



Published by
UAVHUB

A2 CERTIFICATE OF COMPETENCY AIDE-MEMOIRE

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Enquiries regarding the contents of this document should be addressed to the following:

Head of Training and Flight Operations
UAVHUB
Innovation Centre 6
Keele University Science & Innovation Park
Newcastle-under-Lyme
Staffordshire
United Kingdom

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Preface

In order to conduct Unmanned Aircraft (UA) operations within the Open Category within the United Kingdom, operators are required to obtain a A2 Certificate of Competency (A2 CofC) from a Civil Aviation Authority (CAA) Recognised Assessment Entity (RAE).

In order to gain an A2 CofC Remote Pilots must first pass the CAA Drone and Model Aircraft and Registration Service and obtain a Flyer ID, conduct some self-directed training flights with the aircraft within the bounds of subcategory A3 and pass an additional theoretical knowledge examination which is aimed at assessing the knowledge the risk to people on the ground with an RAE.

The UAVHub A2 CofC test comprises 30 multiple choice questions, over 3 primary subjects with a 80% pass mark, and is conducted at a test centre or remotely.

The UAVHUB A2 CofC Course has been specifically designed to develop the UAS pilot's knowledge of the regulations governing Visual Line of Sight (VLOS) operations in the Open Category and help ensure that they are furnished with the appropriate skill-set to move on to become safe, conscientious and successful UAS operators.

The contents of this Aide Memoire are not subject to change once issued and it is the duty of the UAS pilot to ensure that they operate within the rules and regulations valid at the time in the Flight Information Region (FIR) in which they are operating.

Abbreviations

Abbreviation	Definition
ANO	Air Navigation Order
AGL	Above Ground Level
AMC	Acceptable Means of Compliance
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
C3	Command, Control and Communication
ConOps	Concept of Operations
CofC	Certificate of Competency
CAA	Civil Aviation Authority
CAP	Civil Aviation Procedures/Publication
ICO	Information Commissioners' Office
IMU	Inertial Measurement Unit
EASA	European Aviation Safety Agency
FIR	Flight Information Region
FRC	Flight Reference Cards
GPS	Global Positioning System
GM	Guidance Material
GVC	General Visual Line of Sight Certificate
ICAO	International Civil Aviation Organisation
Kg	Kilogram
MORS	Mandatory Occurrence Reporting Scheme
MTOM	Maximum Take Off Mass
MTOW	Maximum Take Off Weight
NAA	National Aviation Authority
OA	Operational Authorisation
OM	Operations Manual
OS	Ordnance Survey
PDRA	Pre-Defined Risk Assessment
RA	Risk Assessment
RAE	Recognised Assessment Entity
RPAS	Remotely Piloted Aircraft Systems

RP	Remote Pilot
SORA	Specific Operations Risk Assessment
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
VLOS	Visual Line of Sight
VO	Visual Observer

Aviation Terms and Conversions

Statute Mile – SM - A Statute Mile is a 'normal' mile such as that used whilst driving. It is equivalent to 5280 feet or 1609 metres (1.6 kilometres).

Nautical Mile – NM – A Nautical Mile is a unit of distance used to measure 1 mile on an aviation or nautical chart. It is equivalent to one minute of arc along a meridian. A Nautical Mile is equivalent to 6076 feet or 1852 metres (1.852 kilometres).

1 Nautical Mile = 1.15 Statute Miles.

Knot(s) – Kt – A knot is a unit of speed which equals 1 nautical mile per hour. 1 Kt is approximately equal to 1.151 statute miles per hour (mph).

Speed of Sound – In dry air at 20°C the speed of sound is 343.2 metres per second, equivalent to 768mph which is approximately one Statute Mile every 5 seconds.

Torque – Tq – Torque is the tendency of a force to rotate an object about an axis, fulcrum or pivot point. Just as a force is a 'push' or a 'pull', Torque can be used to describe the 'twisting' force acting upon an object.

Centre of Gravity – CoG or C of G – The Centre of Gravity of an aircraft is the point about which the aircraft balances if it were to be suspended from two points. The Centre of Gravity affects the stability of the aircraft. To ensure that an aircraft is safe to fly, the CoG must fall within specified limits which are usually established by the aircraft manufacturer.

Millibar – mb – A millibar is equivalent to one thousandth of a bar (1 Atmosphere = 1 Bar). It is the term often referred to when aviators need to set a 'pressure setting' on flight instruments in order to calibrate them to a datum. For example, setting an airfield's pressure setting on the Altimeter may allow the Altimeter to read zero on touchdown. The accepted, international standard pressure at sea level is 1013.25mb which is equivalent to 29.92 inches of Mercury (inHg).

1 millibar = 30"

Hectopascal – hpa – A hectopascal is essentially the same as a millibar. It is the term now used within the United Kingdom FIR and throughout Europe to refer to pressure settings. It is the 'System International' or 'SI' definition of a mb.

Commercial Operation – A flight which is undertaken for 'valuable consideration'. This does not have to be for direct financial compensation.

Controlled Airspace – Airspace with defined dimensions within which Air Traffic Control (ATC) services are provided

Air Safety

This section of the Aide Memoir will lay the foundations for the rest of the booklet, covering some basic fundamentals of Air Safety with Unmanned Aircraft.

Your safety and the safety of everything around you and your drone are essential. The unmanned aircraft must work properly in all respects. And as the remote pilot, you must be alert and attentive to your surroundings during each flight. This training material will take you through everything you need to know to be able fly as safely as possible.

Situational Awareness

In aviation, situational awareness (SA) is often discussed. Situational awareness refers to the pilot (in your case, the remote pilot) being in control of the entire situation – the flight, the aircraft, the surroundings, the airspace, etc. You must be able to understand what happens during the flight and what may affect it: other pilots, weather conditions, the unmanned aircraft and the remote pilot's limitations. The better your situational awareness, the safer the flight.

Environmental Conditions

You are not allowed to fly your unmanned aircraft as you please. There are many areas and airspaces that are closed, either during certain periods or constantly. You may be able to unlock some of them through the use of an app or via permission from air traffic control, while some of them will always stay closed and will not allow flights with unmanned aircraft.

It is important that you are very familiar with the environment and the route in order for the flight to be as safe as possible. Don't forget to notify people nearby that the flight will happen.

Staying Healthy and Focussed

As a remote pilot, you must be sober and well-rested. Drinking alcohol or using drugs or medications that may affect your performance during flight, is prohibited. It is important that you understand how external and internal factors may affect you and your ability. This will be covered in detail within the chapter UAS Operating Principles.

Fly within Visual Line of Sight

One concept that you may come across when flying drones is visual line of sight (VLOS). In addition to being able to see your drone while flying, keeping the drone within your visual line of sight means that you must also keep a safe distance to people, animals, buildings, vehicles and other aircraft. You are never allowed to fly higher than 120 metres from the closest point on the surface of the earth.

Dangerous substances, gases or liquids as payload

In the context of an unmanned aircraft flight, you may also come across the concept of dangerous goods. This refers to such objects or substances carried by the unmanned aircraft, which could be dangerous in case of a crash or an accident.

Flying with dangerous goods without a permit is **prohibited**. Explosive, flammable, toxic, radioactive, corrosive or contagious substances, gases or liquids are all examples of dangerous goods.

Air Law

Definitions

Assemblies of People

Assemblies of people have been defined by an objective criterion related to the possibility for an individual to move around in order to limit the consequences of an out-of-control UA. There is no specific number of people that defines an assembly of people. Qualitative examples of assemblies of people are:

- (a) sport, cultural, religious or political events;
- (b) beaches or parks on a sunny day;
- (c) commercial streets during the opening hours of the shops; and
- (d) ski resorts/tracks/lanes

Uninvolved persons

An uninvolved person is a person that does not take part in the UAS operation, either directly or indirectly. A person may be considered to be 'involved' when they have:

- (a) given explicit consent to the UAS operator or to the remote pilot to be part of the UAS operation (even indirectly as a spectator or just accepting to be overflown by the UAS); and
- (b) received from the UAS operator or from the remote pilot clear instructions and safety precautions to follow in case the UAS exhibits any unplanned behaviour.

In principle, in order to be considered a 'person involved', one:

- (a) is able to decide whether or not to participate in the UAS operation;
- (b) broadly understands the risks involved;
- (c) has reasonable safeguards during the UAS operations, introduced by the site manager and the aircraft operator; and
- (d) is not restricted from taking part in the event or activity if they decide not to participate in the UAS operation.

The person involved is expected to follow the directions and safety precautions provided, and the UAS operator or remote pilot should check by asking simple questions to make sure that the directions and safety precautions have been properly understood.

Spectators or any other people gathered for sport activities or other mass public events for which the UAS operation is not the primary focus are generally considered to be 'uninvolved persons'. People sitting at a beach or in a park or walking on a street or on a road are also generally considered to be uninvolved persons.

An example:

When filming with a UAS at a large music festival or public event, it is not sufficient to inform the audience or anyone present via a public address system, or via a statement on the ticket, or in advance by email or text message.

Those types of communication channels do not satisfy the points above. In order to be considered a person involved, each person should be asked for their permission and be made aware of the possible risk(s).

This type of operation does not fall into the 'open' category and may be classified as 'specific' or 'certified', according to the risk.

UAS Operator

The term UAS **operator** is reserved for the person, organisation or enterprise that is engaged in or offering to engage in an aircraft operation. In other words, the term refers mainly to the legal entity that intends to operate one or more UAS.

An Operator ID registered to the UAS Operator must be affixed to the UAS if the MTOM is over 250g, or, if less than 250g MTOM has a camera.

Remote Pilot (RP)

The remote **pilot** constitutes a natural person who manually operates the UAV or monitors the course for an automatic flight.

All remote Pilots must have a Flyer ID issued by the Civil Aviation Authority

Unmanned Aircraft observer

An unmanned aircraft observer means a person, positioned alongside the remote pilot, who, by unaided visual observation of the unmanned aircraft, assists the remote pilot in keeping the unmanned aircraft in VLOS and safely conducting the flight.

Operating Categories

Operations of unmanned aircraft fall into one of three categories as follows:

Open category – operations that present a low (or no) risk to third parties. Operations are conducted in accordance with basic and pre-defined characteristics and are not subject to any further authorisation requirements.

Specific category – operations that present a greater risk than that of the Open category, or where one or more elements of the operation fall outside the boundaries of the Open category. Operations will require an operational authorisation from the CAA, based on a safety risk assessment.

Certified category – operations that present an equivalent risk to that of manned aviation and so will be subjected to the same regulatory regime (i.e. certification of the aircraft, certification of the operator, licensing of the pilot)

Open Category

Open category operations are bounded by three main factors:

- the maximum take-off mass of the unmanned aircraft must be less than 25kg
- the unmanned aircraft must be operated within visual line of sight (VLOS)
- the unmanned aircraft must not be flown further than 120 metres (400 feet) from the closest point of the surface of the earth

All three of these factors must apply for an Open category operation. If not, then the operation must be conducted under the requirements of the Specific category instead.

The Open category is then further divided down into three operational 'subcategories', in order to allow different types of operation without the need for an authorisation, as follows:

- A1 (fly 'over' people)
- A2 (Fly 'close to' people)
- A3 (Fly 'far from' people)

Operation		UAS		UAS Operator	Remote pilot
Subcategory	Operating Area	Class	Mass/KE/Speed	Registration	Competency
All	- Max height 120m/400ft (see UAS.OPEN.010 [3] & [4] for specific obstacle and sailplane limits) - No dropping of articles - No carriage of dangerous goods - Visual line of sight, must be able to clearly see the unmanned aircraft at all times, in order to safely control it. - Airspace restrictions. Avoid all applicable airspace restrictions. Permanent airspace restrictions can be viewed on this chart. - Be aware of temporary restrictions. Sign up to airspace alerts on the Skywise system to be alerted.			Minimum age 18	
A1	Fly over uninvolved people, but not over crowds	Privately built, or placed on the market before 01 Jan 2026.	<250g flying weight	Only if 'camera' equipped (but not toys)	Read user manual
	No intentional flight over uninvolved persons	A1 Transitional -Not after 01 Jan 2026	<500g 'flying weight'	Yes	- A2 CofC Theoretical test
A2	No closer than 50m horizontally from uninvolved persons	A2 Transitional -Not after 01 Jan 2026	<2kg 'flying weight'	Yes	- User manual - Online training - Online (foundation) test - Self-practical training - A2 CofC Theoretical test
A3	- No uninvolved people present within the area of flight. Maintain 50m separation from any uninvolved people - No flight within 150m horizontally of residential, commercial, industrial or recreational areas	Privately built or placed on the market before 01 Jan 2026.	<25kg 'flying weight'	Yes	- User manual - Online training - Online (foundation) test

Specific Category

The simplest description of a Specific category operation is that it is a UAS operation that 'cannot be done within the Open category but is not complicated enough for the certified category'.

The key point to note is that the category hinges on an operational authorisation (OA) being held by the UAS operator, which has been issued by the CAA, before the operation can be commenced.

For UK UAS operators, you are required to complete a General VLOS Certificate Course and submit an Operations Manual that outlines:

- what, where and how the unmanned aircraft will be operated;
- demonstrate that the operation is 'safe enough' through the provision of a safety risk assessment/safety

Pre-Defined Risk Assessment (PDRA)

In some cases, the requirements for the UAS operator to provide a 'full' safety risk assessment may be able to be lifted, which means that the UAS operator is required to provide a lesser amount of documentation to the CAA in order to obtain an operational authorisation. This type of approach would apply to operations that would likely be conducted by a large number of operators (i.e. it is a pre-defined scenario), but the safety mitigations are relatively simple.

In these cases, the CAA conducts the 'general' risk assessment, rather than each individual operator, and then publishes a short series of requirements (covering topics such as remote pilot competency, ops manual contents etc) that the UAS operator must provide to the CAA as part of a 'shortened' application for an operational authorisation.

This is a prescriptive set of instructions that must be followed, leading to a 'known' operation with a known and understood risk, that must be authorised on the basis of following the set of instructions. Much like following a cake recipe exactly, the intention is to produce an identical cake every time; and an identical safety risk is presented by the operation.

Individual PDRAs are published within CAP722 and will be added to as and when an appropriate need arises.

Each are individually numbered (E.g. UKPDRA01, UKPDRA02 etc).

UKPDRA01 is built around the 'standard permission' that is issued by the CAA for operations within congested areas, and contains the same privileges (i.e. operating within congested areas, 30 metres from uninvolved persons during take-off and landing, and 50 metres during flight).

Collision Avoidance

The collision avoidance requirements for UAS are the same as those for manned aircraft. In combination with the guidance provided in CAP 722, this is where the requirement from which we must maintain VLOS with our Unmanned Aircraft at all times. This must be reduced if the weather conditions and type of platform dictate, in order to maintain both VLOS and adequate control of the UAS to action the see and avoid principle should the need arise.

Civil Air Publications (CAP)

Current publications are available in PDF format via the CAA website. Each publication information page includes a description, edition details, revision status and, for some titles, effective dates.

All titles include a CAP number which you can use as short URL to return to any favourites:

www.caa.co.uk/CAPXXXX

UAS Implementing Regulation

The UAS Implementing Regulation was adopted into the UK from the European Commission on 31 December 2020 concerning the regulations for UAS aircraft.

This created the new framework for UAS categories (Open, Specific and Certified) and their requirements.

The intended purpose of the UAS Implementing Regulation was to harmonise the UAS regulations across the European Union and EASA Members. Since the United Kingdom formally left the European Union and is no longer a member state of EASA, the UK retained the UAS Implementing Regulation, but it is no longer aligned and recognised by any EASA member state due to the UK now defined as a 'third country'.

As of yet, no formal agreement has been made between the UK and the EU to recognise their respective certificates and authorisations concerning UAS.

Air Navigation Order

The Air Navigation Order (ANO) contains the rules of the air regulations for aviation. With regards to Unmanned Aircraft, the articles within the ANO give guidance for operating in or over aerodromes as well as the offences that contravene the wider UAS regulations.

The ANO is an article-based document and there are several key articles worth mentioning:

- **Article 94 A-B** concerning flights that are over or near aerodromes.
- **Article 239** concerning the Power to prohibit or restrict flying by the Secretary of State.
- **Article 240** states A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft. Endangering safety of any person or property.
- **Article 241** states A person must not recklessly or negligently cause or permit an aircraft to endanger any person or property.
- **Article 265A-F** which concerns offenses that contravene Implementing Regulation (EU) 2019/947.
- **Article 257** concerning the CAA's power to prevent aircraft flying.

CAP 722 - Unmanned Aircraft System Operations in UK Airspace - Guidance & Policy

CAP 722 is the CAA document which contains the guidance information for UAS Operations within UK Airspace. It is a particularly useful document to help operators plan and conduct safe operations. Operators are always recommended to keep an electronic copy of CAP 722 accessible during both planning and operations as a quick reference.

It is a document which is under constant review and is revised when necessary to consider advances in technology, feedback from industry, recognised best practice and changes in regulations.

Insurance

As detailed in CAP 722 and with reference to Regulation (EC) No 785/2004, adequate and appropriate insurance is mandatory for any aircraft conducting Commercial Operation.

Currently, it is only 3rd party insurance that is mandatory, insuring the aircraft is optional; although many policies include both types of cover as standard.

The current minimum requirement for 3rd party cover is 0.75m Special Drawing Rights. This is currently equivalent to approximately £750,000.

Airspace Restrictions

While planning a flight you must become familiar with the airspace. There are many types of restrictions that prevent you from flying as you please. They are called Restricted areas, or R-Areas.

You will also encounter control zones (CTR): the controlled airspace around airports and helicopter airports (often near hospitals). You may also find that are restricted areas around some national parks, nature reserves, nuclear power plants and military areas. As a remote pilot, you are obliged to know these things, and take them into account.

NOTAM – Notice to Airmen

NOTAM is short for Notice To Airmen. It is a service that regularly publishes important information about what is going on in the airspace, in order to alert pilots both manned and unmanned to risks that may affect their flight route.

NOTAM is intended for all types of pilots, and you must check these if you fly drones in the open category, allowing you to take into account any warnings and areas with flight restrictions while planning your route.

There are a number of ways you can check for NOTAMS. The simplest way is to use <http://www.dronesafetymap.com> or, if you prefer you can use <https://notaminfo.com/ukmap>

The UK Integrated Aeronautical Information Package (IAIP)

The UK publishes its Aeronautical Information Package through NATS as an electronic package that gets updated every 28 days. The AIP contains information regarding aerodromes, heliports, navigation warning, downloadable charts etc.

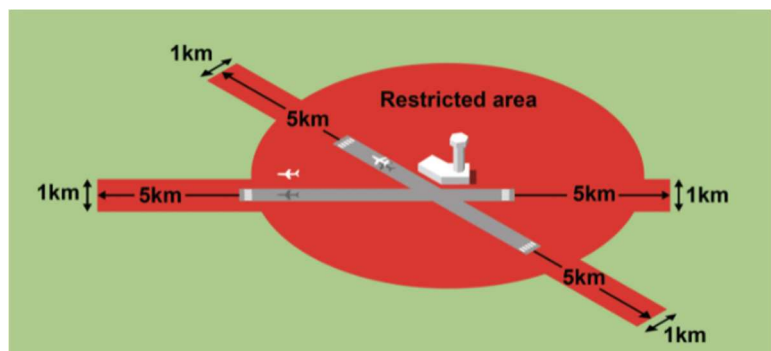
The Electronic AIP (eAIP) is a very useful document to refer to should you need to find a contact number for a specific aerodrome.

Flight Restriction Zones (FRZ)

A Flight Restriction Zone is around every protected aerodrome in the UK, which is a 2 (or 2.5) nautical mile radius cylinder and a series of 5Km rectangular zones from the end of each runway threshold- all of which extend up to 2000ft above the surface.

It is illegal to fly anywhere in an FRZ without permission from the air traffic control unit at the aerodrome, or if not operational, from the aerodrome itself.

You can check the locations of all of the UK FRZs at <https://www.dronesafetymap.com/>



Meteorology

Clouds

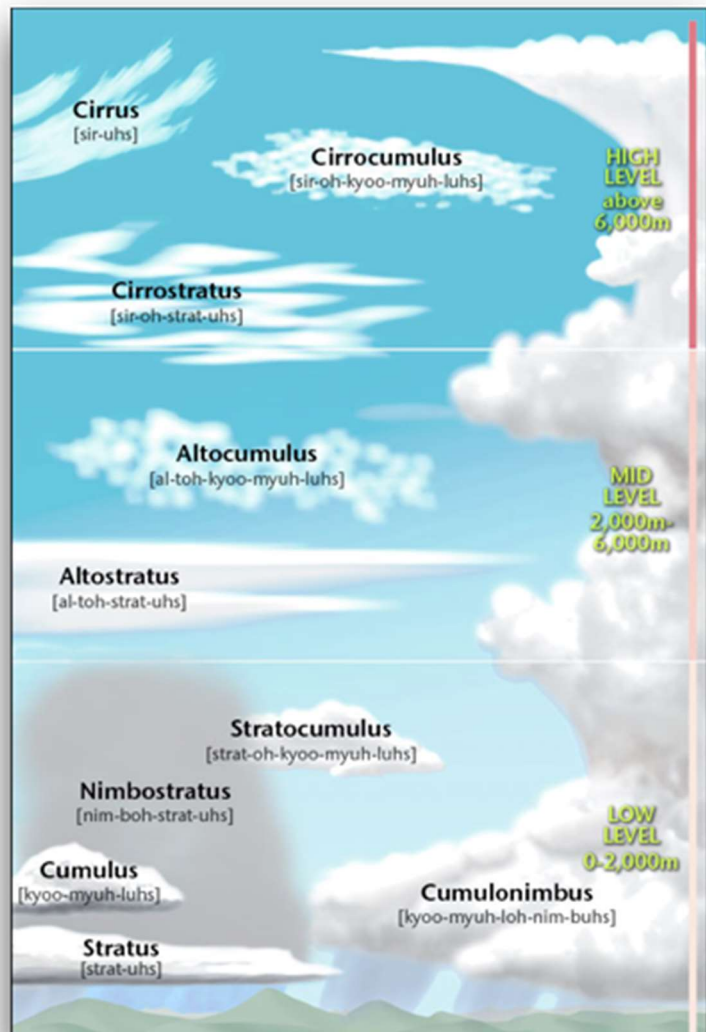
In meteorology, cloud is defined as: 'A visible mass of liquid droplets or frozen crystals made of water or various chemicals suspended in the atmosphere above the surface of a planetary body'.

Clouds are grouped by height.

High Level clouds are classified as those above 6000m.

Medium Level clouds are from 2000-6000m

Low Level clouds are from 0-2000m



Cumulonimbus (Cb) Clouds

Often referred to as Thunder Clouds or Anvil Clouds due to the type of weather they generally bring and the shape of their structure, Cb's are best avoided by aviators!

They carry within and around them many hazards that can seriously affect flying operations, particularly those utilising relatively small UAS that are often made out of composite materials.



A typical Cumulonimbus Cloud (Cb) as seen from the air – the anvil shape is clearly visible

Some of the potentially harmful and hazardous effects on UAS from Cb's are listed below;

- Wind Shear
- Turbulence
- Icing
- Hail Damage
- Reduced Visibility
- Lightning
- Radio Interference
- Compass Interference
- GPS Signal Loss

It is recommended that operators remain a minimum of 10 miles from the anvil, if it is visible and terminate operations until the Cb has cleared the vicinity.

Fog

Fog is defined as 'A cloud of water droplets suspended in the atmosphere at or near the Earth's surface which reduces visibility to less than 1km'.

Fog occurs when the temperature falls to the dewpoint. Fog may affect operations as it will reduce visibility of the UAS and limit range of operations. It should also be noted that due to the increased moisture content of the air, water can ingress into electronic components and cause damage to or loss of the platform. Operations in fog are not recommended at any time.

Wind

Wind is defined as 'The perceptible natural movement of the air, especially in the form of a current of air blowing from a particular direction'. It is caused by pressure naturally trying to equalise from an area of relatively high pressure to an area of relatively low pressure. It increases with height and 'veers' – conversely, it decreases as you get closer to the ground and 'backs'.

Wind can have a huge impact on UAS operations, particularly if it is gusty in nature or we are operating in or around buildings or objects which may generate turbulence.

Urban Effects

Turbulence can be caused by many factors, however the ones which you are most likely to experience as a commercial operator are orographic and domestic.

Orographic turbulence is that caused by the ground and objects attached to it so, for example, being in the wind-shadow behind a large avenue of trees may generate significant turbulence.

Domestic turbulence is that caused by objects such as buildings, or the differential in heating caused by surfaces such as tarmac and grass which may cause the air above them to become unstable, particularly in the summer when the sun's radiation creates a maximal difference in temperature.

Precipitation

The definition of precipitation is 'Any form of water liquid or solid, falling from the sky'. It includes rain, sleet, snow, hail and drizzle plus a few less common occurrences such as ice pellets, diamond dust and freezing rain.

It is essential to know whether or not your platform can operate safely during periods of precipitation and terminate operations if required.

Ingress Protection Rating

IP (or "Ingress Protection") ratings are defined in international standard EN 60529 (British BS EN 60529:1992, European IEC 60509:1989). They are used to define levels of sealing effectiveness of electrical enclosures against intrusion from foreign bodies (tools, dirt etc) and moisture.

First Digit (intrusion protection)

0. (or X - see section below): No special protection. Not rated (or no rating supplied) for protection against ingress of this type.
1. Protection from a large part of the body such as a hand (but no protection from deliberate access); from solid objects greater than 50mm in diameter.
2. Protection against fingers or other object not greater than 80mm in length and 12mm in diameter (accidental finger contact).
3. Protection from entry by tools, wires etc., with a diameter of 2.5 mm or more.
4. Protection against solid objects larger than 1mm (wires, nails, screws, larger insects and other potentially invasive small objects such as tools/small etc.).
5. Partial protection against dust that may harm equipment.
6. Totally dust tight. Full protection against dust and other particulates, including a vacuum seal, tested against continuous airflow.

Second Digit (moisture protection)

0. (or X - see section below): No protection.
1. Protection against vertically falling droplets, such as condensation. ensuring that no damage or interrupted functioning of components will be incurred when an item is upright.
2. Protection against water droplets deflected up to 15° from vertical
3. Protected against spray up to 60° from vertical.
4. Protected against water splashes from all directions. Tested for a minimum of 10 minutes with an oscillating spray (limited ingress permitted with no harmful effects).
5. Protection against low-pressure jets (6.3 mm) of directed water from any angle (limited ingress permitted with no harmful effects).
6. Protection against direct high-pressure jets.
7. Protection against full immersion for up to 30 minutes at depths between 15 cm and 1 metre (limited ingress permitted with no harmful effects).
8. Protection against extended immersion under higher pressure (i.e. greater depths). Precise parameters of this test will be set and advertised by the manufacturer and may include additional factors such as temperature fluctuations and flow rates, depending on equipment type.
9. (K): Protection against high-pressure, high-temperature jet sprays, wash-downs or steam-cleaning procedures - this rating is most often seen in specific road vehicle applications (standard ISO 20653:2013 Road Vehicles - Degrees of protection).

Some Unmanned Aircraft on the market today are rated IP 43 which means:

- The aircraft is protected against solid objects larger than 1mm (wires, nails, screws, larger insects and other potentially invasive small objects such as tools/small etc.), and the aircraft is protected against spray up to 60° from vertical.

Having an IP 43 rating does not mean that the aircraft is waterproof and you should limit the aircraft exposure to the rain.

Temperature & Density Altitude

As height and/or temperature increase the density of the air decreases. It can be described as the altitude that the aircraft 'thinks' that it is at.

The reduction in air density will result in a decrease in lift, so to achieve the same amount of lift we must increase the velocity of the air over the aerofoil. In most rotorcraft to achieve this same level of lift we must spin the propellers faster, which in turn reduces our thrust margin. The reverse is true as we descend and/or as the air gets much colder.

With a reduced thrust margin our aircraft has to work harder to maintain lift, this leads to shorter flight times and reduced stability.

It is recommended that a flight test is conducted at the operating altitude, prior to conducting commercial operations to ensure the viability and performance of the aerial platform/payload.

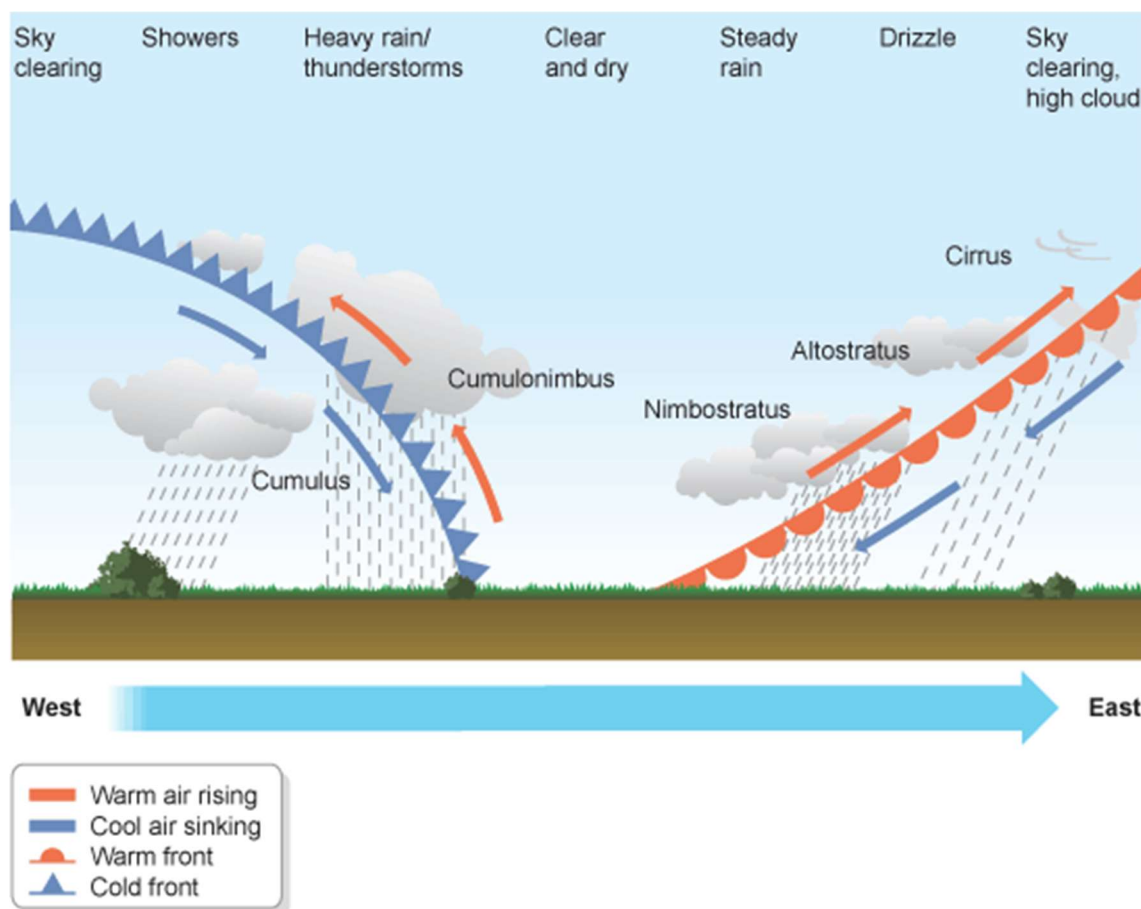
Icing

The outside air temperature doesn't need to be below 0°C for icing to occur on the lift generating surfaces of your Unmanned Aircraft.

Icing can be a severe hazard. Research has shown that ice will accumulate on the body, wing, and propeller of drones in icing conditions. The ice is disturbing the aerodynamics which leads to a significant decrease in performance. There are many cases where icing conditions have led to drone crashes. This is why it is a best practice to not fly drones in bad weather conditions

Weather Fronts

Weather fronts are the main 'driver' of weather change in the United Kingdom. They are usually described as warm or cold fronts and there is often a defined pattern to the weather they bring as outlined below:



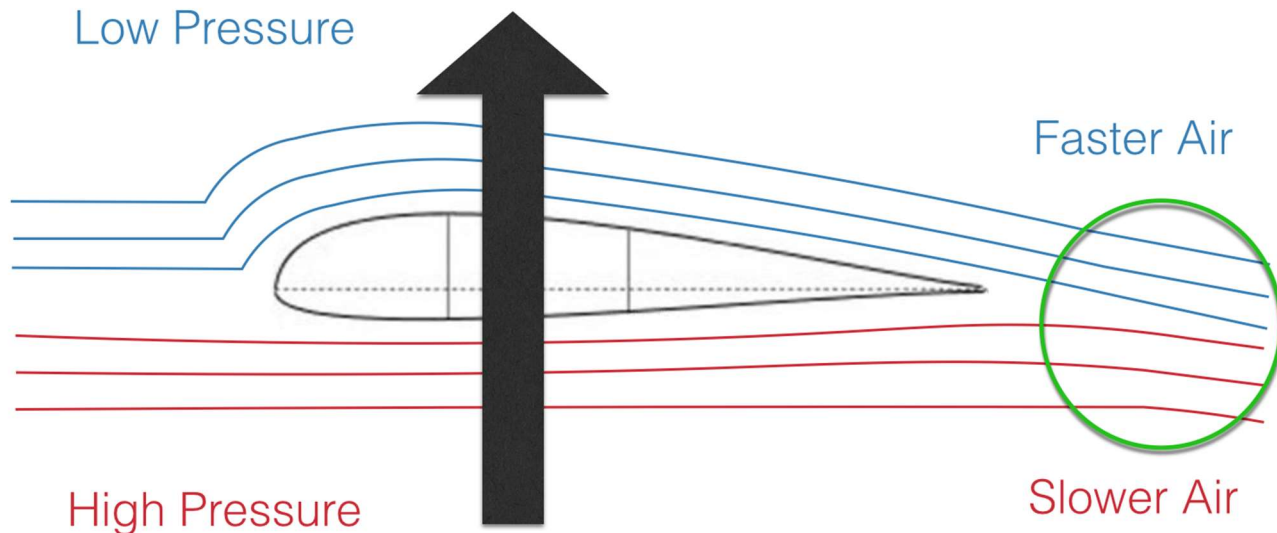
UAS Flight Performance

Principles of Flight

UAS can be either rotary (single or multi-rotor) or fixed wing aircraft. This chapter of the Aide Memoire covers the basic principles of flight for both types of platforms

Lift

Lift is the name given to the force that acts on an aerofoil section to help offset and overcome the weight of an aircraft. It is generated by the differential in pressure created by the different speeds at which air flows over the surfaces of the object.



The recognized equation which is used to determine the amount of lift generated is shown below:

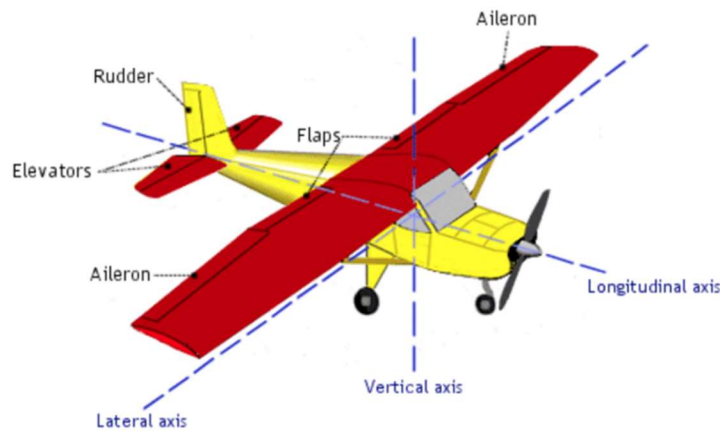
$$\text{Lift} = C_L \times \frac{1}{2}\rho v^2 S$$

- C_L or 'Coefficient of Lift' = The Angle of Attack, Camber and flow of the aerofoil
- $\frac{1}{2}\rho$ or 'rho' = $\frac{1}{2}$ of the density of the air through which the aerofoil is moving
- v^2 = The 'square' of the speed at which the aerofoil is moving through the air
- s = The surface area of the aerofoil

By altering any of these parameters, the total amount of lift generated can be increased or decreased. For example, increasing the speed at which the aerofoil moves through the air will increase the amount of lift generated, as ' v^2 ' will be increased. Conversely, if we decrease the surface area of the wing ' S ', less lift would be generated if all other parameters remain the same.

Fixed-wing

The basic control surfaces utilized by a fixed wing aircraft are shown in the diagram below:



Ailerons are used in pairs to control the aircraft in roll (or movement around the aircraft's longitudinal axis), which normally results in a change in flight path due to the tilting of the lift vector. Movement around this axis is called 'rolling' or 'banking'.

Elevators are flight control surfaces, usually at the rear of an aircraft, which control the aircraft's pitch, and therefore the angle of attack and the lift of the wing.

The rudder is a primary flight control surface which controls rotation about the vertical axis of an aircraft. This movement is referred to as "yaw"

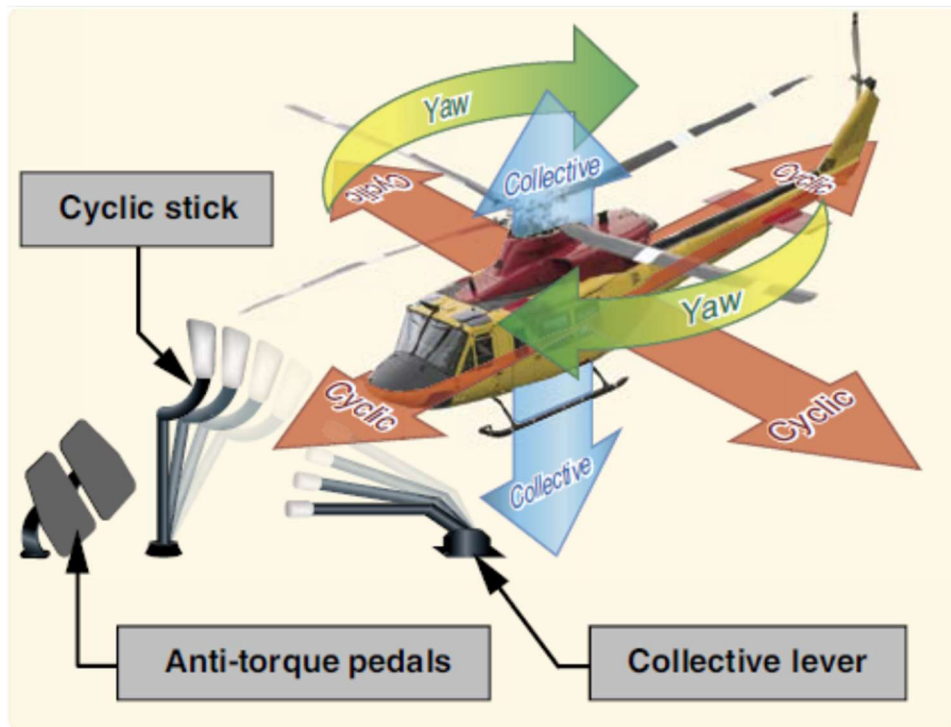
Flaps help to alter the amount of lift generated by a fixed wing aircraft by altering both the surface area of the wing and increasing the camber. Lowering the flaps will increase lift, allowing the aircraft to travel more slowly but generate a sufficient amount of lift to remain airborne; which is ideal for take-off and landing. However, once up to 'normal' flying speed, flaps are usually retracted as they generate a large amount of drag.

Helicopter

Helicopters use a combination of controls to effect their movement.

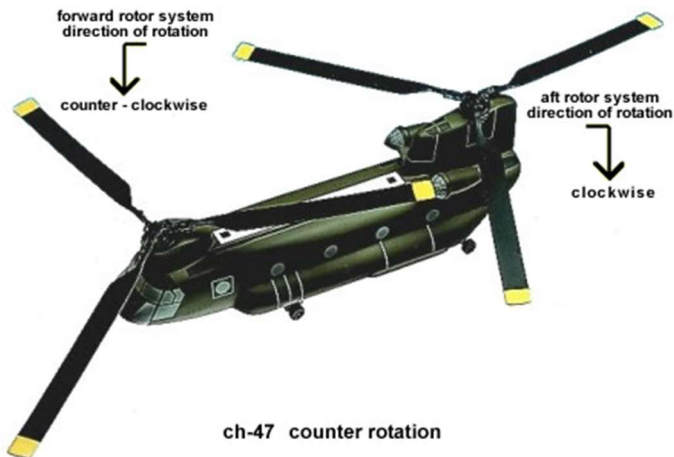
The main rotor head has both cyclic and collective inputs which alter the path along which the 'rotor disc' flies.

The tail-rotor is used to produce an anti-torque reaction which counters the torque generated by the main rotor blades turning. Increasing or decreasing this anti-torque force allows the aircraft to be yawed by the pilot as required.



Multi-rotor

The majority of multi-rotor aircraft have fixed pitch blades and they alter the speed at which the blades rotate to vary the amount of lift generated by each propeller 'disc'. They work very similarly to full sized multi-rotor helicopters, such as the Chinook in that they use contra-rotating rotors which spin in opposite directions in order to offset any torque reaction generated by the blades themselves turning. This means they do not require a tail rotor and directional control in the 'Yaw' plane can be achieved by altering the amount of torque each propeller disc generates.



The Chinook has two rotor discs which rotate in opposite directions, eliminating the requirement for a tail rotor. By altering the pitch and thus the amount of torque travelling through each disc, the aircraft can be 'yawed' much like a conventional helicopter with a tail rotor.

Multi-rotor aircraft operate using the same contra-rotating principle.

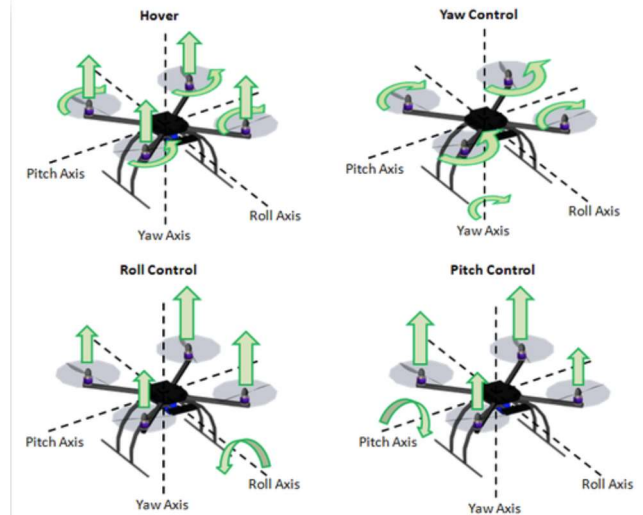
Quadcopters vary the speed of opposite motors to alter the total amount of torque affecting the aircraft. This generates a 'turn' or 'yaw' in the required direction. A similar process occurs in aircraft with more motors, although the algorithms used by the Flight Controller to effect the same movement, balance and lift across more rotor discs are much more complex.



To turn, climb or descend a multi-rotor, the Flight Controller alters the speed at which each motor turns, in order to create the output which the pilot has requested. This is often a complicated combination of yaw, pitch and roll. However, a combination of the basic principles of operation shown below allow most manoeuvres to be performed simply and efficiently.

Multi-rotor control axes and basic control diagram

- *Height* – All four motors change speed
- *Pitch* – Front & Rear pairs of motors
- *Roll* – Left & Right pairs of motors
- *Yaw* – Diagonal pairs of motors
- *GPS* – Actively holds position by combining all controls



Hybrid

Hybrid aircraft use a combination of both fixed-wing and multi-rotor aircraft control surfaces.

Generally, hybrid aircraft will use multi-rotor controls for vertical take-off and landing and to hover the aircraft. Once the aircraft is in full forward motion the aircraft will switch to fixed-wing controls.

The benefits are hybrid unmanned aircraft are that you can take-off and land in a smaller area (when compared to fixed-wing that need a larger take-off and landing area) and, they are more energy efficient when in forward motion when compared to only multi-rotor aircraft.

Command and Control

Although there are several frequency spectrums which are reserved for Command and Control of 'Model' aircraft, including UAS, there are 2 frequency bands which are utilized by the majority of modern UAS Command and Control (C2) Systems; 2.4Ghz and 5.8Ghz.

2.4Ghz is utilized by many systems which include a live video downlink. The maximum legal power output in the UK on 2.4Ghz without a license is 100mW. 2.4Ghz systems have good range and are less prone to C2 Signal break-up/interference when operating in or around obstructions. It is sometimes difficult to get a clear 2.4Ghz signal in congested areas as it is in the same frequency band as household 'Wi-Fi' Router Systems.

5.8Ghz is utilized by many dual-control systems for the inter-link between controller units. It is also used in some C2 systems as it allows a larger amount of data to be sent to the ground-station. It is often used in combination with 2.4Ghz.

Where a 2.4Ghz C2 system will send the control data to the aircraft and a 5.8Ghz C2 system will relay the live video-feed back to the user. 5.8Ghz C2 systems are less prone to interference from other users however the signal degrades very quickly when used in and around objects such as trees or foliage.

The maximum legal power output for a 5.8Ghz system in the UK without a license is 25mW.

Flight Controller Modes

Nearly all flight controllers have basic sensors such as Gyro (Gyroscopes) and Acc (Accelerometer) [AKA the IMU] as well as more advanced sensors such as Barometer (barometric pressure sensors) and magnetometer (compass).

The FC is also a hub for other peripherals such as GPS.

The job of an IMU sensor is to measure the aircraft's movement and orientation. The Barometer is used for altitude hold and GPS can be used to fix the position of the aircraft in the sky.

GPS Mode

This mode maintains the multirotor position both laterally and vertically and is ideal for learning to operate the craft. This mode is very forgiving because it allows you to manoeuvre the aircraft, but when the sticks are released the new position is maintained. For this mode to function properly, it is imperative that the GPS receiver acquired the requisite number of satellites before take-off. Because of this, GPS mode will usually require a start-up sequence that can take longer than that of other modes.

If you lose your 3D position sensor while in flight, for example if you fly under a bridge and lose your GPS, or you fly too high and lose your Vision Positioning system, then all your UA is left with are its Basic Sensors, and it will automatically switch to Attitude Mode.

Attitude (non GPS) Mode

Most advanced flight controllers have barometric sensors that enable them to detect subtle changes in atmospheric pressure. Selecting this mode helps the aircraft maintain the desired altitude, but there may be some fluctuations during windy and gusty conditions. As a result, the aircraft will drift a little in the direction of the wind, but it will maintain the altitude. Increasing or decreasing the throttle stick may still perform changes in altitude. When the stick is returned to centre, however, the multirotor will hold the desired altitude.

Manual Mode

This is primarily used when you want maximum control for manoeuvring. This is the mode preferred by aerobatic pilots and First-Person View racers. Some basic flight controllers only operate in this mode. If the aircraft is pitched forward in this mode, it will move forward. With the stick is centred, the attitude is stabilised, and the aircraft will return to level, although it will continue to drift a little. Throttle control is also manual, and what input on the transmitter will be translated directly to the throttle output.

Return-to-home

Flight controllers with GPS have several advanced safety features that can be of great benefit under certain conditions. If the multirotor is flown beyond a safe distance or orientation is lost, you can initiate a return-to-home and auto land the aircraft back at its point of departure. Assigning a switch on the transmitter that initiates a return-to-home (and/or land) is a highly recommended safety feature for all multirotor operators

These same flight controllers can be programmed to return to home if certain hazardous conditions are encountered. For example, if the radio link is lost or the transmitter loses power, the flight controller automatically enters the return to home mode. Other conditions, such as low voltage, can also be programmed to initiate this feature.

It is important to know that failsafe modes will only function properly if an adequate GPS signal is obtained prior to take-off.

Maximum Take-off Mass

The maximum take-off mass (MTOM) of an aircraft is a value defined by the aircraft manufacturer. It is the maximum mass at which the aircraft is certified for take-off due to structural or other limits. The mass is a fixed value and does not vary with changes in temperature and altitude.

Centre of Gravity (CoG)

When the centre of gravity of an aircraft—in this case an unmanned aerial vehicle—is outside the acceptable range, the aircraft may not be able to sustain flight, or it may be impossible to maintain the aircraft in level flight. The fore-aft centre of gravity affects longitudinal stability of the aircraft. With a forward centre of gravity, although the stability of the aircraft increases, the elevator control is reduced, and it is difficult to raise the nose of the aircraft.

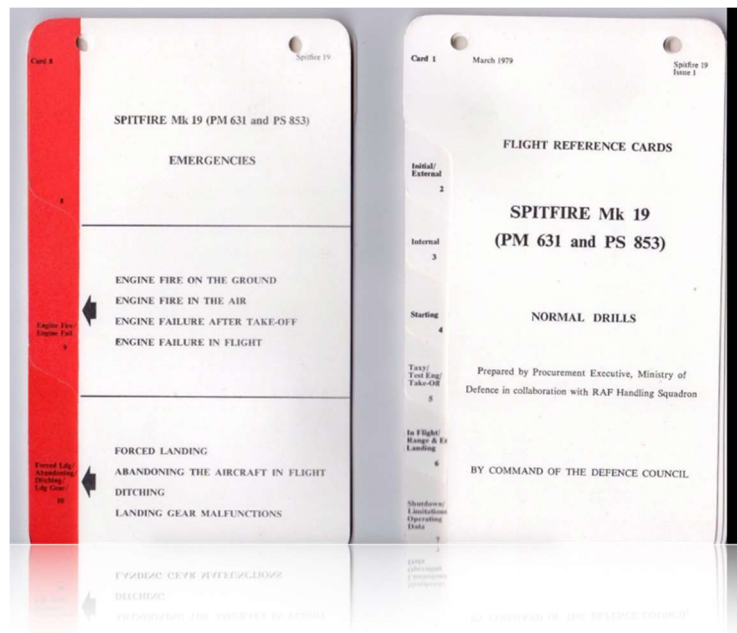
Due to the problems caused by changes in the centre of gravity due to differing payloads, sophisticated calculations are made by the manufacturers to ensure a stable flight.

Flight Reference Cards

Flight Reference Cards (FRCs) contains technical information about your drone and checklists that you should follow before, during, and after any flights. Your FRC should also include your emergency procedures, detailing what steps you will take in different emergency situations.

FRCs are used in manned aviation and professional aircrew use them to ensure no steps are forgotten.

We have provided an example of some checklists that you can use to create your own FRC within the 'Flight Planning and Operating Procedures' chapter.



Emergencies

Emergency procedures should be detailed as part of your Operations Manual. Any potential scenarios that may occur should be detailed with what steps will be followed to ensure the safest outcome possible. These scenarios can then be grouped into sections to make it easier for you to keep track of.

The following stages should be included with actions the RP and crew will take:

Potential Incident Title & Symptom(s) – For the title, name the scenario that may be encountered and detail what may be included in the specific scenario.

Pilot Response – Include immediate action required by the pilot to reduce risk to a point that's ALARP. Structure points with the highest to the lowest priority.

Crew Response – Detail the immediate action of the crew to reduce the risk to the lowest point possible. As above, structure points from highest to lowest importance.

Post Incident Action – Detail the requirements following the incident, again with a high to low priority. This will usually include the statement "Follow the incident reporting tool."

Types of emergencies you should consider are:

- Loss of Control link
- Aircraft incursion
- Public incursion
- Battery failure
- Fire
- Motor/Prop failure
- Operator incapacitation
- GPS interference

Maintenance

You should maintain your aircraft regularly, whether that is a manufacturers requirement or one that you set for yourself. As part of your pre-flight checks, you should ensure that your aircraft is airworthy by checking items such as the props, battery, body of the aircraft, motors, and the payload. If you find anything damaged or loose and you can't replace and/or repair on-site, then you should not fly that aircraft.

As mentioned, the aircraft may come with manufacturers maintenance recommendation such as an official service every 50 hours flight time.

You should check your manufacturer's instructions for any recommendations.

Lithium Polymer Batteries

The increase in the use of remote systems over recent years has largely been attributed to technology advancements in batteries. The Lithium Polymer battery, LiPo, provides a large amount of power for a low pack weight, and can be made in a variety of shapes. There are however some disadvantages.

LiPo's are still fairly expensive, they are volatile and as such require unique and proper care.

Smart vs Standard

The main difference between intelligent smart and “dumb” LiPo batteries is that intelligent batteries have an IBS (intelligent battery sensor) PCB board. This allows users to get more information from their battery.

Below are several potential features of smart intelligent batteries

- Battery Level Display: the LED indicators display the current battery.
- Auto-Discharging Function: To prevent swelling, the battery automatically discharges a safe limit when it is idle for more than a set number of days.
- Balanced Charging: Automatically balances the voltage of each battery cell.
- Overcharge Protection: Charging automatically stops when the battery is fully charged.
- Temperature Detection: The battery will only charge when between the optimal temperatures.
- Over Current Protection: The battery stops charging when there is a high amperage.
- Over Discharge Protection: To prevent over-discharge damage, discharging can automatically stop.
- Short Circuit Protection: Automatically cuts the power supply when a short circuit is.
- Battery Error History: Browse the battery error history.
- Communication: Information pertaining to the battery's voltage, capacity, current, etc. is transmitted to the aircraft's controller.

Specifications

Most LiPo batteries will have a series of information that shows you more about the battery such as the capacity, voltage, how many cells are in their configuration.

If a LiPo battery read 2200mAh 11.1v 25C 3S1P this means

- 2200 mAh = Capacity
- 11.1v = Voltage
- 25C = Discharge rate
- 3S1P = Cell configuration, in this case there are 3 cells wired up in series making 1 battery in parallel

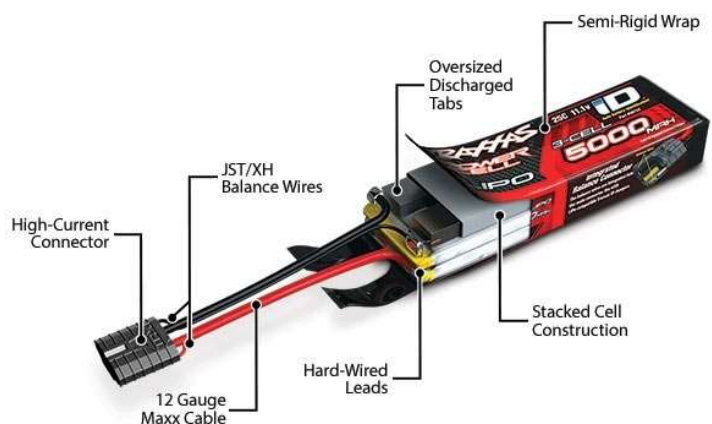
Construction

All LiPo batteries have a basic similar construction regardless of whether they are ‘dumb’ or ‘smart’.

All LiPo batters contain cells which are sired up in series to make a battery in parallel. The voltage from each cell add up to make one battery with a greater combined voltage but the same capacity of each of the cells.

You may find on some ‘dumb’ batteries that the connectors don't always match up to what is on your aircraft. We generally would not recommend using an adapter and to source a battery that has the right connector.

You need to observe the polarity and so to make sure the positive and the negative terminals are the right way around.



LiPo Charging

Over charging and over discharging are the biggest killers of LiPo's.

To get the maximum life from your battery it should be charged at 1-2 C using a balance tap/ balance charger if using a 'dumb' battery. Never discharge a LiPo below 20% unless you are disposing of the battery.

Never leave a charging battery unattended!!

LiPo Safety

LiPo's should be handled with care and inspected for damage before and after every use. Do not expose them to high temperatures as they become unstable, when they are subjected to cold temperatures the ion transfer is inefficient, so they will not last as long. When in use the battery should feel warm to the touch but not hot.

LiPo Usage & Storage

Lithium polymer batteries should ideally be stored at 40% charge. They should be stored in a cool dry place away from high temperatures, flammable objects and away from areas where they can be damaged.

It is recommended that LiPo's are stored in a metal ammo container and when charging it is recommended that they are enclosed in a LiPo bag with the cables protruding.

UAS Airspace Operating Principles

Collision Avoidance

We use the 'See and Avoid' principle with regards to collision avoidance and this is with respect to manned aircraft and other air users, therefore it is always vital to maintain VLOS with your aircraft.

The difficult thing to bear in mind with UAS is without checking your remote controller, you can never accurately judge distance, height and the speed of your aircraft or even other aircraft in the sky. If you ask 10 pilots how high a plane in the sky is, they will each give you 10 different answers.

The recommendation is to keep your aircraft as close to you as you can and to limit the height at which you fly the aircraft. You need to be aware that other aircraft such as emergency services and military may be below 500ft which means they are operating within the same piece of airspace as you with an UAS.

Stress & Pressure

Go/No Go Decisions

As the RP, it will be your decision whether you should fly the UAS or not. This will be determined by several factors such as your health, weather, aircraft airworthiness etc.

These Go/No go decisions that you make are there for the safety of you and other people. Below are a few examples of Go/No go decisions.

- **Sickness** – If you are feeling unwell, you may be unfit to fly your UAS. Some medication can also affect your judgement and capability.
- **Aircraft function** – Is your aircraft airworthy? Have you checked your aircraft over for damage? If you cannot repair or replace items on site, you may be forced to post-pone your flight. You should never fly if your aircraft safety is compromised.
- **Unexpected hazards** – If after you have arrived on site there is an unexpected hazard that can't be mitigated, you may be forced to post-pone or even cancel the flight if no safety measures can be put in place to make the flight safe.
- **Weather** – You should always keep a close eye on the weather. Even on the day of your flight, the weather can change dramatically at short notice, even if the forecast was suitable when you last checked.
- **Lack of planning** – If you get a 'last minute' job that you don't have time to plan for (e.g. checking to see if it's within an FRZ) then you may have to delay the flight until a suitable risk assessment can be conducted.
- **Pressure** – You should never feel pressured to do anything you are not comfortable doing with your aircraft. Clients can sometimes insist on you go above and beyond what you are legally allowed to do. If you feel under pressure to do a flight that you are uncomfortable doing, then stop and do not fly.

Incident reporting

CAP 382 The Mandatory Occurrence Reporting Scheme

It is mandatory to report any incident which may be classed as a Serious Accident or Incident. Such events are defined as:

- Any injury to 3rd parties.
- Significant Damage to Property.

In deciding whether or not to report an occurrence it must be decided whether the event meets the definition as specified in the ANO.

A reportable occurrence in relation to an aircraft means: **Any incident which endangers or which, if not corrected, would endanger an aircraft, its occupants or any other person.**

Formal reporting should also be considered if there is an opportunity for others to learn and possibly prevent or avoid an incident occurring in the future, even if the incident itself does not dictate a Mandatory Occurrence Report. CAA CAP 382 & the ECCAIRS system detail the incident reporting schemes and processes that may be used if required.

Airprox Reporting

If at any time, any person either directly or indirectly involved with flight operations, believes that there was a risk to life from a potential collision between a UAS and a real aircraft, the incident should be filed using the processes detailed at: <http://www.airproxboard.org.uk>.

It is advisable to gather as many details as possible at the time of the incident such as operating location, time, type of aircraft, specific markings, approximate height, approximate speed, direction of movement etc in order to allow the Airprox board to conduct a thorough investigation and publish their findings.

Congested Area Operations

Congested areas now have a clear definition that is any areas that are used for residential, commercial, industrial, or recreational use.

Examples of this could be, not but limited to:

- Hamlets, Villages, Towns and Cities
- Industrial Parks
- Retails Parks
- Public Parks

Planning & Preparation

When operating within congested area you need to make sure you do appropriate planning and preparation before you can fly. You should use all of the tools available to you to ensure that you can operate your drone safely and legally.

- Position – You will want to know where you are flying
 - Use a postcode or consider a more modern method such as what3words for a 3m x 3m position
 - Plan out your flight path and make sure that you can maintain your separation from uninvolved people
- FRZ – check to see if you are within a Flight Restriction Zone. If you are, you'll need to get permission to fly there and possibly even unlock your aircraft because of geo-awareness restrictions.
 - You can check to see if you are within an FRZ by visiting www.dronesafetymap.com
- Use flight planning software – not essential but a useful tool!
 - You can use drone flight planning software to help check airspace for FRZ and other restrictions that may be in place.
- Weather – You should always check the weather conditions and monitor it closely to make sure the conditions are OK for you to fly. Check your aircraft user manual for windspeed limitations!

Emergency Services

You should always note down the nearest (local) emergency services numbers and address details as part of your planning.

These should include:

- Accident & Emergency
- Police
- Fire
- Air Traffic Control

Equipment

We would recommend that you invest in good safety equipment for your flight operations, and it may be worth considering keeping these together in a 'flight box' for convenience.

Items you could consider having with you are:

- High-viz vests/jacket
- Fire extinguisher (dry power or CO2)
- Fire blanket
- Cordon/Control
 - Cones
 - Tape
- Land pad/matt
- First Aid Kit
- Accident book
- Anemometer
- Camping table
- Trolley

Overflight of people, crowds, and gatherings

We would always recommend that, unless absolutely necessary, to avoid overflight of people, regardless of whether they are involved or uninvolved with the flight. If it is necessary for the flight to be over involved people, then you should limit the time doing so.

Below are a few things you should consider when required to overfly people, however, please remember that you cannot fly over crowds and gatherings within the A2 Subcategory of the Open Category.

- **Briefing** – you sufficiently briefed everyone you can and made them aware of the risks and how to react in the event of an emergency.
- **Aircraft** – is the aircraft you intend to fly safe and fit for purpose.
- **Risk Mitigations** – ensure you do a generic and on-site risk assessment and always assume that the aircraft could fall from the sky at any point. Have you made the risks as low as reasonably practicable?
- **Control** – keep the flight as simple as possible. Always keep the aircraft within VLOS and avoid disorientation. The last thing you want is to hit a building because you do not know which way the aircraft is facing.
- **Escape** – do you have a 'ditch' zone and safety buffer should the worst happen, and you need to land your aircraft in an emergency.

Hazard Identification

As you build up your airmanship you will become more attuned to hazard identification when planning for your flights and when you are operating on the ground.

Several things to consider when looking into hazard identification are:

- **Weather** – Weather plays a critical role in hazard identification. Not only could it be too windy or too wet to fly your aircraft if it is too sunny it could be a hazard to yourself! How are you going to protect yourself from prolonged sun exposure?
- **Roads** – If you are flying close to roads you need identify if your flight could be a hazard. If it is a busy road and your aircraft came down would it land on the road and potentially cause an accident? If so, it's probably best to maintain a required separation and not overfly.
- **People** – How are you going to potentially get uninvolved people under your control? If you can't you're going have to make sure you maintain your separation distance from uninvolved people. You might want to consider how you will deal with a member of the public approaching you whilst your drone is in the sky. You don't want to leave the aircraft hovering unattended.
- **Vehicles** - Vehicles do not have to be just cars and other motor vehicles, this could be other aircraft such as the emergency services. How will you react if an aircraft enters your airspace?
- **Overhanging cables** – When you are operating in congested areas there's likely to be overhanging cables for telephones. You need to be aware of these and identify where they are.

- **Access/Escape** – How are you going to access or even escape a site if something goes wrong? You need to make sure that you can protect yourself and your crew and to make sure they know how to safely come and go.
- **Airspace** – You need to be aware of what airspace you are in. If you are near military bases it may be that there are low flying aircraft (remember military aircraft can be lower than 400ft anywhere in the UK!).

Medical Fitness

Substances

It should come as no surprise to the Remote Pilot that their performance will be affected by alcohol, medication, or illicit drugs.

The current law does not prescribe a blood/alcohol limit; however, you must always bear in mind Article 241.

Article 241 - A person must not recklessly or negligently cause or permit an aircraft to endanger any person or property

Alcohol

Alcohol acts as a depressant on the central nervous system, dulling the senses and increasing mental and physical reaction times. It is known that even a small amount of alcohol leads to a decline in an individual's performance and may cause his judgement (i.e. ability to gauge his performance) to be hindered.

Alcohol is removed from the blood at a fixed rate and this cannot be speeded up in any way (e.g. by drinking strong coffee). In fact, sleeping after drinking alcohol can slow down the removal process, as the body's metabolic systems are slower.

Alcohol has similar effects to tranquillisers and sleeping tablets and may remain circulating in the blood for a considerable time, especially if taken with food. It may be borne in mind that a person may not be 'fit' to fly even 8 hours after drinking large amounts of alcohol. Special note should be taken of the fact that combinations of alcohol and sleeping tablets, or anti-histamines, can form a highly dangerous and even lethal combination.

As a general rule, RPs should not operate UA for at least eight hours after drinking even small quantities of alcohol and increase this time if more has been drunk.

The affects of alcohol can be made considerably worse if the individual is fatigued, ill or using medication.

There is a risk that these effects can be amplified if an individual has a particular sensitivity to the medication or one of its ingredients. Hence, an RP should be particularly careful when taking a medicine for the first time, and should ask their doctor whether any prescribed drug will affect their work performance. It is also wise with any medication to take the first dose at least 24 hours before any operation to ensure that it does not have any adverse effects.

Medication

Any medication, no matter how common, can possibly have direct effects or side effects that may impair an RPs performance.

Medication can be regarded as any over-the-counter or prescribed drug used for therapeutic purposes.

- **Analgesics** are used for pain relief and to counter the symptoms of colds and 'flu. In the UK, paracetamol, aspirin and ibuprofen are the most common, and are generally considered safe if used as directed. They can be taken alone but are often used as an ingredient of a 'cold relief' medicine. It is always worth bearing in mind that the pain or discomfort that you are attempting to treat with an analgesic (e.g. headache, sore throat, etc.) may be the symptom of some underlying illness that needs proper medical attention.
- **Antibiotics** (such as Penicillin and the various mycins and cyclines) may have short term or delayed effects which affect work performance. Their use indicates that a fairly severe infection may well be present and apart from the effects of these substances themselves, the side-effects of the infection will almost always render an individual unfit for work.
- **Anti-histamines** are used widely in 'cold cures' and in the treatment of allergies (e.g. hayfever). Most of this group of medicines tend to make the user feel drowsy, meaning that the use of medicines containing anti-histamines is likely to be unadvisable when working as an RP.
- **Cough suppressants** are generally safe in normal use, but if an over-the-counter product contains anti-histamine, decongestant, etc., the RP should exercise caution about its use when working.
- **Decongestants** (i.e. treatments for nasal congestion) may contain chemicals such as pseudo-ephedrine hydrochloride (e.g. 'Sudafed') and phenylphrine. Side-effects reported, are anxiety, tremor, rapid pulse and headache.
- **'Pep' pills** are used to maintain wakefulness. They often contain caffeine, dexedrine or benzedrine. Their use is often habit forming. Over-dosage may cause headaches, dizziness and mental disturbances. Generally, if coffee is insufficient, you are not fit for work.
- **Sleeping tablets** (often anti-histamine based) tend to slow reaction times and generally dull the senses. The duration of effect is variable from person to person. Individuals should obtain expert medical advice before taking them.

Fatigue

Fatigue can be either physiological or subjective. Physiological fatigue reflects the body's need for replenishment and restoration. It is tied in with factors such as recent physical activity, current health, consumption of alcohol, and with circadian rhythms. It can only be satisfied by rest and eventually, a period of sleep. Subjective fatigue is an individual's perception of how sleepy they feel. This is not only affected by when they last slept and how good the sleep was but other factors, such as degree of motivation.

Fatigue is typically caused by delayed sleep, sleep loss, desynchronisation of normal circadian rhythms and concentrated periods of physical or mental stress or exertion. In the workplace, working long hours, working during normal sleep hours and working on rotating shift schedules all produce fatigue to some extent.

Symptoms of fatigue (in no particular order) may include:

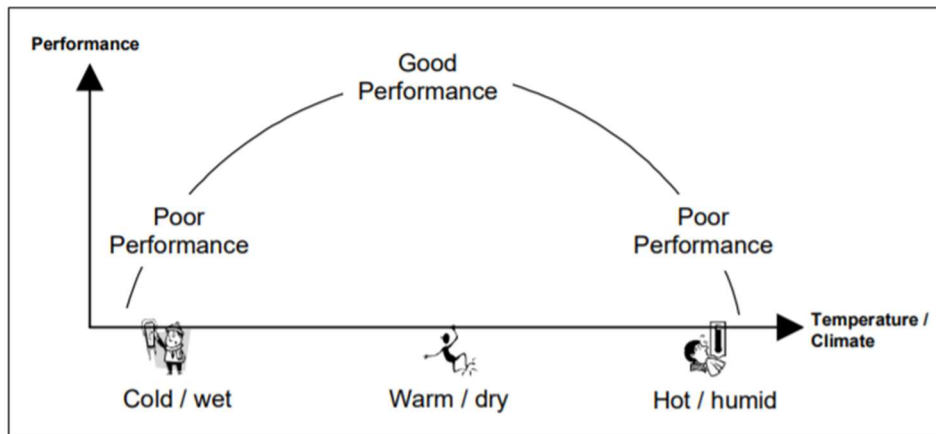
- diminished perception (vision, hearing, etc.) and a general lack of awareness;
- diminished motor skills and slow reactions;
- problems with short-term memory;
- channeled concentration - fixation on a single possibly unimportant issue, to the neglect of others and failing to maintain an overview;
- being easily distracted by unimportant matters;

- poor judgement and decision making leading to increased mistakes;
- abnormal moods - erratic changes in mood, depressed, periodically elated and energetic;
- diminished standards of own work

Outdoor & Lone Working

Effects of weather

Humans can work within quite a wide range of temperatures and climatic conditions, but performance is adversely affected at extremes of these. Thus, as can be seen in the image below, when it is either too cold and/or wet or too hot and/or humid, performance diminishes.



UA Remote Pilots routinely work outdoors. Clearly, exposure to the widest range of temperature and climate is likely to be encountered outdoors. Here, an RP may have to work in direct summer sun, damp conditions, high humidity, or in the depths of winter.

Environmental conditions can affect physical performance. For example, cold conditions make numb fingers, reducing the RPs ability to operate the controller, and working in even mildly windy conditions can be distracting, especially if having to work at height. Extreme environmental conditions may also be fatiguing, both physically and mentally.

Perception

Perception involves the organisation and interpretation of sensory data in order to make it meaningful, discarding non-relevant data, i.e. transforming data into information. Perception is a highly sophisticated mechanism and requires existing knowledge and experience to know what data to keep and what to discard, and how to associate the data in a meaningful manner.

Perception can be defined as the process of assembling sensations into a useable mental representation of the world. Perception creates faces, melodies, works of art, illusions, etc. out of the raw material of sensation.

Examples of the perceptual process:

- the image formed on the retina is inverted and two dimensional, yet we see the world the right way up and in three dimensions;
- if the head is turned, the eyes detect a constantly changing pattern of images, yet we perceive things around us to have a set location, rather than move chaotically.

Decision Process

Having recognised coherent information from the stimuli reaching our senses, a course of action has to be decided upon. In other words, decision making occurs.

Decision making is the generation of alternative courses of action based on available information, knowledge, prior experience, expectation, context, goals, etc. and selecting one preferred option. It is also described as thinking, problem solving and judgement.

This may range from deciding to do nothing, to deciding to act immediately in a very specific manner. A fire alarm bell, for instance, may trigger a well-trained sequence of actions without further thought (i.e. evacuate); alternatively, an unfamiliar siren may require further information to be gathered before an appropriate course of action can be initiated.

We are not usually fully aware of the processes and information which we use to make a decision. Tools can be used to assist the process of making a decision. For instance, for an UA, FRCs are available to supplement the basic decision-making skills of the individual.

Thus, good decisions are based on knowledge supplemented by written information and procedures, analysis of observed symptoms, performance indications, etc. It can be dangerous to believe that existing knowledge and prior experience will always be sufficient in every situation.

Evaluating Distance from People

We are always required to maintain separation distances from uninvolved people. When your aircraft is airborne it can be difficult to evaluate the distance from people.

There is an error called 'parallax' which is a displacement in the apparent position of an object when viewed along two different lines of sight. In other words, an object can 'appear' to be in one place when it is in another.

We would recommend that you use planning software to 'map out' your flight path and use visual clues on the ground to help you judge the distance from objects and other people. For example, you could use the planning software to measure out how far an object is away from where you will be stood as the RP, you'll then know if the aircraft is above that object, you are X metres away.

It's worth visually inspecting the flight path of your drone before you fly it to ensure that if you maintain the planned flight path, you'll have your correct separation distance.

Low-Speed Mode

Some unmanned aircraft have a low-speed mode.

When this mode is activated, the aircraft system may act in a number of different ways, depending on drone model and manufacturer. In some aircraft, more sensors are activated, and in other aircraft movement is softened for a finer and more controlled flight. In some cases, the only difference is the lower speed.

If you are going to fly drones in subcategory A2, it is important that you learn how to handle the low-speed mode of your aircraft properly and that you understand that the low-speed mode works differently in different aircraft.

Since you are allowed to fly as close to people as five metres with this mode activated, you pose a great risk, which must be compensated for by good skills.

You set the low-speed mode's maximum speed via the controller transmitter. Any speed below 6.7 mph (3 m/s) is allowed. But remember, even though you get to fly close to people, you are never allowed to fly over the crowds or assemblies of people!

The 1:1 Rule

The '1:1 rule' is offered as a simple 'rule of thumb' (as opposed to an exact rule in law) which can be used to quickly work out what separation from uninvolved persons is safe enough in the short term.

It is based on the relationship between the unmanned aircraft's height and its distance from the uninvolved person (the 1:1 line) and works as follows:

The 1:1 rule is a short-term separation measure for dealing with unexpected issues.

If the aircraft is above the 1:1 line (i.e. closer to the person than its height), then it must be moved further away quickly, or its height reduced, until below the 1:1 line. If the aircraft is below the 1:1 line, then the remote pilot can continue to monitor the situation until the person has vacated the operating area.



Flight Planning and Operating Procedures

In this chapter, you will find out how to plan and perform a safe flight with your unmanned aircraft. For this reason, it is a good idea to learn certain routines to avoid making mistakes. As the remote pilot, you have specific obligations before, during and after the flight. Also, you need to know where to find information about things that may affect your flight

Responsibilities

Before your flight within the A2 subcategory of the open category, make sure that you have your A2 Certificate of Competency (A2 CofC), then carry it with you throughout the flight.

You get your A2 CofC when you have passed the theoretical examination with UAVHUB.

The certificate is valid for five years from the date of issue. Before every new flight you have to get an overview of the surroundings where you are going to fly. Are there any obstacles or people? What do the area and the airspace look like? Are there any restrictions or is it free to fly? You will have to check all of the above before your flight and be aware of it during the flight.

Your aircraft should be airworthy

Something that may seem obvious, but is crucial for the prevention of accidents, is to ensure that the unmanned aircraft is airworthy. It is your responsibility as the Remote Pilot to ensure that the unmanned aircraft is safe to fly before every flight.

Be Observant

During the flight you must make sure that the drone is in your line of sight. Be observant of the area you are flying in, so that you do not collide with other aerial vehicles, both manned and unmanned. Remember that you have to give way to manned aircraft. It's likely that they won't see you on their flight path.

Do not put anybody in danger

If you and your drone in any way pose any risks or danger to people, animals or the environment, you must immediately abort the flight in the most secure and controlled way possible.

Be well rested and fit to fly

It is important that you are well rested and do not suffer from any medical condition that may affect your control of the flight. You should not fly if you are under the influence of alcohol or other psychoactive substances.

Read the user manual

Always use the unmanned aircraft system according to the manufacturer's user manual.

Pre-flight Checks

Mission briefing

Go through the planned route of your unmanned aircraft with all participants.

Make sure that the start area is free of obstacles and people and that there is information available that flying will take place. The remote pilot should ideally wear a safety vest and if possible, place a sign with information about the flight.

If you are working as a team, it is important that you clarify each person's role before start. Next to the remote pilot, for example, it may be good to have an observer who is paying extra attention to the surroundings. The observer can help the remote pilot detect hazards and ensure that no one is in the area – but also answer questions from passers-by, take phone calls etc. so that the remote pilot is not disturbed.

Check your airspace

If you have no local knowledge, you must check in advance what the area looks like on a map or satellite imagery.

You should check to see if any NOTAMs are in place and whether your flight path will take you within a Flight Restriction Zone or any other Restricted Areas. If the flight is to take place in an FRZ, you must get permission from Air traffic control. You can either call the Air traffic control directly or email your request in advance with attached map, coordinates, flight radius, altitude, times and phone numbers where you can be reached throughout the flight.

A good rule of thumb is to avoid areas where people sometimes gather, such as parks, recreational areas and areas where sports competitions or other events are organised.

Don't fly without permission over people who are not related to your flight, remember, those are uninvolved people.

Check your aircraft

Before you start, it is important to ensure that your entire unmanned aircraft system has the correct settings and that both hardware and software work properly.

First and foremost, you need to check the battery levels – both transmitters and aircraft should be fully charged before each new flight.

Make sure that there are no frequency interferences that could affect the video and receiver, and that memory card and photo and video equipment are in place and functioning properly.

If a compass calibration is needed, make sure this is done.

Start the controller transmitter first, and then the aircraft. (If you do the opposite, the RTH function might in rare cases be activated, if the aircraft cannot communicate with the controller transmitter.)

Finally, you can start any other equipment. Once the aircraft is switched on, it is time to start the camera and make sure all camera settings are correct: stills camera, video, FPS (frames per second), colour system etc.

Are all controls in neutral position? If the answer is yes, you are ready to fly.

It is important that the aircraft and all equipment are checked carefully before each start. It might be a good idea to appoint a technically responsible person if several users fly the same aircraft.

Aircraft Sensors

Some Unmanned Aircraft have sensors such as IR sensors to help with its positioning and to avoid collisions. The sensors can be disturbed by reflections from shiny surfaces, such as water, glass or mosaic. This may result in the aircraft losing control of its own position and height, which, in turn, may result in a crash. If you are going to fly over lakes, sea areas, ponds or other water accumulations, you should turn off the sensors located on the underside of the drone.

Take-off position

Be careful when you choose the location for take-off and landing, so that both can be performed safely. The surface should be even, there must be plenty of space, and the place must be located far from obstacles and people. Surfaces with gravel should be avoided to avoid debris being blown up into the propellers. If this is not possible – use a launch pad. Check out and select alternative landing areas in case you have to make an emergency landing.

Check the weather

Before you start, check temperature, wind, fog and cloudiness, and keep in mind that if the temperature falls below the freezing point, this may have a negative effect on the batteries.

In temperatures below the freezing point, you will need detailed knowledge of the batteries, make sure you are familiar with how your batteries are affected. Also, make sure you keep them heated before start. At freezing temperatures and humid air, ice may build up on the propellers, dramatically increasing the risk for crash. Keep in mind that wind speed often increases with altitude

In-Flight Checks

Starting the Flight

If you are flying a multirotor drone you should, first of all, check it while it is in the air at low altitude. Do this by lifting it around five metres above the ground and then let it hover in that position. Listen for unusual sounds and check that the steering is responding normally and that the battery levels are adequate.

Finally, make sure the GPS is working properly.

Whilst Flying

As the remote pilot, it is important that you keep your fingers on the controller transmitter at all times. Also, make sure that the controller transmitter's aerials are pointed correctly to the drone for the best reception capability. This is especially important for long distance flights.

Never fly more than 120 metres above the closest point on the surface of the earth and always keep your drone in sight.

You must also be aware of the area under and around the drone at all times.

Try to rise to optimum height to reduce risks and noise, and avoid flying over animals, electrical lines and buildings.

In most cases, you are not allowed to fly over people.

You must not interfere with ongoing activities or emergency operations, unless you have been granted permission from the emergency services.

Immediately land the drone if a helicopter or other low flying aircraft approaches the area.

If people or animals move toward the area, fly away from them to a safe place and wait until all is clear. If this is not possible – abort the flight and land the drone.

Emergencies

Emergencies can occur when you least expect it, and therefore you must be prepared. Emergencies may be the result of errors in the aircraft's system or construction, but they may also be caused by natural forces. Below are some examples of what might happen.

Compass interferences

The compass function may be disrupted in areas with high electronic interference, for example where there are electrical wires, aerials or larger metal objects.

Land the aircraft and recalibrate the compass. If you still find that you are getting compass interference, the safest option is to not fly the aircraft within that area,

Engine malfunction

Different aircraft have different numbers of engines, and therefore react differently during an engine malfunction. It is more likely that a smaller aircraft with fewer engines, such as quadcopters crash if one engine fails, whilst aircraft with many engines (six or more) might be able to continue flying, and land safely.

A fixed wing aircraft can use its wings to land smoother without engines in case of a failure.

Some types of unmanned aircraft have an auto rotation function that is activated in case of an engine failure. This means that the aircraft will start to rotate instead of falling straight down to the ground – and thus land more softly. It

also gives you and others in the area more time to seek protection from the falling aircraft. So find out how your drone works and what it can handle.

Icing

Icing is the build-up of ice on the propellers. If this happens, the propellers will not create the lift necessary for a safe flight, which may, in the worst-case scenario, result in a crash. Some aircraft have safety functions that are activated in icing conditions. The aircraft will then auto-land. It is not possible to control the aircraft's vertical speed during an auto landing, but you can control its flight path to avoid obstacles.

Loss of C2 link

Contact between the control transmitter and the aircraft can be lost. If RTH is activated, it is important that you have set a safe height for an automatic return to home position.

In addition, it is important that you have the settings for RTH and start position that are best suited for the specific occasion. For example, if the drone is flying over water while you are in a moving boat, it may be advisable not to let the drone fly back to its start position, which would mean it will land in the water. In this case, a better idea would be to have the drone follow the control transmitter. This is done by placing out new home positions during the flight. A good idea is to include this in a checklist before the flight, so that you are always prepared for what happens if the RTH is activated.

Bird Collision

Not only is it important to be attentive to other aircraft in the airspace, but also to birds. Birds are often curious, sometimes even aggressive, disturbing the flight and posing an actual hazard. If you are flying over water, you should also keep in mind that birds like to fly low, close to the surface of the water. If your aircraft is surrounded by curious or aggressive birds, you should consider landing and aborting the flight.

Post-Flight Checks

You can land both automatically and manually. A common way is to activate RTH and let the drone fly back automatically to the starting position or the control transmitter and then land automatically – or to choose to take over and land manually.

You must check if there are any obstacles or risks in the landing area. Once you have done this, land the aircraft at a safe distance from any obstacles and people. If you land with a fixed wing drone, a larger area without trees and other obstacle is required.

After landing

When you have landed and switched off the power of the aircraft and other equipment, you should – if you have flown in an FRZ – inform any air traffic control tower that the flight has been completed. You should also fill in a logbook or in some other way ensure that the flight has been registered. If accidents or crash have occurred during the flight, you must report them to the CAA via the ECCAIRS portal.

Check the aircraft

Carry out an ocular inspection to look for damage and abnormal wear and tear on and around the fuselage, cables and propellers. All loose parts, such as screws, brackets and joints, must be securely fastened.

If you spin the propellers, they should not make much of a sound. A crunching noise may indicate dirt in the engine's ball bearings. If the propellers are damaged in any way, they must be replaced.

Batteries

The batteries require careful maintenance. After each landing, remove them and charge them as soon as possible. The batteries should then be stored in a dark, cool and safe place on a fireproof surface, ideally within a LiPo safe bag. If you don't recharge the batteries so that they have a chance to discharge into "store mode", but instead leave them stored with too low charge (below 10 percent), they can take permanent damage and be dangerous to fly with.

Checklists

Make a practice of going through checklists both before and after flight to make sure things go as smoothly and safely as possible. The lists look different, but you can customise them to your unmanned aircraft and combine them into FRCs. Below we have provided examples of what they can look like.

Ocular inspection

1. Are there any cracks in the fuselage or slack in the joints around the folding arms etcetera?
2. Does any unusual sound come from the propellers if you spin them with your fingers? A crunching noise may indicate dirt in the engine's ball bearings and should not be ignored.
3. Are screws, brackets, joints or fasteners loose or damaged? Replace if necessary.
4. Are the propellers damaged in any way, such as cracks? Never fly with damaged propellers.
5. Are there any loose or damaged cables?
6. Are there any loose or damaged connections?
7. Are the propeller brackets, screws and propeller locks tight? Make sure they are.

Compass calibration

You should always follow the manufacturer's instructions for compass calibration in the drone's manual. If you don't have the access to the manual and you need to calibrate the compass you can follow the generic instructions below:

1. Remove watches and other metal objects from your clothing and body.
2. Turn on the controller transmitter.
3. Place the drone outdoors on a metal-free surface. Switch the power on.
4. Wait until at least six satellites are visible in the app or on the controller transmitter's display.
5. Start calibration in the app (if applicable) or via the controller transmitter.
6. Put the controller transmitter aside, stand behind the drone with the camera facing away from you, then lift the drone and hold it with straight arms.
7. Make a complete clockwise rotation in about 5–7 seconds.
8. "Tip" the drone forward so that the camera points straight down towards the ground. Complete a new rotation at the same pace as before.
9. Put the drone down and ensure that the calibration is completed.

Preparation before start

1. Are the controller transmitter and aircraft batteries fully charged?
2. Are there any frequency interferences that affect video and receiver?
3. Is a compass calibration needed?
4. Are the photo and video equipment mounted correctly?
5. Is the take-off position secured?
6. Are there any airspace restrictions?
7. Start the controller transmitter first, then the aircraft and at last any other equipment.
8. Start the camera system (if applicable).
9. Are all control sticks in neutral position?
10. Does the direct remote identification system work properly?
11. Take-off!

During flight

1. Keep your fingers on the controller transmitter at all times.
2. Don't fly higher than 120 metres above the ground and keep the aircraft within your visual line of sight.
3. Rise to optimal height to reduce risks and noise.
4. Avoid flying over people, animals, electrical wiring and buildings.
5. Don't disturb ongoing rescue operations.
6. Immediately land the drone if a helicopter or other low flying aircraft is approaching.

Landing

1. Check the landing area for obstacles or any other hazards.
2. Land the drone at a safe distance from obstacles and people.
3. Switch the aircraft off.

After flight

1. If needed, inform the air traffic control tower that you have completed the flight.
2. Switch off the camera and any other equipment.
3. Carry out an ocular examination: look for damage and abnormal wear and tear.
4. Remove the batteries, recharge them (if required) and store them in a safe place.

Useful Websites

Topic	Website
CAP 382	https://www.caa.co.uk/cap382
Air Navigation Order	https://www.caa.co.uk/uk-regulations/aviation-safety/civil-aviation-act-1982-the-ano-2016-the-rules-of-the-air-2015-and-the-dg-regulations-2002/the-civil-aviation-air-navigation-order-2016/
CAP 722	https://www.caa.co.uk/cap722
UAS Implementing Regulation 2019/947	https://caa.co.uk/cap1789a
Drone Safety Map	https://www.dronesafetymap.com/
Aviation Weather	http://www.checkwx.com
Low Flying System Info	http://www.gov.uk/military-low-flying
Navigation Conversions	http://www.gridreferencefinder.com
Airprox Reporting	http://www.airproxboard.org.uk
NATS NSF	https://nsf.nats.aero/
what3words	https://what3words.co.uk
UAVHUB Blog	https://blog.uavhub.com
UAVHUB Resource Library	https://courses.uavhub.com
Mr MPW YouTube	https://www.youtube.com/mrmpw
National trust Land ownership map	https://www.nationaltrust.org.uk/features/follow-the-history-of-our-places-with-land-map
Crown Estate Map	https://thecrownestate.maps.arcgis.com/
MAGIC Map	https://magic.defra.gov.uk/
Airfield Cards	http://www.airfieldcards.com/
ECCAIRS reporting link	https://aviationreporting.eu/