DUTCH DRONE ACADEMY
ONLINE COURSE
OPEN CATEGORY A1 / A3

MAY 2022

https://www.dutchdroneacademy.com

Welcome
Thank you for choosing an online training of Dutch Drone Academy !

The aviation industry is a highly complex industry. The Unmanned Aircraft (UA or drone) sector as a newcomer in the aviation world has important economic and social relevance, expected to greatly increase in the future. Like in manned aviation, a number of institutions are major actors within this sector. The International Civil Aviation Organization (ICAO) is a specialised agency within the United Nations (UN), which sets standards and recommended practices for the aviation industry. This body will also set standards for the drone industry.

The European Aviation Safety Agency (EASA) is an agency of the European Union which helps the EU to develop laws and regulations for safe and efficient aviation. To ensure the free circulation of drones and a level playing field within the European Union, EASA has developed common European rules. These regulations have been introduced in July 2019 and are in effect as of the 31st December 2020.

To pilot a drone with a mass of 250 g or more you will need to have a licence. Under the EASA regulations there are three main categories, ascending in risk profile. These are: A. OPEN category; B. SPECIFIC category; C. CERTIFIED category. This book contains all the information you need to pass the theory exam for the EASA OPEN category.

NOTE

The legislator has determined that we have to monitor the candidates progress before entering the exam. Therefore the exam will only become available when you have finished reading all chapters and done the practice questions.

Preface | Abroad | Course guide | START! | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Exam

The introduction and implementation of the new European drone rules differ in some areas per country. Familiarise yourself with the drone rules for the appropriate country. Information can be found using this link.

Your certificate is valid in the following European countries:

Austria	Finland	Latvia	Portugal
Belgium	France	Liechtenstein	Romania
Bulgaria	Germany	Lithuania	Slovakia
Croatia	Greece	Luxembourg	Slovenia
Cyprus	Hungary	Netherlands	Spain
Czech Republic	Iceland	Malta	Sweden
Denmark	Ireland	Norway	Switzerland
Estonia	Italy	Poland	United Kingdom*

In this course there is information that is required for the exam (everything in normal text, photos and illustrations), extra information that we find is useful or helpful to know (in blue), and information relevant to the local regulations in The Netherlands (in orange). Here three examples:

This text is required for the exam.

> Extra information
>
> This information is useful or helpful to know.

> The Netherlands
>
> This information is important if you fly in The Netherlands.

This course is for the EASA Open Category A1/A3 exam and certificate and is completely online. Pass the exam to apply for your certificate!

Proof of completion of the online training.

Support

IMPORTANT: throughout the course you will find references to websites or other sources of useful information that, although not required, are very useful to know. Here you will see (support), this can be found at www.dutchdroneacademy.com/support, and is always kept up to date.

Keep in mind that if you buy a new drone, or decide to start operating differently than before, that there is a good chance that you will need a different certificate. You can always check this via www.dronewijzer.nl.

We hope you enjoy this course, success and many safe flights!

Heart-felt greetings,
Team Dutch Drone Academy

Questions regarding this course can be asked via openA1A3@dutchdroneacademy.com. We do our best to respond within 48 hours. Thank you for choosing us!

There are many rules, regulations and laws which cover unmanned aircraft operations. Some are specific to drone operations while others refer to manned aviation law. The whole regulatory framework is quite complex and sometimes confusing, but you need to study it to know exactly when, where and how to operate a drone safely.

After you have read the chapter, we invite you to answer a number of practice questions.

Practice questions

Aviation regulations and airspace restrictions

Table of contents

1.1. Introduction

There are many rules, regulations and laws which cover unmanned aircraft operations. Some are specific to drone operations while others refer to manned aviation law. All the rules together are quite complex and sometimes confusing. However, you have to study them so that you know exactly when, where and how you can use a drone safely.

If you fly a drone as a hobby, then the drone pilot is also the drone operator. For professional operations, where a drone pilot is hired by the business which is undertaking the job, the business is the drone operator, and the person flying the drone is the pilot. Officially they are known as the Remote Pilot (Dutch: piloot op afstand). Depending on the type of drone flight, different terms may be used for the same things. That usually relates to hobby or professional use of drones. The language is also different for a professional drone operation. However, as we explained before, the EASA regulations are the same for hobby and professional use. The term used for someone flying a drone depends on the nature and level of the flight, and the language used. All these terms are acceptable:

- drone pilot / remote pilot / drone operator

There are also other people involved with a drone flight. Working with somebody who monitors the airspace where you are flying, and the area around the take-off and landing site, makes life much easier and greatly reduces the risks. While you are focussed on your drone and the shot you want to take, important things may be happening elsewhere. For example, an approaching air ambulance helicopter, a flock of birds, or a heavy thunderstorm approaching you. That person is known as the observer.

Finally, the camera or other sensor carried by your drone may need a separate operator. This is most often the case with more expensive systems, where the camera is controlled using a second transmitter. The person controlling the camera is the camera operator. Anything which is connected to your drone, but which does not form part of the drone, is known as the 'payload'. It is usually a camera but could be something else. So, the terms to remember are:

- observer
- camera operator (cameraman/camerawoman)
- payload

To fly a drone with a mass (weight) of 250 g or more you will need to have a certificate. The EASA rules define three main categories. The differences between the categories, and the training requirements, relate to the risks associated with each category. The three main categories are:

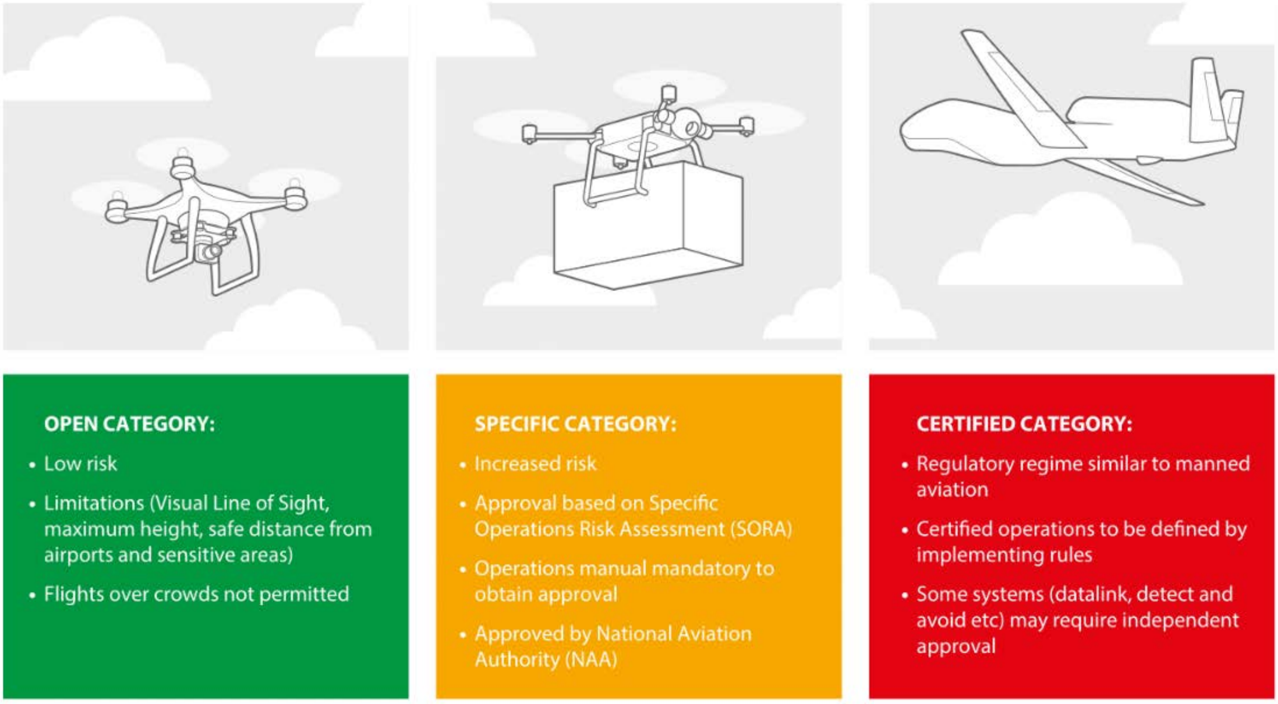


Figure 1.1 - EASA categories.

1.2. Regulations - General

There are national and international regulations about UAs and they change regularly. Different regulations often use different terms and abbreviations to describe UAs:

Table 1 - abbreviations, terms and meaning.

Abbreviation	Term
-	Drone
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System (= aircraft + ground station, etc.)
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System (= aircraft + ground station, etc.)
UAV	Unmanned Aerial Vehicle (this term is not used anymore in regulations)

In this book we mostly use “UA/UAS” because these terms are used in the European regulations.

We also occasionally use “drone”. You can find more English and Dutch terms in the Drone Dictionary (www.eda.aero/dictionary). In this book “pilot” means the person in control of a UAS during an operation. The “operator” is the entity which is certified to carry out the operation.

1.3. Organisations

International agency: ICAO

The International Civil Aviation Organization (ICAO) is the main regulatory body in general aviation, setting standards and recommended practices for the industry in the form of 19 annexes. ICAO's international standards are followed by national and supranational bodies such as EASA.

Supranational agency: EASA

Based on ICAO, EASA publishes rules that are valid within all EU Member States. All national rules of EU member states comply with these supranational rules.

Under these basic rules, all drone operators are allowed to operate, with largely the same rights and obligations, throughout EU airspace. This makes life easier for operators working in more than one country.

The Netherlands

On www.dronewijzer.nl you will find a list of all the member states of EASA. This appears after you start at dronewijzer, on the second page.

It is important to emphasize here that there are still national regulations which may vary between countries, so it will be up to the pilot or operator to ensure that they abide by these rules.

National Aviation Authority (NAA) and other national agencies

Every country has a National Aviation Authority (NAA), also called Civil Aviation Authority (CAA), which implements regulations based on the standards set by ICAO, or EASA in the case of countries within the EU.

Inspectie Leefomgeving en Transport
Ministerie van Infrastructuur en Waterstaat

The Netherlands

The main agency relevant to UAS pilots in the Netherlands is the Human Environment and Transport Inspectorate (ILT, Inspectie Leefomgeving en Transport), an important division of the Ministry of Infrastructure and Water Management (Ministerie van Infrastructuur en Waterstaat). Their main task is to monitor the aviation sector and ensure that all airspace activities are conducted in accordance with the rules. ILT also publishes information related to aviation regulations, and their website (support) contains a lot of useful information. It is a good idea to check it regularly to see if there are any changes in the regulations.

LVNL

The Netherlands

Air Traffic Control the Netherlands (LVNL, Luchtverkeersleiding Nederland) controls civil airspace in the Netherlands. LVNL monitors the location of aircraft in their assigned airspace by radar and communicates with the pilots via radio to prevent collisions. LVNL supplies information and other support for pilots. LVNL publishes aeronautical charts (maps) and important notices (NOTAMS), and has a website (support) with aeronautical information (AIS the Netherlands).

Extra information

The Belgian Civil Aviation Authority (BCAA) is part of the Federal Public Service (FPS) Mobility & Transport. Their air navigation service provider, Skeyes, provides aeronautical information and weather briefings. The Belgian Civil Drone Council was established in 2019 by the directorate general aviation and air traffic control (Skeyes), to promote cooperation and experience within the Belgian drone sector.

The German air navigation service provider (Deutschen Flugsicherung, DFS) controls civil airspace in Germany. Their Aeronautical Information Management division produces and publishes the AIP and aeronautical charts for Germany and Europe. Their Control Centre division operates the largest radar control centre in Europe, located in Langen.

Extra information

This is a document which breaks down the main points of Regulations EU 2019/945 and 2019/947, and explains them. The Acceptable Means of Compliance (AMC) explains what you, the operator/pilot, need to do in order to operate legally and safely under the available categories.

Guidance material (GM) helps you understand the regulations better, and presents the different operating categories and sub-categories in a clear fashion (support).

1.4. EASA Regulations

EASA published the rules for using drones in European airspace, namely regulations EU 2019/945 and EU 2019/947. At www.dutchdroneacademy.com/support you will find links to these documents. There is no difference between hobby and professional flying. Everybody must meet requirements before using a drone. According to EASA rules, there are two ways to make drone operations safer.

1. the use of equipment built to European safety standards (CE mark).
2. a risk assessment that takes into account the risk of the operation and competence of the remote pilot.

While the regulations cover rules for all drone operations, only the details concerning the open category are explained in this publication. It is always a good idea to read the regulations documents yourself. There are many references to other articles and regulations, which can make things confusing when having to look at several documents at once, but after spending some time reading through them you will have a good understanding of their structure.

In general, aviation regulations take a long time to be developed due to the importance of safety, and the EASA rules for drones are no exception. To allow the drone sector to continue to operate while the NAAs adapt to these regulations, special conditions are usually put in place during a transitional period. These rules can be found in the EASA regulations.

1.4.1. Acceptable means of compliance

The EASA legislation includes rules for all sorts of drone flights. However, this course is limited to the details relevant to the A1/A3 Open Category, as discussed below. It is always a good idea to read the regulations yourself. This is because they contain many references to other articles and regulations. Having to look at several documents at once can be confusing. However, if you spend some time reading through them you will get a good understanding of their structure.

1.4.2. Transition period rules (until 1st January, 2024)

Extra information

The development of aviation regulations usually takes long because safety plays a large role. This also applies to the EASA regulations. Because the drone sector must continue to function while the national rules change over to European rules, a transitional period with special rules has been put in place. These rules are also covered in the EASA regulations.

Between the 1st January 2021 and the 1st January 2024 there are special conditions while the EASA regulations are implemented. This allows current UAS operators to continue operating, and new pilots to continue flying older UAs. The details of these special conditions can be found in regulation EU 2019/947 (support).

With the introduction of the new European drone rules come new classifications of drones, CE classes. The usual CE markings, required for any goods sold on the market, have been expanded to include special class marks for drones, namely C0 to C6. For operations in the Open Category, C0-C4 drones will be used. C5 and C6 will be used in the Specific Category.

The technical requirements for the classes are defined in the regulation documents. However, since this is still new there are not yet any of these drones available. It is also not possible to simply give existing drones a class mark.

In order to allow drone pilots to continue operating with their existing (legacy) drones in the Open Category, transitional period rules have been laid out. The general rules still apply for each subcategory, but with some differences:

- With a drone up to 250 g in subcategory A1
- Drones between 250 g and 500 g in A1 with an online test
- With a drone up to 2 kg in subcategory A2. An additional condition is that you must keep at least 50 m distance from people
- Drones heavier than 2 kg (but not heavier than 25 kg) fall into subcategory A3

After 1st January 2024, if you have a drone without a CE class mark, you will still be able to use it in subcategory A1 if its weight is up to 250 g and in subcategory A3 if its weight is up to 25 kg.

Table 1.4.2. - transition period - examples.

Examples			
Drone	**MTOM**	**Before 1st January, 2024**	**After 1st January, 2024**
DJI Mavic Mini 2	249 g	A1	A1
Parrot Anafi	320 g	A1	A3
DJI Mavic Air 2	570 g	A2	A3
DJI Mavic 2 Pro/Zoom	907/905 g	A2	A3
DJI Phantom 4	1380 g	A2	A3
DJI Inspire 2	4250 g	A3	A3

Table 1.4.3. - Rules during the transition period.

<table>
<tr><th>CE class mark</th><th>MTOM</th><th>Subcategory</th><th>Restrictions</th><th>Operator registration</th><th>Remote Pilot competence</th></tr>
<tr><td>None (legacy)</td><td rowspan="2">< 250 g</td><td rowspan="6">A1</td><td rowspan="2">Not above assemblies of persons **</td><td rowspan="2">Only if the drone has a camera ***</td><td rowspan="2">No certificate required, but must be familiar with the drone's user manual</td></tr>
<tr><td>C0</td></tr>
<tr><td>None (legacy)</td><td rowspan="2">Toy drones *
< 250 g</td><td rowspan="2">No minimum age</td><td rowspan="2">No</td><td rowspan="2">No certificate required</td></tr>
<tr><td>C0</td></tr>
<tr><td>None (legacy)</td><td>< 500 g</td><td rowspan="2">Not above uninvolved persons</td><td rowspan="2">Yes</td><td rowspan="2">A1/A3 certificate</td></tr>
<tr><td>C1</td><td>< 900 g</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>None (legacy)</td><td>< 2 kg</td><td rowspan="2">A2</td><td>Minimum horizontal distance of 50 metres from uninvolved persons</td><td rowspan="2">Yes</td><td rowspan="2">A2 certificate</td></tr>
<tr><td>C2</td><td>< 4 kg</td><td>Minimum horizontal distance of 30 metres from uninvolved persons, or 5 metres with low-speed mode (tripod) enabled</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>None (legacy)</td><td rowspan="3">< 25 kg</td><td rowspan="3">A3</td><td rowspan="3">Only in areas where there are no people
150 m from residential, commercial, industrial or recreational areas</td><td rowspan="3">Yes</td><td rowspan="3">A1/A3 certificate</td></tr>
<tr><td>C3</td></tr>
<tr><td>C4</td></tr>
<tr><td></td><td colspan="5">*
'Toy drones' means that it is proposed for use by children under the age of 14. Toys must comply with the Directive 2009/48/EC on the safety of toys. The compliance of a drone with that directive is declared in the corresponding EU declaration of conformity.

Directive 2009/48/EC:
This Directive shall apply to products designed or intended, whether or not exclusively, for use in play by children under 14 years of age (referred to as toys).</td></tr>
<tr><td></td><td colspan="5">**
'Assembly of persons' means gatherings where persons are unable to move away due to the density of the people present.</td></tr>
<tr><td></td><td colspan="5">***
Operators of unmanned aircraft should be registered if they operate an unmanned aircraft which is equipped with a sensor able to capture personal data. (photo camera, video camera, infrared camera, etc.).</td></tr>
</table>

1.5. Aeronautical Information Service (AIS)

Extra information

According to the Chicago Convention on International Civil Aviation, every country needs to provide an Aeronautical Information Service (AIS) to users of its airspace. The aim is to improve the safety, reliability and efficiency of international air traffic. Incorrect, outdated or misleading information could lead to incidents or accidents. Every country also needs to publish an Aeronautical Information Publication (AIP) and updates.

Air Traffic Control Services provide an Aeronautical Information Service (AIS) which usually includes:

- Aeronautical Information Publications (AIP)
- Aeronautical Information Circulars (AIC)
- Aeronautical Information Regulation and Control information (AIRAC)
- NOTAMs (Notices to Airmen)

You will need to check with the NAA relevant to you for local regulations. On the EASA website (support) is listed all the members states and their websites.

The Netherlands

In the Netherlands this is provided by LVNL. Most of this information is available on their website.

1.6. EASA Categories

EASA drone rules define three distinct risk levels:

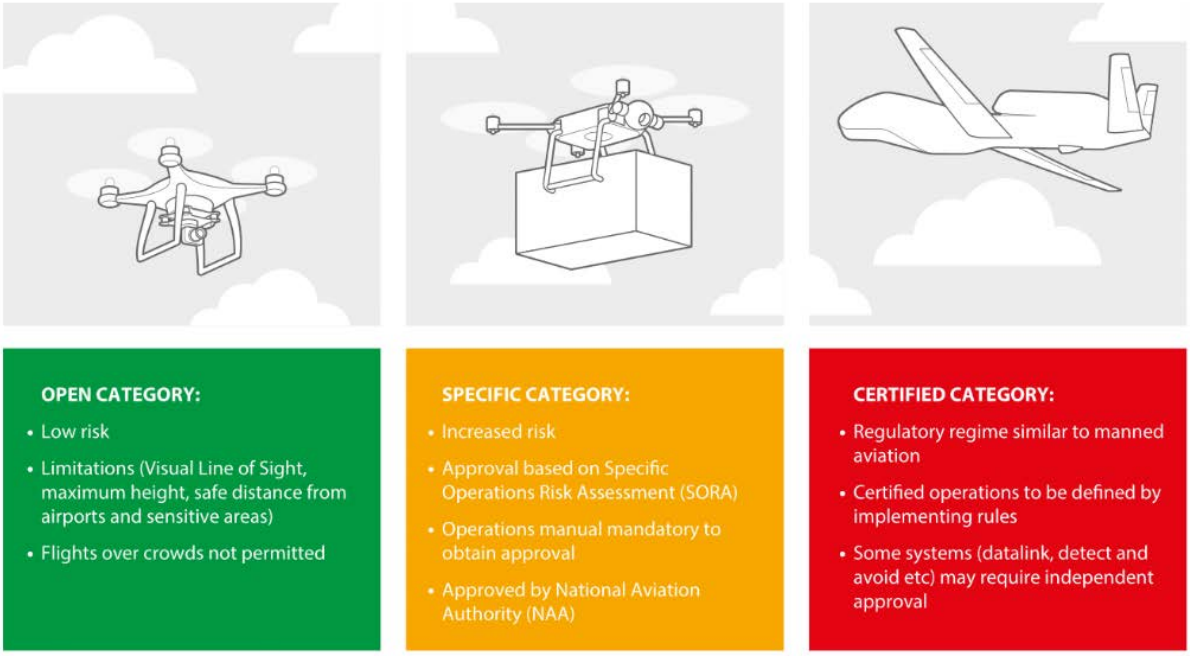


Figure 1.1 - EASA categories

1.6.1. Category A (Open)

In this Category, drones of up to 25 kg may be used for low risk operations. Operators are able to fly without prior permission under certain conditions. The drone must not exceed a height of 120 m and the pilot must keep the aircraft in visual line of sight (VLOS), away from people. This Category is further divided into 3 sub-categories:

Subcategory	UAS							Restrictions		Operator/Pilot	
	Class	MTOM	Max height	Max speed	Physical serial number, electronic ID, and geo-awareness	Physical markings		Operational restrictions	Distance from people	Operator registration required	Remote pilot competence
A1	Privately built	< 250 g	* ≤ 120 m	19 m/s (68 km/h)	NO	N/A	N/A	If a follow-me mode is active (DJI active track) maximum 50 m from pilot and 50 m height	not be conducted over open-air assembly of persons	**NO	familiarised with the UAS
	C0	< 250 g			NO	0	CE				
	C1	< 900 g			YES	1	CE			YES	online test
A2	C2	< 4 kg		None, but must be equipped with low speed mode of 3 m/s (11 km/h)	YES	2	CE		not flown over uninvolved persons; 30 m from uninvolved persons, or 5 m with low speed mode enabled		certificate of remote pilot competency- online test, additional theory test, declaration of practical self-training
A3	C2	< 4 kg						150 m from residential, commercial, industrial or recreational areas.	in an area where the remote pilot reasonably expects that no uninvolved person will be endangered		online test
	Privately built	< 25 kg		None	NO	N/A	N/A				
	C3				YES	3	CE				
	C4				NO	4	CE				

'privately built UAS' means a UAS assembled or manufactured for the builder's own use, not including UAS assembled from a set of parts placed on the market by the manufacturer as a single ready-to-assemble kit.

* When the operation involves flying the UA in close proximity (50 m) of a fixed obstacle that is taller than 105 m, the maximum height of the UAS operation may be increased up to 15 m above the height of the obstacle, for the portion of the flight in close proximity to it and at the request of the entity responsible for the obstacle. A C0 UAS must have a maximum attainable height above the take-off point limited to 120 m, therefore does no apply to this exception.

'geo-awareness' means a function that, based on the data provided by Member States, detects a potential breach of airspace limitations and alerts the remote pilots so that they can take effective immediate and action to prevent that breach.

'follow-me mode' means a mode of operation of a UAS where the unmanned aircraft constantly follows the remote pilot within a predetermined radius.

'assembly of persons' means gatherings where persons are unable to move away due to the density of the people present.

** Operators of unmanned aircraft should be registered if they operate an unmanned aircraft which is equipped with a sensor able to capture personal data.

Figure 1.2 - subcategories.

Height, distances and proximity

There are several factors affecting how you fly your drone. An important consideration is how high you are allowed to fly, how far away and how close you may fly to other people.

All drone operations must remain within 120 m of the ground. Most UAs measure height above the take-off point. Sometimes it may be important to take note of changes in elevation, such as hills or mountains, so that you can calculate the UA's height above the ground.

This height limitation can be extended by 15 m if flying within 50 m horizontally of an obstacle that is taller than 105 m, as long as you have permission from the person responsible of the obstacle.

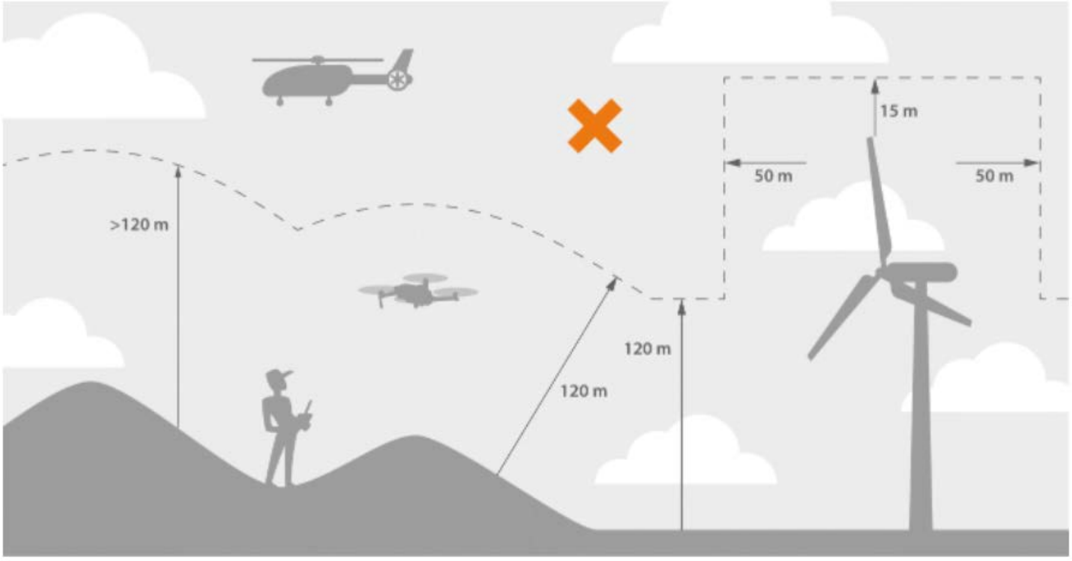


Figure 1.3 - height and distance from ground.

You are never allowed to fly above assemblies of people, which means gatherings where persons are unable to move away due to the density of the people present.

Extra information

Example
To decide if you can fly over a group of people you could ask yourself the following questions: imagine that your drone develops a problem and starts flying very unpredictably. You want to land the drone as soon as possible. You are flying over a large group of people. You, or a member of your team, have to warn these people as quickly as possible. In that case, ask yourself:

- can we warn everybody in time, can they hear us?
- can these people run away or are there barriers around the group ?

Once they have been warned they will want to run away, and also look up to see where the drone is. So, the next question is also relevant:

- can people, while looking up occasionally, run away from the centre of the group without tripping over each other?

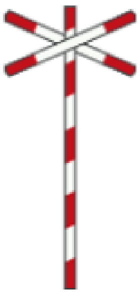
The proximity to people at which you can fly depends on the subcategory and drone class:

A1	A: With a drone weighing less than 250 g, you may overfly uninvolved persons but never overfly assemblies of people; B: With a UA marked as Class C1, you may only fly where you reasonably expect that no uninvolved person will be overflown and never overfly assemblies of people. In the event of unexpected overflight of uninvolved persons, you must reduce as much as possible the time during which the unmanned aircraft overflies those persons.
A2	Must not be flown over uninvolved persons and at a safe horizontal distance of at least 30 metres from them; you may reduce the horizontal safety distance down to a minimum of 5 metres from uninvolved persons when operating an unmanned aircraft with an active low speed mode (a function that limits the speed to 3 m/s).
A3	Must be conducted at least 150 metres from residential, commercial, industrial or recreational areas, and in an area where you reasonably expect that no uninvolved person will be endangered within the range where the drone is flown.

NOTE

These are the rules for flying with drones bearing the new CE marking (C0-C4). If your drone does not have a CE marking, then you need to follow the transition period rules.

Distance to roads and railways

BOARD/SIGN	ROAD TYPE	ROAD MARKINGS	UAS RESTRICTIONS
	Highway speed limit 130 Km/h		Minimum horizontal distance from these roads when in use: • 50 m, in subcategory A1 and A2 • 150 m, in subcategory A3
	Motorway speed limit 100 km/h		
	Road speed limit 80km/h		
 	Railway crossing without barrier Railway crossing with barrier		Minimum horizontal distance from railways: • 25 m, in subcategory A1 and A2 • 150 m, in subcategory A3

It is forbidden to operate an unmanned aircraft within a horizontal distance of 150 metres from objects or areas that are part of vital infrastructure, as shown below:

- High-voltage grid network for national or regional transport, and electrical power distribution
- Drinking water supply stations
- Surface water collection points for the preparation of drinking water

Safety risks
To help ensure safety, it is important to keep as much distance as possible between the drone and other people or objects. Just because you are allowed to fly closer, it doesn't mean that you always should.

When operating in the proximity of uninvolved people you need to be especially careful. This is because they may not be aware of the dangers involved or simply be curious and get too close to the drone. You also risk colliding with people if they move in an unexpected direction. Similarly, if you fly with a heavier drone you should keep a greater distance because it may be less manoeuvrable and poses a greater risk should something go wrong.

Conducting a survey of the operational area beforehand is a good way to gauge how close you would be able to fly safely. In particular, you should pay attention to:

a. People and public areas
b. Animals
c. Property an buildings
d. Vehicles
e. Other airspace users

Of course there may be other considerations, too. This will be up to you to determine when on site, as every operation is different!

Validity of pilot competency

In order to ensure that pilots maintain a good level of safety, you will need to renew your certificate every few years. Whether for subcategory A1/A3 or for subcategory A2, you will need to complete a theory exam. Both certificates, Certificate of completion of online training and Certificate of remote pilot competency, are valid for five years.

1.6.1. Subcategory A1

Designed for the use of small, lightweight drones, subcategory A1 offers the easiest way to operate under the EASA rules. It allows you to operate without a certificate, provided that your drone weighs less than 250 g. If you pass an exam you can operate drones under 900 g. Most consumer drones fall within this weight range, and since this poses the lowest risk it allows you to operate relatively unrestricted as long as you do it safely under the following conditions:

UAS under 250 g:

- UAS must be marked as class C0, or be privately built with a maximum speed of 19 m/s
- You may fly over uninvolved persons but never over assemblies of people
- When a follow-me mode is active, the UA is never farther than 50 m from the pilot and not higher than 50 m
- The pilot must be familiar with the UAS manufacturer's instructions in the UAS manual

UAS under 900 g:

- UAS must be marked as class C1
- not flown over assemblies of people and reasonably expect that no uninvolved person will be overflown
- The pilot must be familiar with the UAS manufacturer's instructions in the UAS manual
- The pilot must hold a certificate of completion of online training (online exam)

Certificate of completion of online training:

- Complete online training
- Pass an online exam

‘**assemblies of people**’ means gatherings where persons are unable to move away due to the density of the people present.

‘**uninvolved persons**’ means persons who are not participating in the UAS operation or who are not aware of the instructions and safety precautions given by the UAS operator. People that sit at a beach or in a park, or walk on a street or on a road, are also generally considered uninvolved persons.

‘involved persons’ have given explicit consent (it may be verbal) to the UAS operator or remote pilot to be part of the UAS operation (even indirectly as a spectator or just accepting to be overflown by the UAS).

They have received from the UAS operator or from the remote pilot clear instructions and safety precautions to follow in case the UAS exhibits any unexpected behaviour. All involved persons are expected to follow the directions and safety precautions provided by the UAS operator or the remote pilot, and the UAS operator or the remote pilot should check by asking simple questions to make sure that the directions and safety precautions have been properly understood.

1.6.1. Subcategory A2

To operate slightly heavier drones you will have to meet a few more requirements. In addition to the online exam required for A1, you will have to pass an additional theory exam aimed at further assessing your knowledge, and declaring that you have sufficient skills to pilot your drone safely (declaration of self-training).

Conditions:

- UAS must be marked as class C2
- Not flown closer than 30 m from uninvolved persons
- Flown up to 5 m from uninvolved persons if there is an active low speed mode (3 m/s) and after an evaluation of the area regarding:
    - Weather conditions
    - Performance of the UA
    - Segregation of the overflown area
- The pilot must be familiar with the UAS manufacturer’s instructions in the UAS manual
- The pilot must hold a certificate of remote pilot competency

Certificate of remote pilot competency:

- Complete online training
- Pass an online exam for A1/A3
- Declare that you have completed the self-practical training
- Pass an additional exam

1.6.1. Subcategory A3

This subcategory is left fairly flexible in that you are allowed to operate a number of different drones, including self-built, as long as they are less than 25 kg. The limitation here is that you can only fly outside of congested areas where no people are expected to get in the way.

Conditions:

- Be conducted in an area where you reasonably expect that no uninvolved person will be endangered
- Be conducted at a safe horizontal distance of at least 150 metres from residential, commercial, industrial or recreational areas
- The pilot must be familiar with the UAS manufacturer's instructions in the UAS manual
- Be performed with UA that:
  - Is privately built less than 25 kg
  - Is marked as class C2, C3, or C4
- The pilot must hold a certificate of completion of online training (online exam)

1.6.2. Category B (Specific)

Extra information

Category B (Specific) covers higher risk operations which all require authorisation from the NAA. For example flying outside VLOS or in controlled airspace, drone operators must perform a risk appraisal in accordance with the Specific Operations Risk Assessment (SORA), or an alternative accepted by the National Aviation Authority. Standard scenarios will become available for the implementation of common types of drone flights within this category. Operators of larger drones can also ensure certification via the Light UAS Operator Certificate (LUC).

In the higher category, BVLOS operations are permitted. Unlike VLOS flights, which are operated within the pilot's line of sight, BVLOS flights are flown beyond visual line of sight. BVLOS capabilities enable a drone to cover far greater distances. To carry out this type of operation, a UTM system is needed.

Unmanned Aircraft System Traffic Management (UTM) is a separate "traffic management" ecosystem for UAS operations. UTM is also complementary to the Air Traffic Management (ATM) system.

1.6.3. Category C (Certified)

Extra information

Category C (Certified) is the highest-risk category, like manned aviation. High risk operations like flying above crowds or delivery drone operations or even drone taxis for transporting people. In this category, the requirements for people, machine and organisation are of the same level as in manned aviation. All operations that do not fall under category A or B will be under this category.

1.7. UAS classes

All UAs used within the open category, except privately built UAS, must be classified as one of 5 Classes. Each Class, C0-C4, has different requirements and limitations, and must include a user manual and an information notice published by EASA providing applicable limitations and obligations under EU law.

All drone classes also need to be certified to be safe to use on the European market (CE mark) and must include a declaration of conformity. This is not an issue for most of the larger drone manufacturers as they usually already have their products certified with all the required documentation readily available. But it should be a consideration when looking into buying a new drone.

Class	Maximum weight (MTOM)	Flight control system	Max speed	Physical serial number, electronic ID, and geo-awareness	Physical markings	
C0	< 250 g	maximum height set to 120 m	19 m/s (68 km/h)	NO	0	CE, including declaration of conformity
C1	< 900 g	*maximum height selectable by the pilot		YES	1	
C2	< 4 kg		None, but must be equipped with low speed mode of 3 m/s (11 km/h)	YES	2	
C3	< 25 kg		None	YES	3	
C4		no automatic flight modes		NO	4	

*this is the limitation of the drone itself, but you should still ensure that you do not exceed to maximum allowed height according to your certification

Figure 1.4 - UAS classes.

After 1 January 2024, UAs without CE markings may continue to operate in the Open Category under the following conditions:

- in subcategory A1, provided that the UA has a maximum take-off mass of less than 250 g, including its payload
- in subcategory A3, provided that the UA has a maximum take-off mass of less than 25 kg, including its fuel and payload.

1.7.1. Privately built

Those operating within the open category are allowed to operate with privately built drones, provided that they comply with the limitations of the appropriate subcategory and are only used by the builder. As long as the UAS is not placed on the market, it does not need to be class rated or CE certified.

Extra information

‘privately built UAS’ means a UAS assembled or manufactured for the builder's own use, not including UAS assembled from a set of parts placed on the market by the manufacturer as a single ready-to-assemble kit.

1.8. UAS pilots and operators

Under EASA when flying a UA you are considered as an Operator. Whether you run a large operation with several UAs or a single pilot with just one UA you need to know your responsibilities.

In most cases, when flying in the open category, you will take the role of both the operator and pilot and have their responsibilities.

1.8.1. Registration

In most cases you are required to register yourself as an Operator when flying a UA. The procedure may differ per country, but according to EASA this must include the following:

- Full name and the date of birth
- Address
- Email address and telephone number
- Insurance policy number
- the confirmation by legal persons of the following statement: 'All personnel directly involved in the operations are competent to perform their tasks, and the UAS will be operated only by remote pilots with the appropriate level of competency'

> The Netherlands
>
> In the Netherlands, the RDW handles the registration of UAS operators. They are also responsible for issuing A1/A3 and A2 permits for the Open Category. Upon a successful completion of this course, you will need to apply for your permit at the RDW, using the unique RDW-url we send you.

1.8.2. Responsibilities of the operator

The operator must comply with the following:

- Develop procedures for their operations
- Ensure the correct use of radio equipment
- Designate a pilot for each flight
- Ensure that their pilots hold the required certificates and that they are valid
- Update no-fly zones in the UAS
- Ensure that the UAS has the correct CE markings and certificates
- Ensure in the case of an UAS operation in subcategory A2 or A3, that all involved persons present in the area of the operation have been informed of the risks and have explicitly agreed to participate.

1.8.3. Responsibilities of the remote pilot

The whole operation, from start to finish, is controlled by the Remote Pilot (RP). In most cases, the RP operates the ground station and flies the UA. In some cases the RP gives instructions to another crew member who operates the ground station. The RP also gives instructions to the payload operator and the observer(s).

Before flight:

- Have the appropriate competency certificate
- Check for any additional information on no-fly zones relative to the operation
- Check the surroundings for obstacles
- Check the surroundings for uninvolved persons
- Ensure that the UAS is in a condition to safely complete the intended flight, and if applicable, check if the direct remote identification is active and up-to-date
- If fitted with an additional payload, ensure that the MTOM is not exceeded

During flight:

- Not fly under the influence of psychoactive substances or alcohol, or be unfit to perform tasks due to injury, fatigue, medication, sickness or other causes
- Keep the UA in Visual Line Of Sight (VLOS), and land immediately if the UA poses a risk to other aircraft, people, animals, environment or property
- Comply with any airspace or no-fly zone restrictions
- Always be in control of the UA
- Operate the UAS in accordance with manufacturer's instructions
- Comply with the operator's procedures when available
- When operating at night, ensure that a green flashing light on the UA is activated
- During the entire flight, the drone must be controlled with the same controller

During the flight, remote pilots and UAS operators shall not fly close to or inside areas where an emergency response effort is ongoing unless they have permission to do so from the responsible emergency response services.

For the purposes of VLOS, remote pilots may be assisted by an observer. In such case, clear and effective communication shall be established between the remote pilot and the unmanned aircraft observer.

1.8.4. Visual Line Of Sight (VLOS) range

The maximum distance of the UA from the remote pilot should depend on the size of the UA and on the environmental characteristics of the area (such as the visibility, presence of tall obstacles, etc.).

The pilot should keep the UA at a distance such that they are always able to clearly see it and evaluate the distance of the UA from other obstacles. If the operation takes place in an area where there are no obstacles and the remote pilot has unobstructed visibility up to the horizon, the UA can be flown up to a distance such that the UA remain clearly visible. If there are obstacles, the distance should be reduced such that the remote pilot is able to evaluate the relative distance of the UA from that obstacle. Moreover, the UA should be kept low enough so that it is essentially 'shielded' by the obstacle, since manned aircraft normally fly higher than obstacles.

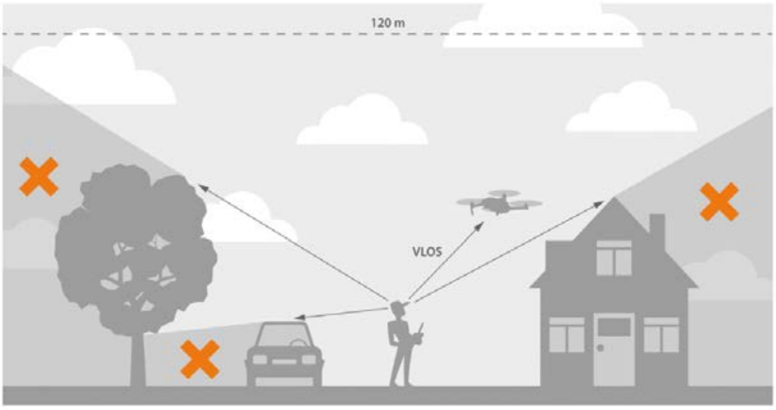


Figure 1.5 - Visual Line Of Sight (VLOS).

1.8.5. Discontinuation of flight

It is up to the pilot to maintain good situational awareness, and scan the surrounding airspace for manned aircraft. Because UAs are generally small, pilots of manned aircraft may not be able to see them. This means that the pilot of the UA is primarily responsible for avoiding collisions.

If the pilot sees a parachute or other aircraft in the area, they must immediately give way and keep the UA at a safe distance. In most cases it is safest to land the UA immediately.

1.8.6. Emergency response effort

An emergency response is the action of responding to a dangerous or unexpected event, such as emergency services responding to an accident.

When there is an emergency response effort taking place in the operational area of a UAS, the UAS operation should be immediately discontinued unless it was explicitly authorised by the responsible emergency response services. Otherwise, a safe distance must be maintained between the UA and the emergency response site so that the UA does not interfere with, or endanger, the activities of the emergency response services. The UAS operator should take particular care to not hinder possible aerial support and to protect the privacy rights of persons involved in the emergency event.

1.8.7. First Person View (FPV)

The remote pilot may be assisted by a UA observer helping them to keep the UA away from obstacles. The UA observer must be situated alongside the remote pilot in order to provide warnings to the remote pilot by supporting them in maintaining the required separation between the UA and any obstacle, including other air traffic.

UA observers may also be used when the remote pilot conducts UAS operations in first-person view (FPV), which is a method used to control the UA with the aid of a visual system connected to the camera of the UA. In any case, including during FPV operations, the remote pilot is still responsible for the safety of the flight.

As the UA observer is situated alongside the remote pilot and they must not use aided vision (e.g. binoculars), their purpose is not to extend the range of the UA beyond the VLOS distance from the remote pilot. Exceptions are emergency situations, for instance, if the pilot must perform an emergency landing far from the pilot’s position, and binoculars can assist the pilot in safely performing such a landing.

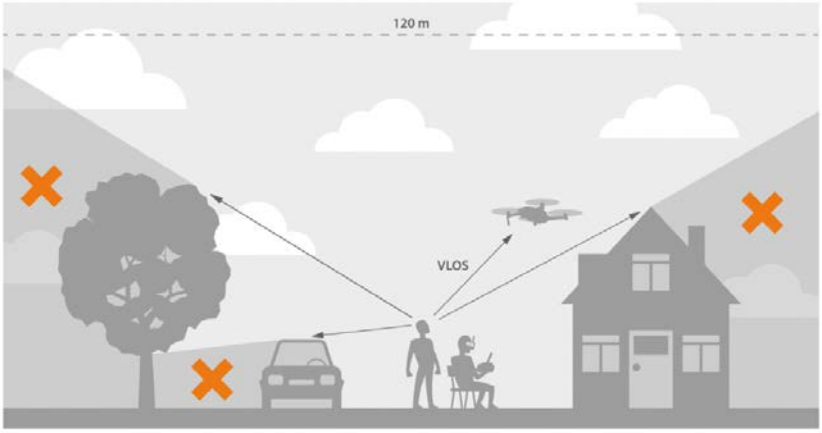


Figure 1.6 - FPV with an observer.

1.9. Air traffic rules

The air traffic rules for UAs are simple:

- UAs must give priority (right of way) to all other air traffic
- If two UAs are on crossing routes then the UA which has the other UA on its right side must give priority to the other UA
- If two UAs approach each other head-on then both pilots must turn to the right (as seen from the direction of flight)
- Other UAs must give priority to a UA which is going to land

1.10. Airspace classification

Airspace is divided into various zones, some controlled by Air Traffic Control (ATC) and others uncontrolled depending on the class of airspace. Check local regulations to see in which airspaces you are allowed to fly, as this may vary between countries. Usually there is a no-fly zone chart for UA operations, highlighting all areas where flying is not allowed, or areas where there are more limitations (height, distance, etc.) (support).

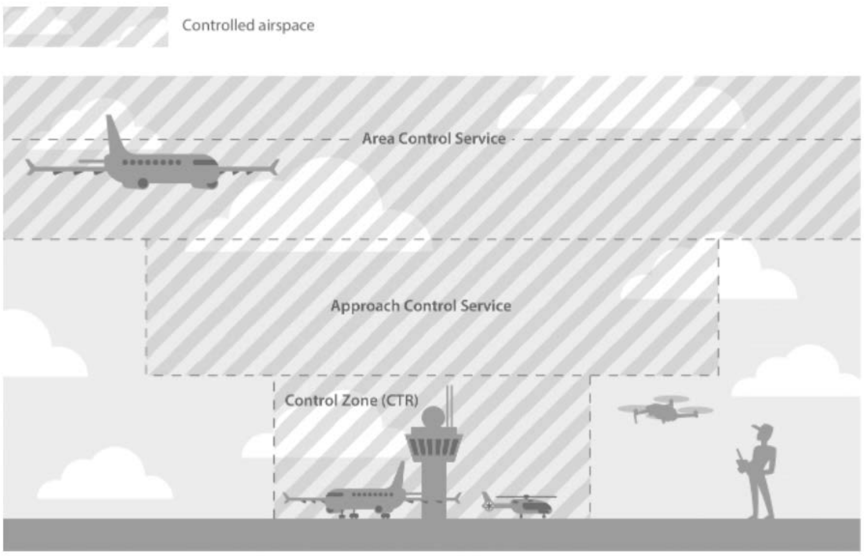


Figure 1.7 - airspace structure.

Common zones include:

- Aerodromes : airports, airfields, heliports, flying clubs.
- Control Zones (Controlled Traffic Region or CTR): controlled airspace surrounding large airports
- Military training areas: usually used for helicopter training, and thus often train at low level.
- Low flying areas and routes: areas where military planes and other aircraft are permitted to fly much lower than usual.
- Prohibited areas
- Restricted areas
- Dangerous areas

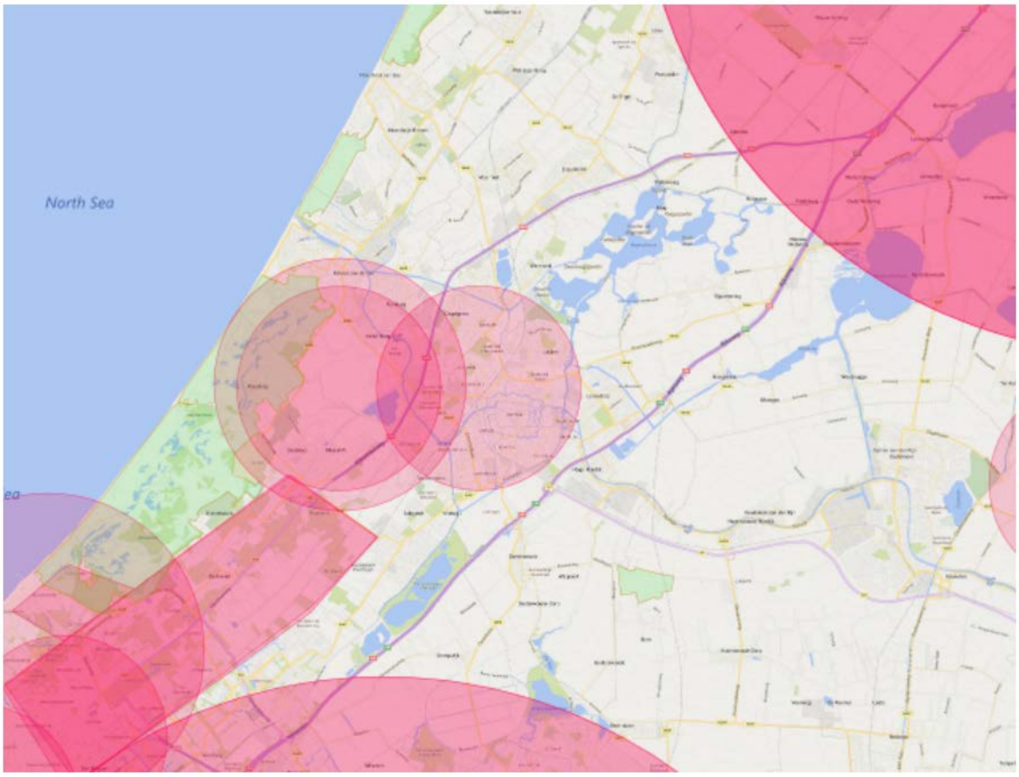


Figure 1.8 - example of no-fly zones.

1.11. Nature reserves

There are laws to protect the plants and animals in some areas. Under the European Natura 2000 system they are also protected against noise. Most sensitive areas are indicated on aeronautical charts by green dashed outlines, but may not include all nature reserves. Therefore you should check the Natura 2000 map (support). If you want to fly your UA in one of these areas then you need to get permission from the relevant province.

1.12. Daytime and night-time operations

Normally it is safest to fly a UA during the Uniform Daylight Period (UDP). This period starts 15 minutes before sunrise and ends 15 minutes after sunset. You can find these times on the AIS website (support). When using UDP tables always check if they refer to local time or UTC and if you have to make a correction for summer time.

The aviation industry often uses Universal Time Coordinated (UTC), also known as Zulu Time:

- During the winter time period CET is 1 hour ahead of UTC
- During the summer time period CET is 2 hours ahead of UTC

In relation to UDP you may come across the following abbreviations:

- SR = Sunrise
- SS = Sunset

Flying at night is usually prohibited. Check with local CAA regulations whether night flying is possible.

When looking up times in aeronautical information you must always check if the time is given as LT (Local Time), UTC, CET or CET summer time.

> The Netherlands
>
> In the Netherlands, it is not permitted to fly at night in the Open Category.

1.13. Accidents and incidents

Both accidents and incidents (events which could easily have led to accidents) have to be reported (support). This is so the authorities and other operators and pilots can learn from them. It also helps to discover technical problems which affect a particular model of UA.

Serious breaches of the legislation and regulations can lead to criminal prosecution. However, safety investigations are always completely separate from criminal investigations. This is to encourage people to be open and honest in safety investigations.

1.13.1. Definitions

Aviation accidents and incidents are defined in EU regulation 996/2010.

Accident
An occurrence associated with the operation of a UA which takes place between the time the aircraft is ready to move with the purpose of flight until it comes to rest at the end of the flight and the primary propulsion system is shut down, in which a person is fatally or seriously injured as a result of direct contact with any part of the UA, including parts which have become detached from the UA or direct exposure to the engine exhaust stream.

Serious incident
An event involving circumstances indicating that there was a high probability of an accident and is associated with the operation of an aircraft, which in the case of a UA takes place between the time the aircraft is ready to move with the purpose of flight until such time it comes to rest at the end of the flight and the primary propulsion system is shut down.

Incident

A. Any safety-related event which exposes an aircraft or persons to danger or which, if it had not been corrected or compensated for, could have exposed them to danger;
B. An event resulting in damage or a structural defect of the UA which reduces its strength, performance or flight properties and which normally requires extensive repair or

replacement of the affected part, except in the case of engine/motor failure or damage which is limited to the engine/motor, its cover or components; or damage limited to the propellers, wing tips, antennas, tyres, brakes, fairings or dents or small holes in the UA fuselage;

C. An event resulting in the loss or inaccessibility of the UA.

1.13.2. Accident and incident reporting

You must report accidents and serious incidents in accordance with EU Regulation 376/2014. The local AIS will have contact information for accident and incident reporting (support).

The Netherlands

In the Netherlands you do this with the General Aviation reporting form on the IL&T website. If an accident leads to injury or death you must call the emergency services first, on 112. After that you have to inform the Dutch Safety Board (Onderzoeksraad voor de Veiligheid), on 0800 - 6353 688 (support).

Examples of reportable events:

- Injury to persons (operator's crew or third parties) due to contact with the UA
- Collision or near-collision with another aircraft (manned or unmanned)
- Emergency landings and precautionary landings
- Loss of the UA (fly-away), even if it is later recovered
- Temporary or permanent loss of control of the UA
- Landing outside the safety zone, at close proximity to uninvolved persons, buildings, obstacles, roads, boats, vehicles, etc.
- Bird strike or attack by birds
- Problems with the batteries, fuel or oil
- Wrongly loaded or overloaded
- Pilot incapacitated due to illness or feeling unwell during the flight
- IMSAFE incidents
- Problems during the flight which affect flight safety
- Damage to the UA or damage to the property of third parties due to contact with the UA
- Incorrect procedures
- Problems due to the condition of the take-off and landing place
- Technical problems
- Technical malfunctions affecting the flight properties of the UA
- Fire or smoke (UA or ground station)

- Temporary or permanent loss of the Command and Control (C2) link
- Deliberate violation by the Remote Pilot of the rules and regulations, in the interest of safety

1.13.3. Investigations

A serious UA accident or incident can lead to two types of investigation:

- A safety investigation by the Safety Board to determine the underlying causes so that the aviation community can learn from them. Any information you give to this investigation cannot be used for a criminal investigation.
- A criminal investigation by the Aviation Police or other government body, to determine if you have committed a crime and should be prosecuted in court. This investigation is completely separate from a Safety Board investigation

1.13.4. AIRPROX

In case of an AIRPROX (air proximity incident) your UA and another aircraft (UA or conventional aircraft) came so close to each other that there was a risk of an accident. This must be reported using a special AIRPROX form, usually found on the local AIS website.

The Netherlands

In the Netherlands this form is found on the IL&T website (support).

1.13.5. Just Culture

In aviation we aim for a Just Culture, where pilots and others can admit and report genuine mistakes without risking prosecution. This is why information you provide to the Safety Board cannot be used against you in a prosecution. However, deliberately or recklessly causing damage or injury is not acceptable. The concept of Just Culture is covered by several EU regulations and national legislation (support).

The official definition of Just Culture (EU regulation 691/2010) is:

"Just culture means a culture in which front-line operators or others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but where gross negligence, wilful violations and destructive acts are not tolerated."

1.14. Airmanship and aviation safety

The Remote Pilot (RP) is directly responsible for the aircraft and is the final authority for the operation. Thus, the safety of the operation is the responsibility of the RP.

1.14.1. Airmanship

A good, successful and professional pilot practices “good airmanship”. A good pilot with good airmanship uses good judgment consistently before, during and after the operation. Safety in the air and on the ground is leading. For that, a good pilot has three important qualities. They have well-developed skills through training, gaining experience though practice, and following changes in the industry to carry out flight objectives professionally.

Proper planning and preparation
The pilot should have good flying skills and have the ability to manage their work seriously. Pre-flight planning is therefore a particularly important element in every operation. The pilot can make

good flight preparations beforehand by checking flight information publications, aviation weather reports and determining aircraft performance. Most importantly, the pilot must know their personal limitations.

In short, airmanship is the consistent use of good judgment and well-developed skills to carry out flight operations. This consistency is forged on a cornerstone of uncompromising flight discipline and is developed through systematic skill acquisition and ability. A high state of situational awareness completes the airmanship picture and is obtained through knowledge of one’s self, aircraft, environment, team and risk.

Dangers to people
Flying drones can cause serious injury to people and/or property and interfere with planes and other aircraft. All rules and limitations are in place to ensure the safety of people. Because every flight poses a different level of risk, it is important to do proper planning to minimise the possibility of endangering people on the ground. The open category is divided into three sub-categories based on the risk they pose related to their weight, speed and usage.

Table 1.9 - distance from people.

Subcategory	Description	Drone Class	MTOM
A1 Over people	Over uninvolved people but not over crowds	C0	< 250 g
		C1	< 900 g
A2 Close to people	At a safe distance from uninvolved people (1:1 rule)	C2	< 4 kg
A3 Far from people	Safe distance from urban areas (150 m)	C3	< 25 kg
		C4	

Dangers to other aircraft
A drone can fly high and is able to reach over 10,000 feet (3 km) in ideal conditions. That is why drones are a very real threat to general air traffic. The height limit for drones in the EASA rules is there for good reason. Without specific reasons and official permission, it is illegal to fly above the permitted height limit.

A drone is indeed not very big. If a single drone hits the body of a stationary airplane, the plane will probably be only slightly damaged. But don't forget the speed in the air. Small things at high speed can also cause serious damage, especially to vulnerable parts like a windscreen or a propeller. If a drone hits an engine, it can certainly cause massive damage with severe consequences. Drones can easily cause the failure of that engine and millions of euros of damage.

Small drones are very difficult for an airplane pilot to see, and cannot be seen by on-board radar. So, fly safely. Do not fly above the allowed limit and keep a safe distance from all other airspace users.

1.15. Privacy and data protection

Accessing areas where taking photos may violate people's privacy rights is very easy to do with a UA. For example filming someone in their home or garden, or taking photos of someone on private property.

Since 2018 all European member states must follow the General Data Protection Regulation (GDPR).

The Netherlands

In the Netherlands this is the Algemene Verordering Gegevensbescherming (AVG).

Through the new GDPR people have more rights regarding privacy.

If you publish information about someone (photos or videos of them) then you first need their permission to do so. You also need permission from someone to work with their personal details (such as name, address, and telephone number, etc.). People have the right to withdraw these permissions just as easily as they are given, and demand that their personal data be erased from your database and administration and any other organisations that you have passed on the data to. This is called the "right to erasure (right to be forgotten)" in the GDPR, or in the Netherlands the "Recht op vergetelheid" in the AVG. For example this could be photo that you publish on social media with somebody clearly identifiable, that person has the right to demand that the photo be deleted.

The GDPR is meant to protect people's details and personal information, and lay down requirements for the safe storage of this data. According to the GDPR you are obligated to protect any data that you collect, for example by means of encryption. The data must also be accessible for anyone who asks what information you have stored of them. This means that you should store the data redundantly to prevent inaccessibility in the case of an error or corruption.

1.16. Insurance

When operating within the EU it is required to be insured in accordance with Regulation EC 785/2004. This covers third party liability, hijacking and acts of war. You are obligated to follow the rules according to the relevant member state, and check for any local regulations that way differ between member states.

Extra information

Most insurance companies have geographical limitations of policy coverage, for example only within The Netherlands. Some cover an extra drone (backup) under the same insurance policy, some require a certain amount of UA flying hours before coverage is given. In order to get be best coverage for you, it is advised to do some research and compare insurance policies before obtaining one.

1.17. Security

Every flight brings risks, both for those on the ground and those in the air. In the event of a malfunction a UA could crash into a person on the ground, the battery could catch fire in a difficult to reach location, or a UA that is uncontrollable could fly away towards an airport. In addition to the specific risks associated with each flight there are general rules put in place to guarantee the safety of people on the ground and other airspace users. These general rules are based on the weight of the UA, and can be found in the relevant subcategory regulations (A1, A2, or A3)

There are also areas where it is forbidden to fly your UA. These are usually situated around sensitive areas, such as hospitals, public events, prisons, industrial areas, government buildings, nature reserves, or public transport infrastructure. Member states may have additional forbidden areas in place, so check with the local regulations.

The Netherlands

For The Netherlands you can find more information on the (support) page.

1.18. Dangerous goods

‘dangerous goods’ means articles or substances, which are capable of posing a hazard to health, safety, property or the environment in the case of an incident or accident, that the UA is carrying as its payload, including in particular:

a. explosives (mass explosion hazard, blast projection hazard, minor blast hazard, major fire hazard, blasting agents, extremely insensitive explosives);
b. gases (flammable gas, non-flammable gas, poisonous gas, oxygen, inhalation hazard);
c. flammable liquids (flammable liquids; combustible, fuel oil, gasoline);
d. flammable solids (flammable solids, spontaneously combustible solids, dangerous when wet);
e. oxidising agents and organic peroxides;
f. toxic and infectious substances (poison, biohazard);
g. radioactive substances;
h. corrosive substances;

Blood falls under the category of 'dangerous goods' according to ICAO provisions, when it is contaminated or unchecked (potentially contaminated). If the blood is considered to not pose a hazard to health, such as medical samples of uncontaminated blood, then it can be transported in the Open Category.

Dangerous goods are only allowed to be carried by UAs in the certified category, as well as the dropping of material.

As a drone pilot you are an important part of the entire operation, which can only be executed safely and effectively if you perform well. In this chapter we look at some of the factors which affect your performance. For example, your eyesight and hearing must be good enough to track the drone, monitor your surroundings and listen to feedback from your crew.

- Open the chapter
- After you have read the chapter, we invite you to answer a number of practice questions.

Practice questions

Table of contents

2.1. Health

2.1.1. General health

You must be in good general health to operate a UA. If you are not feeling well you cannot respond quickly if anything unexpected happens. If you are very tired or stressed you also cannot respond quickly and you are more likely to make mistakes. In those cases you must not operate a UA.

Make sure you sleep well, prepare your work well and get to the work site on time without having to rush. You will then feel better and do a better job.

Food poisoning can affect you quickly. If, after eating, you start feeling unwell you must stop the UAS operation immediately.

2.1.2. Breaks for eating and drinking

If you work all day without taking a break to eat something then your blood sugar level can get too low. This can make you dizzy and clumsy. The same can happen if you do not drink enough. Those on a diet or fasting, whether for personal or religious reasons, must consider how it affects your performance. Taking regular breaks will also avoid stress and will help you do your work more effectively.

2.1.3. Medicines

If you take medicines when you operate a UAS you must always check the medicine information leaflet. Some prescription medicines can make you drowsy (sleepy): the information leaflet will tell you not to operate machinery or drive a car. In that case you must not operate a UA.

Some over-the-counter (non-prescription) medicines have the same effect. Examples include: hay fever and anti-allergy medicines (anti-histamines), decongestants (to unblock your nose) and cold and fever remedies. There are hay fever medicines which do not cause drowsiness: ask the pharmacist for information.

Table 2.1 - Medicines and their effects.

Medicine	**Possible effects**
Anti-histamines (hay fever and anti-allergy medicines)	Drowsiness and dizziness
Aspirin	Body temperature changes, breathing affected, thins your blood
Sleeping pills	Longer reaction time, poorer concentration
Diet pills (often contain amphetamines)	Worse decision-making
Decongestants	Anxiety, shaking hands, headache, increased heart rate
Cough medicines (often contain anti-histamines or decongestants)	Depends on the contents: see above
Motion sickness medicine (against car sickness or sea sickness)	Drowsiness, dizziness, blurred vision
Anti-diarrhoea medicine	Feeling sick (nausea), drowsiness, dizziness
Antacids (against too much stomach acid)	Feeling sick, vomiting
Antidepressants, ADHD and epilepsy medication	Various effects

You must be especially careful when you use medicines you have not used before. It is best to wait a few days to see if they affect your ability to operate a UAS.

2.1.4. Alcohol and recreational drugs

You must make sure that your ability to operate a UA is not affected by alcohol or recreational drugs. After drinking alcohol you must wait at least 10 hours before operating a UAS (this is the legal requirement). But 24 hours is safer (this is the recommendation for airline pilots), especially if you drank a lot.

The maximum permitted alcohol concentration in blood or breath is much lower for aviation operations than for driving a car.

Table 2.2 - Maximum permitted alcohol concentration.

	Alcohol concentration, breath	Alcohol concentration, blood
Aviation	90 micrograms/l	0.2 milligrams/ml
Driving (experienced driver)	220 micrograms/l	0.5 milligrams/ml

2.2. Vision

To fly a UA safely and efficiently you need to have good eyesight. You must know about how your eyes work and what can affect them, because if you cannot see the drone due to poor eyesight then it is no longer VLOS.

2.2.1. Factors influencing VLOS

In most scenarios you will be flying your drone within Visual Line of Sight (VLOS). This is because it is always safer when you can see the UA yourself, and you can therefore act faster to avoid collisions or dangerous situations. In addition to the physiological aspects that affect our vision, there are many other influences that can impair our visual contact with the UA. These include:

- Objects - such as trees, fences, vehicles and buildings. Objects can break the line of sight between you and the UA, whether you piloted it behind the object or whether the object moved in front of you.
- Weather - such as fog, rain and hail. Water in the air lowers the visibility, and wind has the same affect by blowing up dust into the air. Wind affects your eyes as well, especially at high windspeeds or if some dirt is blown into your eyes.
- Sun - direct sunlight or reflections. If you have to close your eyes because it is too bright then you can no longer see the drone.
- Distractions - such as loud noises, chatter, movement in your surroundings and curious bystanders. If something causes you to look elsewhere, even briefly, then it may be difficult to find where the UA is again. This can be especially difficult when flying against a background of similar colour to the drone.

2.2.2. Perception

The way in which we observe the world around us is made up from many small visual and audible cues. Looking at just one cue does not give all that much information, but when combined with others we are able to form a three-dimensional image of our surroundings.

Depth perception

Depth perception is the ability to determine distance between you and an object, or in this case your UA. Subtle changes in size, colour, contrast, and movement affect how far away we perceive an object to be.

When observing an object on the ground, you can easily judge the distance between it, you, and other objects by referring to their relative position one another and size. For example you observe a car parked down a road, you can see that it is parked behind several other cars because their views obstruct one another, and you know the approximate size of the cars and markings on the road. You are therefore able to determine the distance to the car. But if you were to remove all references, as is often the case when observing a UA in the sky, it is much more difficult.

Judging distance laterally left and right is much easier because you can use the background as a reference, and as long as you keep the background observable between the drone and an object then you know that they won't collide.

Determining the distance between a UA and objects behind it is particularly difficult, because there are no cues to help you other than the relative size of the object which is not easy to determine accurately with the naked eye. This can be effectively mitigated by using an observer positioned between the UA and the object in such a way that they can observe the distance laterally left and right as mentioned above.

Luckily many UAs are, or can be, equipped with proximity sensors to help prevent collisions, further helping us mitigate collisions due to bad depth perception.

Speed
The speed at which an object, or UA, is travelling is very difficult to accurately gauge. You need to have a reference, whether the ground or a close background, to help you estimate speed, but even then it is not easy. If equipped with GPS, the drone can measure its ground speed and display it to you. In most cases you can set a maximum speed for your UA, so that it will not fly faster than what is safe or permitted.

Height
Much like determining distance, height can be more easily determined when looking at the UA from the side. Flying over your head makes it more difficult, as well as disorientating.

When flying a UA close to the horizon, it is perceived to be farther away when close to the horizon and when moving farther from the horizon appears to be closer. For example you hover your UA on the horizon then climb directly upwards, it will appear to move closer towards you.

The best way to determine the height of your drone is to use an altimeter, which most UAs come equipped with.

2.2.3 Night vision

At low light levels you see less clearly and you can hardly see colours, especially from a distance. This is known as **night vision**. If you go from a bright area (indoors) into a dark area (outdoors) then your eyes need time to adapt. This can take more than half an hour and takes longer as you get older. With night vision your peripheral vision is sharper than your central vision, so a good method for seeing better at night is to look slightly to the side of what you are focussing on.

2.3. Tiredness (fatigue)

A pilot must be sharp and focused in order to be ready for any type of emergency that can occur during a flight. A fatigued pilot will be sluggish and slow to react to unexpected situations. Tiredness (fatigue) can have the same effects on your work as stress:

- You make more mistakes
- Everything takes you longer
- It is more difficult to concentrate
- It is more difficult to deal with anything unexpected
- The quality of your work goes down

Tiredness which starts suddenly (**acute fatigue**) can be caused by working too hard or too long, and by poor sleep the night before the operation. Planning the work well, with enough breaks and "slack" (time to deal with unexpected things) can help prevent acute fatigue.

Tiredness which builds up over a longer period (**chronic fatigue**) is usually due to poor sleep, working too much and stress over a long period of time. You can prevent it by ensuring that you get enough uninterrupted sleep and by avoiding too much stress. There is plenty of information available about improving your sleep – look for it if you think you suffer from chronic fatigue!

2.4. IMSAFE

Before you start work you must take a minute to check if you are fit to fly. This is known as a “health self-assessment” and is based on the IMSAFE checklist:

Table 2.3 - IMSAFE checklist.

	Check	Example
Illness	Do I feel ill, so that it could affect my work?	You feel dizzy because you have a heavy cold.
Medication	Am I taking medication (prescription or non-prescription) which could affect my work?	You feel drowsy because of the pills you are taking.
Stress	Am I suffering from stress which could affect my work?	You are very stressed because you got stuck in traffic for an hour and arrived late at the job site.
Alcohol	When did I last drink? How much?	You went to a party last night and have a UAS operation in the morning, and your last drink was less than 10 hours ago.
Fatigue	Am I awake enough to fly?	You slept badly all week.
Emotion	Am I upset about anything, so that it could affect my work?	You just had a serious argument with the client or a colleague.
Eating	Do I feel hungry, so that it could affect my work?	You skipped breakfast because you were in a hurry to get to work.

It is always safest to postpone the operation if you do not pass the IMSAFE checklist. It is important, as the Remote Pilot, to know your own limits and when it is unsafe to operate.

2.5. Situational awareness

To fly a UA safely you need to have good situational awareness. This term is widely used in aviation and refers to the combination of observation, comprehension and decision making. Situational awareness means a continuous perception of all the elements within the observable environment of your operation and that you are able to anticipate future situations. Assess which elements need to be acted upon and how to manage them. When flying a UA, situational awareness includes:

- observing the distance between the UA and surrounding obstructions
- hearing and understanding information provided by other team members
- monitoring the status of your UAS
- looking out for other air users
- maintaining a “listening watch”
- being aware of changing weather conditions

- keeping your team informed
- predicting possible public encroachments

Situational awareness is understanding all this information, knowing whether things are as they should be or not, and taking the necessary measures to ensure an acceptable level of safety.

The mechanics of flight are fairly complex but they help you understand how a drone flies. In this chapter you will learn how lift is generated, and how you can influence these forces to control your aircraft effectively.

- Open the chapter
- After you have read the chapter, we invite you to answer a number of practice questions.

Practice questions

Table of contents

3.1. Laws of Motion

Extra information Although you do not have to know these laws to pass your exam, they are useful background knowledge.
Newton's 1st Law (Law of Inertia) Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.
Newton's 2nd Law (Law of Acceleration) The acceleration of an object as produced by a force is directly proportional to the magnitude of the force, in the same direction as the force, and inversely proportional to the mass of the object.
Newton's 3rd Law (Law of Action and Reaction) For every action there is an equal and opposite reaction.
Bernoulli's principle (fluid dynamics) An increase in the speed of a fluid occurs simultaneously with a decrease in pressure.
Torque Torque is the rotational force of an object moving around an axis. This is highly relevant in aircraft motors as they produce rotational energy and, due to Newton’s 3rd law, also reaction energy. It is this reaction energy which means you need a tail rotor (anti-torque rotor) on a helicopter.

3.2. The four forces of flight

Every aircraft, whether fixed wing plane, helicopter or rocket, is affected by four forces:

- thrust which pushes it forward
- lift which pushes it up
- drag which pulls it back
- weight which pulls it down

Control surfaces, such as the rudder or ailerons, adjust the direction of these forces, allowing the pilot to use them to control the aircraft. A force is a push or pull in a specific direction. It is a vector quantity, which means a force has both a magnitude (strength) and a direction. Here we look at fixed wing aircraft. Other aircraft, such as hot air balloons and helicopters, use the same basic principles but in different ways.

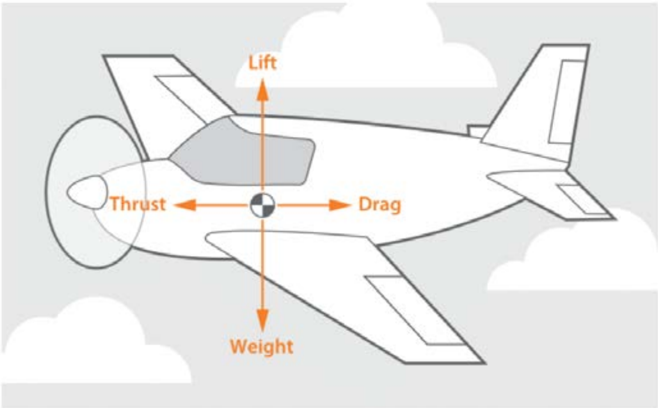


Figure 3.1 - the four forces on an aircraft.

3.2.1. Lift

Lift is an aerodynamically generated force, generated by air moving over the wings of an aircraft.

An airfoil (shape of the wing) is shaped so that the air flowing over the top of the wing moves faster than the air under the wing. This faster airflow results in a lower air pressure on the top surface of the wing, and the slower airflow under the wing causes a higher air pressure on the bottom.

As a result, the air under the wing pushes the wing up towards the lower pressure, creating lift.

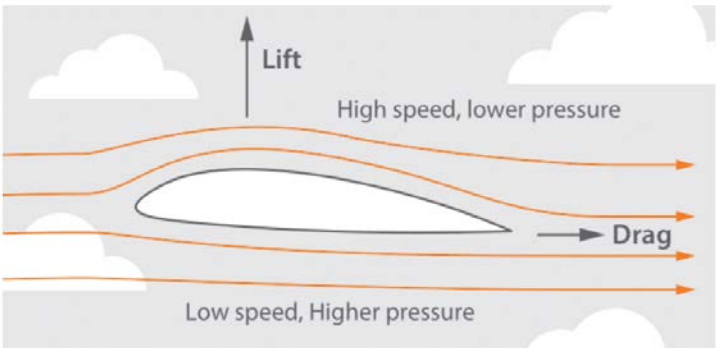


Figure 3.2 - aerofoil.

3.2.2. Drag

Drag is the resistance to motion of aircraft through the air and acts in the same direction and parallel to the airflow over the aircraft.

3.2.3. Weight

Weight acts vertically down towards the centre of the earth through a single point on the aircraft known as the centre of gravity.

While the aircraft is on the ground, its weight is balanced by a reacting force of the ground through the wheels, but during flight weight must be balanced by another force, the lift.

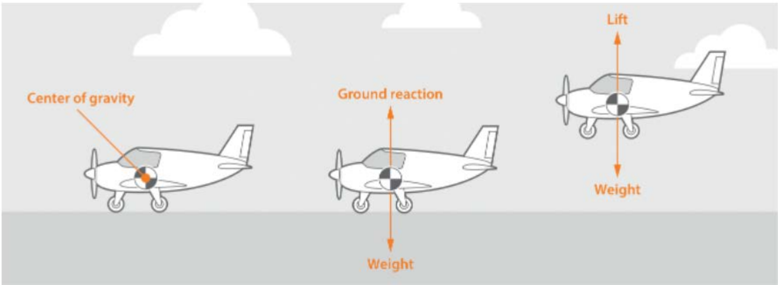
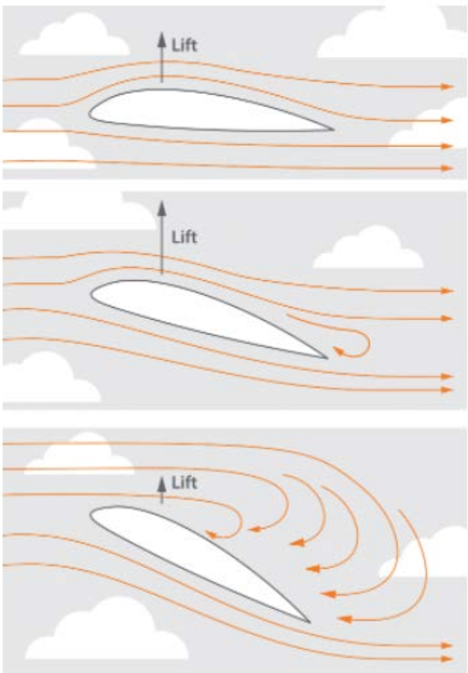


Figure 3.3 - weight vs lift on the ground and in the air.

3.2.4. Thrust

Thrust is the force that counteracts drag and pulls or pushes an aircraft through the air. Thrust is provided by a propeller-engine combination or jets.

3.3. Stall



The angle of attack is the angle between the wing chord and relative airflow. With a low angle of attack, airflow is smooth and creates a moderate amount of lift.

As the angle of attack increases the lift force builds up to a peak, then the airflow begins to break away from the surface of the wing starting at the trailing edge.

A stall occurs when the airflow breaks away completely, resulting in a sudden loss of lift.

Figure 3.4 - stall.

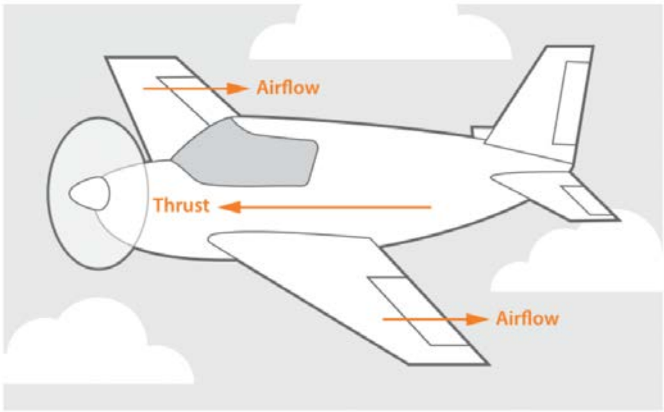


Figure 3.5 - thrust and airflow.

3.4. Environmental conditions and performance

The main factors affecting performance are wind and air density. If you fly in too strong a wind then you risk the UA being blown away or into an object, or are unable to land without flipping the UA.

Air density depends on the pressure and temperature of the air. If the pressure is low then the air molecules are further apart, and a higher temperature expands the air further making the UA perform as though it were flying much higher, sometimes thousands of feet! Flying at higher altitudes means the air is thinner, the wings or propellers produce less lift and must therefore work harder to keep the UA in the air. Humidity also plays a part here, because higher humidity means more water vapour and less air.

When flying in rain the electrical components inside the UA may get wet and short-circuit causing damage. Most manufacturers include details on water resistance in the user manual, but usually the UA can only withstand small amounts of water such as a light drizzle.

The performance of your UA will vary depending on a number of factors, but as long as these factors remain within limits then performance will not fall below an acceptable level. However, always consider your own limitations as well because while the UA may be able to fly in certain conditions your experience may not be up for it.

3.5. Command and control

The control link (C2) carries the commands given by the pilot’s transmitter to the flight controller and other systems on the UA. This radio link usually uses a frequency of 2.4 GHz.

The C2 link also carries flight data (altitude, speed, battery status, etc.) from the UA to the pilot. This provides the pilot with information about the UA and its performance.

3.5.1. Transmitter (Remote controller)

This is the controller which the pilot uses to control the UA. It has two sticks which can be moved in any direction, allowing for the control of four separate axes. There are normally also some switches and buttons which can be assigned to various functions, such as flight modes or failsafe.

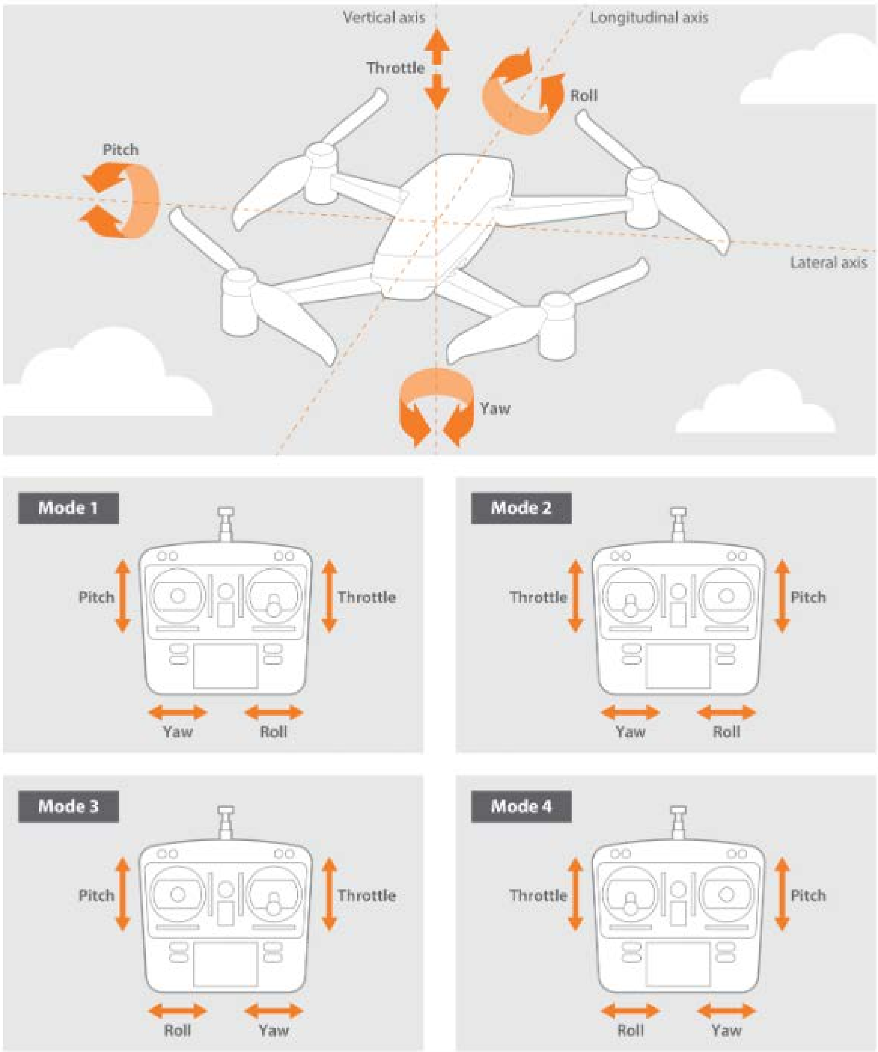


Figure 3.6 - transmitter modes and their controls.

3.5.2. Receiver (RX)

The receiver is what communicates with the transmitter, receiving signals and sending the appropriate signals to the equipment such as servos.

Binding the receiver is the process in which it is connected to a transmitter. Once bound, the receiver will only communicate with that specific transmitter, until it is bound to another. Most receivers require a button to be pressed or a physical plug to be inserted to enter bind mode, which helps prevent accidentally binding during flight or even being hacked.

3.5.3. Servos

A servo is what makes things move on a UA. It consists of a small electric motor geared to give more strength than speed, enclosed in a housing. On top is an arm which can rotate left or right, normally up to 180 degrees total. To move a control surface, a metal rod (push rod) attaches it to the servo arm which can then move the rod forward or backward.

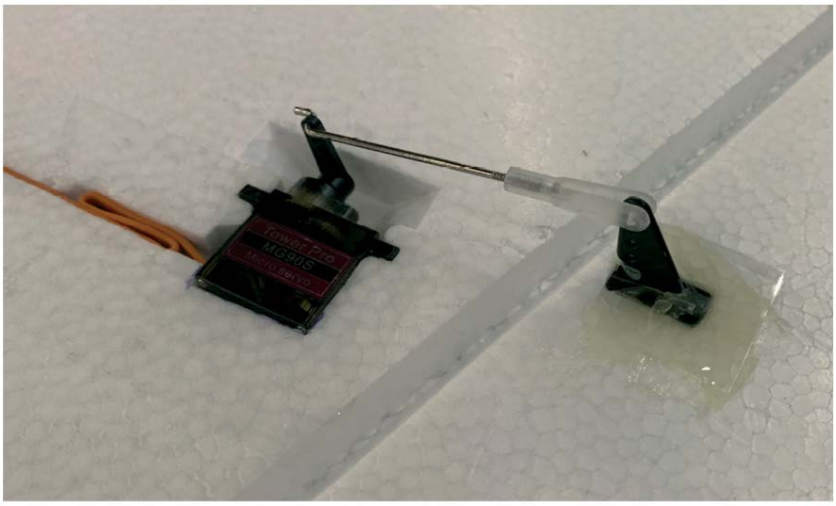


Figure 3.7 - servo used for a control surface.

3.5.4. Radio frequency spectrum

- Frequency
  Measured in Hertz or Hz, frequency is defined as cycles per second.

- Wavelength
  The wavelength is the distance where the wave form begins to repeat. As the frequency of a radio wave increases, the wavelength decreases.

The radio spectrum is very wide, starting at 34 Hz and goes all the way up to 3000 GHz. Almost the entire radio spectrum is used for various applications.

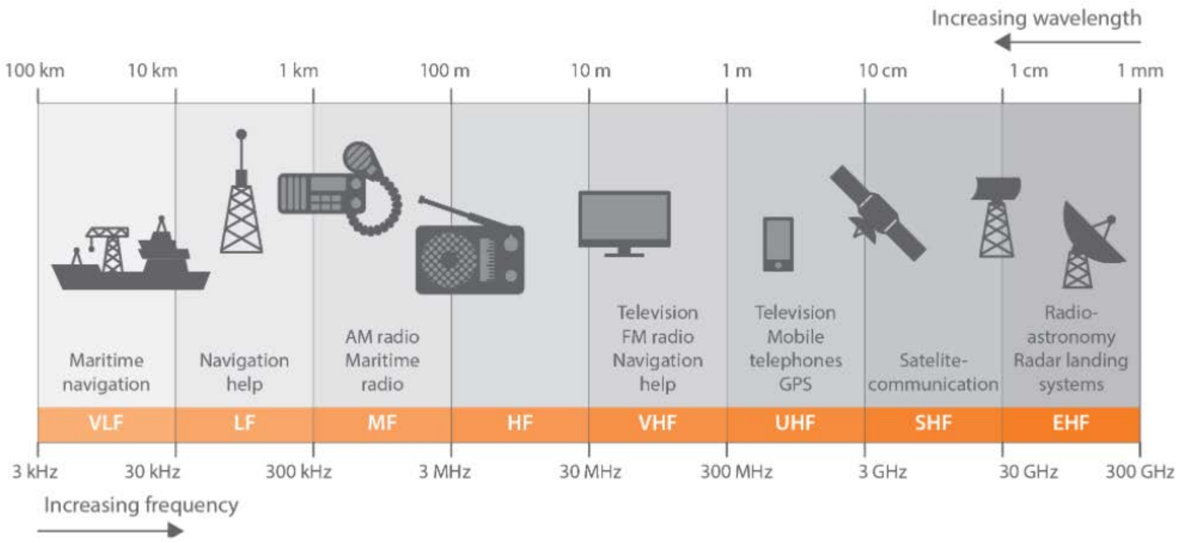


Figure 3.8 - radio spectrum.

3.5.5. Range

Most modern UA radio control systems have a range which is much greater than the UA operating range which is currently permitted. You might therefore think that you do not have to worry about the radio control range. However, the range quoted in your UA manual applies under the best possible conditions. This means a clear radio line of sight, dry atmosphere and no interference.

3.5.6. Radio line of sight

> Extra information
>
> As long as you work under VLOS (Visual Line Of Sight) conditions you are also likely to have radio line of sight. In that case the radio links between the UA and the ground station will probably work. But as soon as you fly behind a building or other structure, the signal strength will be reduced or you may lose the signal completely. If you have to fly an operation like this you must prepare it very carefully, do a test flight while monitoring the signal strength, and make sure your procedures cover loss of signal.

3.5.7. Interference

Interference means signals from other sources which affect your radio link. Interference can be caused by thunderstorms and cumulonimbus clouds (even at a distance) and other atmospheric phenomena. Electrical equipment such as generators in wind turbines, heavy industrial equipment and overhead power lines cause electromagnetic interference (EMI). This can interfere with the C2 link and other sensors on the UA such as the compass. Finally, there are many other systems which use the same radio frequencies as our UAs, for example car unlocking systems, Wi-Fi, remote controls, etc. which can cause interference.

Figure 3.9 - example of interference on an industrial site.

The Kp index indicates the strength of disturbances in the earth's magnetic field (geomagnetic field). The Kp-index has a value between 0 and 9. The disturbances can lead to radio interference. If the Kp index is higher than 5 the interference can affect both the radio link between the ground station and the UA, and GNSS reception. In that case you cannot fly the operation. This is why you always check the Kp index when preparing an operation. The (support) page includes links to websites with the Kp index (https://www.swpc.noaa.gov/products/planetary-k-index).

Figure 3.10 - signal strength indicator on a UA ground station.

3.5.8. Flight modes

Different UA flight modes provide different amounts of automation. The exact name and functions of the flight modes depend on the UA manufacturer. If you start using a UA made by a different manufacturer than you are used to then you must check their definitions of the flight modes. The most common flight modes are:

- Fully manual: this is usually only available on racing drones. In this mode the pilot has to control all aspects of the UA's operation. Flying a UA in this mode is very difficult because it is unstable.
- Stabilised/attitude mode (atti mode): the Flight Controller keeps the UA in a horizontal attitude when the sticks of the transmitter are in the neutral position. When the sticks are moved, the UA will mimic the exact angle of tilt of the sticks. Note that the UA will still drift with the wind, unless corrected by the pilot.
- Position hold (GPS mode): this is the easiest to control. The UA uses GNSS, and sometimes other sensors (discussed later in this chapter), to keep it in a fixed position over the ground or flying in a straight line with a fixed wing. The flight controller automatically tilts the UA into the wind where necessary to avoid unwanted drift, and in the case of a fixed wing automatically applies a wind correction angle to maintain a straight course.
- Programmed flight: the UA flies from one preprogramed waypoint to another. This is particularly useful for surveys. This flight mode is also referred to as automatic flight. It is a legal requirement that the pilot can take over control at any time. This means that the pilot must have the ground station at hand all the time. Leaving the ground station in the car, starting the programmed flight with your laptop and then going to drink a cup of coffee is not permitted!
- Intelligent flight modes: the UA flies a manoeuvre or tracks a subject without input from the pilot (for example DJI active track or quick shots)

As the Remote Pilot you must always be in control of the UA. This means that if you use any kind of automated flight modes you must always be able to take back control. Usually this is as simple as moving the sticks on the transmitter or pressing a “stop” button.

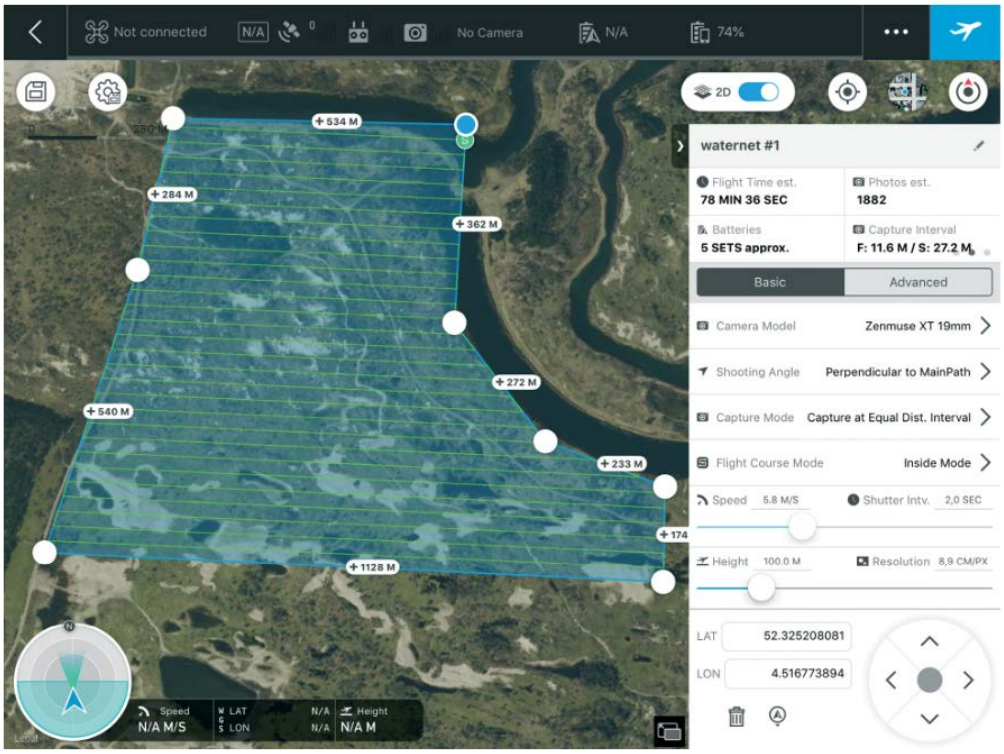


Figure 3.11 - example of a waypoints mission flown by Waternet.

3.6. Basic elements of an airplane

A fixed wing airplane relies on a wing fixed to its fuselage (hence the name) to generate lift, and makes use of one or more motors or engines to provide thrust. Because the wing is fixed, the airplane must maintain airspeed in order to fly.

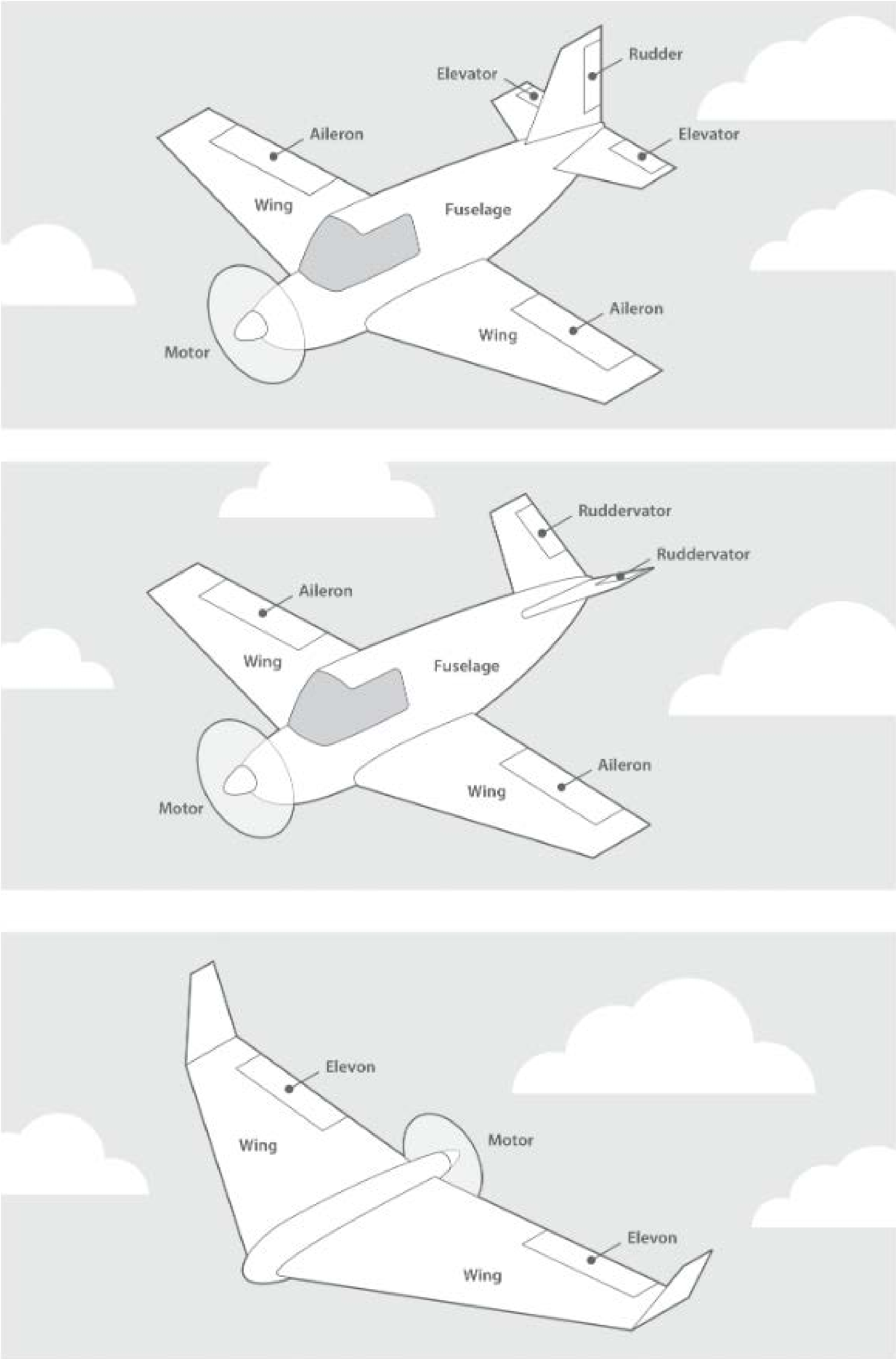


Figure 3.12 - parts of different fixed wing designs.

3.6.1. Elevator

The elevator helps control the elevation (altitude) of the aircraft. It is usually located on the tail of the aircraft and serves two purposes. The first is to provide stability by producing a downward force on the tail. Airplanes are usually nose-heavy and this downward force is required to compensate for that. The second is to move the nose of the aircraft either upwards or downwards (pitch control) to make the airplane climb and descend.

3.6.2. Ailerons

The ailerons are located at the rear of the wing, one on each side. They work opposite to each other, so when one is raised, the other is lowered. They increase the lift on one wing, while reducing the lift on the other. By doing this, they roll the aircraft sideways, which allows the aircraft to turn. This is the primary method of steering a fixed-wing aircraft. Some UAs combine elevators and ailerons, called elevons, as seen on flying wing UAs (aircraft without a tail) and perform the functions of both control surfaces.

3.6.3. Rudder

The rudder is located on the tail of the aircraft. It works identically to a rudder on a boat, steering the nose of the aircraft left and right. Unlike the boat however, it is not the primary method of steering. Its main purpose is to counteract the drag caused by the lowered aileron during a turn. This drag causes the nose of the airplane to point away, or outwards, from the direction of the turn. The rudder helps to correct this by pushing the nose in the correct direction.

3.6.4. Throttle

Throttle controls the power of the engine and speed of the propeller. This is done by controlling the flow of fuel to an internal combustion engine, or by controlling the flow of electrical current to an electric motor.

3.6.5. The propeller

The propeller of a fixed wing works exactly like a wing, just orientated vertically instead or horizontally. When looked at from the side, you will see that a propeller is shaped like an airfoil. Usually they are also wider at the centre and narrower at the propeller tips. This is to distribute the thrust evenly across the blade, because the propeller tips move faster than at the centre. Reducing the surface area at the tips balances the increase in speed (refer to the lift formula).

3.7. Basic elements of a multirotor

This type of UA has multiple rotors, usually four or more but sometimes three. By controlling the power of the motors independently it can manoeuvre through the air.

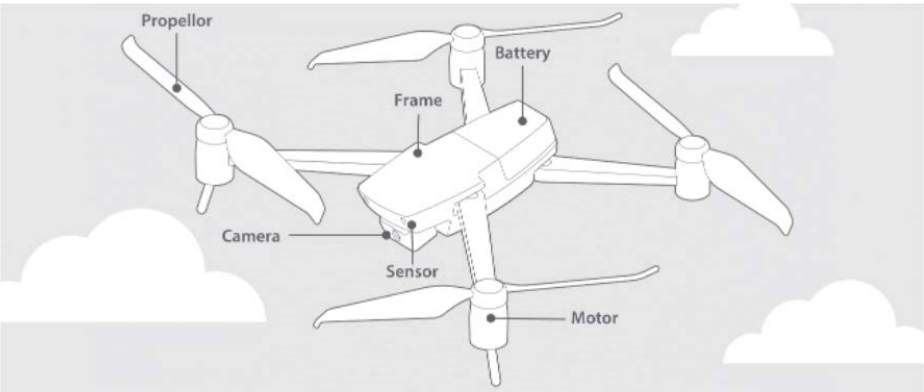


Figure 3.14 - parts of a multirotor.

Instead of using control surfaces like a fixed wing, multirotors are controlled entirely by manipulating the power of the motors. More power means a propeller turns faster and generates more lift and more torque.

3.7.1. Pitch and Roll

Both pitch and roll are controlled in the same way, by giving more or less lift to different sides of the aircraft. To tilt the aircraft, more power goes to the motor(s) on the side opposite to the desired direction of tilt. For example when tilting to the left, more power goes to the motor(s) on the right side.

3.7.2. Sideways movement

We also control the rotors to move the UA left/right and forward/backward. When a UA pitches or rolls, the force produced by the rotors is divided in two parts:

1. lift acting vertically upwards and
2. thrust acting horizontally in the direction of tilt.

The lift keeps the UA in the air, and the thrust moves it left/right or forward/backwards.

Because some of the force is used to move the UA, there is less lift force, so the UA will descend. Most multirotors will automatically increase power to all motors to maintain the altitude. (On some race drones the pilot has to make this adjustment.)

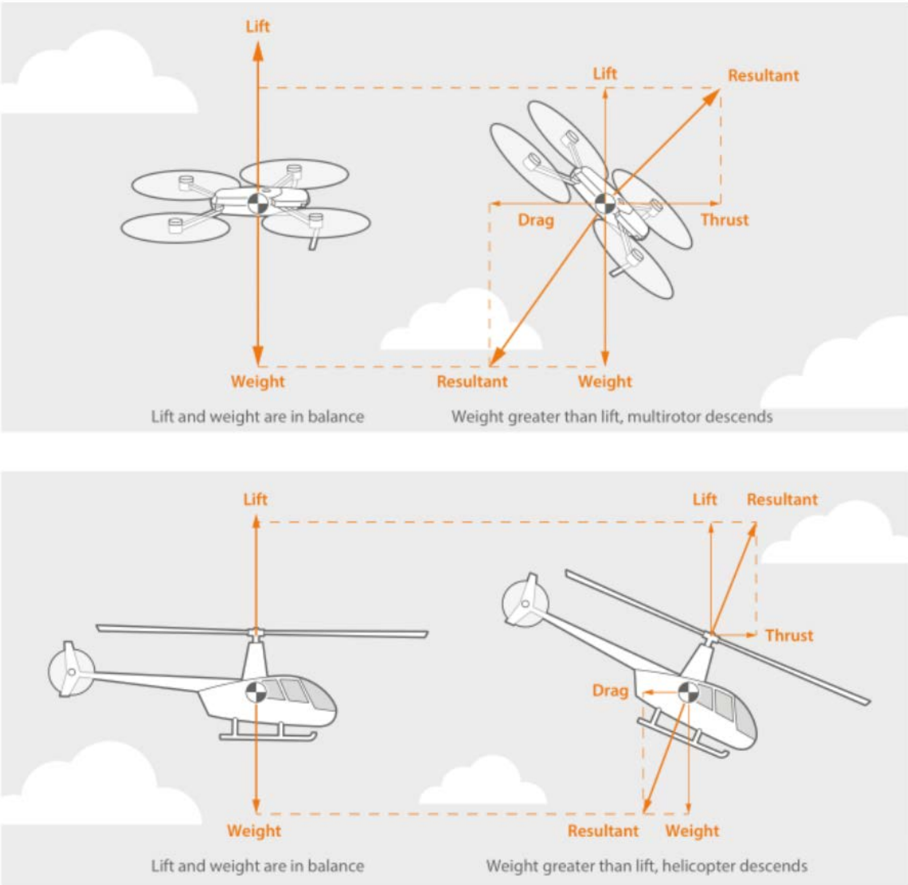


Figure 3.15 - how tilting a rotorcraft affects lift.

3.7.3. Preventing rotation

If all the rotors of a multirotor UA rotated in the same direction, the UA body would also rotate (yaw). To prevent that, half the rotors rotate to the left and the other half rotate to the right. This creates the same amount of torque to the left and to the right, so the UA does not rotate.

If you want the UA to rotate you provide more power to one set of rotors (all turning in the same direction). This provides torque in one direction which then rotates the UA. At the same time you reduce the power to the rotors turning in the other direction, to keep the lift constant and prevent the UA climbing (ascending).

3.7.4. Climbing and descending

Altitude control is fairly simple with a multirotor, because all the rotors are horizontally orientated. To climb, more power is given evenly to all the motors. To descend, less power is given to the motors.

3.8. Basic elements of a helicopter

A helicopter uses one main rotor to generate lift, with a small tail rotor for stabilisation. This main rotor can be seen as a wing moving round and round, which is why helicopters are also referred to as rotary wing aircraft.

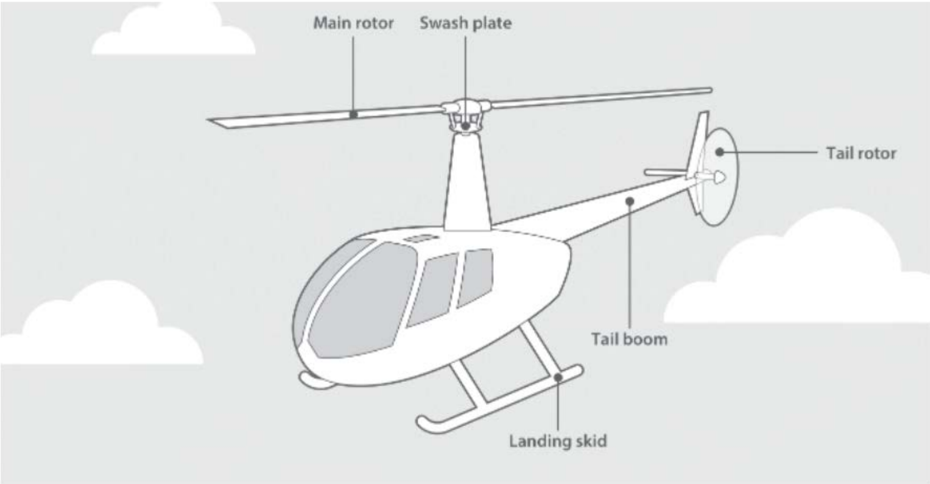


Figure 3.16 - parts of a helicopter.

While a helicopter is a far more complex machine than a fixed wing aircraft, the fundamental principles of flight are the same. The rotor blades work the same way as the wings of an airplane: when air moves over them, lift is produced. The crucial difference is that the air flow is made by rotating the wings (rotor blades) rather than moving the whole aircraft.

3.8.1. Main rotor

The lifting force is produced by the main rotor. To create more lift (so the helicopter climbs) the pilot adjusts the pitch angle of the rotor blades.

The main rotor includes a swash plate mechanism to change the pitch angle (and the lift) of the rotor blades during part of their rotation. If the pilot increases the lift at the back of the helicopter, the rotor tilts forward and the helicopter moves forward. (Multirotor UAs do not have swash plates, instead they are controlled by spinning the rotors at different speeds.)

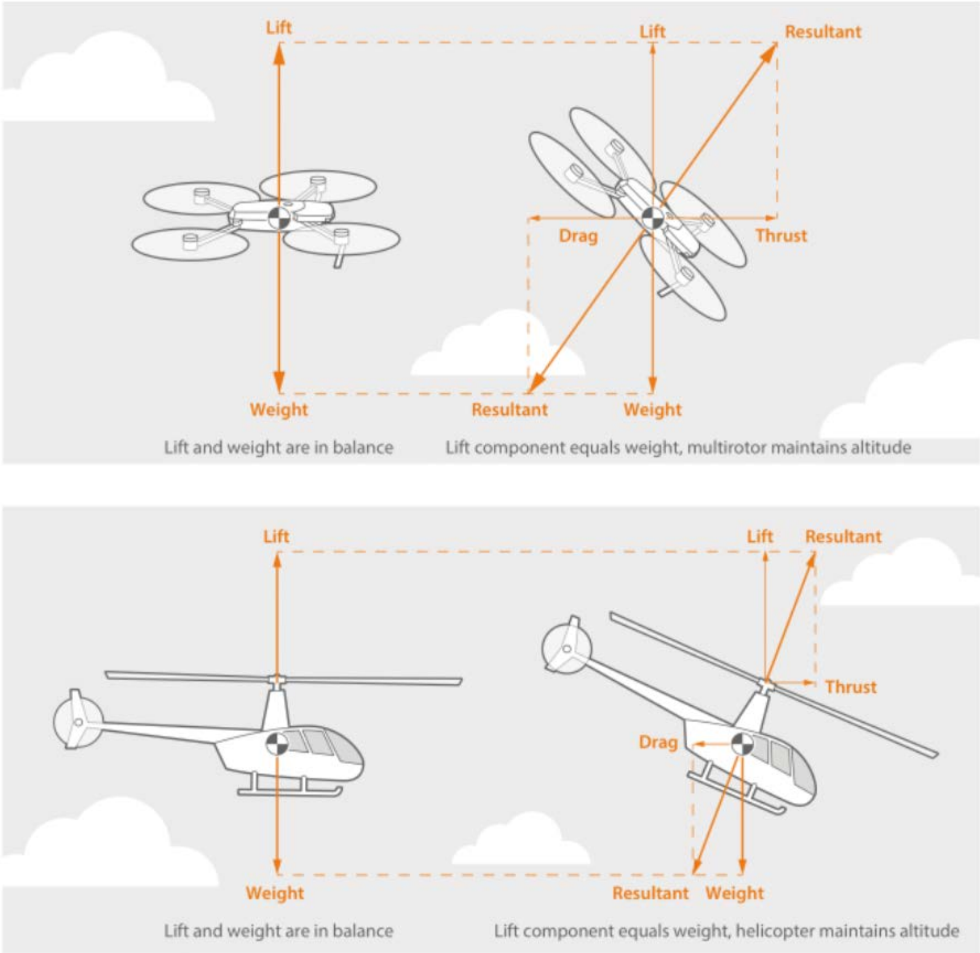


Figure 3.17 - how to maintain altitude when a rotorcraft is tilted.

3.8.2. Tail rotor

If you spin the main rotor with the engine, the rotor will rotate, but the engine and helicopter body will tend to rotate in the opposite direction to the rotor. This is called torque reaction. The tail rotor compensates for this torque and holds the helicopter straight. (On twin-rotor helicopters, the rotors spin in opposite directions, so their reactions cancel each other out like on a multirotor UA.)

3.9. Sensors

Nearly all UAs use some form of sensor(s) to aid the pilot in flying it smoothly, accurately and safely. Automated and intelligent flight modes are especially dependant on additional sensors to allow for flight without input from the pilot. These sensors include:

- Inertial Measurement Unit (IMU): a small chip containing a three-axis gyroscope and three-axis accelerometer (used to measure linear acceleration) and sometimes also a compass. The UA uses data from this chip to measure its movement and orientation in the air. Without the IMU, even the most simple of drones would not function. Most modern drones have at least two IMUs for redundancy and higher accuracy.
- Compass: measures the direction of the ambient magnetic field. Because the earth has a magnetic field, a compass can be used for navigation. This magnetic field is always even and needs to be taken into account, and often a compass calibration is needed when operating in a new location.

- Altimeter: shows you the height at which you are flying. The altimeter works by measuring changes in air pressure during flight. Because air pressure decreases as you go up, the altimeter can accurately measure the height of the UA.
- Proximity sensor: usually used to measure distance to the ground, which can be useful when taking off and landing. They are also used to detect obstacles around the UA.
- Optical flow sensor (vision positioning with DJI drones): detects lateral movement of the UA, allowing the flight controller to hold the UA in position with GNSS.
- Warning indicators (status LED): shows the status of the UA. This can be to show battery level, signal strength, flight mode, or even if you get too close to an object.

Figure 3.18 - proximity sensors.

3.10. Limitations

Weather conditions play an important role in the safe operation of UAs. The effects of weather on the UA can lead to big problems and sometimes cause the UA to crash. This is an important aspect to consider when planning a flight, and you should take the specific weather limitations of your UA into account.

3.10.1. Maximum weight

The maximum Take-off Mass (MTOM) is the maximum allowed mass of the entire UA. This limitation should be specified by every UA manufacturer in the UAS user manual.

Loading the UA heavier the MTOM will make the UA dangerous to fly, or too heavy to even take off. Although flying at low altitudes with an overloaded UA may be possible, it will likely behave unpredictably to your controls or be unable to remain stable when encountering wind or turbulent air.

3.10.2. Centre of gravity

The Centre of Gravity (CG) is the effective point where all weight is considered to be. This point is not fixed but moves forwards or backwards, left or right along the axes, depending on how the UA is loaded. It is essential that its centre of gravity remains within certain limits. This is because a UA that is too heavy on one side will either not fly, or be so difficult to control that it becomes too dangerous to fly. These limits are referred to as its CG envelope. It is different for every UA, for this reason it is important to read the manual for each UAS.

3.10.3. Wind

The UAS user manual contains weather limitations for the UA, one of these is the maximum wind speed.

Wind has a big effect on the speed of the UA. With a headwind, the UA's forward speed will be slower and with a tail wind the UA's speed will be faster. If there is a crosswind (wind from the side) you will have to tilt into the wind or adjust your course to prevent the UA from drifting away.

If the wind speed exceeds the UA limitations it will start to encounter problems, such as limited ability to control the UA or even a fly-away where control is lost completely. The motors need to work harder when compensating for strong winds and could overheat and stop working. Harder working motors also means more energy consumption and the battery will drain faster.

When flying close to obstructions (buildings, hills, dikes, or mountains) you should pay attention to turbulence. When wind moves around obstructions it causes turbulent air that can cause unpredictable flight behaviour.

3.10.4. Temperature

The temperature limitations found in the UA's user manual contains a minimum and maximum temperature. Exceeding either of these limitations could damage to the UA and cause the flight to be unsafe.

Electronic components are sensitive to high temperatures, which could cause them to malfunction or even burn.

The temperature is particularly important batteries. If a battery is cold it cannot produce enough power to fly the UA safely. Some UAs measure the battery temperature and will not take off if the battery is too cold.

3.10.5. Batteries

Most UAs will inform the pilot about the remaining battery capacity. Often they will also initiate an automatic landing or return home when the remaining battery capacity falls to a low level.

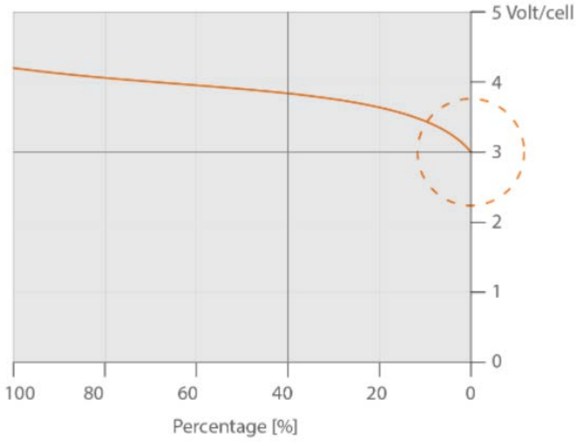


Figure 3.19 - discharge curve.

3.11. Controlling the UAS

3.11.1. Take-off

Most UAs need to be armed before they will take off, and will be described in the UAS user manual.

For rotorcraft (multirotors and helicopters):

- Start the motor(s)
- Increase the power to take-off (default left stick)
- Use pitch and roll controls to keep the UA stable (default right stick)

For airplanes (fixed wings):

- Start the motor
- Increase the throttle to full (default left stick)
- When there is sufficient airspeed, lift the nose of the UA to take off (default right stick)

3.11.2. During flight

Orientation control (UA is facing in different directions) is one of the most important skills to learn while hovering or flying various patterns.

For rotorcraft (multirotors and helicopters):

- Practice hovering over a spot, using small pitch and roll corrections. Maintain a constant height above the ground by adjusting the power
- When flying various patterns or manoeuvres you should be able to stop at any point, for example to avoid an obstacle. This should also affect the speed that you fly.

For airplanes (fixed wings):

- Make sure to maintain a safe airspeed. You should not need full throttle in normal flight, but if the UA flies to slow it may stall and crash. Find a throttle setting that is just right, every UA will handle differently.
- Practice making coordinated turns, by rolling into the turn and lifting the nose slightly to maintain height.

3.11.3. Landing

Landing the UA is usually the most difficult part of flying. Plan the descent carefully and keep the UA stable when approaching to land.

For rotorcraft (multirotors and helicopters):

- Return to the landing area, and hover in place.
- Start descending by decreasing the power, while keeping the UA steady with pitch and roll corrections.
- Once on the ground, stop motor(s) immediately.

For airplanes (fixed wings):

- Plan the approach to the landing area, so that the UA lands into the wind.
- Line up with the landing area (runway), decrease the throttle and lower the nose of the UA to start descending.
- Just before landing, decrease the throttle completely (idle) and use pitch and roll corrections to gently land the UA.

After landing turn off the UA or prepare for another flight.

3.12. Safety features

3.12.1. Failsafe

This is what is preprogramed to happen when the receiver loses signal from the transmitter. Flight controllers offer very sophisticated failsafe functions, such as auto land or return to home, and can also be activated manually. The failsafe setting should be selected beforehand depending on the situation. With most UAs this in the settings menu. This is usually to return home by default with most UAs, but can also be immediate landing or hover.

Return to home
This is the most common failsafe setting for UAs. When the failsafe is triggered, whether due to loss of link or manually activated, the UA climbs or descends to a predetermined height then flies in a direct line back to its home point. It is a good idea to set the return home height 15 to 20 metres higher than the highest object between the pilot and the UA. It then hovers for a few moments before descending to land. By default, the home point is set as the take off point with most UAs, but can also manually selected before or during the flight. Fixed wing UAs require more planning beforehand because they cannot hover in one place. You will usually need to program the descent to landing manually to avoid trees and other obstacles, or program to descend while loitering (see below) if there is enough space.

Direct landing
Probably the best option when operating indoors. Direct landing will have the UA immediately descend to land in its current position. Be aware though that if flying without a reliable GNSS signal or other means of positioning (vision positioning with DJI drones) then the UA will not be able to hold its position. During landing and will most likely continue to drift in the direction it was moving in at the moment the failsafe was triggered. Direct landing with a fixed wing will first have the UA loiter. Then, while circling, the UA descends until it lands on the ground.

Hover (rotorcraft)
With this setting, the UA will stop where it is, and remain in that position waiting for a signal. When the battery reaches a certain level (usually around 15%), the UA will initiate the direct landing procedure.

Loiter (fixed wing)
Because a fixed wing needs airspeed to generate lift it cannot hover in one place. So instead it will circle around a position over the ground. This is known as loitering, and the UA will remain in this state until either the connection is re-established or it has to initiate a direct landing due to low battery.

3.12.2. Proximity sensor

The addition of a proximity sensor gives the UA more functionality and makes it safer to fly. The most common proximity sensors are ultrasonic. These sensors work best over hard surfaces like concrete. Over surfaces such as grass the signal can be absorbed and the proximity sensor will be less effective.

These sensors are used most to measure distance to the ground, which can be useful when taking off and landing. They are also used to detect obstacles around the UA.

Figure 3.18 - proximity sensors.

3.12.3. Geo-fencing

Based on GNSS information received by the UA certain areas such as no-fly zones can be activated and prevent the UA from taking off. Geo-fencing can also be used to warn the pilot when flying close to sensitive areas for example, or cause the UA to land.

No-fly zones databases are updated regularly, so make sure to be familiar with the UAS user manual and how to update these zones for your UAS. Usually the software automatically checks for updates and warns you when the system is outdated, but you can usually update manually via the settings menu on the UAS.

3.12.4. Height and distance limit

Much like geo-fencing, maximum height and distance limits can usually be set up on the UA. Refer to the UAS user manual when setting these limitations, usually done via the settings menu on the UAS. 120 m should be the standard maximum height for all flights, but sometimes setting a lower height is safer if you are expecting other airspace users for example.

3.12.5. Detect and avoid systems

Some of the current generation of UAs already integrate detect and avoid systems . They can detect objects and limit or stop their movement to prevent collisions. These techniques will be further developed so UAs will be able to detect other aircraft and manoeuvre automatically to avoid one another.

3.12.6. Remote identification systems

These are electronic system that transmit information about the UA such as a registration number or operator details. This information can be used by the authorities to identify whether the UA is allowed to fly in a certain area or not. This remote ID should be updated when necessary to display the correct information, and should be updated in accordance with the UAS user manual, usually down via the settings menu on the UAS.

3.12.7. Warning indicators

When operating a UA, it is important to have some form of indicator that can warn you when about the status of the UA. This can be to show battery level, signal strength, or even if you get too close to an object.

Most UAs today use a status LED (light) mounted on the UA which can change colour and flash in different ways to communicate important information to the pilot. With some UAs you can program the colours yourself, but usually they come preprogramed and are defined in the UA's user manual. It is also possible to have warning indicators on the pilot's controller or ground station, often using a buzzer instead of a light so the pilot doesn't need to take their eyes off the UA.

The most used functions of warning indicators include:

- Battery level

- GNSS signal strength
- Control signal strength (RSSI)
- Flight mode
- Failsafe
- Distance from the pilot
- Speed

Figure 3.20 - example of status / navigation LEDs.

3.13. Safety considerations

As a pilot you always have to check that the UA is in good condition and that you have all the equipment (UA, camera, batteries, etc.) before you go to the operations site.

3.13.1. Payload

Before and after every flight you must do a quick check of the UA: can you see any damage, are all components secure, is the battery connected correctly, is there any damage to the propellers, etc.?

If the UA has a removable payload, it is especially important to check that it is secured correctly. If the payload were to come loose during flight, it could seriously affect the stability of the UA (CG) or injure people on the ground.

3.13.2. Danger of spinning propellers

UA propellers are usually made from carbon fibre, plastic or from wood. The edges can be sharp and when spinning fast can cause serious injuries. There have been reported cases of deep wounds or permanent damage to the eyes.

3.13.3. Safe handling of batteries

Most UAs use Lithium batteries. This is because they can store large amounts of energy, are lightweight, and are able to discharge very quickly without being damaged.

The downside to these kinds of batteries is that they can catch fire or even explode if handled incorrectly. If a lithium battery is damaged (by dropping, a hard landing, etc.) it is safest to stay away from it for at least half an hour. After that you can carefully investigate how serious the damage is.

Lithium battery voltage
Lithium batteries are very sensitive, and must remain between specific voltages. A single lithium cell has a nominal (average) voltage of 3.7V. It should never be charged to more than 4.2V, or

discharged below 3V. The minimum voltage of a LiPo is not exact. Some LiPo batteries can be discharged up to 3V safely, while others may be significantly damaged. It is therefore wise to add a safety margin. Generally, 3.5V is used as a minimum cell voltage.

Charging lithium batteries
You must always charge lithium batteries with a suitable charger and read the manuals of the batteries and the charger. Never charge batteries with a charging current higher than that advised by the manufacturer. If the charging current is too high the batteries can be damaged or ignite.

Always charge batteries at room temperature and never charge batteries which are very cold (< 0°C) or hot (> 45°C) to prevent damaging the batteries.

Battery storage
Lithium batteries should be stored in a battery bag, at room temperature, in a dry place. The storage temperature limits are given in the battery manual, and are often between -20° and +30°C.

Ideally a battery should be stored with around 60% charge. With the cell voltage roughly in the middle this helps prevent the battery from being damaged by falling below the minimum voltage. Storing a full battery means that if something were to go wrong the battery will release its maximum amount of energy, but by storing it at 60% means there is less energy and a more stable battery.

Batteries slowly lose power during storage. This is known as self-discharging. As a result, during storage a battery can reach a low charge state which can damage it. So even if you do not use a battery for a few months you have to check it and, if necessary, top up the charge.

Travelling with batteries
When transporting batteries in your own vehicle you must protect them against damage. It is a good idea to keep them in battery bags.

Extra information

There are restrictions on transporting lithium batteries on aircraft. Both ICAO and IATA (International Air Transport Association) have produced regulations and guidelines (support). Airlines also have their own regulations, which may be stricter than the ICAO and IATA regulations.

3.14. Maintenance

Safe and efficient operations depend on effective maintenance. The maintenance is usually described in detail in the UAS user manual.

The UA needs to be maintained in accordance with procedures determined by the manufacturer. They can specify the frequency of which maintenance must be done, usually every number of hours or flights where certain parts have to be checked, cleaned or replaced.

If you work for a small operator you probably undertake the maintenance yourself. But even if the operator has a maintenance technician, you, as the pilot, still have the ultimate responsibility for the UA during the operation.

3.14.1. Software updates

Updating the firmware and software can be very useful, especially when it comes to fixing bugs, improving accuracy and adding new features. However, it can also drastically change the way the UAS works and the flight characteristics of the UA. It is always recommended to wait a while before updating when a new update is released, so that you can check with other users and the manufacturer whether it is safe or not. After any update it is recommended to test the UAS as far as possible on the ground in a controlled environment to ensure that everything is functioning correctly before performing a test flight.

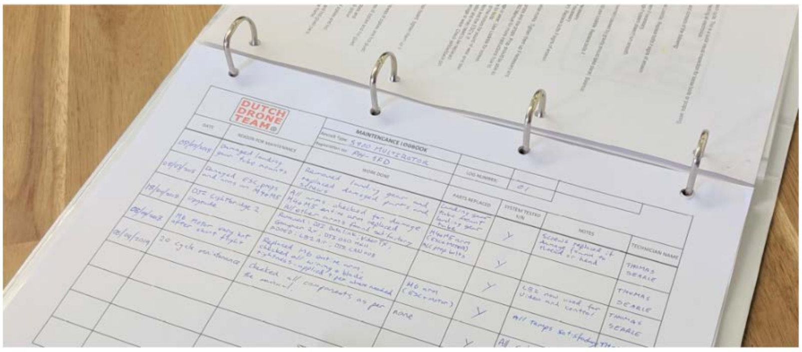


Figure 3.21 - maintenance log.

A drone operation generally consists of more aspects than you may think, beginning long before the drone even leaves the ground. Preparation for each operation needs to be done in detail to ensure that it is safe, efficient and legal.

- Open the chapter
- After you have read the chapter, we invite you to answer a number of practice questions.

Practice questions

Table of contents

4.1. Remote Pilot

The whole operation, from start to finish, is controlled by the Remote Pilot (RP). In most cases, the RP operates the ground station and flies the UA. The RP also gives instructions to the payload operator and the observer(s).

Your duties as a pilot during the operation include, but are not limited to:

- Undertaking the operation in accordance with the open category regulations
- Leading the team
- Ensuring the safety of the team, customer and bystanders at all times
- Knowing the status and operation of the UA at all times
- Having full control over the UA at all times

- Checking the weather forecast to decide if the operation can start or continue
- Staying within the operational limits of the UA (mass, centre of gravity, flight time, etc.)
- Staying within your own limitations (skill level, VLOS, IMSAFE)
- Ensuring that the UA is properly maintained before starting the operation
- Keeping everything to hand that is needed to undertake the operation safely (documentation, crowd barriers, fire extinguisher, Personal Protective Equipment (PPE), etc.)
- Monitoring anything on the ground (obstacles, vehicles, people, etc.) which can affect the operation
- Monitoring anything in the air (change in weather conditions, other UA, manned aircraft, etc.) which can affect the operation
- Checking the C2 link between the ground station and the UA (no interference from other transmitters, weather conditions, solar activity, etc.)
- Complying with all legislation
- Considering the privacy of people in houses and gardens near the operations site

As a pilot you can come across a situation where it is safer to violate the rules and regulations than to comply with them. That is permitted, but you have to be able to explain why you violated the rules and regulations.

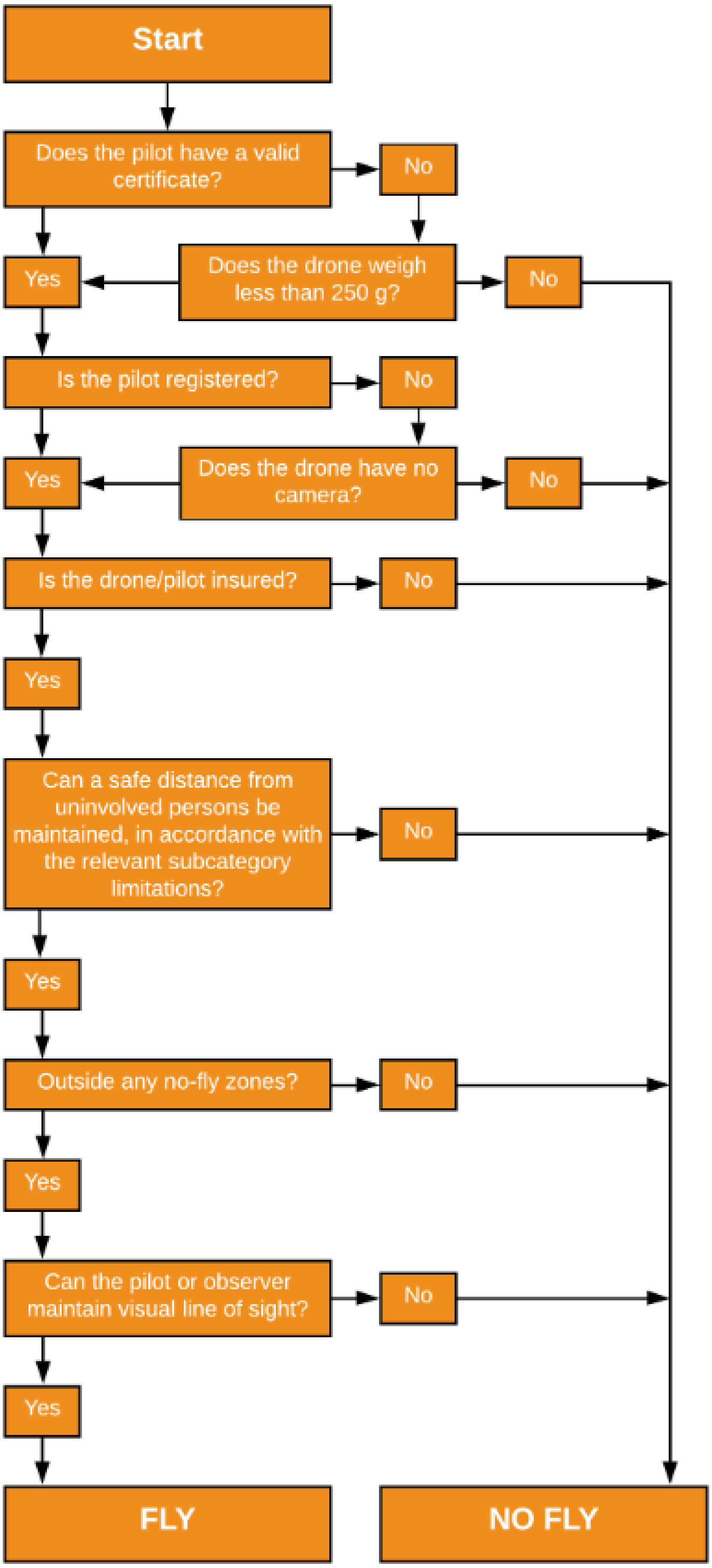


Figure 4.1 - flight preparation flow chart.

4.2. Observer

In some scenarios you may need to work with an observer. This is someone who assists you with various tasks during the operation:

- Increase your situational awareness
- Assist with maintaining visual line of sight (VLOS)
- Ensure that the landing area is clear and safe before landing
- Monitor the distance between the UA and obstructions and uninvolved persons
- Monitor the movements of uninvolved persons and informing them if necessary of the operation

You need to have good communication with the observer in order to work efficiently and safely. This needs to be discussed beforehand, and plan what to do in various situations.

Extra information

Tip: if you have agreed on the duration of the flight beforehand and want to take certain shots within that time, then it is a good idea to ask the observer to read out the time every 3 minutes. That way the pilot and everyone else involved will know how much time is left to do the planned work. If you run out of time, then decide beforehand what the most important shots are, and which you can do without. As a pilot, you don't want to have to think about that during the flight. Never rush anything - that creates stress. If you are stressed, you are much more likely to have an accident.

Sometimes having an observer is mandatory to keep the operation safe, for example when flying with FPV (first person view) goggles on.

4.3. Flight preparation

A safe and efficient operation starts with careful preparation. Flight planning starts long before a flight and you need to do many tasks before taking off. Some points to consider when planning a flight and preparing the operational site are listed below. But you always need to decide if there is anything else that could affect the operation.

Back at the office you start by planning and making the operational plan using:

- AIP (Aeronautical Information Publication) for information about the airspace
- A map of the area and satellite photographs (e.g. Google Earth), to check if there are roads, industrial sites, etc. near the work site (remember that the maps and photographs may not be up-to-date)
- A plan and photographs of the work site to identify obstacles such as trees and fences
- When working in the hills or mountains: elevation of the site above sea level

You use this information to determine:

- Areas where you can fly
- Areas to avoid

- The most efficient flying route for the operation
- Where you can take off and land
- Where you can land safely in an emergency
- Where you can park your car
- Areas where the radio link can be affected by interference (near high voltage lines, wind turbines, transmitters, heavy electrical equipment)
- Who to include in the crew (always a pilot and an observer, often a payload operator, and anyone else)
- If there is an airport near the operations site then you have to check where flying is permitted and under what conditions
- When working in the hills or mountains: if the elevation above sea level affects the performance of your UA

4.3.1. Airspace

Your first step is always to check the local AIS. This shows:

- No-fly zones
- Other relevant areas - sites used by gliders, microlight aircraft, hang-gliders, model aircraft and parachute jumpers
- Protected areas - bird breeding areas, wetlands, nature reserves, etc. in The Netherlands this is Natura 2000

After checking the AIS you use ordinary maps, aerial photographs, etc. to identify:

- Potential take-off and landing points
- Motorways and other roads
- Railway lines
- Rivers and canals
- Built-up areas
- Industry
- Civil engineering structures (kunstwerken: bridges, etc.)
- Areas where there are expected to be uninvolved people

4.3.2. Site assessment

It is always a good idea to visit the site of the operation beforehand and take notes and photographs. During the site visit consider the requirements of the flight (what to do, when, special safety requirements, etc.).

Your site assessment must include at least:

- Obstructions: trees, masts, wires, train lines, roads, industrial hazards, etc.
- View limitations: anything that makes VLOS difficult or impossible
- People: are there likely to be assemblies of people and are barriers required?
- Animals (farm animals or wild animals)
- Surface: flat, sloping, rough, wet, grass, dusty
- Public: footpaths, gates, privacy issues

- Communication: are two-way radios required?
- Take-off and landing area: safe and convenient position
- Flight area: are there any hazards or obstructions?
- Emergency area: safe and convenient position
- Return to home: any obstacles in the way in case of return to home
- Emergency services: accessible for emergency services
- Interference: any radio transmitters or masts that may interfere with the operation
- Minimum distance from residential, commercial, industrial or recreational areas as required by the relevant subcategory.

4.3.3. Uninvolved people

When operating within the open category you must pay particular attention to uninvolved persons. In your site assessment you should identify where you would expect people to be, and avoid flying over that area.

In general it is a good idea to avoid:

- Recreational areas
- Roads
- Cycling paths
- Footpaths
- Beaches

If you must fly in an area where there are likely to be other people, you should follow the 1:1 rule. This ensures that there is a safe distance between the UA and people. Placing signs or posters along the borders of your planned flight area will make others aware of you activities, thus mitigating the risk that they will wander too close to the UA.
Team meetings or briefings should be done with all members, where you discuss how to deal with uninvolved persons. At some sites you will need more observers to keep an eye on bystanders, or close the area off with red/white tape or cones. This benefits both safety and security.

Figure 4.2 - take-off and landing area with barriers.

4.3.4. Weather conditions

The manual of your UA and your operations manual specify the limits for wind, temperature, rain, etc. You have to check the weather forecast shortly before the UA operation and keep an eye on the weather while you are working. If it looks like the weather is going to deteriorate you have to prepare to stop the operation.

The Kp index must also be checked. Usually this is forecast a maximum of 3 days in advance and may change unexpectedly, so be sure to check it again before flying.

There are many sources of weather information, on the internet and mobile apps on your smartphone. Always check multiple sources and compare the forecasts to get the most reliable prediction.

4.4. VLOS

If you can see the UA at all times during the operation then it is a VLOS (Visual Line Of Sight) operation. If there are times when you cannot see the UA yourself, then you will need to fly it by following instructions given by an observer. You and the observer have to discuss the operation, and how instructions are given, in detail. In most cases you will use two-way radios to communicate with each other. An important issue is what to do when both you and the observer lose sight of the UA, or when your radio link fails.

If you are working on a construction site or an industrial site then you have to discuss the frequency or channel setting of your two-way radios. This is because they may also be using similar equipment and you need to avoid interference.

4.5. Night operations

When flying in the dark it can be difficult to maintain VLOS. Lights need to be on the UA, with different colours for the sides to help with orientation, and a green flashing light. Depending on the location, it may also be necessary to use lighting to illuminate objects that may affect the safety of the flight, as well as using additional observers to help maintain a safe distance to objects and people. Flying at night is not always permitted, so you must check with local regulations to see if it allowed.

4.6. UAS preparations

Part of the flight preparation is a ground evaluation of the UA. Is the system in working order and maintained in accordance with the maintenance manual?

Before flight, with the help of a checklist, perform a final check on the UA to make sure that everything is working correctly. This usually involves checking the battery level, propellers, connection with the transmitter and overall condition etc.

4.7. Checklists

Checklists play a vital role in every operation. They are often the last safety barrier before a problem may occur. While procedures for every stage of an operation are carefully thought out to avoid unsafe situations, having a checklist as a safety net is very effective in catching things which you might have missed or glanced over. Just as with manned aviation, there are stages of a flight which require a higher level of safety and are more demanding on the pilot and crew. This is where a checklist is used.

When operating, you must make sure you have all the necessary checklists with you on hand. It also helps to have already read them, so that when it comes to completing them they are already familiar to you. Some good examples are:

- Embarkation checklist (ensure you have everything with you before you leave the office)
- Arrival checklist (check that nothing was forgotten or damaged during travel)
- Pre-flight checklist (check that the UAS is safe to fly and that everything works correctly)
- Post-flight checklist (check that the UAS was not damaged during flight and has been shut down correctly)

In addition to the above, it can be useful to have a checklist of your own to help make the mission go more smoothly. It can even include simple things such as remembering to bring lunch and water, or sun protection and glasses.

Figure 4.3 - pre-flight checklist.

4.8. Flying the operation

Once you have spent hours at your desk preparing for the operation it is time to go to the operations site, put you high-visibility vest on and get flying! Because there are many things to consider you really have to use checklists to make sure you do not overlook anything.

During the operation you must constantly check if the conditions are starting to change. Here are some examples:

- The wind gets stronger
- Somebody parks a truck on the spot where you want to land
- The customer realises they did not clearly describe the part of the building you have to inspect
- Your UA develops a technical problem

If you have planned the operation carefully, which includes considering what can go wrong, you will be able to adapt to changing circumstances. You must always be ready to stop the operation when necessary.

4.9. Communication

In aviation, communication not only includes the use of a radio but also how you communicate with the people around you during a flight.

Operating in a team is the best way to ensure that you, as the pilot, do not become overloaded with tasks (task saturated). Having more team members who you can allocate tasks to means that you can focus more attention on flying the UA. Operating alone is strongly discouraged, the main reason being that whilst piloting a UA it is very difficult to deal with anything else. Not only is this true for managing the flight itself but also dealing with unwanted intrusions, customers or even malicious interference and injury.

Sometimes, however, you may have a customer who is willing to assist with the operation. In this case it is important to brief them thoroughly on what you expect of them before, during, and after the flight. Also be wary of their ability carry out their role, and since you may have only just met the customer it is important to gauge their how well they communicate.

A crew briefing well before hand is always a good idea, and how you communicate with your team is the most important aspect to cover. Depending on the size of your crew, it can be useful to have a member whose only role is to stand next to you and have any person wishing to speak to you to speak to them instead. This can be particularly helpful when working in a crowded area (assemblies of people).

> Extra information
>
> Authority of control is more relevant to manned aircraft where multiple pilots must clearly indicate who is the one flying, but is also important to UA operations if there is more than one pilot. This is most often the case with flight training, where the instructor can give control to a second transmitter for a student by the press of a button. Handover of control is always stated by one pilot, “your control” and then acknowledged by the other, “my control”.

During flying lessons with an instructor, the instructor is considered to be the responsible "remote pilot". He is responsible for a safe execution and must be able to take over the control of the UA at any time.

Figure 4.4 - two pilots passing control.

4.10. Operating with other air users

When operating with multiple UAs in the same area you need to discuss beforehand how to safely maintain separation.

4.11. Normal procedures

4.11.1. Take-off

Before starting the operation, check the surroundings to ensure that people are at a safe distance and check that your crew is ready. After setting the failsafe and checking for any warnings, start the motors. If you use checklists, make sure to use them at the relevant moments (pre-flight, in-flight, post-flight).

Take off and begin the flight as planned. Checking the flight controls after take-off is a good idea, climb to 2 m above the take-off point move the controls to make sure they are functioning correctly.

4.11.2. During flight

During the flight you must keep the UA in visual line of sight (VLOS). You must also maintain situational awareness, checking for other air traffic and making sure the situation on the ground stays safe. When working with an observer they can assist you with situational awareness. Monitor the height of the UA at all times to ensure you do not exceed any height limitations, and the battery level so that there is enough left to return to land safely.

Make sure that during the flight you have control of the UA and are able to avoid any obstacles or people that get in the way.

4.11.3. Landing

Before returning you must ensure that the landing area is clear and safe. If you are working with an observer, you can ask them to check that the landing area is ready.

When you are unable to land for whatever reason, then you must manoeuvre the UA to a predetermined alternate landing area.

After landing stop the motors and turn off the UA or prepare for another flight. After completing a flight the UA needs to be checked for damage, usually done with the help of a checklist. Backup any image and video recordings if necessary and fill in the logbooks.

4.12. Contingency and emergency procedures for abnormal situations

4.12.1. Incursion of (uninvolved) persons in the area of operation

Despite good flight preparation and warning signs there is a possibility of an incursion of uninvolved persons. Always keep your drone at a safe distance. The observer can confront the person and kindly ask them to leave the area of operation. If necessary, land the drone in the designated landing area (or alternate landing area).

4.12.2. Exceeding the area of operation

There are circumstances when the drone goes outside the planned area of operation. This could be, for example, when you lose orientation or have problems with the controls. First try to fly the drone back to the area of operation. If that doesn’t work, try to activate the failsafe. If nothing works, inform (if applicable) the nearest airfield, the police, and uninvolved persons that may be in the drone's flight path.

4.12.3. Incursion of manned aircraft in the area of operation

Airplanes, helicopters and other manned aircraft usually fly with high speed and can show up unexpectedly. If this happens, immediately descend the drone. When the danger has passed, you can continue with your operation. When working together with an observer make arrangements prior to the flight on how to communicate, for example: "Helicopter at 3 o clock!"

4.12.4. Smoke or fire

If the UA catches fire or emits smoke, you must:

- Warn all other crew members
- Warn members of the public in the area and keep them at a safe distance
- Assess the source of the smoke or fire
- If the source is the battery: stay clear of the smoke and use the fire extinguisher to prevent the fire from spreading.
- If the source is not the battery: disconnect the battery and use the fire extinguisher if necessary (if there is only smoke and no fire then disconnecting power will often stop further smoke developing)
- Inform the emergency services if necessary
- Take photographs of the incident
- Write a report, including photographs

If there is a fire, there is little time to discuss or coordinate what to do. So you must discuss the action plan before the operation. All crew members must assist where they can. This includes calling the emergency services and evacuating the area, if necessary. Suitable portable fire extinguishers must be available at the operating site. LiPo batteries can lead to serious fires and produce dangerous fumes.

The key task of all crew members is to prevent further injuries in case of an accident.

Figure 4.5 - type D fire extinguisher.

4.12.5. Emergency landing

Not all systems are intuitive to use, and some include special safety functions. This means you have to be thoroughly familiar with the system you work with. Safety systems can land the UA automatically if there is a problem with the control system or the radio link. As the pilot, you have to check the operation of the safety system before the start of the flight.

In the event of an emergency landing you must make sure that the landing area is clear (or have another crew member clear the area). It is a good idea to have a predetermined emergency landing area cordoned off so that you do not need to waste time clearing the area.

In some cases you can initiate a return home function. In that case the UA will first climb or descend to a pre-set height, then fly back to the home location and land automatically. As the pilot you can select the home location at the start of the operation. Some UAs use the location where the system was initialised as the home location.

4.12.6. Loss of radio link

When the UA loses the C2 link then it automatically switches to failsafe mode. This needs to be set up before the flight accordingly.

While the UA is following the failsafe procedure, check that the landing area is clear and safe. The landing area will depend on the failsafe setting, for example for a “direct landing” failsafe you will need to clear the area directly below the UA.

4.12.7. Loss of GNSS signal

GNSS is a general term which covers all satellite navigation systems, but most UAs and pilots still just call it GPS. Many flight modes rely heavily on the UA knowing exactly where it is, and if this system fails then these modes will no longer function safely. The most important use of GNSS is the failsafe.

Loss of GNSS signal will generally not trigger the failsafe, but rather switch to the next most stable flight mode. This is normally some form of horizon hold (ATTI mode with DJI drones), where the UA will keep level with the horizon and maintain altitude but drift with the wind.

Failsafe without the help of GNSS is still possible, but with limited functionality. Return to home will no longer work because the UA will not know which direction to go. Direct landing and hover/loiter will work however, but remember that the UA will drift with the wind and probably end up some distance away from the operating area.

4.12.8. Fly away

A fly away means the UA does not respond to control input from the pilot and begins to fly away. If that happens you must make a note of the route, speed, height and battery status of the UA. Next you inform the local air traffic control centre and the police. You tell them about the route, height and remaining flying time. If the UA is flying a programmed route it will probably keep following that and not climb or descend. You must try to discover if the GNSS unit on the UA still works. If it does not then the UA may change its heading and ground speed.

It is a good idea to fit your UA with a tracking unit. This is a small device with a transmitter which acts as a beacon. With a receiver showing the direction to the transmitter you can find the UA.

4.12.9. Pilot incapacitation

If the pilot becomes incapacitated, for whatever reason, during a flight the observer or another team member must take control of the UA. Depending on whether they are competent in flying the UA or not, initiating the failsafe procedure may be the safest option. This is an important point to be discussed during the crew briefing.