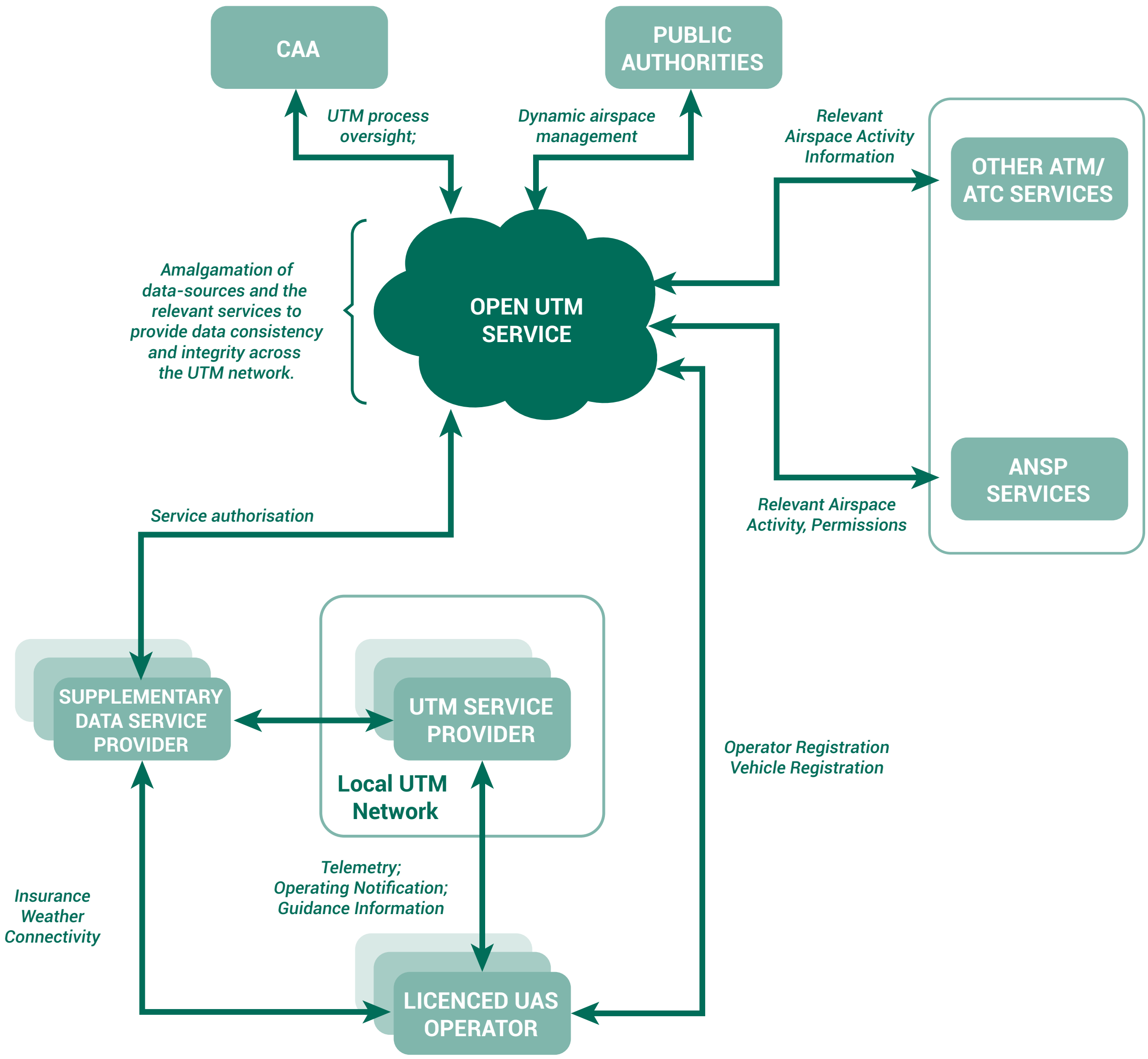



*Figure 11. High-level architecture view*

The Open UTM Services is placed at the centre – it is purposefully ambiguous as to whether this service is itself implemented as a centralised or distributed system. This, and the "ownership" of the regulated Open UTM Service will need to be decided by Government, including how responsibilities might be delegated from the CAA to local public authorities, authorised UTM services and the relevant ATM services.

A major consideration when designing a comprehensive UTM framework will be the compromise that will need to be made between working within existing regulatory constraints and making significant revisions or even overhauling regulations in a manner that will pave the way towards a more suitable and digital form of unified air traffic management built with automation in mind.

Building on this top-level operational view, a preliminary logical architecture view informed by the Open UTM Services and the relevant key features can be visualised in figure 12. Figure 12 shows a degree of centralisation of major regulated services – however, variations of the architecture exist that are consistent with the principles and UTM service descriptions provided above. For example, the responsibilities for some regulated services could potentially be delegated from the regulator to public authorities (as previously described). Following this first phase, the programme will continue to work to better understand stakeholder requirements to deliver a more comprehensive and detailed view on how the regulator, the industry and the public may interface with UTM as a whole.

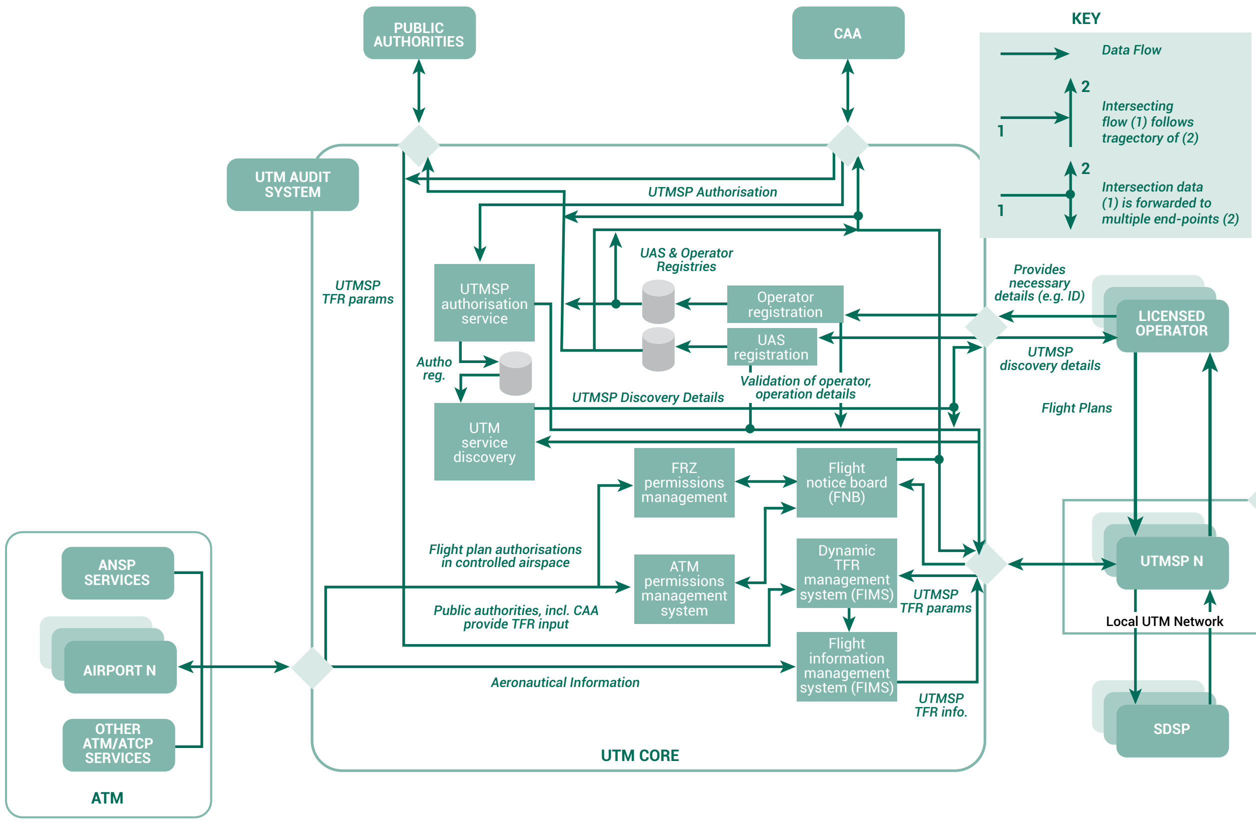



*Figure 12. Notional logical UTM architecture*

***Note:** As with the majority of other UTM initiatives, the consortium fully expects the underlying communications system of the future UTM network to be integrated using internet-based technologies and built on industry standards and protocols.*

## UTM Disruptions and Conflict Management Framework

A range of possible disruptions to nominal drone operations must be anticipated by the implemented UTM system to enact and coordinate the relevant risk-mitigation procedures. Developing these procedures will be a major objective behind the follow-on research of this programme. Table 6 lists and describes the principle disruptions initially considered by the consortium.

| # | DISRUPTION | DESCRIPTION |
|---|---|---|
| 1 | **In-flight conflict with dynamic geo-fence/exclusion zone** | Temporary flight restrictions (TFRs) are dynamically applied within an area of UAS operations |
| 2 | **In-flight conflict with emergency services (air)** | Emergency services helicopter flies through airspace occupied by UAS. Air operations must be appropriately prioritised and deconflicted |
| 3 | **In-flight conflict with non-cooperative UAS** | A non-cooperative UAS is detected and determined to be operating within the vicinity of other airspace users. The airspace must be appropriately deconflicted |
| 4 | **Flight path conflict between cooperative UAS** | In some circumstances, cooperative UAS flight paths may interfere. Such interferences must be resolved to strategically and tactically deconflict the airspace |
| 5 | **Lost control with UAS** | Control of the UAS is lost by the operator, however, communications (i.e. telemetry) is maintained. The uncontrolled UAS poses a risk to other airspace users, and people and property on the ground. There is a need to ensure information is disseminated to nearby airspace users to take appropriate action and reduce the risk |
| 6 | **Lost communication with UAS** | Communications (and hence, control) with the UAS is lost by the operator. The uncontrolled UAS poses a risk to other airspace users, and people and property on the ground. There is a need to ensure information is disseminated to nearby airspace users to take appropriate action and reduce the risk |
| 7 | **Unscheduled flight termination by operator** | Operator decides to terminate flight during the mission. This may be as a result of changes in circumstances to the operator, the operating environment, emergencies or other changes |
| 8 | **In-flight mission re-plan** | Operator requests to alter flight plan in-flight.<br>It was agreed that in-flight re-planning was not something that was typically carried out in traditional aviation. However, it was recognised that, in the context of UAS that may be deployed to fulfil rapidly changing needs, there is a need to consider how vehicles may be re-tasked without negatively impacting other airspace stakeholders |
| 9 | **Intervention by ATC in controlled airspace** | ATC intervenes in UAS operation at different stages of operations:<br>A) Before UAS deployment<br>B) During UAS deployment<br>This may be to perform the following:<br>A) Temporarily conduct holding pattern<br>B) Conduct emergency landing |
| 10 | **Intervention by public authorities** | Public Authorities intervene in UAS operation at different stages of operations:<br>A) Before UAS deployment<br>B) During UAS deployment<br>This may be to perform the following:<br>A) Temporarily conduct holding pattern<br>B) Conduct emergency landing |

*Table 6. Description of potential disruptors to nominal UTM operations*

***Note:*** ***This is not an exhaustive list of disruptors but operating incidents that are considered most likely to impact UTM operations. Whilst not considered in this report, it will be necessary to consider additional disruptions resulting from poor implementation or IT vulnerabilities of a UTM system (e.g. server overloads, lost communications between ground infrastructure systems, etc.).***

To respond to these conflicts and disruptions, a Conflict Management Framework is proposed. This framework will describe the processes required to manage low-level airspace conflicts, and disruptions listed in table 6. This framework will likely require the engagement across the stakeholder community and, in particular, the CAA to explore how to minimise operational risks across the broad range of circumstances and operating environments. The development of such a framework will be explored in the next stage of this programme.

# What UTM means for Industry

## Open Access UTM for the Drone Operator

The drone operator is, typically, the end-user of the end-to-end UTM solution and, as a result, will be the target customer for many of the new services developed in the UTM framework. It is therefore important to understand what the end-to-end UTM solution will mean to the drone operator – i.e. what will the UTM solution enable the drone operator to do and how will the drone operator interface with the system as a whole.

It is expected that the drone operator will engage with the UTM system in cases where the flight is expected to be carried out over BVLOS range, potentially in congested airspace areas, in controlled airspace (FRZs in particular), and other areas that may, in the future, have a mandatory UTM-engagement operating requirement. There is no current commitment that these areas will indeed mandate UTM-engagement in the future, however this is a reasonable assumption as operating in such conditions and environments may require other airspace users or stakeholders to be notified or made aware prior to their operations.

UTM-engagement may also bring significant benefits to the operators who volunteer participation and are not operating BVLOS or in controlled airspace, but rather operate their drones within VLOS, and in uncontrolled airspace. In volunteering their activity data (position/airspace reservation, etc.), operators will provide other nearby airspace users with an improved awareness of their surroundings to generally improve safety. As UTM-engaged flights will be logged for audit purposes, a record of appropriate drone operations may be used to improve service offerings in the future, and potentially even reduce the cost of insurance – similar to how telematics boxes are now widespread in the car insurance sector.

From the architecture illustration (see figure 11 & 12), there are three major points of interaction between the operator and the UTM system:

1. **Drone operator** – Authorised UTMSP.
2. **Drone operator** – The Open UTM Service.
3. **Drone operator** – Authorised SDSP.

The drone operator is, typically, the end-user of the end-to-end UTM solution and, as a result, will be the target customer for many of the new services developed in the UTM framework.

**Drone Operator – The Open UTM Service**

The drone operator engages directly with the Open UTM Service to do two important things. The first – to register their details. The second – to "discover" an appropriate UTMSP which is capable of providing the relevant services required for their operations.

The interface between the operator and the Open UTM Services is to be openly accessible – i.e. a standardised and open interface, providing operators with a straightforward means of adding or amending their registered details online.

**Drone Operator – Authorised UTMSPs**

The most critical aspect throughout the drone operator's engagement with UTM will be their communication and coordination with the UTMSP. Data is exchanged continuously with the UTMSP throughout all phases of the operation. Importantly, the UTMSPs act as a means of sharing relevant information with the relevant Open UTM Services that are further "downstream" in the flow of data.

In order to provide the necessary continuous data-exchange between the drone operator and the UTMSP, there may be a need for interfacing between UTMSPs and drone manufacturer, or the corresponding equipment suppliers that can provide relevant information. There is, therefore, a potential opportunity for standardisation of Manufacturer-to-UTMSP interfaces.

**Drone Operator – Supplementary Data Service Provider**
The engagement with the SDSPs will typically be to further inform the drone operator of additional operating circumstances, or procure further services such as insurance. Interfacing with SDSPs might be carried out independently but may also be carried out through the UTMSP interface.

## Journey of the Drone Operator

Following these descriptions, figure 13 illustrates the drone operator's user-journey- i.e. their journey as they engage with the Open UTM System to conduct their operation. This journey is divided into three segments: the pre-flight phase, in-flight phase and post-flight phase.

**Pre-Flight Phase**
Here, the operator is assumed to have registered with the state-level operator registry, prior to engaging with the Open UTM System.

From the perspective of the drone operator, the pre-flight stage primarily involves the development of a proposed flight plan that can be submitted to, and validated by, a selected UTMSP. The validation exercise may require the drone operator to revise the proposed flight plan to appropriately deconflict with other airspace users and other issues that the UTMSP may anticipate.

The proposed flight plan indicates the volume of airspace within which the drone operation is expected to occur, the corresponding time and duration of the operation, and potentially any additional information/locations of key operational events such as the launch and recovery and emergency landing locations of the planned operation. The drone operator may also interrogate external data sources (e.g. SDSPs) to inform their flight planning activities.

With the flight plan proposed and accepted by the UTMSP, the drone operator will be notified of any disruptions or conflicts with their operation, up until the activation period of their flight plan – i.e. the beginning of their scheduled window of operation. As previously discussed, such conflicts might include higher-priority operations that override their operation.

**UTM-engagement may also bring significant benefits to the operator that volunteers participation who may not be operating BVLOS or in controlled airspace, but rather operate their drones within VLOS, and within uncontrolled airspace. In volunteering their activity data, operators will provide other nearby airspace users with an improved awareness of their surroundings to generally improve safety.**

For cases where the operator's proposed or accepted flight plans have been rejected, it will be important that the operator is provided with some reasoning behind the rejection to make an informed decision of their potential next steps, and potentially how to revise and resubmit their proposed flight plans.

**UTMSP Discovery Service**
The operator will down-select from the available UTMSPs based on mission requirements, commercial or personal preferences

**Registration Service**
The operator will down-select from the available UTMSPs based on mission requirements, commercial or personal preferences

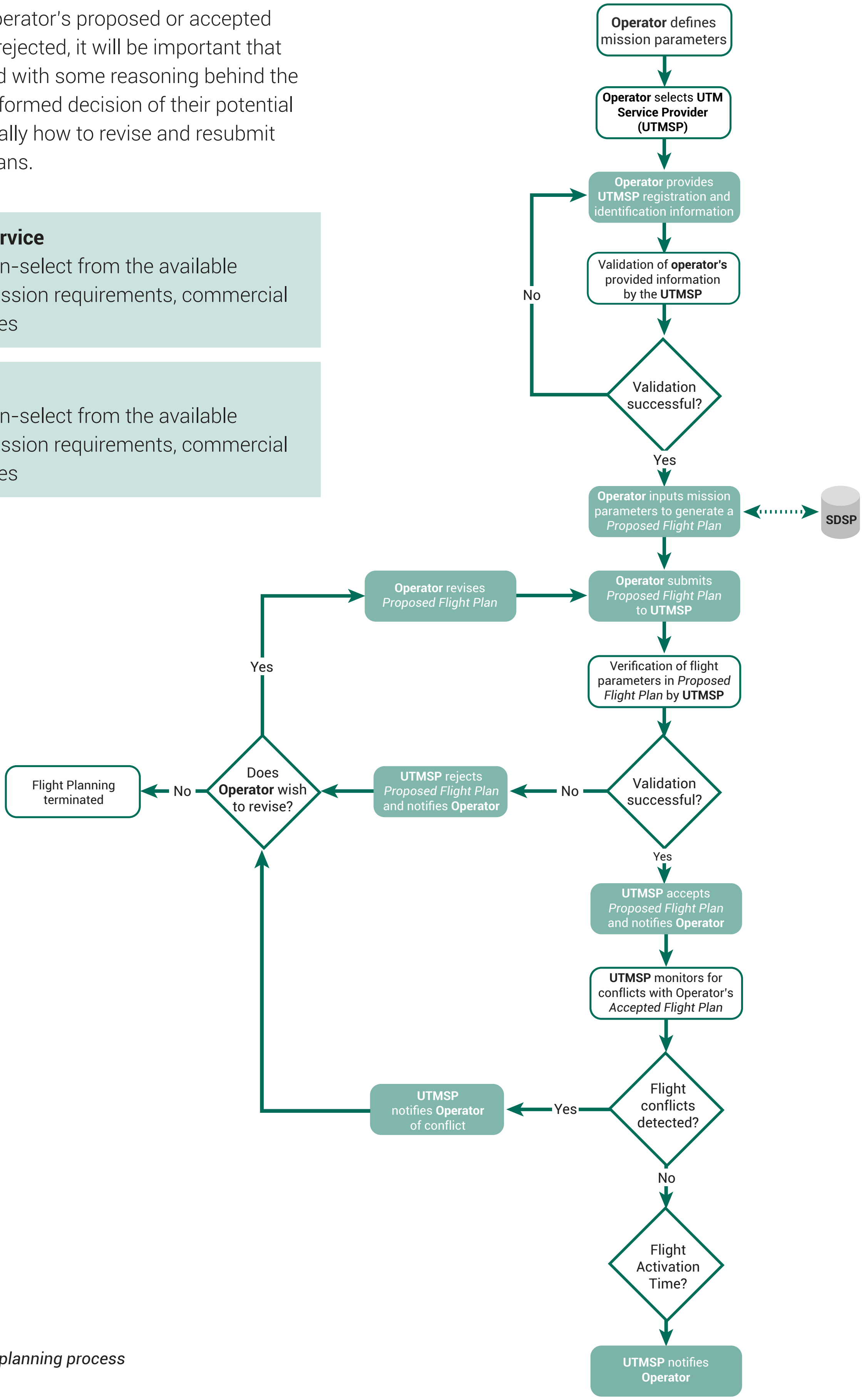



*Figure 13. Proposed flight planning process*

**In-Flight Phase**
The In-Flight phase begins by activating the accepted flight plan i.e. start engine(s) and sending all the necessary activation data to the UTMSPs. Throughout the flight, the drone operator will share telemetry data such as vehicle position, heading, speed, health status data, etc., with their UTMSP – necessary to inform the UTMSP to ensure that operations are appropriately managed, and to ensure that deconfliction strategies can be enacted in case of potential disruptions. These activities are known as conformance monitoring of the drone flight, and tactical deconfliction.

The operator is expected to operate their vehicle within the volume constraints as defined in the accepted flight plan. If the drone exceeds these constraints, the UTMSPs can alert both the operator directly, but also alert relevant actors in the surrounding areas such as other airspace users, ATC, and local authorities. With the events automatically logged by the UTMSP, necessary actions can be taken post-flight to investigate what happened, and potentially hold the operator to account in the case of negligence and inappropriate behaviour, or illegal activities.

**Post-Flight Phase**
The operator is expected to indicate if the flight terminates as planned, or if there is a need to notify the relevant authorities in the case of an unscheduled or unexpected flight termination. This notification is likely to be carried out directly through the UTMSP interface.

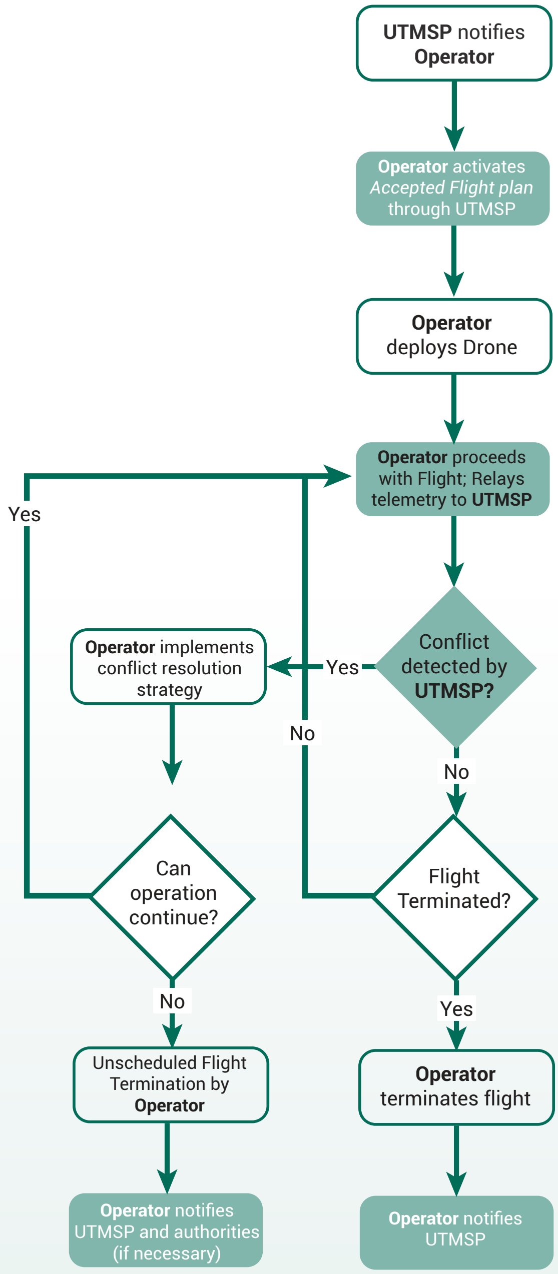



*Figure 14.*
*Proposed in-flight and post-flight processes*

## Throughout the flight, the drone operator will share telemetry data such as vehicle position, heading, speed, health status data, etc., with their UTMSP.

## Open Access UTM for the UTMSPs

UTMSPs are clearly a central and important enabler of the Open UTM system as-a-whole, therefore it is wholly appropriate to define key underlying UTMSP requirements.

It is expected that to regulate the wider UTM, the participating UTMSPs must be approved by an authority to appropriately and safely provide unmanned air traffic management services to drone operators. To get approved as an "authorised" or "certified" UTMSP by the CAA, there will likely be a set of formalised requirements that the UTMSP must fulfil. Additionally, there may be a range of different classes of UTMSPs, authorised to conduct different classes of operation, manage specific classes of vehicles, operate with different levels of "privilege" and authorised to different levels of certification.

More clarity is required to better understand all such requirements of the UTMSP and are expected to be further developed throughout the later stages of the Open Access UTM Programme.

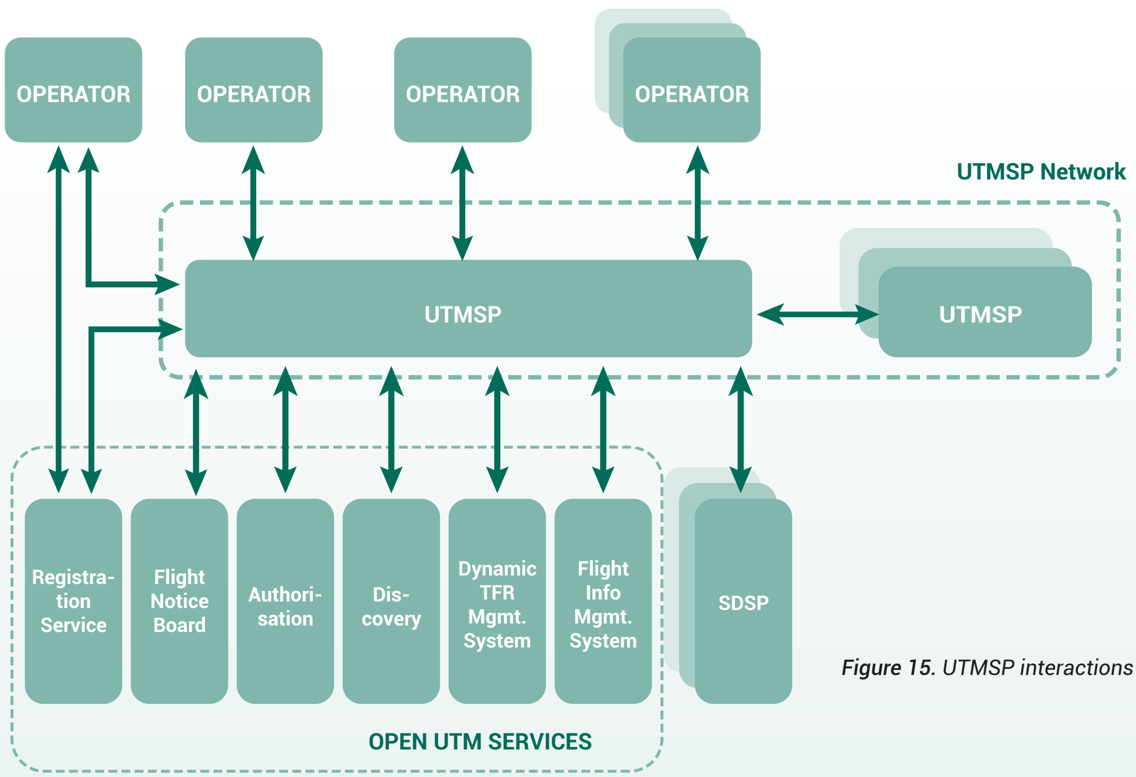



*Figure 15. UTMSP interactions*

There are four major points of interaction for the UTMSP, described below:

1. **UTMSP** – Drone Operators.
2. **UTMSP** – The Open UTM Service.
3. **UTMSP** – SDSPs.
4. **UTMSP** – UTM Network (LUN).

**UTMSP – Drone Operators**
The UTMSP and drone operator interface continuously throughout the pre-flight, in-flight and post-flight stages of the operation. This has largely been described in the previous section.

**UTMSP – Open UTM Services**
The most intensive data-exchange activity will likely be between the UTMSP and The Open UTM Service, enabling the UTMSP to request and submit operation-related information for the operator, and also engage with the relevant UTM services including the Registration service system, Flight Noticeboard services, the TFR repository, and other relevant services previously described.

The digital engagement across these services is expected to be carried out on a high-frequency basis that is not achieved using today's conventional processes. Therefore, significant time and effort will be required to transition existing systems from a slow, paper-based process, and develop digital and automated solutions.

**UTMSP – SDSPs**
UTMSPs are expected to engage with authorised SDSPs to improve their service offerings. This is expected to occur on an open-market basis, with the UTMSPs free to work with relevant data and service providers to deliver better services to their customers.

**UTMSP – UTMSP Network**
The UTMSP will engage with other UTMSPs. This will primarily be done in two instances: **a)** during inter-UTMSP negotiation activity; and **b)** alerting UTMSPs with operators neighbouring a vicinity with non-conforming drone operation.

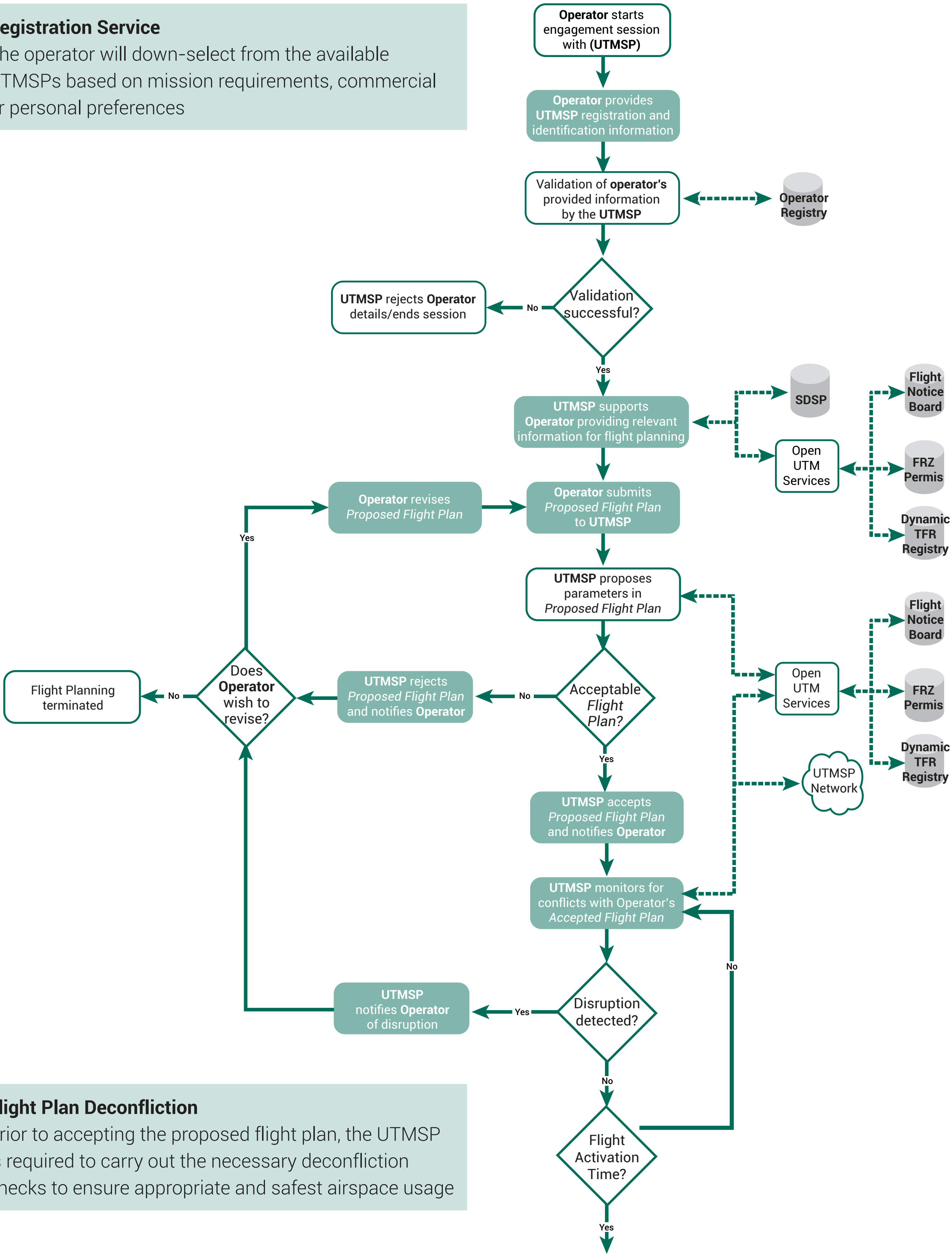
To engage with the UTMSPs, a UTMSP (say, UTMSP A) would be expected to engage with the registration service to determine communication details of the target UTMSP (UTMSP B) – e.g. IP addresses. UTMSP A can also directly engage with multiple UTMSPs – effectively directly publishing information necessary to deconflict airspace and assure safety.

## Journey of the UTMSP

The following section describes the journey of the UTMSP through engagement of a drone operation. As before, the journey is divided into the pre-flight phase, and the in-flight and post-flight phases, and is illustrated in figure 16.

**Pre-Flight Phase**
The pre-flight journey closely follows the journey of the drone operator due to the continuous and direct engagement between both parties. These figures show the engagement with the relevant data-sources and services that are necessary for the UTMSP to make appropriate decisions – i.e. validation of the operator, approve proposed flight plans, and then carrying out recurring checks to ensure minimal disruption to airspace activities.

**Registration Service**
The operator will down-select from the available UTMSPs based on mission requirements, commercial or personal preferences




**Flight Plan Deconfliction**
Prior to accepting the proposed flight plan, the UTMSP is required to carry out the necessary deconfliction checks to ensure appropriate and safest airspace usage

*Figure 16. Flight planning process*

**In-Flight Phase**
There are two major responsibilities of the UTMSP during the in-flight phase of the drone operation:

1. **Drone Conformance monitoring** – monitoring the drone's operations and performance to ensure it conforms to the operator's accepted flight plan and subsequently notifying adjacent airspace users in the case of non-conformance
2. **Monitoring airspace** activities through the engagement with the Open UTM Services and potentially other UTMSPs; and subsequently notifying the drone operator in the case of disruptions

Monitoring airspace activities through the Open UTM Services is a major necessity that is expected to be required of UTMSPs by the regulator to be recognised as an "authorised" provider. As illustrated in figure 17, there is continuous engagement with the Open UTM Services to monitor other airspace states and activities through the Flight Notice Board, FRZ and Dynamic TFR Management systems. The rate at which data is refreshed across the UTM network during this in-flight phase should be considered to be as high as is reasonably possible, allowing disruptions to be managed using near real-time data.

**Recurring Flight Plan Checks**
The accepted flight plan will undergo recurring checks against the relevant data sources to ensure that any conflicts are addressed, and the relevant parties notified

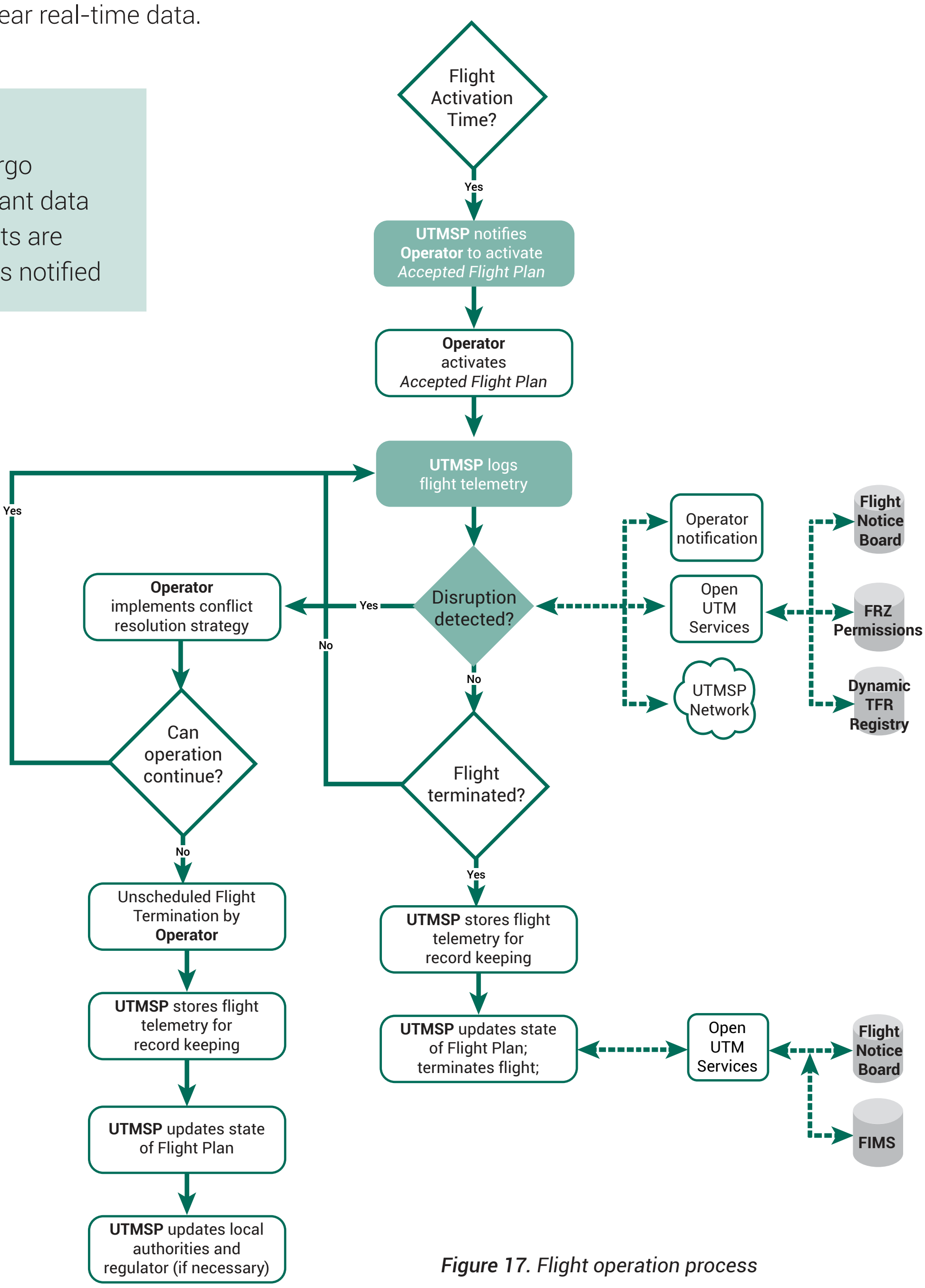



*Figure 17. Flight operation process*

**Post-Flight Phase**
The responsibilities of the UTMSP post-flight are centred around determining the state of the flight termination and communicating this state with relevant stakeholders. In nominal conditions, the operation will conclude as planned. Otherwise, the UTMSP must engage the drone operator and/or interrogate the received telemetry to determine if the flight has been terminated as expected. In unscheduled/unexpected flight terminations, the UTMSP may directly inform local authorities and/or the regulator if necessary.

Though not elaborated on in the figures, future UTMSPs may also provide support in implementing a conflict resolution strategy in the case of a disruption – potentially suggesting suitable changes to flight plans in-flight, as well as proposing locations to carry out emergency landings — i.e. low-risk sites.

## Open Access UTM for the Regulator

The regulatory authority, the UK CAA, provides oversight across the aviation sector to maintain safety for the users and the public. It will work with stakeholders to ensure the safe deployment of UTM, oversee air traffic operations, enforce regulations and hold airspace users accountable. The Open UTM system provides the regulator with a means to monitor and manage the increasing volume of airspace activities in partnership with delegated responsibilities to UTMSPs, airspace managers and operators.

Following earlier descriptions, the proposed Open Access UTM system provides the regulator with the following capabilities:

1. **Authorise service providers to participate in UTM data-exchange activities and Support the UTM Discovery Service**
   The regulator will define standards that entities must meet to be authorised as an approved service provider and participate within the UTM system. Approved service providers are registered with the regulator who can then share service provider information to support UTM discovery services.

2. **Manage registration repositories**
   It is the role of the regulator to ensure that registration information is maintained and shared appropriately and that the processes to interface with the registration system are defined. This will enable the stakeholders to access the relevant information as required.

3. **Monitor and manage general airspace usage**
   The regulator may maintain the highest access privileges ("access rights") in the UTM network and is expected to monitor and manage airspace usage. This may be through the approval of TFRs (UVRs) or through the delegation of TFR-issuance authorities to local authorities or authorised UTMSPs

4. **Audit operations-of-interest and enforce regulations**
   With UTM-engaged operations logged, the regulator will be able to review and audit the activities of drone operators, service providers and other participants. Such audits can be delegated, might be carried out routinely, or in the case of an incident, for investigative purposes. Here, UTM auditors can review data, or may be able to request data directly from the UTMSPs or operators and enforce penalties if regulations have not been appropriately followed.

## Open Access UTM for the Public Authorities

Through the Open UTM system, public authorities may be able to monitor local airspace activities, and respond to airspace incidents. They may also be able to dynamically organise local airspace to respond to incidents, or restrict local airspace access. This need for public authorities to be able to create temporary airspace restrictions points to a need for a level of delegation for airspace management.

Emergency services will also benefit from UTM due to enhanced situational awareness provided to both the pilots of emergency air services, as well as to the manned and unmanned aviation community operating in proximity of emergency response air operation and enable all participating actors to follow emergency response protocols – e.g. emergency land in case of low-altitude VLOS drone operation.

## Open Access UTM for the Public

An often-overlooked benefit of UTM is the positive features that can be provided to the wider public. ***Security*** and ***Transparency,*** as previously described as two of the six underpinning principles of UTM, is necessary to assure that airspace is appropriately managed securely and fairly. It is clear that public trust will be a key factor to enable widespread and effective drone usage in the future, and so there may be an openly available means of interaction with drones via the Open UTM system by members of the public. This is not unusual as there are currently many websites which provide flight data which the public can access.

The Open UTM system, with its ability to share information on authorised flights, will potentially have an important role in facilitating the public and other stakeholders to determine if drone activity initially deemed suspicious is in-fact scheduled to be in operation. Enabling the public to participate voluntarily will improve awareness of the technology, promote positive attitudes, increase confidence and reinforce public trust in drone operations that are engaged with the UTM system.

An example of where this might play a role is in the proximity of airports. In 2019, drone sightings at Heathrow airport by the public led to the suspension of airport runway activity. This may have been further exacerbated by the public who may have confused the subsequent active police drones with reoccurring nuisance drone operations.

UTM may also have a role in holding nuisance operators accountable. Naturally, if such operators fly with UTM-connected drones, or drones equipped with remote-identification technologies, their operations may be logged and potentially reviewed to assess for poor or illegal behaviour.

It should be noted that, within this concept, whilst this might work when differentiating conforming drone operations from others, this solution is not likely to stop the malicious reporting of drone-sightings. As a result, there is a potential need to integrate UTM solutions, particularly within sensitive areas and around critical infrastructure, with counter-UAS technologies such as drone detection and localisation systems.

## Open Access UTM for Manned Aviation

The manned aviation sector comprises of traditional airspace users, both commercial and recreational, Air Traffic Service providers and airports, who are all key stakeholders bringing together a broad user base to the Open UTM system.

Generally, much of the discussions about UTM has been framed around how unmanned vehicles can integrate with conventional air traffic management systems - implying that the focus is with the drone community to ensure safe and appropriate aerial operations. To capitalise on the growing drone market opportunity, and to encourage safer and more efficient use of airspace, it is logical to suggest that there is a need for a well-coordinated strategy that involves both the manned and unmanned communities to collaborate to achieve the ambitions of both sectors. One example of such a collaboration might be a general consensus on the minimum-equipage-level requirement for electronic conspicuity, aimed at providing shared operational intelligence to all parties to ensure safety and separation for all.

The focus of this whitepaper related to manned aviation is primarily centred around the ATM-provided services that manage flight requests within FRZ and controlled airspace (see page 7). Whilst further development and testing around these concepts are important, permissions management around FRZs is considered one of the more important capabilities regarding UTM, and the safeguarding traditional air traffic in comparatively congested and low-altitude environments.

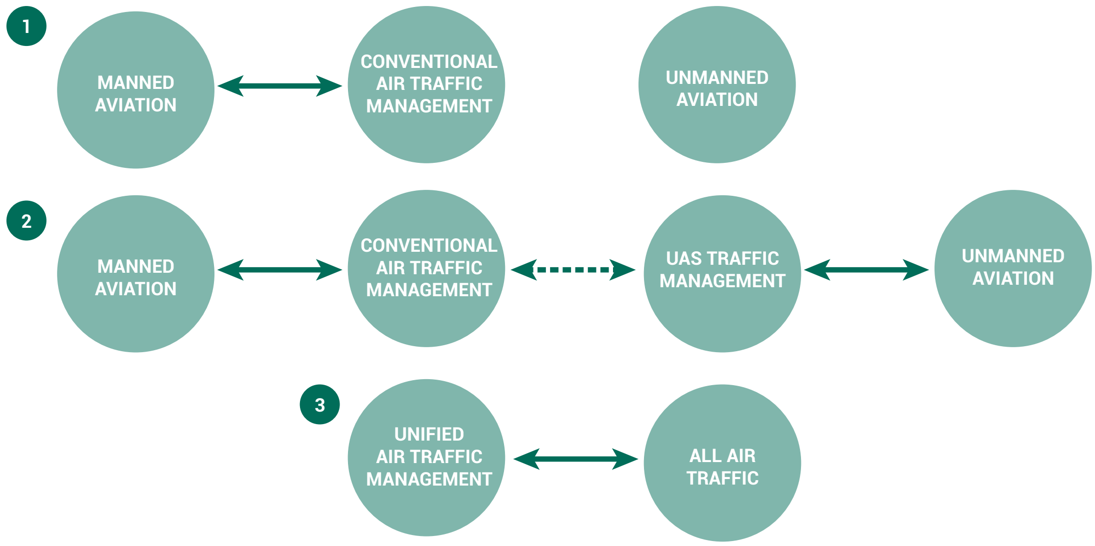



*Figure 18. Traffic management: (1) Current, (2) Proposed integration using UTM and (3) Generational shift to unified air traffic management.*

The underpinning technology behind UTM – communication and data sharing, strategic and tactical deconfliction, airspace management, automation – should be expected to have a significant impact in conventional air traffic management strategies moving forward. Figure 18, illustrates potential next steps of general air traffic management with respect to:

1. Currently, unmanned aviation is typically carried out independently of conventional air traffic management with the exception of operations behind undertaken within the new FRZs.

2. The rollout of UTM will require cooperation with today's ATM and new policy and regulation for UTM users and services.

3. There is significant potential for air traffic management services to converge and unify in the future due to the cross-over of technologies in the unmanned sector to the manned sector. Both ICAO's General ATM plan (2016) and the Single European Sky ATM (SESAR), European ATM plan (2015) identify modernization ambitions for technology and services to ensure sustainability and competitiveness through improvements in performance and the ability to meet demand and capacity. Traffic management is already becoming an important point when considering the discussions occurring around urban air mobility – i.e. flying taxis, vertical-ports (e.g. verti-ports), fully-automated commercial aircraft. The technology utilised here will be similar if not the same as that implemented by the unmanned sector.

ATMSPs will, in the future, be likely to adopt technologies and employ services that enable UTMSPs to dynamically request air traffic information, as well as manage permissions to operate – these are digital services that will become increasingly automated (ATM-UTM interface) – in stark contrast to how ATM traditionally engage with manned aviation.

# Call to Action – Conclusion

**The UK is limited in its resources to research all aspects of UTM. In the US, NASA and FAA programmes have already benefited from several years and hundreds of millions of USD worth of government-funded research initiatives. The EU's Sesar JU initiative has provided similar support in Europe, while competing nations in East and South-East Asia have received comparable support structures for their research activities.**

The UK should therefore be pragmatic in its approach as to what research areas must be focused on to deliver the greatest impact in the shortest amount of time. It is also suggested that the Government should secure the necessary funding for the regulator to continue engaging with the relevant industries such that consensus can be generated from the ground up.

A significant engagement activity is required to coordinate with the proposed UAS initiatives and work-streams in the UK – specifically across Government such as DfT's Pathfinder programme and BEIS' Future Flight programme which focuses on enabling airspace integration for unmanned operations. In particular, Future Flight programme's vision of accelerating the development of Systems for enabling airspace integration provides significant opportunity to accelerate the development of the Open Access UTM framework. Coordination with the CAA Sandbox and initiatives such as NESTA's Flying High Challenge, the CASCADE project and activities at UK's UAS test environments such as the National Beyond visual line of sight Experimentation Corridor (NBEC) provide R&D opportunities in subject matter relevant to UTM.

Moving forward in the following stages, the programme will become increasingly dependent on engagement with the CAA to provide expert input on the programme's approach, and challenge decisions and findings made by the industry. Ultimately, this programme is as much about informing Government as a whole, as it is about informing and coordinating with industry.

**The consortium strongly believes that the stakeholders of future UTM and the wider drone community must take a collaborative approach to help develop these deconfliction procedures and rules.**

## Research Focus

Throughout the report, a list of research areas have been highlighted that correspond to the described services. These research areas will together formulate a range of challenges that will be addressed in the next stage of this programme with significant input from the industry and regulator.

As a priority, the following three points are given as focus areas for the Open Access UTM programme 2019-2020:

**A.** Deep engagement with the industry and the regulator to develop consensus and details around the architecture, communications framework, implementation strategy and roadmap for a future UTM.

**B.** The Open UTM Service concepts that have been described must be matured include the Flight Notice Board concept, the Dynamic TFR concept, and Dynamic Permissions Management around Controlled Airspace (FRZs).

**C.** Formulating strategic and tactical deconfliction principles, strategies and processes that can be generally applied to UTM stakeholders – similar to providing safe operating ***rules-of-the-air.*** It will be key to bring together subject matter experts from industry and the regulator to pool relevant information that will inform how operations can be safely planned, de-risked and executed.

## Trials and Demonstrators

Following this programme, greater clarity and increased granularity around the systems design and implementation strategy that will enable groups of UTM stakeholders to trial, demonstrate the formulated UTM services that will ultimately unlock future UTM capabilities. These demonstrations should involve multiple UTM stakeholders, in particular, multiple UTMSPs to demonstrate appropriate data-exchange and deconfliction strategies through the designed Open UTM Services. Importantly, these trials will inform Government stakeholders around policy development in this rapidly emerging sector.

Demonstrating these services will provide a means to validate the developed research but will also provide a means to identify further research gaps that the wider UTM community will need to subsequently and collectively address. Opportunities already exist to carry out such trials, with an increasing number of sites across the UK participating in drone and UTM-related activities, including Snowdonia Aerospace, the NBEC Corridor, as well as Project Nightingale in the Solent region. Other areas of interest may also include other sites traditionally used for military aircraft testing - engagement with such sites may require coordination with MOD and relevant partners.

The UTM community will need resources to carry out these trials and projects and accelerate the research and development behind UTM in general. It is therefore recommended that Government, the relevant funding bodies and initiatives such as Future of Flight be prepared to invest in UK UTM research projects.

## Roadmap

Following this work, the CPC aims to work with collaborators, industry stakeholders and the regulator to inform and generate a UTM roadmap that illustrates how relevant milestones that correspond to technological, operational, regulatory and financial requirements are organised to produce an industrial strategy, that brings a formal UTM system from the conceptual stage, to real-world implementation. This will also consider the state of affairs today, the state of relevant ongoing UK and other initiatives, and how the UK can effectively distribute resources to compete with the world-leading initiatives.

# Acknowledgement

**The project was supported by the Department for Transport who also provide steer across the project.**

The following organisations participated in the Open Access UTM programme.
The organisations were selected through an open and competitive procurement process.

| ORGANISATION | DESCRIPTION |
|---|---|
| Connected Places Catapult | The Connected Places Catapult (previously the Transport Systems Catapult) accelerates smarter living and travelling in and between the places of tomorrow. CPC focuses on growing businesses with innovations in mobility services and the built environment that enable new levels of physical, digital and social connectedness.<br>The CPC has technical research programmes, specifically around developing UAS operations, their safe and efficient integration into the airspace and developing standardised risk assessment methodologies to support the regulators and industry stakeholders to exploit the technology.<br>The CPC is also a central figure of the UK Department for Transport's Government Drone Pathfinder Programme's Governance committee alongside the UK Civil Aviation Authority (CAA) and the Department for Business, Energy and Industrial Strategy. |
| NATS UK | NATS Holdings is the main Air Navigation Service Provider in the United Kingdom. It inherited the traditions of UK air traffic control, the world's first air traffic control regime. It provides en-route air traffic control services to flights within the UK Flight Information Regions and the Swanick Oceanic Control Area and provides air traffic control services to fourteen UK airports. |
| Thales UK | Thales has been delivering Air Traffic Management solutions for nearly half a century with ATC automation systems operating in over 130 ATC control centres and with a significant ATM footprint in ten countries, allowing them to participate in regional UTM initiatives (such as SESAR and NextGen) as a UTM service provider. |
| ANRA Technologies | ANRA Technologies is a provider of low altitude airspace management UTM services and has, over the past three years, worked on collaborative research with NASA/FAA and other industry partners such as Amazon, GE, Intel and Google's Project Wing to test VLOS and BVLOS UTM operations and concepts as part of ongoing UTM research programs. |
| Altitude Angel | Altitude Angel is an aviation technology company who creates global-scale solutions that enable the safe integration and use of fully autonomous drones into global airspace. Altitude Angel have developed a cloud-based UTM platform compatible across Europe and the US and delivers market-leading services to drone operators, manufacturers and software developers.<br>Their solutions for ATM enable them to access a rich source of real-time airspace, environmental and regulatory data which is expertly customised to the specific operation. In this project, the primary role of Altitude Angel is to support the development of the UAS Traffic Management Service (UTMSP). |
| Cranfield University | Cranfield University is a postgraduate and research-based public university specialising in science, engineering, technology and management. The main campus is unique in Europe for having an operational airport on campus, which it owns and operates. As part of the £67million Digital Aviation Research and Technology Centre (DARTeC), Cranfield recognises the challenges of developing and delivering UTM – developing airspace management solutions that will bring higher levels of system resilience, safety and security. |
| Satellite Applications Catapult | The Satellite Applications Catapult is one of a network of UK technology and innovation companies that aim to drive economic growth through the commercialisation of research.<br>The Satellite Applications Catapult is interested in supporting the scale-up of commercial and government drones' applications, products and services enabled by satellite downstream technologies and services. Satellite communications, satellite navigation and geospatial information generated from Space will contribute towards such goal as well as the digital and physical infrastructure required to enable a safer and more efficient integration of drones in the shared airspace; and particularly, in BVLOS use cases and autonomous operations. Therefore, Satellite Applications Catapult works towards the UTM implementation in the UK and beyond with particular focus on communications, navigation and surveillance fields; and promoting large programmes and projects to demonstrate and validate these concepts applied to different vertical markets such as transport, O&G and energy, extractive industries and agriculture. |

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