



Innovation Hub
**Beyond Visual Line of Sight in
Non-Segregated Airspace**
Fundamental Principles & Terminology

Introduction

The purpose of this guide is to provide an introduction to the fundamental terminology and principles of flying unmanned aircraft systems beyond visual line of sight, including guidance for systems that could enable aircraft to fly in non-segregated airspace.

Operating an unmanned aircraft Beyond Visual Line of Sight (BVLOS) is not explicitly prohibited or restricted by regulation, in the UK, however it does require the permission of the CAA to do so. [Page 3](#) of this guide describes how the maturity of technological and operational mitigations is not yet sufficient to authorise BVLOS operations in non-segregated airspace.

An unmanned aircraft operating BVLOS no longer has the protection ('see & avoid') of the remote pilot or observer to avoid terrain, obstacles or other aircraft. Segregated airspace is a means of mitigating this risk, and [page 4](#) describes why there is a need to operate in non-segregated airspace.

Pilots flying under visual flight rules (VFR) in Class E and G airspace are required to see and avoid potential conflicts, whether that be with other airspace users or with terrain and obstacles.

As the pilot of an unmanned aircraft is not able to provide the same 'see & avoid' mitigation for potential conflicts, the unmanned aircraft system must perform an equivalent function. [Page 5](#) describes some of the fundamentals of 'Detect & Avoid'.

However, there is no single solution for Detect & Avoid, and so [page 6](#) introduces the functional capability framework we call the Detect & Avoid Ecosystem. This requires that combinations of technologies, communications and procedures operate collaboratively to provide a holistic capability, depending on the type and nature of the operation.

Looking to the future, the CAA recognises that it is not sustainable to operate on exemptions alone, and that a business-as-usual approach to operating BVLOS in non-segregated airspace is required. Therefore, [page 10](#) provides some indications as to the regulatory roadmap that could lead to normalised BVLOS operations in the future.



What is BVLOS?

The CAA's Drone Code describes how remote pilots should keep their drone in sight. This means that they can see and avoid other things while flying. This is known as flying within **Visual Line of Sight (VLOS)**.

The guidance & policy document for unmanned aircraft systems (UAS) operations produced by the CAA known as CAP722 also defines VLOS as an operation in which the remote pilot maintains direct unaided visual contact with the unmanned aircraft. It also gives a distance for VLOS up to 500m horizontally from the remote pilot, but only if the aircraft can still be seen at this distance

Restricting Unmanned Aircraft to fly within this distance limits their potential applications. In the UK, **Extended Visual Line of Sight (EVLOS)** allows remote pilots to be supported by deployed observers who can maintain visual line of sight with the aircraft and communicate any potential risks of issues back to the remote pilot. This enables flights further than 500m from the remote pilot.

Operating UAS in this way is perfectly adequate for many businesses. However, there are significant opportunities of greater efficiency, productivity, safety and economic value from operating a UAS without the need or ability to keep the aircraft within view – known as **Beyond Visual Line of Sight (BVLOS)**.

According to the ICAO definition we believe that there are few, if any, instances globally of true non-segregated BVLOS being operationalised. Outside the UK, operations involving an observer (EVLOS) are sometimes referred to as BVLOS.

Operating BVLOS is not explicitly prohibited or restricted by regulation, however it does require permission from the CAA to do so. In order to authorise BVLOS operations in non-segregated airspace, the maturity of technological and operational mitigations requires significant work. This is where the CAA Innovation Hub can work collaboratively to support the development of these solutions.

Beyond Visual Line of Sight

An operation in which the remote pilot or RPA observer does not use **visual reference** to the remotely piloted aircraft in the **conduct of flight**

- ICAO

“**Visual Reference**” – Either the inability to use visual reference, or choice not to.

“**Conduct of Flight**” – Ensuring that the aircraft remains well clear of other airspace users, obstacles & terrain.

“**RPA**” – Remotely Piloted Aircraft.

Potential BVLOS Applications



Street mapping a city with optical and acoustic sensors



Transporting parcels from a distribution centre to a customer



Long-distance aerial surveys of a highway construction project



Persistent surveillance at the scene of an incident, operated from a control centre

Non-Segregated Airspace

An unmanned aircraft operating BVLOS no longer has the protection (See & Avoid) of the remote pilot or observer to avoid terrain, obstacles or other aircraft.

Many BVLOS operations are at a height where the risk of collision with terrain and obstacles is negligible. However, mid-air collision with other aircraft is a high risk at all heights.

With regards to the risks to other airspace users, CAP722 highlights 3 options for operating unmanned aircraft BVLOS –



Prove that the intended operation poses no aviation threat



Demonstrate a technical capability at least equivalent to 'see and avoid'



Operate in airspace segregated from other users

Today, UAS BVLOS operations are most commonly conducted in **segregated airspace** which is typically provided by a Temporary Danger Area (TDA). For a sustainable BVLOS business model, the TDA is not a practical long term solution, due to its 90-day validity and inability to re-establish without significant changes once expired. In addition, more permanent changes to airspace design require significant supporting evidence, resource investment and may not be suitable for the intended operation.

The challenge is therefore to demonstrate a technical and operational solution that provides equivalent or superior see-and-avoid without the need for a temporary or permanent airspace change, allowing operations within airspace that is shared with other aircraft – i.e. in **non-segregated airspace**.



Detect & Avoid

Pilots flying under visual flight rules (VFR) in Class E and G airspace are required to see and avoid potential conflicts, whether that be with other airspace users or with terrain and obstacles.

Typically, this relies on the pilot's eyesight alone, but can be augmented with additional sensors or technologies, such as ADS-B, FLARM, TCAS, etc¹.

According to ICAO, the hazards that present a threat to aircraft can include:



terrain & obstacles



hazardous meteorological conditions



conflicting traffic



ground operations



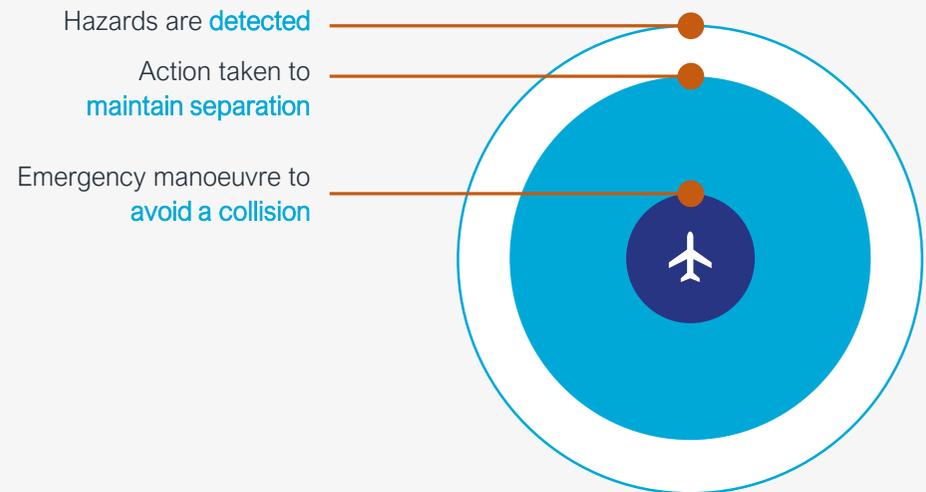
other airborne hazards

As the remote pilot of an unmanned aircraft is not able to provide the same 'see-and-avoid' mitigation for potential hazards, the unmanned aircraft system itself must be capable of performing an equivalent function.

We refer to this as **Detect & Avoid**, which includes detection of the hazard, maintaining safe separation, and the ability to perform a collision avoidance action.

¹ See SORA Annex D for Tactical Mitigation Performance Requirements (TMPR) including qualitative criteria for the different functions and levels of the TMPR.

Proximity of Hazards



Detect & Avoid

The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action

- ICAO

Detect & Avoid Ecosystem

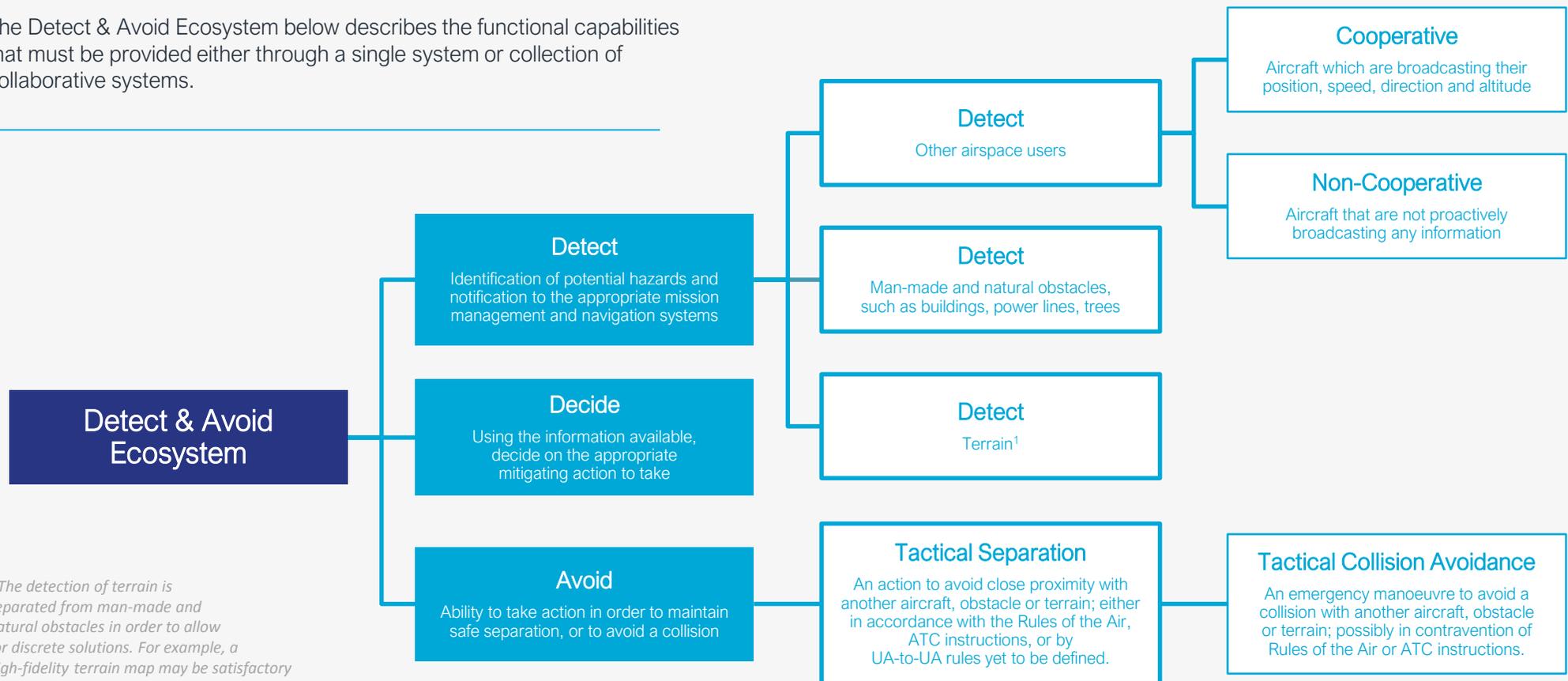
There is no single solution for Detect & Avoid.

Therefore we must consider that a collection of technical air and ground based mitigations, designed to reduce the risk of collision, work in collaboration to provide the overall Detect & Avoid capability.

The Detect & Avoid Ecosystem below describes the functional capabilities that must be provided either through a single system or collection of collaborative systems.

The CAA's intention is to build on the Detect & Avoid Ecosystem described below to support innovators and operators to comply with the intent of the regulations.

CAP1861a, published Oct 2020, provides an overview of the Detect & Avoid Ecosystem Framework, and builds further on the concept outlined below.



¹ The detection of terrain is separated from man-made and natural obstacles in order to allow for discrete solutions. For example, a high-fidelity terrain map may be satisfactory to ensure terrain avoidance, but will need to be supplemented by sensors to detect obstacles.

Detect & Avoid Solutions

The Detect & Avoid Ecosystem requires that combinations of technologies, communications and procedures operate collaboratively to provide a holistic capability.

The CAA recognises that each operation will demand a different combination of technical and operational solutions according to the risks.

It may be the case that in the future that a single 'black box' can provide the required capabilities for a given operation, but we must look to how non-segregated BVLOS can be enabled in the near term.

With this in mind, the CAA has identified a [matrix of potential solutions](#) with 4 types of technology. In some combination these are expected to provide the necessary functional capabilities for different operations. It is expected that Innovators will test these combinations and generate evidence to support a future approval framework.

Following activities conducted in the CAA Sandbox, as well as in programmes such as the Pathfinder Programme and Future Flight Challenge, the CAA Innovation Hub will share learnings via the CAA Innovation Gateway.

Detect & Avoid Ecosystem – CAP1861a

CAP1861a has been developed by the CAA Innovation Hub to provide a framework for understanding the necessary functions of DAA, and for describing proposed DAA solutions. Please refer to this CAP for more information.

Combinations of the 4 categories of technology below are expected to form part of the safety case for BVLOS operations in non-segregated airspace, coupled with operational mitigations.



Ground-Based Infrastructure

The detection of cooperative and non-cooperative airspace users can be significantly supplemented by ground infrastructure including radar.



Electronic Identification & Conspicuity*

The identification, position, speed, heading and altitude of other aircraft are critical data for determining Detect & Avoid actions.



On-Board Detect & Avoid Equipment

This includes both the detect functions, provided by various sensors, and the avoid function, provided by flight controllers.

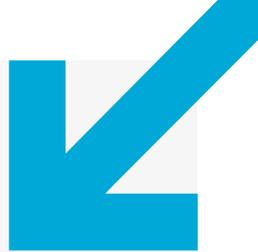


Unmanned Traffic Management

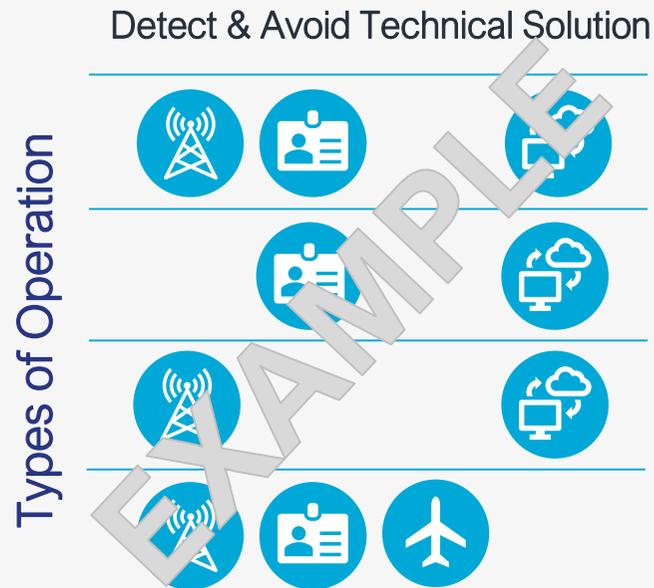
UTM has significant potential to bring elements of data collection, processing and dissemination to the Detect & Avoid ecosystem, as well as interaction with ATM.

Electronic Conspicuity primarily contributes to being **detected by other aircraft, but is also intended here as a means to detect other cooperative aircraft.*

Detect & Avoid Solutions Matrix



The example below describes how different combinations of technologies are necessary in order to provide a suitable Detect & Avoid solution for different operations.



Alongside the type of operation, the **level of automation** involved in flying the operation may also have an impact on the specific make-up of the Detect & Avoid solution.

The exact construct of this matrix will require substantial evidence to support it and will be explored through testing and research.

Performance-Based Approach

The Detect & Avoid solution matrix gives an indication of the approach being taken by the CAA when considering each application.

The mix of potentially technologies required for any detect & avoid solution will be dependent on the characteristics of the operation, the level of automation employed in the system, the ground and air risks, security, privacy and other factors.

The CAA Innovation Hub does not intend to specify which technologies are required in each case, but will look to support innovators in developing solutions that meet the intent of the regulations, and to share learnings to enable deployment and further development.



BVLOS Development Pathway



Test in Segregated Airspace

Test and development of the Detect & Avoid solution in a safe, segregated environment where the operator has control over the air and ground hazards.

Evidence needs to provide sufficient assurance to allow testing with other aircraft sharing the same airspace.



Test in [Non] Segregated Representative Environment

Test and development of the Detect & Avoid solution in a safe environment that is representative of the intended operation, where the operator has full visibility of other airspace users and ground hazards.

Evidence needs to provide sufficient assurance to allow operation in the non-segregated airspace intended for the operation.



Trial in [Non] Segregated Target Environment

Tests of the Detect & Avoid solution in the non-segregated airspace intended for the operation.

Evidence needs to provide the assurance that the solution is safe and reliable in the operational environment to allow an exemption to be given.



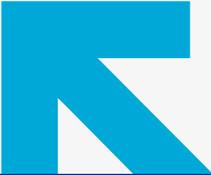
Non-Segregated BVLOS Operations

CAA approval for BVLOS operations in non-segregated airspace.

This recommended development pathway provides an indication of the type of progression and development that the CAA currently expects in order for the operator to **mature their safety case** in a safe and iterative fashion.

It is possible for an operator to enter the development pathway at any stage, or to skip a stage, as long as they present sufficient satisfactory evidence within their safety case to demonstrate that they are at the necessary level of maturity.

We expect that as solutions are developed, commercialised and standardised operators will be able to employ these standard approaches rather than needing to progress through the development pathway.



**Principle
Performance-Based**

Regulatory Route Map

The CAA recognises that it is not sustainable to operate on exemptions alone, and that a business-as-usual approach is required.

The long-term aspiration of operators is for BVLOS operations to be a routine part of business across the UK. This vision requires a significant volume of evidence, experience and learning by everyone involved.

There will inevitably be a need for innovators and the CAA to build, test, learn and repeat in small steps to work towards the vision.

This route map gives an indication of the goal we would like to achieve and the steps to reach it.

TODAY
BVLOS in segregated airspace only, with minimal regulatory guidelines to support non-segregated operations



Evidence from CAA Sandbox, Pathfinder Programme, Future Flight, etc

Routine updates to regulatory guidance, CAP722, etc



Development of the Detect & Avoid Solutions Framework (CAP1861a)

Monitoring and development of international standards, regulations and guidance

Increasing complexity of BVLOS operations in non-segregated airspace



Increasing the evidence base to enable non-segregated BVLOS



GOAL
Regulatory Guidelines enable routine approvals of Non-Segregated BVLOS



Terminology & References

BRLOS – Beyond Radio Line of Sight (ICAO) – Radio Line of Sight (RLOS) and Beyond Radio Line of Sight (BRLOS) refer to the method of operation of the command and control (C2) link between the ground control station and the unmanned aircraft. ICAO defines RLOS as “a situation in which the transmitter(s) and receiver(s) are within mutual radio link coverage and thus able to communicate directly or through a terrestrial network”. BRLOS is defined as “any configuration in which the transmitters and receivers are not in RLOS” and therefore may include transmission of C2 signals via a satellite. Alternatively, BRLOS can also describe a situation in which the terrestrial network cannot complete transmission in a timeframe comparable with an RLOS system.

Automated vs Autonomous (Dstl Biscuit Book) – One of the greatest potential benefits of BVLOS is the opportunity to automate the operation. Automation can be introduced into the operation (both the procedures and the equipment) progressively from no automation up to full automation.

A fully automated system is one which follows a set of procedures that were predefined by a human programmer but requires no human intervention during its operation. An autonomous system is a leap beyond fully automated, where the system is able to modify its parameters during the operation in order to adapt to off-nominal situations.

Small vs Large UAS (CAP722) – In the UK, CAP722 specifies that a Small UAS is any unmanned aircraft, other than a balloon or a kite, having a mass of not more than 20kg without its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight.

EU UAS Regulations will mean that UAS are no longer categorised only by mass, but will be categorised as open, specific or certified. For more information, refer to the CAA Guidance (CAP1789).

Controlled vs Uncontrolled Airspace (ICAO) – Controlled airspace is an airspace of defined dimensions within which air traffic control services are provided to Instrument Flight Rules (IFR) flights and to Visual Flight Rules (VFR) flights in accordance with the airspace classification.

Controlled airspace is a generic term which covers ATS airspace classes A, B, C, D, & E. Controlled Airspace includes Control Areas, Terminal Control Areas, Airways and Control Zones.

Uncontrolled airspace is therefore airspace where ATC services are not provided, or cannot be provided for any reason. Class G airspace is uncontrolled.

Remote Pilot vs Operator (UK Air Navigation Order) – Article 94G of the ANO 2018 states that the “remote pilot” is an individual who –

- (i) operates the flight controls of the small unmanned aircraft by manual use of remote controls, or
- (ii) when the small unmanned aircraft is flying automatically, monitors its course and is able to intervene and change its course by operating its flight controls;

The operator of an unmanned aircraft is the person or legal entity who has control over that aircraft and who organises how that aircraft is or may be used. An unmanned aircraft operator has legal accountability for the safe “management” of the aircraft according to the ANO. This includes flights that are being undertaken by another person i.e. a separate remote pilot.



Visit the CAA Innovation Hub online for latest updates, guidance and challenges
caa.co.uk/innovation

References

CAA Dronecode

<https://dronesafe.uk/drone-code/>

Unmanned Aircraft System Operations in UK Airspace - Guidance & Policy (CAP722)

<https://publicapps.caa.co.uk/CAP722>

The Detect & Avoid Ecosystem for BVLOS in Non-Segregated Airspace

<https://publicapps.caa.co.uk/CAP1861a>

Testing Novel Technology in UK Airspace

<https://publicapps.caa.co.uk/CAP1930>

Electronic Conspicuity Devices

<https://www.caa.co.uk/General-aviation/Aircraft-ownership-and-maintenance/Electronic-Conspicuity-devices/>

European Drone Regulations, and associated CAA Guidance (CAP1789)

<https://www.easa.europa.eu/regulations#regulations-uas---unmanned-aircraft-systems>
<http://publicapps.caa.co.uk/docs/33/CAP1789%20EU%20UAS%20Regulations-Guidance.pdf>

ICAO RPAS CONOPs

<https://www.icao.int/safety/UA/Documents/RPAS%20CONOPS.pdf>