UK
Civil Aviation
Authority

Innovation Hub

A Unified Approach
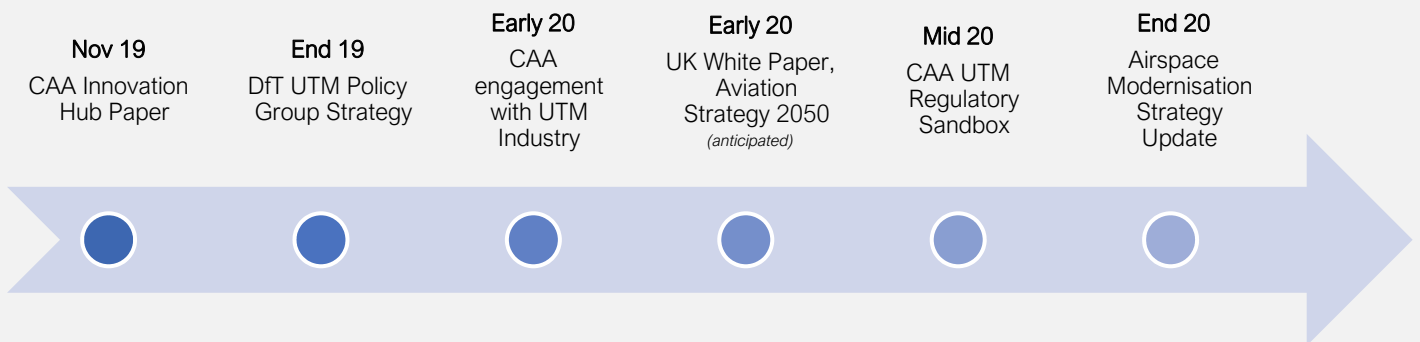to the Introduction of
UAS Traffic Management

Introduction

The intention of this Innovation Hub paper is to recommend actions to create a policy framework that will facilitate the introduction of a unified approach to the safe integration of unmanned aircraft systems (UAS).

The paper also aims to give an appreciation of the scale and breadth of impact that the integration of UAS into UK airspace could have across the aviation ecosystem. This aims to justify why the development and implementation of policies, regulations, technology and systems will require extensive collaboration and leadership on a national and international scale.

The recommendations are summarised on page 29 and are aimed primarily at the CAA and HM Government to facilitate positive action in the near term. Publishing these recommendations is intended to aid transparency on the process and progress of the CAA in this area.

It is expected that the paper will inform the government's Aviation Strategy 2050 via the joint UTM Policy Group, which may also take forward some of the actions. Necessary enabling work, once it is defined, will be included in an updated Airspace Modernisation Strategy to help deliver UAS traffic management (UTM) in coordination with the other initiatives to modernise the UK's airspace.

Nov 19	End 19	Early 20	Early 20	Mid 20	End 20
CAA Innovation Hub Paper	DfT UTM Policy Group Strategy	CAA engagement with UTM Industry	UK White Paper, Aviation Strategy 2050 *(anticipated)*	CAA UTM Regulatory Sandbox	Airspace Modernisation Strategy Update

What is UTM?

The potential uses, benefits and risks of UAS are such that there is a global race to enable their safe integration into our lives. Currently there is insufficient infrastructure in place to fully enable and safely manage the widespread use of unmanned aircraft in the UK. While projections of the number of unmanned aircraft operating in future vary, they generally agree that the numbers are increasing dramatically and so will need to be managed in some way.

Definitions

The concept of 'UAS traffic management' was popularised by NASA who researched prototype technologies that could develop airspace integration requirements for enabling safe, efficient low-altitude operations[1].

ICAO defines UAS traffic management as

"a specific aspect of air traffic management which manages UAS operations safely, economically and efficiently through the provision of facilities and a seamless set of services in collaboration with all parties and involving airborne and ground-based functions."

In Europe, an equivalent concept was named 'U-Space'. This represents a set of procedures and services that enable safe integration of unmanned aircraft into the airspace. The objectives outlined in the U-Space Blueprint[2] represent a vision which is shared by others including the CAA: creating a new airspace environment that accommodates new technology in a way that is sustainable, flexible and scalable.

Like NASA's UTM, U-Space also considers the interaction between the so-called 'very low level' airspace, typically below 500ft, and traditional air traffic operating above 500ft[3].

The Connected Places Catapult (CPC) [4] are leading UAS traffic management work through 2019-20 to build on previous work to develop a UK framework based on open access principles, with support from the Department for Transport (DfT), CAA, a consortium of industry specialists and broader consultation. This work recommends an architecture for UAS traffic management that includes several key roles:

- **Central Services** offering vital services to the UAS traffic management ecosystem including a flight information and management system, the authorisation and directory of UAS traffic management Service Providers, a flight notice board, and UAS and operator registration.

- **UAS traffic management Service Providers**, offering specific UTM services to the public, businesses, local authorities, and others.

- **Supplementary Data Service Providers** who provide the data that supports the functioning of the UAS traffic management ecosystem, including weather, terrain and obstacle data along with insurance and surveillance data.

- **Air Traffic Service Providers** who will need to interact in some way with the unmanned traffic system.

- **Public Authorities,** who may in future be required to engage in the ecosystem as an authority holder for certain operations.

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[1] https://utm.arc.nasa.gov/index.shtml
[2] https://www.sesarju.eu/sites/default/files/documents/reports/U-space%20Blueprint%20brochure%20final.PDF
[3] The Ministry of Defence routinely operates below 500ft in the UK.
[4] The Connected Places Catapult (https://cp.catapult.org.uk/) are one of 9 'catapult' organisations which are funded by Innovate UK (Department for Business, Energy and Industrial Strategy) to accelerate technology uptake and integration across different sectors in the UK.

What is UTM?

- **The regulator (CAA),** with the ability to licence, certify and conduct oversight of those operating within the ecosystem.

Some explanation of the types of 'services' that could form part of this ecosystem are given later.

The Benefits of UAS traffic management

There are many articulations of how UAS traffic management can bring benefits across society, but the Single European Sky ATM Research Joint Undertaking (SESAR-JU) work below describes it well:
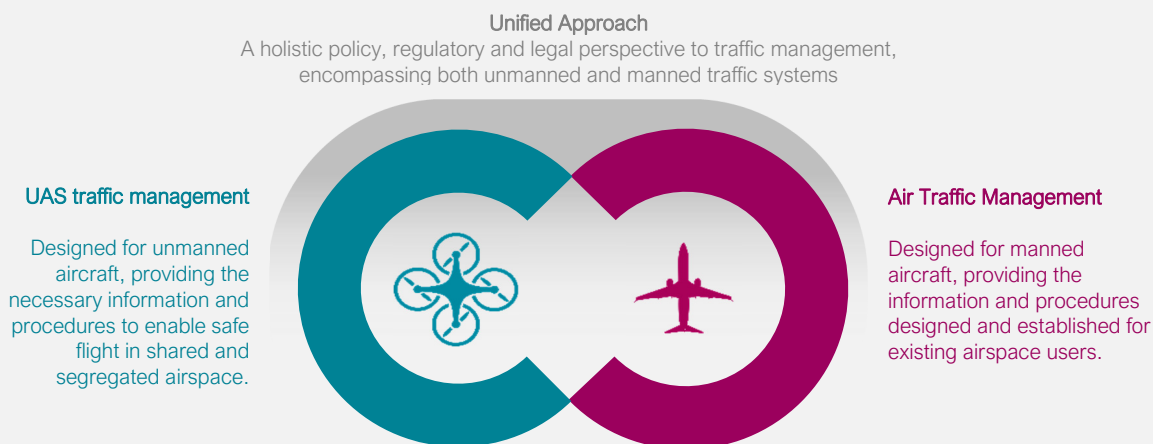
The U-Space Blueprint also describes a number of 'principles' which help to describe the purpose of UAS traffic management as well as an indication of its benefits:

- Enable safety for all users of the U-Space framework, as well as those on the ground.
- Enable a scalable, flexible framework that adapts to technology and demand, while managing the interface with manned aviation.
- To enable high-density operations with multiple automated drones under the supervision of fleet operators.
- To guarantee equitable and fair access to airspace for all users.
- To enable competitive and cost-effective service provision at all times, supporting the business models of drone operators
- To minimise deployment and operating costs by leveraging existing technology and infrastructure.
- To accelerate deployment by adopting technologies and standards from other sectors
- To follow a risk-based and performance-driven approach when setting up appropriate requirements for safety, security and resilience, while minimising environmental impact and respecting privacy.

The CAA recognises the synergies across these initiatives and believes that taking a unified approach to the safe integration of UAS into UK airspace will involve elements from all of these.

A 'Unified' Approach

Air Traffic Management (ATM) enables the safe and efficient movement of aircraft through the air and on the ground. It includes many different but connected systems that work together to achieve this. It also requires a significant amount of human input and control.

Unified Approach
A holistic policy, regulatory and legal perspective to traffic management, encompassing both unmanned and manned traffic systems

UAS traffic management

Designed for unmanned aircraft, providing the necessary information and procedures to enable safe flight in shared and segregated airspace.

Air Traffic Management

Designed for manned aircraft, providing the information and procedures designed and established for existing airspace users.

It is sensible to assume that unmanned air traffic will need to be managed in the future for the same purpose. As such, if manned and unmanned air traffic continue to be managed separately into the future this will limit the safety and economic performance and efficiency that can be achieved, so a unified approach is required.

What is UTM?

In addition, there are several features of any potential UAS traffic management services which could feasibly benefit manned traffic as well, either directly (e.g. a service developed for unmanned aircraft which could be used directly by manned aircraft) or indirectly (e.g. the reduction in the risk of mid-air collision between an unmanned and a manned aircraft). As such, we must be cognisant of the increasing overlap between the manned and unmanned.

The Scope of UAS Traffic Management Services

There is already a growing market of services around the world aiming to provide elements of an ecosystem that manages unmanned aircraft, with significant work being done to try and define a standard set of services and procedures as well as the regulatory frameworks necessary.

The on-board technology of future UAS, such as 'detect and avoid', will go some way to increasing the scope and capability of some unmanned operations by enabling flight beyond visual line of sight for example. However, an UAS traffic management system is expected to unlock the scale of safe integration, with the resultant increase in regular commercial operations and the economic and societal benefits which that brings.

A roadmap to this vision can take different paths since many of the building blocks could reasonably operate and add value in isolation (see 'Building Blocks' below).

The generic concept of operations for UAS traffic management tends to include several services and functionalities. The non-exhaustive list of functions below helps to explain what constitutes an ecosystem that manages unmanned traffic:

Phase of Operation	UTM Service	Description
Approvals & Licencing	UAS Traffic Management Services	Formal approval or endorsement of UAS traffic management services against a specific regulatory framework.
	Operators, Remote Pilots & Aircraft	Encompassing training, approval, registration, insurance and more
	Data	Approval and oversight of the fundamental data necessary for UAS traffic management services.
Flight Planning	Flight planning	calculating a safe and efficient route, accounting for air and ground risks
	Flight notification or declaration	publication of a flight plan in such a way that other flight planning services can carry out their own flight plan ("strategic") deconfliction.
	Airspace authorisations	allowing specific authorities, such as an air navigation service provider (ANSP), to authorise access to controlled or otherwise managed airspace.
	Flight plan deconfliction	to minimise loss of separation and the risk of mid-air collision with other manned and unmanned aircraft, based on other flight plans. Sometimes referred to as 'strategic' or 'pre-tactical'[5] deconfliction

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[5] 'Pre-tactical' is used by U-Space.

What is UTM?

Pre-Flight	Pre-flight checks	supporting the remote pilot to complete pre-flight checklists, or in some cases carrying them out on behalf of the remote pilot.
	Pre-flight authorisations	confirming the approved flight plan before take-off, and as required by certain procedures or geographical locations.
	Approval to take-off	including the coordination with ATM where necessary
During Flight	Sharing of real-time flight information	position[6], speed, heading are shared from the aircraft to air traffic service providers, local and enforcement authorities, government, other aircraft (manned and unmanned), etc
	In-flight deconfliction	real-time commands are given to pilots or aircraft directly to mitigate loss of separation or a mid-air collision between both manned and unmanned aircraft. Often referred to as "tactical" deconfliction.
	Dynamic airspace restrictions	enabling immediate segregation or notification of airspace for specific purposes (e.g. enforcement authorities clearing airspace over an incident, or in support of counter-terrorism operations)
	Re-planning and re-routing of unmanned traffic	enabling immediate segregation or notification of airspace for specific purposes (e.g. enforcement authorities clearing airspace over an incident, or in support of counter-terrorism operations)
	Re-planning and re-routing of unmanned traffic	in response to a change in the airspace picture or change in mission.
	Urgency or Emergency Response	Management of other air traffic in response to an aircraft urgency or emergency
Post-Flight	Flight review & recording	for audit, statistics and traceability
	Oversight	Regulatory monitoring and review of unmanned aircraft activity

With regards to services that deconflict aircraft trajectories either at the flight planning stage, or during flight, there is currently no harmonised position on how aircraft should be prioritised. While deconfliction will likely consider the ICAO prioritisation described in CAP 493 Manual of Air Traffic Services[7], this does not specifically account for unmanned aircraft. Therefore, there is currently uncertainty of the prioritisation of manned vs unmanned, and unmanned vs unmanned (for example): manned life-saving vs unmanned life-saving; unmanned people-carrying vs unmanned cargo-carrying; etc. There may be assumptions as to how these are dealt with, but this is not yet formalised.

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[6] Position in time and space
[7] CAP 493 Manual of Air Traffic Services[7] Part 1, Section 1, Chapter 4, Control of Traffic, Page 6,
https://publicapps.caa.co.uk/docs/33/CAP493_28DEC2017(P).pdf#page=84

What is UTM?

In addition, the extent of unmanned aircraft and other new airspace users below 400ft is unknown. If traffic intensifies and certain flight plans start to become prevalent, a broader approach might be needed, similar to that in controlled airspace whereby routes are designed through evidence and public consultation. There may then need to be a mechanism in future for monitoring whether any paths or plans become prevalent, and whether they are having an impact on other airspace users and people on the ground. An UAS traffic management system could potentially offer or support this functionality.

Recommendation 1
The ICAO flight priorities should be assessed in the context of airspace that is shared by all airspace users, taking account of both the category of aircraft and its operational purpose.

Building Blocks of UAS Traffic Management

While there are indications that ATM is transitioning away from routine interventions by Air Traffic Controllers (ATCO) towards predominantly 'monitoring' functions[8], UAS traffic management systems are expected to be designed from the start with automation in mind (with a minimal requirement for human-in-the-loop) driven by the high volume of aircraft expected to rely on it.

Recommendation 2
Existing roadmaps showing the progression of UAS traffic management should be assessed and either recognised by the CAA or used to generate a CAA roadmap.

Building Blocks

Services working in isolation to add value, e.g.
- Detect & Avoid
- Electronic Conspicuity
- Remote Id
- Geo-fencing
- Registration
- Automation
- Spectrum

Interim solutions

New systems created from combining several building blocks, e.g.
- Flight Notification
- ATC interface
- Airspace authorisations
- Local fleet management
- Shared Air Picture

Unmanned Traffic Mgt

Phased introduction of regulated UTM system(s) with high capability, e.g.
- Established ATM-UTM interface
- Real-time and strategic aircraft deconfliction
- Dynamic airspace restrictions
- Delegated airspace authorities
- Aircraft-UTM integration

Illustrative roadmap for the development and integration of UAS traffic management

Several components, systems and policies are expected to contribute to UAS traffic management. The full extent is still to be established, and is dependent on the system architecture that is taken forward, but is likely to include:

- Static and dynamic airspace information, structures (e.g. Control Zones, Control Areas) and restrictions (Prohibited/Restricted/Danger Areas)

- Aeronautical information

- Airspace classifications

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[8] For example, the NATS Airspace User Portal (AUP) provides general aviation and remote pilots with a way to request access to controlled airspace via an online service or a smartphone app. For the airspace controller it also provides a way to set rules for automatic decline / approve of requests, and an interface that can be used to see outstanding requests. https://aup.nats.aero/

What is UTM?

- Electronic conspicuity

- Geographical information (e.g. terrain)

- Obstacle information (e.g. buildings)

- Operator registration

- Unmanned aircraft registration[9]

- Meteorological information

- Communications, Navigation and Surveillance (CNS) and Spectrum

- Airspace regulation & delegated powers or authority

To ensure that the resultant ecosystem is open and transparent, and to achieve flexibility, scalability and sustainability, all the above will need to be underpinned by agreed standards, protocols and procedures.

Stakeholders

The number of stakeholders who could potentially interact with an UAS traffic management system is extensive. Below is an indication of the variety of involved stakeholders:

- UAS Remote Pilots

- UAS Operators

- Manned aircraft pilots

- Manned aircraft operators

- UAS traffic management Service Providers

- ANSP / ATC / other ATM Service Providers

- Equipment manufacturers

- Aerodrome operators

- Emergency services

- Enforcement authorities

- Public & Local authorities

- Government

- Military[10]

- Meteorological and aeronautical information service providers

- CAA & other regulators

- Overflown communities

- Non-Government Organisations, campaign groups etc

- Passengers (on manned or unmanned)

- Shippers (on manned or unmanned)

- Consumers of the goods shipped

- Academics

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[9] Including the record of aircraft performance and/or equipage
[10] Noting that this encompasses many of the functions listed above but in a military context.

The CAA Perspective

There are existing laws, policies and regulatory guidance across UK Government and the CAA that have an impact on the unified approach to air traffic management at a strategic, programme and component level. There are also numerous initiatives seeking to facilitate a safe and efficient use of airspace into the future. To achieve positive progress on this approach for the UK a recognition of this context is necessary.

Where the existing legal and regulatory context may prove problematic for UAS traffic management, recommendations will be developed to consider how to maintain progress such as, for example, changing or introducing policy, or interpreting policy for new requirements.

The Legal and Regulatory Context

The CAA's Legal Duties

The CAA is tasked with various functions by the Secretary of State for Transport through powers defined in Section 66 of the Transport Act 2000 (as amended). These legal functions of the CAA are described in the Civil Aviation Authority (Air Navigation) Directions 2017 (as amended). Section 70 of the Transport Act describes the approach the CAA should take when exercising its air navigation functions. This establishes that maintaining a high standard of safety should be prioritised and outlines seven further considerations including the need to:

a) to secure the most efficient use of airspace consistent with the safe operation of aircraft and the expeditious flow of air traffic;

b) to satisfy the requirements of operators and owners of all classes of aircraft;

c) to take account of the interests of any person (other than an operator or owner of an aircraft) in relation to the use of any particular airspace or the use of airspace generally;

d) to take account of any guidance on environmental objectives given to the CAA by the Secretary of State after the coming into force of this section;

e) to facilitate the integrated operation of air traffic services provided by or on behalf of the armed forces of the Crown and other air traffic services;

f) to take account of the interests of national security;

g) to take account of any international obligations of the United Kingdom notified to the CAA by the Secretary of State (whatever the time or purpose of the notification).

Under the Directions it is the CAA's function to have a strategy and plan for the use of UK airspace (Direction 3(e)), and to make decisions that determine the design of UK airspace (direction 5). The 'design' of airspace includes both the physical structures as well as the procedures applied within it.

Subject to our primary duty to maintain a high standard of safety, the CAA's Section 70 duties include an obligation to "satisfy the requirements of operators and owners of all classes of aircraft". The CAA is therefore required to consider the needs and requirements of unmanned aircraft users in its strategy when exercising its air navigation functions.

Airspace Design

Airspace design includes blocks of controlled airspace with varying classifications of A, C, D or E and the classification determines the behaviours and equipage requirements, set by provisions in the Air Navigation Order 2016 (as amended) (ANO), for aircraft entering the airspace. Class G represents uncontrolled airspace.

The CAA Perspective

However, those requirements specifically do not apply to small[11] unmanned aircraft, which are presently regulated only by specific articles in the ANO (2, 94, 94A, 94B, 94C, 94D, 94E, 94F, 94G, 95, 239, 241 and 257). Therefore, although controlled airspace can extend to ground level (such as around airports), this is not directly applicable to small unmanned aircraft.

There are other airspace structures which are applicable. Small unmanned aircraft are restricted from entering the Flight Restriction Zone (FRZ) around airports, defined by Article 94B, as well as any other areas which are defined as prohibited or restricted areas, such as around nuclear power stations. Unmanned aircraft remote pilots must seek permission from relevant authority (Air Traffic Control Unit (ATCU), Flight Information Service Unit (FISU), the airport operator or the person responsible for the site) to fly in these areas.

Restricted, prohibited or danger areas are detailed in the UK Aeronautical Information Publication (AIP) and apply to unmanned aircraft where stated. For example, the City of London restricted area (EG R158) applies from the surface up to 1,400ft and only allows flights by certain aircraft (not including unmanned aircraft) specified in the publication which are carrying out specific operations.

Sports, leisure and recreational manned aircraft flying by visual flight rules (VFR) can fly in certain classes of controlled airspace (not Class A) if they request and receive permission from Air Traffic Control. They must also fly above 500ft, unless taking off, landing, or otherwise granted permission to operate at a lower altitude and comply with SERA (the Rules of the Air).

Small unmanned aircraft must not fly above 400ft AGL[12] unless they have received permission to do so from the CAA, however they may operate up to 2,000ft within an FRZ when given permission to do so by the appropriate authority.

It should also be noted that the Ministry of Defence are directed by the Government to generate and maintain certain military capabilities. This requires them to routinely operate aircraft at low level, and so any system will need to be cognitive of this and facilitate safe operations for military aircraft at low levels.

> ### Recommendation 3
> A review should be conducted of the target safety outcomes that are to be achieved through introduction of UAS traffic management services, to inform necessary airspace design requirements

The Airspace Modernisation Strategy, described in more detail later in this paper, includes an initiative to review airspace classification, but which will also be looking at the policy framework for implementing airspace class changes.

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[11] The ANO makes the distinction of small unmanned aircraft as being those which have a mass of not more than 20 kg without its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight.
[12] Above Ground Level (AGL)

The CAA Perspective

Applicability to UAS Traffic Management

In order to pursue a unified approach to the safe integration of UAS into airspace, and therefore implementation of UAS traffic management services, legislative change will be necessary as there is presently no single airspace structure that is applicable to UAS and meets the objectives of the unified approach. As discussed further below, electronic conspicuity is a fundamental enabler to safe integration of drones in airspace; consideration should therefore be given to new airspace structures or equipage requirements that can enable electronic conspicuity, and thus UAS traffic management.

Recommendation 4
The legislative changes necessary to pursue UAS traffic management should be explored, potentially through amendment of the Air Navigation Order 2016.

This could be achieved through amendment to the ANO to either produce a new airspace structure (in the same manner as an FRZ) and/or to mandate minimum equipage requirements for both manned and unmanned aircraft operating in an integrated area.

Additionally, the CAA could add this policy objective into its Airspace Modernisation Strategy, described later.

The CAA Perspective

Government

Currently there are several strategic workstreams within Government which have some influence on UAS traffic management.

Aviation Strategy 2050

A key objective of the Government's Aviation Strategy 2050 is to "improve the passenger experience, including through technology and innovation." Chapter 8 focuses on encouraging innovation and new technology and includes a proposal to:

> *"…work with the CAA and industry to determine the next steps for UTM technology and regulation in the UK, and more widely consider the impact that UTM will have on the aviation sector as a whole".*

Several other parts of the strategy are also relevant including

- Chapter 2: 'Building a global and connected Britain', with UAS traffic management offering opportunities for import and export of services, products and skills;

- Chapter 3: 'Ensure aviation can grow sustainably', where the expansion of unmanned traffic, and the need to modernise airspace, will undoubtedly include consideration for UAS traffic management;

- Chapter 4: 'Support regional growth and connectivity', where UAS traffic management will enable the scale of commercial operations that will ultimately benefit the public and UK economy;

- Chapter 6: 'Ensure a safe and secure way to travel', with UAS traffic management providing a mitigation against certain safety risks while also improving data, reporting and traceability; and

- Chapter 7: 'Support General Aviation', where UAS traffic management will be designed to work cooperatively with GA where appropriate to ensure that airspace is shared safely and efficiently.

Airspace Modernisation Strategy

The Airspace Modernisation Strategy (AMS) recognises the need to fully consider the introduction of new classes of aircraft into UK airspace, in accordance with Section 70 of the Transport Act 2000. UAS traffic management is an important piece in the puzzle as it provides a new means of managing air traffic at lower altitudes.

Policy gaps (UTM Policy Group) → CAA UTM initiative → UTM delivery through AMS
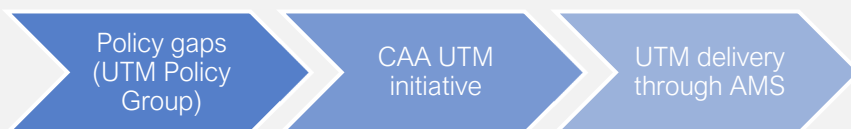
The governance of the AMS flows down from the Aviation Minister through a DfT-CAA Sponsor Group, to the Delivery Management and Oversight (DMO) team who will ensure that industry-led Delivery Groups are meeting the necessary milestones to deliver the AMS.

The AMS has been identified as a key delivery mechanism for UAS traffic management in the UK, but to enable this, a 'CAA initiative' must be written based on firm policy positions. Currently there are several policy gaps (see Chapter 6) for UAS traffic management which require additional evidence and decisions. For example, which market model should be employed, with arguments for and against monopoly, competitive and mixed models. Therefore, a UTM Policy Group has been established to feed into the DfT/CAA Sponsor Group, tasked with forming specific policy recommendations which in turn enable the production of a delivery plan for UK UAS traffic management.

Due to the current lack of strategic leadership and direction on UAS traffic management in the UK, the AMS offers a chance to take immediate action, for example to:

> **Recommendation 5**
> The AMS UTM Policy Group should address policy and regulatory gaps, agree a coherent position, and establish a series of proposals for the implementation of UAS traffic management in the UK

- Continue with the establishment of a UTM Policy Group under the governance of the AMS.

- Agree positions and actions across CAA and Government on the policy and regulatory gaps relating to UAS traffic management.

- Publish a route map and series of proposals for taking forward UAS traffic management in the UK.

Industrial Strategy: Future Flight Challenge

As part of the UK's Industrial Strategy, the Future of Mobility Grand Challenge[13] sets a target for the UK to be a leader in shaping the future of mobility, by embracing new technology and innovation.

In 2018 the Government announced £125m to be made available through the Industrial Strategy Challenge Fund[14] for a 'Future Flight Challenge'. With Innovate UK managing the programme on behalf of the BEIS Sponsor, the Future Flight Challenge will run a series of competitions over the next 4 years aiming to develop and demonstrate a novel new aviation system across 3 main pillars:

- New models of airspace management and anticipatory regulation (synthetic environment for airspace management, urban airspace management, etc);

- Ground infrastructure systems demonstrators (city and sub-regional airports for drones, electric aircraft, etc);

- New operating models for operators and users (synthetic environments, drone services, electric urban and sub-regional aircraft, etc)

The programme is not designed to fund the development of new aircraft, but instead to take existing unmanned aircraft and urban air mobility vehicles and to integrate them into a new aviation system, encompassing new models of operation.

The development and demonstration of UAS traffic management is clearly pivotal to achieving the outcomes of this work.

DfT UTM Working Group 2016

In 2016 a DfT-led working group produced a technical paper on 'Unmanned Traffic Management', with members including DfT, NATS[15], CAA, Transport Systems Catapult[16], Satellite Applications Catapult[17] and Inmarsat[18].

The paper included a first attempt at describing a potential system architecture for UAS traffic management, based on a series of principles.

This work subsequently led to DfT commissioning the Transport Systems Catapult in 2018 to explore the concept of operations and technical requirements for an 'open access' UAS traffic management system – i.e. being based on transparent and collaborative design principles.

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[13] https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/industrial-strategy-the-grand-challenges#future-of-mobility
[14] https://www.ukri.org/innovation/industrial-strategy-challenge-fund/
[15] https://www.nats.aero/
[16] The Transport Systems Catapult was renamed as the Connected Places Catapult (CPC) in 2019 following a merger with another Catapult organisation.
[17] https://sa.catapult.org.uk/
[18] https://www.inmarsat.com/

The CAA Perspective

DfT Research: Open Access UTM

The CPC's Open Access UTM research initiative[19] completed its first year in March 2019. The resultant white paper[20] was created in collaboration with Altitude Angel[21], ANRA[22], Cranfield University[23], NATS, Thales[24] and Satellite Applications Catapult. Arguably the greatest achievement was the consensus across the consortium on a 'UTM framework' including a revised set of principles, a high-level architecture, identification and description of key roles and responsibilities, and the definition of specific messaging protocols.
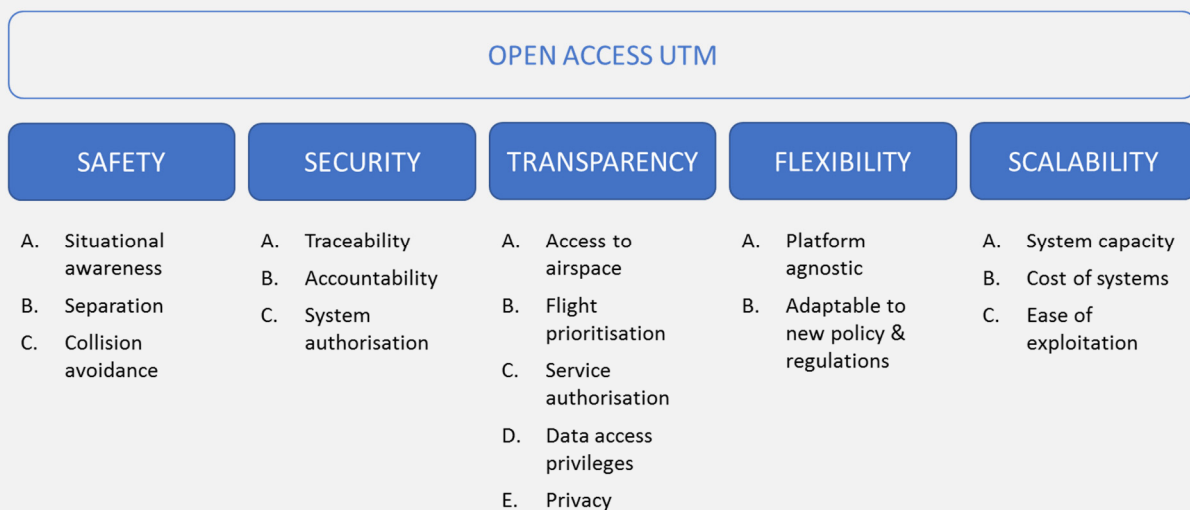
This work has formed the basis of the CPC's DfT-funded 2019-20 continuation project which aims to:

- expand the consensus to a wider reach of national and international stakeholders,

- focus on specific research areas of interest that were identified in the first year, and

- develop a roadmap for the implementation of UAS traffic management.

> ### Recommendation 6
> The principles set out in the Open Access UTM Framework should be accepted and publicised by the CAA as the foundation for all UAS traffic management development in the UK

A key recommendation of the CPC's white paper is the agreement of several principles that should underly any future UAS traffic management policy, regulation, or solutions:

OPEN ACCESS UTM

SAFETY	SECURITY	TRANSPARENCY	FLEXIBILITY	SCALABILITY
A. Situational awareness B. Separation C. Collision avoidance	A. Traceability B. Accountability C. System authorisation	A. Access to airspace B. Flight prioritisation C. Service authorisation D. Data access privileges E. Privacy	A. Platform agnostic B. Adaptable to new policy & regulations	A. System capacity B. Cost of systems C. Ease of exploitation

The CAA Regulatory Sandbox and Future Flight Challenge are two key initiatives which offer opportunities to test the assumptions and initial design of the Open Access UTM Framework. Therefore, it is proposed that the framework developed and agreed by this consortium forms the basis for a set of CAA UAS traffic management guidelines, the purpose of which are to offer an indication of the type of ecosystem that should be aspired to.

> ### Recommendation 7
> The CAA adopts the Open Access UTM Framework output as a baseline set of guidelines for the development of an UAS traffic management technical framework, to be validated or modified as a result of testing in the CAA Regulatory Sandbox and other National programmes

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[19] https://ts.catapult.org.uk/news-events-gallery/news/traffic-management-research-to-open-pathway-to-commercial-drone-operation-in-the-uk/
[20] Open Access UTM White Paper, https://cp.catapult.org.uk/2019/09/30/new-report-points-way-to-shared-airspace-between-drones-and-traditional-aircraft/
[21] https://www.altitudeangel.com/
[22] http://www.anratechnologies.com/home/
[23] https://www.cranfield.ac.uk/
[24] http://www.thalesgroup.com/en

The CAA Perspective

Until the outstanding questions and policy gaps are cleared by DfT and CAA through the AMS UTM Policy Group, this will need to be accompanied by appropriate caveats.

UK Government Drones Pathfinder Programme

The Pathfinder Programme was initially a Ministry of Defence initiative to harness the learning from both military and commercial applications of unmanned aircraft. After moving ownership to the DfT in 2016, the focus shifted towards enabling a UK market for beyond visual line of sight (BVLOS) and automated unmanned aircraft operations.

With underlying principles of transparency and collaboration, the Pathfinder Steering Group (DfT, BEIS, DIT, CAA and CPC) published a new Programme Framework in November 2018 that established firm goals, criteria and a methodology for the new approach.

In April 2019, the first set of Pathfinder Challenges were published, with support from the CAA UAS Policy Team and the CPC, articulating a series of technical and operational challenges which are viewed as priority blockers to routine BVLOS operations in non-segregated airspace.

The Pathfinder Programme recognises UAS traffic management as being a key enabler for scaled routine BVLOS and automated unmanned aircraft operations.

A website for the programme is available here: https://ts.catapult.org.uk/current-projects/pathfinder/

Industry

UK industry has typically been at the forefront of system and service design and development in ATM. UAS traffic management offers a chance for this expertise to be coupled with software and systems skills to develop world-class UAS traffic management products.

There is currently a lack of strategic leadership on how UAS traffic management should or could be implemented in the UK. Other parts of the world also suffer in this area, so there is an opportunity for the UK to take a strong step forward ahead of international competition by establishing clear leadership and consensus.

The number of entities involved in some degree of UAS traffic management activity reflects the perceived opportunity available for Industry to compete in this space. Below is a non-exhaustive list that offers examples of this ongoing activity:

Airbus https://www.airbus.com/	In support of their Urban Air Mobility concept, Airbus' Blueprint for Sky outlines how they see UAS traffic management providing traffic management solutions to enable the next generation of aviation. Airbus UAS traffic management outlines 5 core principles for UAS traffic management Deployment which largely agree with the principles set out by the CPC Open Access UTM project.
Airmap https://www.airmap.com/	As one of the more established service providers, Airmap have worked closely with the Swiss FOCA to provide a complete air picture across the whole country. A demonstration at the World Economic Forum also showed integration of 3rd party data streams, including a ground population indicator based on mobile phone signal density.
Altitude Angel https://www.altitudeangel.com/	Altitude Angel are one of the 6 participants in the CAA's Regulatory Sandbox. As one of the UK's providers of initial UAS traffic management services, Altitude Angel have developed a suite of applications centred around their 'Guardian UTM' platform. In October 2018, Altitude Angel delivered Operation Zenith in partnership with NATS and Manchester Airport Group. The demonstration showed how the Altitude Angel system could be integrated into the Manchester Airport air traffic

	control tower, with several drone demonstrations on and off the airfield. While the demonstration was closely scripted, it showed that there is potential for unmanned aircraft to fly safely in proximity to manned aircraft, and in fact to add significant value to aerodrome operations. In the context of UAS traffic management, Altitude Angel represents an example of a UTM Service Provider (UTMSP).
Bluebear Systems Research https://bbsr.co.uk/	BBSR have developed a number of components that could support an UAS traffic management system. They are one of the CAA's first cohort of Regulatory Sandbox participants as part of the National Beyond visual line of sight Experimentation Corridor (NBEC) consortium.
Collins Aerospace https://www.rockwellcollins.com/	In the USA, Collins Aerospace have been testing their own UAS traffic management system as part of the NASA UTM program. Uniquely, Collins Aerospace look to employ CNPC-1000, an in-house command and control data-link optimised for the operation of small and large UAS.
DJI https://www.dji.com/uk	As a drone manufacturer, DJI are also developing aspects of UAS traffic management technology. Aeroscope provides remote identification of DJI drones and was demonstrated as part of the NATS / AA / MAG Operation Zenith.
Google's Wing https://wing.com/	Wing are operating commercial deliveries in the US, Australia and Helsinki, on a trial basis. This is enabled by their in-house UAS traffic management platform, OpenSky[25], that directly manages flight paths of multiple drones simultaneously. The system also enables operators to manage fleets of drones with capabilities such as 'manage-by-exception'. Wing are now collaborating with drone operators, manufacturers, and service providers to build an interoperable UAS traffic management platform that makes flying safe and simple.
Thales https://www.thalesgroup.com/	The Thales ECOsystem UTM solution helps addressing the challenges of UAS integration into the airspace. The digital cloud-based platform proposes a suite of services for low altitude airspace management which enable safe, secured and efficient manned and unmanned operations: Airspace access: providing automated flight authorizations to drone users Airspace monitoring: monitoring the presence of drone in the low altitude airspace and ensuring there are no conflicts with traditional aircraft Airspace management: setting up flight paths for drones
Unifly https://www.unifly.aero/	Unifly have developed a suite of tools for users, airports, authorities and equipment manufacturers that centres on a UAS traffic management platform. Throughout 2019 they have raised significant funding and contributed to numerous research projects and demonstrations. In 2017, Thales and Unifly partnered to offer 'ecosystem UTM'. The system "integrates drone registration, pilot registration, flight planning, and regulatory/business rules with geospatial and meteorological information to enable adaptable workflows for managing drone operations as well as customizable situational awareness using tools such as map overlays, terrain views and 3D projections".

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[25] https://wing.com/opensky ; https://opensky.wing.com/visitor/map?lat=-28.418053&lng=133.454211&zoom=4

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The UK's En-Route ANSP: NATS

NATS' capability in relation to UAS has expanded over recent years to include commercial operations, training provision as a Nationally Qualified Entity (NQE), and development of UAS traffic management systems. These services have historically been offered by NATS Services Limited.

In 2018, NATS and Altitude Angel brokered a strategic partnership to develop UAS traffic management capabilities based around Altitude Angel's 'Guardian UTM' platform[26].

As previously described in this paper, there are several areas of policy development necessary to establish the best model for implementation. NATS aspire to provide a 'central service' for UK UAS traffic management, integrated closely into the existing ATM services, and have developed the foundations of such a platform based on Guardian UTM.

> **Recommendation 8**
> The DfT and CAA should consider setting clear policy positions on the regulation of UAS traffic management to offer clarity to the ANSP industry.

To progress this issue, it is expected that the AMS UTM Policy Group will provide clarity on the policies for UAS traffic management, and therefore help to establish a clear position on how and where UAS traffic management is regulated in the UK.

Standards

The role of standards in the development and implementation of UAS traffic management will be very important, especially in countries that wish to enable a competitive, federated approach where multiple service providers are required to collaborate.

UK Standards

The British Standards Institute (BSI) UAS Technical Committee[27] is striving to develop a portfolio of standards focused on safety and quality, as opposed to technical specifics. These are intended to promote a baseline level of agreement and understanding in all aspects of UAS, including UAS traffic management. Their primary objective is to publish standards through the International Standards Organization (ISO) and have already done so in 2018 for other UAS topics. Currently their 'UAS traffic management' standard is still in development but is expected to remain high-level in its approach.

International Standards

The standards body ASTM (formerly American Society for Testing and Materials) are in initial stages of writing standards for UAS Remote ID and Tracking (WK65041) and for Service provided under UAS Traffic Management (WK63418). UAS traffic management companies are already coming together to demonstrate these draft standards to aid in their development.

The Global UTM Association (GUTMA) are not a standards-making body per se but have a membership that includes the vast majority of companies working in UAS traffic management. Their UTM Architecture report from 2017 provides an initial collective view on roles and responsibilities, systems breakdown, and system interfaces.

EUROCAE Working Group 105 have been tasked by EASA to develop specific UAS traffic management standards. The objective of their work is to develop standards related to the operation of UAS while under 'U-space'. They have identified two specific areas for the development of such standards:

- **E-Identification**, i.e. the capability to identify a flying Unmanned Aircraft (UA) without direct physical access;

- **Geo-fencing**, i.e. providing the Remote Pilot (RP) with information related to the UA position and its airspace environment and limiting the access of the UA to certain areas.

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[26] https://www.altitudeangel.com/blog/nats-enters-strategic-partnership-with-altitude-angel/
[27] https://standardsdevelopment.bsigroup.com/committees/50259034

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Unmanned Integration Concept of Operations (CPC & Trax International)

Under the Future Airspace Strategy[28], Trax International[29] and the CPC are investigating how unmanned aircraft could be safely integrated with manned operations in different scenarios.

The work is intended to describe and demonstrate to existing airspace users how the integration of unmanned aircraft could result in improvements for manned aircraft.

The results of the study are expected to inform a series of blueprints to describe specific scenarios where unmanned aircraft are required to transition through various types of airspace or interact with other airspace users. These blueprints could form the basis for a series of future trials and demonstrations.

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[28] That which preceded the current Airspace Modernisation Strategy.
[29] Trax International is an Airspace and ATM consultancy who work closely with the CAA across various discrete projects.

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International

Airspace modernisation in the UK must take account of any international recommended practices or obligations related to the UK's air navigation functions, such as those from ICAO and the EU. Alignment with international arrangements offers the opportunities for harmonisation resulting in import and export of skills and services, as well as interoperability between national systems, allowing non-UK operators to easily conduct drone operations in the UK within a national UAS traffic management ecosystem.

European Regulatory

European Aviation Safety Agency Basic Regulation

The European Aviation Safety Agency (EASA) 'Basic Regulation' was originally introduced in 2002 to give competency and authority to EASA for airworthiness and environmental certification of all aeronautical products, parts, and appliances designed, manufactured, maintained or used by persons under the regulatory oversight of EU Member States. In 2018 the Basic Regulation was updated (Regulation (EU) 2018/1139), consolidating the scope of European Union competence to formally cover the full spectrum of the aviation landscape and reinforce the European aviation system. This also widened the scope of EASA's authority to include UAS.

EASA: U-Space Regulation

U-Space was first introduced by EASA as their approach to implementing UAS traffic management in Europe. The first iteration includes a roadmap of capability levels from U1 to U4.

In partnership with the European Commission, Eurocontrol and SESAR-JU, EASA's early draft of the U-Space regulation covers the high-level safety aspects of UAS traffic management as opposed to any specific architectural or implementation details.

EASA plan to further develop the draft regulation through consultation throughout the summer 2019, with an Opinion expected to be adopted by the end of 2019.[30] Following this, the formal process of developing and introducing a new regulation will follow the processes within the European Commission. As such, a final regulation is not likely to come into force until after 2020.

CAA will proactively engage in this activity where possible.

Concept of Operation for European UTM System (CORUS)

Gathering experts from aviation (manned and unmanned), research and academia, the CORUS consortium has developed and produced a concept of operations for U-Space and aims to address very low level airspace including the airspace around airports.

Starting from the U-Space blueprint and the ATM Master Plan[31] update, the project produced detailed definitions of the services necessary for lower level drone operations over the next two years.

The services will be defined in a way that shows how they can and should be used together to enable safe drone operations while balancing the needs of the drone sector with those of society as a whole.

Joint Authorities for Rulemaking on Unmanned Systems (JARUS)

JARUS is a group of experts from the National Aviation Authorities (NAAs) and regional aviation safety organisations. Its purpose is to recommend technical, safety and operational requirements for the certification and safe integration of UAS into airspace and at aerodromes. The objective of JARUS is to provide guidance material aiming to facilitate each authority to write their own requirements, to avoid duplicate efforts, and to promote harmonisation.

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[30] https://www.easa.europa.eu/newsroom-and-events/events/u-space-workshop-2019#group-easa-downloads
[31] https://www.atmmasterplan.eu/

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Within JARUS are several working groups, including Working Group 6 "Safety & Risk Management" who are currently developing the Specific Operations Risk Assessment (SORA) methodology. Annex H of SORA v2 will provide guidance as to how an UAS traffic management service can be used to carry out typical operator responsibilities within the SORA process.

In the UK, there is work to be completed in parallel with JARUS SORA to identify whether UAS traffic management services can be accepted as part of an unmanned aircraft operation as a mitigation of certain risks.

> **Recommendation 9**
> CAA should identify whether and where an UAS traffic management service can be used as a risk mitigation for unmanned aircraft operations.

SORA v2 will soon be included by EASA as an acceptable means of compliance (AMC) with the European UAS regulations (Basic Regulation 2018), allowing operators to use the SORA process to identify, assess and describe their operational safety case. Therefore, from July 2020 when this comes into force, it is expected that UAS traffic management service providers will expect the UK CAA to recognise their services against parts of the SORA.

Eurocontrol

Eurocontrol's role is to ensure safe integration of UAS, maintain the "Big picture", safeguard the rights of all airspace users and work together with all actors towards safe integration[32].

Eurocontrol are the primary coordinator of the CORUS project, as well as the EU-funded PODIUM project which plans to perform BVLOS flights covering eighteen operational scenarios, including multiple drone flights and near airports. The project aims to collect and analyse feedback from drone operators, air traffic controllers, supervisors and authorities with a view to validating the ease-of-use and benefits of U-Space.

Single European Sky ATM Research – Joint Undertaking (SESAR-JU)

SESAR-JU have been pivotal to the development of the U-Space concept, having published the U-Space Blueprint[33] in 2017 and since coordinated several demonstration programmes[34] and research in the area.

International Civil Aviation Organisation (ICAO)

In response to demand, ICAO published a common framework[35] for UAS traffic management with core principles for global harmonisation. It recognises that, "while UAS traffic management is already under development, a common agreement on its framework and principles is essential to ensuring global harmonisation and interoperability. Accordingly, ICAO is supporting States, UAS industry leaders, academic and aviation professionals in the development of a common agreement on the framework that will remain consistent with the principles of the Convention".

At the ICAO Air Navigation Conference 13 in 2018 one of the recommendations relating to the long-term evolution of current Communication, Navigation and Surveillance systems and frequency spectrum access. ICAO was asked to establish a multi-disciplinary task force to produce a roadmap for their evolution. This work will be supported by the CAA, with our active participation where possible, and for which UAS traffic management should form a pillar.

Other National Aviation Authorities

The issue of UAS traffic management is a high priority for many countries around the world. The following gives an overview of activity taking place in the most prominent countries:

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[32] https://www.eurocontrol.int/uas
[33] https://www.sesarju.eu/sites/default/files/documents/reports/U-space%20Blueprint%20brochure%20final.PDF
[34] https://www.sesarju.eu/node/3346
[35] https://www.icao.int/safety/UA/Pages/UTM-Guidance.aspx

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United States

The FAA explains that UAS traffic management is how airspace will be managed to enable multiple BVLOS drone operations conducted where air traffic services are not provided.

Following the NASA UTM research program, a Research Transition Team (RTT) has been established between the FAA, NASA and industry to coordinate the UAS traffic management initiative. The FAA and NASA have also developed a joint UAS traffic management Research Plan to document research objectives and map out the development of UAS traffic management.

In 2017 the FAA introduced the UAS Integration Pilot Programme, which aimed to identify ways to balance local and national interests related to drone integration; improve communications with local, state and tribal jurisdictions; address security and privacy risks; and accelerate the approval of operations that currently require special authorisations. Several state authorities, designated as the Lead Participants are evaluating a host of operational concepts, including night operations, flights over people and beyond the pilot's line of sight, package delivery, detect-and-avoid technologies and the reliability and security of data links between pilot and aircraft.

NASA's 'UTM' programme sets out 4 technology capability levels (TCL) to help drive research and development in this area. These are described below[36]:

TCL1	TCL2	TCL3	TCL4
▪Concluded field testing in August 2015 ▪Undergoing additional testing at an FAA site ▪Technologies in this activity addressed operations for agriculture, firefighting and infrastructure monitoring, with a focus on geofencing, altitude "rules of the road" and scheduling of vehicle trajectories.	▪Completed in October 2016 ▪Leveraged TCL1 results and focused on beyond visual line-of-sight operations in sparsely populated areas. ▪Researchers tested technologies that allowed dynamic adjustments to availability of airspace and contingency management.	▪Completed in May, 2018. ▪Leveraged TCL2 results with focus on testing technologies that maintain safe spacing between cooperative (responsive) and non-cooperative (non-responsive) UAS over moderately populated areas.	▪Ongoing through 2019 ▪First of two flight tests completed in Reno, Nevada in May, 2019 ▪Second to be conducted in Corpus Christi, Texas, in August. ▪Will leverage TCL3 results and focus on UAS operations in higher-density urban areas for tasks such as news gathering and package delivery. ▪Also test technologies that could be used to manage large-scale contingencies.

In partnership with industry, the FAA introduced a UAS data exchange platform called Low Altitude Authorization and Notification Capability (LAANC)[37]. It provides access to controlled airspace near airports through near real-time processing of airspace authorisations below approved altitudes in controlled airspace. The system automatically checks requests for airspace access against a 'UAS Data Exchange' giving access to flight restrictions, NOTAMs, and maps. This fully-digital system enables near real-time approval decisions.

New Zealand

To deliver UAS traffic management in New Zealand, a subsidiary of the country's ANSP was created – AirShare Ltd. The first AirShare UTM service was introduced in 2015 to manage UAV airspace approvals into controlled airspace and eventually integrate into the country's ATM system. More recently, AirShare entered into an agreement with Dubai-based

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[36] https://utm.arc.nasa.gov/index.shtml
[37] https://www.faa.gov/uas/programs_partnerships/data_exchange/

Exponent Systems to provide the next generation of UAS traffic management and has expanded its service to include visual line of sight (VLOS) flight authorisations and tracking in both controlled and uncontrolled airspace[38].

The company is currently testing integration of 4G communication systems using the Long-Term Evolution (LTE) protocol with global navigation satellite system (GNSS) receivers to support a vehicle's inertial navigation system (INS), as well as and low-cost ADS-B technologies for enabling the key building blocks – detect-and-avoid and command-and-control – of BVLOS operations.

India

Starting from a position of zero tolerance to unmanned aircraft, India announced its Digital Sky platform in 2018 alongside a suite of new regulations aimed at enabling drones to be used in the country.

The regulations outline that permission must be sought for any UAS flights (no permission, no take-off). Unfortunately, the platform seems to have been developed in isolation from key industry stakeholders such as DJI and requires UAS to be equipped with bespoke tracking devices to enable any sort of flight.

However, in May 2019, the Indian Directorate General of Civil Aviation invited calls of interest for conducting experimental BVLOS operations, stating that permission to fly BVLOS is predicated on a successful outcome of any experiments.

Switzerland

In Switzerland, several stakeholders have worked on products and services linked to U-Space. With the view to ensure transparency and inclusiveness, the Swiss Federal Office of Civil Aviation (FOCA) has facilitated the creation of the Swiss U-Space Implementation (SUSI) platform. FOCA has launched this new platform with initial member partners Skyguide, AirMap, Swisscom, INVOLI, Wing, senseFly and Auterion.

Under the Swiss U-Space concept the programme is divided into a centralised and a competitive environment, enabling public service operations to be handled directly by the centralised system, whereas other flights are given the freedom to select a 'UTM Service Provider' which itself coordinates with the central system.

The architecture centres around a Flight Information and Management System (FIMS) and is described in their implementation paper and CONOPs[39], developed in partnership with Airmap.

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[38] Airspace of defined dimensions within which air traffic control service is provided in accordance with the airspace classification. Controlled airspace is a generic term which covers ATS airspace Classes A, B, C, D and E as described in ICAO Annex 11 paragraph 2.6 and Appendix 4. Uncontrolled airspace covers ATS airspace Classes F and G.
[39] https://www.bazl.admin.ch/bazl/en/home/good-to-know/drones-and-aircraft-models/u-space.html

The CAA Perspective

The UTM Task Force

The concept of UAS traffic management clearly spans across the various facets of the CAA. To enable the appropriate CAA functions to be kept informed and contribute to the CAA's position and activity on UAS traffic management, a task force has been established, led by the Innovation Hub and including representation from the following CAA departments and teams:

- Aerodromes
- Air Traffic Management
- Airspace Regulation
- Cyber
- Future Airspace
- Future Strategy
- Meteorological and Aeronautical Information Service
- CNS & Spectrum
- UAS Policy and Sector
- Consumer and Markets Group

Through development of this paper, it has become increasingly clear that UAS traffic management is progressing at a fast pace towards a state of 'Business as Usual' where regulation and oversight will be required. For example, the draft EASA regulation (as of July 2019) proposes that a body such as the CAA will need to take on oversight of the U-Space Service Providers in accordance with existing ANSP performance and quality standards[40].

> **Recommendation 10**
> CAA should consider the organisational design implications for how to integrate the new regulatory responsibilities relating to UAS traffic management within its business.

The following sections articulate the positions and recommendations of the relevant CAA departments or teams.

CAA Horizon Scanning

UAS traffic management is a growing business objective to enable wider use of UAS. However, it may also influence other areas of ATM as the technology to enable UAS traffic management becomes available and proven and may transfer across into traditional ATM areas.

In 2018 an increasing number of acquisitions and strategic partnerships between ANSPs, traditional ATM equipment providers and UAS traffic management companies have been made. This implies long-term implications for changes to ATM innovation, business models and mode of operation.

The view from ANSPs globally is divided, but most of those that are forward-leaning (including NATS and SkyGuide) openly see UAS traffic management as an existential threat and opportunity to influence the way that ATM business currently runs, and that this is a once-in-a-generation opportunity to springboard developments which are long overdue in this sector. This has proven to be a useful lever in which to engage the current ATM stakeholders, internally and externally, that ultimately UAS traffic management is not just about unmanned aircraft.

The risk for CAA that must be managed is that we will not have the appropriate knowledge or resource to be able to assure safe integration of UAS traffic management within our airspace.

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[40] Refer to Subpart B of Annex III to Regulation (EU) 2017/373

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Airspace

A significant benefit foreseen from UAS traffic management is the ability to introduce controls for air traffic in lower altitudes, specifically over urban areas, and thereby enable routine operations of unmanned aircraft and urban air mobility aircraft.

For the concept to become scalable, there may need to be a delegation of airspace authority down to regional authorities or UAS traffic management service providers, together with the numerous issues that brings. This is a big step away from the existing legal and regulatory framework and would therefore need to be explored. Academic work is being done in this area, and the CAA will continue to engage in this where possible.

> **Recommendation 11**
> The potential policy, legal and regulatory requirements associated with the delegation of airspace authority beyond those authorities that exist today should be explored through both desktop and sandbox research.

The need for new airspace structures specifically for lower airspace operations, and the mechanism by which these structures could be introduced also needs to be investigated, as the digital approach to UAS traffic management potentially enables greater flexibility.

These airspace issues are pivotal to the implementation of any UAS traffic management ecosystem.

Airspace Information & Data Exchange

The information that describes the structure of airspace is critical to UAS traffic management. Without it, the ability to incorporate pre-flight planning, deconfliction and other complex tasks would be ineffective.

Project Chatham was a trial sponsored by DfT, with support from CAA and NATS, to test whether UAS-relevant airspace information that is notified in the AIP could be published in a format which is suitable for integration into 3rd party systems, such as smartphone apps and websites. This project concluded in 2018 having succeeded in its goals.

The UAS Policy Team has since taken lead of the objective under the Drone Zones project and is aligning this with the requirements of the EASA Basic Regulation 2018 Article 15 which allows Member States to publish airspace information pertinent to drones. The process and structure for implementing

> **Recommendation 12**
> The goals and roadmaps to enabling implementation of a digital state-approved airspace information dataset should be considered.

this service is being developed by the UAS Policy Team in coordination with Airspace Regulation (AAA), the Meteorological (MET) and Aeronautical Information Management (AIM) policy team, and the Consumer & Markets Group (CMG). This is expected to incorporate the current 'no fly zones' established in the ANO, including those around airports.

The Drone Zone project is therefore pivotal to the foundation of any UAS traffic management ecosystem.

Drone Registration and Education System (DRES)

The Drones Registration and Education System (DRES) project was initiated by DfT to meet new legislative requirements set out in the ANO Amendment 2018 (No. 623), as well as those in the EASA Basic Regulation 2018, for operators of small unmanned aircraft to register with the CAA. The DRES project is being delivered by the CAA and was available for public use in October 2019.

This data repository of UK UAS operators will provide a key information asset for UAS traffic management providing a linkage between unmanned aircraft operating within the traffic management system and their registered operators. To enable this, it is critical that the registration system is able to be integrated into the UAS traffic management ecosystem.

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Electronic Conspicuity Deployment Programme

The CAA's Electronic Conspicuity Deployment Programme aims to determine the necessary requirements and formulate a strategy for electronic conspicuity in the UK. The programme is funded by the DfT and will feed strongly into the Government's Aviation Strategy 2050, expected to be published by the end of 2019.

A call for evidence concluded in May 2019, followed by the 'Share the Air' conference in June where the CAA set out plans to proactively explore options for mandating electronic conspicuity for all airspace users.

> ### The 'Share the Air' Strategy
>
> The Call for Evidence which ran from March to May 2019 concluded that:
>
> - There is general support, albeit with some uncertainty around the CAA's role.
> - Continued segregation is unsustainable.
> - The approach needs to recognise different available technologies.
> - The approach needs to be flexible to meet local demand.
> - There is some uncertainty about mandating location specific areas.
> - GA is a diverse group and their differing needs need to be recognised.
> - UAS cannot *see* and avoid, UAS need the capability to *detect* and avoid.
>
> As a result, the CAA will:
>
> - Conduct a trial in early 2020.
> - Establish a technical working group to address challenges and set requirements.
> - Develop a full strategy , with a consultation in 2020

The ability to electronically and remotely identify an aircraft and thereafter to automatically determine its expected flight path, destination, and perhaps even its type of payload is fundamental to UAS traffic management. Therefore, the CAA's UTM Task Force includes the ECDP team and regular engagement will continue to maintain mutual awareness and enable alignment where appropriate.

Air Traffic Management (ATM)

While the Air Navigation Order currently defines a clear upper altitude limit for small unmanned aircraft[41], this segregation between unmanned and manned traffic is likely to restrict progression and efficiency gains in the future. The rules of the air[42] were written in a time that didn't include the shapes and sizes of unmanned aircraft we see today and in the near future, and UAS traffic management will likely impact on their evolution.

For UAS traffic management to successfully enable the integration rather than separation of drones or other unmanned vehicles in UK airspace, it needs to collaborate seamlessly and automatically with existing manned air traffic management.
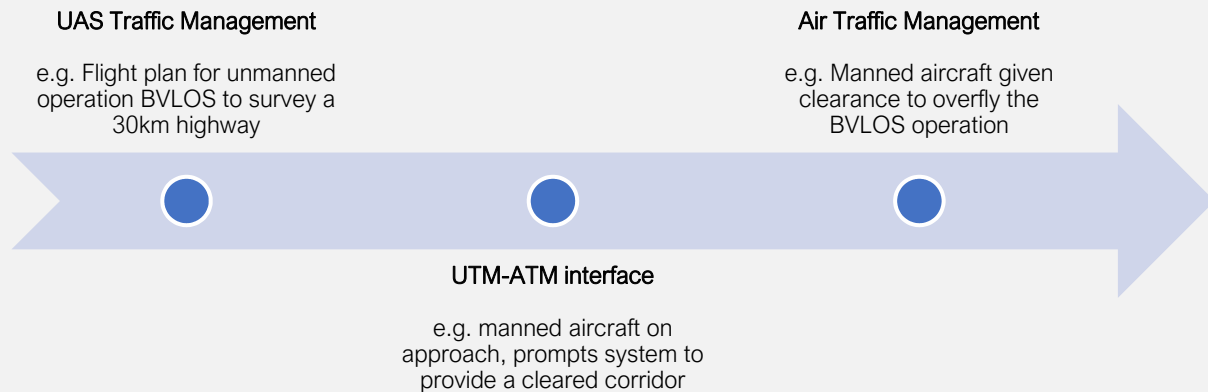
In addition, UAS traffic management and Air Traffic Management protocols and procedures will need to work in partnership to avoid any unnecessary increases in complexity. For example, in how airspace users are notified either through internationally agreed formats and publications (AIP/NOTAM[43]) or innovative digital (websites, apps) methods while maintaining high levels of data quality. There are also many benefits to the ATM system from incorporating technologies and procedures developed for UAS traffic management.

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[41] Air Navigation Order (Amendment) 2018, Article 94A extended the 400ft height restriction to all small unmanned aircraft.
[42] ICAO Annex 2 'Rules of the Air', Commission Regulation (EU) 923/2012 'Standardised European Rules of the Air' and The Rules of the Air Regulations 2015 (S.I. 2015 No. 840)
[43] Notice to Airmen (http://publicapps.caa.co.uk/docs/33/CAP1535_Skyway_Code_V2_PRINT.pdf#page=27)

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UAS Traffic Management

e.g. Flight plan for unmanned operation BVLOS to survey a 30km highway

Air Traffic Management

e.g. Manned aircraft given clearance to overfly the BVLOS operation

UTM-ATM interface

e.g. manned aircraft on approach, prompts system to provide a cleared corridor

A simple example to demonstrate why UTM-ATM integration is necessary.

There is therefore a necessity for a clearly defined 'UTM-ATM' interaction protocol which accounts for the technological and operational progression that is likely to happen in ATM – for example the introduction of intelligent air traffic systems that utilise artificial intelligence. This should be considered as part of the UAS traffic management roadmap.

Airspace in the Vicinity of Aerodromes

In response to the potential risks presented by drones being flown near active aerodromes, recent ANO amendments have introduced, and then further adapted, new airspace structures around aerodromes that specifically restricts drones[44].

UAS traffic management, coupled with electronic conspicuity and other technologies, offers the possibility of intelligently controlling access to this and other sensitive airspace. In addition, there are systems being developed by industry which offer aerodrome traffic service providers the ability to better manage the access parameters and approvals.

Coupled with various local detection capabilities ('counter-drone' equipment), UAS traffic management also supports aerodromes in identifying and mitigating the effects of infringements, including those by manned aircraft.

It should be noted that UAS traffic management and its components do not provide a solution to 'bad actors' but can support a richer surveillance picture allowing aerodromes and security services to screen out cooperative operators, helping to focus and prioritise scarce resources.

Cyber Security & Safety

Due to the progressively interconnected nature of industry systems, the aviation industry must remain aware of direct and indirect cyber threats, as a result of attacks and through reckless or negligent behaviour. The risk profile is dynamic: attackers (people, artificial intelligence systems or self-replicating viruses) are always looking to exploit vulnerabilities and can quickly develop new ways of breaching cyber security.

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[44] Air Navigation (Amendment) Order 2019, Articles 94A and 94B

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Given the ubiquity of digitally connected technology and its criticality to novel and innovative operations it will be necessary for any stakeholder in the UAS traffic management ecosystem to ensure that they have sufficiently considered and managed any cyber risks. The National Cyber Security Centre (NCSC) has prepared the Cyber Assessment Framework (CAF)[45] to assist entities in assessing their cyber risk. This framework provides a set of principles which should be assumed as relevant to any development of UAS traffic management, as well as of any ATM system.

> **Recommendation 13**
> All development activity for UAS traffic management in the UK should consider the NCSC Cyber Assessment Framework to ensure adequate mitigation of cyber risks.

In addition, the CAA have now refreshed the CAA Cyber security oversight process[46] for aviation in October 2019. CAP1753 provides the basis for all cyber security oversight activity by the CAA and includes detail of good cyber security practice against four key objectives.

Meteorological and Aeronautical Information

Existing manned aircraft operations require reliable meteorological and aeronautical information as part of their flight planning and in-flight planning activities.

Today there are many legacy processes which rely on the conversion of meteorological and aeronautical information into different formats when being transmitted from the source through to the end user. For example, aeronautical charts are produced in a digital format and printed for publication. In some operations the printed maps are then scanned into a separate digital file by a separate organisation which is then used by the pilot via an electronic display. The quality of the chart degrades each time the format is changed.

To mitigate this in future, both meteorological and aeronautical domains are working towards ICAO requirements for the digital provision of information using XML data exchange models, IWXXM for meteorological information and AIXM for aeronautical information.

These data exchange models will produce digital information which can be disseminated more efficiently and therefore the quality of the original data is maintained throughout the process. This was successfully tested by DfT's Project Chatham in 2018 which used the AIXM format provided directly from the NATS AIP database.

The use of these data exchange models will also ensure that remote pilots and operators of unmanned aircraft have access to a state-approved database of aeronautical information. This access could be provided through an UAS traffic management service.

Meteorological Information

At present there is little understanding of the airworthiness aspects or safety considerations of how different weather phenomena impact unmanned aircraft operations. There is a need to understand the critical weather limits at which safe operation of unmanned aircraft take place. e.g. what are the wind speeds that cause unmanned systems to be unable to land safely. It is anticipated that snow, hail, poor visibility, low cloud and rain may also affect unmanned systems and it will be necessary to quantify this impact to assess the observational and forecast requirements.

Weather observations are important for ATM purposes and are required to be provided at

> **Recommendation 14**
> A gap analysis should be considered to assess the viability of using existing meteorological services to understand if the current accuracy and gridded data resolution are enough for unmanned operations, and if any additional services are required.

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[45] https://www.ncsc.gov.uk/collection/nis-directive/cyber-assessment-framework/introduction-to-the-cyber-assessment-framework
[46] https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=9242

aerodromes and reported at half hourly intervals, it is currently unclear how or if a similar requirement will be needed for the UAS traffic management environment.

Today aviation weather forecasts are provided both in site specific form, and for en-route flight planning purposes as grid point information. Start-up businesses in the UAS sector, such as Flock Cover[47], are using 'micro-weather' reports to support operations and to determine on-demand insurance products.

Aeronautical Information

As with meteorological information, aeronautical information is required by operators as part of the flight planning requirement. Aeronautical information that is part of the UK AIP is updated monthly according to the 'AIRAC' cycle.

Regulations now define the necessity to maintain the data quality aeronautical information throughout the production and distribution processes. This is expected to be delivered through the digitalisation of aeronautical information products and processes, as described earlier.

> **Recommendation 15**
> A review of the current regulatory requirements for the notification of obstacles relevant to unmanned operations should be considered to ascertain whether those requirements are suitable for future operations.

Obstacle data can include permanent or temporary structures, such as cranes. However, there is currently a weakness with the UK's obstacle data in that at present there is no requirement for the CAA to be notified of an obstacle above 300ft away from aerodromes. There is likely to be an ANO amendment later in 2019 that will require obstacles to be notified, however this has not yet been confirmed and may not fully correct the issue.

For complex and high-volume unmanned operations, with elements of beyond visual line of sight and automation involved, there will be a need for high quality obstacle maps at lower altitudes.

Radio Spectrum

Existing manned aircraft operations are heavily dependent on high quality Communication, Navigation and Surveillance (CNS) systems, underpinned by the radio spectrum with an appropriate level of protection to enable their safe operation. Future CNS systems will need to consider compatibility and interoperability across all platforms, as well as harmonised transition mechanisms.

Operations of unmanned aircraft will require an increasing amount of radio spectrum to meet their capability needs in the future and will need to take account of radio spectrum already assigned and available to manned aviation. There will be a need to consider the global and regional standardisation of spectrum allocation as well as the strong challenge from other industries for spectrum access. The long-term evolution of current CNS systems nationally and globally, and wider spectrum efficiency requirements, will need to be evaluated and new requirements defined as early as possible, as there are long timescales for achieving changes to the international radio regulations, which govern the use of radio spectrum.

In respect of each area of CNS systems, communications providing command and control links will need to consider issues around integrity, security, priority, availability and power levels. Potential navigation issues include Global Navigation Satellite System (GNSS) incumbent vulnerabilities as well as the potential need for an alternative primary navigation system. The evolving surveillance environment may need to consider the ability for other aircraft systems to know about an aircraft position and intent and, where appropriate, negotiate modifications to that intent. These aspects would benefit from further testing and validation, for example through the CAA Regulatory Sandbox.

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[47] https://flockcover.com/

Summary of Recommendations
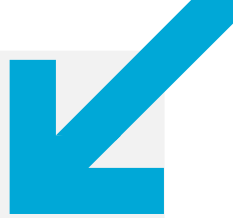
The recommendations throughout this paper have been consolidated into a single list below. These will be taken forward through the AMS UTM Policy Group, with support from the CAA UTM Task Force and the Innovation Hub.

#	Recommendation
1	The ICAO flight priorities should be assessed in the context of airspace that is shared by all airspace users, taking account of both the category of aircraft and its operational purpose
2	Existing roadmaps showing the progression of UAS traffic management should be assessed and either recognised by the CAA or used to generate a CAA roadmap
3	A review should be conducted of the target safety outcomes that are to be achieved through introduction of UAS traffic management services, to inform necessary airspace design requirements
4	The legislative changes necessary to pursue UAS traffic management should be explored, potentially through amendment of the Air Navigation Order 2016.
5	The AMS UTM Policy Group should address policy and regulatory gaps, agree a coherent position, and establish a series of proposals for the implementation of UAS traffic management in the UK including an appropriate economic model.
6	The UTM Principles should be accepted and publicised by the CAA as the foundation for all UTM development in the UK.
7	The CAA should adopt the Open Access UTM Framework output as a baseline set of guidelines for the development of an UAS traffic management technical framework, to be validated or modified as a result of testing in the CAA Regulatory Sandbox and other National programmes.
8	The DfT and CAA should consider setting clear policy positions on the regulation of UAS traffic management to offer clarity to the ANSP industry.
9	CAA should identify whether and where an UAS traffic management service can be used as a risk mitigation for unmanned aircraft operations.
10	CAA should consider the organisational design implications for how to integrate the new regulatory responsibilities relating to UAS traffic management within its business.
11	The potential policy, legal and regulatory requirements associated with the delegation of airspace authority beyond those authorities that exist today should be explored through both desktop and sandbox research.
12	The goals and roadmaps to enabling implementation of a digital state-approved airspace information dataset should be considered.
13	All development activity for UAS traffic management in the UK should consider the NCSC Cyber Assessment Framework to ensure adequate mitigation of cyber risks.
14	A gap analysis should be considered to assess the viability of using existing meteorological services to understand if the current accuracy and gridded data resolution are enough for unmanned operations, and if any additional services are required.
15	A review of the current regulatory requirements for the notification of obstacles relevant to unmanned operations should be considered to ascertain whether those requirements are suitable for future operations.
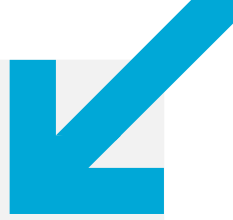
CAA Innovation Hub

The Innovation Hub is taking a forward-looking perspective, enabling innovators to test novel technologies and new business models across our remit. This will allow innovators to better understand the existing regulatory frameworks, best practice lessons to be shared across the sector, and prepare the CAA to develop a better understanding of innovations and how existing regulations may need to evolve.

The hub will simplify the way innovators reach out to the CAA. It will provide education, awareness and information about the path to regulatory assessments and approval, and how engaging with the CAA can better inform the development of their innovation.

In making this new approach available, the CAA will remain focussed on its role of protecting the consumer and the public.

The innovation hub offers three services:

- **An innovation gateway** Allowing innovators to access information about existing regulatory frameworks, seek guidance on how to engage with the CAA and receive education on areas of regulatory complexity. The gateway will also allow innovators to submit ideas for the aviation and travel sector and get a quick answer from us as to whether it needs regulatory input or approval.

- **A regulatory sandbox** Where users can work with the CAA to test and trial innovative solutions in a safe environment, in particular those solutions that may not fit within the existing scope of regulations, permissions, and exemptions.

- **A regulatory lab** This will set out a roadmap and develop test cases in key areas of interest, initially looking at issues like automation and urban air mobility. Bringing together everyone with an interest in the area such as other regulators, academia and the public, to develop potential regulatory models and avoid duplication between agencies.

> For any general enquiries, please visit the website at www.caa.co.uk/innovation or contact us through our email address, innovation@caa.co.uk.
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> If you have a proposal that you would like to discuss with us, please complete our submission form.