BVLOS
Beyond Visual line of Sight RPAS Level 1 Complex Preparation Course

Brampton
Flight Centre

Overview

- Introduction
- Catagories
- Costs
- RPAS Operator Certificate
- Regulations
- Safety Factors
- Exams
- Licensing
- Flight Review Requirements

Certification

At the end of this course, you will be issued a certificate of completion. This Certificate and your record of the course and flight reviews will be kept as required by Transport Canada.

The Certificate will indicate that you have completed the required 20 hours of Ground School for the LLC1 Transport Canada Certificate. You will be required to complete a LLC1 Flight Review, and you will have to submit your RPOC (RPAS Operators Certificate to Transport Canada)

New regulatory structure for RPAS

RPA are regulated under the CARs. Part IX of the CARs deals with RPA by operating weight and complexity of the operation to be conducted. Prior to the 2025 amendments, Part IX covered up to and including 25 kg (55 lb) flown in visual line of sight (VLOS). Other operations like above 25 kg and BVLOS operations required a Special Flight Operations Certificate – RPAS.

The 2025 amendments to Part IX added operations of medium RPA that weigh more than 25 kg (55 lb) up to and including 150 kg (331 lb) and introduced rules for beyond visual line-of sight (BVLOS), sheltered, and extended VLOS operations.

Operating environments are divided into basic operations, advanced operations, and level 1 complex operations.

Level 1 complex operations covers small RPA and medium RPA operated in BVLOS below 400 feet in uncontrolled airspace, over unpopulated and sparsely populated areas, and away from aerodromes.

Other operations using RPA that do not fall within the scope of these regulations will continue to require a Special Flight Operations Certificate–RPAS from Transport Canada

Introduction

The ability to fly your RPAS in a Beyond Visual Line of Sight conditions opens up a wealth of opportunities for RPAS users but also opens up many safety and logistical issues.

Benefits Of BVLOS Drone Operations

- BVLOS flights are autonomous. Controlled by data provided by onboard instruments, UAVs flying BVLOS can change flight parameters, depending on position, altitude, speed, and direction of flight.
- With BVLOS flights, companies can cover long distances – between 20 and 30 miles a day and collect high-quality data more quickly than traditional means.
- BVLOS drone operations allow companies to save money to reinvest, innovate, and create more jobs.
- BVLOS is cost-effective.
- It enables service providers to conduct complex drone operations without human interference.
- BVLOS allows a drone to collect more data in fewer deployments.
- It significantly reduces the risk of accidents.
- It prevents humans from being placed in a dangerous situation, either removing them from an aircraft or a hazardous area.

What Is Beyond Visual Line Of Sight (BVLOS)?

Beyond Visual Line Of Sight (BVLOS) operations means flying an unmanned aircraft without the Remote Pilot, keeping a visual line of sight on the UAVs at all times. Instead, the Remote Pilot flies the aircraft by instruments from a Remote Pilot Station (RPS) instrument.

Commercial businesses that utilize BVLOS drone operations can significantly reduce expenses and maximize their investment in drone technologies. According to a case study by Precision Hawk, for instance, an electric utility company that inspects 10,000 miles of power lines a year would save $1.7 million in the first year of operation, a saving that could amount to $9 million over five years. With a manned helicopter, the costs range from $40-$700 per mile, whereas, with a BVLOS drone, the cost ranges from $10-$25 per mile of inspection. These potential savings could be applied to many more businesses across various industries.

BVLOS Categories Level 1 Low Risk Operations

Defining Level 1 Low risk operations

Remote Areas

Two phases for coming into force

The new regulations will come into force in two phases to give stakeholders time to get their appropriate training, certification, and to familiarize themselves with the new rules.

You can now start flying BVLOS, EVLOS, or Sheltered operations as of **November 4, 2025**.

You will be able to take the new Level 1 Complex exam and apply for an RPAS Operator Certificate (RPOC) through the Drone Management Portal starting **April 1, 2025**.

This approach avoided changing operating rules during the peak summer flying season in 2025. If you wanted to fly these types of operations before November 4, you still needed to apply for a Special Flight Operations Certificate.

Lower-risk beyond visual line-of-sight (BVLOS)

The new regulations introduce a new pilot certification process for lower-risk BVLOS called Level 1 Complex Operations. To conduct lower-risk BVLOS, you must:

- Be at least 18 years old
- Pass the online exam for advanced and Level 1 Complex Operations
- Complete at least 20 hours of ground school and successfully pass a flight review

Individuals, businesses, and organizations wishing to conduct BVLOS operations must have an RPAS Operator Certificate (RPOC). To obtain an RPOC, pilots, businesses, and organizations will be required to have policies and procedures in place that reflect the size and complexity of the operations they will carry out.

Where can you fly ?

Where you will be able to fly BVLOS

All lower-risk BVLOS operations must

- remain in uncontrolled airspace
- stay below 122 meters (400 feet)
- stay away from airports and aerodromes

If you are flying a small or medium drone, you may operate at least 1 km away from a populated area.

If you are flying a small drone, you may also operate over a sparsely populated area or less than 1 km from a populated area.

Expanding privileges for Advanced Pilot Certificates

As of November 4, 2025, the following drone operations will be permitted for pilots with a Pilot Certificate – Advanced Operations:

- Sheltered operations
- Extended visual line-of-sight (EVLOS) operations
- Medium drones within VLOS

If you already hold a Pilot Certificate – Advanced Operations today, you do not need to re-apply for your certificate, however you do need to familiarize yourself with the new operating rules. And make sure you keep your certificate current!

Sheltered operations

Sheltered operations are flights with a small drone that are close to a structure, such as a building. To conduct sheltered operations, you must fly the drone:

- More than 30 meters (100 feet) away from people not involved in the operation
- No greater than 30 meters (100 feet) above the structure
- Less than 61 meters (200 feet) horizontally from the structure

Extended visual line-of-sight (EVLOS) operations

EVLOS operations are short-range flights with a small drone, but where the drone is far away enough from the pilot that it cannot be seen by an unaided eye. To conduct EVLOS, you must:

- Remain in uncontrolled airspace
- Fly more than 30 meters (100 feet) away from people not involved in the operation
- Receive assistance from a trained Visual Observer (VO) holding an RPA pilot certificate
- Fly the drone within 2 nautical miles (3.6 km) of yourself, the VO and the Control Station

VLOS, EVLOS AND BVLOS – WHAT IS THE DIFFERENCE?

The acronyms VLOS, EVLOS and BVLOS are commonly used in the world of unmanned aerial vehicles and their systems –, but often questions arise on what each of them actually mean and how to evaluate to match it to your planned flight mission.

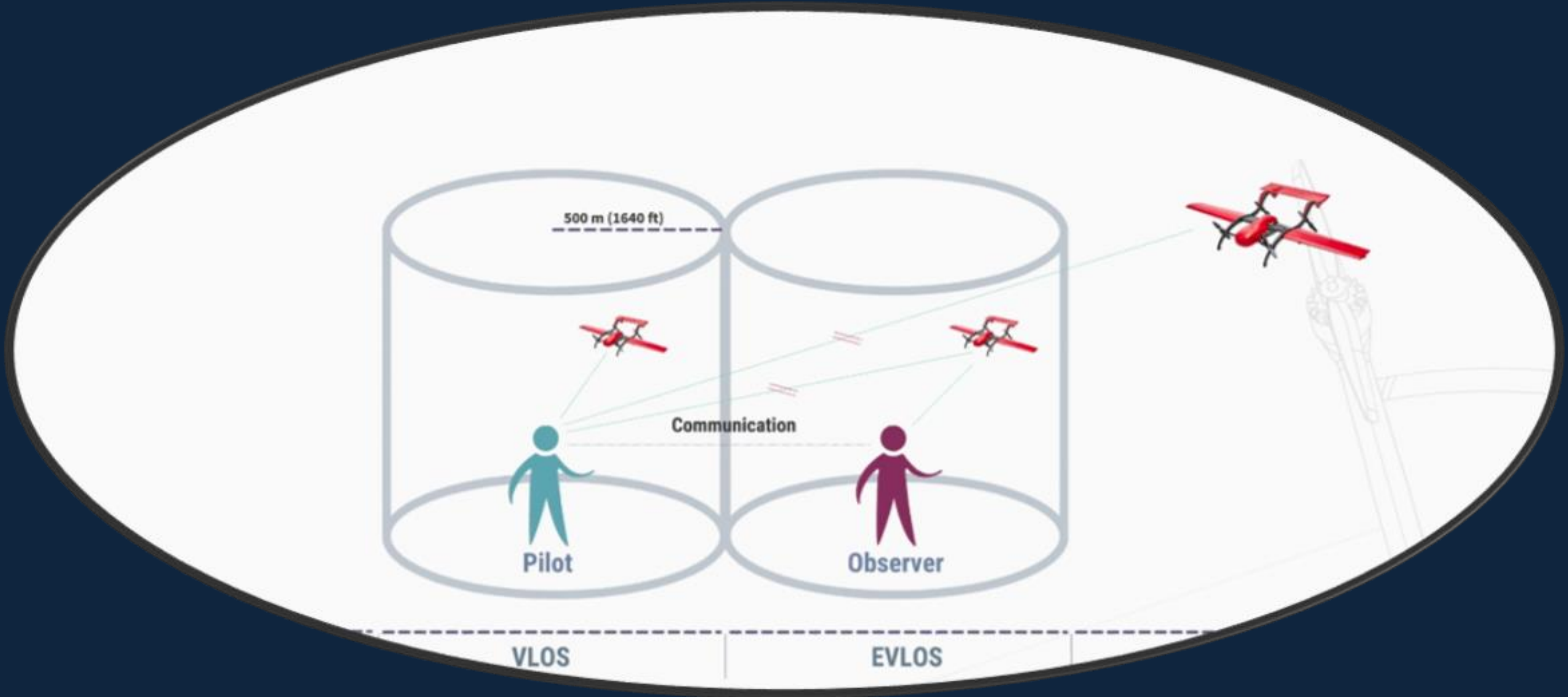
Let’s begin with a closer look at each of these terms.

VLOS stands for **Visual Line of Sight**, meaning that the drone during the entire flight mission must be clearly visible by the drone operator without any additional aid – equipment such as binoculars, FPV goggles etc. The operator monitors the area and controls the UAV to avoid any collisions or obstacles.

EVLOS stands for **Extended Visual Line of Sight**. This allows to operate a drone further than VLOS by using one or more visual observers. The observers must be trained and instructed. During the flight observers keep a visual contact with the drone and communicate with the drone operator about observations and alerts the pilot if necessary.

BVLOS stands for **Beyond Visual Line of Sight**. In this mode, the drone operator does not maintain visual contact with a drone at all times, and the drone is able to carry out a mission without assistance of observers. The drone operator uses a remote pilot station or ground control station to monitor and control the mission.

EVLOS operations example



Medium drones within VLOS

To fly your medium drone within VLOS, the drone must be declared as safe and able to perform the specific advanced operations that you want to conduct. You can fly medium drones in uncontrolled airspace or in controlled airspace with permission from air traffic control. (over 25 kg up to 150 kg)

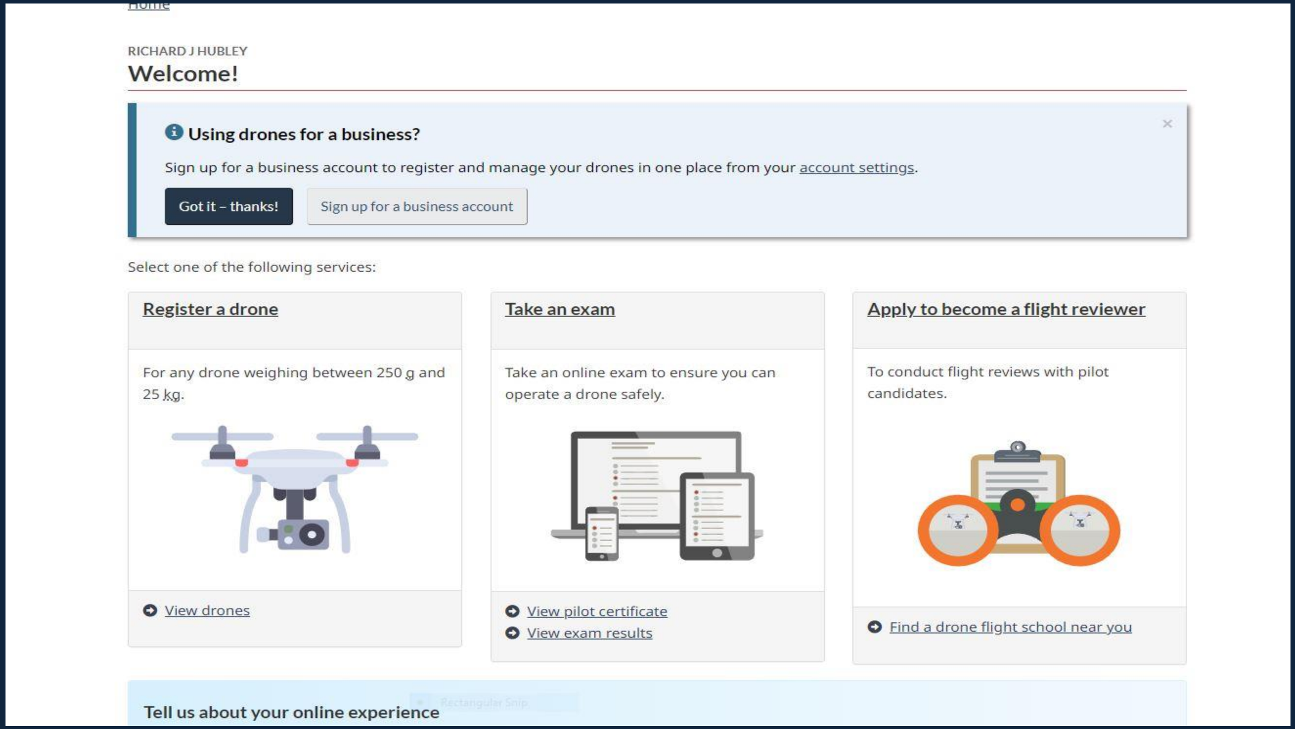
New requirements for microdrones at advertised events

As of April 1, 2025, an SFOC will now be required to fly microdrones at advertised events.

Examination prerequisites

Candidates for exams must create an account on the Transport Canada Drone Management Portal. Prior to attempting the Remotely Piloted Aircraft Systems – Level 1 Complex Operations exam the candidate must have completed the required Level 1 complex operations ground school instruction and the Advanced Exam.

NOTE: Applicants must be able to read the examination questions in either English or French without assistance. Requests for accommodations may be made in advance using the contact information in the Drone Management Portal.



New and updated service fees for services provided by Transport Canada
Introducing fees for new exams, certificates, and declarations.

Service	New Fee
Level 1 Complex Operations Exam	$50
Pilot Certificate – Level 1 Complex Operations	$125
Pre-Validated Declarations	$1,200
RPAS Operator Certificate (RPOC)	$125

As of November 4, 2025, anyone applying for an SFOC-RPAS will need to pay a fee, except for government organizations involved with emergency response. These operations include higher altitude flights, operations at an advertised event, and flying a drone that weighs more than 150 kg.

Service	New Fee
SFOC – Very Low complexity	$20
SFOC – Low complexity	$75
SFOC – Medium complexity	$900
SFOC – High Complexity	$2,000

As of April 1, 2025, drone registration fees increased to $10.00

Materials required

The examinations are delivered via computer and requires an internet connection. However, we suggest having a pencil and paper handy before beginning the examination, to take notes, make diagrams or execute calculations during the examination.

Time limits and pass marks

Examination	Questions	Time limit	Pass mark
Remotely Piloted Aircraft Systems – Level 1 complex operations:	50	1 ½ hours	80%

Rewriting of examinations

In the case of any RPAS examination, the examination may be rewritten after 24 hours.

Examination feedback

Feedback statements in the results letter will inform the candidate the subject of questions that were answered incorrectly. Feedback will outline general subject areas, to ensure exam integrity is maintained.

Example of feedback statement:

Identify classes of airspace from an aeronautical chart.

Recommended study material

Transport Canada publications (TP), including the following, may be purchased from retailers, or at the following web site: http://www.tc.gc.ca/eng/civilaviation/publications/menu.htm.

Transport Canada Aeronautical Information Manual (TC AIM) (TP 14371)
http://www.tc.gc.ca/eng/civilaviation/publications/tp14371-menu-3092.htm

AC 903-001 – Remotely Piloted Aircraft Systems Operational Risk Assessment
https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars#900-series

AC 107-002 – Safety Management System Development Guide for Smaller Aviation Organizations
https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-

107-002Human Factors for Aviation – Basic Handbook (TP 12863),
https://tc.canada.ca/en/aviation/publications/air-publications-abstracts#tp12863

Knowledge areas: ....

Section 1: air law, air traffic rules and procedures (APK)

Section 2: RPA airframes, power plants, propulsion, and systems (KNO) ....

Section 3: Human factors (SAW / KNO / LTW / WLM / PSB) ....

Section 4: Meteorology (APK / KNO) ....

Section 5: Navigation (APK / KNO / SAW / PSD) ....

Section 6: Flight operations (WLM / SAW / KNO / LTW) ....

Section 7: Theory of flight (KNO / FPM) ....

Section 8: Radiotelephony (APK / KNO / PSD / COM) ....

New regulatory structure for RPAS

Operating environments are divided into basic operations, advanced operations, and level 1 complex operations.

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Other operations using RPA that do not fall within the scope of these regulations will continue to require a Special Flight Operations Certificate–RPAS from Transport Canada.

General RPAS exam information

Where to write the examinations
The examinations required for the operation of RPAS may only be completed online via the Transport
Canada Drone Management Portal.

https://tc.canada.ca/en/aviation/drone-safety

Examination prerequisites
Candidates for exams must create an account on the Transport Canada Drone Management Portal.
Prior to attempting the Remotely Piloted Aircraft Systems – Level 1 Complex Operations exam the candidate must have completed the required Level 1 complex operations ground school instruction and the Advanced Exam.

NOTE: Applicants must be able to read the examination questions in either English or French without assistance. Requests for accommodations may be made in advance using the contact information in the Drone Management Portal.

(Definitions)

Define remotely piloted aircraft.
Define remotely piloted aircraft system.
Define command and control link.
Define control station.

Administration and Compliance

Who may demand to inspect aviation documents ?

Computer-stored records may be used in place of paper records if measures are taken to protect them.

Transport Canada (Minister)

Any Law Enforcement Agency


Transport Canada

Pilot certificate

Small Remotely Piloted Aircraft System (RPAS), Visual line-of-sight (VLOS)

The individual indicated below may exercise their privileges to fly a drone subject to the rules and regulations listed on the back and set out under the Canadian Aviation Regulations (CAR).

Issued to:
John Drone
6400 Nancy Greene Way
North Vancouver, BC V7R 4K9

Date issued (YYYY-MM-DD): 2019-01-30

Certificate number: PC1234567890

Transport Canada account: TC123456789

☑ Basic operations ☐ Advanced operations ☐ Flight reviewer rating

Rules and regulations

This is not a legal document. For information only.

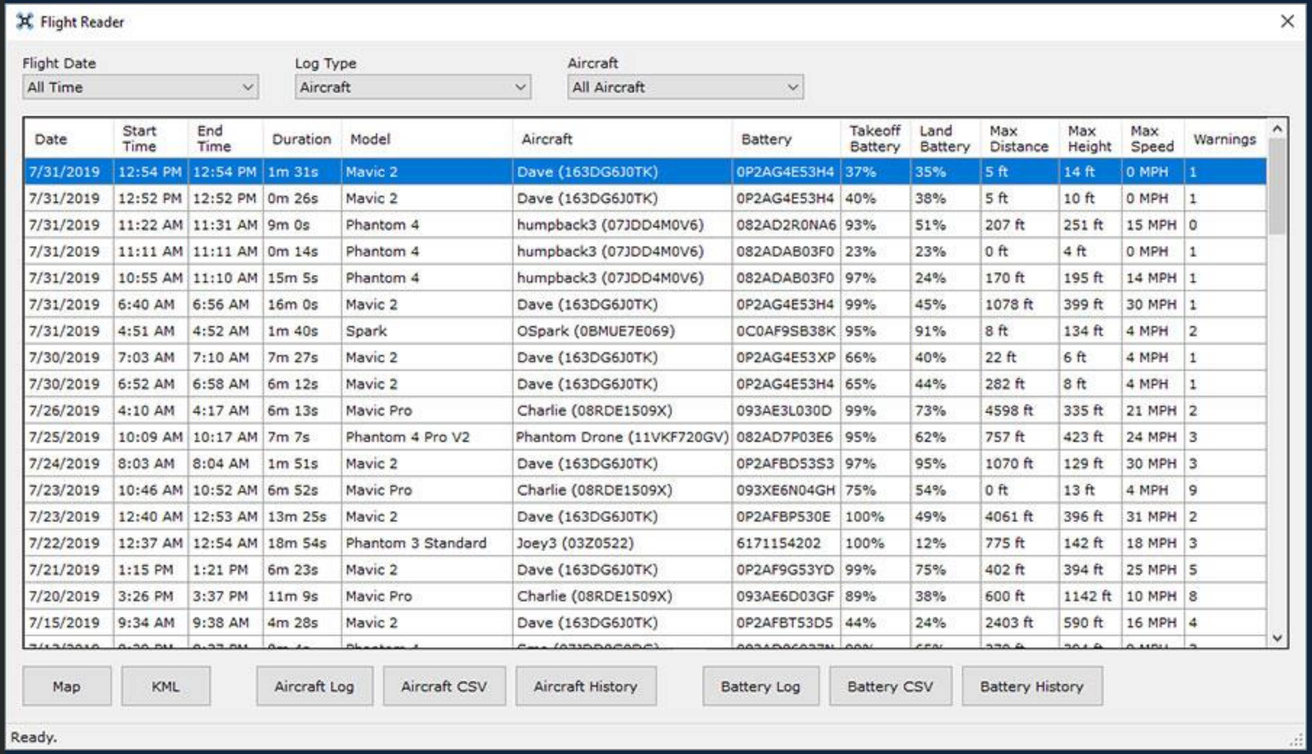
Pilot
- Must be at least 14 years of age (CAR 901.54)
- Must meet recency requirements (CAR 901.56)

Drone
- Register with Transport Canada (CAR 901.02)
- Marked with a Transport Canada registration number (CAR 901.03)
- Properly maintained to manufacturer instructions (CAR 901.29)

Operating rules
- Maintain visual line-of-sight (VLOS) at all times (CAR 901.11)
- Must be fit to fly, which includes not suffering from fatigue or having consumed drugs or alcohol within the last 12 hours (CAR 901.19)
- Remain in uncontrolled airspace (CAR 901.14)
- Night operations permitted with proper lighting (CAR 901.39)

Safe distances
- Maximum altitude of 400 ft (122 m) (CAR 901.25)
- No flights within 5.6 km (3 nautical miles) of an airport, or 1.9 km (1 nautical mile) of a heliport (CAR 901.47)
- 100 ft (30 m) minimum horizontal distance from people (CAR 901.26)

Computer-stored records may be used in place of paper records if measures are taken to protect them.



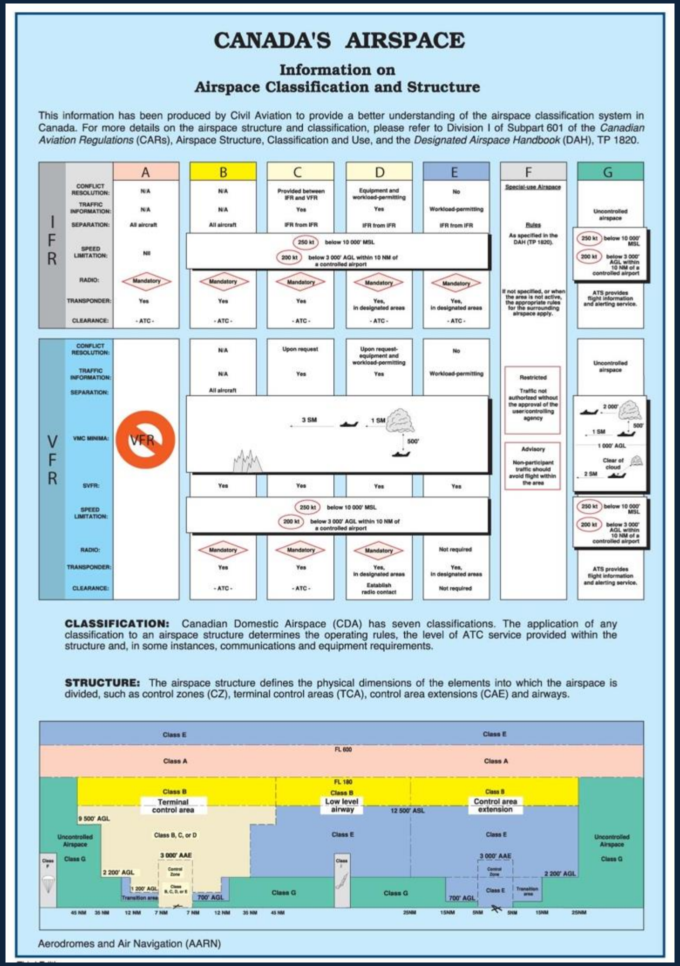
Flight Reader

Date	Start Time	End Time	Duration	Model	Aircraft	Battery	Takeoff Battery	Land Battery	Max Distance	Max Height	Max Speed	Warnings
7/31/2019	12:54 PM	12:54 PM	1m 31s	Mavic 2	Dave (163DG6J0TK)	0P2AG4E53H4	37%	35%	5 ft	14 ft	0 MPH	1
7/31/2019	12:52 PM	12:52 PM	0m 26s	Mavic 2	Dave (163DG6J0TK)	0P2AG4E53H4	40%	38%	5 ft	10 ft	0 MPH	1
7/31/2019	11:22 AM	11:31 AM	9m 0s	Phantom 4	humpback3 (07JDD4M0V6)	082AD2R0NA6	93%	51%	207 ft	251 ft	15 MPH	0
7/31/2019	11:11 AM	11:11 AM	0m 14s	Phantom 4	humpback3 (07JDD4M0V6)	082ADAB03F0	23%	23%	0 ft	4 ft	0 MPH	1
7/31/2019	10:55 AM	11:10 AM	15m 5s	Phantom 4	humpback3 (07JDD4M0V6)	082ADAB03F0	97%	24%	170 ft	195 ft	14 MPH	1
7/31/2019	6:40 AM	6:56 AM	16m 0s	Mavic 2	Dave (163DG6J0TK)	0P2AG4E53H4	99%	45%	1078 ft	399 ft	30 MPH	1
7/31/2019	4:51 AM	4:52 AM	1m 40s	Spark	OSpark (0BMUE7E069)	0C0AF9SB38K	95%	91%	8 ft	134 ft	4 MPH	2
7/30/2019	7:03 AM	7:10 AM	7m 27s	Mavic 2	Dave (163DG6J0TK)	0P2AG4E53XP	66%	40%	22 ft	6 ft	4 MPH	1
7/30/2019	6:52 AM	6:58 AM	6m 12s	Mavic 2	Dave (163DG6J0TK)	0P2AG4E53H4	65%	44%	282 ft	8 ft	4 MPH	1
7/26/2019	4:10 AM	4:17 AM	6m 13s	Mavic Pro	Charlie (08RDE1509X)	093AE3L030D	99%	73%	4598 ft	335 ft	21 MPH	2
7/25/2019	10:09 AM	10:17 AM	7m 7s	Phantom 4 Pro V2	Phantom Drone (11VKF720GV)	082AD7P03E6	95%	62%	757 ft	423 ft	24 MPH	3
7/24/2019	8:03 AM	8:04 AM	1m 51s	Mavic 2	Dave (163DG6J0TK)	0P2AFBD53S3	97%	95%	1070 ft	129 ft	30 MPH	3
7/23/2019	10:46 AM	10:52 AM	6m 52s	Mavic Pro	Charlie (08RDE1509X)	093XE6N04GH	75%	54%	0 ft	13 ft	4 MPH	9
7/23/2019	12:40 AM	12:53 AM	13m 25s	Mavic 2	Dave (163DG6J0TK)	0P2AFBP530E	100%	49%	4061 ft	396 ft	31 MPH	2
7/22/2019	12:37 AM	12:54 AM	18m 54s	Phantom 3 Standard	Joey3 (03Z0522)	6171154202	100%	12%	775 ft	142 ft	18 MPH	3
7/21/2019	1:15 PM	1:21 PM	6m 23s	Mavic 2	Dave (163DG6J0TK)	0P2AF9G53YD	99%	75%	402 ft	394 ft	25 MPH	5
7/20/2019	3:26 PM	3:37 PM	11m 9s	Mavic Pro	Charlie (08RDE1509X)	093AE6D03GF	89%	38%	600 ft	1142 ft	10 MPH	8
7/15/2019	9:34 AM	9:38 AM	4m 28s	Mavic 2	Dave (163DG6J0TK)	0P2AFBT53D5	44%	24%	2403 ft	590 ft	16 MPH	4

General operating and flight rules

Airspace

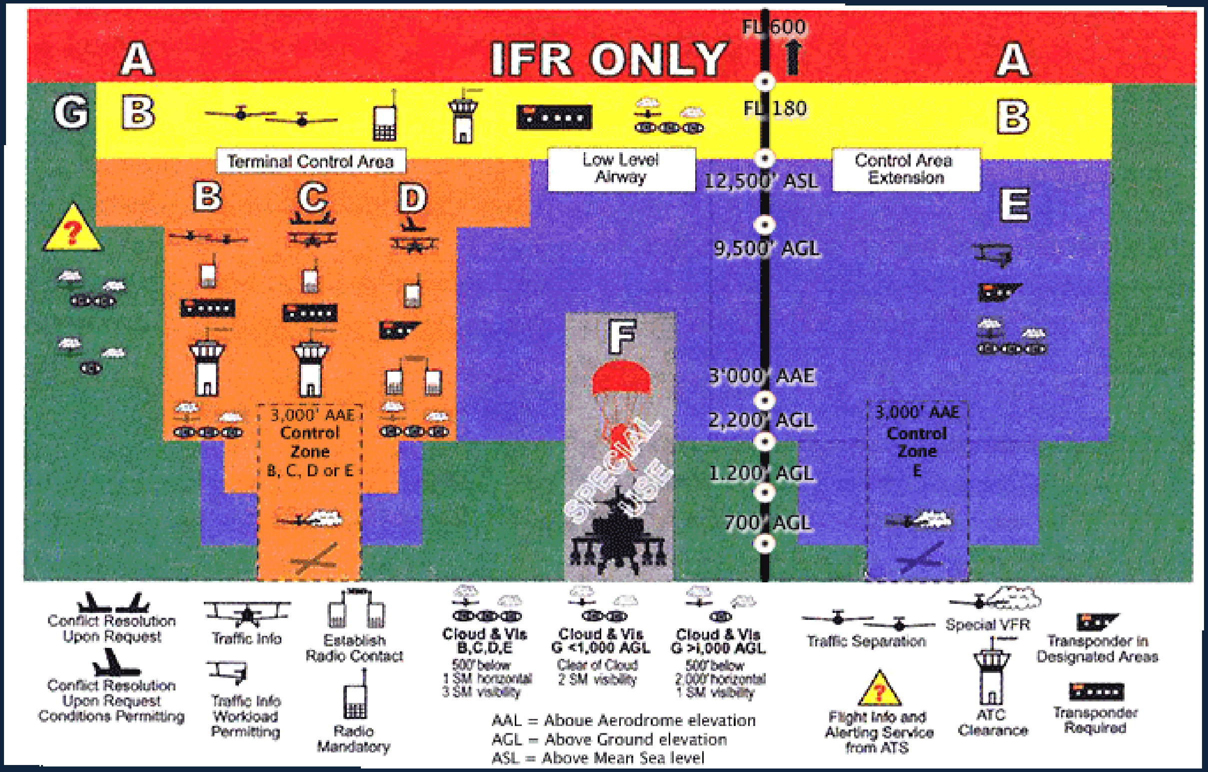
Airspace structure, classification, and use



Airspace Classification – Controlled

601.02: (1) The class of any controlled airspace of a type referred to in subsection 601.01(1) is one of the following, as specified in the Designated Airspace Handbook:

Class A;
Class B;
Class C;
Class D;
Class E;
Class F Special Use Restricted; or
Class F Special Use Advisory



Airspace Classification – Uncontrolled

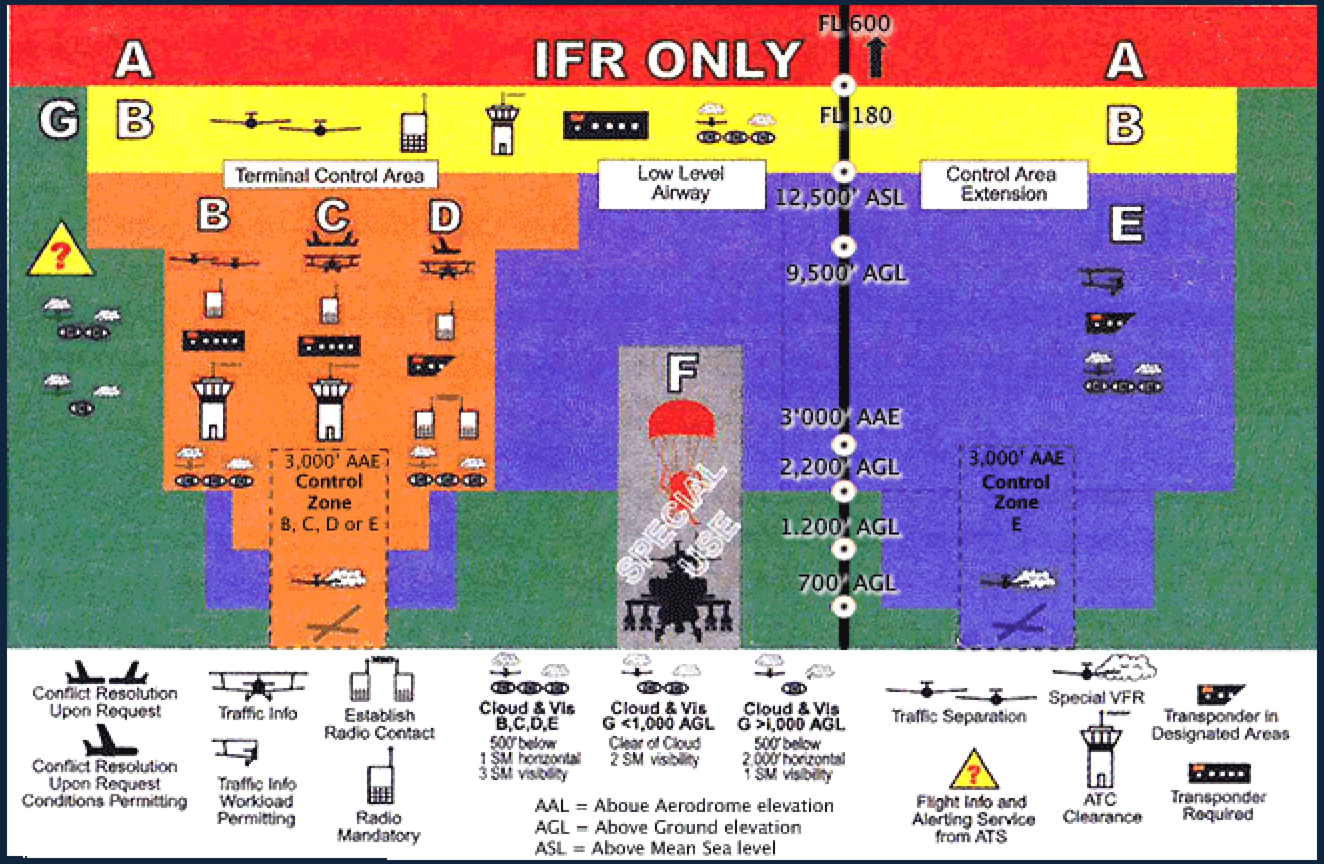
601.02 cont.:(2) The class of any uncontrolled airspace of a type referred to in subsection 601.01(2) is one of the following, as specified in the Designated Airspace Handbook:

Class G;

Class F

Special Use Restricted (CYR); or

Special Use Advisory (CYA)



Airspace

Special Use – Class F – Advisory, Danger, Restricted!

Class F Airspace is special use airspace and can be either restricted or advisory. Class F can be controlled airspace, uncontrolled airspace, or a combination of both, depending on the classification of the airspace surrounding it.

Class F Restricted Airspace

Class F restricted airspace is denoted as CYR followed by three numbers (e.g. CYR123). The letter D for danger area will be used if the restricted area is established over international waters. Class F restricted airspace is identified on all VNCs and VTAs as well as the National Research Council Canada drone site selection tool and is restricted to all airspace users except those approved by the user agency. CYRs can be found over federal prisons and some military training areas, for example. To gain access to Class F Restricted airspace, RPA pilots should contact the user agency as listed for the specific block of airspace in the DAH.

Class F Advisory Airspace

Class F Advisory airspace is denoted as CYA followed by three numbers (e.g. CYA123). Class F advisory airspace is identified on all VNCs and (VTAs as well as the National Research Council Canada Drone site selection tool. CYA denotes airspace reserved for a specific application such as hang-gliding, flight training, or helicopter operations. RPA pilots are not restricted from operating in advisory airspace and no special permission is required, but pilots should be aware of the reason the airspace has the advisory and take steps to identify any additional risks and mitigate them. Many activities in a CYA often bring directly piloted (manned) aircraft into airspace below 400 ft AGL and are therefore a greater risk to RPA operations.

Useful terms to know

Populated area means an area with more than five people per square kilometer.

Sparsely populated area means an area with more than 5 but not more than 25 people per square kilometer.

Visual Observer (VO) means a crew member who is trained to assist the pilot in ensuring the safe conduct of a flight.

Advertised event means an outdoor event that is advertised to the public, like a concert, festival, market or sporting event.

Definitions:

New Terms You'll Want to Remember

Beyond Visual Line of Sight (BVLOS): Operations where the pilot cannot see the drone with the naked eye during flight.

Extended Visual Line of Sight (EVLOS): Operations where the pilot maintains control of the drone beyond direct and unaided sight, typically with the support of a visual observer.

Sheltered Operations: Flights carried out in controlled areas near buildings or structures, where maintaining direct Visual Line of Sight or using a visual observer may not always be possible.

Level 1 Complex Certificate: A certification that qualifies operators to perform specific types of complex operations, including certain BVLOS flights.

RPAS Operator Certificate (RPOC): A certificate for operators that allows them to legally conduct advanced or complex drone operations under the new regulatory framework.

Populated Area: An area where more than five people live per square kilometer.

Sparsely Populated Area: An area where there are more than five, but no more than 25 people per square kilometer.

Medium Drone: A drone that weighs between 25 kg and 150 kg.

Terms used in RPA operations

Small remotely piloted aircraft means a remotely piloted aircraft that has a maximum take-off weight of at least 250 g (0.55 pounds) but not more than 25 kg (55 pounds)

Medium remotely piloted aircraft RPA that weigh more than 25 kg (55 lb) up to and including 150 kg (331 lb)

Command and control link means the data link between a remotely piloted aircraft and a control station that is used in the management of a flight

Payload, means a system, object or collection of objects, including a slung load, that is onboard or is otherwise connected to a remotely piloted aircraft but that is not required for flight.

visual observer means a crew member who is trained to assist the pilot in ensuring the safe conduct of a flight

For small or medium remotely piloted aircraft (RPAs) operating in Level 1 complex operations, both normal and emergency procedures must be established. These procedures cover a range of scenarios, including pre-flight, take-off, landing, and recovery.

Normal Operating Procedures:

- **Pre-flight:** This includes checks to ensure the RPA is in good working order and ready for flight, including pre-flight checks and scheduled maintenance to protect against latent failures.

- **Take-off:** Procedures for launching the RPA and achieving a safe altitude.

- **Launch:** Specific procedures for deploying the RPA into the air.

- **Approach:** Procedures for guiding the RPA towards its intended landing point.

- **Landing:** Procedures for safely bringing the RPA down and securing it on the ground.

- **Recovery:** Procedures for retrieving the RPA after a flight, including any necessary maintenance or repairs.

Emergency Procedures:

Control Station Failure:

Procedures to follow if the control station is incapacitated, including how to handle a fly-away situation.

Equipment Failure:

Procedures for dealing with failures of the RPA's equipment, such as sensors, navigation systems, or propulsion systems.

Remotely Piloted Aircraft Failure:

Procedures for dealing with failures of the RPA itself, such as structural damage or system malfunctions.

Loss of Command and Control Link:

Procedures for regaining control of the RPA if the signal between the control station and the aircraft is lost.

Fly-away:
Specific procedures for recovering the RPA if it drifts away from the intended flight path.

Flight Termination:
Procedures for safely terminating the flight if necessary, including shutting down the engines and bringing the RPA down in a controlled manner.

Detection and Avoidance of Conflicting Air Traffic and Hazards:
Procedures for identifying and avoiding other aircraft or hazards in the airspace.

Additional Considerations for Level 1 Complex Operations:

- **Redundancies and Critical Items:**
- RPAs used in Level 1 complex operations must be designed with redundancies in key systems, and pilots must be able to anticipate and plan for system failures and abnormalities.
- **Flight Envelope Protection:**
- The RPA should have systems in place to prevent it from entering unsafe flight envelopes, such as exceeding its altitude limits or speed limits.
- **Special Flight Operations Certificate (SFOC):**
- For operations in higher-risk environments, pilots may need to obtain an SFOC, which requires demonstrating the RPA's capabilities and compliance with regulations.

In general, no person can operate a remotely piloted aircraft (RPA) weighing 250 grams (0.55 pounds) or more to provide commercial air service unless they are Canadian or an employee, agent, or representative of a Canadian RPA operator, according to the Canadian Aviation Regulations. There are exceptions for citizens or permanent residents of foreign countries with free trade agreements with Canada, and for those holding a license under the Canada Transportation Act for air transport services.

General Rule:
The primary prohibition is that non-Canadians cannot operate RPAs for commercial air services unless they are part of a registered Canadian RPAS operator.

Exceptions:
Free Trade Agreement: Non-Canadians who are citizens or permanent residents of countries with free trade agreements with Canada and authorized by the agreement can operate RPAs for specialty air services, but only if they have a special flight operations certificate.

Air Transport Services: Individuals holding a license under section 61 of the Canada Transportation Act can operate RPAs for air transport services, even if they are not Canadian or part of a Canadian RPAS operator.

Commercial Air Service:
This refers to any use of an aircraft for commercial purposes, including the transport of passengers, goods, or mail for payment or hire.

Registration:
RPAs operating in Canada, especially those involved in commercial operations, are required to be registered, and the pilot must have easy access to the certificate of registration

In Level 1 complex operations, a small or medium RPA must maintain a minimum distance of 30 meters (100 feet) from people not involved in the operation. This applies regardless of whether the drone is within visual line-of-sight (VLOS) or beyond visual line-of-sight (BVLOS), as long as the operation is conducted in uncontrolled airspace. Additionally, the drone must remain within 2 nautical miles (3.6 km) of the pilot, the visual observer (VO), and the control station.

Level 1 Complex Operations:

This category of drone operations allows for flights beyond visual line-of-sight (BVLOS) in certain controlled conditions, specifically below 400 feet above ground level in uncontrolled airspace, over unpopulated and sparsely populated areas, and away from aerodromes.

30-meter (100-foot) Distance:
This distance requirement ensures a safe margin between the RPA and non-involved people, minimizing the risk of accidental impact or injury.

2 Nautical Mile (3.6 km) Limit:
This limit ensures that the pilot and the visual observer maintain a visual line-of-sight to the drone, even when flying beyond their immediate view.

Visual Observer (VO):
A trained visual observer is required for operations where the drone is not within the pilot's direct visual line-of-sight. The VO must have a RPA pilot certificate and assist in maintaining situational awareness.

Uncontrolled Airspace:
Level 1 complex operations are permitted only in uncontrolled airspace, which means airspace where air traffic control does not provide services.

Safe Zones:
The drone must be operated at least 1 km away from populated areas or over sparsely populated areas.

For Level 1 complex operations of a small or medium RPA, the minimum visibility requirement is three miles. This includes maintaining a minimum ground visibility of three miles and staying clear of clouds. Additionally, the aircraft must be operated with visual reference to the surface and not less than 500 feet from clouds vertically and one mile horizontally.

Level 1 Complex Operations:
These operations involve small and medium RPAs (drones) flown beyond visual line of sight (BVLOS) in uncontrolled airspace, below 400 feet, over unpopulated and sparsely populated areas, and away from aerodromes.

Minimum Visibility:
The regulations require a minimum ground visibility of three miles to ensure the pilot can maintain awareness of the drone's surroundings and potential hazards, particularly when operating BVLOS.

Cloud Clearance:
The aircraft must also maintain a minimum distance from clouds, which is 500 feet vertically and one mile horizontally.

Visual Reference:
The operation must be conducted with visual reference to the surface, meaning the pilot must be able to visually see the drone and its surroundings.

For Level 1 complex operations of a small or medium RPA, the minimum ceiling is below 400 feet Above Ground Level (AGL). This applies when flying Beyond Visual Line of Sight (BVLOS) in uncontrolled airspace, over unpopulated or sparsely populated areas, and away from aerodromes.

Populated Area: An area where more than five people live per square kilometer.

Sparsely Populated Area: An area where there are more than five, but no more than 25 people per square kilometer.

When conducting a Level 1 complex operation, a small or medium RPA must remain at least 5.6 kilometers (3 nautical miles) from a certified airport or military aerodrome and 1.9 kilometers (1 nautical mile) from a certified heliport.

Transport Canada notes that these distances apply even when flying within controlled airspace.

Distance Requirements:

Airports/Military Aerodromes: A minimum distance of 5.6 kilometers (3 nautical miles) from a certified airport or military aerodrome.

Heliports: A minimum distance of 1.9 kilometers (1 nautical mile) from a certified heliport.

Importance of Air Traffic Control Permission:
While these distances are generally required, it's crucial to note that with the proper permission from air traffic control, operations can be conducted within controlled airspace, even closer to these facilities.

To operate a remotely piloted aircraft system under the Level 1 Complex Operations certification, the pilot must have completed one of the following recency requirements within the past 24 months: being issued a pilot certificate for the Level 1 Complex Operations or successfully completing any of the examinations referred to in CARs 901.55(b), 901.64(b), or 901.90(d).Essentially, you need to demonstrate ongoing competence in the knowledge and skills required for this level of operation.

Methods of Meeting Recency:
Pilot Certificate: Being issued or having the pilot certificate for Level 1 Complex Operations.

Examinations: Successfully completing any of the examinations mentioned in CARs 901.55(b), 901.64(b), or 901.90(d), which cover various aspects of remotely piloted aircraft operations.

Level 1 Complex Operations:
A Level 1 Complex Operations certificate is needed for more complex drone operations that go beyond basic and advanced operations.

RPOC:
This certificate ensures that operators have effective safety policies and procedures in place for these more complex operations.

SFOC-RPAS:
If your drone operation falls outside of the scope of Level 1 Complex Operations, you will still need to obtain a SFOC-RPAS. This certificate is required for operations in higher-risk environments or conditions, such as flying over 25 kg, flying beyond visual line of sight, or flying above 122 meters (400 ft),

Beyond Visual Line of Sight (BVLOS):
BVLOS operations require specific safety measures and may necessitate an SFOC-RPAS depending on the operation's characteristics

RPAS manufacturers will be **required** to apply **for declarations for** drones weighing more than 25 kg, up to 150 kg (i.e. medium sized drones), **RPAS** ...

Standard 923, Vision-Based Detect and Avoid (DAA), can be used in lieu of a declared DAA system under specific conditions outlined in the Canadian Aviation Regulations (CARs). These conditions include a visual observer maintaining unaided visual contact, the distance from the RPAS to the pilot and observer, and specific weather conditions.

Standard 923 - Vision-Based Detect and Avoid - Canadian Aviation Regulations (CARs)

This standard applies to operations with a remotely piloted aircraft system without a declaration having been made in respect of the technical requirements set out in section 922.10 of Standard 922. If a visual observer maintains unaided visual contact with the airspace in which the remotely piloted aircraft is operating in a manner sufficient to detect conflicting air traffic and other hazards and take action to avoid them and the operation follows the requirements below:

The distance from the RPA to the pilot and control station must be no greater than 4 nm.
The distance from the RPA to nearest visual observer performing vision-based DAA must be no greater than 2 nm.

The weather conditions in the operational volume at the time of flight must meet the following condition:

- ground visibility must be greater than or equal to three miles;
- a cloud ceiling is greater than or equal to than 1000 feet AGL; and,
- visual obstructions are less than or equal to 5 degrees of visual angle upwards from the horizon in the quadrant (90° of azimuth) centered on the RPA location.

The Sun position is:

- Outside of the quadrant (90° of azimuth) centered on the RPA location; or,
- 45° or greater of elevation above the horizon; or,
- Below the horizon (i.e., night operations).

For Division VI (Level 1 Complex) operations of Remotely Piloted Aircraft Systems (RPAS) in Canada, permitted modifications are governed by the Canadian Aviation Regulations (CARs). Essentially, modifications must not compromise the RPAS's ability to meet the technical requirements outlined in Standard 922, especially if the modifications affect aspects like safety, reliability, or command and control.

Manufacturer Declaration:
Before operating an RPAS under Division VI, the manufacturer must declare to the Minister of Transport that the model meets the technical requirements of Standard 922. This declaration applies to each model of RPAS intended for advanced operations.

Standard 922:
This standard sets out performance-based requirements for RPAS operation, covering aspects like safety, reliability, and control.

Modifications and Declarations:
Any modification to an RPAS that alters its design, construction, or reliability must be considered in relation to Standard 922. If a modification could affect the RPAS's ability to meet the standard's requirements, it may necessitate a new or updated declaration.

Pre-Validated Declarations:

In some cases, manufacturers or service providers need to submit a plan to Transport Canada demonstrating how their aircraft or system design will meet Standard 922. This process, called the Pre-Validated Declaration, adds a step before a final declaration, according to Transport Canada.

Operation Categories:

Standard 922 is divided into operational categories, each with specific requirements. The sections of Standard 922 may include: operations in controlled airspace, operations near and over people, safety and reliability, containment, command and control link reliability, and detect-and-avoid systems.

Special Flight Operations Certificate (SFOC):

For operations that are considered higher risk, a SFOC for RPAS may be required.

Level 1 complex operations are divided by RPA operating weight, population density and in BVLOS complexity.

RPA Operating Weight:
Small RPA: RPA with a gross weight of 250g to 25kg.
Medium RPA: RPA with a gross weight of more than 25kg but not more than 150kg.

Population Density:
Unpopulated Areas: Areas with minimal or no human presence, often defined as more than 1km from any populated area.
Sparsely Populated Areas: Areas with lower population density, often requiring a visual observer.
Populated Areas: Areas with high population density, requiring more stringent regulations.

BVLOS Complexity:
Low-Risk BVLOS:
Operations in uncontrolled airspace, below 400 feet AGL, and at least 5 nautical miles from aerodromes.

Advanced BVLOS:
Operations requiring a RPAS Operator Certificate (RPOC) and demonstrating specific policies and procedures.

To train individuals for a Level 1 Complex Pilot Certificate without prior experience, a structured approach involving ground school instruction, practical training, and assessment is required. This includes a minimum of 20 hours of ground school led by a certified instructor, covering topics outlined in TP 15530, followed by a flight review conducted by a flight reviewer.

Ground School Instruction:
Individuals must enroll in a ground school program that meets the requirements outlined in TP 15530.

The program should be a minimum of 20 hours and cover the knowledge requirements for Level 1 Complex Operations.

The ground school must be led by an instructor who is authorized to provide such training.

Practical Training (Flight Review):

After completing ground school, candidates must undergo a flight review conducted by a flight reviewer who is also authorized to provide such services.

The flight review assesses the candidate's ability to safely and effectively operate a remotely piloted aircraft system in complex operations.

The flight review must adhere to the requirements outlined in Standard 921.02 of the Canadian Aviation Regulations (CARs) and TP 15395E.

Assessment:
Both the ground school and flight review components involve assessment to ensure the candidate has met the required knowledge and skills.

Ground school assessment may include written exams and practical demonstrations.
The flight review assesses the candidate's ability to plan, execute, and manage an RPA flight safely and efficiently.

Requirements:
Candidates must demonstrate the ability to comply with training program requirements and describe the roles and responsibilities of crew members in a Level 1 Complex flight.

They must also be able to explain the concepts of safety management and reporting requirements.

Foreign Pilots:

Foreign pilots looking to conduct Advanced or Level 1 Complex Operations need to successfully pass the applicable exam and receive their SFOC-RPAS before undertaking the flight review.
The processing of an SFOC-RPAS application for foreign pilots may take up to 30 working days.

To be a Level 1 Complex drone training provider, you need to have a qualified Chief Ground Instructor and deliver training through a structured program that includes lectures, homework, and self-paced elements, but not fully self-directed,. The training must also include a flight review, which verifies the pilot's ability to fly safely in the Level 1 Complex environment,.

- **Chief Ground Instructor:** The training must be delivered by a qualified instructor, specifically a Chief Ground Instructor, either in-person or virtually.

- **Structured Program:** The training should be structured and include lectures, homework, and some self-paced elements.

- **Flight Review:** You'll need to complete a flight review with a flight reviewer to get your Pilot Certificate – Level 1 Complex Operations.

- **Online Exams:** Pilots must also pass the online exams for both advanced operations and Level 1 Complex Operations.

- **Ground School:** A minimum of 20 hours of ground school is required.

Training and Flight review

To conduct a flight review for a Level 1 complex operations pilot certificate, a flight reviewer must be at least 18 years old, hold a valid Pilot certificate – remotely piloted aircraft – Level 1 Complex Operations, have at least 6 months of experience with Level 1 complex operations, and have successfully passed the Remotely Piloted Aircraft Systems – Flight Reviewer exam. They must also be affiliated with a self-declared TP 15530E RPAS training provider and complete recency requirements every 2 years.

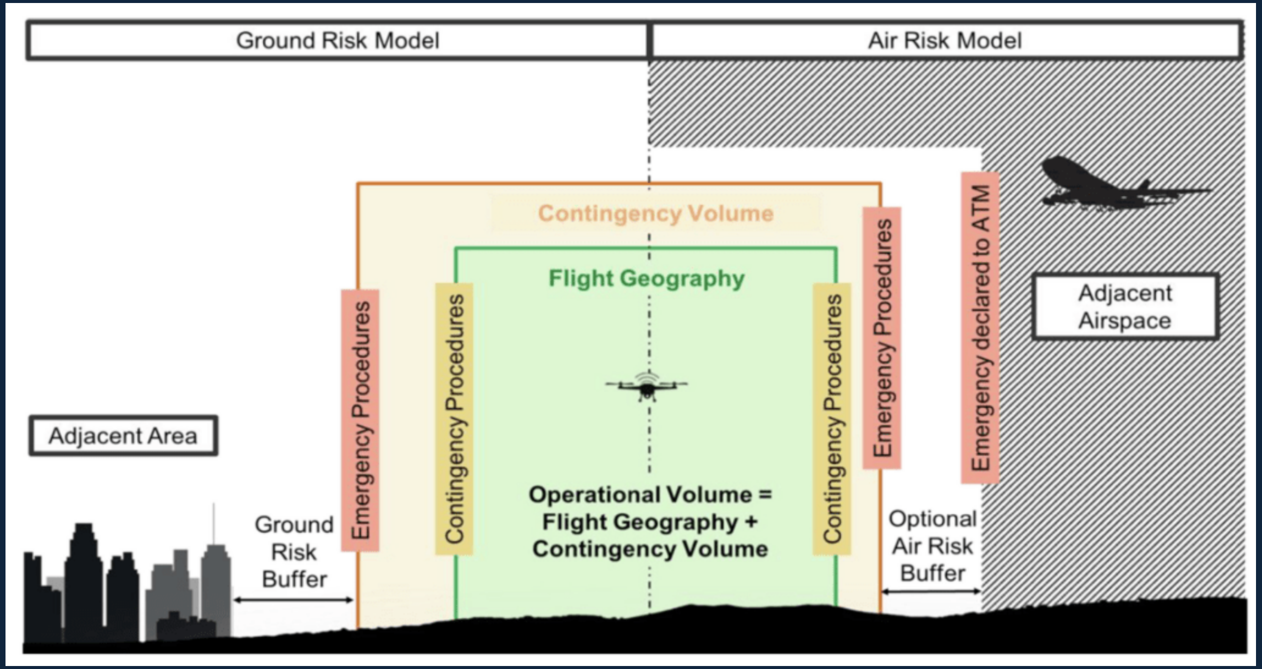
Mandatory action means the inspection, repair or modification of a remotely piloted aircraft system that is necessary to prevent an unsafe or potentially unsafe condition.

BVLOS operation means an operation of a remotely piloted aircraft that is not in visual line-of-sight, but does not include an extended VLOS operation or a sheltered operation

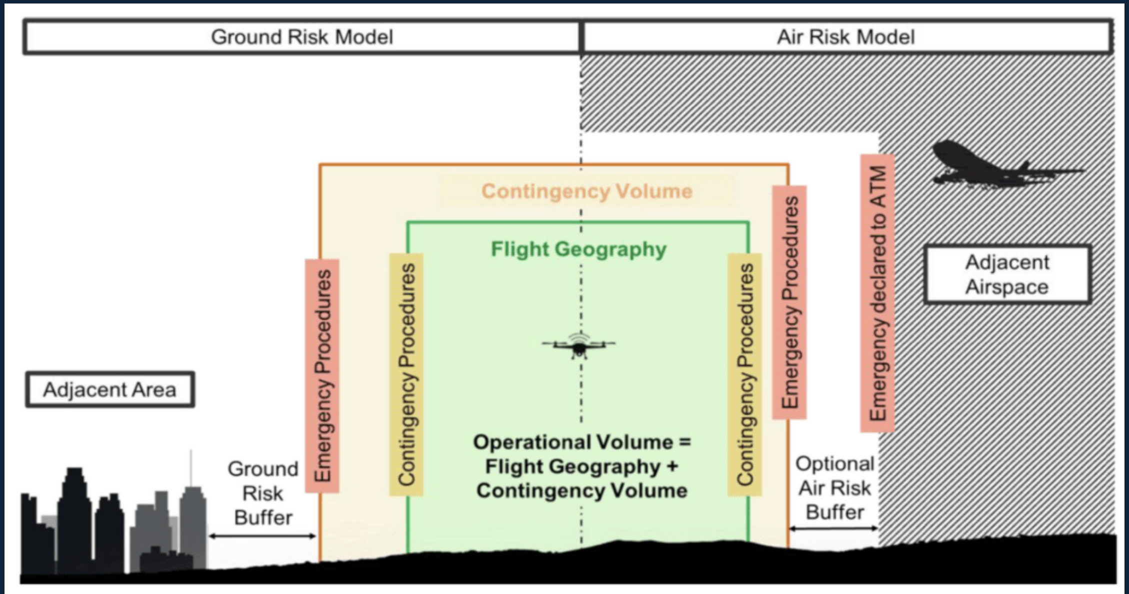
Contingency procedures means the procedures to be followed to address conditions that could lead to an unsafe situation.

Contingency volume means the area immediately surrounding the flight geography within which contingency procedures are intended to be used to return a remotely piloted aircraft to the flight geography or safely terminate the flight.

Flight geography means the area within which a remotely piloted aircraft is intended to fly for a specific operation



Ground risk buffer means the area immediately surrounding the contingency volume that, when measured horizontally from the perimeter of the contingency volume, is at least equal to the planned maximum altitude of the remotely piloted aircraft for the flight.



Operational volume means the area that is composed of the flight geography, contingency volume and ground risk buffer

Operating weight means the weight of a remotely piloted aircraft at any point during a flight, including any payload and any safety equipment that is on board or otherwise connected to the aircraft

Populated area means an area with more than five people per square kilometre

Sparsely populated area means an area with more than 5 but not more than 25 people per square kilometre

Medium remotely piloted aircraft means a remotely piloted aircraft that has an operating weight of more than25 kg (55 pounds) but not more than 150 kg (331 pounds)

Operating weight means the weight of a remotely piloted aircraft at any point during a flight ,including any payload and any safety equipment that is on board or otherwise connected to the aircraft

VLOS operation means an operation of a remotely piloted aircraft in visual line-of-sight.

Inadvertent Entry Into Restricted Airspace

A person who operates a remotely piloted aircraft shall ensure that the appropriate air traffic control unit, flight service station or user agency is notified immediately any time the aircraft is no longer under the person’s control and inadvertently enters or is likely to enter into Class F Special Use Restricted airspace, as specified in the *Designated Airspace Handbook*.

General Operating and Flight Rules for All RPAS

Restrictions to operations in the vicinity of forest fire areas/police/safety agency site.

While some emergency response teams use drones to fight forest fires, flying a drone over or near a forest fire without permission increases the risk that a firefighting aircraft will collide with the drone. If a drone is spotted in the area, emergency response teams need to ground their operations, which puts lives at risk.

Canadian law requires all drone pilots to fly according to the Canadian Aviation Regulations, which state that only someone with permission can fly a drone over a forest fire, or within 9.3 kilometres (5 NM) of a forest fire.

THE AIRSPACE AROUND AND OVER A FOREST FIRE IS CLOSED TO ALL AIRCRAFT, INCLUDING DRONES, EXCEPT THOSE DIRECTLY INVOLVED IN FIGHTING FIRES.

Does not apply to the operation of a remotely piloted aircraft for the purpose of an operation to save human life, a police operation, a fire-fighting operation or any other operation that is conducted in the service of a public authority.

Division VI Part IX Application to Level 1 Complex Operations

Operational Procedures

Division VI Part IX provides a detailed framework for the execution of Level 1 operations. This includes standardized procedures that ensure consistency, accuracy, and efficiency in daily tasks. These procedures are designed to minimize errors and streamline workflows.

Risk Management

Risk management is a pivotal aspect of Division VI Part IX. It outlines the measures necessary to identify, assess, and mitigate risks associated with Level 1 operations. By adhering to these guidelines, organizations can prevent potential disruptions and maintain smooth operational flow.

Resource Allocation

Effective resource allocation is critical for the success of Level 1 operations. Division VI Part IX specifies how resources should be distributed and utilized to optimize productivity. This includes human resources, technological tools, and financial assets.

Compliance and Monitoring

Compliance with Division VI Part IX is mandatory for all Level 1 complex operations. Regular monitoring and audits are conducted to ensure adherence to the established guidelines. Non-compliance can lead to operational setbacks and potential legal consequences.

Conclusion

Division VI Part IX plays a fundamental role in governing Level 1 complex operations. Its detailed guidelines on operational procedures, risk management, and resource allocation are crucial for maintaining efficiency and compliance. Organizations must prioritize understanding and implementing these protocols to ensure their Level 1 operations are optimized and aligned with regulatory standards.

Rules for the Use of Visual Observers in Level 1 Complex Operations

Visual observers play a crucial role in ensuring the safety and efficiency of level 1 complex operations. Their primary function is to maintain situational awareness, monitor the environment, and provide real-time feedback to the operational team. This document outlines the rules and guidelines for the effective use of visual observers in such operations.

Role and Responsibilities

Visual observers are responsible for:

- Monitoring the operational area for potential hazards and obstacles.
- Communicating relevant information to the operational team promptly.
- Ensuring that all safety protocols are adhered to.
- Assisting in the identification and mitigation of risks.

Training and Qualifications

To serve as visual observers in level 1 complex operations, individuals must:

- Possess a thorough understanding of the operational procedures and safety protocols.
- Demonstrate proficiency in communication and observation skills.
- Maintain up-to-date knowledge of relevant regulations and guidelines.

Operational Guidelines

During level 1 complex operations, visual observers should:

- Position themselves in locations that provide optimal visibility of the operational area.
- Use communication devices to relay information effectively to the operational team.
- Remain vigilant and focused throughout the duration of the operation.
- Report any anomalies or safety concerns immediately to the team leader.

Coordination and Communication

Effective coordination and communication are essential for the success of visual observers. The following practices should be implemented:

- Establish clear communication channels between visual observers and the operational team.
- Conduct pre-operation briefings to discuss roles, responsibilities, and potential risks.
- Maintain a continuous flow of information to ensure situational awareness.
- Utilize standardized procedures for reporting and responding to incidents.

Conclusion

Visual observers are vital to the safe and efficient execution of level 1 complex operations. Adhering to the outlined rules and guidelines will ensure that visual observers can effectively fulfill their roles, thereby minimizing risks and enhancing overall operational success.

No person shall operate a remotely piloted

A person may operate a remotely piloted aircraft system that includes a remotely piloted aircraft that is not registered in accordance with this Division if the operation is conducted in accordance with a special flight operations certificate — aircraft system that includes a remotely piloted aircraft having an operating weight of 250 g (0.55 pounds) or more unless the remotely piloted aircraft is registered

Registration Number
900.14 No pilot shall operate a remotely piloted aircraft system unless the registration number referred to in paragraph 900.16(3)(a) is clearly visible on the remotely piloted aircraft.

Qualifications To Be Registered Owner of Remotely Piloted Aircraft

(1) Subject to subsection (2), a person is qualified to be the registered owner of a remotely piloted aircraft if they are

(a) a Canadian citizen or permanent resident of Canada;
(b) a corporation or entity that is incorporated or formed under the laws of Canada or a province; or
(c) a government in Canada or an agent or mandatary of such a government.

(2) No individual is qualified to be the registered owner of a remotely piloted aircraft unless that individual is at least 14 years of age.

Registration Requirements

The application shall include the following information:

(a) if the applicant is an individual,**(i)** the applicant’s name and address,

(ii) the applicant’s date of birth, and

(iii) an indication as to whether the applicant is a Canadian citizen or permanent resident of Canada;

b) if the applicant is a corporation or entity that is incorporated or formed under the laws of Canada or a province,

(i) the corporation’s or entity’s legal name and address,
(ii) the name and title of the person making the application, and
(iii) the business number assigned to the corporation or entity by the Minister of National Revenue, if any;

(c) if the applicant is His Majesty in right of Canada or a province,

(i) the name of the government body, and

(ii) the name and title of the person making the application;

(d) an indication as to whether the aircraft was purchased or built by the applicant;
(e) the date of purchase of the aircraft by the applicant, if applicable;
(f) the manufacturer and model of the aircraft, if applicable;
(g) the serial number of the aircraft, if applicable;
(h) the category of aircraft, such as a fixed-wing aircraft, rotary-wing aircraft,
hybrid aircraft or lighter-than-air aircraft; and

(i) any Canadian registration number previously issued in respect of the aircraft.

(3) On registering the remotely piloted aircraft, the Minister shall issue to the registered owner of the aircraft a certificate of registration that includes

(a) a registration number;
(b) the name and address of the registered owner; and
(c) the serial number of the aircraft, if applicable.

Register of Remotely Piloted Aircraft
The Minister shall establish and maintain a register of remotely piloted aircraft in which there shall be entered, in respect of each aircraft for which a certificate of registration has been issued under section 900.16,

(a) the name and address of the registered owner;
(b) the registration number referred to in paragraph 900.16(3)(a); and
(c) any other particulars concerning the aircraft that the Minister determines necessary for the registration of the remotely piloted aircraft.

What aeronautical information must be consulted before flight.

No pilot shall operate a remotely piloted aircraft system unless, before commencing the operation, they determine that the operational volume is suitable by conducting a site survey that takes into account the following factors:

(a) the type of airspace and any requirements applicable to the fligh tgeography, including any specified in a NOTAM;
(b) the altitudes and routes to be used for approach, take-off, launch, landing or recovery;
(c) the proximity of other aircraft operations;
(d) the proximity of airports, heliports and other aerodromes;
(e) the location and height of obstacles, including wires, masts, buildings, cellphone towers and wind turbines;
(f) the predominant weather and environmental conditions and the weather forecast for the duration of the flight;
(g) in the case of a VLOS operation, an extended VLOS operation or a sheltered operation, the horizontal distance from any person not involved in the operation; and
(h) in the case of a BVLOS operation, the distance from any populated area or sparsely populated area.

In level 1 complex operations, it is crucial to establish comprehensive procedures for both normal and emergency scenarios when operating small or medium Remotely Piloted Aircraft (RPA). These procedures ensure the safety, reliability, and efficiency of RPA operations.

Pre-flight Checks

- Verify the RPA's structural integrity.
- Ensure all control surfaces are functional.
- Check battery levels and ensure adequate power for the operation.
- Confirm that all onboard instruments are calibrated and functional.
- Review the mission plan and weather conditions.
- Conduct a communication check between the RPA and ground control station.

Flight Operations

- Maintain clear and continuous communication with the RPA.
- Monitor RPA telemetry data closely to ensure optimal performance.
- Adhere to established flight corridors and altitude restrictions.
- Execute maneuvers as per the mission plan.
- Regularly check for any signs of malfunction or data anomalies.

Post-flight Procedures

- Safely land the RPA in the designated area.
- Conduct a thorough inspection for any damage or wear.
- Log the flight data and any incidents encountered during the operation.
- Recharge the batteries and prepare the RPA for the next mission.

Emergency Operations Procedures

Loss of Communication

- Activate the RPA's autonomous return-to-home feature.
- If the RPA fails to return, initiate manual recovery procedures.
- Notify all relevant authorities and stakeholders of the situation.

System Malfunction

- Immediately assess the severity of the malfunction.
- Attempt to regain control using backup systems.
- If control cannot be regained, prioritize a safe landing in an open area.
- Document the malfunction and report it to the maintenance team.

Unexpected Weather Conditions

- Monitor real-time weather updates continuously.
- Alter the flight path to avoid hazardous conditions.
- If unable to avoid, safely land the RPA and suspend operations.

Safety Protocols

- Ensure all personnel are trained in emergency response procedures.
- Equip the RPA with fail-safes such as auto-landing and parachute deployment.
- Conduct regular emergency drills to maintain preparedness.

Conclusion

By establishing and rigorously following these procedures, operators of small or medium RPA in level 1 complex operations can ensure safe and efficient performance in both normal and emergency situations. The protocols should be regularly reviewed and updated to incorporate technological advancements and lessons learned from past operations.

Minimum distance that a small or medium RPA must remain from a person in level 1 complex operations

No pilot shall operate a remotely piloted aircraft at a distance of less than **100 feet** (30 m) from another person, measured horizontally and at any altitude, except from a crew member or other person involved in the operation.

Minimum visibility required for the operation of a small or medium RPA in level 1 complex operations.

Minimum Visibility Standards

The following visibility standards are recommended for small to medium RPAs engaged in level 1 complex operations:

Visual Line of Sight (VLOS)

- Operators must maintain a continuous visual line of sight with the RPA throughout the operation.
- Visibility should be minimally ten meters (33 feet) horizontally from the operator's position.
- Vertical visibility must be unobstructed up to a minimum height of 150 meters (492 feet).

Meteorological Visibility

- Clear weather conditions are essential for safe operation. Minimum meteorological visibility should be at least 5 kilometers (3 miles).
- Operations should be suspended during fog, heavy rain, or snow, which can significantly reduce visibility.

Environmental Factors

- Operators must ensure the absence of obstructions such as buildings, trees, or other structures within the operational area. Lighting conditions should be adequate, avoiding twilight or nighttime operations unless equipped with suitable lighting systems.

Technological Aids

In addition to natural visibility, employing technological aids can enhance operational safety:

Onboard Cameras and Sensors

- RPAs should be equipped with high-resolution cameras to provide real-time video feeds to the operator.
- Proximity sensors and collision avoidance systems are vital for navigating complex environments.

Ground Control Systems

- Ground control stations should be equipped with monitors displaying the RPA's camera feed and sensor data.
- Real-time data analysis tools can assist operators in making informed decisions during flight.

Conclusion

Ensuring minimum visibility standards for small to medium RPAs in level 1 complex operations is critical for safe and efficient operation. By adhering to the recommended visibility guidelines and utilizing technological aids, operators can significantly mitigate risks and enhance the performance of RPAs in challenging environments

A pilot may operate a remotely piloted aircraft to conduct a BVLOS operation in cloud or when the ground visibility is less than three miles if

(a) a declaration referred to in section 901.194 has been made in respect of the model of remotely piloted aircraft system of which the aircraft is an element and in respect of the technical requirements set out in section 922.10of Standard 922 and the operating manuals applicable to the system allow for operation in those conditions; or

(b) the operation is conducted in accordance with a special flight operations certificate — RPAS issued under section 903.03. (SFOC)

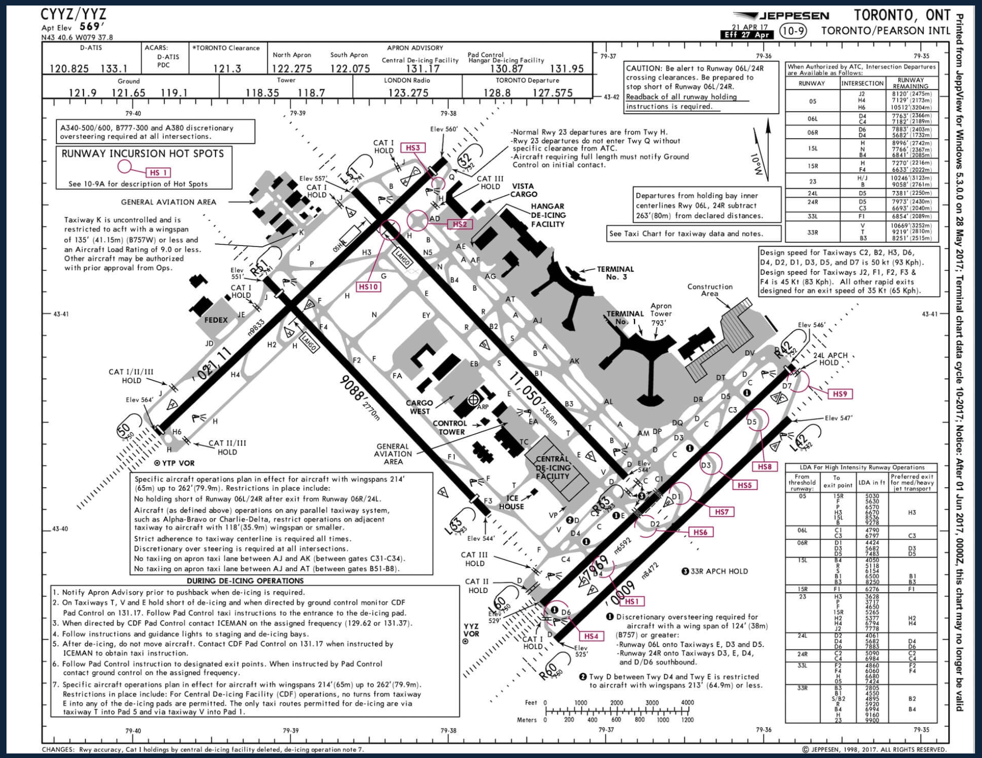
Minimum ceiling required for the operation of a small or medium RPA in level 1 complex operations. 500 Feet AGL. Specifically, Level 1 Complex Operations, conducted within Controlled Airspace or near aerodromes , require a minimum cloud ceiling of 500 FT AGL and visibility of at least 3 statute miles (about 5 KM)

Minimum distance that a small or medium RPA must remain from an airport, aerodrome and heliport when conducting a level 1 complex operation.

5.6km (3)nautical) Airport/Aerodrome

1.9km (1)nautical Heliport

In uncontrolled airspace, below 400 feet above ground level (AGL), and at least five nautical miles away from aerodromes listed in the Canadian Flight Supplement or Water Aerodrome Supplement.



Factors that must be included in a site survey for the operation of all small or medium RPA in level 1 complex operations.

Flight planning/Site Survey

The RPA pilot operating within level 1 complex operations must be able to:

•Have the ability to use flight planning software, and confirm their use of valid data sources.

•Provide Time/Distance/Energy/Endurance Calculations with the effect of wind on groundspeed.

•Be able to determine the effect of wind on range and endurance.

•Determine effect of wind on contingency planning, including return to home and other flight termination procedures.

•Consider flight termination procedures and flight termination routes when planning the operation.

•Find obstacles on a map and determining their height.

•Describe digital terrain , including digital surface model (DSM) and digital elevation model (DEM), and issues associated to terrain and obstacle avoidance.

•Demonstrate the ability to identify areas of other airspace users, gliders and ultralight flying areas, parasailing areas, etc.

•Determine the population density of a given area.

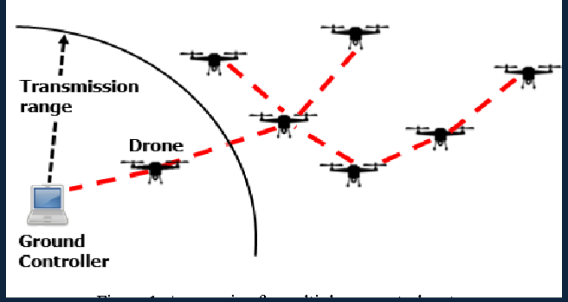
•Consider environmental considerations of proposed operations, including noise, wildlife encounters, etc.

- Explain their responsibility with respect to keeping the RPA away from another person and populated areas.
- Demonstrate how to identify population density of a given area.
- Describe how to plan DAA procedures.
- Calculate critical point/point of no return.
- Describe affects on a flight within locations that may have effects on GPS reception and impose limitations on auto pilots.
- Determine from a map what is the appropriate frequency to monitor.
- Demonstrate the ability to locate possible contingency and emergency alternate landing sites using aeronautical charts.

Air law, air traffic rules and procedures

Define remotely piloted aircraft.

Define remotely piloted aircraft system.



Define command and control link.

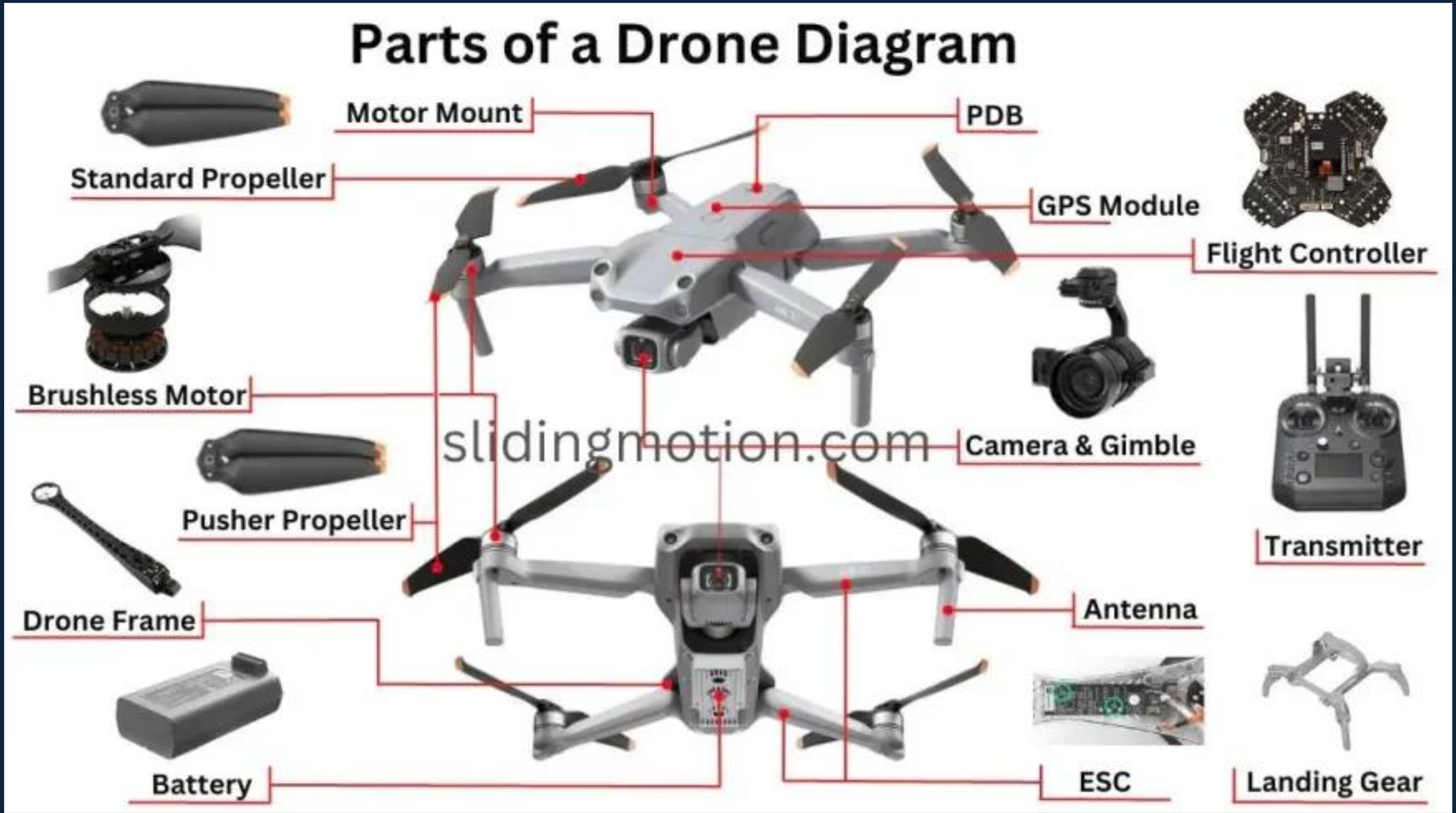
Define control station.

Special Flight Operations – Remotely Piloted Aircraft Systems

The RPA pilot operating within level 1 complex operations must be able to:

Examples of the types of BVLOS operations that would require a special flight operations certificate

RPA airframes, power plants, propulsion, and systems



Airframes

How to decide if an airframe is airworthy after something out of order is found during a pre-flight inspection.

The Importance of Airframe Design

A well-designed airframe is crucial for drone functionality. It must be:

- Lightweight: To maximize flight time and efficiency.
- Strong: To withstand the forces of flight and potential impacts.
- Payload-Capable: To carry sensors, cameras, and other mission-specific equipment.
- Maneuverable: To enable agile flight and precise control.
- Durable: To withstand varying weather conditions and operational stresses.

A. Standard Prop

The "tractor" propeller are the props at the front of the quadcopter. These props pull the quadcopter through the ai like a tractor. While some drones like the DJI Phantom look more or less the same from any angle, there is a front and back.

Most drone propellers are made of plastic and the better quality made of carbon fiber. For safety, you can also add drone prop guards which you need especially if you are flying indoors or near people.

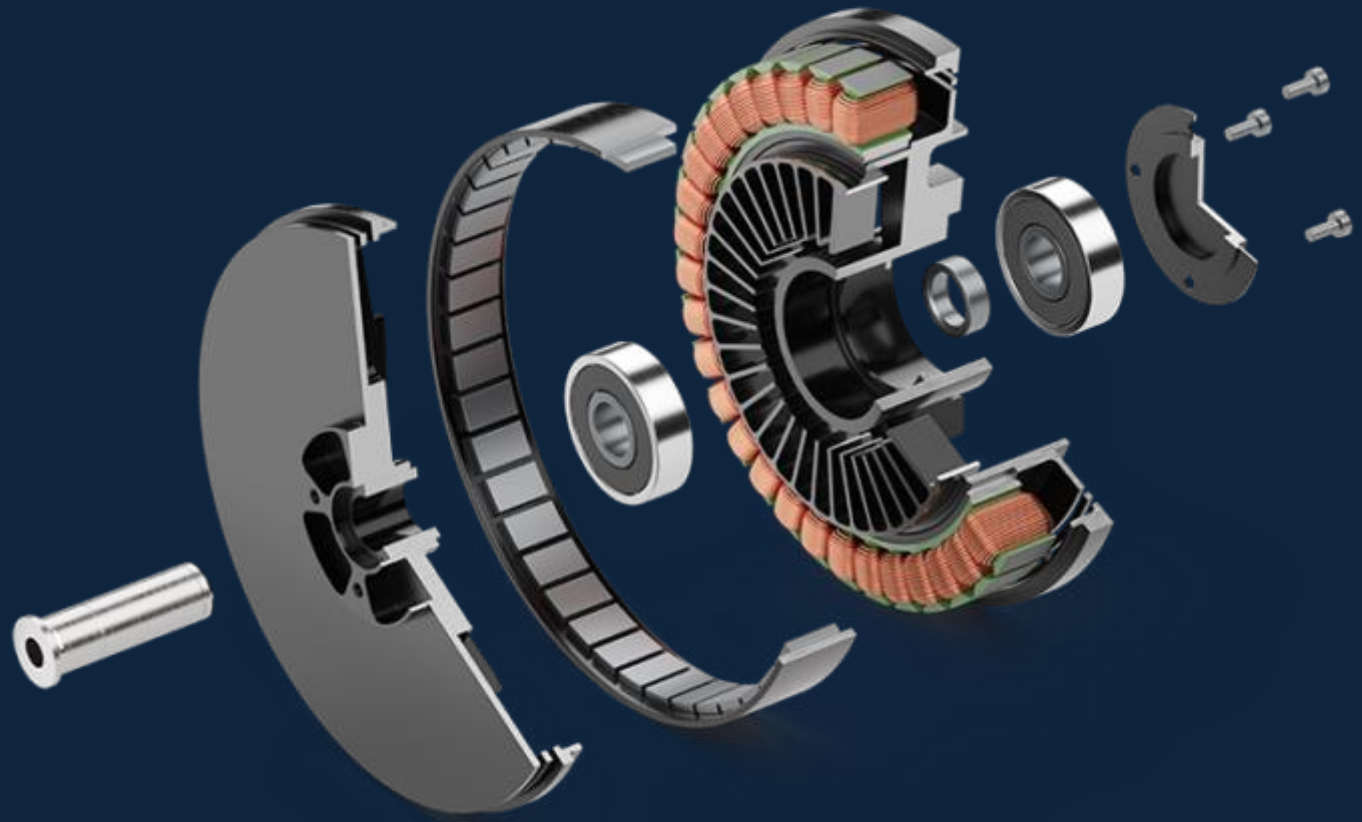
Propeller design is an area where there is plenty of new innovation. Better prop design will assist in a smoother
flying experience and longer flight times. There is also some big innovation towards low noise RPA props.

Tip: It is always good practice to inspect your props before flying and carry an extra set in case you notice some
damage on a prop. Never fly with a damaged or bent prop.

B. Pusher Prop

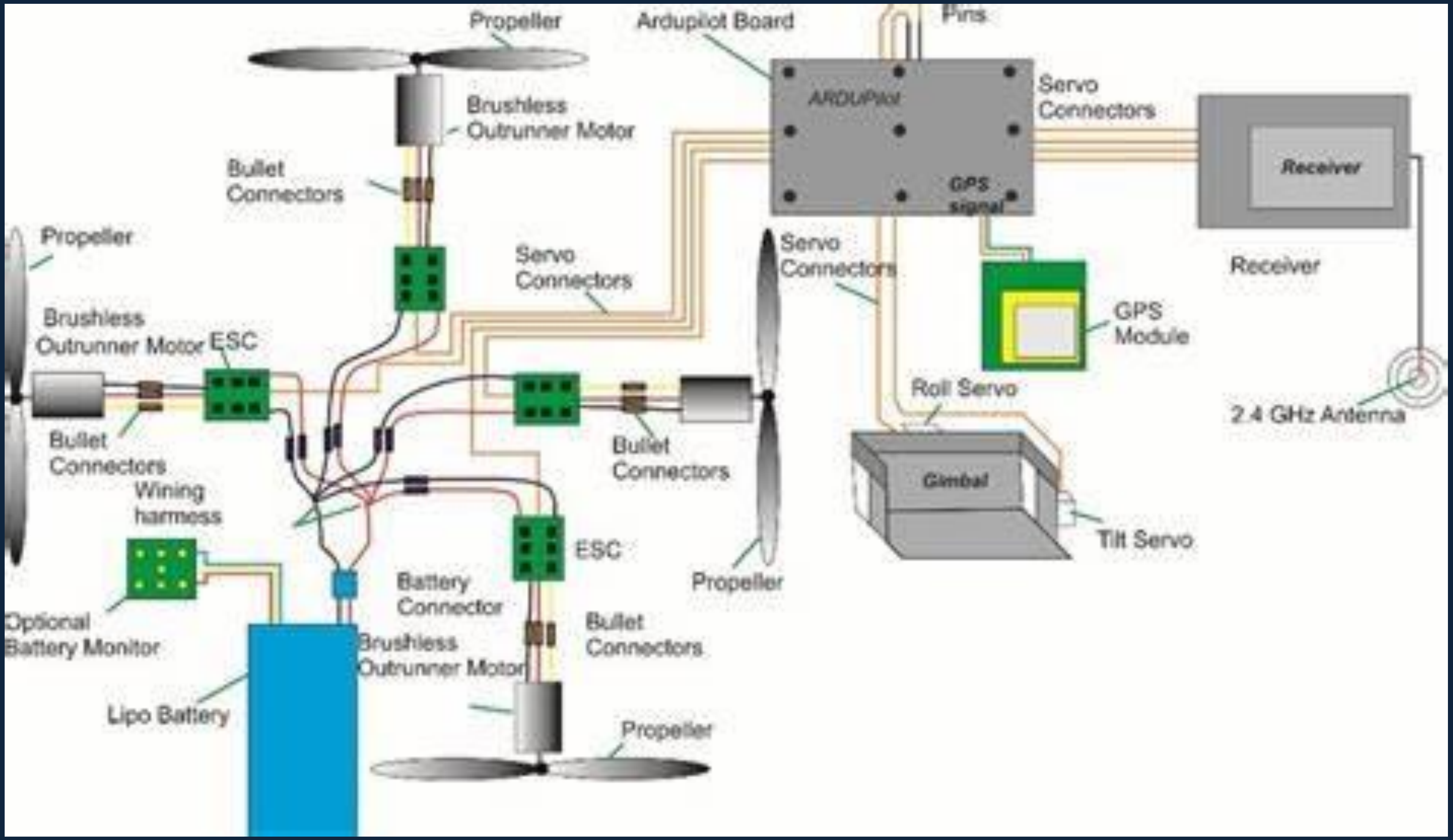
The Pusher props are at the back and push the UAV forward hence the name "Pusher props". These contra-rotating props exactly cancel out motor torques during stationary level flight. Opposite pitch gives downdraft.
These can be made of plastic with the better pusher props made from carbon fiber. You can also purchase guards for the pusher props.

Brushless Motors



Practically all the latest drones use a brushless electric "out-runner" type, which is more efficient, more reliable, and quieter than a brushed motor. Motor design is important. More efficient motors save battery life and give the owner more flying time, which is what every pilot wants.

Electrical Systems



The importance of keeping components within the manufacturer’s recommended specifications regarding moisture, temperature and any other environmental limitations.

Generally, it’s not recommended to fly drones in rain, mist, high humidity, or over water bodies with strong winds. Many drones have venting holes that can expose the electronics inside to moisture. Once water gets inside, short circuits can occur and possibly damage your drone. If precipitation gets inside a drone mid-flight it can impair the electrical components, making it inoperable and possibly causing it to crash.

how to determine battery consumption during flight

Some manufacturers do build drones that are capable of handling varying levels of moisture based on their application. However, unlike most consumer drones, waterproof drones have special frames that are completely sealed to protect the electronic parts. They’re able to resist heavy rain, but usually not for a very long time. DJI’s Matrice 300 RTK is an example of a Propeller-supported drone that is water resistant.

How to determine battery consumption during flight ?

Drone Energy Consumption Calculator - Fly Eye

In a BVLOS flight it is more than ever very important to be able to monitor and manage emergency of your RPA. Factors such as speed, attitude , winds and other factors come into the equation.

There are calculators on the internet that can help you determine your power consumption and potential flight times.

Be aware you must consider all environmental factors.

Redundancies and critical items

The value of having redundancy built into RPAS operating scenarios.

How to anticipate and plan for system failures and abnormalities, in developing mitigation procedures.

How to identify single points of failure in an RPAS.

latent failures & how to identify abnormal operating conditions.

How pre-flight checks and scheduled maintenance can protect against latent failures.

Describe related cascading failures of systems or components.

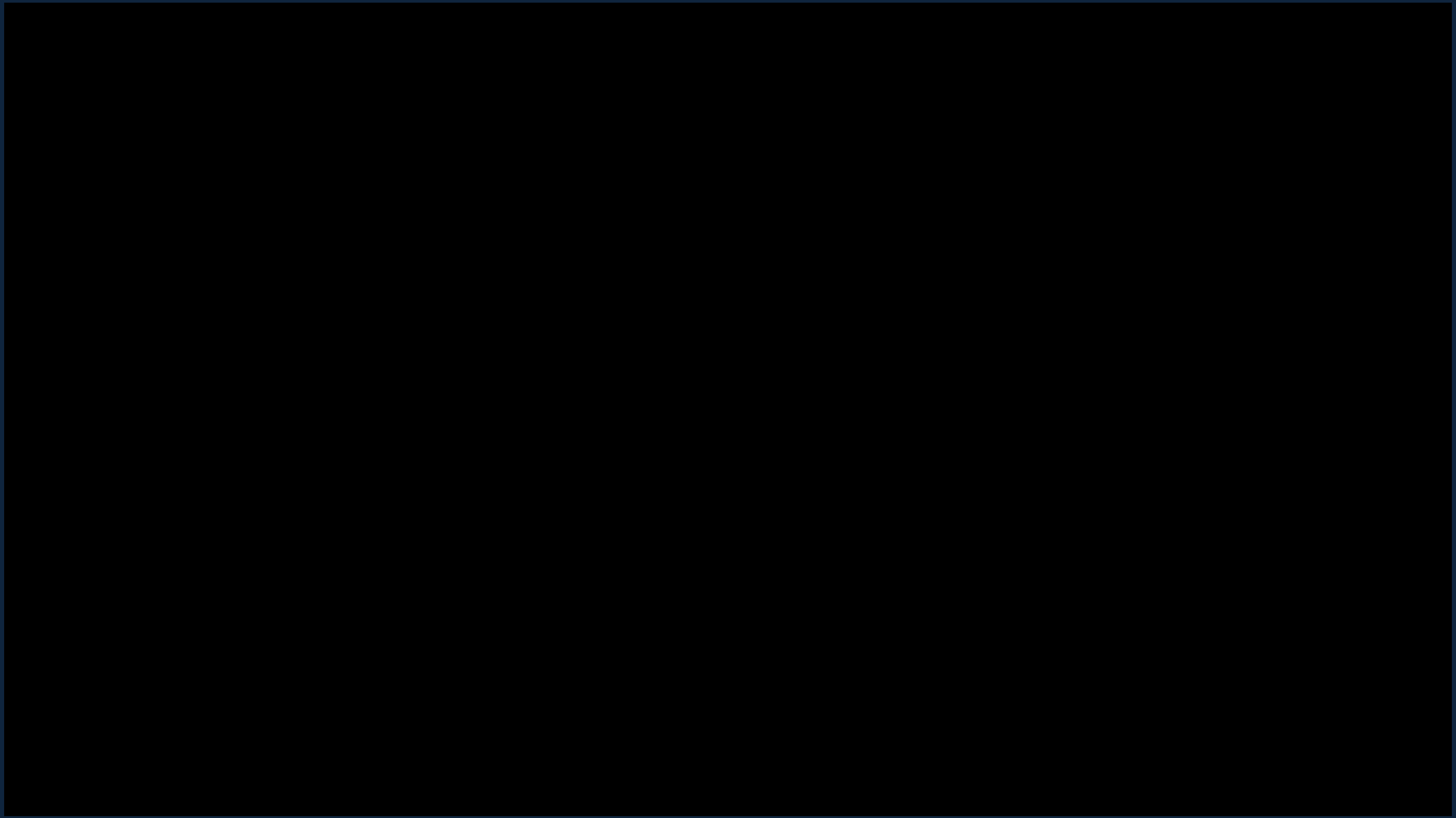
Describe flight envelope protection systems and what their purpose is.

Ground control station (GCS)

UAV ground control station (**GCS**) is a land- or sea-based control center that provides the facilities for human control of *Unmanned Aerial Vehicles* (UAVs or "drones").

Importance of antenna orientation.

Ensure your communication antennas on your control station are properly positioned and that they have a clear line of sight to the RPA.



Data and command and control (C2) links

The radio frequency (RF) environment can significantly impact RPAS operations by creating interference with command and control (C2) links, navigation systems, and sensors. This interference can lead to lost links, disrupted navigation, and even complete system failures, potentially impacting safety.

- **C2 Link Disruptions:**
- Radio signals from nearby sources, such as Wi-Fi hotspots or cellular networks, can interfere with the C2 link between the pilot and the RPA, leading to delays, lost control, and potential safety hazards.
- **Navigation and Guidance Issues:**
- Interference can disrupt the RPA's ability to accurately navigate, potentially leading to deviation from planned flight paths or even crashes.
- **Sensor Data Degradation:**
- RF interference can interfere with the RPA's sensors, such as compasses or other navigation sensors, leading to inaccurate data and affecting the RPA's ability to operate effectively.

Mitigation Strategies:

- **Frequency Selection:**
- Choosing appropriate frequencies for C2 links and other communication channels to minimize interference with other devices.
- **Antenna Design:**
- Using antennas with appropriate gain and pattern to maximize signal strength while minimizing interference.
- **Interference Mitigation Techniques:**
- Employing techniques like filtering or signal processing to reduce the impact of interference on the C2 link and other systems.
- **Redundancy:**
- Implementing redundant systems and communication channels to ensure that if one system fails, another is available to take over.
- **Operational Procedures:**
- Establishing procedures to address potential lost links and system failures, including contingencies for safe recovery.
- **RF Environment Assessment:**
- Conducting thorough assessments of the RF environment before operations to identify potential sources of interference and develop mitigation strategies.

An RPAS Command and Control (C2) system facilitates communication and control between a remotely piloted aircraft (RPA) and its remote pilot station (RPS), enabling the pilot to operate the RPA safely and efficiently. The system's purpose is to ensure the RPA can be commanded and monitored, providing the pilot with real-time data and situational awareness.

Control:
The C2 system allows the pilot to issue commands to the RPA, including flight maneuvers, altitude adjustments, and payload operations.

Monitoring:
It provides the pilot with real-time data about the RPA's status, such as altitude, speed, battery level, and sensor readings.

Safety:
The C2 system helps ensure the safety of the RPA and those on the ground by providing real-time feedback and enabling quick responses to emergencies.

Situational Awareness:
The C2 system provides the pilot with a comprehensive view of the RPA's surroundings, including other aircraft, obstacles, and potential hazards.

Function:

•**Data Link:**
The C2 system relies on a data link (e.g., radio, cellular, satellite) to transmit commands from the RPS to the RPA and receive data from the RPA back to the RPS.

Control System:
The C2 system includes software and hardware components that translate the pilot's inputs into commands that the RPA's flight management system can interpret.

Telemetry:
The C2 system sends telemetry data, such as sensor readings and aircraft health parameters, from the RPA to the RPS for monitoring and analysis.

Feedback:
The C2 system provides feedback to the pilot, confirming that commands have been received and executed, and alerting the pilot to any potential issues or errors.

Situational Awareness Display:
The C2 system often incorporates a ground station display that visualizes the RPA's position, flight path, and surroundings, providing the pilot with a comprehensive view of the operational environment.

The choice between radio, cellular, or satellite command and control (C2) links for telemetry and control of a Remotely Piloted Aircraft (RPA) depends on the specific operational environment, with each offering different trade-offs in terms of range, bandwidth, latency, and reliability.

Radio C2 Links:

Suitability:

Radio links are best suited for short to medium ranges, within visual line of sight (VLOS) or near-VLOS, where secure, dedicated communication is needed.

Advantages:

Radio offers dedicated channels, low latency, and good security, as it is not subject to network congestion or interference from other users.

Disadvantages:

Range is limited by the line of sight and terrain, and the signal can be obstructed by buildings or vegetation.

Applications:

Ideal for visual operations, close-range missions, or situations where secure communication is paramount.

Cellular C2 Links:

Suitability:
Cellular C2 links are best for longer ranges and situations where the RPA needs to operate in areas with good cellular coverage.

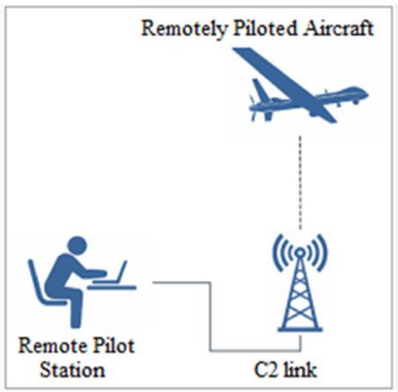
Advantages:
Cellular offers higher bandwidth and access to a wider network infrastructure, potentially allowing for more complex data transmission, like high-resolution video or sensor data.

Disadvantages:
Latency can be higher due to network congestion, signal interference, and cellular infrastructure limitations. Security and reliability can be a concern due to reliance on external network infrastructure.

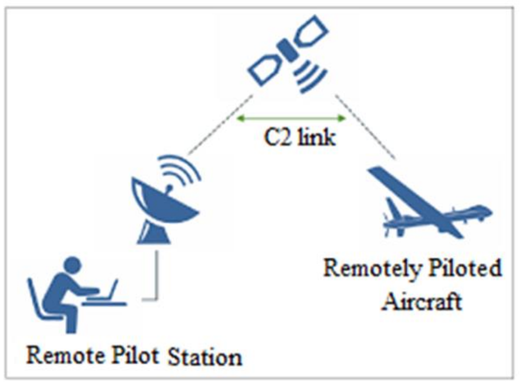
Applications:
Suitable for missions where extended range, high bandwidth, and real-time data transmission are required, such as infrastructure inspection, surveillance, or search and rescue.

Satellite C2 Links:

Suitability:
Satellite C2 links are best for very long ranges, beyond visual line of sight (BVLOS), or when operating in areas without cellular coverage or reliable radio communication.



C2 link of Line-of-sight (LOS) drone



C2 link of Beyond visual line of sight (BVLOS) drone

Advantages:
Satellite offers the broadest range and can provide connectivity even in remote or challenging environments.

Disadvantages:
Latency can be higher due to the long distance between the satellite and the RPA. Cost can be higher due to satellite access and infrastructure requirements.

Applications:
•deal for missions where extensive range is required, such as over-the-horizon surveillance, research, or disaster response in remote areas.

The difference between latency and bandwidth.

Bandwidth and latency are two distinct aspects of network performance, often confused as measures of speed, but they relate to different characteristics. Bandwidth refers to the maximum amount of data that can be transferred over a network in a given period. Latency, on the other hand, is the delay or time it takes for data to travel from one point to another on the network.

Bandwidth:
Think of bandwidth as the capacity or "width" of a highway. A highway with more lanes (higher bandwidth) can handle more traffic (data) simultaneously.

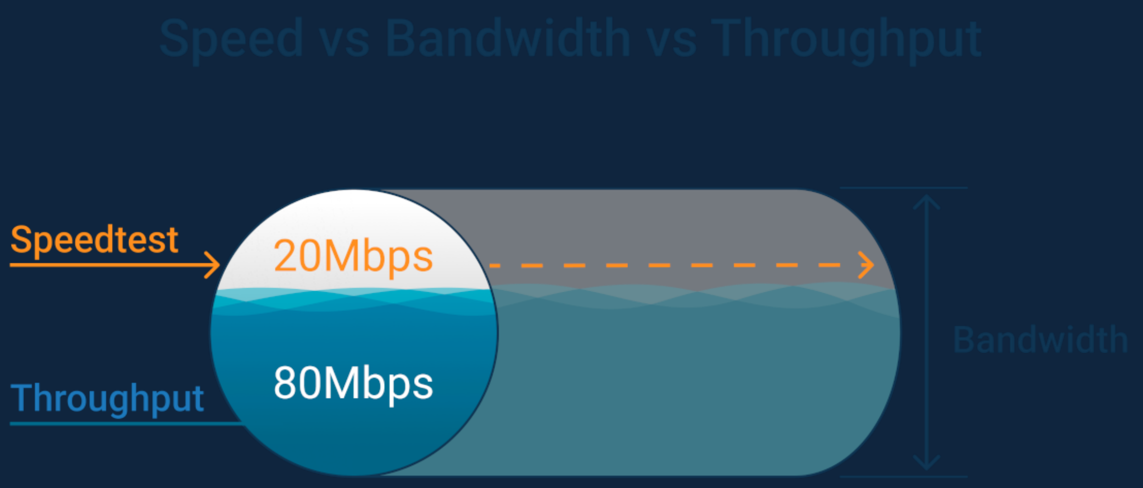
Latency:
Imagine latency as the amount of time it takes for a car to travel from one end of a highway to the other. A shorter highway with lower latency results in faster travel time.

In essence:
Bandwidth: focuses on how much data can be transferred.
Latency: focuses on how quickly data is transferred.

Data speed, or the rate at which data can be transmitted, has a direct impact on bandwidth. Higher data speeds generally require more bandwidth to handle the increased volume of data flowing through a network. While a fast data speed might enable quick downloads or streaming, a low bandwidth connection could result in slower speeds and potential buffering or lag.

Bandwidth as Capacity:

Bandwidth refers to the maximum amount of data that can be transferred over a network in a given period, often measured in megabits per second (Mbps). It's essentially the "capacity" of the network or connection.



Example:

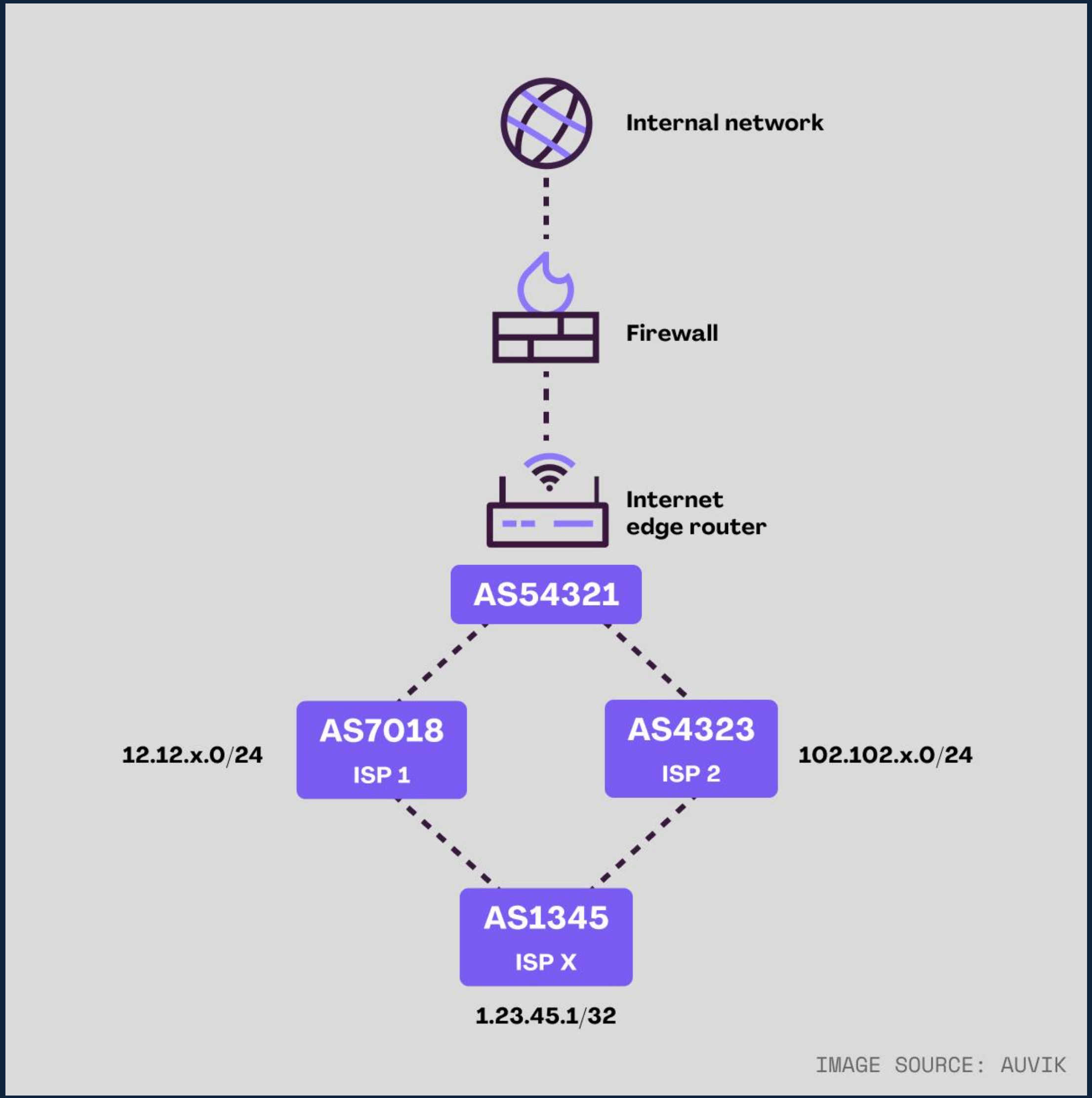
Imagine a pipe carrying water (bandwidth) and the water flow (data speed). If you want to increase the water flow (faster data speed), you'll need a wider pipe (higher bandwidth) to accommodate the increased volume.

ISP and power redundancy are crucial for reliable operation of internet-based ground control stations and C2/C3 links, ensuring uninterrupted communication and control even in the face of failures. ISP redundancy involves using multiple internet service providers, so if one link fails, the other takes over. Power redundancy uses backup power sources, like generators, to ensure continuous operation during power outages.

Concept:
ISP redundancy employs multiple internet connections, typically from different providers, to avoid single points of failure.

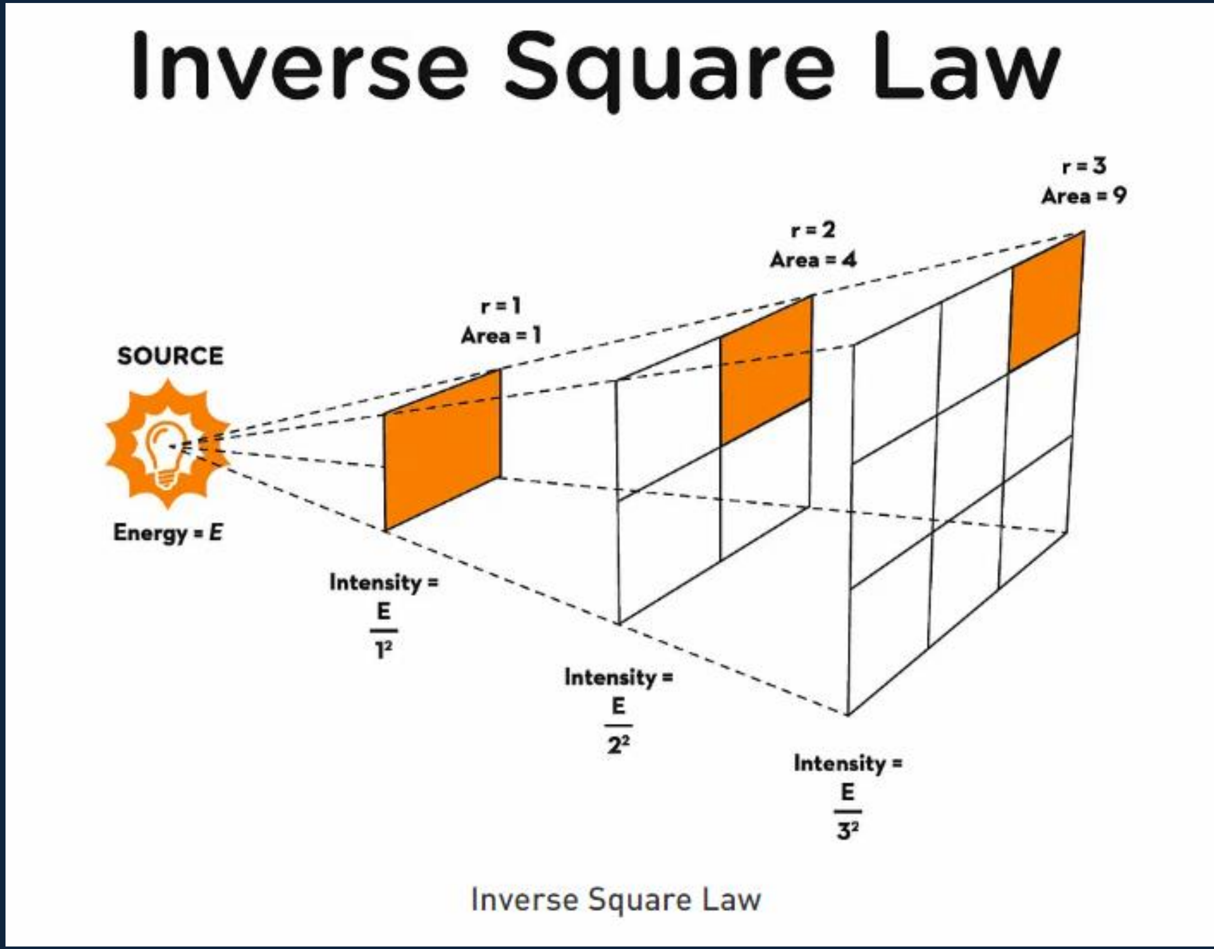
Types:
Load Sharing: Traffic is distributed across multiple ISPs, improving overall throughput and resilience.

Primary/Backup: One ISP is designated as the primary, with the backup taking over if the primary fails.



Radio waves – Characteristics & modulation

The inverse square law states that for a point source of waves that is capable of radiating omnidirectionally and with no obstructions in the vicinity, the intensity I decreases with the square of the distance, d, from the source.



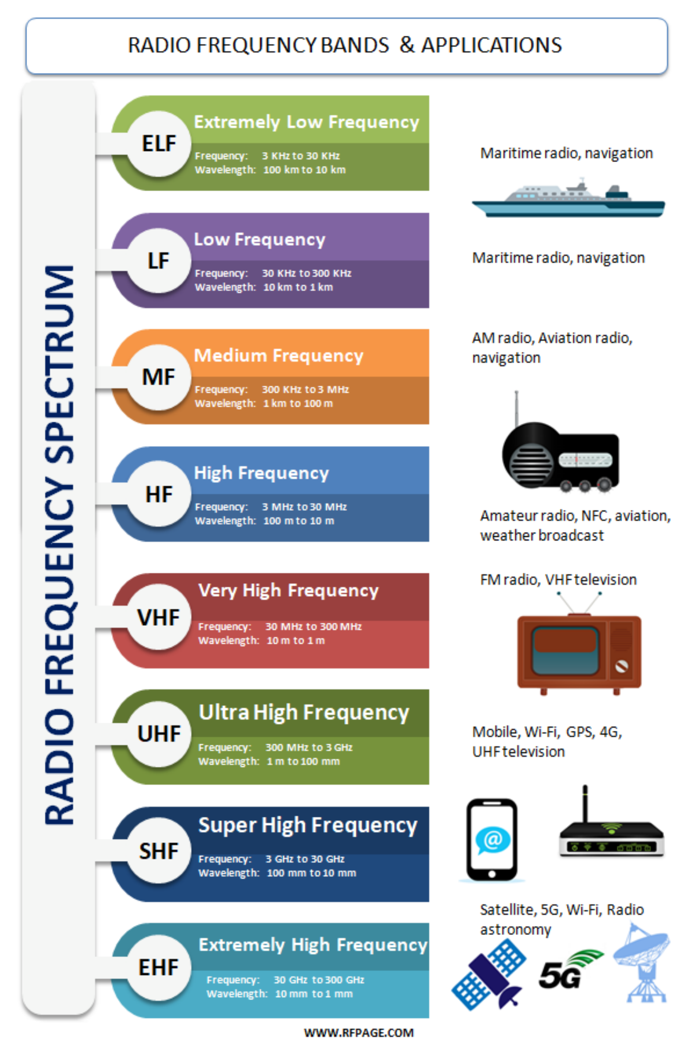
Division into Bands:

The radio spectrum is divided into bands, which are ranges of frequencies grouped for easier identification and management.

These bands are often labeled with abbreviations like LF, MF, HF, VHF, UHF, SHF, and EHF.

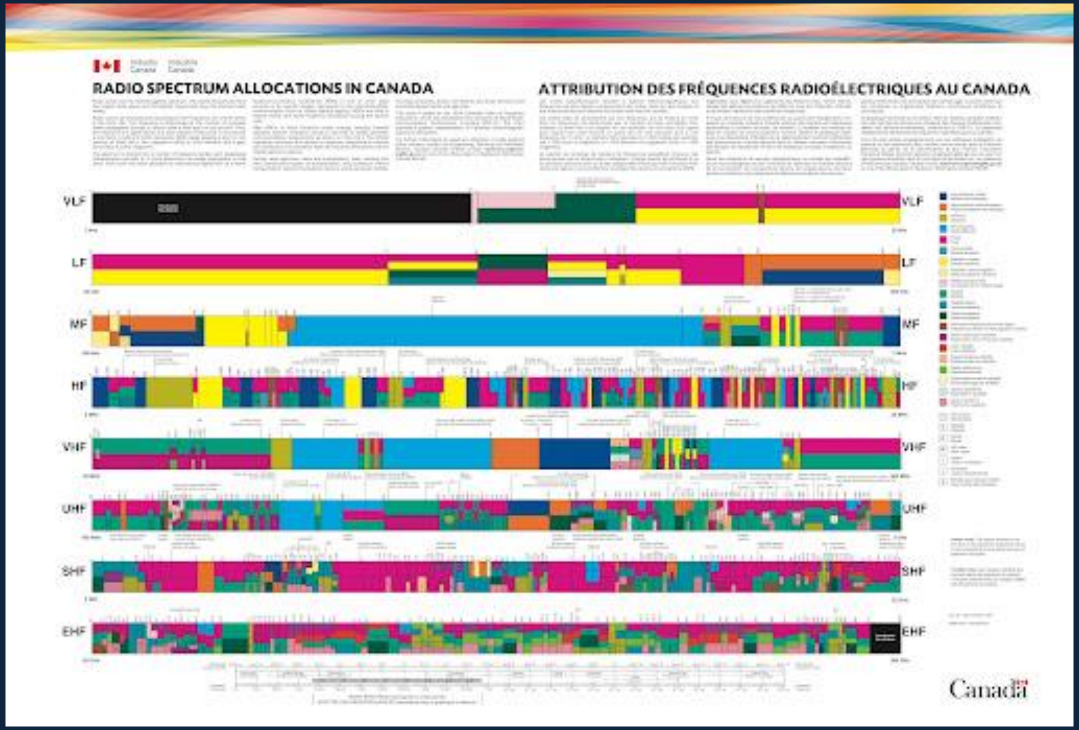
Examples of radio frequency bands and applications:

- **LF (Low Frequency):** Used for long-range communication and navigation.
- **MF (Medium Frequency):** Used for AM radio broadcasting.
- **HF (High Frequency):** Used for shortwave radio and amateur radio.
- **VHF (Very High Frequency):** Used for FM radio broadcasting, television, and some military communication.
- **UHF (Ultra High Frequency):** Used for mobile radio, television broadcasting, and some wireless data transmission.
- **SHF (Super High Frequency):** Used for satellite communication, radar, and some microwave applications.
- **EHF (Extremely High Frequency):** Used for radar, satellite communication, and some millimeter-wave applications.



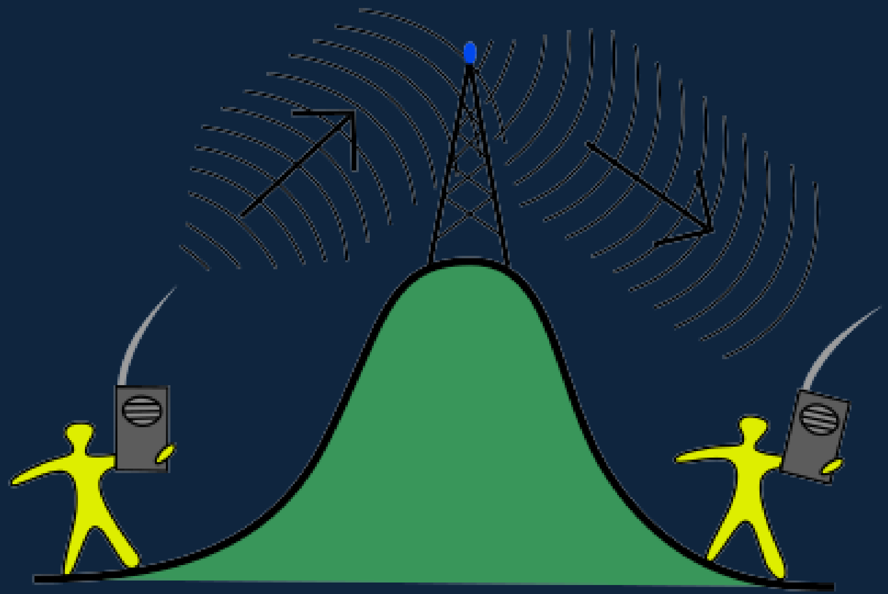
In Canada, specific frequency bands are designated for use by Remotely Piloted Aircraft Systems (RPAS), and approval from Innovation, Science and Economic Development Canada (ISED) may be required depending on the operation. Specifically, the 2.4 GHz band and the 5.7 GHz band are considered Industrial, Scientific and Medical (ISM) bands, often used for wireless communication, including by drones.

Additionally, the 118-136 MHz range is used for aviation radio communication, and the 225-328.6 MHz and 335.4-399.9 MHz bands are reserved for the Government of Canada, according to RSS-210.



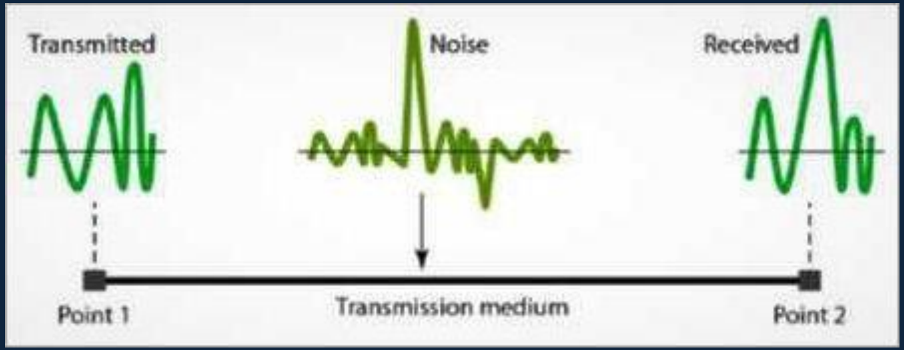
Radio Line Of Sight

Radio transmission requires a clear path between antennas known as **radio line of sight**. It is necessary to understand the requirements for **radio line of sight** when designing a network operating in the 2.4Ghz ISM band. **Line of sight** is the direct free-space path that exists between two points.




Drone Danger Zones

Attenuation is a term used in data communication to describe the loss of signal strength as it travels over a long distance or through a medium. In simple words, attenuation refers to the weakening or reduction of a signal.



Causes of Attenuation

Attenuation, in the context of data communication, refers to the loss of signal strength as it travels through a medium. There are several factors that can cause attenuation, including:

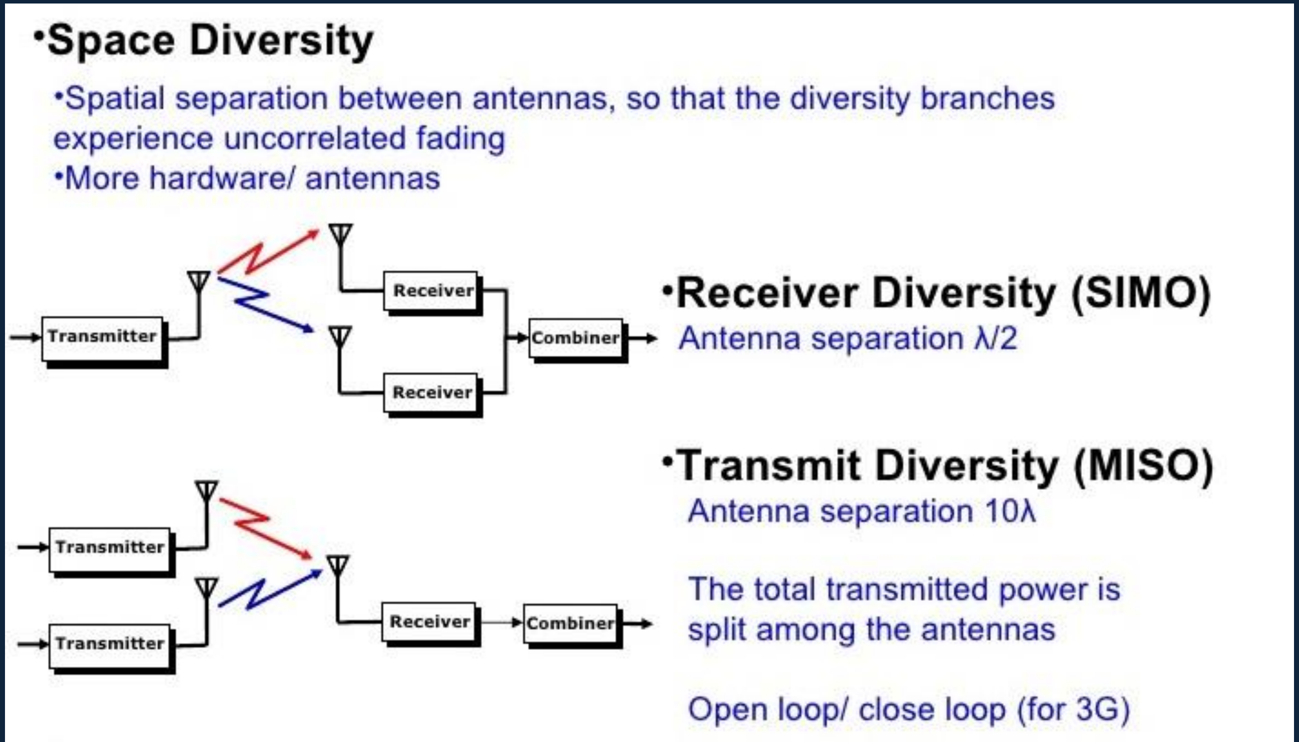
- **Distance:** As the signal travels a longer distance, it gradually loses power and becomes weaker. This can be particularly significant when transmitting data over long distances.
- **Noise:** Electrical noise from various sources, such as electromagnetic interference or crosstalk, can interfere w the signal and cause attenuation. This noise can distort or disrupt the signal, leading to a loss of data integrity

- **Impedance mismatch:** When there is a mismatch between the impedance of the transmitting device and the impedance of the medium or the receiving device, it can result in signal reflections and attenuation.

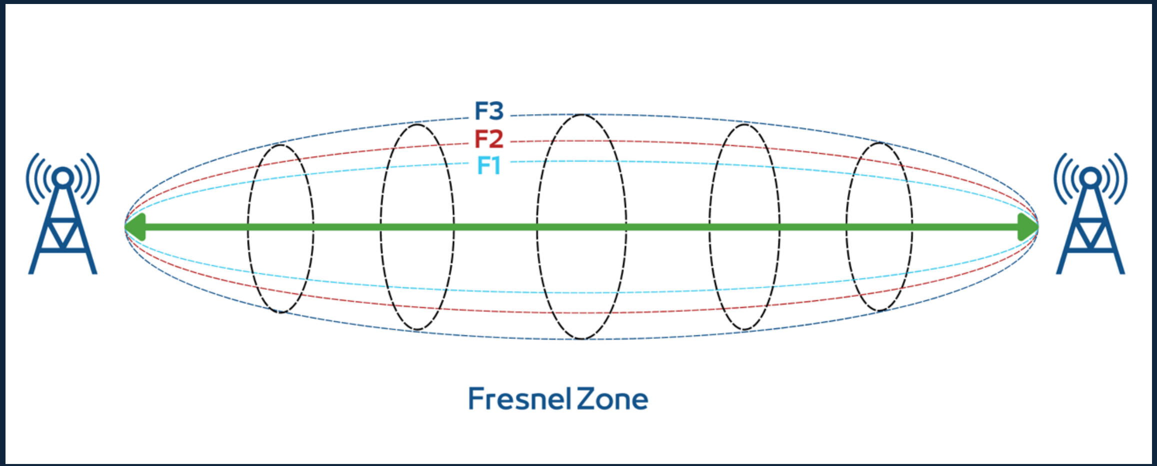
- **Signal interference:** Other signals present in the same medium can interfere with the desired signal, causing attenuation. This can happen in situations where multiple devices are transmitting simultaneously, creating a "cluster" of signals.

It is important to note that attenuation is a natural phenomenon in data communication, and its occurrence is inevitable to some extent. However, understanding the causes of attenuation allows engineers to develop strategies to minimize its impact and improve the overall quality of communication.

Spatial diversity is a wireless communication technique that utilizes multiple antennas to improve signal quality and reliability by leveraging the different spatial paths a signal can take. By transmitting the same signal through multiple antennas at both the transmitter and receiver, spatial diversity combats signal fading and interference, especially in environments with obstructions like buildings or trees. The receiver then combines the signals from these different antennas, potentially mitigating the effects of fading on one path



The Fresnel zone is an elliptical region of space surrounding the line of sight between a wireless transmitter and receiver, critical for wireless communication. Obstructions within the Fresnel zone can cause signal degradation and interference, making it a vulnerability for C2 links.



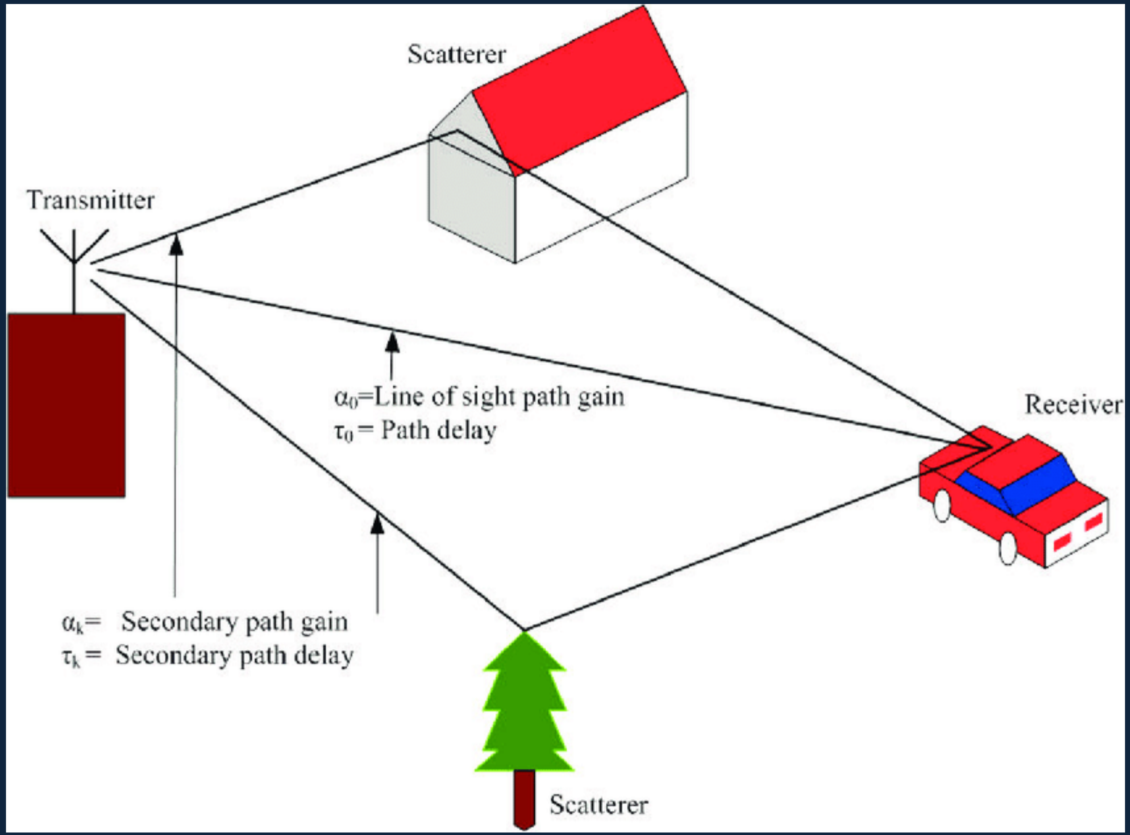
Vulnerability:
A C2 link (command and control) relies on reliable wireless communication for real-time data transmission. If the Fresnel zone is obstructed, it can lead to:

Signal degradation: The signal strength may be reduced or distorted.
Interference: Radio waves can bounce off obstacles and interfere with the main signal.

Communication failure: In severe cases, the connection might be lost entirely.

In radio communication, **multipath** is the propagation phenomenon that results in radio signals reaching the receiving antenna by two or more paths. Causes of multipath include atmospheric ducting, ionospheric reflection and refraction, and reflection from water bodies and terrestrial objects such as mountains and buildings.

When the same signal is received over more than one path, it can create interference and phase shifting of the signal. Destructive interference causes fading; this may cause a radio signal to become too weak in certain areas to be received adequately. For this reason, this effect is also known as **multipath interference** or **multipath distortion**.



Explain the basic measures to follow to maximize signal strength during long range missions ?

Communication and Control:
Maintaining a reliable communication link between the pilot and the drone is crucial, especially over longer distances.

Factors Affecting Drone Range:

Battery Life: Longer flight times are crucial for extended missions.

Communication Technology: 4G or other robust communication systems are essential for reliable control and data transmission.

Weather Conditions: Wind and other environmental factors can impact range and flight time.

Payload Weight: The weight of the payload can affect the drone's range and flight performance.

For Remotely Piloted Aircraft System (RPAS) Command and Control (C2) links, common frequencies include 5030-5091 MHz (C-band) and 2.4 GHz/5.8 GHz, with various modulation schemes like FM, QAM, and spread spectrum techniques being used. Satellite C2 links may also operate in the 1545-1555/1645.5-1656.5 MHz and 1610-1626.5 MHz bands.

Principal Frequencies:

5030-5091 MHz (C-band): This band is a primary candidate for both terrestrial and satellite C2 links, as it's also used for aeronautical radionavigation.

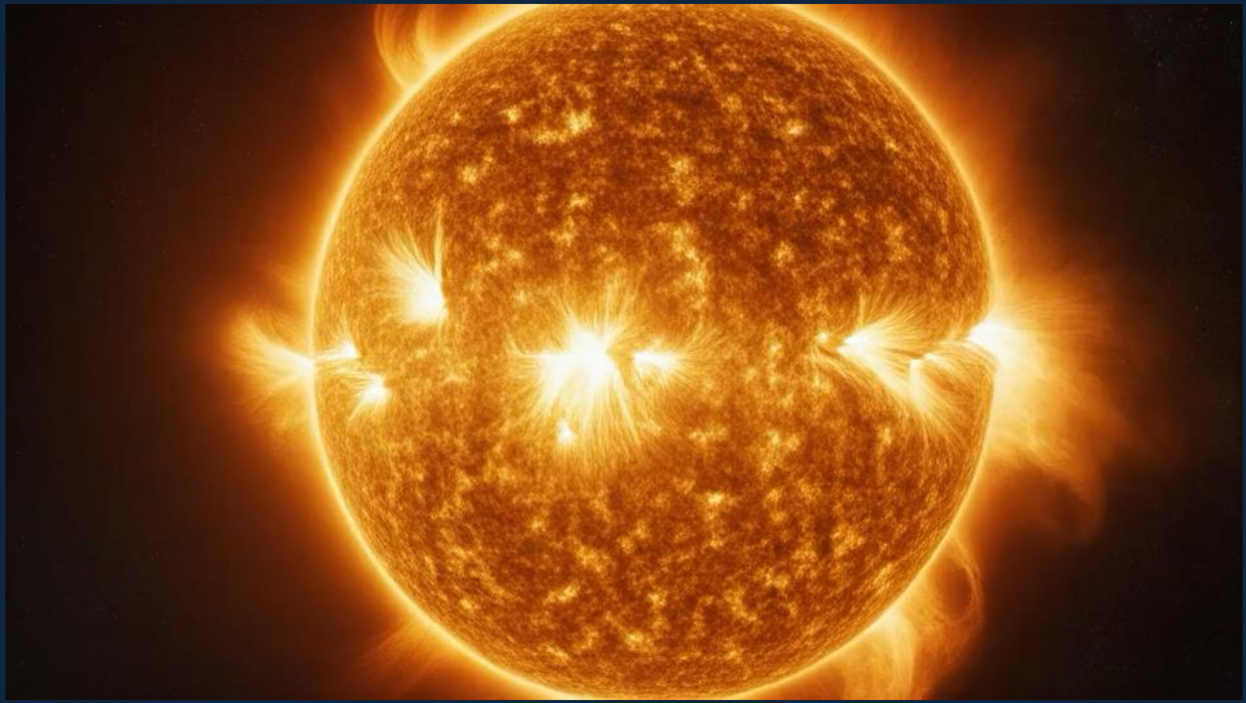
2.4 GHz/5.8 GHz: These bands are frequently used for UAVs and are commonly associated with commercial drone systems.

1545-1555/1645.5-1656.5 MHz, 1610-1626.5 MHz: These frequencies are used for satellite-based C2 links.

Electromagnetic interference (EMI)

Electromagnetic interference (EMI) in drones refers to unwanted electromagnetic signals that disrupt the normal operation of a drone's electronic systems. This interference can lead to malfunctions, loss of control, and even crashes. It's a significant concern for all drone applications, especially in demanding environments like military operations where reliability is critical.

The K-index, and by extension the Planetary K-index, are used to characterize the magnitude of geomagnetic storms. Kp is an excellent indicator of disturbances in the Earth's magnetic field and is used by SWPC to decide whether geomagnetic alerts and warnings need to be issued for users who are affected by these disturbances.
The principal users affected by geomagnetic storms are the electrical power grid, spacecraft operations, users of radio signals that reflect off of or pass through the ionosphere, and observers of the aurora.



Why Drone Pilots Must Monitor the Kp Index

Don't Let Space Weather Ground Your BVLOS Flight

As a professional drone pilot, you constantly manage risks like wind, rain, and air traffic. But an invisible, silent factor originating **93 million miles away** can suddenly turn a smooth operation into a disaster: **space weather**. This is where the **Kp index** becomes your critical pre-flight check.

The **Kp index** (Planetary K-index) is an essential global measure of **Earth's geomagnetic activity** [1, 3]. It quantifies disturbances in our planet's magnetic field caused by powerful solar events like solar flares and coronal mass ejections (CME) [1, 2]. It’s measured on a scale from **0 to 9** [1, 3]:

- **Low Kp (0-3):** Indicates quiet, stable geomagnetic conditions.
- **High Kp (4-9):** Indicates disturbed conditions. A Kp of **5 or more** is formally classified as a geomagnetic storm (G1 Minor) [3].

How High Kp (4-9) Jeopardizes Your Drone ⚠️

High geomagnetic activity primarily interferes with the electronic and satellite systems critical for safe drone operation, especially those conducting **Beyond Visual Line of Sight (BVLOS)** and Level 1 Complex missions.

1. GPS Signal Degradation (The Biggest Threat)

•**Impact:** This is the most significant issue, leading to **GPS signal degradation or loss** [1, 2]. Geomagnetic interference directly impacts the reliability of GNSS (Global Navigation Satellite Service) signals [2].
•**Effect:** A drone's normal positioning accuracy can degrade dramatically. While typically accurate to a few meters, during a strong storm, the error box can swell to **15 to 20 meters or more** [2]. This renders high-precision tasks like surveying or mapping potentially **worthless** ("garbage in, garbage out") and is a major flight hazard [2].

Flight Stability and Navigation Issues

•**Impact:** Loss of reliable GPS forces the drone to revert to less accurate stabilization methods, such as its basic **downward-facing vision system** .
•**Effect:** The drone may experience **drift**, an inability to hold a stable position, or **anomalies in compass readings** affecting the autopilot's accuracy This is particularly risky when operating near obstacles or over **low-contrast surfaces** (e.g., open water or gravel) .

Communication Interference

•**Impact:** Increased geomagnetic activity leads to **radio interference** and heightened risk of **electromagnetic interference (EMI)** [**Effect:** This can potentially impair communication links, affecting control and telemetry data, and increasing the risk of a loss-of-link scenario

For **BVLOS** and Complex operations, the Kp index requires mandatory assessment and strict mitigation.

Phase I: Pre-Flight Go/No-Go Decision

- **Kp Index Check:** Check the current and forecasted Kp index using reliable sources (e.g., NOAA SWPC, UAV Forecast) [2, 3].
- **Manufacturer Limit:** Confirm the current Kp index **does not contravene the drone manufacturer's instructions** or maximum Kp limit [2].
- **GPS Accuracy Requirement:** If the mission requires high-precision GPS (e.g., surveying or mapping), the flight is a **NO-GO**. The data collected will likely be unreliable [2].
- **Controlled Airspace Compliance:** If flying in controlled airspace, confirm that expected GPS degradation **will not invalidate the minimum accuracy** required for your Safety Assurance Declaration (SAD) [2].
- **Risk Management:** Document the Kp index and integrate the geomagnetic hazard into the overall **risk management process** [1].

Phase II: System Check & Mitigation

- **Compass Calibration:** Perform a fresh **compass calibration** immediately prior to take-off, accounting for potential magnetic fluctuations [2].
- **GNSS Lock Redundancy:** Confirm the drone has locked onto a **high number of satellites** across multiple GNSS systems (GPS, Galileo, BeiDou) to maximize signal reliability [2].
- **Low-Contrast Avoidance:** Ensure the planned flight path and takeoff/landing zones **avoid low-contrast surfaces** (water, featureless terrain) that could confuse the vision positioning system if GPS is lost [2].
- **Obstacle Spacing:** If operating near obstacles, **increase separation distances** beyond the minimums to account for potential positional drift [2].

Phase III: In-Flight Management 🔭

•**Monitor Telemetry:** Maintain **heightened awareness** by constantly monitoring the satellite count and GPS positional accuracy.
•**Watch for Drift:** Immediately look for signs of unexpected **positional drift** or an inability to hold a stable hover
•**Contingency Activation:** Be ready to activate **contingency plans** for loss of GPS, communication link interruptions, or unstable flight control [1].
•**Immediate Landing:** If significant anomalies or flight control issues arise, initiate an **immediate, controlled descent and landing**.
•**Final Authority:** Remember, the final safety decision rests entirely with the **pilot-in-command**

Other EMI Sources : Harmonic radiation refers to undesired radio frequency emissions that are integer multiples of the intended transmission frequency, also known as the fundamental frequency. These harmonics can cause interference with other radio services or electronic devices if they lie outside of the intended frequency band.

Harmonic radiation can interfere with radio signals in several ways:

Interference with other radio services:

Harmonics can fall within the frequency bands of other radio services, such as broadcast radio, television, or mobile phone networks, causing interference.

Interference with electronic devices:

Harmonics can also interfere with electronic devices that use radio frequencies, such as televisions, radios, and mobile phones, causing distorted audio or video.

Reduced signal quality:

Harmonics can reduce the quality of the intended radio signal, making it weaker and more difficult to receive.

To minimize C2 link interference using EMI measurements, first identify the interference sources and paths. Then, implement filtering, grounding, and shielding solutions based on the measured EMI levels. Finally, test and verify the effectiveness of the implemented solutions to ensure compliance with relevant standards.

Frequency Analysis:
Analyze the frequency spectrum of the interference to identify the frequencies where the interference is most significant.

Batteries

Risks associated with transporting lithium-ion batteries.

The relevance of the TDG Act regarding transportation of LiPo batteries.

How improper handling, use or storage can affect battery capacity.

A drone battery can catch fire due to overcharging, physical damage, or using incompatible chargers. It's important to charge batteries on a fireproof surface and never leave them unattended while charging to prevent such incidents.

The **battery** is one of the parts of your **drone** that needs special attention. Like any other **battery**, poor maintenance can quickly reduce the power storage capacity of the **battery** of your **drone**. At worst, you could end up with a **battery** that explodes or catches **fire**.

Drone
Carry on baggage
Yes
Checked baggage
Yes

Lithium ion batteries with a watt-hour (Wh) rating of 100 Wh or less may be carried in a device in either carry-on or checked baggage.

Spare batteries: Spare lithium ion batteries of 100 Wh or less must be packed in carry-on and are **permitted only with air carrier approval** in checked baggage.

Fuel systems

Fuel Cells for Drones & UAVs

Fuel cells are rapidly emerging as a leading power solution for drones and UAVs. They offer advantages such as long-endurance flight, high efficiency, and reduced environmental impact. From hydrogen fuel cells to proton exchange membrane (PEM) and solid oxide fuel cells, these power systems provide alternatives to conventional lithium-ion batteries and internal combustion engines. As the demand for reliable, efficient, and high-performance RPAS power solutions increases, fuel cell technology is transforming the unmanned systems landscape.

Methods to assess fuel quantity and consumption under different flight conditions

Kerosine
Hydrogen

Weather/ Temperature/Wind

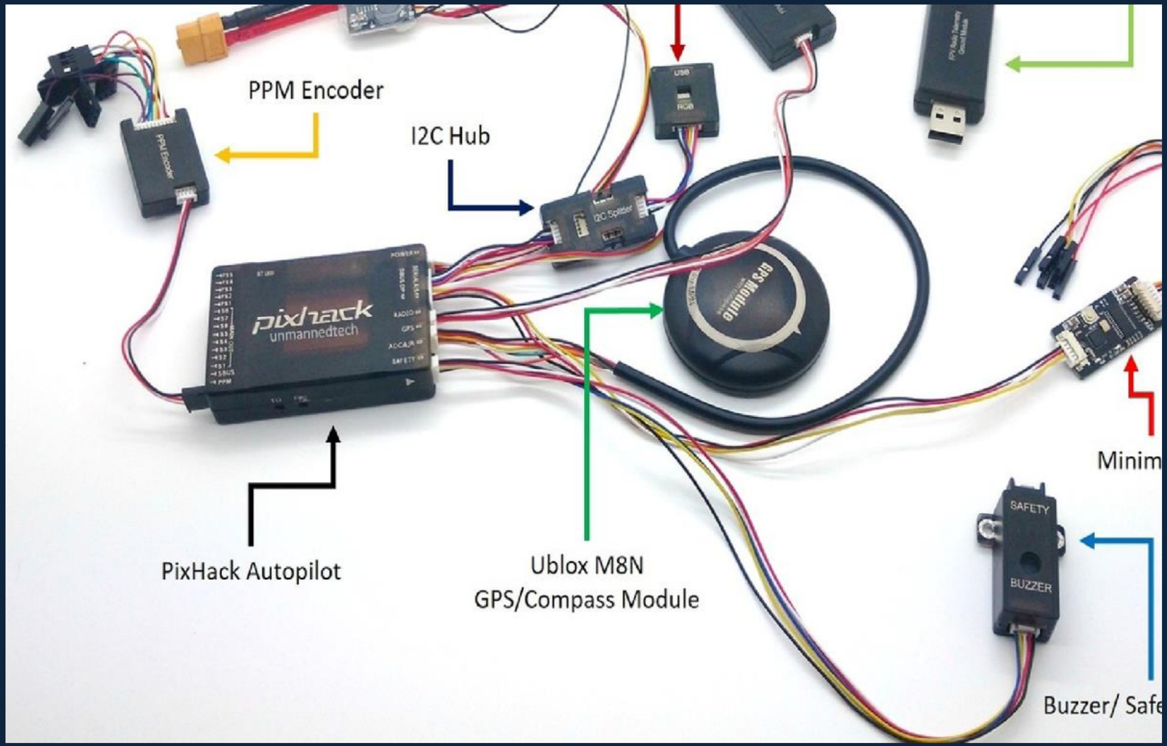
Distance assessment

Altitude

Safe Storage Methods
Approved storage containers for fuels

Autopilots

There is no fixed definition, but I like to refer to an autopilot as a complete system that enables your drone to fly autonomously to way-points etc..., And a flight controller is just the device that will keep your aircraft stable. However, depending on who you talk to many people use these two words interchangeably.



Typical issues with Autopilots

Loss of Signal to the drone

Software or Firmware issues

Remember to Always be monitoring your drones progress when using Autopilot.

In case of an emergency override the autopilot and activate the return to home function if possible.

Propulsion

Propulsion system types

It should be noted that drones have three types of propulsion systems, namely the fuel, hybrid fuel-electric, and pure electric.

Typically, a failure of any of these propulsion system will lead to a crash after power to the motors stops.

Two-stroke engines are designed so that a complete power cycle requires two movements of the piston (one up and one down) while the engine's crankshaft completes one revolution. As they are smaller and lighter than four-stroke engines, 2-stroke engines are a common choice for UAV (unmanned aerial vehicle) propulsion.

Four-stroke engines are a form of internal combustion engine that are designed in such a way that their power cycle involves four distinct strokes of each piston for one revolution of the engine's crankshaft – these strokes are known as intake, compression, combustion and exhaust.

2 Stroke engine

Payloads

What comprises the payload vs. the rest of the system ?

RPAS can carry a variety of payloads. Most of us are familiar with the site of a RPAS carrying a camera, however RPAS used in industry can carry a variety of payloads.

These can include specialized Cameras for film and TV , Packages and a variety of other sensors such as radiation detection equipment , farming spray, infra- red , equipment

Payload –means all elements of the aircraft that are not necessary for flight but are carried for the purpose of fulfilling specific mission objectives. This may include such sub-systems as intelligence and surveillance assets, communication relay equipment, sensors, cargo and cameras.

Payload Operator –means the person (s) trained to operate the payload system, and in some cases, manage the flight profile.

Payload considerations

OEM Payloads

An OEM payload as example would be a camera or other system produced by a manufacturer specifically for that RPA.

A drone delivery service would be an example of where a payload would just be transported rather than a part of the overall system.

An example of a payload that might be changed during a flight would be a camera or other sensor related to completion of the mission.

Keep in mind that carrying a payload of any kind will have an effect on the overall performance of the drone in terms of time in the air and distance the drone can travel.

Launch and recovery systems

Danger areas associated with launch and recovery operations

Launch and recover of your drone should be thought out carefully and included in your site survey and emergency procedures and operations manual.

Every operator should have a recovery plan during all RPAS operations. This can include commercial recovery systems such as parachutes, which will ensure the safety of the public and your equipment during a failure condition , or normal flight operations depending on the type of RPAS you fly. Again your site survey should show potential recovery areas should the need areas to make a forced landing away from your initial launch point.

Launcher Performance what can affect them ?

There are different types of launch systems that can be used on fixed wing drone. These include elastic cord launchers , pneumatic and hydraulic. Each if these can be affected by temperature thus decreasing their effectiveness.

In case of launch failure, you should ground your operation until it is determined what caused the issue

Hydraulic Launcher

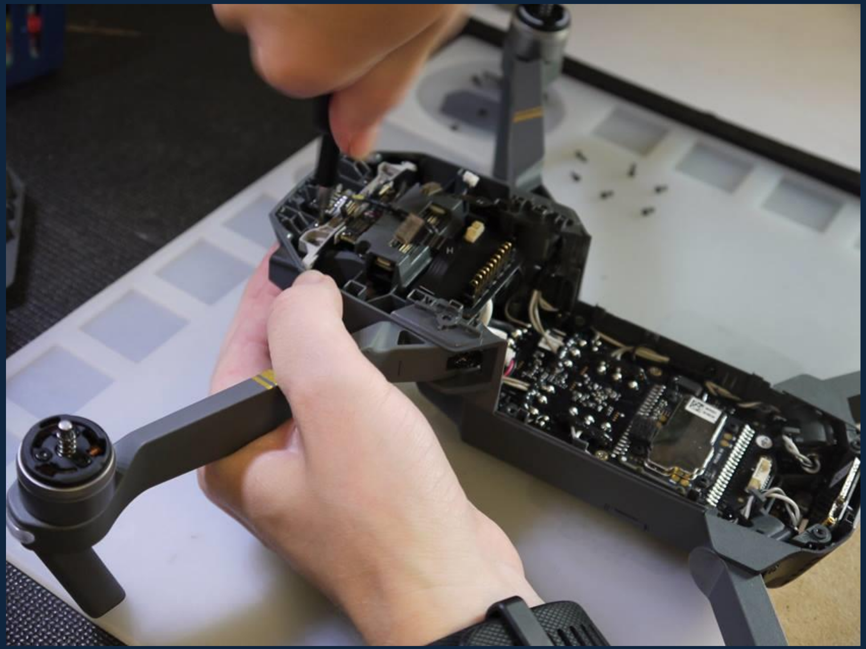
Pneumatic Launcher

How does temperature affect a rubber band's elasticity?
Room-**Temperature Rubber**. At room **temperature**, a **rubb** **band** snaps back due to its **elastic** molecular properties. The strands that make up the **rubber band** stretch, but forces in the **rubber** molecules pull them back to their original shape.

The **rubber** band actually expands when it gets colder! This seems counterintuitive because most materials expand when they are heated and contract when they get cold. This occurs because of the unusual polymer structure of **rubber**. ... When the chains cool down, they relax and stretch out, causing the material to expand.

Most solid materials expand when they **heat** up, but **rubber** bands **shrink** because the **heat** makes the **rubber** molecules move around and lose alignment, which causes them to **shrink**, according to Vince Calder in "**Rubber** Bands and Elasticity." ... Use a hair dryer to blow hot air on the **rubber** band.

Maintenance and record keeping

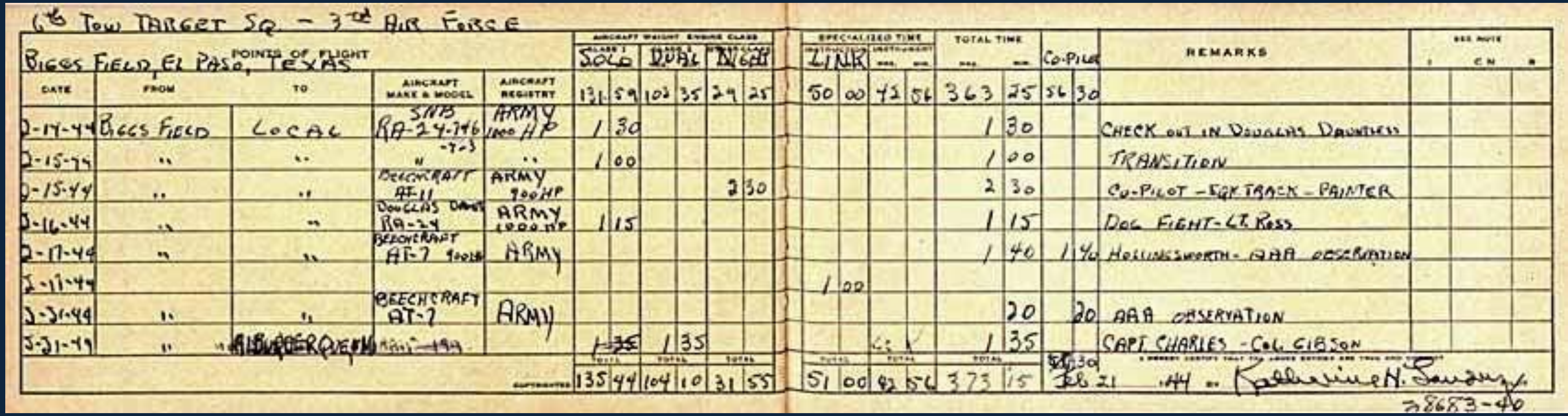


It is critically important to keep proper records of your RPAS operations. These should include the following.

Aircraft maintenance records

These are critical and must be kept to ensure the drone is operating properly before each flight. All maintenance should follow manufacturers specifications.

These records should be available for independent verification if required.



6th Tow Target Sq – 3rd Air Force

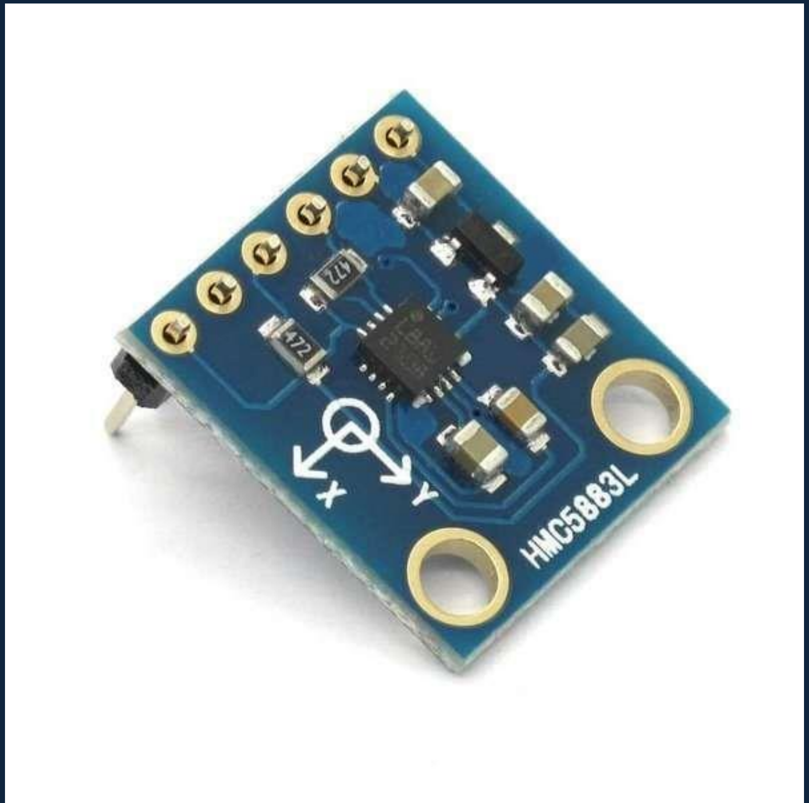
Biggs Field, El Paso, Texas

Date	From	To	Aircraft Make & Model	Aircraft Registry	Solo	Dual	Night	Link	Instrument	Total Time	Co-Pilot	Remarks
					131 59	103 35	29 25	50 00	42 56	363 25	56 30	
[illegible]-14-44	Biggs Field	Local	SNB RA-24-746	ARMY 1000 HP	1 30					1 30		Check out in Douglas Dauntless
[illegible]-15-44	"	"	-7-3 "	"	1 00					1 00		Transition
[illegible]-15-44	"	"	Beechcraft AT-11	ARMY 900HP			2 30			2 30		Co-Pilot – Sqr Track – Painter
[illegible]-16-44	"	"	Douglas Dauntless RA-24	ARMY 1000 HP	1 15					1 15		Dog Fight – Lt. Ross
[illegible]-17-44	"	"	Beechcraft AT-7 900HP	ARMY						1 40	1 40	Hollingsworth – AAA observation
[illegible]-17-44								1 00				
[illegible]-31-44	"	"	Beechcraft AT-7	ARMY						20	20	AAA observation
[illegible]-31-44	"	Albuquerque	RA-24-[illegible]		~~1 35~~	1 35				1 35		Capt. Charles – Col. Gibson
				Total	135 44	104 10	31 55	51 00	42 56	373 15	58 30	Feb 21 '44

Magnetic compass

How a compass sensor is generally used by RPA

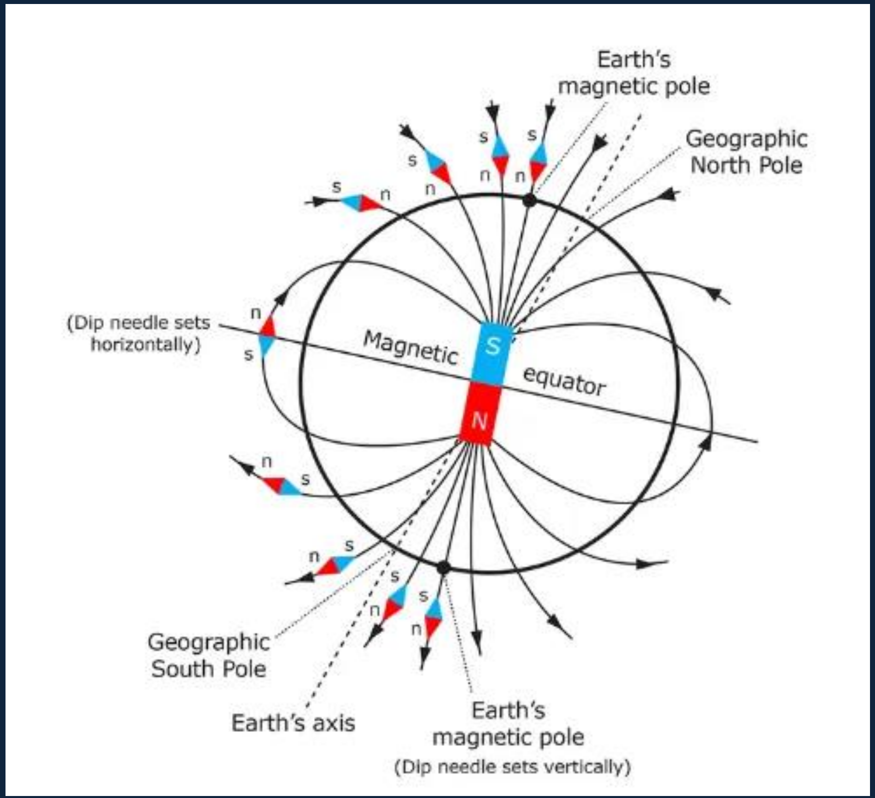
Drones have a digital compass inside them. The compass and GPS are usually in the same sensor and placed on top or inside the drone.



The Compass and Flight
The compass plays a crucial role in a drone's flight. It essentially tells the drone which direction it's facing compared to Earth's magnetic field. This information is vital for the drone to know where to go during flight and maintain its position.
Compass helps the drone fly smoothly and stay balanced in the air.

What is Compass Calibration?
Our planet has a magnetic field, like a giant invisible magnet. The strength and direction of this field can vary depending on location. Compass calibration addresses these variations.

Imagine you're using a regular compass. The needle points towards magnetic north, which isn't always the same as true north. Calibration helps account for this difference, ensuring your compass readings are accurate.
During calibration, the drone is rotated in various directions. This process gathers data on the magnetic field's strength and direction at that specific location. The data is then used to adjust the compass and eliminate any errors, allowing the drone to determine its heading and direction of travel accurately. Think of it as fine-tuning the compass to match the local magnetic field.



Why Calibrate?
Compass calibration is crucial for accurate navigation and a stable flight path. By calibrating, you eliminate magnetic interference and ensure the compass aligns with Earth's magnetic field. Without proper calibration, the drone could experience:
•**Navigation Errors:** The drone might fly in the wrong direction or struggle to maintain its course.
•**Flight Path Issues:** Difficulty maintaining a straight line or experiencing unexpected changes in heading.

Altimeter

Principles of Operation

This type of altimeter is known as an **Aneroid Barometer**

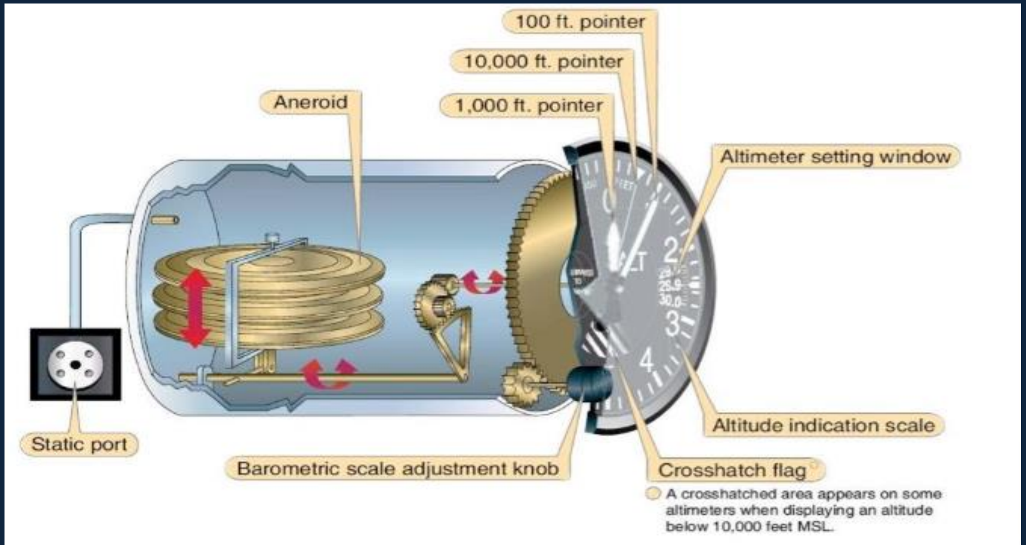
The instrument is connected to the **Static Port** which is located in the slipstream of air on the fuselage of the aircraft

Inside the instrument are a number of aneroid capsules which are filled with air at a pressure of 29.92 in Hg

As the aircraft climbs or descends pressure outside the aircraft changes which passes through the static port and into the Altimeter

Pressure increase causes the aneroid capsule to contract, indicating a descent

Pressure decrease causes the aneroid capsule to expand, indicating a climb

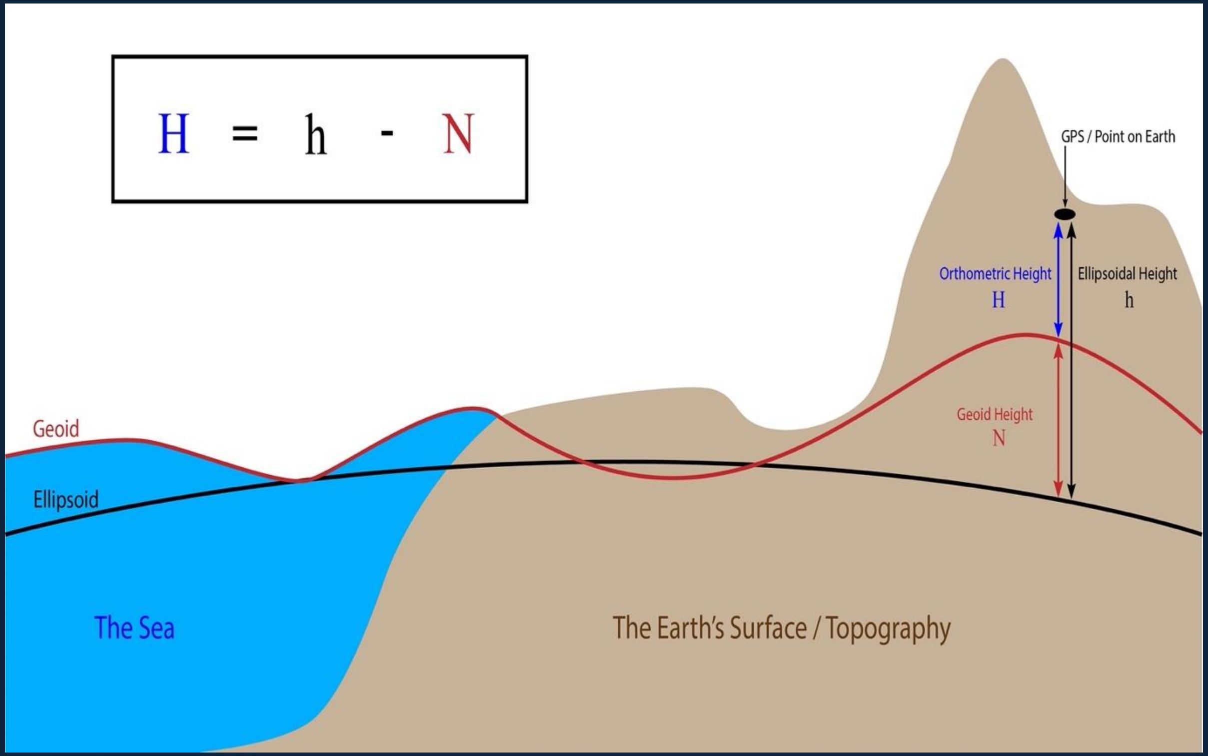


Altimeters measure pressure altitude above a given datum and have to be calibrated to be accurate. GPS altitude is derived from a receiver that times signals from multiple satellites to work out your distance from the ground.

The **Ellipsoidal Height (h)** is the difference of the vertical distance between a point on the Earth's Surface and the ellipsoid. The Ellipsoidal height is also known as the **geodetic height** and should not be confused with geodetic datums.

When capturing coordinates with a GPS receiver, the elevation data references the ellipsoid, which means each captured coordinate needs to be calculated to match elevations with the more accurate geoid height.

To convert GPS altitude to Above Sea Level (ASL), you'll need to calculate the geoid height at the specified latitude and longitude. The GPS altitude is an ellipsoidal height, while ASL (or orthometric height) is referenced to a vertical datum like the mean sea level. You can use online tools like the Geoid Height Calculator from UNAVCO or the World Coordinate Converter https://twcc.fr/to find the geoid height, and then subtract it from the GPS altitude to obtain the orthometric height (ASL).



A geometric altitude measurement tells you exactly how far you are from the ground.

Altimeter Setting and Standard Pressure Region Altimeter Setting Region The altimeter setting region is an airspace of defined dimensions below

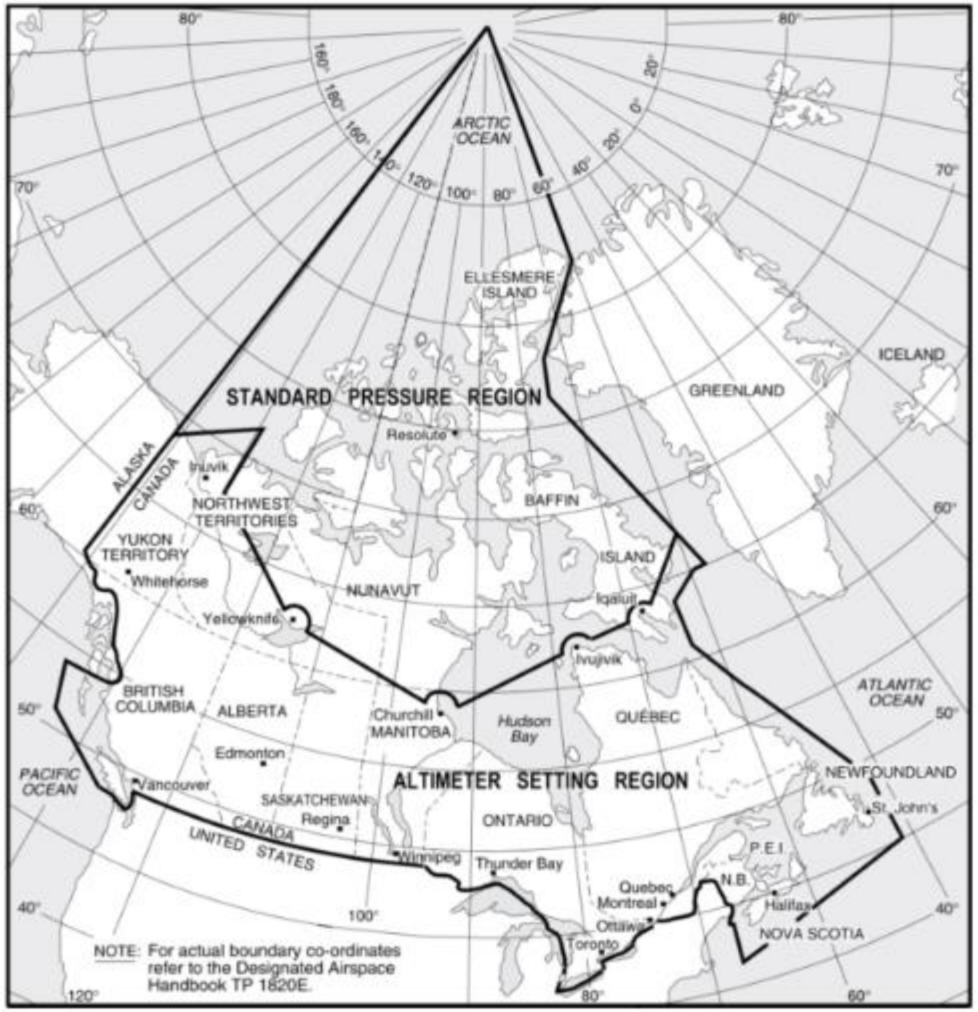
The altimeter setting region is an airspace of defined dimensions below 18,000 feet ASL within which the following altimeter setting procedures apply:

Departure – Prior to takeoff, the pilot shall set the aircraft altimeter to the current altimeter setting of that aerodrome or, if that altimeter setting is not available, to the elevation of the aerodrome.

En route – During flight the altimeter shall be set to the current altimeter setting of the nearest station along the route of flight or, where such stations are separated by more than 150 NM, the nearest station to the route of flight.

Arrival – When approaching the aerodrome of intended landing the altimeter shall be set to the current aerodrome altimeter setting, if available.

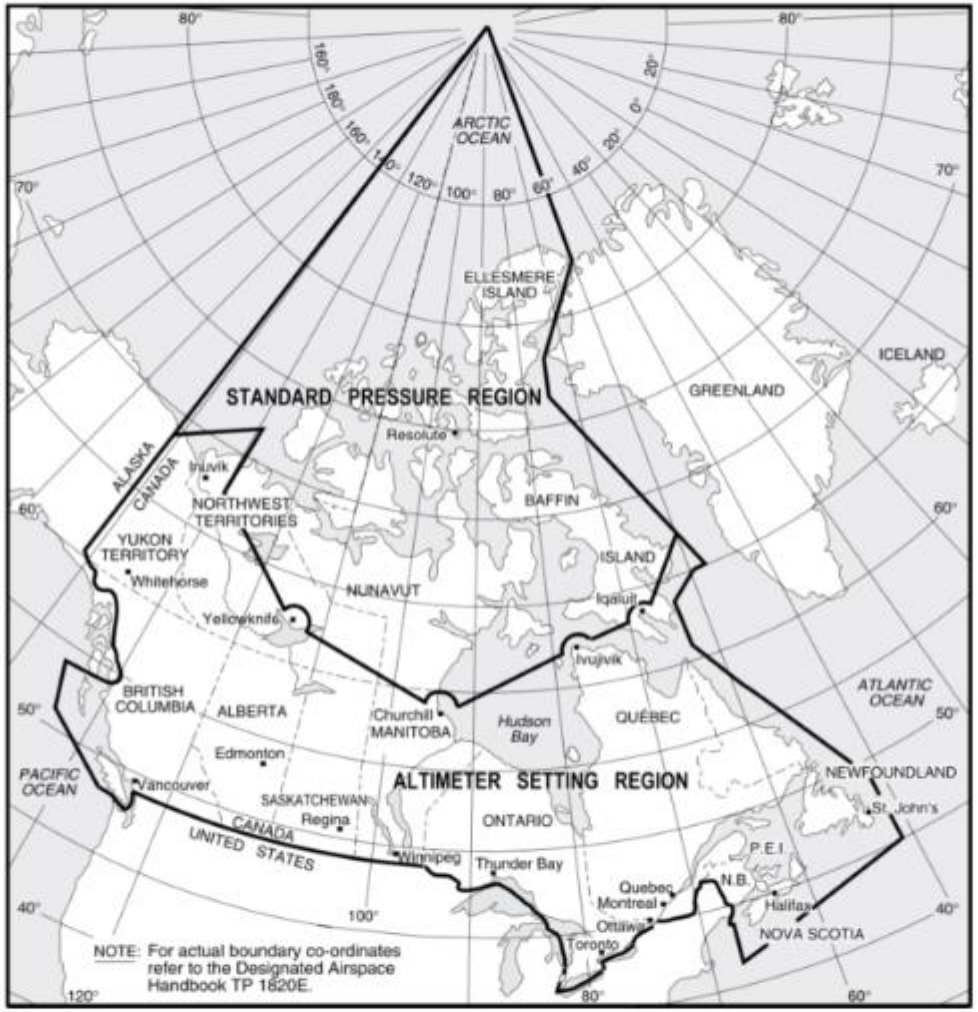
Standard Pressure Region



Altimeter Setting and Standard Pressure Regions

Transport Canada – Aeronautical Information Manual

The standard pressure region includes all airspace over Canada at or above 18,000 feet ASL (the high-level airspace), and all low-level airspace that is outside of the lateral limit of the altimeter setting region. Within the standard pressure region the following flight procedures apply: General – Except as otherwise indicated below, no person shall operate an aircraft within the standard pressure region unless the aircraft altimeter is set to standard pressure, which is 29.92 inches of mercury



Altimeter Setting and Standard Pressure Regions

Transport Canada – Aeronautical Information Manual

Airspeed indicator

True Airspeed is calibrated airspeed which is corrected for air density

This is known as the actual speed of the plane through air

This can be calculated using a flight computer, or a true airspeed indicator

As a note: True airspeed is always higher at the stall, at high altitudes or high temperatures – however, indicated airspeed will always remain the same

What is the difference between airspeed and ground speed ?

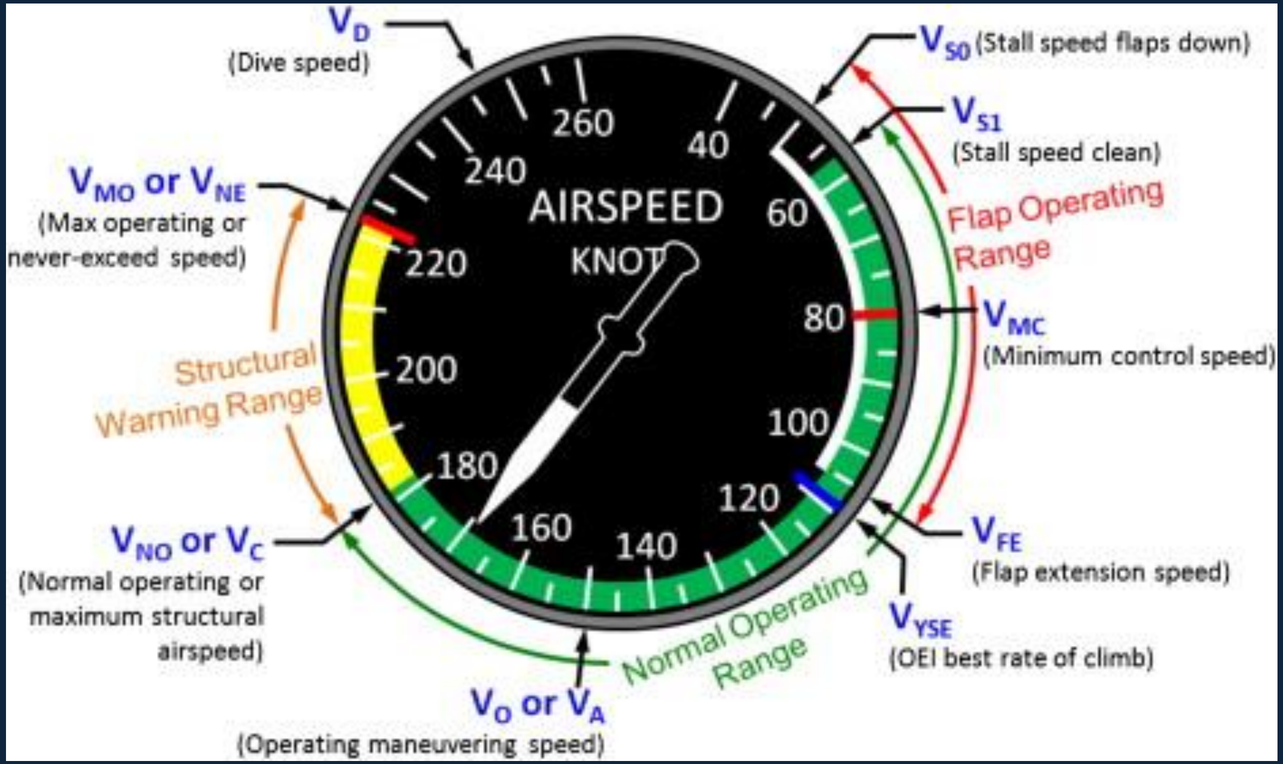
- **Airspeed:**
- This is the speed of an aircraft relative to the air it's flying through. Wind can influence this speed, but the aircraft's airspeed remains constant regardless of wind conditions.

- **Ground Speed:**

- This is the aircraft's speed over the ground, taking into account the effect of wind. A tailwind will increase ground speed, while a headwind will decrease it.

In essence, ground speed is a combination of airspeed and wind speed. If there's no wind, airspeed and ground speed are the same.

Drones primarily use airspeed for navigation and flight control. While ground speed is also important (especially for certain applications like mapping), it's not the primary metric used by the drone's flight computer.



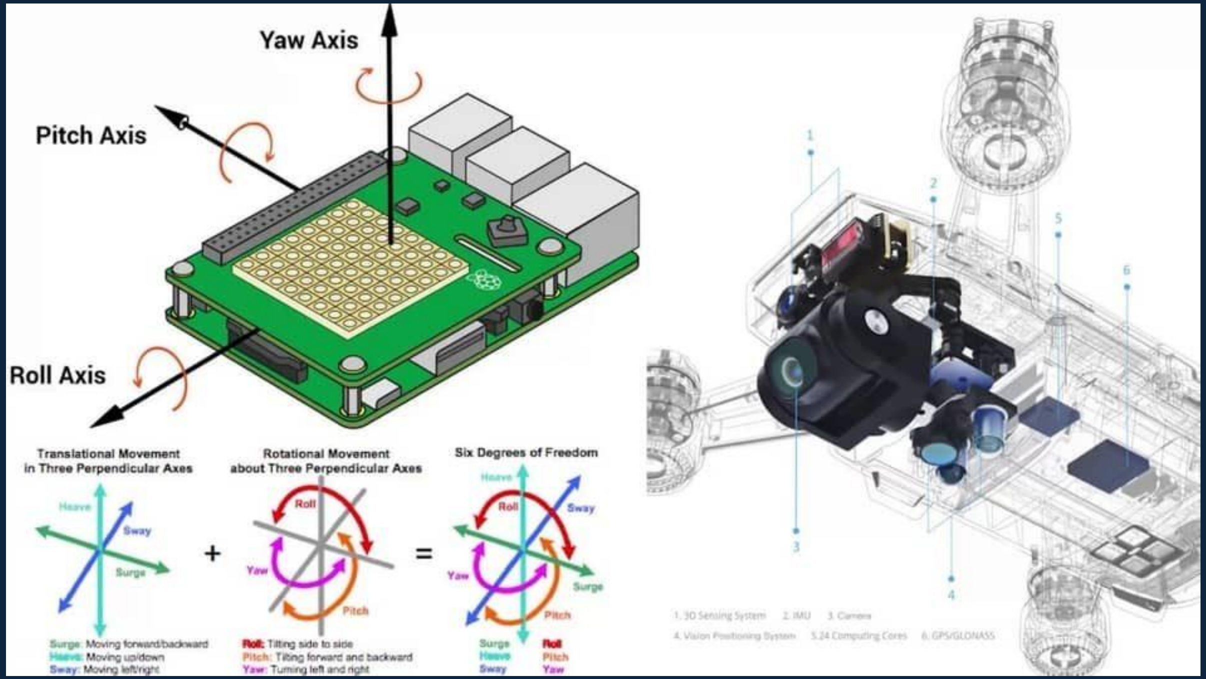
Inertial measurement unit (IMU)

An inertial measurement unit (**IMU**) is an electronic device that measures and reports a body's specific force, angular rate, and sometimes the magnetic field surroundings the body, using a combination of accelerometers and gyroscopes, sometimes also magnetometers.

Effects of an uncalibrated or defective IMU.

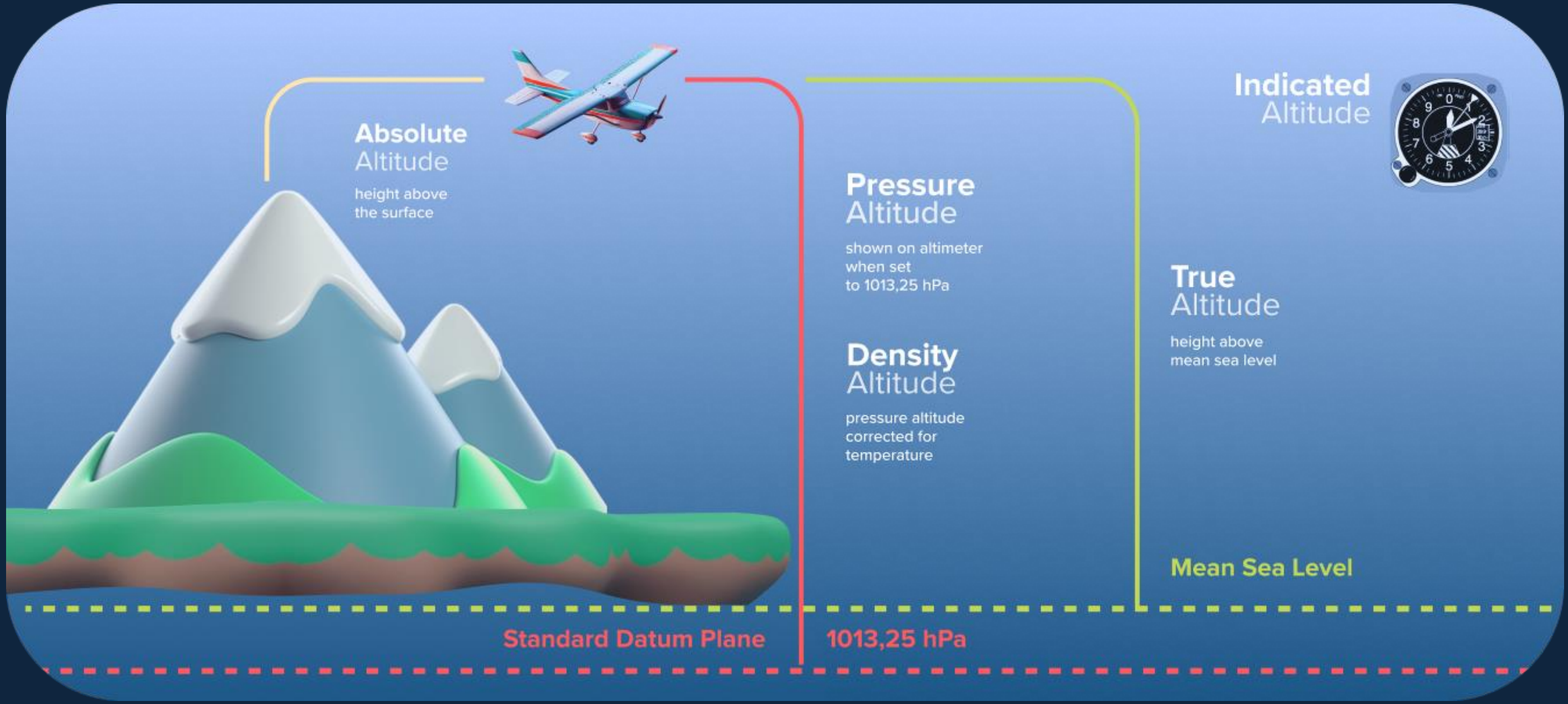
When certain features are not correctly calibrated and in sync with other components, the drone could operate out of balance. The IMU's sole purpose is to keep your drone as level and flat as possible.

The sensor will realize zero motion with no movement up, down, left, or right when calibrated correctly. The reverse is also true. A Wrong calibration on your IMU will bring inaccurate angular velocity, leading to a short rapid drift of integral orientation. When your drone keeps drifting, it becomes challenging to control and stabilize the aircraft.

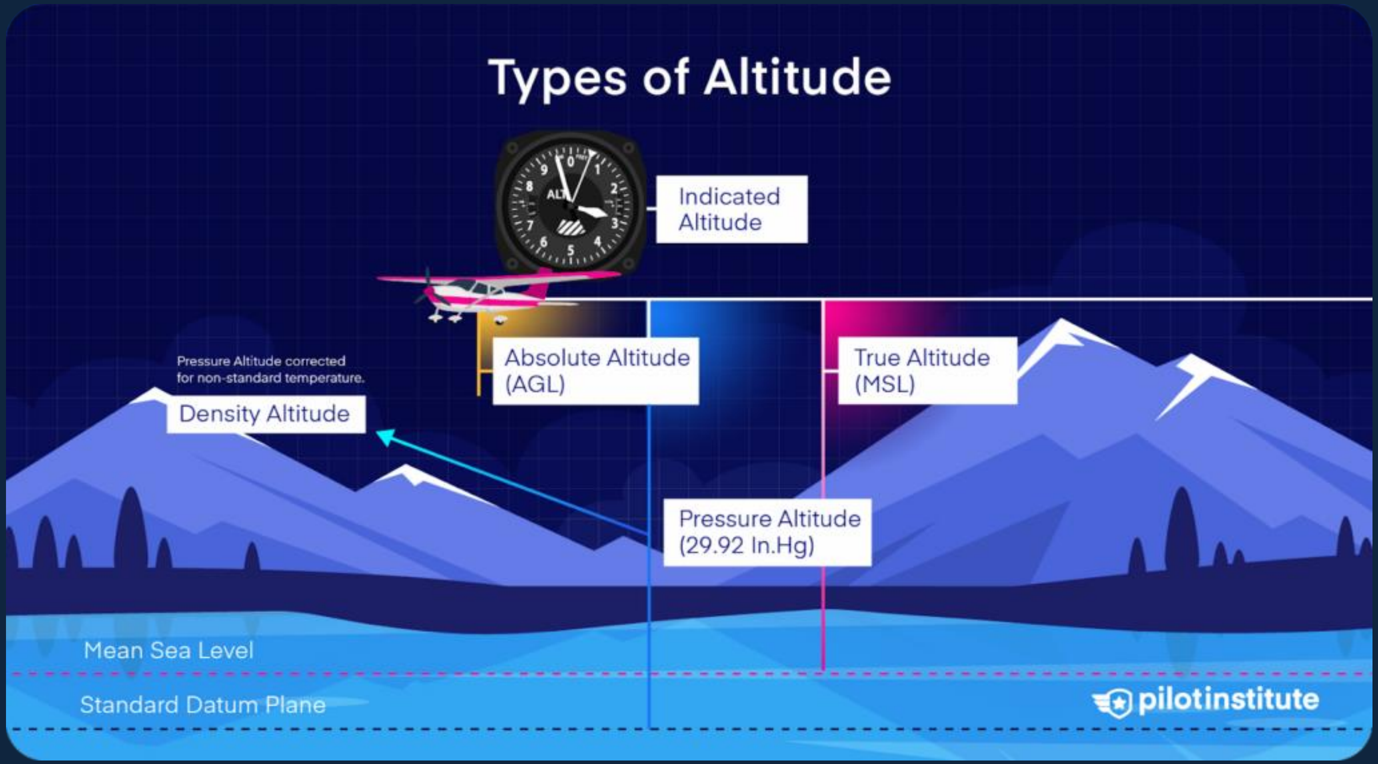


Altitude Metrics:
According to Transport Canada, understanding different altitude metrics like Height Above Earth (HAE), Altitude Above Ground Level (AGL), Altitude Above Sea Level (ASL), Barometric Altitude (Baro Corrected), and Pressure Altitude is crucial for accurately positioning and operating the GCS.

Altitude metrics are different ways of measuring an object's height above a reference point, such as "mean sea level" (MSL) or "above ground level" (AGL). Common metrics include **true altitude** (height above MSL), **pressure altitude** (height above the standard datum plane used in aviation), and **density altitude** (pressure altitude corrected for temperature).



Example:
If the GCS is situated at an elevation of 1000 feet AGL and the Baro Corrected altitude is 1020 feet, the pilot needs to understand the relationship between these two measurements and how they might be affected by external factors. For instance, a change in atmospheric pressure could affect the Baro Corrected altitude, while the AGL would remain the same if the terrain doesn't change.

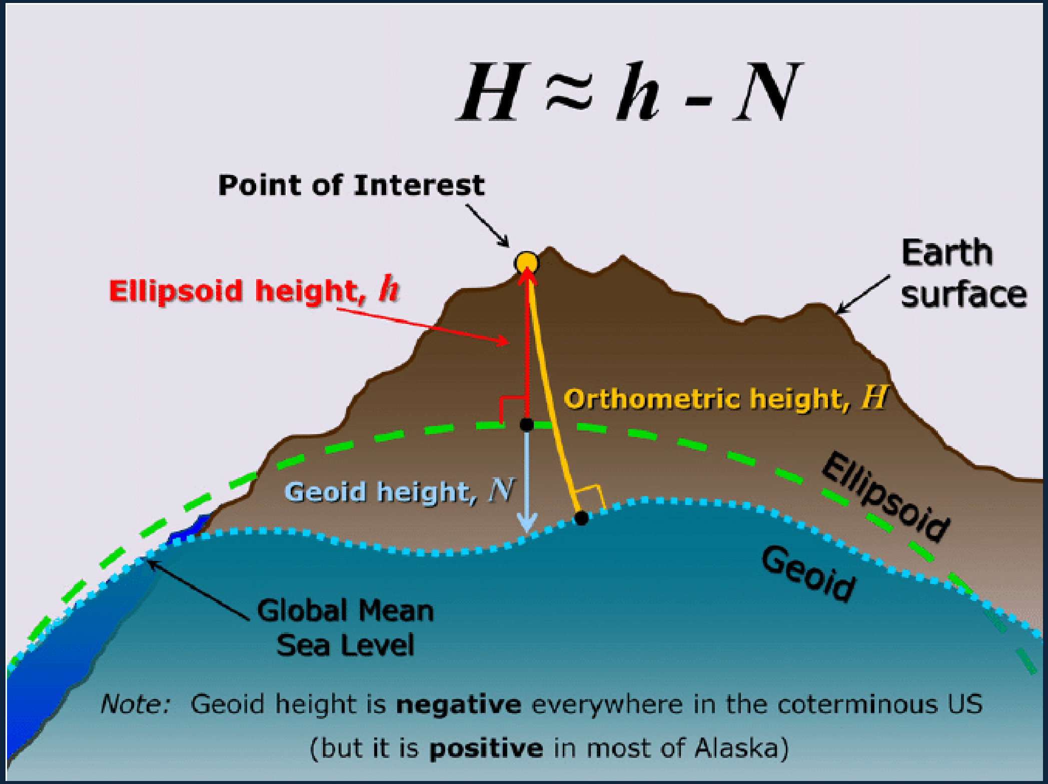


Different altitude metrics related to ground control station location (HAE, AGL, ASL, Baro Corrected, Pressure Altitude) and how to convert between them.

What is Height Above Ellipsoid

Have you ever heard the term Height Above Ellipsoid or HAE?

It is a form of measurement common in GPS circles, but perhaps unknown for most lay people. Most people just use GPS for a horizontal location – standard latitude and longitude, or an x/y. That's what we're used to seeing on the maps on our phones. Yet tour GPS receiver might also display a height measurement, which sometimes appears in HAE. Understanding this vertical location measurement requires a little more information about how GPS systems produce their data.



Height Above Ellipsoid (HAE):
This is the raw altitude reported by the GPS receiver on the RPAS, measured from the WGS84 ellipsoid (a mathematical model of the Earth's surface). It's important to note that HAE is not directly equivalent to ASL and requires further conversion.

Altitude metrics related to a ground control station (GCS) are crucial for ensuring accurate navigation, communication, and operational efficiency in various aerial applications, including remotely piloted aircraft systems (RPAS) and unmanned aerial vehicles (UAVs). Here are some key considerations:

•**Absolute Altitude**: The elevation of the GCS above mean sea level (MSL), which affects signal transmission and reception.

•**Relative Altitude**: The height of the UAV or RPAS in relation to the GCS, essential for maintaining safe flight operations.

•**Barometric Pressure Adjustments**: Ground control stations often use barometric sensors to calibrate altitude readings, ensuring accuracy in varying atmospheric conditions.

•**Terrain Awareness**: Understanding the topography around the GCS helps in flight planning and obstacle avoidance.

•**GPS-Based Altitude Data**: Many GCS systems integrate GPS to provide precise altitude measurements, aiding in navigation and automated flight control.
For more detailed insights, you can explore on RPAS operations or check out on ground control station development. Let me know if you need specifics on a particular aspect!

Indicated Altitude to True Altitude (in Aviation):
Formula:
True Altitude = Indicated Altitude + (ISA Deviation × 4/1,000 × Indicated Altitude).

Explanation:
Indicated altitude is what the altimeter reads, but true altitude considers

temperature deviations from the Standard Atmosphere (ISA).

ISA Deviation:
This is the difference between the actual temperature and the standard temperature at a given altitude.

Pressure Altitude:
Formula: Pressure Altitude = Elevation + (1013 - QNH) x 30.

Explanation: This adjusts altitude based on the local barometric pressure (QNH), which is the atmospheric pressure at the station elevation. 1013 is the standard pressure at sea level.

Example: If you're at an elevation of 1800 feet and the QNH is 1027, the pressure altitude would be: 1800 + (1013 - 1027) x 30 = 1380 feet.

Altitude and Air Pressure:
Concept:
Air pressure decreases as altitude increases. You can calculate the approximate air pressure at a given altitude using various formulas and calculators.

Detect and avoid systems (DAA)

Detect and avoid (DAA) system enables operators to sense and avoid other aircraft and obstacles autonomously. These systems use sensors, such as radar, acoustic, and visual, to detect and avoid obstacles in the airspace.

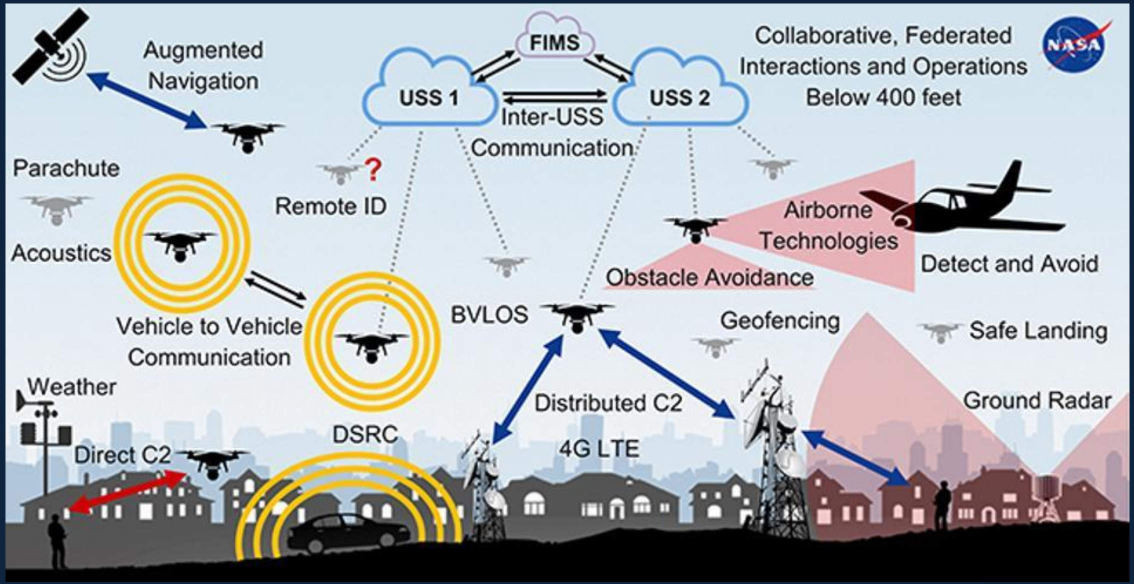
With DAA technology, drones can operate safely beyond visual line of sight, expanding their range of capabilities and applications.

Risks of vision-based DAA

•risks associated with carriage of dangerous or potentially dangerous payloads;

•Risks associated with air-to-air collisions between two RPAs;

•security risks not confined by the airworthiness of the systems (e.g., C2 link protection from interference is addressed, but protection of the ground control station from external malicious interference is not)



We are seeing Stereo Vision, Monocular Vision, Ultrasonic, Infrared, Time-of-Flight and Lidar sensors being used to detect and avoid obstacles. Manufacturers are fusing these various sensors together to create the obstacle detection and collision avoidance systems.

Types

We are seeing Stereo Vision, Monocular Vision, Ultrasonic, Infrared, Time-of-Flight and Lidar sensors being used to detect and avoid obstacles. Manufacturers are fusing these various sensors together to create the obstacle detection and collision avoidance systems.

Each of these systems have strengths and weaknesses

Single Failure Considerations. (LOS) Both the low and high robustness containment standard require that no single failure result in a fly-away of the RPA. Therefore, the containment means needs to be independent from any systems on the RPAS that could result in a fly-away. For example, a flight termination system that relies on the RPAS C2 link for activation would not meet the single failure requirement, because presumably, a failure of the C2 link would result in an inability to both control and flight-terminate the RPA. The result would be that the operator no longer has the means to ensure containment.

Lidar DAA Sensor

Sensor range on the area the RPAS can move within

Factors Limiting Operation Range of RPAS DAA Sensors

Terrain

Weather

Electronic Interference

Hardware

Coverage Areas ADS-B

Air traffic

Automatic and manual collision avoidance systems offer distinct advantages for drone operation. Automatic systems use sensors and algorithms to detect obstacles and adjust flight paths, while manual systems rely on the pilot's awareness and control.

Advantages:

Reduced Pilot Workload: The drone handles obstacle detection and avoidance, allowing the pilot to focus on other tasks.

Improved Safety: Sensors can react quickly to unexpected obstacles, reducing the risk of collisions.

Enhanced Precision: Algorithms can optimize flight paths for efficiency and safety.

Disadvantages:

Sensor Limitations: Obstacle avoidance systems may have limitations in certain environments (e.g., dynamic environments, reflective surfaces).

False Positives: Sensors may sometimes detect obstacles that are not actual threats.

Complexity: Automatic systems can be more complex and costly to implement.

Manual Collision Avoidance:

Advantages:

Human Awareness: Pilots can make informed decisions based on their understanding of the environment.

Adaptability: Pilots can react to unexpected situations more effectively than a pre-programmed system.

Cost-Effective: Manual collision avoidance can be less expensive than automatic systems.

Disadvantages:

Pilot Fatigue: Constant vigilance can lead to fatigue and errors.

Limited Reaction Time: Pilots may not always react quickly enough to avoid collisions.

Human Error: Pilot mistakes can lead to accidents.

Visual based camera detection systems use cameras and image processing to identify and locate objects or events within a scene. These systems can detect presence, orientation, and accuracy of parts, or provide alerts when objects or people are within a certain range of machinery. While effective, they have limitations, including difficulty with obscured or partially visible objects, dependence on clear visibility, and susceptibility to environmental conditions like lighting.

Function:

Image Capture:

Cameras capture images, and the resulting digital information is then processed.

Object Recognition:

Image processing algorithms analyze the captured images to identify and classify objects, patterns, or defects.

Alerting or Action:

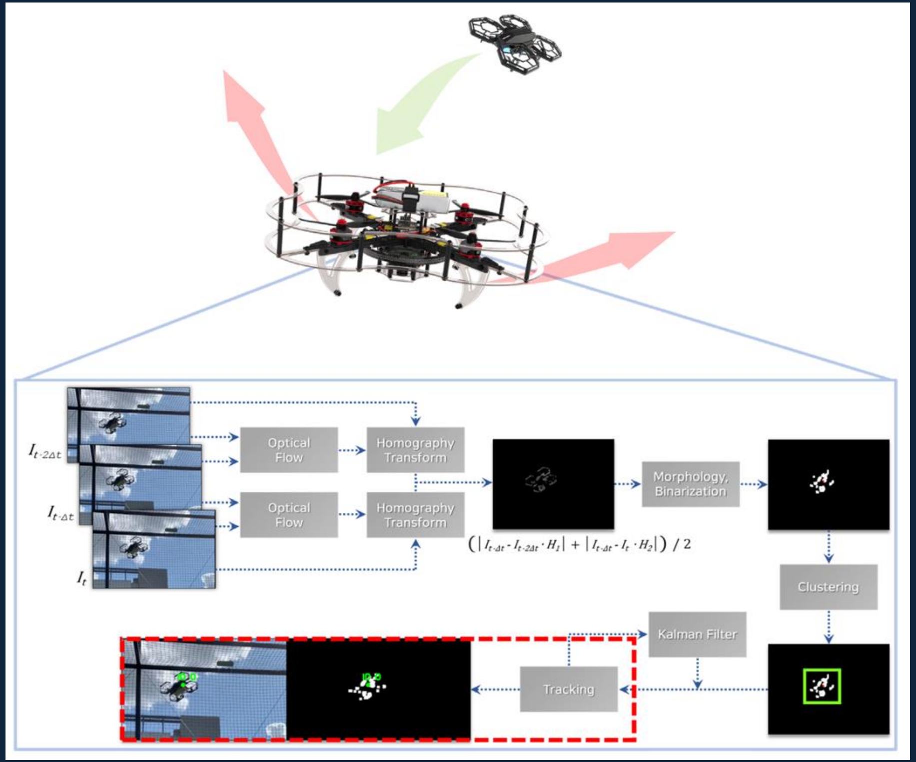
Once an object or event is detected, the system can

Visibility Issues:

Poor visibility due to low light, fog, or smoke can significantly hinder the performance of camera detection systems.

Environmental Factors:

•Variations in lighting, temperature, and humidity c impact image quality and affect the accuracy of detection.



On-wing (airborne) and ground-based radar systems serve distinct functions and face unique limitations. On-wing radar, often used in aviation, provides pilots with weather information, while ground-based radar supports air traffic control, defense, and various other applications. Both types have limitations, including range, resolution, and the ability to penetrate certain materials.

Limitations:

Range: These systems typically have a maximum range of around 300 miles, limiting their ability to see weather conditions beyond that distance.

Resolution: The resolution can also be a limitation, meaning the radar may struggle to differentiate between closely spaced objects or details within a weather event.

Weather Conditions: Radar signals can be affected by various atmospheric conditions, including rain, snow, and fog, which can reduce the radar's effectiveness.

Ground-based Radar:

Function:

Ground radar plays a vital role in air traffic control, air defense (e.g., ground-controlled interception), command guidance, and various other applications. It can also be used for ground surveillance, tracking vehicles and personnel.

Limitations:

Ground Penetration: Ground-penetrating radar (GPR), a type of ground radar, can't always penetrate through all materials, particularly metallic objects or highly conductive materials like clay soils and salt-contaminated soils.

Range: Some ground-based radar systems have limited range, particularly those designed for short-range applications like ground surveillance.

Resolution: Like airborne radar, ground-based radar can have limitations in resolution, making it difficult to distinguish between closely spaced targets.

A vision-based Detect and Avoid (DAA) system requires robust visual detection capabilities, precise object tracking, and reliable decision-making algorithms to ensure safe airspace operations. Key requirements include the ability to detect and track potential threats (other aircraft, obstacles), and make timely avoidance maneuvers. The system must also be reliable and fail-safe, with clear annunciations for loss of function.

Visual Detection and Tracking:

Robust Object Detection: The system must be able to accurately identify and classify potential threats, including other aircraft and obstacles, even in challenging conditions like low light or clutter.

Precise Tracking: The system needs to track the detected objects accurately over time to estimate the trajectory and approach speed.

Distance Measurement: The ability to measure the distance to detected objects is crucial for making informed avoidance decisions.

Decision-Making and Avoidance Maneuvering:
Conflict Resolution: The system must be able to identify potential conflicts (situations where the RPA is on a collision course with another aircraft) and propose appropriate avoidance maneuvers.

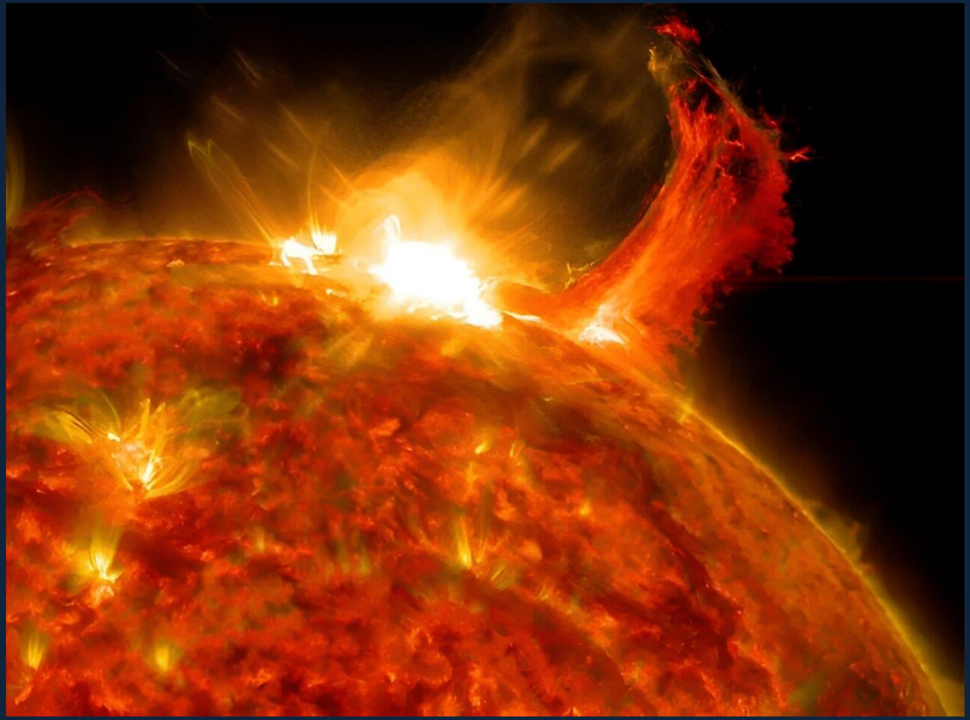
Maneuver Planning: The system should be able to plan avoidance maneuvers that are both safe and efficient, considering factors like the RPA's capabilities and the airspace environment.

Automatic or Manual Control: The system can be designed to execute avoidance maneuvers automatically or provide the pilot with the necessary information to make their own decisions.

Global navigation satellite system (GNSS / GPS)

Effect of solar activity on GNSS signals

GNSS signals are prone to interference as they travel through the Earth’s ionosphere. The ionosphere is a layer of the Earth's atmosphere that contains a high concentration of ionized gas molecules. As GNSS signals pass through the ionosphere, they may be refracted or slowed down. The ionosphere is not uniform, and the density of the ionized gas varies with location and time. The variation in the ionosphere is amplified during periods of increased solar activity and there are two different effects that are experienced by the user of GNSS systems:



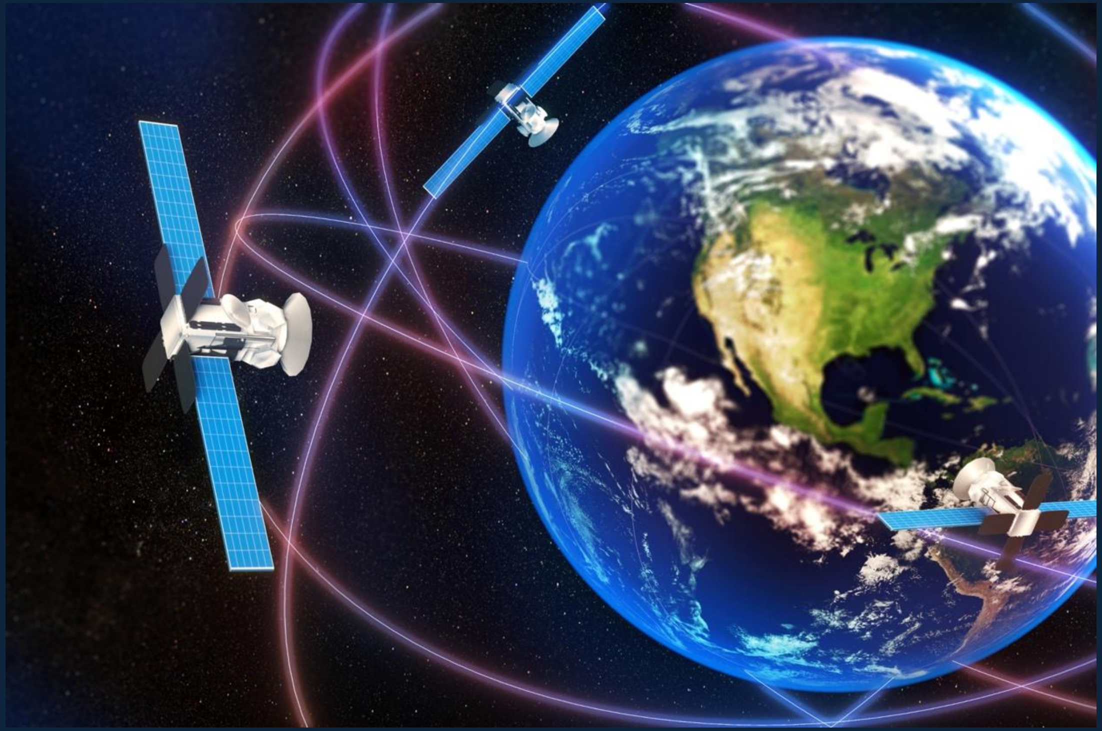
Increased ionospheric activity can introduce large errors/biases (up to 15 metres) into single frequency DGNSS because of the failure in the differential process to cancel the effects of the ionospheric delay between the reference station and the user

Signal limitations caused by the flight environment and geography.

A GPS receiver needs to get a signal from at least four satellites to determine its location. However, four is the absolute minimum and the reported location may not be accurate. Reception of more satellites by the receiver will result in increased accuracy. Signal strength also plays a part in accuracy too; weak signals lead to errors in pinpointing the receiver's location.

Sources of GPS interferences include Personal Privacy Devices.[1] Moreover, 1.2GHz-transmitters used in certain First-Person View (FPV) video and Closed-Circuit Television (CCTV) are being analyzed as potential interference sources to certain GNSS constellations.

Environmental factors limit the effectiveness of GPS. Weather conditions such as snow, rain or fog can degrade a GPS signal. Tall buildings like those found in cities can block a path to satellites altogether, and geographical features like valleys, canyons or tunnels causes a condition known as multipath. Multipath occurs when the signal bounces off an obstruction, which causes the receiver to detect the satellite as being further away than it is in reality.

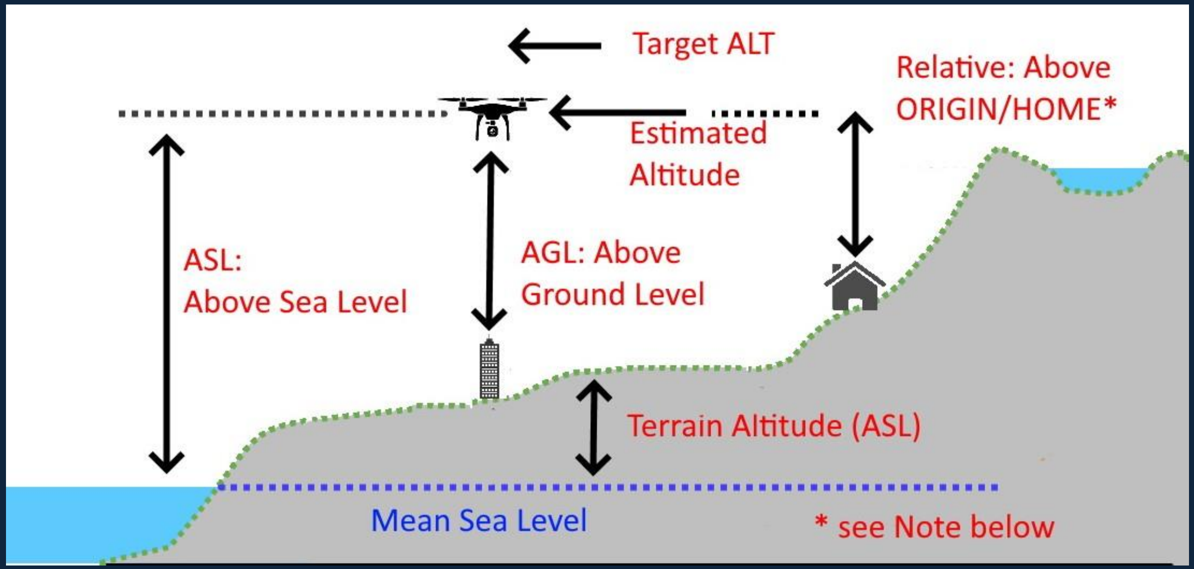


To convert GPS altitude to Above Sea Level (ASL), you need to add the ground altitude of the area where the GPS reading is taken. GPS altitude is measured relative to an ellipsoid, not sea level. ASL altitude is measured relative to mean sea level.

Calculation:

ASL Altitude = GPS Altitude + Ground Altitude

Example:
If your GPS shows an altitude of 200 meters and the ground altitude at that location is 50 meters, then the ASL altitude would be 200 meters + 50 meters = 250 meters.



Terrain Changes:
Be aware that terrain can change, especially in mountainous areas. Ensure your ground altitude data is up-to-date and accurate for the specific location.

Various GNSS positioning solutions and augmentation systems

The precision and integrity of a GNSS positioning solution can be improved significantly with augmentation. Augmentation is achieved by accessing an external source of corrections and/or warning messages. This information is usually generated from tracking data originating from a GNSS reference station or network. Figure 1 presents an overview of the continuum of GNSS augmentation services under three main categories, distinguished mainly by end-user requirements and service performance. While sharing a number of common features, the service categories can be significantly different in terms of the density of their tracking networks and the methods used to estimate and disseminate corrections. The main categories of augmentation services are usually referred to as Real-Time Kinematic (RTK), Precise Point Positioning (PPP)

X 1080

Application	Land Survey	Machine Guidance	Natural Resources	Natural Hazards	Marine Navigation	Air Navigation
Category	RTK		PPP		DGPS/WAAS	
Coverage	Regional		Global		Coastal/Continental	
Purpose	Positioning		Monitoring		Navigation	
Communications	Terrestrial				Satellite	
Corrections	Commercial				Public	
Performance	Accuracy		Reliability		Integrity	
Method	Differential		Undifferenced		Differential	
Observable	Carrier phase		Carrier Phase		Pseudorange	
Precision	CENTIMETRE				METRE	
	20		100	200	500	

Reference Station Spacing (km)

Human factors

Aviation physiology

Safe and efficient aviation requires that human performance be considered at all stages of the system lifecycle, from design, construction, training of personnel, operation and maintenance. Human performance is sometimes considered when referring solely to the negative impacts of errors, procedure violations, physiological limitations and the like. However, there is increasing recognition that unique human characteristics, such as flexibility and the capacity for problem solving, can make a significant positive contribution to system performance. In developing standards and recommended practices for RPAS, it is important to recognize that the people in the system can have both negative and positive contributions to system performance.

Human interaction with machines (also called "hardware")

1.• Examples include the interface between the RPS and pilots, support technicians, and maintenance personnel.

2. Operational procedures

• Including checklists, policies, and procedures for pilots and a traffic control.

3. Environment

• Including lighting, time of day, and the presence or absence o noise, vibration or other sensory cues.

4. Interactions with other people

• Examples include crew coordination, and communication between pilots and air traffic control.

One of the most common physiological problem for operators and crew of a RPAS

Fatigue can be caused by;

- Lack of Sleep
- Stress
- Temperature
- Monotony
- Pressures at work
- Poor Nutrition
- Prolonged working hours
- Humidity
- Heavy Workloads
- Family Issues

Autokinesis

- An illusion of the eye at night
- When a pilot's eye stares at a light against a dark background with no other visual references around it, such as a star or the light from another aircraft, the pilot will get the impression that the light is moving.

White Out Illusion

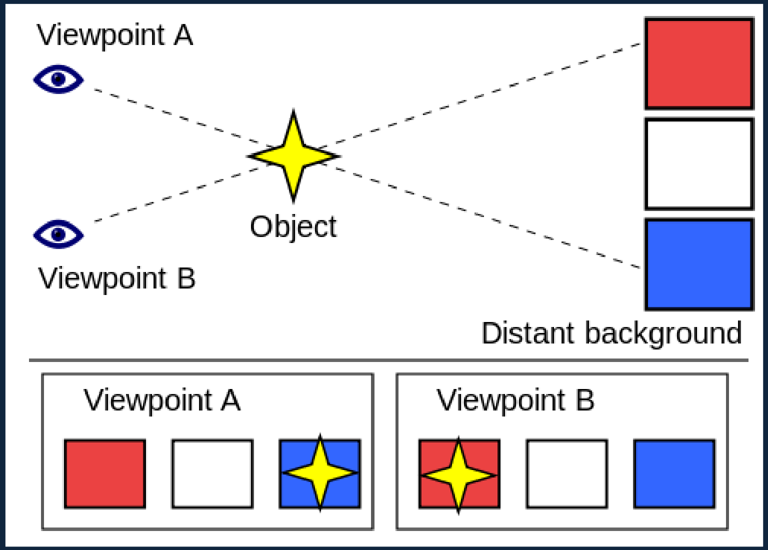
- Occurs during the winter when there is snow covering the ground and white cloud cover makes the horizon seem like it disappeared

Black Out Illusion

- Similar to white out illusion but can occur any time of the year

Visual Illusions

Perspective Illusions



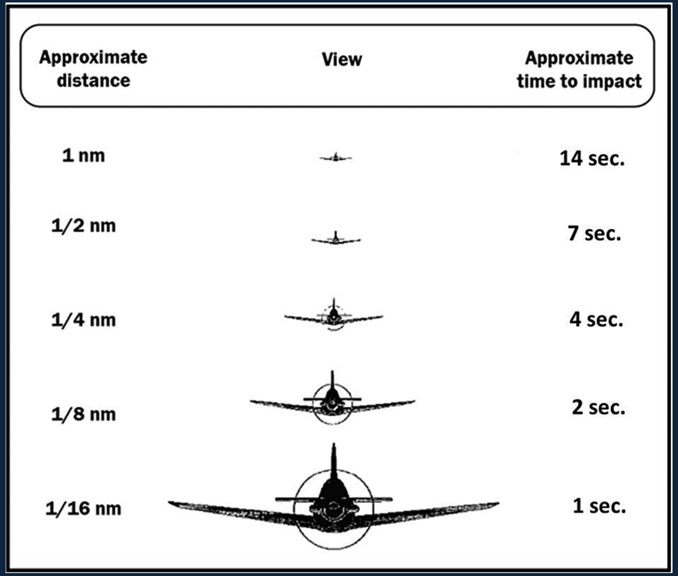
Parallax Illusions

A displacement or difference in the apparent position of an object viewed along two different lines of sight

Nearby objects show a larger parallax than farther objects when observed from different positions

Collision Geometry

If an aircraft looks like it is stationary in the sky but getting larger, it is coming towards you



Environment

Due to the nature of RPAS operations, operators may be exposed to extreme environments, typically in outdoors

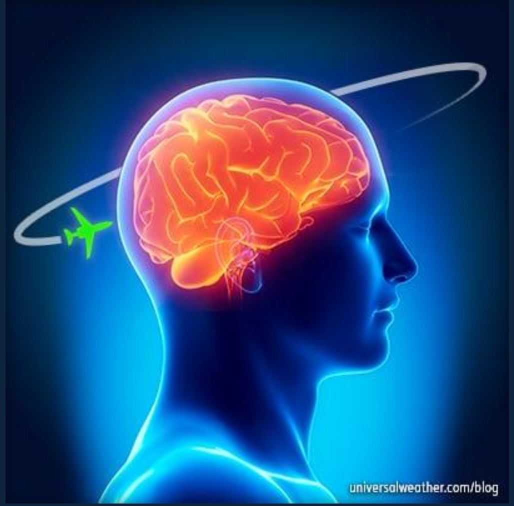
- Includes working in intense heat, wind, cold, humidity and insect infested areas

These environments can severely affect safe flight operations

You should seek to mitigate these effects, by properly planning preparing for the environment the operator and flight team will be working in

Aviation Psychology

Sometimes it's because of physical, psychological, or physiological stressors. For whatever reason, there are circumstances that can compromise a pilot's ability to make good decisions. This is the point where hazardous attitudes start to come up.



Anti-Authority

There are two sides to an anti-authority attitude.

1. The first has to do with an outright resentment of having someone tell them what to do or brushing the rules off as unnecessary.

1. The second is a manner of justifying not following the rules, given exceptional circumstances.

Impulsivity

The common stressor for people who display impulsivity is time – or rather, a lack thereof. Impulsivity is exhibited by hurrying through decisions or situations. This is dangerous as it makes it more likely for pilots to commit to a wrong course of action.

Invulnerability

People think that accidents happen to other people simply because they are careless or are not fit for the job that they are doing. In the case of pilots, they need this psychological shield of invulnerability. Without it they get paralyzed with the fear of a crash whenever they climb into a cockpit.

Macho

As with any professional field, there is inherent competitiveness in aviation. This is usually not a problem unless pilots start taking unnecessary risks just to prove that they are better than the others.

Despite the macho attitude commonly attributed to male pilots, female pilots are also prone to exhibiting it.

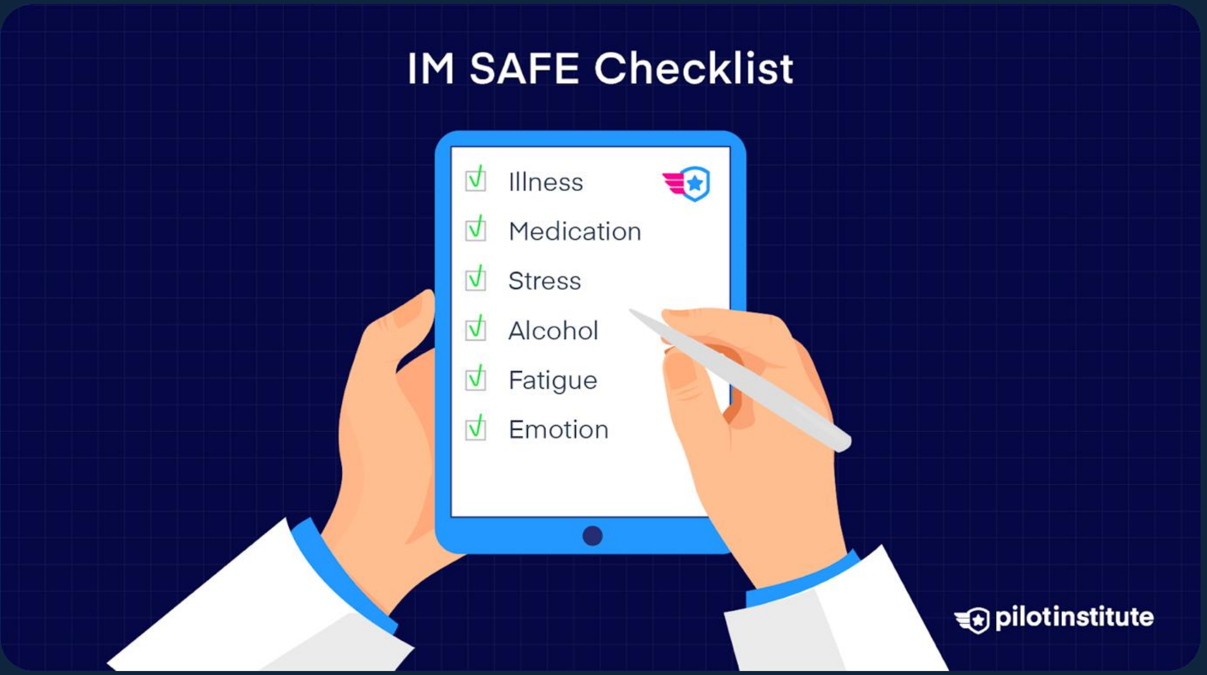
The macho attitude can also snowball from an unchecked and misplaced sense of confidence. To be clear, pilots need to have a certain level of confidence.

Resignation

A dangerous attitude for a pilot faced with a difficult situation is to just give up and wait for the situation to resolve itself. They may feel that they are not good enough to come up with a solution or are just experiencing bad luck.

Resignation is risky because it makes a pilot give up and accept a bad outcome instead of working to find a solution.

Self-Assessment With the IM SAFE Checklist



Normally, a trained pilot is expected to avoid these dangerous attitudes and make smart decisions. But under stress, this can change, making it crucial for pilots to stay away from stress whenever possible.

The IM SAFE checklist helps pilots spot early signs that their decision-making might be affected.

These are the items to be considered when doing a self-assessment using the IM SAFE checklist:

The importance of Crew Resource Management in RPAS operations.

Crew Resource Management (CRM): is the effective utilization of all resources including crew members, aircraft systems, supporting facilities and persons to achieve safe and efficient operations. The objective of CRM is to enhance communication, interaction, human factors and management skills of the crew members concerned. Emphasis is also on the non-technical aspects of crew performance.

With flight operations, there is never a typical day. Circumstances can change in the blink of an eye, and what started as a normal day can quickly become abnormal. CRM is about mitigating unforeseen problems and maintaining the safety and integrity of the aircraft.

Identifying problems accurately can help us, but only if we analyse all the information presented.
Collaboration is critical as working together to solve problems will more likely give you a solution. Using the right balance of assertiveness when contributing information to a problem will ensure that the team stays level-headed and there is more likelihood of making a correct judgement.
A good team leader will keep everyone on task and involved in the process and follow up with them. A continuous review of the action plan is vital to ensure that nothing is missed and that necessary adjustments or changes are made.

Potential impact of RPAS-operations

A lack of shared fate, potential for increased risk-taking, responsibility for flight termination, and disposability of the RPA.

It is possible for crew members to not be all in alignment when it comes to their functionality in a crewed RPAS operation. Improper crew briefings or a lack of any comprehensive list of who is responsible for various aspects of an operation.

Confusion can often occur when many people are involved in a specific operation , such as who is responsible for obstacle avoidance, crowd control , flight termination and other aspects of a mission.

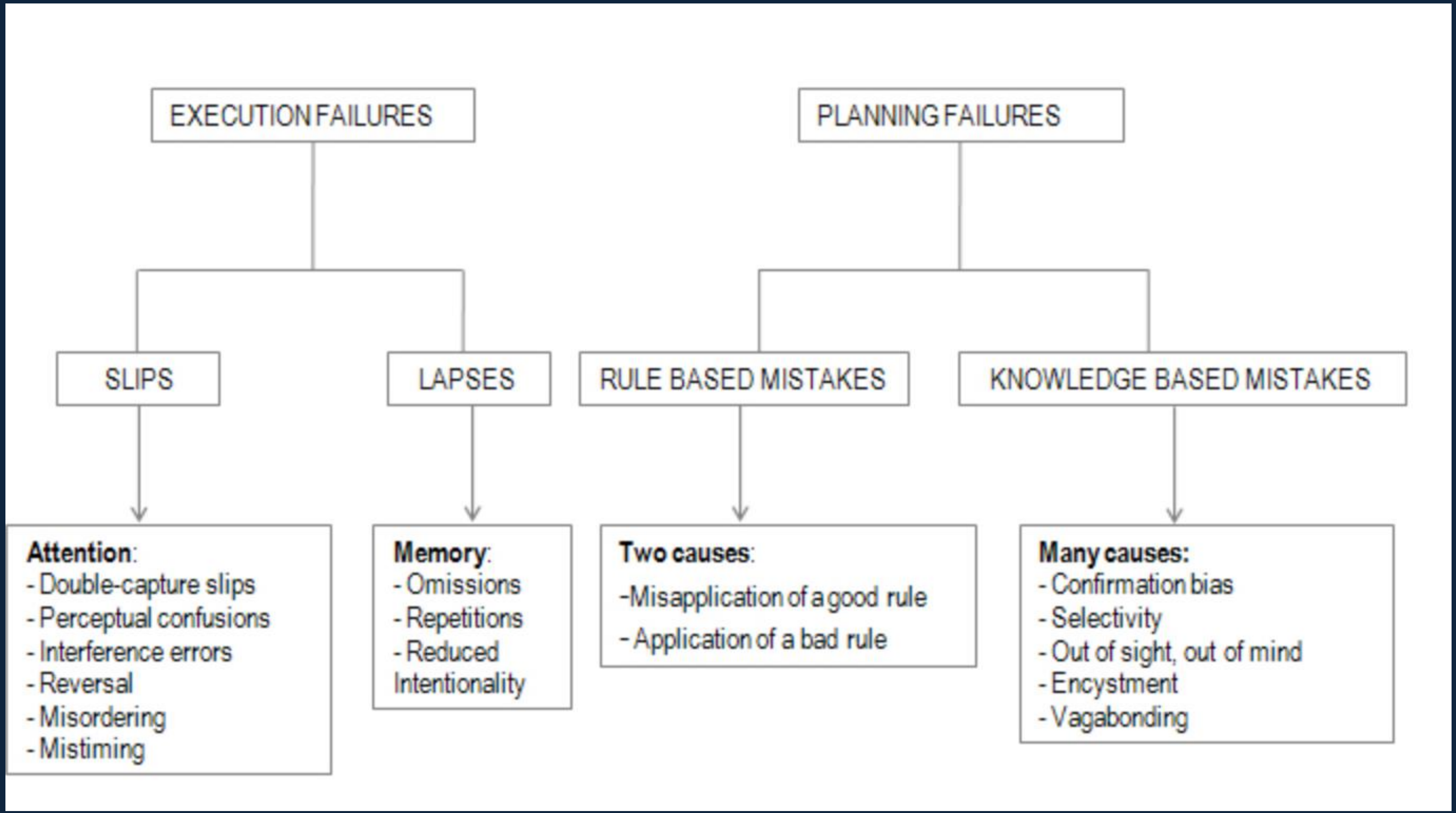
There could be need for the decision to actually allow the drone to be lost for safety concerns. In this case there could likely be a variety of disagreements over the disposability of the RPA

Clear mission roles and responsibilities must be laid out in advance of the flight with regards to each persons responsibilities and authority during a mission.

James Reason's second level "Unsafe Acts Model" includes the following unintended actions

Errors are the result of actions that fail to generate the intended outcomes. They are categorized according to the cognitive processes involved towards the goal of the action and according to whether they are related to planning or execution of the activity.

Slips.
Lapses.
Mistakes.
Violations.



Slips and Lapses
In a familiar and anticipated situation people perform a skill-based behaviour. At this level, they can commit skill-based errors (slips or lapses). In the case of slips and lapses, the person's intentions were correct, but the execution of the action was flawed - done incorrectly or not done at all. This distinction, between being done incorrectly or not at all, is another important discriminator.

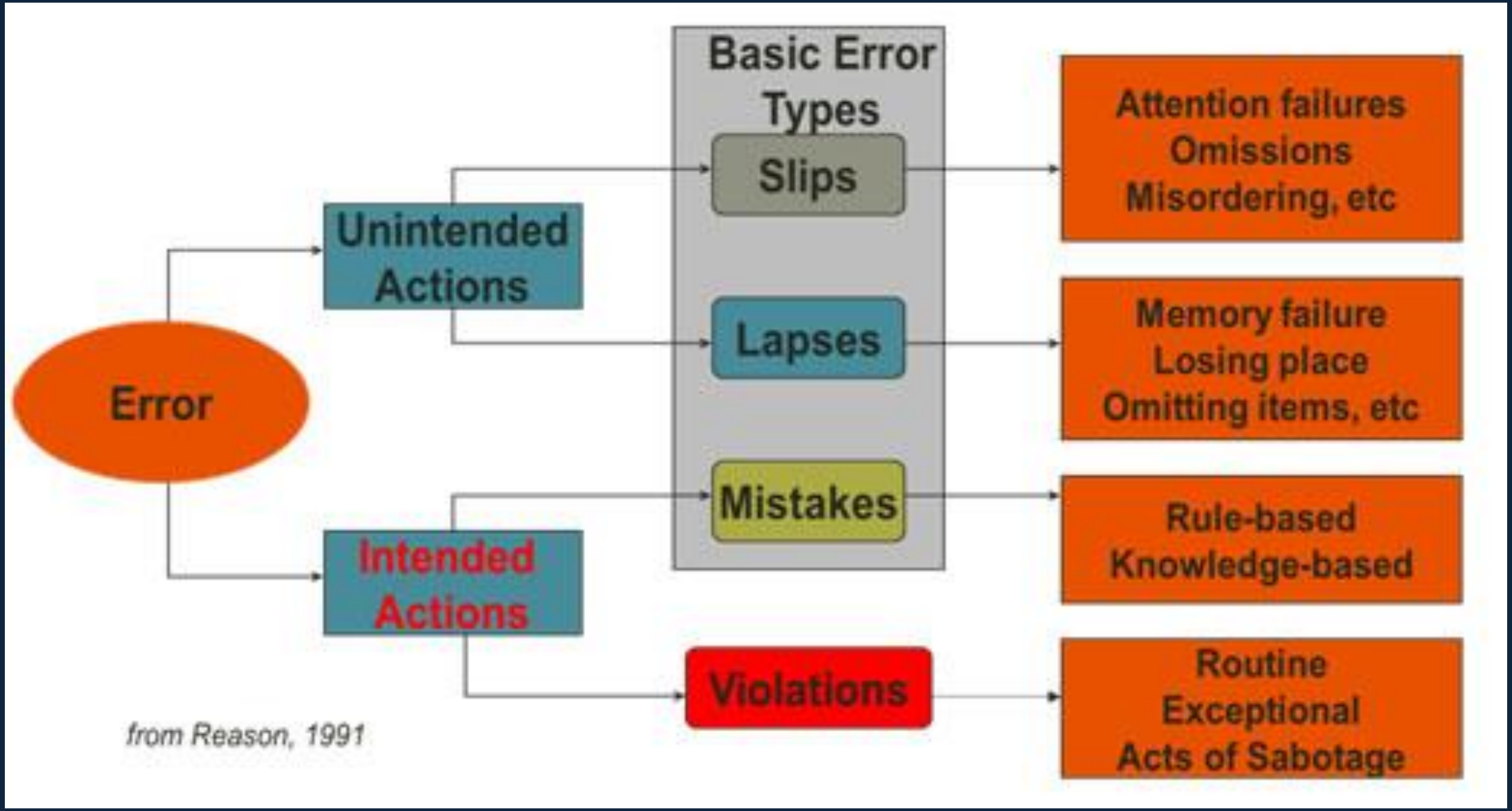
When the appropriate action is carried out incorrectly, the error is classified as a slip. When the action is simply omitted or not carried out, the error is termed a lapse. "*Slips and lapses are errors which result from some failure in the execution and/or storage stage of an action sequence.*" Reason refers to these errors as failures in the modality of action control: at this level, errors happen because we do not perform the appropriate attentional control over the action and therefore a wrong routine is activated.

Mistakes
Once a situation is recognised as unfamiliar, performance shifts from a skill-based to a rule-based level. First of all, the human tries to solve the problem by relying on a set of memorised rules and can commit rule-based mistakes. These kinds of error depend on the application of a good rule (a rule that has been successfully used in the past) to a wrong situation, or on the application of a wrong rule.

In the case of planning failures (mistakes), the person did what he/she intended to do, but it did not work. The goal or plan was wrong. This type of error is referred to as a mistake.

Violations

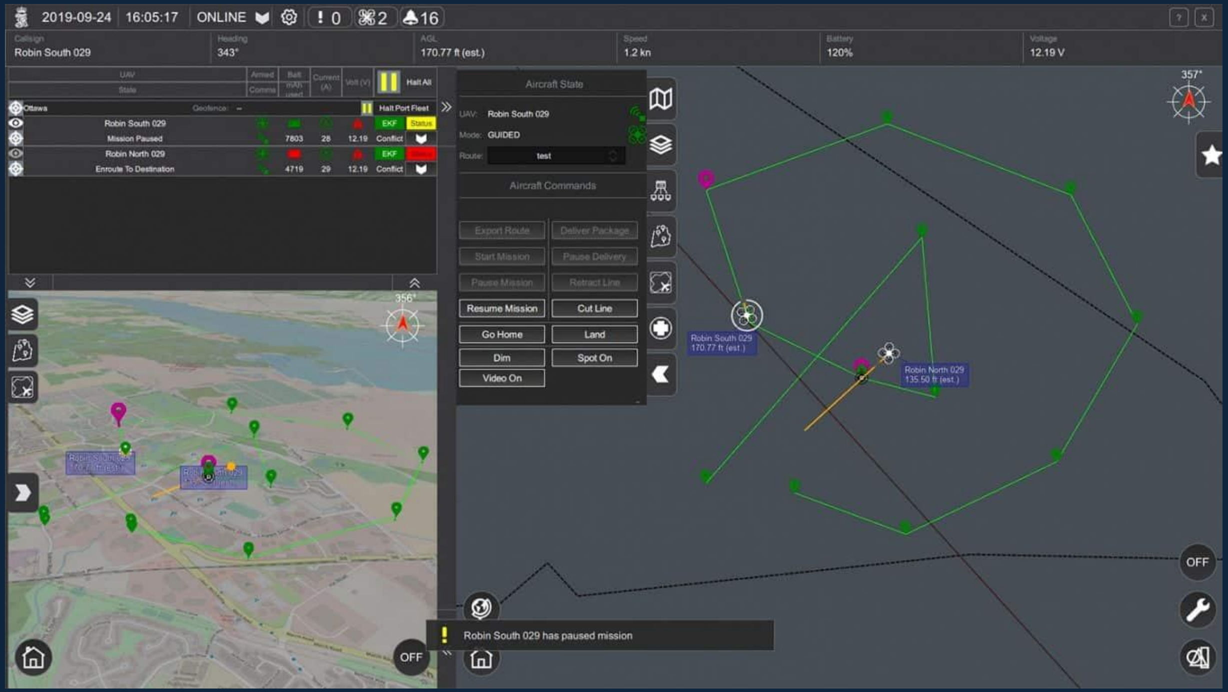
An intentional action that could lead to catastrophic failure



The importance of Situational Awareness and factors that can contribute to its degradation in BVLOS operations

You may think that flying a drone is a straight forward task, but when it comes to situational awareness, there are distinct differences depending on whether you are flying beyond visual line of sight (BVLOS), extended visual line of sight (EVLOS), or visual line of sight (VLOS).

When flying a drone BVLOS, you rely heavily on the data and information provided by these technologies to maintain situational awareness. This means that you need to have a clear understanding of the drone's position, altitude, speed, and any potential obstacles or hazards in its flight path.



Without direct visual contact with the drone, you must rely on the information displayed on the controller, spotters with binoculars following the drone or ground station to make informed decisions.

Automation complacency

RPAS operations at large are becoming increasingly automated, and RPAS has often been at the forefront of this technological movement. Automation's presence in the has been quite advantageous by improving economics, enhancing safety, and arguably reducing workload.

However, its implementation has also presented several challenges, including but not limited to complacency and overreliance on automation, manufacturer design errors, and automation surprise. To overcome these challenges and mitigate safety issues pre-emptively, methods and strategies must be devised to improve the implementation of automation in RPAS

Pilot—equipment/materials relationship

It is possible that during an operation you may be interrupted during a checklist or flight. Many people would try to pick up where they left off during the checklist, but the proper procedure and the best practice in this instance is to start from the beginning. NOT WHERE YOU THINK YOU LEFT OFF.

The same should be doe if for some reason your interrupted during a flight. Best to land the RPA sort out the issue and then return to flight once the interruption is no longer a factor

Do not be complacent during your operation even if the majority of your mission may be automated. Lack of situational awareness can lead to unwanted events.

In certain situations, it may be better to take the hands-on approach to flying the RPA rather than relying on automation.

An example of this would be flying in widely varying terrain.

Interpersonal relations

Crew Resource Management: the effective use of all available resources for flight crew personnel to assure a safe and efficient operation, reducing error, avoiding stress and increasing efficiency.

This means that the crew is less of a hierarchy and more of a team

All crew members have important and valuable skills that need to be used, for the safe operation of the flight

You should use all the resources available to you

This can include
- Family relationships
- Peer groups
- Employers
- Customers

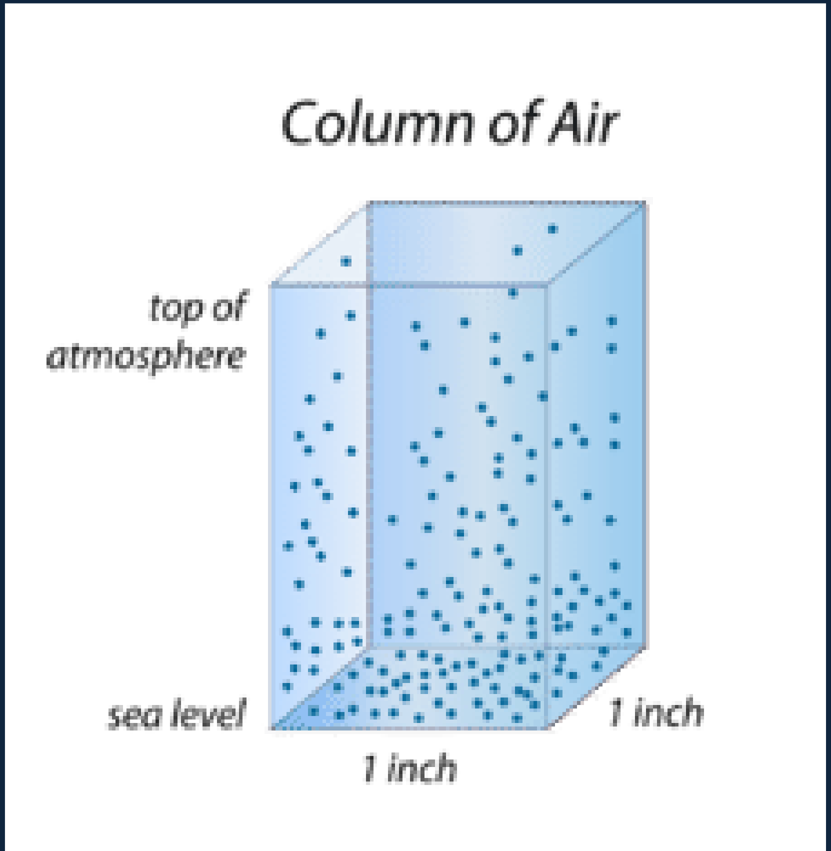
Remember to:
- Resolve differences peacefully
- Promote open communication

Safety should be more important than the hierarchy or a person's position in an organization

Meteorology

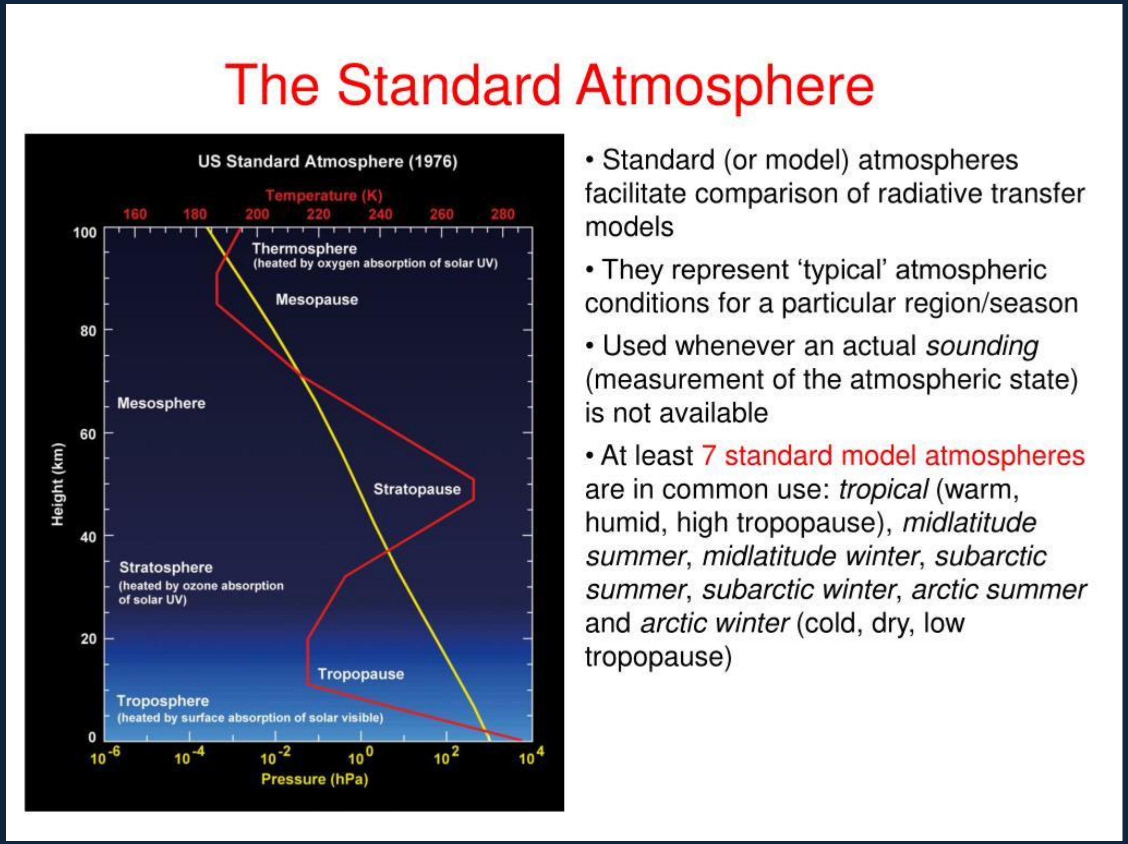
The earth's atmosphere

Altitude and Density
Altitude is height above sea level. The density of air decreases with height. There are two reasons: at higher altitudes, there is less air pushing down from above, and gravity is weaker farther from Earth's center. So at higher altitudes, air molecules can spread out more, and air density decreases



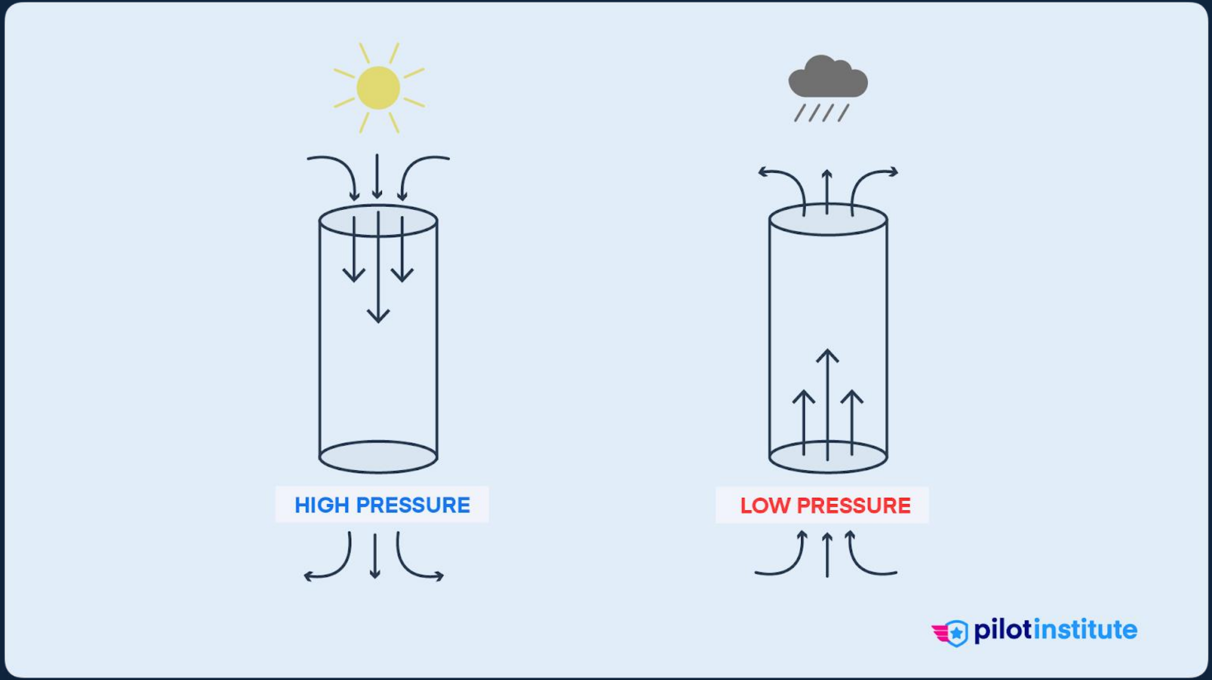
Conditions of the Standard Atmosphere

The International Standard Atmosphere is a static atmospheric model of how the pressure, temperature, density, and viscosity of the Earth's atmosphere change over a wide range of altitudes or elevations. It has been established to provide a common reference for temperature and pressure and consists of tables of values at various altitudes, plus some formulas by which those values were derived.



Atmospheric pressure

convergence, and divergence



Air also always moves from high pressure to low pressure. In other words, air comes together in areas of low pressure and goes away from areas of high pressure.

The Difference Between High and Low-Pressure Systems

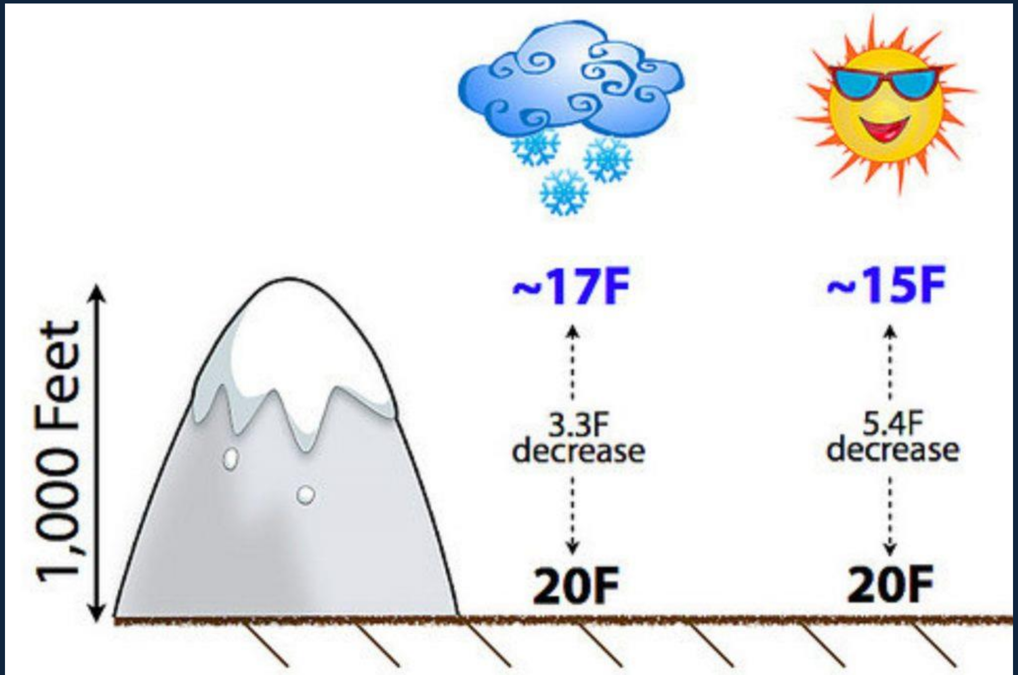
The most fundamental difference between high and low-pressure systems is the movement of air.

In high-pressure systems, air descends toward the ground, resulting in stable atmospheric conditions.

In low-pressure systems, air rises, leading to more unstable atmospheric conditions.

Effects of temperature on the rate of change in pressure with height

As you increase in elevation, there is less air above you thus the pressure decreases. As the pressure decreases, air molecules spread out further (i.e. air expands), and the temperature decreases. If the humidity is at 100 percent (because it's snowing), the temperature decreases more slowly with height



Effect of temperature on air density, performance, and efficiency

Density Altitude

The more appropriate term for correlating aerodynamic performance in the nonstandard atmosphere is density altitude – the altitude in the standard atmosphere corresponding to a particular value of air density.
As the density of the air increases (lower density altitude), aircraft performance increases. Conversely, as air density decreases (higher density altitude), aircraft performance decreases. A decrease in air density means a high-density altitude; an increase in air density means a lower density altitude. Density altitude has a direct effect on aircraft performance.
Air density is affected by changes in altitude, temperature, and humidity. High-density altitude refers to thin air while low-density altitude refers to dense air. The conditions that result in a high-density altitude are high elevations, low atmospheric pressures, high temperatures, high humidity, or some combination of these factors. Lower elevations, high atmospheric pressure, low temperatures, and low humidity are more indicative of low-density altitude.

Meteorological aspects of altimetry

Effects of Pressure on Density

Since air is a gas, it can be compressed or expanded. When air is compressed, a greater amount of air can occupy a given volume. Conversely, when pressure on a given volume of air is decreased, the air expands and occupies a greater space. That is, the original column of air at a lower pressure contains a smaller mass of air. In other words, the density is decreased. In fact, density is directly proportional to pressure. If the pressure is doubled, the density is doubled, and if the pressure is lowered, so is the density. This statement is true only at a constant temperature.

Effects of Temperature on Density

Increasing the temperature of a substance decreases its density. Conversely, decreasing the temperature increases the density. Thus, the density of air varies inversely with temperature. This statement is true only at constant pressure.

In the atmosphere, both temperature and pressure decrease with altitude and have conflicting effects upon density. However, the fairly rapid drop in pressure as altitude is increased usually has the dominant effect. Hence, pilots can expect the density to decrease with altitude.

Pressure altitude is the height of an aircraft above a theoretical reference point called the standard datum plane, where the atmospheric pressure is 29.92 inches of mercury (Hg). It is measured using an altimeter set to this standard pressure, allowing for consistent altitude readings across different conditions.

Effects of Humidity (Moisture) on Density

The preceding paragraphs are based on the presupposition of perfectly dry air. In reality, it is never completely dry. The small amount of water vapor suspended in the atmosphere may be negligible under certain conditions, but in other conditions, humidity may become an important factor in the performance of an aircraft.

Water vapor is lighter than air; consequently, moist air is lighter than dry air. Therefore, as the water content of the air increases, the air becomes less dense, increasing density altitude and decreasing performance. It is the lightest or least dense when, in a given set of conditions, it contains the maximum amount of water vapor.

Humidity, also called relative humidity, refers to the amount of water vapor contained in the atmosphere and is expressed as a percentage of the maximum amount of water vapor the air can hold. This amount varies with the temperature; warm air can hold more water vapor, while colder air can hold less. The perfectly dry air that contains no water vapor has a relative humidity of zero percent, while saturated air that cannot hold any more water vapor has a relative humidity of 100 percent. Humidity alone is usually not considered an essential factor in calculating density altitude and aircraft performance; however, it does contribute.

Surface based layers

Fog:

Fog is nothing more than a low cloud, which has its base within 50' of the ground, reducing visibility to less than 5/8 Statute Miles (SM)

Fog forms and is therefore dependent on the air becoming temporarily supersaturated

Haze:

Haze is a suspension in the air of extremely small particles invisible to the naked eye and sufficiently numerous to give the air an opalescent appearance. It reduces visibility by scattering the shorter wavelengths of light. Haze produces a bluish color when viewed against a dark background and a yellowish veil when viewed against a light background. Haze may be distinguished by this same effect from mist, which yields only a gray obscuration. Certain haze particles increase in size with increasing relative humidity, drastically decreasing visibility. While visibility is a measure of how far one can see, including the ability to see the textures and colors therein, haze is the inability to view a similar scene with equal clarity

- Haze occurs in stable air and is usually only a few thousand feet thick, but may extend upwards to 15,000 ft (4,600 m). A haze layer has a definite ceiling above which in-flight (air-to-air) visibility is unrestricted. At or below this level, the slant range (air-to-ground) visibility is poor. Visibility in haze varies greatly, depending on whether the pilot is facing into or away from the Sun

Smoke:

Smoke is a suspension in the air of small particles produced by combustion due to fires, industrial burning, or other sources. It may transition to haze when the particles travel 25 to 100 mi (40 to 160 km) or more, and the larger particles have settled and others become widely scattered through the atmosphere. Not only can smoke reduce visibility to zero, but many of its compounds are highly toxic and/or irritating. The most dangerous is carbon monoxide, which can lead to carbon monoxide poisoning, sometimes with supporting effects of hydrogen cyanide and phosgene

When skies are clear above a surface-based layer of haze or smoke, visibility generally improves during the day. Heating during the day may cause convective mixing, spreading the smoke or haze to a higher altitude, and decreasing the concentration near the surface. However, the improvement is slower than the clearing of fog. Fog evaporates, but haze and smoke must be dispersed by the movement of air. A thick layer of clouds above haze or smoke may block sunlight, preventing dissipation. Visibility will improve little, if any, during the day

Effects on RPA

The effects on your RPA in these conditions can create hazardous situations. Visibility being the main factor. This is a larger problem when only relying on a camera for DAA.

Even with a visual observer their view of the RPA may be severely obscured

In fog conditions moisture can form on the drone and cause mechanical problems.

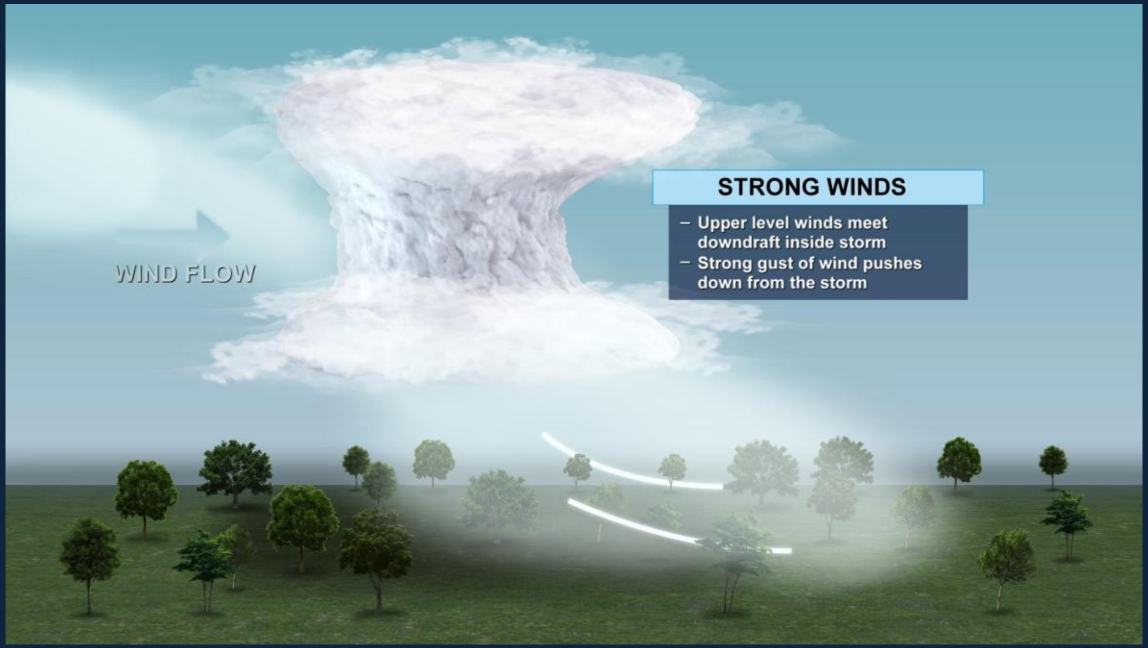
In winter operations Ice can form in the fog as well causing vital components of the drone to freeze such a props, and for a layer of ice on the RPA itself.

Elements that can dissipate these surface-based layers

- Wind
- Solar heating
- Precipitation
- Artificial

Defining wind gusts

A wind gust is a sudden, short-lived increase in wind speed. Unlike a steady or steady wind, a wind gust is characterized by a rapid, often unpredictable increase in wind speed that can last from a few seconds to a few minutes. These fluctuations in wind speed are typically measured in meters per second (m/s) or miles per hour (mph) and are often contrasted with the average or “steady” wind speed observed over a longer period of time.
Wind gusts can occur in a variety of weather conditions, from calm and clear days to the midst of severe storms. They are often the result of complex interactions between air masses, terrain, and other meteorological factors that can create localized areas of turbulence and instability in the atmosphere.

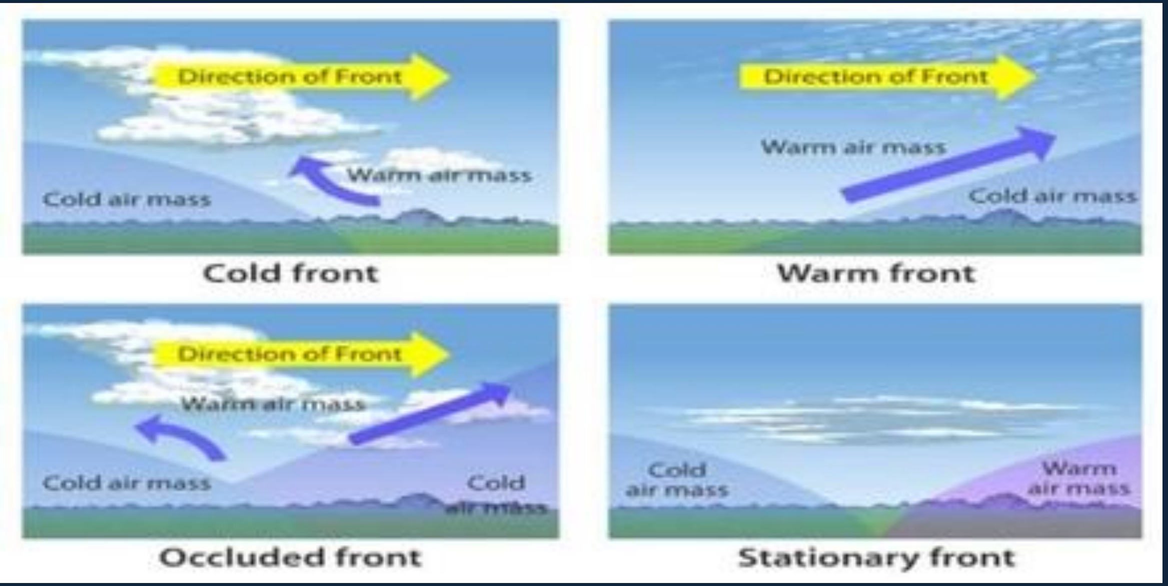


Risks
Sudden destabilization of the RPA leading to a crash or loss of control

Urban airflow and items that affect it.

Fronts and frontal weather

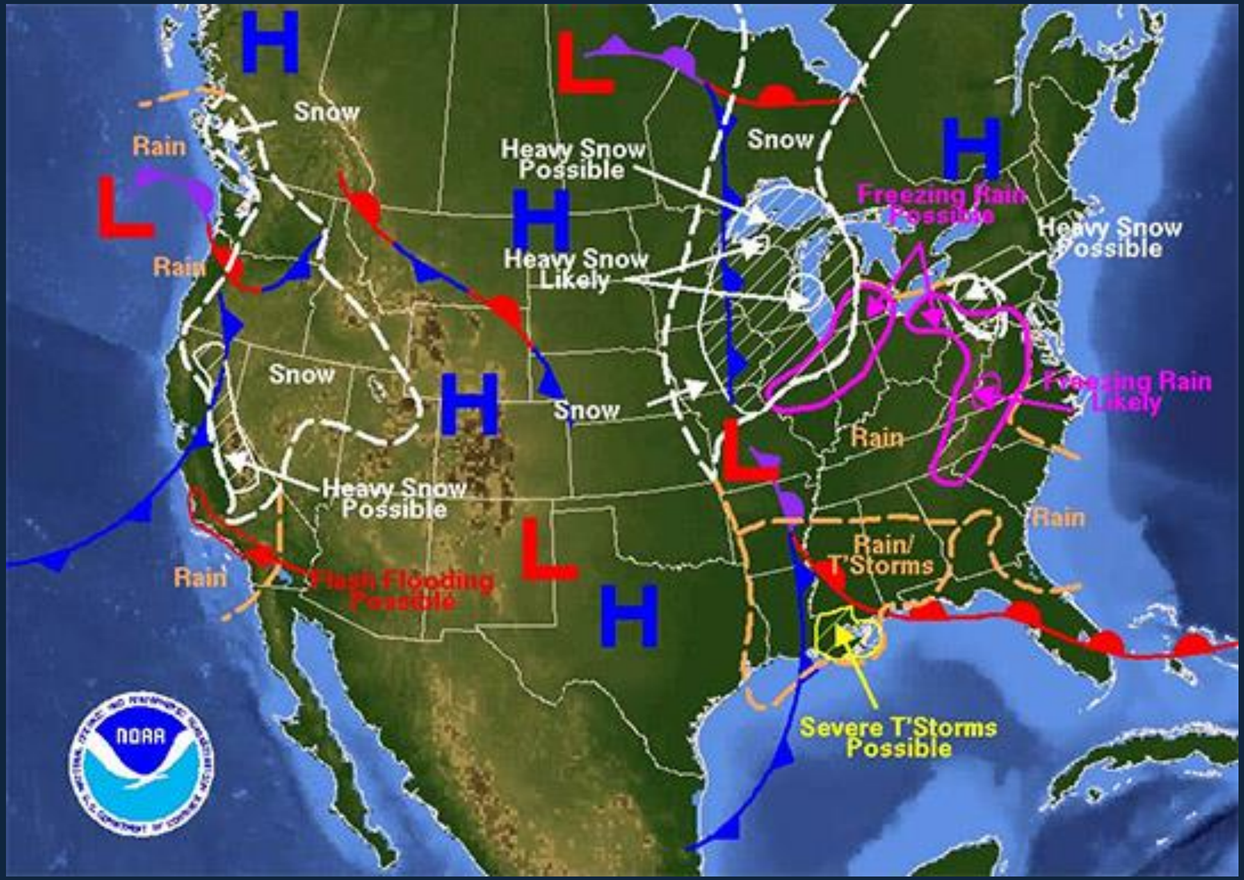
A weather front is a boundary separating air masses for which several characteristics differ, such as air density, wind, temperature, and humidity. Disturbed and unstable weather due to these differences often arises along the boundary. For instance, cold fronts can bring bands of thunderstorms and cumulonimbus precipitation or be preceded by squall lines, while warm fronts are usually preceded by stratiform precipitation and fog



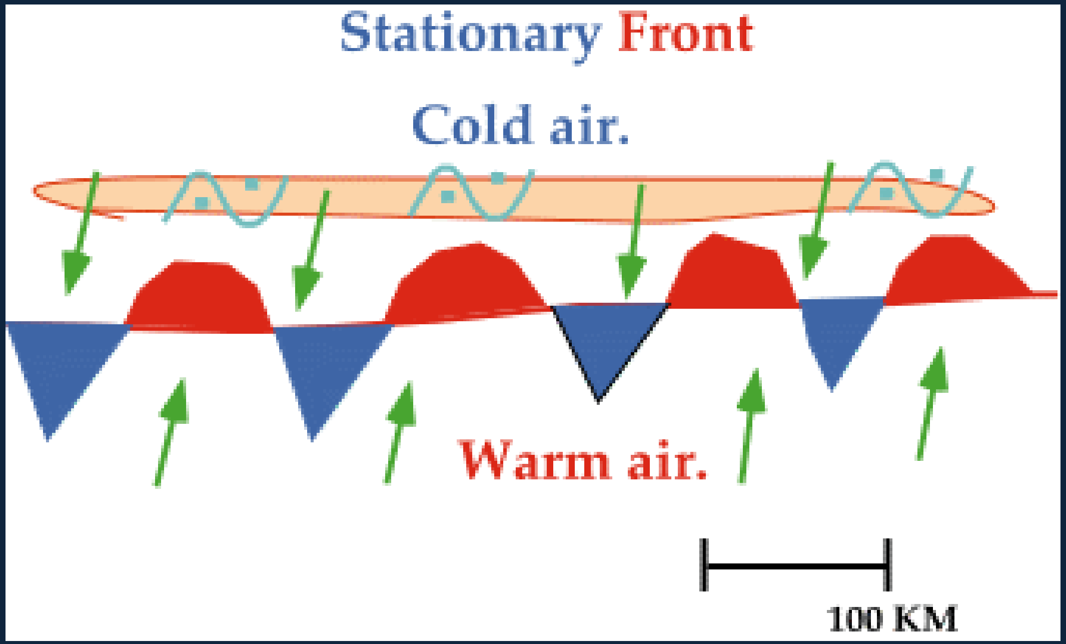
How weather fronts may affect RPA operations

BVLOS operations will be longer in distance. with various weather fronts and the associated hazards.

BVLOS operations will potentially cross multiple weather fronts with the RPA subjected to changes in precipitation, pressure, wind, and temperature. The remote pilot must be confident in planning for and dealing with these real-world effects and ensure safety of the operation.



Stationary fronts can be associated with the production of freezing rain. A stationary front separates cold air to the north from warm moist air to the south. Freezing rain develops as upper-level winds (typically light and southwesterly) push warm moist air over the colder air north of the stationary front, producing a narrow band of freezing rain on the cold side of the frontal boundary.



Aircraft icing

RPAS Components Susceptible to Icing: (In order of most critical)

1. Propeller
2. Motors
3. Body

Ice form when:
Flying where the temperature is at or below freezing

Aircraft comes into contact with a supercooled water droplet

Droplet freezes and adheres to the plane
Can occur flying in cloud, in freezing rain, or freezing drizzle

Depending on the size of the droplet and how quickly it freezes determines the type of icing

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Can occur flying in cloud, in freezing rain, or freezing drizzle

Depending on the size of the droplet and how quickly it freezes determines the type of icing

Identify whether the RPA is capable of flight in known icing conditions and under manufacturer limitations.

Thunderstorms

Hazards associated with thunderstorms;

- Up and downdrafts (turbulence)
- Downburst
- Microbursts
- Wind Shear
- Gust Fronts

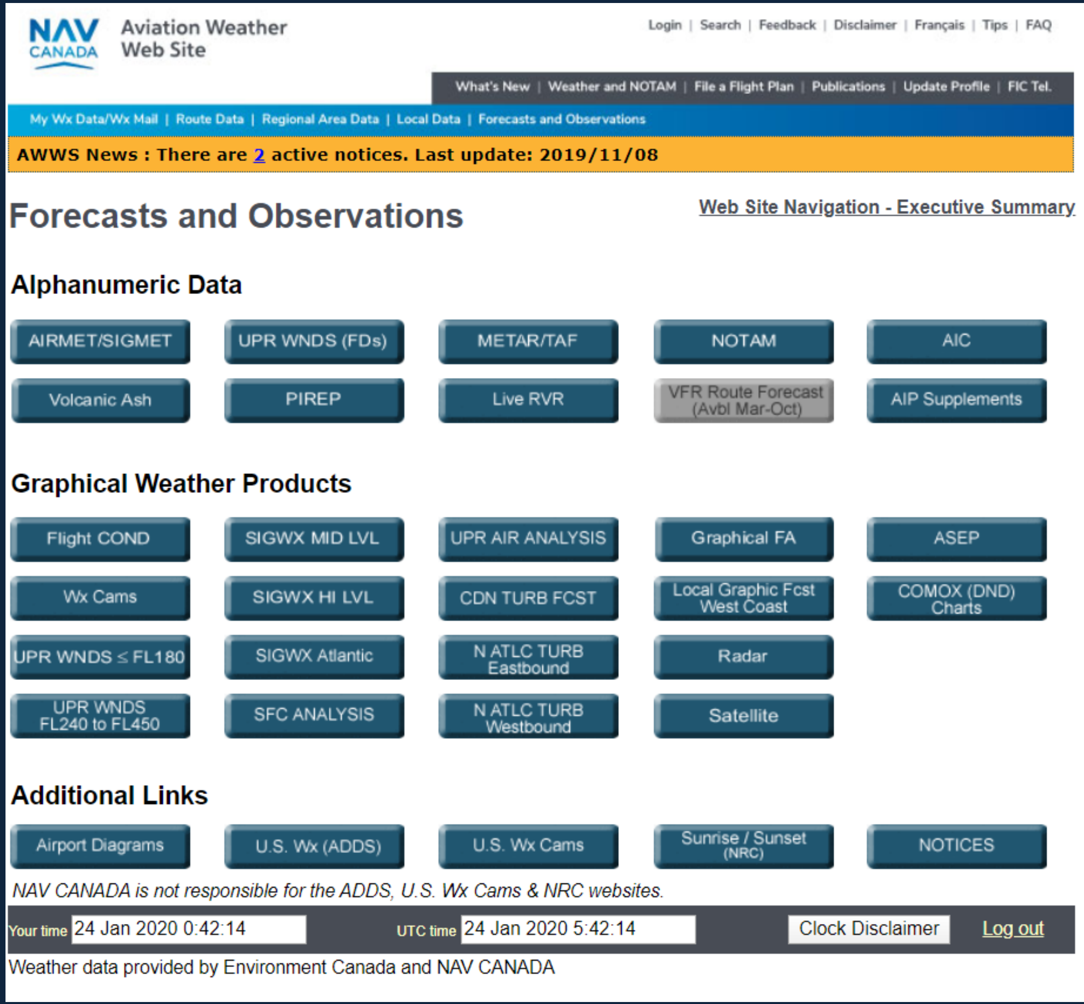
- Lightning (increased probability between -5°C and 5°C)
- Icing
- Hail

Meteorological services available to pilots

Aviation Weather Web Site (AWWS)

The official aviation weather information site for Canada

Provides coded weather information to pilots, along with NOTAM and route information, weather cameras, forecasts, upper winds and numerous other products



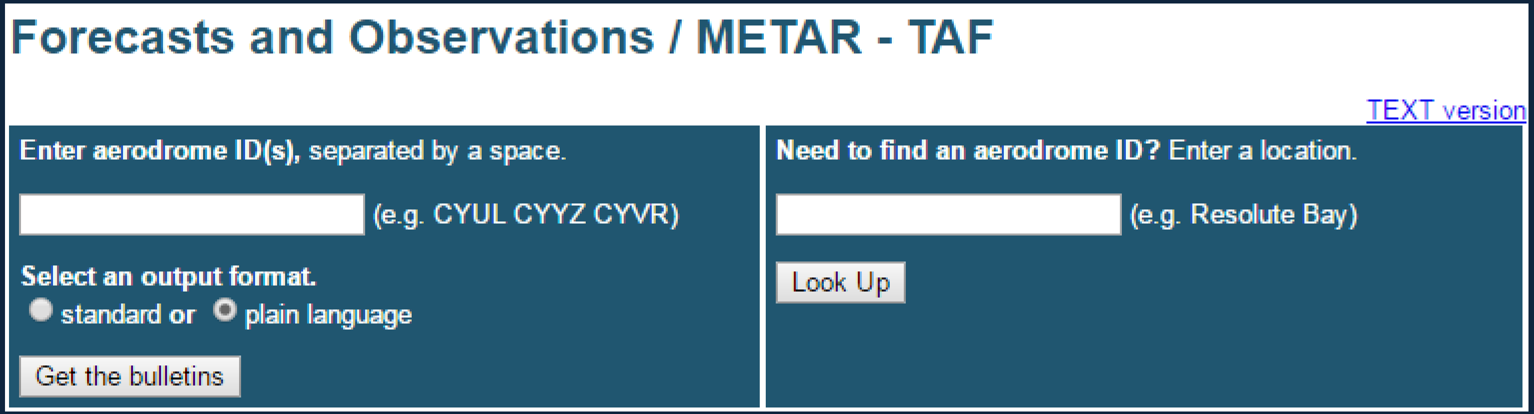
Official Sources

METAR – Aviation Routine Weather Report

Standardized and coded current weather observation at a specific station

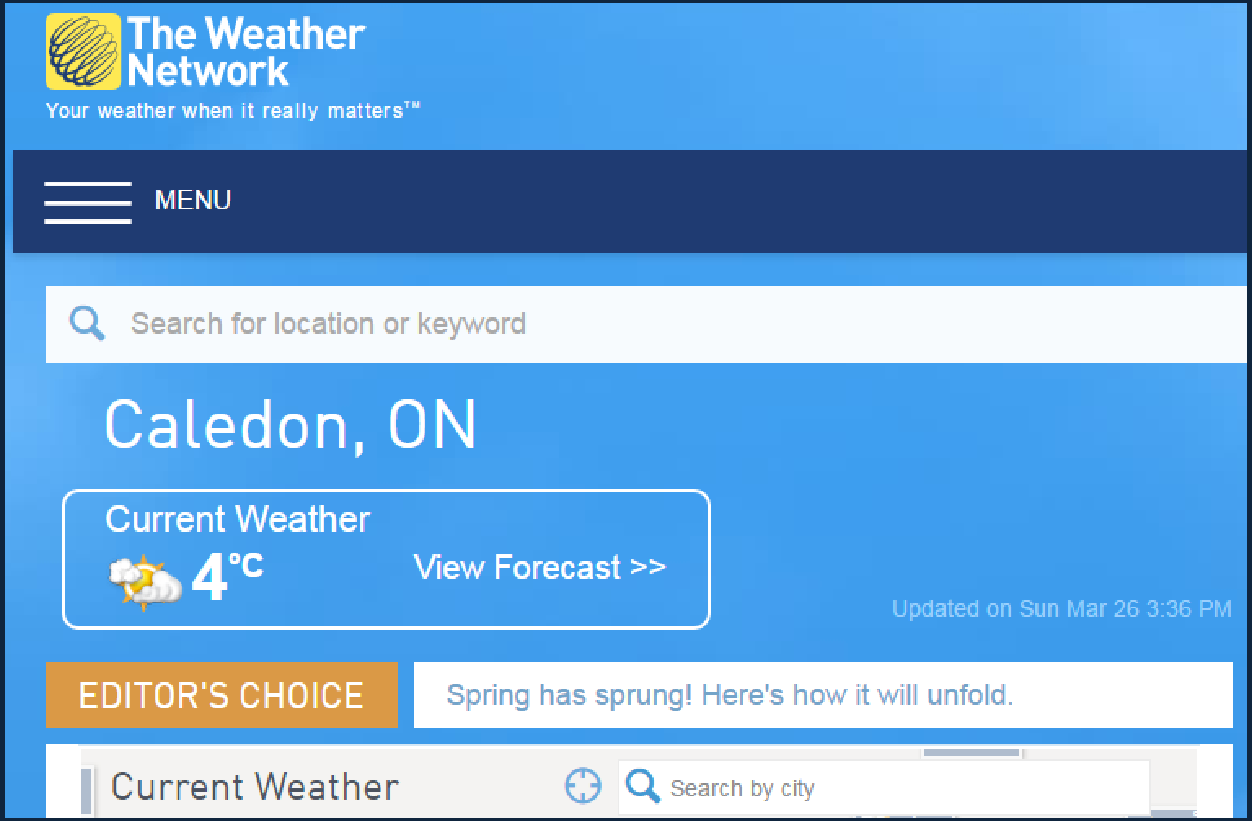
TAF – Terminal Aerodrome Forecast, coded to the same general principles of the METAR, only apply to the terminal area surrounding the airport station (5 nm)

You can use AWWS to search for the METAR/TAF closest to you



Local weather where there is no official source of reporting.

Civilian Weather Products: not very accurate, precise or geographically specific however very easy to use and understand



Weather trends and how they can be used to predict fog or icing conditions.

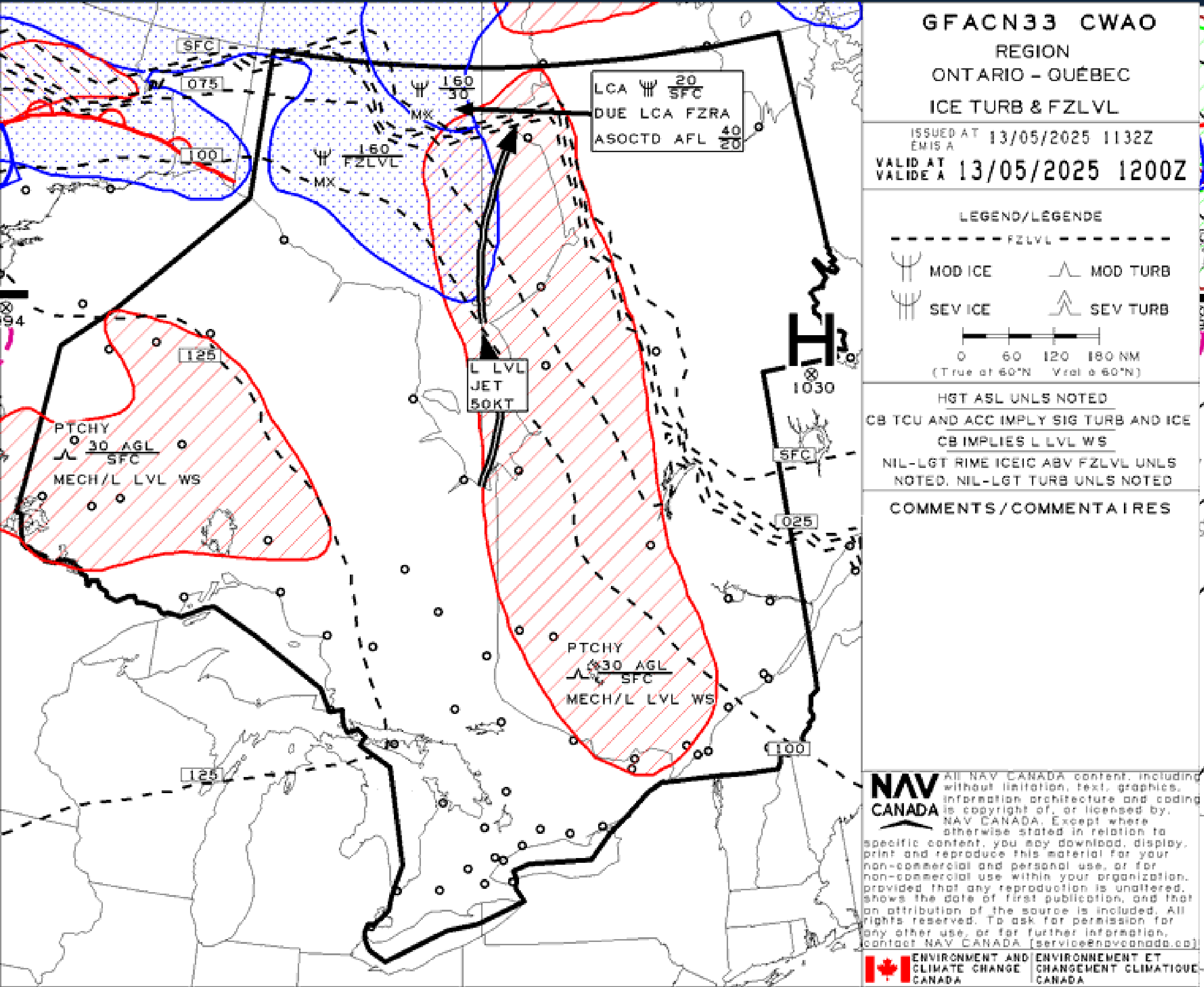
Weather patterns refer to the recurring atmospheric conditions in a specific region over time. They encompass variations in temperature, humidity, precipitation, wind speed, and atmospheric pressure. Understanding these patterns is crucial for predicting short-term weather conditions and assessing longer-term climatic trends. The significance extends beyond daily forecasts; it also sheds light on the dynamics of climate.

Assessing forecast weather in comparison to control station requirements, C2 links, and RPA requirements.

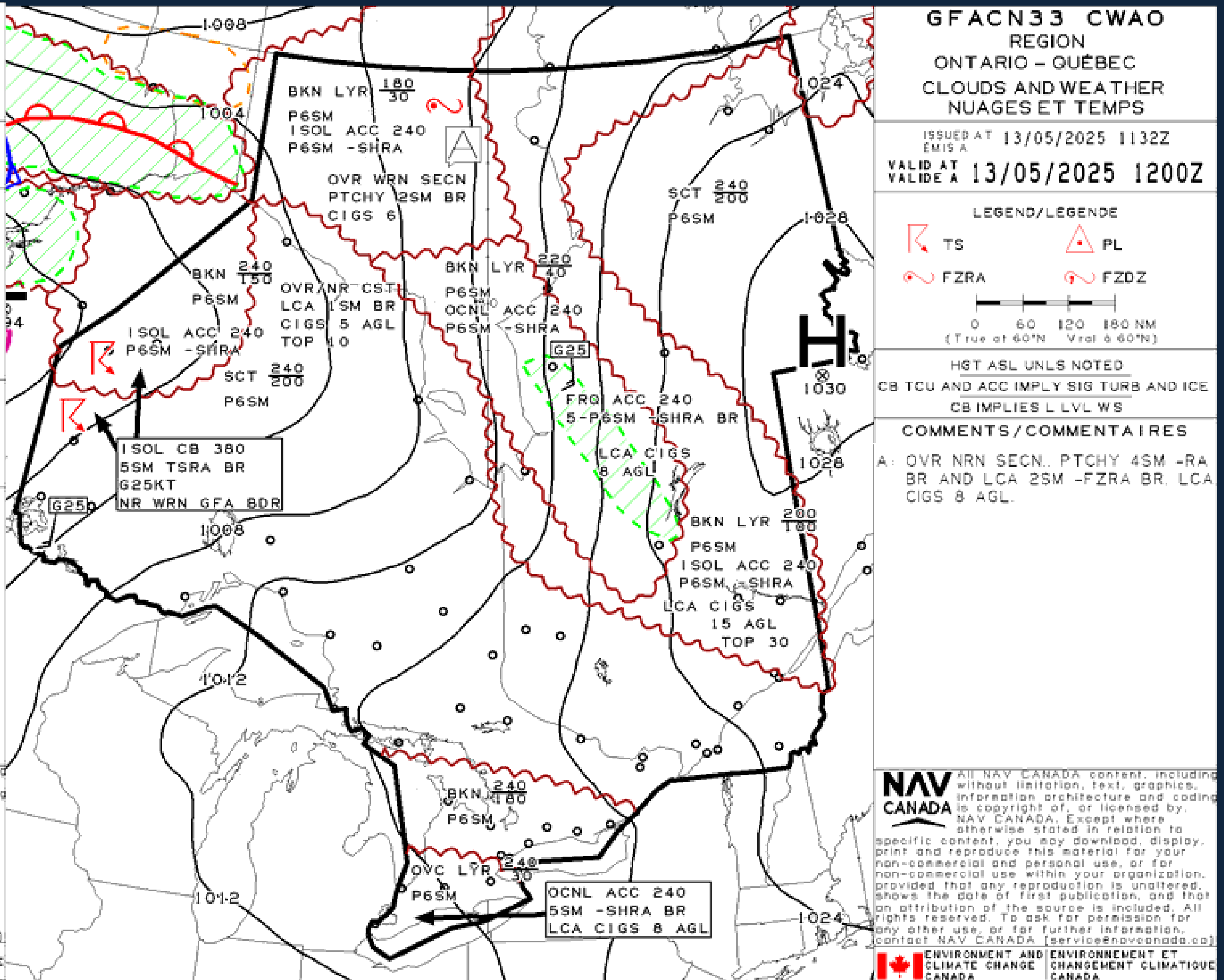
When planning your flight, you must always take into consideration the operating requirements of both your RPA and its control system. A variety of weather factors may be beyond the limitations of your RPA or its control station. Wind, Icing, temperature precipitation etc.

Forecasts and Observations / Graphical Area Forecast (GFA)

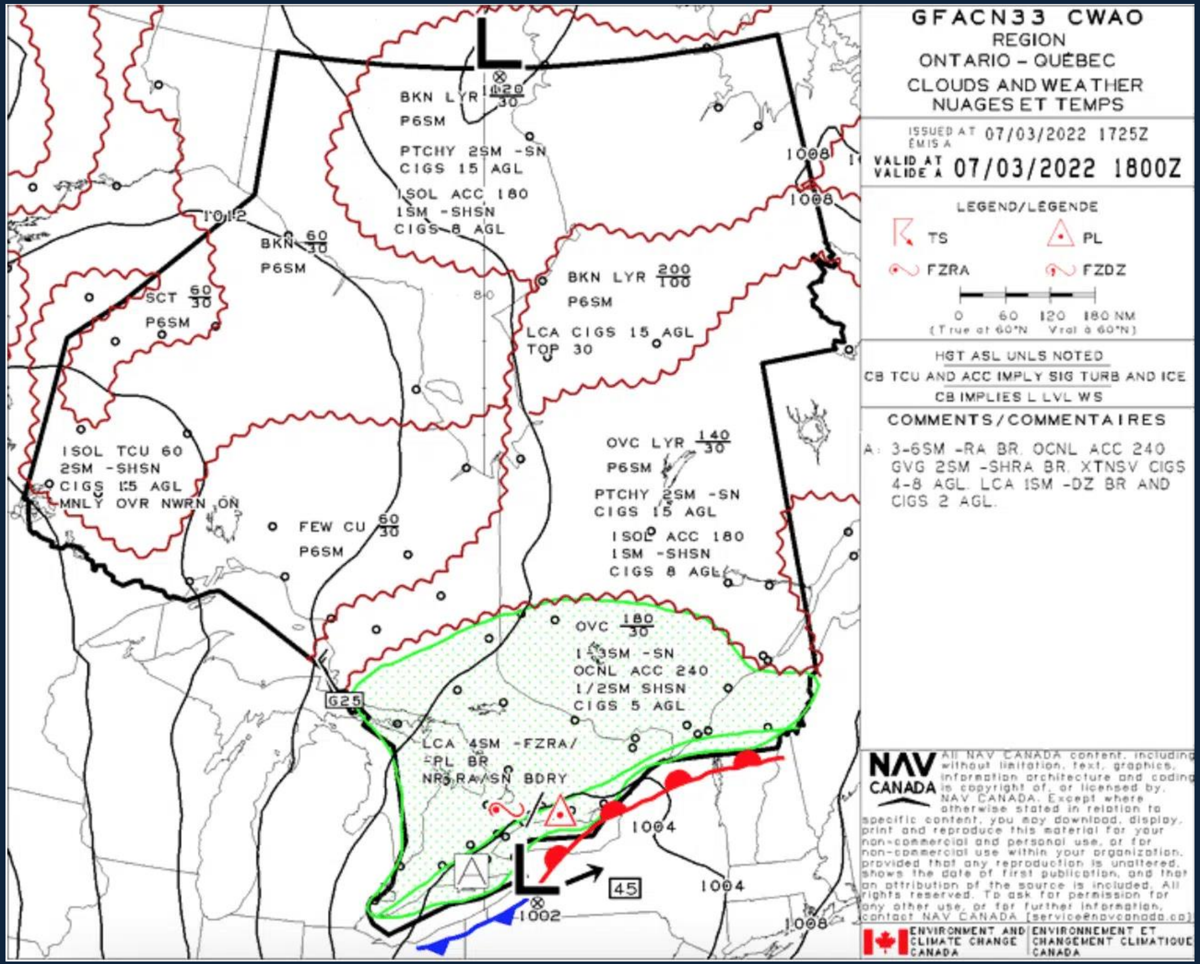
Icing, Turbulence & Freezing level - Ontario & Quebec (GFACN33)



Clouds & Weather - Ontario & Quebec (GFACN33)



To successfully extract key weather information from a Graphical Forecast Area (GFA) for RPAS Level 1 complex operations, you need to be able to identify and interpret various elements on the chart. This includes recognizing forecast areas of icing and turbulence, including their type, intensity, base, and tops. You should also be able to locate and interpret symbols representing freezing levels and other significant weather phenomena. Additionally, understanding how GFA weather charts depict the most probable weather below 24,000 ft is crucial.



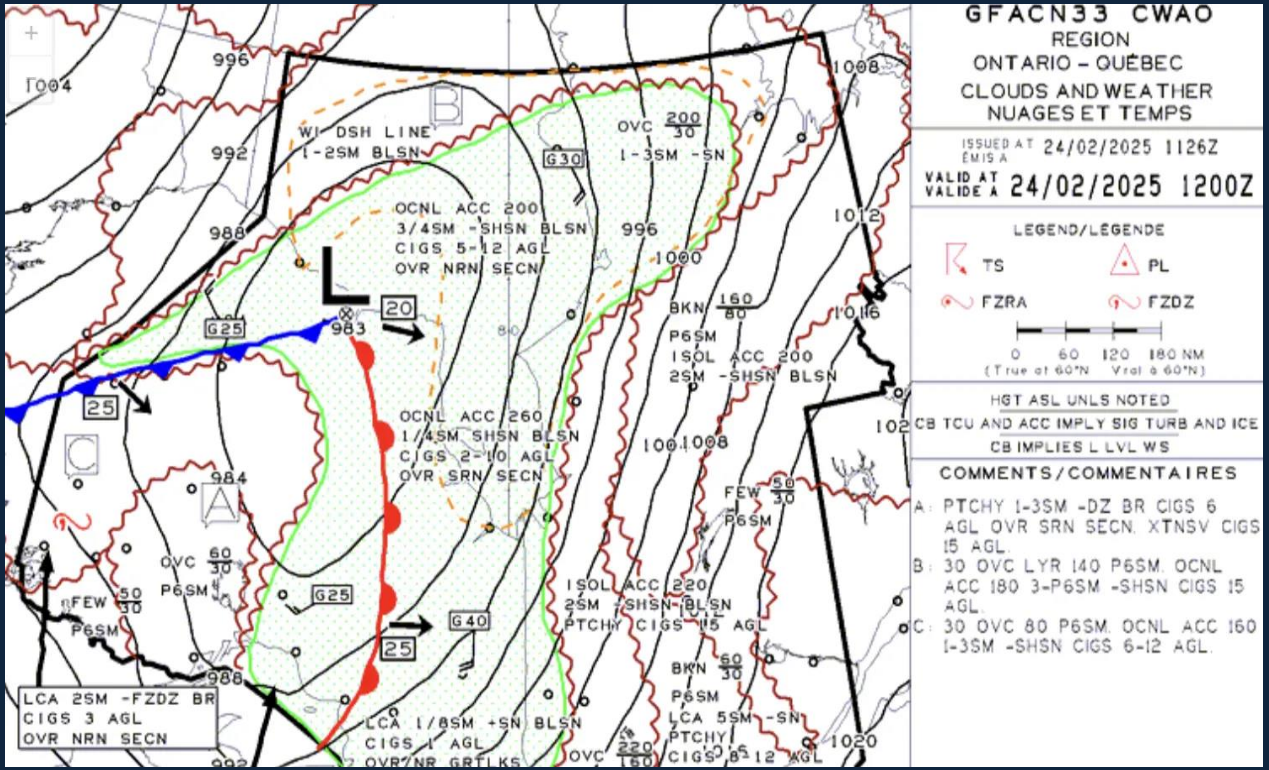
https://flighttrainers.ca/gfa-graphical-area-forecast/

Here's a breakdown of key skills and elements to focus on:

Identifying Areas of Icing and Turbulence:
Be able to recognize and interpret the symbols and text used to denote areas of icing (e.g., "MODERATE ICE", "LIGHT ICE") and turbulence (e.g., "MODERATE TURBULENCE", "LIGHT TURBULENCE").

Understanding Intensity and Heights:
Determine the intensity of icing or turbulence (e.g., "MODERATE", "LIGHT", "SEVERE") and the altitudes at which these phenomena are forecast (e.g., "Base: 5000 ft", "Top: 10000 ft").

Locating and Interpreting Symbols:
Be familiar with the symbols used to represent freezing levels and other relevant weather phenomena (e.g., thunderstorms, fog).



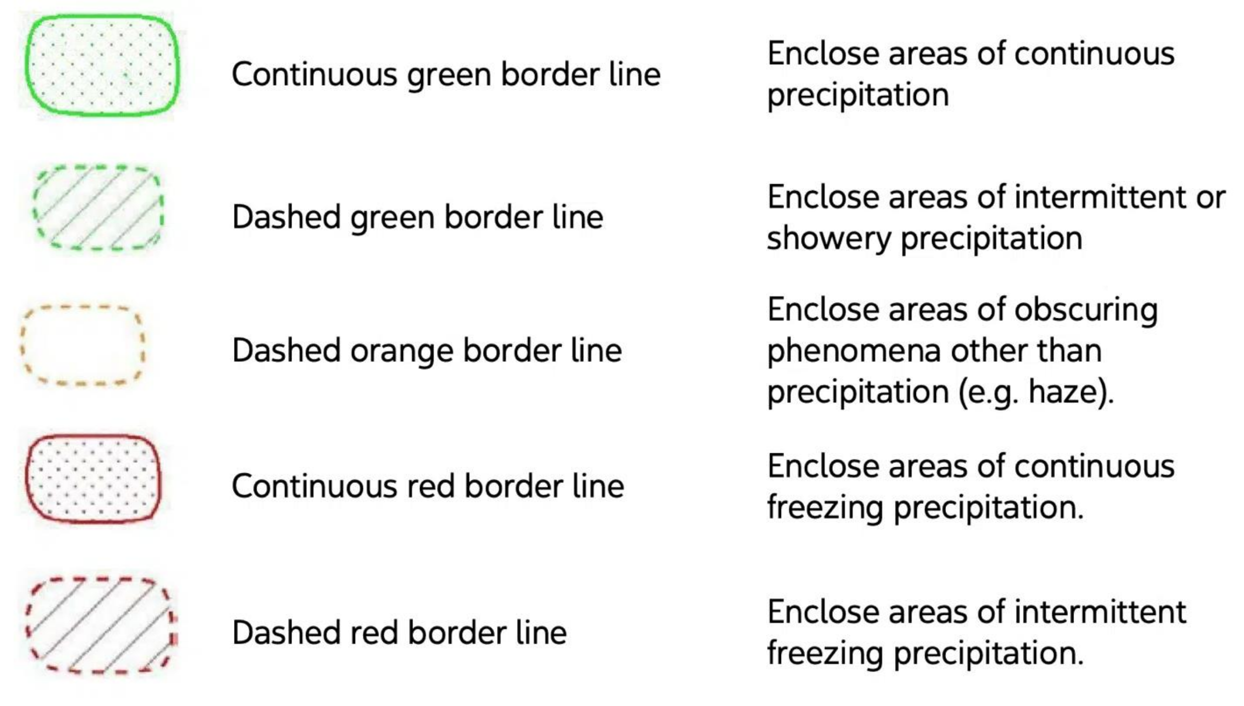
Understanding GFA Scope:

Recognize that GFA weather charts primarily focus on the most probable weather below 24,000 ft.

Assessing Forecast Weather:
Compare the forecast weather with the requirements of the control station (C2 links, RPAS, operational requirements).

Identifying Sources of Weather Reports:
Be aware of various weather reporting sources, including official sources, local sources, and trends that can help predict conditions.

Predicting Weather Trends:
Understand how weather trends can be used to anticipate potential changes, such as the development of fog or icing.



Navigation Terms

Speeds

•**Calibrated Airspeed (CAS):** Indicated airspeed corrected for instrument or position inaccuracies. The calibrated airspeed can be found in the pilot operating handbook or on the airspeed indicator.
•**Indicated Airspeed (IAS):** The airspeed read directly from the airspeed indicator.

•**Groundspeed (GS):** The actual speed of the airplane passing over the ground. Groundspeed is true airspeed corrected for wind. You can find the aircraft ground speed by calculating it with a flight computer.
•**True Airspeed (TAS):** The actual speed relative to the surrounding air. True airspeed is calibrated airspeed corrected for nonstandard pressure and temperature. You can determine the aircraft's true airspeed with a flight computer.

Altitudes

•**Indicated Altitude:** The altitude depicted on the altimeter. Indicated altitude is the vertical distance above mean sea level (MSL), not above the ground.

•**Density Altitude:** Pressure altitude corrected for nonstandard temperature. You can calculate density altitude with a flight computer.

•**Pressure Altitude:** The altitude shown on the altimeter when the altimeter is set to 29.92 inches or standard atmospheric pressure.

•**Absolute Altitude:** The vertical distance of the aircraft above the surface of the earth, or above ground level (AGL).

•**True Altitude:** The aircraft altitude above mean sea level (MSL). You can determine the true altitude with a flight computer

Directional

•**True North:** The geographic north pole is located at the Earth's northernmost point. True north is not the same location as magnetic north, due to the rotation of the earth in relation to the earth's magnetic field.

•**Magnetic North:** The northern location where the Earth's magnetic force has the most downward pull. If you were to stand on magnetic north, a magnetic compass would point straight down. Magnetic north varies due to shifts in the Earth's core and is at a different location than true north.

•**Magnetic Variation:** The angular difference between true north and magnetic north. Also known as declination.

•**Magnetic Deviation:** A magnetic anomaly that affects the compass. The magnetic compass in the aircraft is affected by surrounding magnetic and electrical disturbances in the airplane.

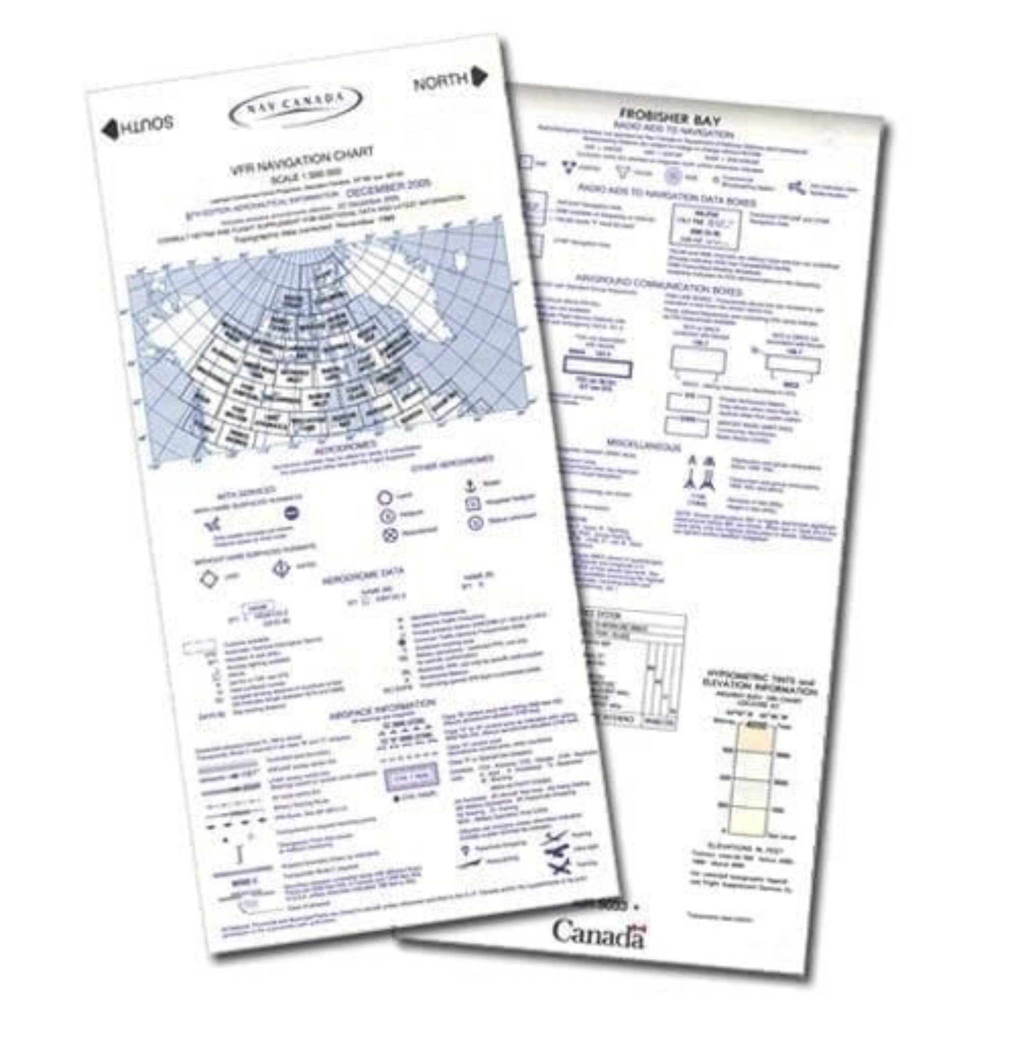
•**Compass Heading:** The aircraft's magnetic heading corrected for deviation. The deviation is found on a compass card or a placard near the compass, and it usually varies by just a degree or two.

•**Magnetic Course:** True course corrected for magnetic variation.

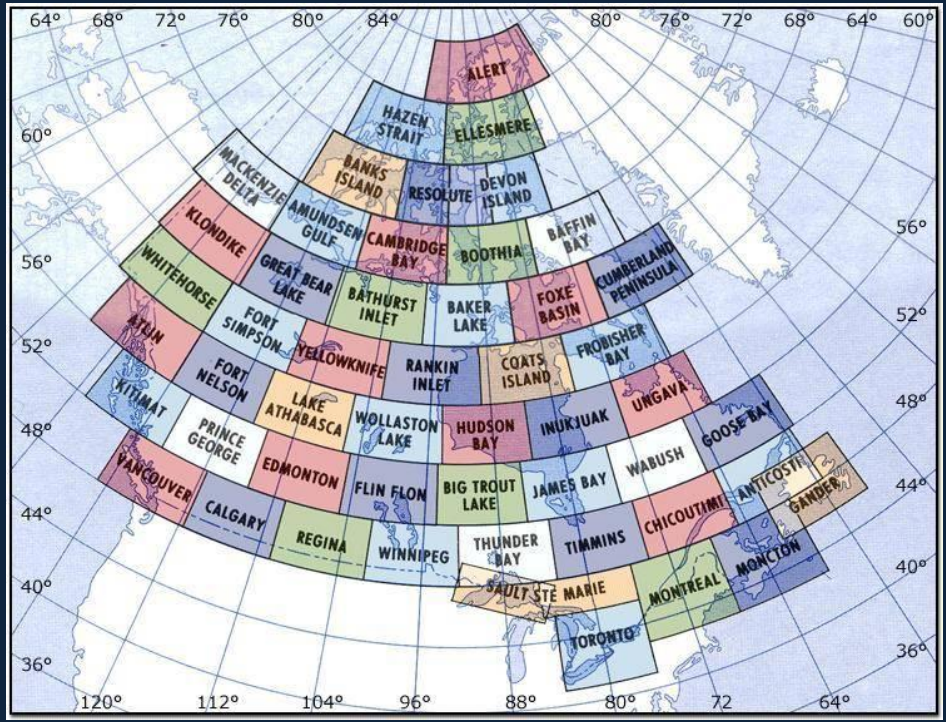
•**Magnetic Heading:** True heading corrected for magnetic variation. You can determine the magnetic variation from a sectional map.

•**True Course:** The aircraft's course over the ground relative to true north. True course is measured with a navigation plotter and a sectional map.

Maps and charts



Validity of a VNC or VTA Chart



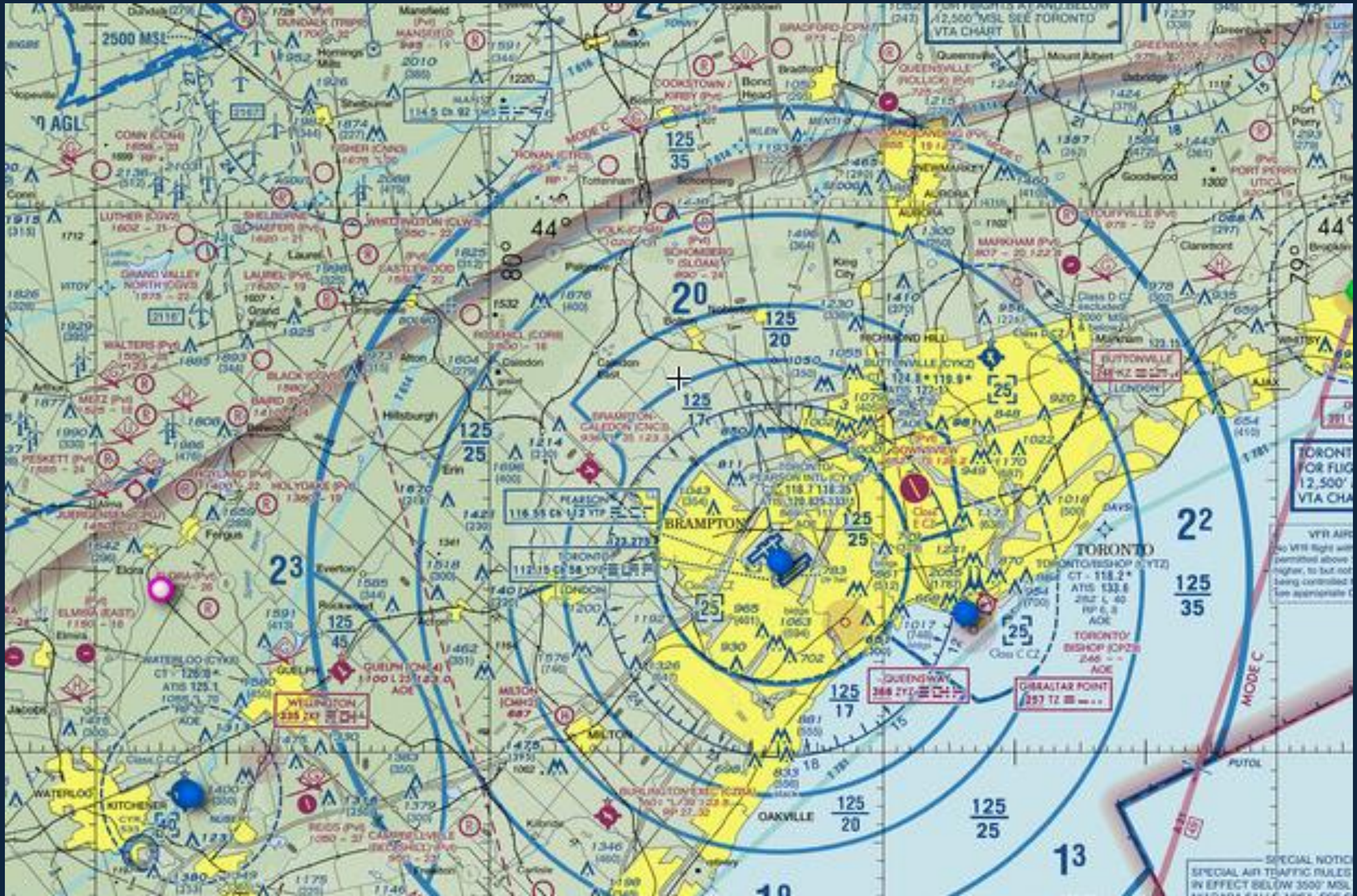
VNC Chart Areas Canada

The VFR Navigation Chart (VNC) series is intended for VFR navigation throughout Canada on short to extended cross-country flights at low to medium altitudes and at low to medium airspeeds. The VNC series satisfies the requirements of visual air navigation for operations at or below 12,500 feet Above Mean Sea Level (AMSL). To facilitate air navigation, the chart displays aeronautical information and sufficient topographic detail with a unique colour scheme, layer tinting, and shaded relief. The scale is 1:500,000

Demonstrate the ability to interpret Aeronautical charts: VNC, VTA.

Identify a controlled or uncontrolled airspace on an aeronautical chart.

Determining ground elevation from a map.



CFS (Canada Flight Supplement)

The Canada Flight Supplement **contains essential information and ground plates for all Canadian aerodromes**. It also contains route planning information, communications information - basically everything a VFR or IFR pilot needs. Aerodromes are divided by first letter.


CANADA FLIGHT SUPPLEMENT / GPH 205

AERODROME/FACILITY DIRECTORY B159

CHIPEWYAN LAKE AB

REF

OPR

FLT PLN NOTAM FILE CYMM

RWY DATA

COMM

CHIPMAN AB

REF

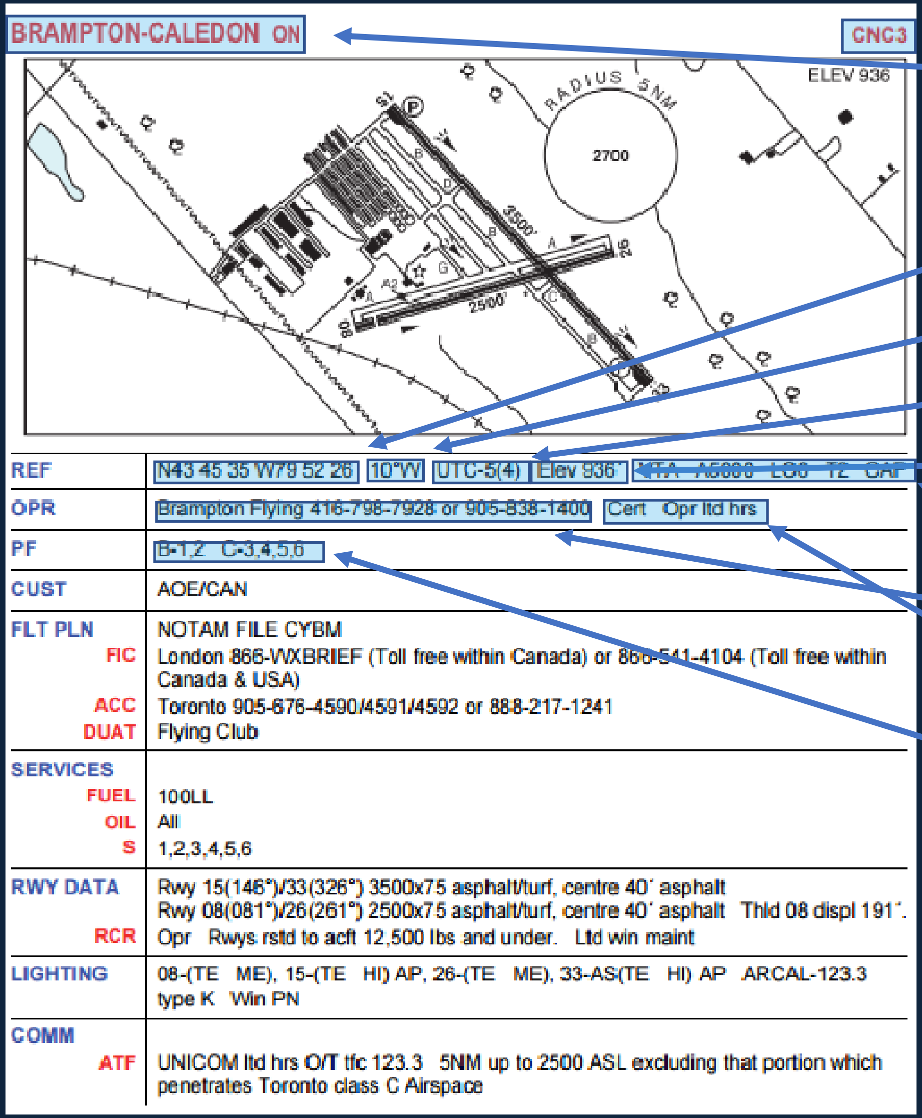
OPR

FLT PLN NOTAM FILE CYEG

RWY DATA

COMM

CAUTION


BRAMPTON-CALEDON ON — CNC3

ELEV 936 · RADIUS 5NM · 2700 · 3500' · 2500'

REF	N43 45 35 W79 52 26 · 10°W · UTC-5(4) · Elev 936´ · VTA A5000 LO6 T2 CAP
OPR	Brampton Flying 416-798-7928 or 905-838-1400 · Cert Opr ltd hrs
PF	B-1,2 C-3,4,5,6
CUST	AOE/CAN
FLT PLN	NOTAM FILE CYBM
FIC	London 866-WXBRIEF (Toll free within Canada) or 866-541-4104 (Toll free within Canada & USA)
ACC	Toronto 905-676-4590/4591/4592 or 888-217-1241
DUAT	Flying Club
SERVICES	
FUEL	100LL
OIL	All
S	1,2,3,4,5,6
RWY DATA	Rwy 15(146°)/33(326°) 3500x75 asphalt/turf, centre 40´ asphalt Rwy 08(081°)/26(261°) 2500x75 asphalt/turf, centre 40´ asphalt Thld 08 displ 191´.
RCR	Opr Rwys rstd to acft 12,500 lbs and under. Ltd win maint
LIGHTING	08-(TE ME), 15-(TE HI) AP, 26-(TE ME), 33-AS(TE HI) AP ARCAL-123.3 type K Win PN
COMM	
ATF	UNICOM ltd hrs O/T tfc 123.3 5NM up to 2500 ASL excluding that portion which penetrates Toronto class C Airspace

Airport Name and Province

Airport Identifier

Coordinates

Magnetic Variation

Time Zone

Airport Elevation

Charts airport is listed on

Airport operator and number

Certified airport with limited hours

Public Facilities

A – Available in Terminal Building

B – On aerodrome

C – 5nm of Aerodrome

D – 30nm of Aerodrome

1 – Telephone

2 – Food

3 – Taxi

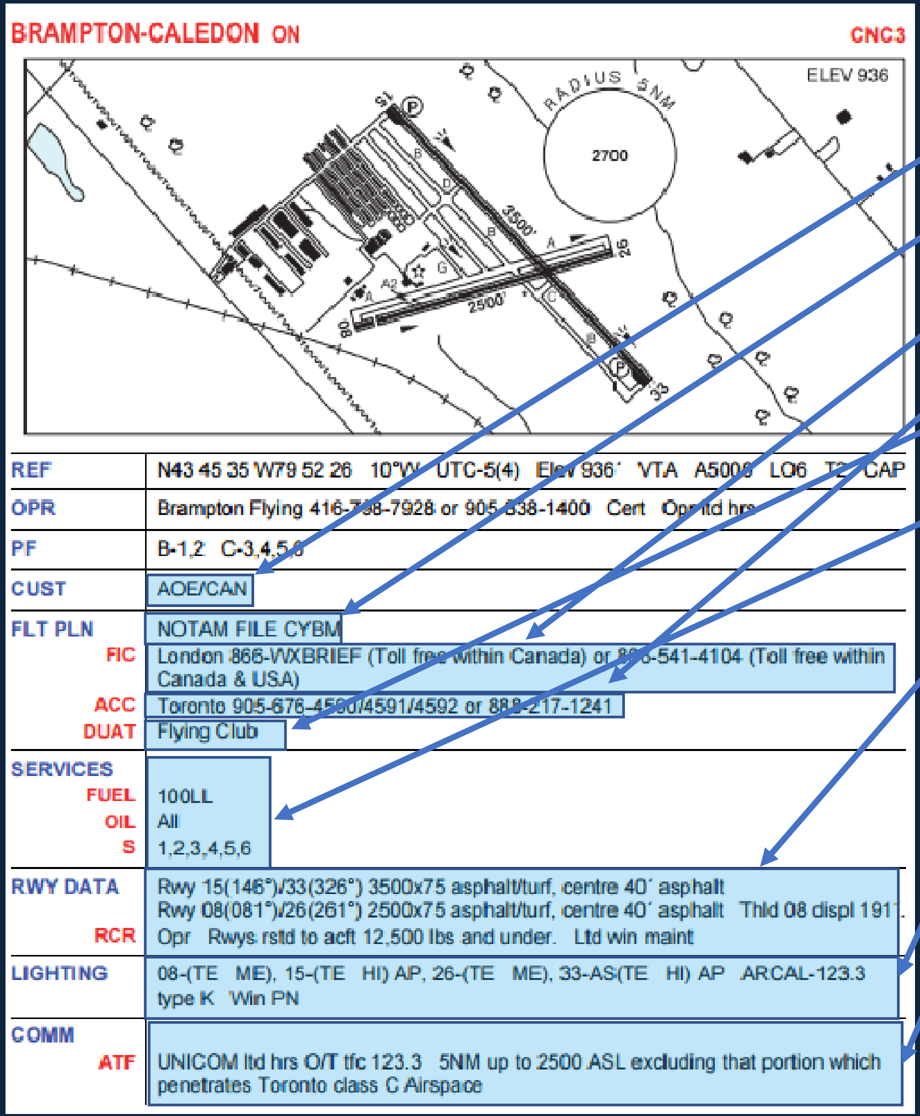
4 – Medical Services

5 – Hotel

6 – Car Rental

7 – Public Wi-fi

8 – Public internet access



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DUAT	Flying Club
SERVICES	
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RWY DATA	Rwy 15(146°)/33(326°) 3500x75 asphalt/turf, centre 40´ asphalt Rwy 08(081°)/26(261°) 2500x75 asphalt/turf, centre 40´ asphalt Thld 08 displ 191´
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COMM	
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Customs Available

NOTAM file name

Flight Information Centre

Area Control Centre phone number

Direct User Access Terminal Service

Aircraft Repair Services Available

Runway information

Airport Lighting

Communication frequencies

Demonstrate the ability to plot latitude and longitude on aeronautical charts.
Demonstrate the ability to find locations on aeronautical charts using latitude and longitude

Latitude and longitude (sometimes shortened at lat/long) are imaginary graph lines covering the earth's surface. They're measurements on a map or globe used to determine location coordinates.

Here's another way to understand that basic description of lat and long.

Do you remember algebra from your school days? A teacher would show you a graph and ask you to plot points to form a line. If you recall, the axes of this graph were X and Y axes. Each horizontal graph line corresponds to a point on the X-axis. Every vertical graph line corresponds to a point on the Y.

In that case, you already understand latitude (represented by the Y-axis) and longitude (represented by the X-axis). Now let's apply this to how to plot points on a map.

Because the world is spherical and not flat, imaginary latitude lines encircle the globe east-west and parallel to each other. The central reference point is the equator — the zero latitude. Latitude lines, or parallels, that run above the equator (towards the North Pole) go from one to 90 degrees. Parallels below the equator (towards the South Pole) are from -1 to -90 degrees.

On the other hand, imaginary longitude lines have no natural zero reference point. The Greenwich Observatory in London is the zero longitude or the prime meridian. Longitude lines run around the earth from the North pole to the South pole and parallel to the prime meridian.

Meridians east of the prime meridian go from one to 180 degrees. Meridians to the west range from -1 to -180 degrees. Longitude, therefore, measures the distance east and west of the prime meridian.

Flight planning

Flight planning software

There is a variety of Flight planning software available for RPAS operations. This is UAV Forecast

Full Tabletop Exercise

Site Survey and full Mission Plan

Provide Time/Distance/Energy/Endurance Calculations with the effect of wind on groundspeed.

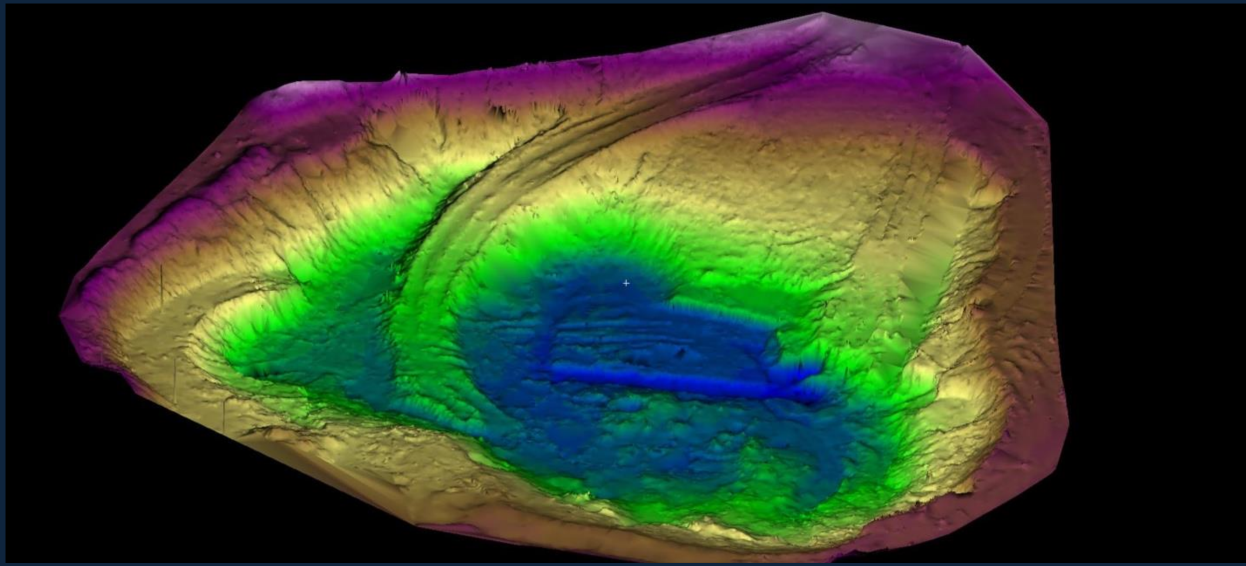
Demonstrate how to determine the effect of wind on range and endurance.

Determine effect of wind on contingency planning, including return to home and other flight termination procedures.

Consider flight termination procedures and flight termination routes when planning the
operation.

Find obstacles on a map and determining their height.

The digital terrain model (DTM) is a simplified representation of ground altimetry. The available data is in the form of an irregular triangular mesh (TIN). This is polygon numerical geographic data constructed by triangulating a set of points. The vertices are connected to a series of segments to form a mesh of triangles of different dimensions. This representation can be used as a basis for the 3D buildings of the digital base model. It should be noted that the data made available by the City is proposed for planning purposes and not for construction purposes given the associated decimeter details.



Digital surface model

A Digital Surface Model (DSM) is a 3D representation of the Earth's surface that includes all objects and features, such as buildings and vegetation. It is used in various applications like urban planning, forestry management, and flood modeling to provide detailed elevation data.

Drones traversing terrain and avoiding obstacles face challenges related to sensor accuracy, environmental conditions, and the complexity of dynamic environments. These challenges can lead to collisions with terrain or obstacles, especially in complex or unpredictable situations.

Sensory Challenges:

Sensor Accuracy:

•Drones rely on various sensors (stereo vision, infrared, lidar) to detect obstacles and terrain. These sensors can be affected by factors like low light, reflections, or weather conditions, leading to inaccurate data and potential collisions.

Sensor Limitations:

•Different sensors have different ranges and limitations. For example, stereo vision might struggle in low-light conditions, while infrared might be affected by smoke or dust.

The ability to identify areas where other airspace users, like gliders, ultralights, and parasailers, operate is crucial for safe and responsible flying. This includes recognizing areas where these activities are common and understanding potential hazards they pose.

- **Visual Navigation Charts (VNCs):**
- VNCs, which are like sectional charts, are essential for identifying areas of specific airspace use, including those for gliders, ultralights, and parasailers.
- **Local Knowledge:**
- Consulting with local pilots and instructors can provide valuable insights into the specific areas and practices of these airspace users, helping to avoid potential conflicts.
- **Restricted Areas (RAs) and Prohibited Areas (PAs):**
- These are areas where specific rules and restrictions apply, and it's crucial to be aware of them, especially for activities like paragliding, which often operate in close proximity to these zones.
- **Communication and Coordination:**
- Maintaining communication with other airspace users, particularly those involved in similar activities like gliders and ultralights, is essential for ensuring safe

•**Detect and Avoid Functions:**

•If using visual observers, reliable and timely communication between the pilot and observers is necessary to detect and avoid any conflicting air traffic or hazards.

•**Environmental Considerations:**

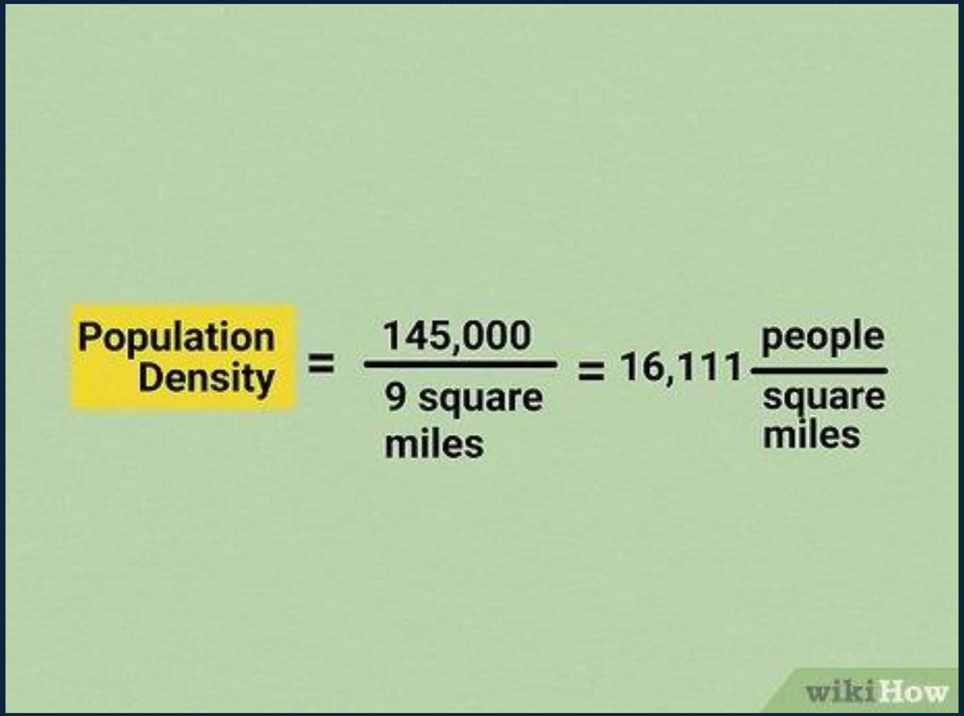
•When considering operations near these areas, it's important to assess potential environmental impacts, including noise levels and potential wildlife encounters.

Low Level Complexity 1 Determine the population density of a given area.

One Method would be to use an available population density calculator

NRC (National Research council) plans on adding this function to their current drone site selection tool

Another method for acquiring this information would be to request it from Census Canada



Here's a breakdown of how to identify population density:

Define the Area of Interest:

Clearly specify the geographic area for which population density is being calculated. This could be a specific block, a neighborhood, or a larger region.

Gather Population Data:

Obtain the number of individuals (people) residing within the defined area. This data can be found from various sources:

Census data: Government census data provides official population figures for different geographic areas.

Local government statistics: Local authorities often collect and publish population data for specific regions.

Demographic studies: Researchers and organizations may conduct studies to estimate population within particular areas.

Determine the Area:

Accurately measure the area of interest. This can be done using mapping software, GIS tools, or by consulting existing maps and

documents. Ensure the area is measured in consistent units (e.g., square kilometers, square miles).

Apply the Formula:

Once you have the population number (n) and the area (A), use the formula D = n/A to calculate the population density.

Consider Grid Size:

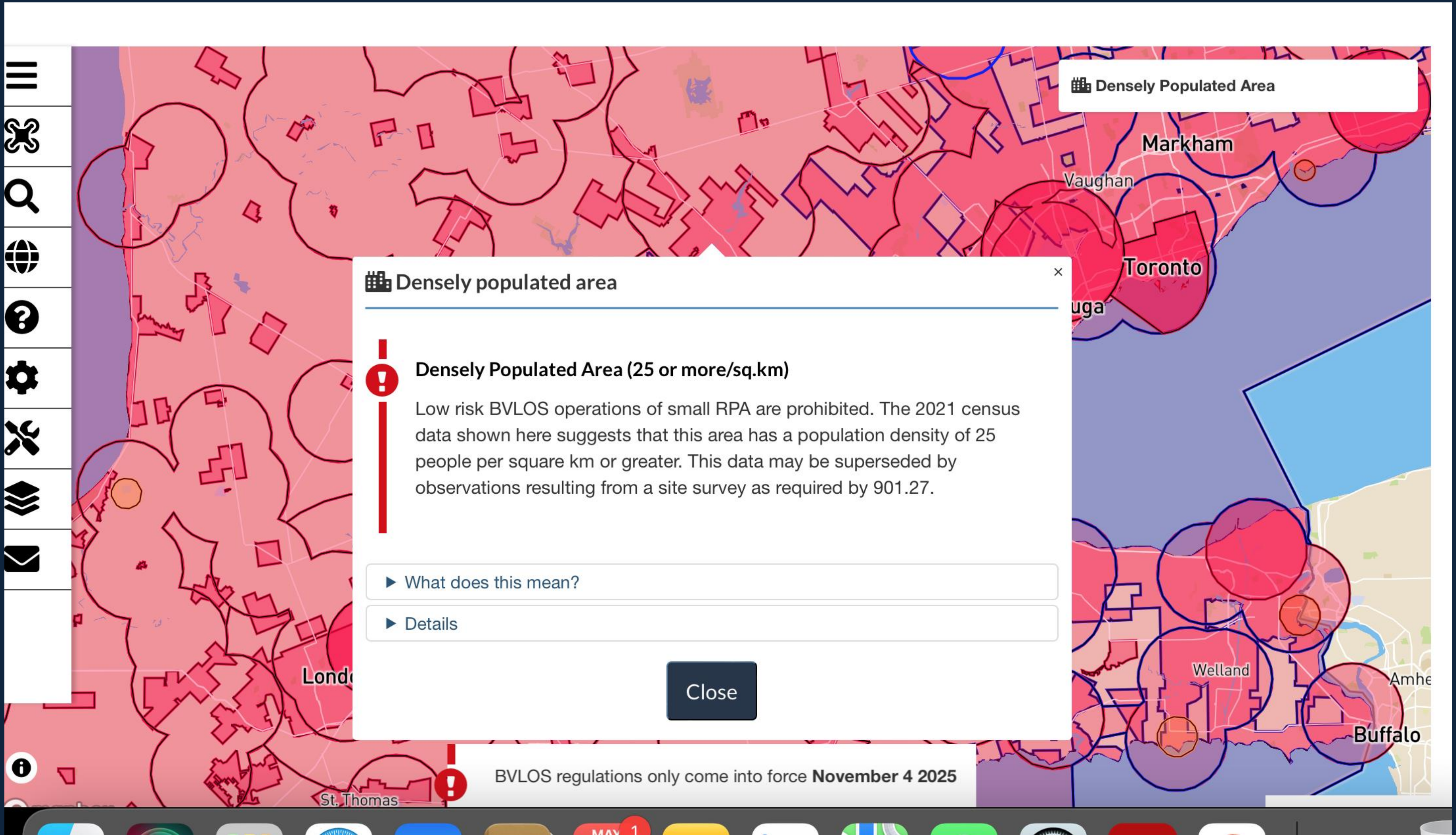
When using maps or GIS data, be aware that the grid size can influence the calculated population density. Smaller grid sizes may result in higher density values within those cells.

Example:
If a 100 km² area has a population of 10,000 people, the population density would be 10,000 people / 100 km² = 100 people/km².

By following these steps, an RPAS pilot can accurately determine the population density of a given area, which is crucial for ensuring safe and responsible RPAS operations, especially in Level 1 Complex operations.

Determine population density for this BVLOS flight using available tools

Note that BVLOS data presented here is for pilot familiarization only and has not yet come into force in regulations. Pilot licensing and drone registration are now based on the new rules, but you still must follow the current operating rules until **November 4 2025.**



Consider environmental considerations of proposed operations, including noise, wildlife encounters,

Drones can lead to stress responses, habitat abandonment, and behavioral changes in wildlife, which may disrupt feeding, mating, and nesting.

The noise of a drone could also be an issue even in low population density areas.

Best practices include maintaining adequate distance and altitude, opting for silent drones, and choosing appropriate times and locations for drone flights to minimize disturbance.

Responsibility with respect to keeping the RPA away from another person and populated areas.

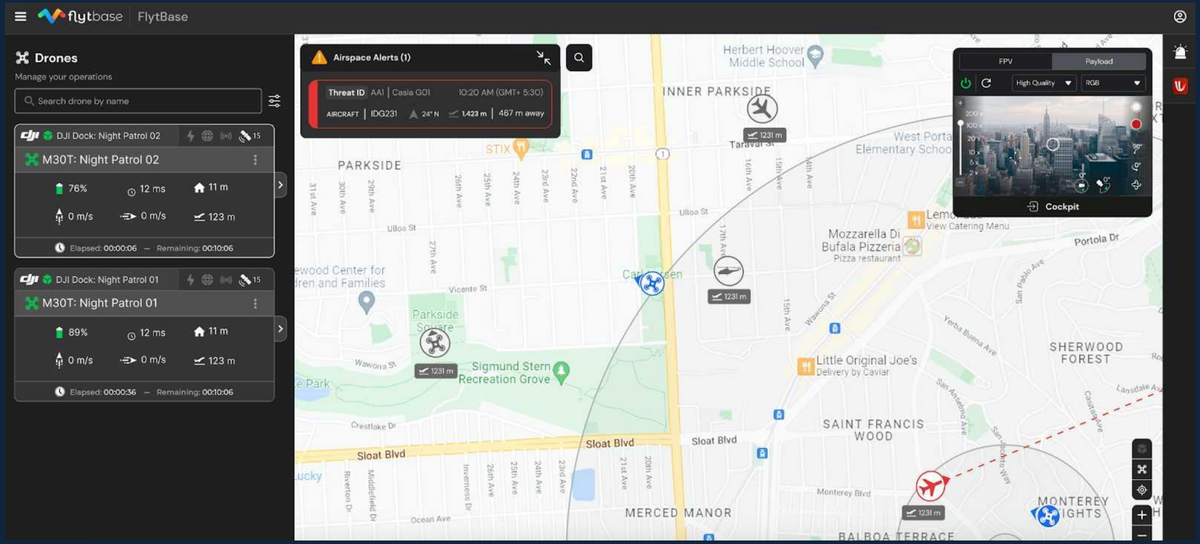
Proper Planning is essential for BVLOS operations. Your RPA must be kept away from populated areas and persons not involved in the operation. The PIC will ultimately be responsible for any violations.

Planning DAA procedures

•**Go through the mission:** Who is the remote pilot and what are the roles of any other people involved in the flight? What do you want to achieve with the flight?

•**Check the drone system:** Propellers, battery levels, transport protection, gimbal and compass calibration. Set the RTH and its altitude if there is such a function and check for any error messages.

•**The area of the flight:** Carry out a risk analysis. Are there any masts, trees or people nearby? Are there any sources of interferences like metal or aerials? When flying over water – turn off the sensors. You also need to be able to ensure safety distances to people and buildings according to the rules for the particular class you fly. You should also consider if you need to put up fences or signs, or if you need help from other people to maintain safety.



Calculate critical point/point of no return.

Calculation of the point of no return is critical to your operations.
Factors that must be taken into consideration

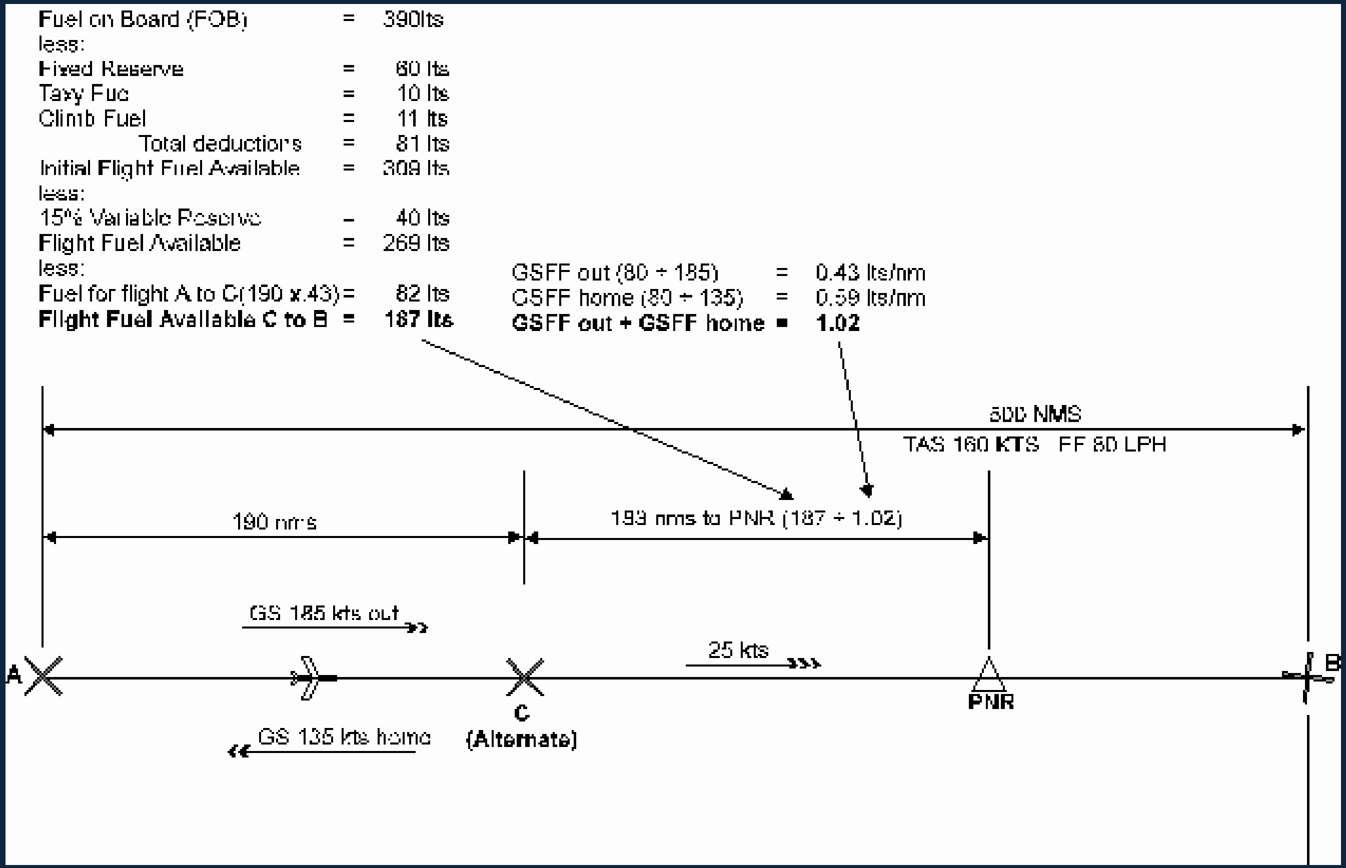
Weather conditions

Changes in air Density due to terrain changes

Available Battery power

Payloads

Groundspeed



Affects on a flight within locations that may have effects on GPS reception and impose limitations on auto pilots.

When working in remote areas terrain can be a major factor for GPS reception which could limit your ability to monitor the flight or use autopilot functions in a safe manner

Determine from a map what is the appropriate frequency to monitor.

Exercise

Let's look at an area of this VNC chart to determine the proper frequency to monitor

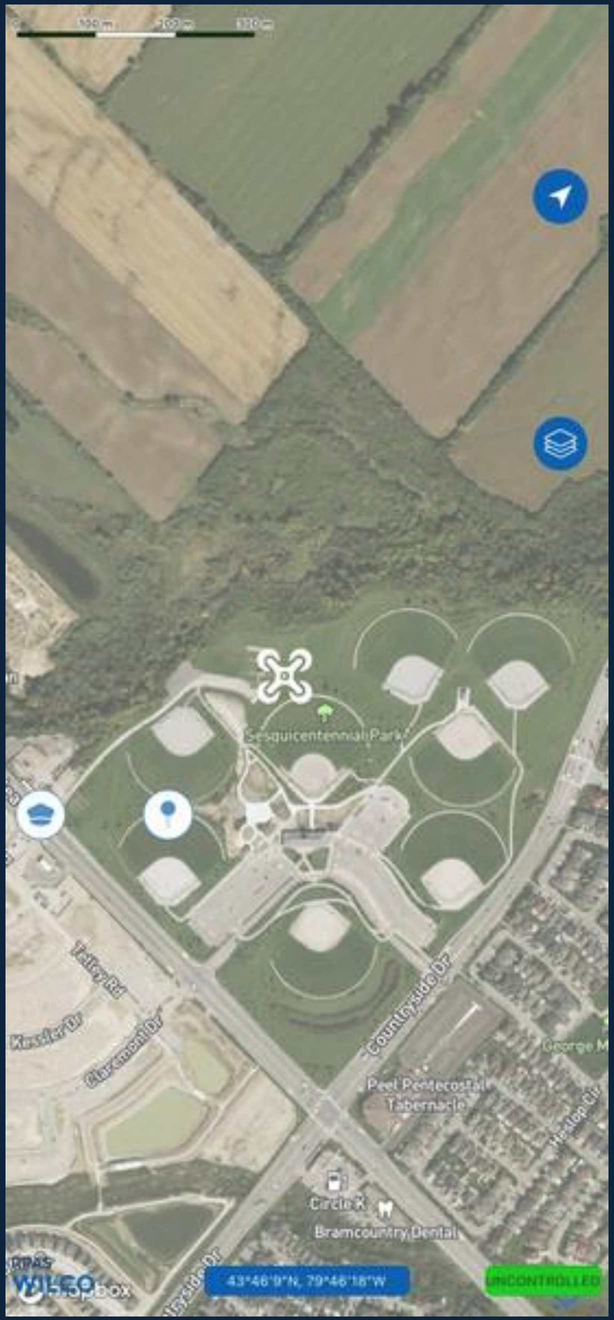
Locate possible contingency and emergency alternate landing sites using aeronautical charts.

Let's find an emergency landing site using site survey and VNC chart

A **site survey** is a mandatory pre-flight assessment required by **Transport Canada**. It ensures the area is safe for drone operations, checks for hazards, and keeps you compliant with regulations.

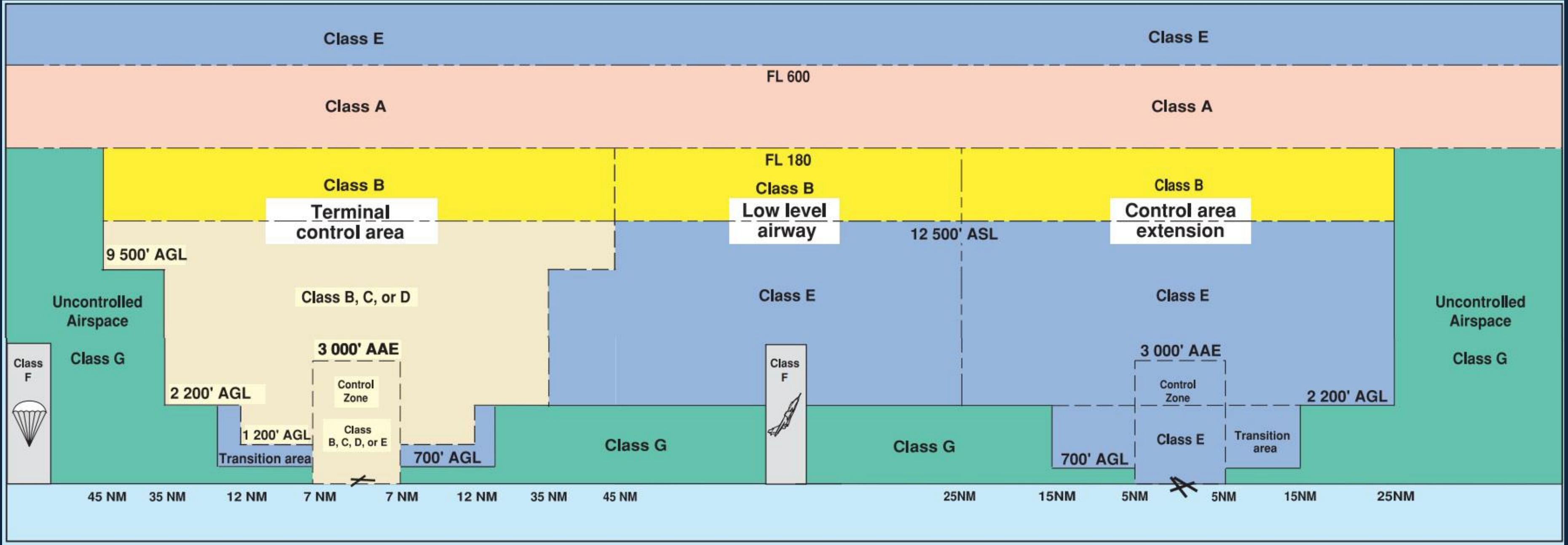
Site Survey
Obstacles (if available)
Nearby Aerodromes
Canadian Aviation Regulations
GFA
Aerodrome Supplements
-METAR & TAF (if available)
-NOTAMs
-CFS

- The boundaries of the area of operation
- Airspace classification and regulations from Transport Canada
- Altitudes and routes for takeoff and landing
- Proximity to manned aircraft and aerodromes
- The location and heights of obstacles like buildings, power lines, and antennas
- Weather and environmental conditions for the operational area
- Distance from persons not involved in the operation



Overlying Airspaces
No Airspace Info Available
Nearest Aerodromes & Distance from Operation
BRAMPTON-CALEDON (CNC3 - AERODROME - Cert) Lat: 43.76 Long: -79.874 8.284KM 4.47NM W
BRAMPTON (NATIONAL D) (CPC4 - HELIPORT - Reg) Lat: 43.833 Long: -79.701 9.084KM 4.9NM NE
BOLTON (CNB2 - HELIPORT - Cert) Lat: 43.852 Long: -79.695 11.075KM 5.98NM NE
LESTER B. PEARSON INTL (CYYZ - AERODROME - Cert) Lat: 43.676 Long: -79.63 15.389KM 8.31NM SE
TARTEN (CPA5 - HELIPORT - Cert) Lat: 43.654 Long: -79.658 15.728KM 8.49NM SE

Airspace Classification

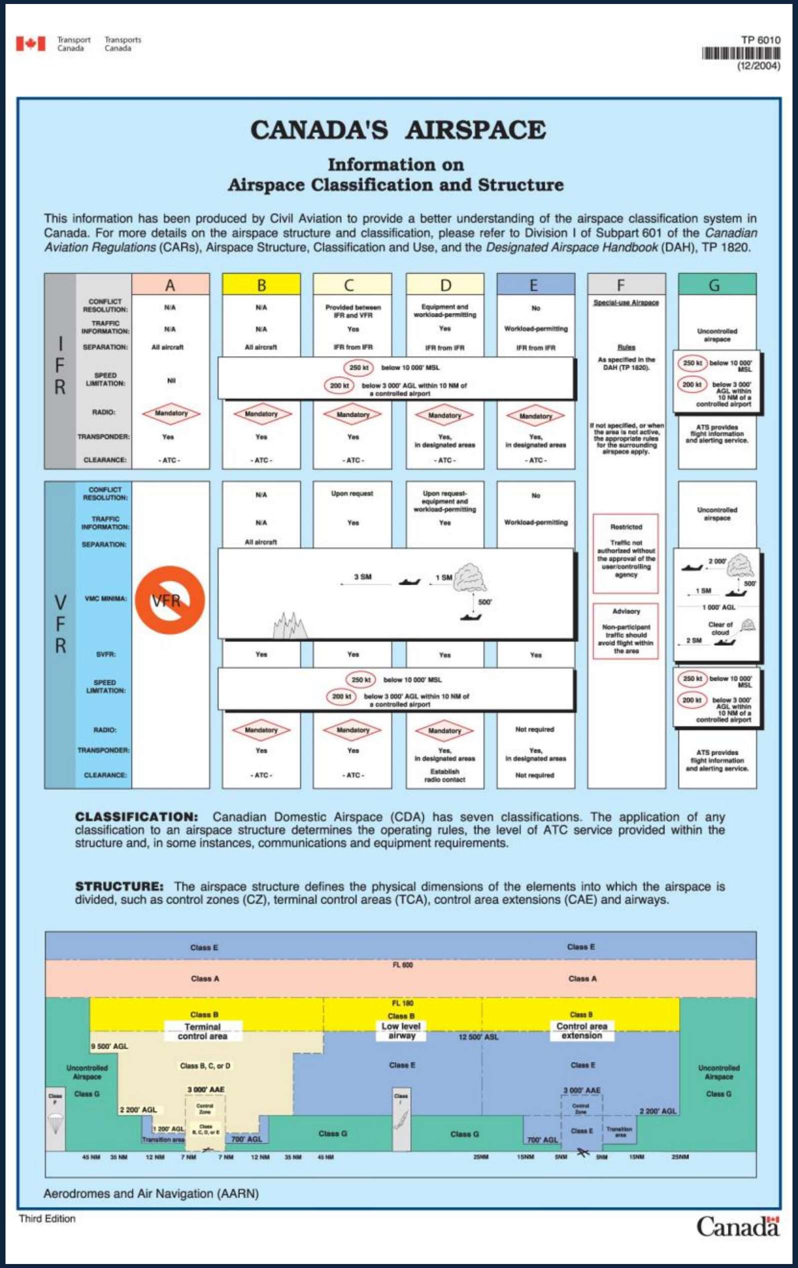


Understanding Airspace Classifications:

Controlled Airspace:

This includes Class C, D, and E airspace, where aircraft are required to communicate with air traffic control. VTA charts provide detailed information on these areas, including boundaries, altitudes, and required communications.

Class C, D, and E airspace in Canada are all controlled airspace, meaning air traffic control (ATC) services are provided. They differ in the level of complexity and restrictions placed on aircraft operating within them. Class C airspace is typically found around busy airports with a high volume of traffic, while Class D airspace is for medium-sized airports and Class E is for airspace where controlled operations are needed but don't meet the requirements for the other classes.



Class C Airspace:

Used for busy terminal areas and airspace above FL195 (19,500 ft).

ATC provides separation between IFR traffic and other IFR and VFR flights, and may also provide traffic information and conflict resolution for radar-identified VFR flights.

Requires two-way radio communication with ATC before entering, but an explicit clearance is not always required.

Aircraft need a functional Mode C transponder.

Class D Airspace:
Used for all control zones and most terminal areas around medium-sized airports.

Extends from the surface to 2,500 feet above the airport field elevation, but the exact shape and size can vary.

Requires two-way radio communication with ATC before entering, and ATC may instruct aircraft to "remain outside".

ATC provides separation only to IFR traffic.

Used for airspace where controlled operations are needed, but not as complex as Class C or D.

Generally extends from 3,500 feet (1,070 m) to FL195 (19,500 ft; 5,950 m), except around TMA's and North Sea.

No specific entry requirements, but there are VFR weather

minimums. ATC provides separation only to IFR traffic.

Uncontrolled Airspace:
This includes Class G airspace, where flight operations are not subject to ATC control. VNC and VTA charts also depict uncontrolled airspace, often with specific limitations or requirements for drone operations.

Determining Validity of Aeronautical Publications:

Chart Edition Dates:
Pilots must understand that aeronautical charts have a specific validity date, which indicates when they are current.

Chart Legend:
Pilots need to be familiar with the chart legend, which explains the symbols and information displayed on the chart, such as airports, radio aids, and airspace boundaries.

Drone site selection tool

From: National Research Council Canada

▶ Image description - Map: Drone site selection tool

NRC Reference

A Simple Site Survey is Just not enough

If you fly drones for anything beyond a quick hobby shot—inspections, infrastructure, search & rescue, deliveries, or operations that are **Level 1 Complex** or **Beyond Visual Line of Sight (BVLOS)**—a one-page site survey simply won't cut it.

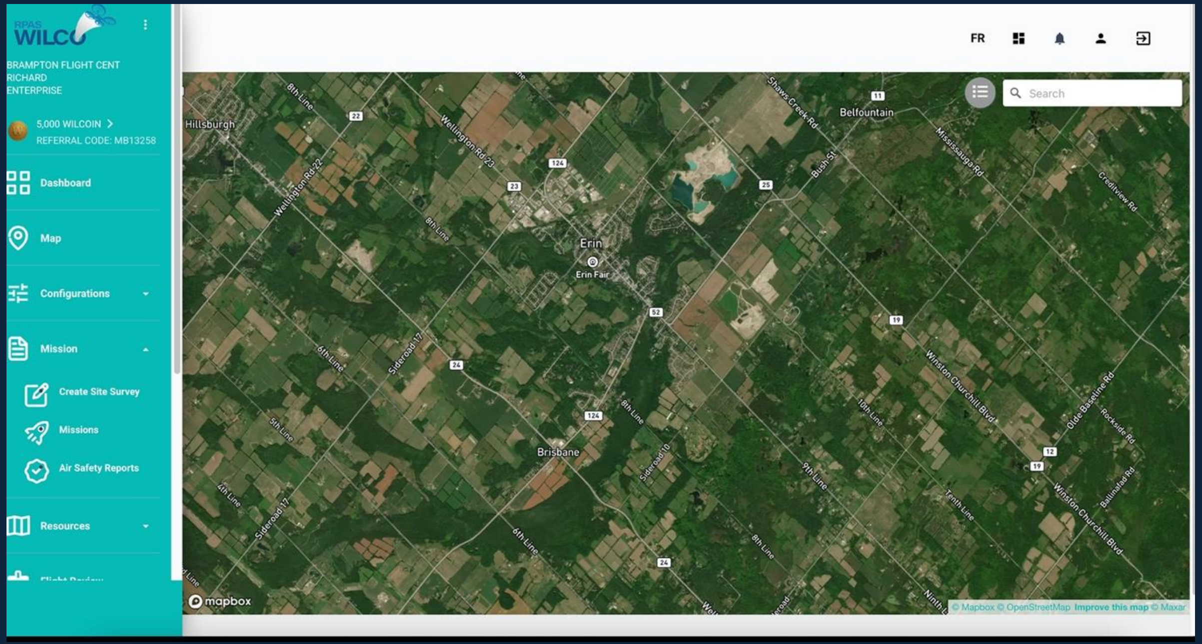
While **Transport Canada's (TC) Part IX rules** set the baseline safety expectations, responsible operators go further. They build a mission-level **Flight Plan** that clearly explains the **Who, What, Where, When, Why, and How** of the job, and, most critically, **documents the decisions made to mitigate risk**.

A robust Mission Flight Plan is essential: it protects people on the ground, minimizes operational surprises, and safeguards your business reputation and legal position [Justice Laws].

The Problem with "Just a Site Survey"

A typical site survey (required by Part IX for many flights) is valuable—it verifies obstacles, launch/land sites, and basic local hazards—but it's often just a static, snapshot checklist. Complex operations and BVLOS work demand a more comprehensive approach that includes:

- A clear **Concept of Operations (ConOps)** describing crew roles and system behavior.
- **Dynamic population-risk assessment** (population density, flows, events).
- **Contingency and emergency-landing site** selection.
- Evidence that mitigation measures are in place and understood by the whole team [Transport Canada].



The Mission Flight Plan: Using the 5Ws to Build a Defensible Plan

Frame your plan so that anyone—a client, an inspector, or another pilot—can understand it quickly and clearly. This structure, based on the classic **5Ws**, makes the plan both readable and defensible [Transport Canada]:

The 5 W's	Component	Details
Who	Personnel	Pilot-in-command, visual observers, spotters, client Point of Contact (POC), remote system owner.
What	Equipment	Aircraft make/model, payload (camera, LiDAR), weight, and fail-safe modes.
Where	Location/Airspace	Geo-coordinates of launch, flight corridors, altitudes, all NOTAMs or airspace constraints [Justice Laws].
When	Timing/Conditions	Exact date/time, daylight/lighting conditions, and the weather minima and forecasts used.
Why	Objective/Risk	Mission objective, critical success criteria, and acceptable risk thresholds.

Concept of Operations (ConOps): The Heart of Complex Planning

The **ConOps** explains exactly how the operation is intended to run end-to-end: crew composition, communications, command and control (C2) links, automation levels, failover/reroute logic, data handling, and interfaces with other airspace users.

For regulatory submissions and internal safety assurance, TC expects a clear ConOps that demonstrates you’ve thoroughly considered all operational and system behaviors. Make this section short but specific—it's your "operational story" [Transport Canada].

Enhanced Site Survey: Going Beyond the Basic Checkboxes 🗺️

For complex and BVLOS flights, the site survey must be **enhanced** to specifically address population risk, contingencies, and the dynamic nature of the operating environment:

1. **On-Site Inspections (Pre-Mission & Day-of-Mission)**
2. A robust plan requires both virtual and physical verification [Transport Canada AC 901-002]:
   - **Pre-Mission:** Conduct a physical site visit well in advance to validate the initial desktop planning, confirm obstacle heights, and verify the feasibility of designated emergency landing locations.

   - **Day-of-Mission:** Perform a final check immediately before the flight commences to ensure that no **transient hazards** (e.g., unexpected construction, temporary crowd gatherings) have arisen that could invalidate the pre-mission risk assessment.

3. **Population-Density Assessment**
4. TC recommends a three-part approach: (1) virtual analysis, (2) in-person verification (via the site visit), and (3) active monitoring during flight [Transport Canada - AC_903-001 Appendix G]. Record your population density figures and explain your mitigation measures.

Emergency & Contingency Landing Sites
This is mandatory for Level 1/BVLOS flights. Identify multiple pre-checked emergency landing sites (coordinates, surface type, obstacles, owner/permission status) and document the decision logic for when you will use them [Transport Canada].

Airspace & Coordination
List all controlled airspace boundaries and document coordination with Air Traffic Control (ATC) or NAV CANADA [NAV CANADA].

Communications, C2 Assurance, and Monitoring
Document primary and backup command-and-control links, frequency use, latency expectations, and the criteria for aborting.

Recommended Annexes: Supporting Documentation for Defensibility 📑

To make the Mission Flight Plan robust and defensible, include Annexes containing primary source documents and visuals. These provide verifiable evidence of your pre-flight research:

Annex	Content	Source/Reference
A	Mission Site Visuals (Vertical)	Screenshots from **Google Earth** detailing the mission boundaries, obstacles, and proximity to airports/aerodromes.
B	Aeronautical Charts (Horizontal)	Screenshot from the relevant **VNC/VTA** (VFR Navigation/Terminal Area Chart). Visually confirms airspace classification and restricted areas [NAV CANADA].
C	Weather Forecast	Primary source output detailing the official weather minima and forecasts used for the planned mission timeframe [Transport Canada].
D	NOTAMs	Screenshot of the current and forecasted **NOTAMs** (Notice to Air Missions) for the operating area, verifying all temporary airspace restrictions have been identified [NAV CANADA].

Final Thoughts: Why This Matters

A proper **Mission Flight Plan** transforms an operation from an "accepted risk" into a documented, mitigated activity. For Level 1 Complex and BVLOS flights, regulators and clients expect evidence that the team has assessed population risk, planned for contingencies, and has a clear **ConOps** that can be followed under pressure [Transport Canada]. That level of preparation is not only safer and more professional, but it's often faster in the long run when things don't go exactly to plan.

When used as the basis for a mandatory **Pre-flight Briefing**, it ensures every crew member has assessed the population risk, understands the contingencies, and knows the **ConOps** they must follow under pressure. This shared, documented understanding is the cornerstone of safe, professional, and compliant complex drone operations.

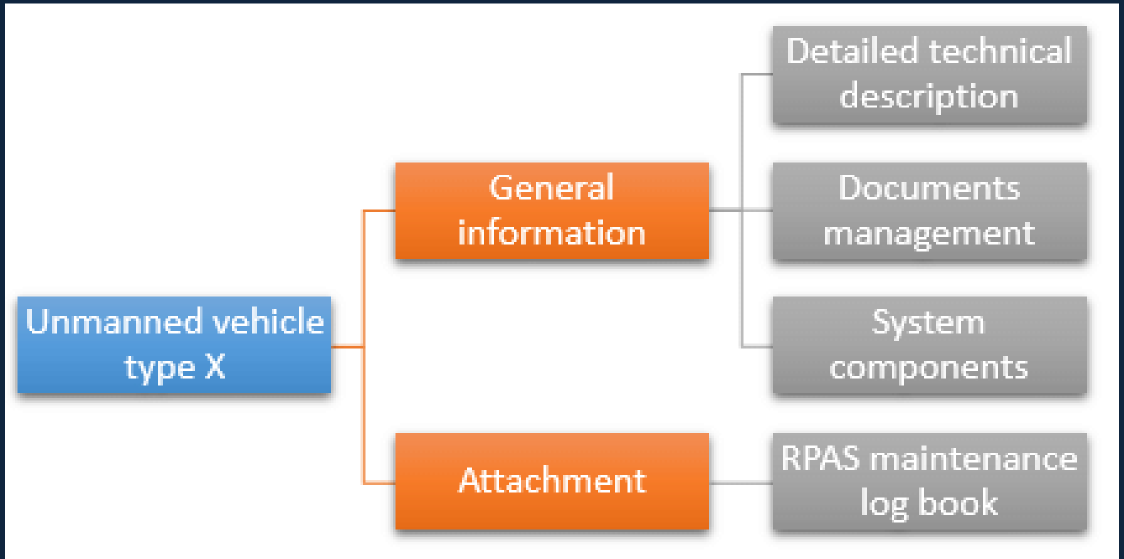
Flight operations

Need for, and elements of, an operational structure required by a RPOC.

RPAS Operators are to establish and maintain their own manuals which reflect their organizational and operational reality. RPAS Operators are expected to assess risk, make logical decisions on how to proceed when hazards/risks are identified, and assess the effectiveness of their safety program on a continuous basis.

TC may verify that declared framework exists, and during any oversight, certification, or inspection activities as per SI SUR-001, to confirm that the system is effective and compliant with CAR 901.214, 901.217 and 901.218, 901.219, and 901.221.

The RPAS operations manual consists of instructions and methods necessary to enable operations personnel, including pilots and Visual Observers, to perform their duties. Operations manual is distributed to all operations personnel.



Maintenance Control Manual (MCM)

Processes

Information management

This list is a best practice and not exhaustive.

(a) Accountable Executive
(b) Chief Pilot
(c) Training Pilot
(d) Pilot in Command
(e) Maintenance Manager
(f) Visual Observer

RPAS fleet

Flight operations

Detail how your company/organization will conduct flight operations

YOUR LOGO HERE		RPAS Operations manual for		
Ver. X	Rev. 1	Date xx.xx.2016	[Company Name]	Page 1 Of 59

Intended purpose for RPAS operations manual template for small and medium-sized RPAS/UAS/drone companies.

This template is prepared by the Civil Aviation Authority to standardize the operative documentation that must be present for commercial, research, or new operations with RPAS in Norway in the categories RO2 and RO3. RO1 operators are advised to use this template as their operational documentation. This template is based on the previous template of RPAS operations manual published in 2012, which is updated according to the requirements in "Regulations concerning aircraft without a pilot on board etc." (From now on referred to as RPAS Reg. The regulation came into effect on 01.01.2016.)

Text in blue color and italics is to be seen as information and explanation of the template, and thus not to be included in the completed operations manual. Also included in the manual is a short summary of requirements for main categories and sub categories of input sections. The individual company may decide to keep the completed manual in a) only English, b) only Norwegian or c) both English and Norwegian manuals. Important: If the company is operating outside of Norway - or plan to do so, documentation in English may be necessary.

If the company is subject to, or is part of a larger company or corporation/company, the customization and integration of this completed manual by your company, into the larger company`s existing quality system could be necessary. This must be formulated where needed. If your company already has an approved operations manual for manned aviation, it is recommended that the operations manuals be kept separate and possibly refer to one another where it is needed. This to avoid full approval for both operations manuals - when/if only minor differences occur in the two separate manuals.

The template has parts/sections and a chapter buildup. It is recommended to use this document as a template, and utilize the modern word processing systems precedence to make the manual user friendly. The company's task is to fill in relevant information where it belongs, so that the manual is adapted to each separate company's unique operational needs.

The overall goal of a process safety management system is to protect workers, the surrounding community, and the environment while also protecting the business and its assets. Although process safety slightly differs from other occupational health and safety programs, they complement each other and are equally important for protecting workers.

Process safety focuses on the control of hazards and risks associated with highly hazardous processes. These processes involve chemicals, where process incidents or failures may result in fatalities, injuries, exposures, fires, explosions, chemical releases,, equipment malfunctions, and other consequences. Process safety management involves the use of systems and principles to continuously identify hazards, assess risks, and control hazards associated with high-risk processes. Process safety management is also important for responding to and recovering from process-related incidents.

When new processes are being introduced or when there are changes to a process, hazards, risks, and control measures need to be revalidated. Process safety management is important for many types of industries, Including RPAS

Flying beyond visual line of sight:
This is the primary reason for requiring a SFOC-RPAS for BVLOS, as it increases the complexity and risk of the operation in Higher level complexity flights

Flying above 122 meters (400 ft):
Higher altitudes generally require more rigorous safety assessments and may necessitate the use of BVLOS techniques.

Operating more than five drones at a time:
Managing multiple drones simultaneously, especially beyond visual range, requires specialized procedures and coordination, making a SFOC-RPAS necessary.

Operating within 5.6km of an aerodrome:

Proximity to airports or aerodromes requires careful planning and coordination to avoid interference with other aircraft, often necessitating the use of BVLOS techniques and a SFOC-RPAS.

Carrying dangerous or hazardous payloads:
These operations pose higher risks and require specific safety protocols, which are typically addressed within a SFOC-RPAS.

Operating in controlled airspace:
Flying in areas designated for air traffic control requires additional permits and procedures, often involving BVLOS and a SFOC-RPAS.

Flying over bystanders:
This type of operation requires careful risk assessment and safety procedures, often necessitating the use of BVLOS and a SFOC-RPAS.

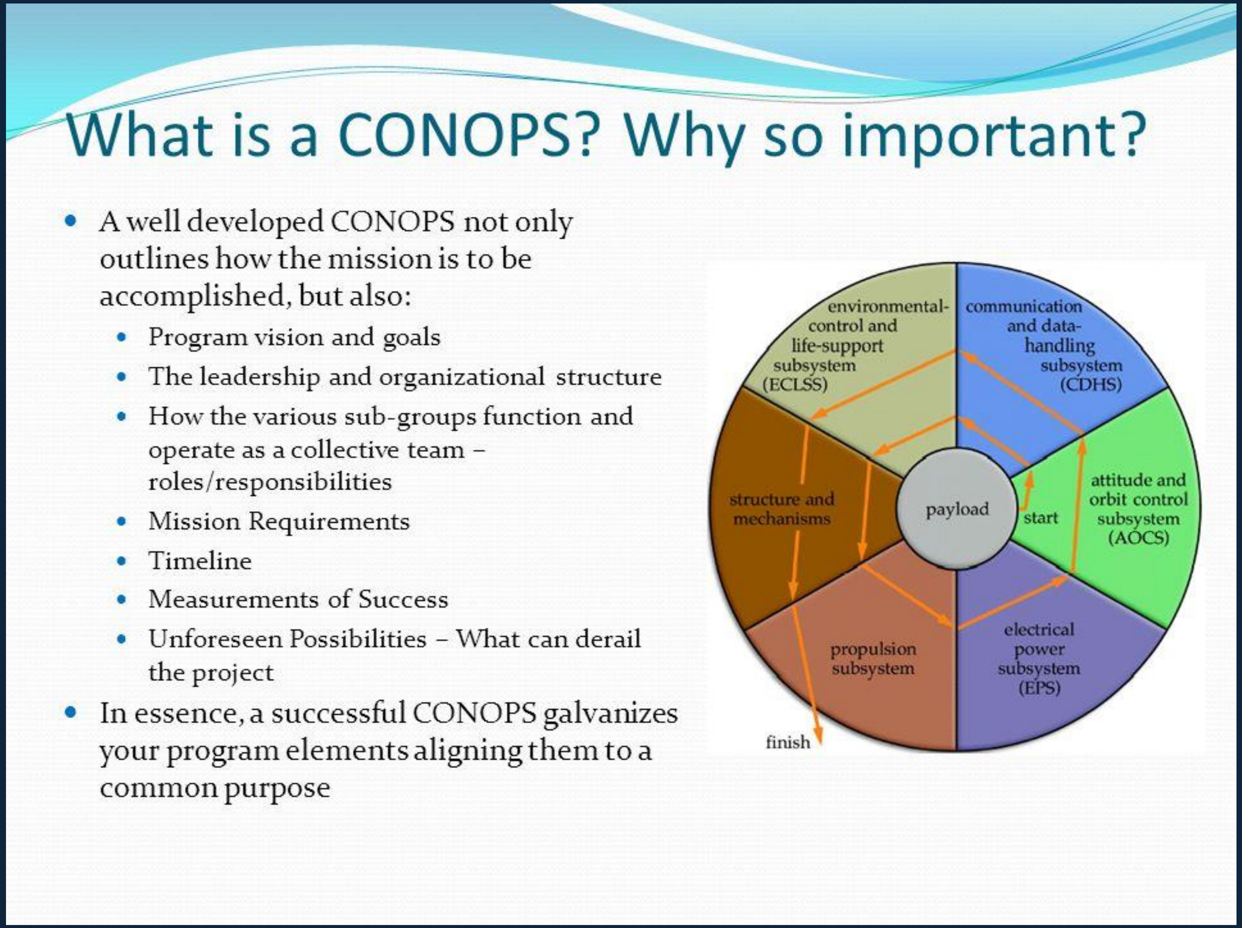
Flying within 30 meters (100 feet) of bystanders (measured horizontally):

While not directly BVLOS, this type of operation also requires a high level of safety assurance and may involve BVLOS techniques, requiring a SFOC-RPAS.

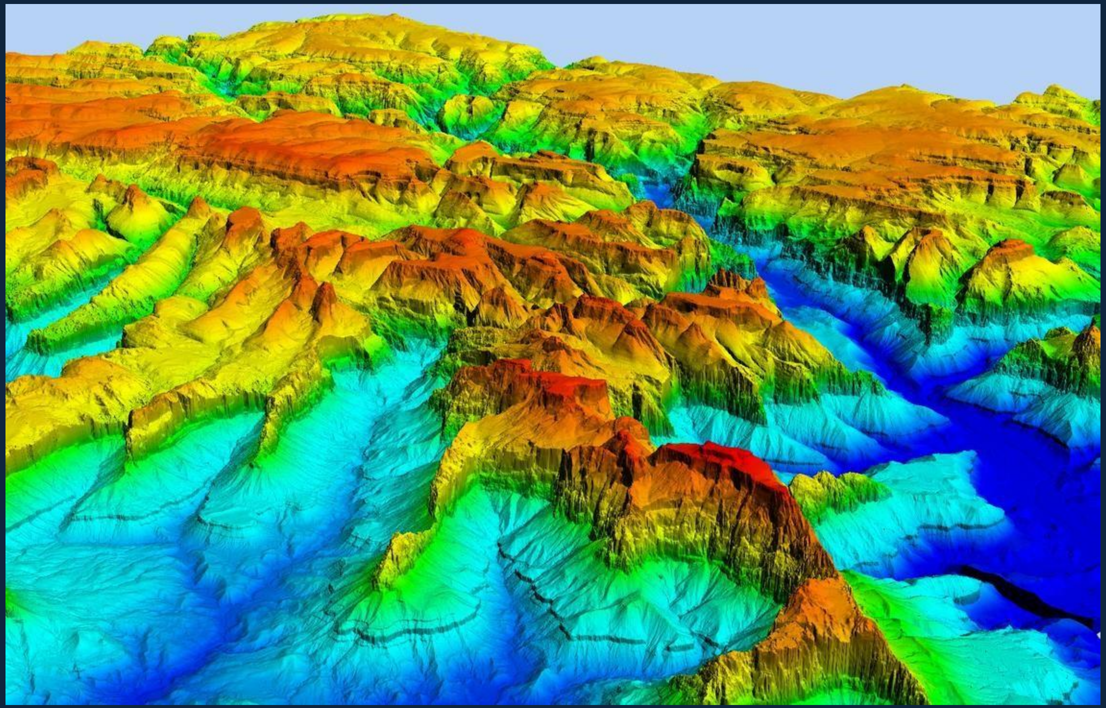
There are many other required aspects in the RPOC (RPAS Operators Certificate)

We do Deliver a separate course detailing how to build your documentation so as it meets Transport Canada requirements. Keep in mind the RPOC is a requirement to fly LLC1 BVLOS. It is not optional !

A concept of operations is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system. Examples include business requirements specification or stakeholder requirements specification. CONOPS is used to communicate the quantitative and qualitative system characteristics to all stakeholders. CONOPS are widely used in the military, governmental services and other fields. A CONOPS generally evolves from a concept and is a description of how a set of capabilities may be employed to achieve desired objectives or end state.



Expanding needs for using UAV (Uncrewed Aerial Vehicles) remote sensing approaches, such as terrain-following aerial mapping applications using LiDAR (light detection and ranging) in catastrophic applications. New extracts in UAV mapping still contain a limited number of studies for analyzing fine-scale mapping accuracy in UAV remote sensing methods—terrain-following aerial mapping for UAVs based on external airborne LiDAR integrated with the flight controller. We introduce the UAV system for the terrain after mapping the high-rise area by circumventing obstacles around it, expanding it so that UAVs flying at low altitudes can collect high-quality ground information while protecting them from all kinds of obstacles up and down.



Pre-flight Fuel Planning

Fuel planning begins well before the aircraft leaves the ground. Pilots must calculate the fuel requirements by factoring in various conditions, including the flight distance, weather, and potential air traffic delays. Tools such as performance charts or advanced flight planning software like ForeFlight or Garmin Pilot are invaluable for calculating accurate fuel estimates. These tools account for aircraft performance, weight, weather conditions, and Notices to Airmen (NOTAMs) that may affect your flight.

Monitoring Fuel During Flight

In-flight fuel management is equally important. Once airborne, pilots need to regularly monitor actual fuel consumption against the planned figures. Weather changes, air traffic control instructions, or even minor deviations from the original flight plan can alter fuel consumption. For instance, unexpected headwinds may cause higher fuel burn, requiring pilots to adjust their fuel estimates mid-flight.

Contingency Planning

Even with the most meticulous pilot fuel planning, unexpected events such as air traffic delays, weather changes, or mechanical issues may arise, impacting fuel consumption.

Post-Flight Assessment

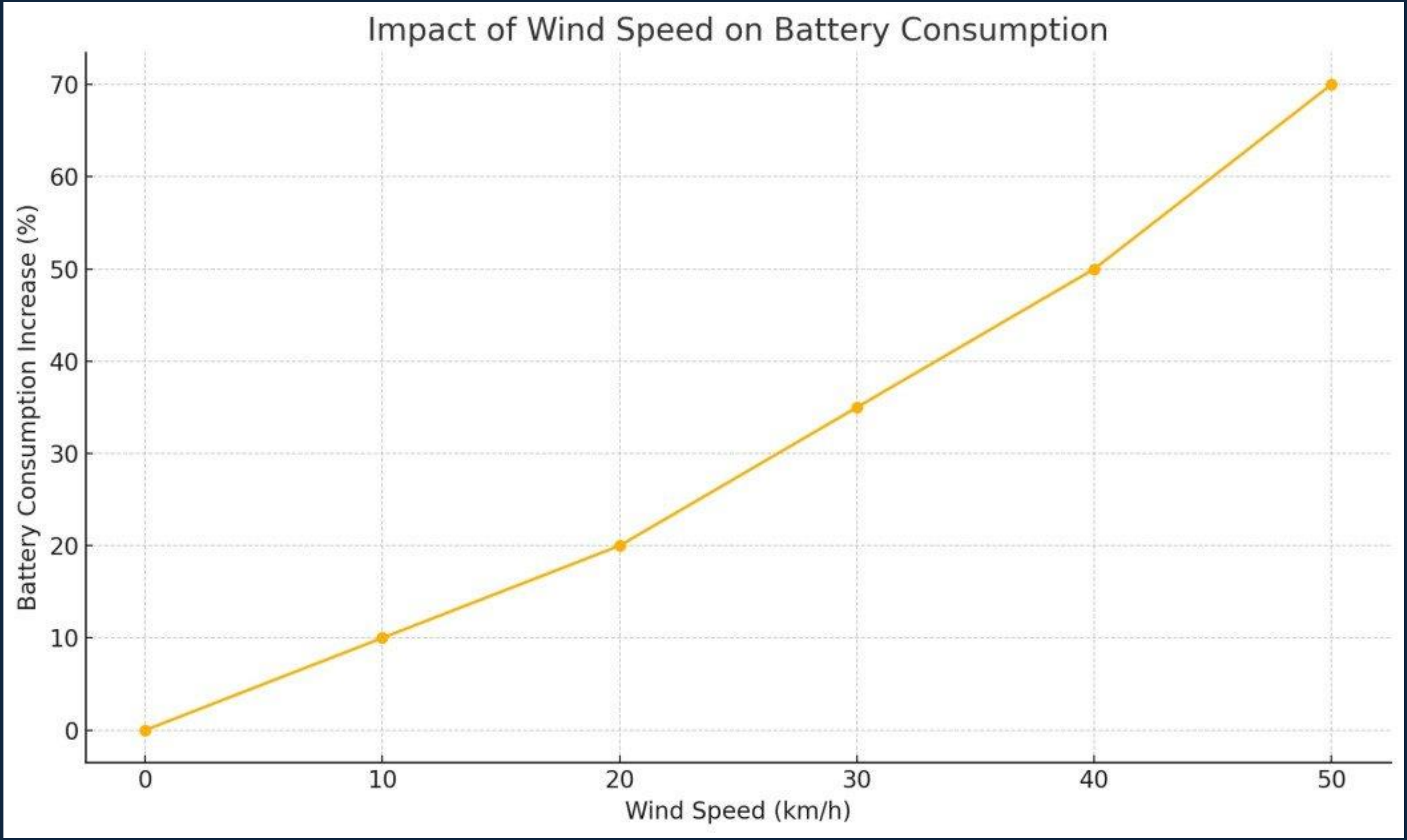
After landing, it's a good idea to review how the actual fuel usage compared with your pre-flight estimates. This post-flight assessment helps pilots refine their pilot fuel planning for future flights. Understanding any discrepancies between planned and actual fuel consumption—whether caused by unexpected weather, equipment issues, or air traffic delays—can improve future accuracy.


WIND
REDUCED DR

Performance charts/data

When flying a UAV in high winds, understanding wind resistance is crucial to maintaining control and stability. A drone's ability to withstand strong gusts depends largely on its design, weight, and motor power. Lightweight drones, for instance, are more susceptible to being blown off course, while heavier, more robust models often handle turbulence better but may experience greater battery drain.

Wind resistance is often measured as a threshold, indicating the maximum wind speed a drone can endure before performance deteriorates. Pilots should familiarize themselves with their drone's specifications, including its wind resistance rating, to determine safe operating conditions. Additionally, aerodynamic designs with streamlined frames can minimize drag and improve performance during flight in high winds.



Impact of Wind Speed on Battery Consumption
Battery Consumption Increase (%)
Wind Speed (km/h)
0
10
20
30
40
50
60
70

Weight and balance

When choosing a payload, consider how the center of gravity may shift and how that could affect your ability to control the aircraft in flight.

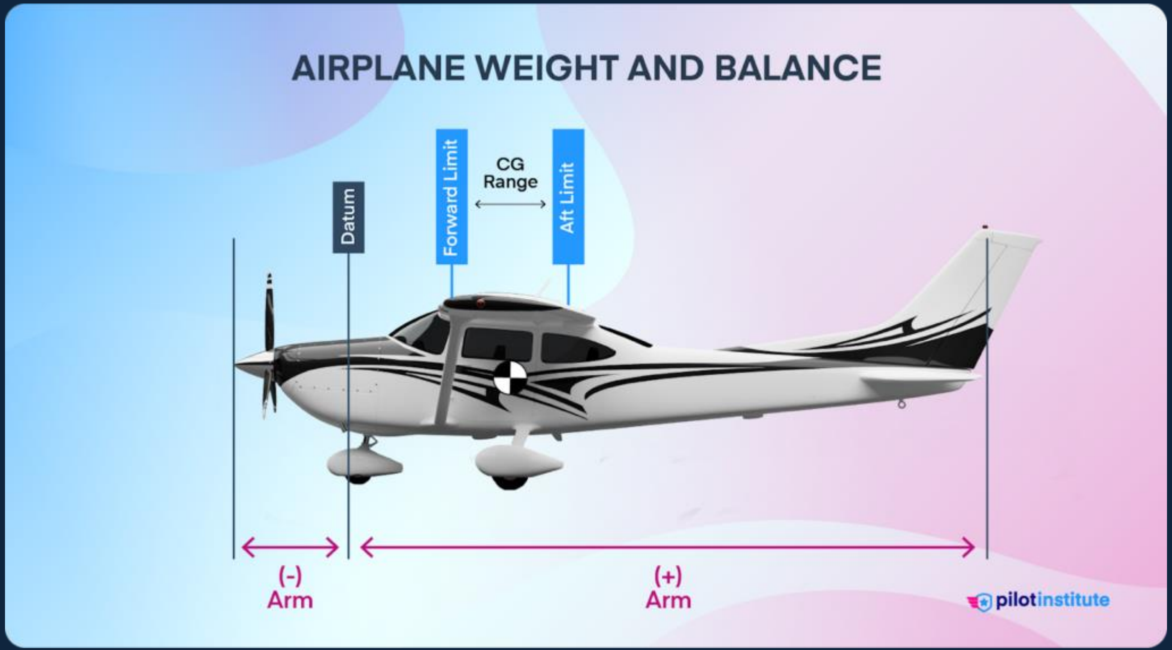
Higher weights require the drone to produce more lift. Increased lift is accomplished by spinning the propellers faster, which draws more power from the fuel source.

https://www.flyeye.io/drone-calculators-directory/

Arm as a measurement

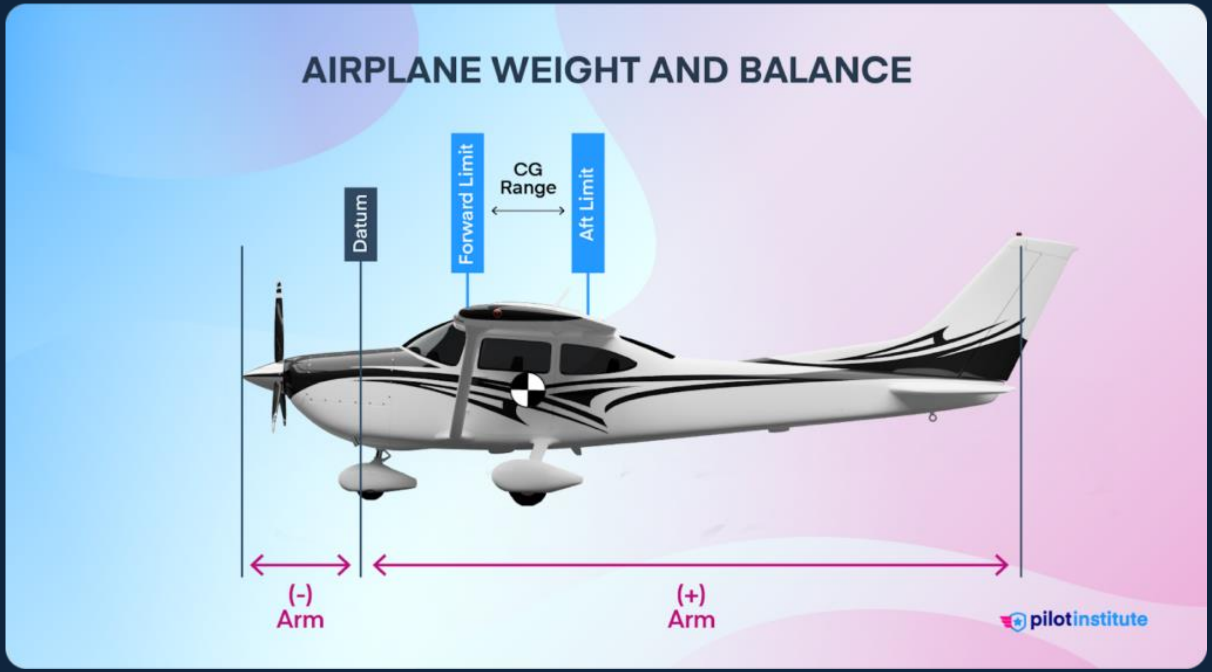
•**Definition**: The horizontal distance from the reference datum to the center of gravity of an item.
•**Purpose**: It is a critical component in calculating an aircraft's weight and balance, which is essential for flight safety.
•**Measurement**: It is typically measured in inches.
•**Signs**:

- **Positive arm**: A positive distance when the item is located *aft* (behind) the datum.
- **Negative arm**: A negative distance when the item is located *forward* (in front) of the datum.

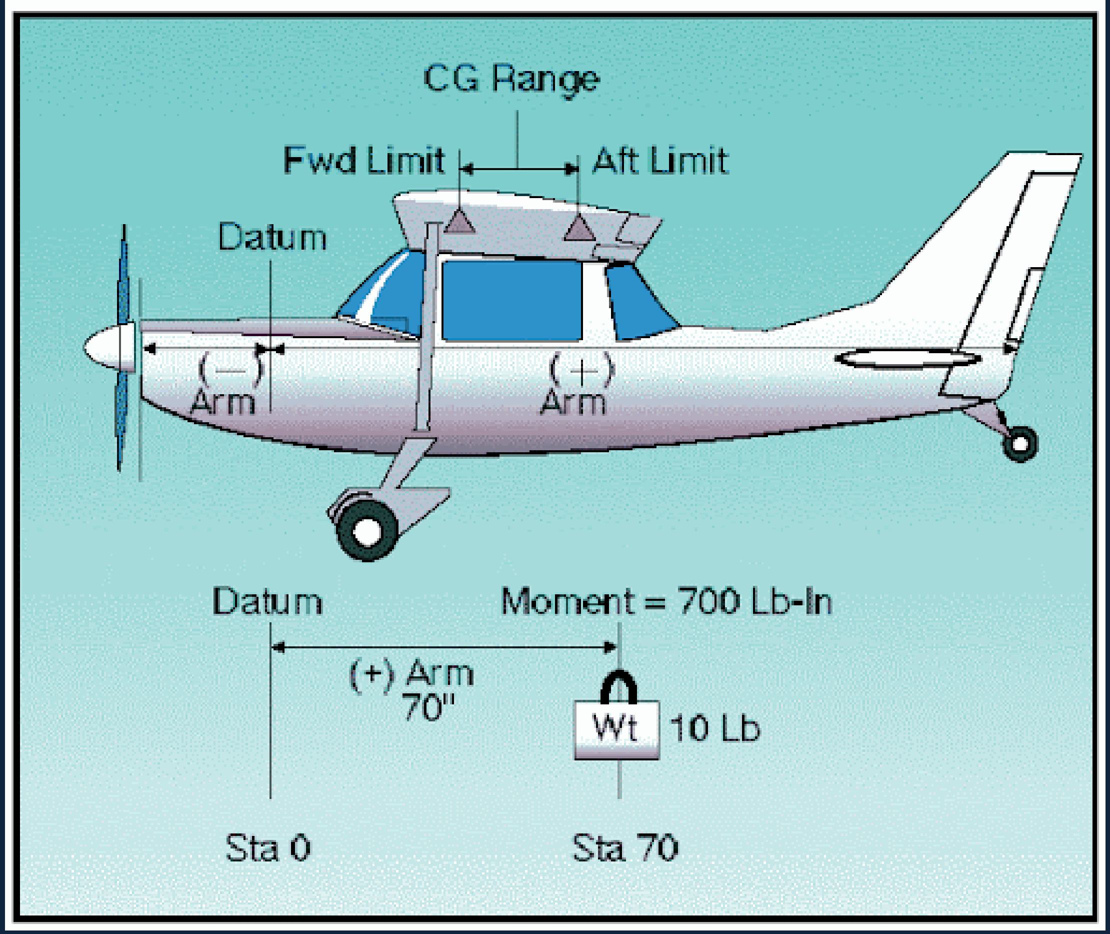


In aviation, an "arm" is the horizontal distance in inches from a reference point called the datum to the center of gravity of an item on an aircraft, used for weight and balance calculations. For example, a passenger's seat has a specific arm distance from the datum. Arm can also be used as a verb, meaning to place a device in an active mode, such as an autopilot function.

In aviation, a datum is a **reference point**, such as a vertical plane, line, or point, used to measure and calculate an aircraft's weight and balance. This reference, established by the manufacturer, allows for consistent calculations of moment arms and the location of the center of gravity (CG) by providing a consistent starting point for all measurements. The datum is typically located well forward of the aircraft to simplify calculations, often at a specific distance ahead of the nose.



In aviation, "moment" refers to
a force that tries to cause rotation, calculated by multiplying an object's weight by its "arm" (the distance from a reference point called the datum). This calculation is crucial for weight and balance procedures, which ensure an aircraft is loaded safely within its limits by using the total moment and total weight to find the aircraft's center of gravity (CG).



Safety:
Ignoring an RPA's weight limit warning can lead to several dangerous consequences, including a crash or loss of control. Overweighting the aircraft can significantly reduce its performance, stability, and maneuverability, potentially making it difficult or impossible to control in flight.

Weight and Balance Example:

Imagine an RPAS with an empty weight of 5 kg and a moment of 0.5 kg-m. Now, you add a 1 kg payload with an arm of 0.2 m (moment = 1 kg * 0.2 m = 0.2 kg-m).

Total Weight: 5 kg + 1 kg = 6 kg
Total Moment: 0.5 kg-m + 0.2 kg-m = 0.7 kg-m CG: 0.7 kg-m / 6 kg = 0.117 m (approximately)

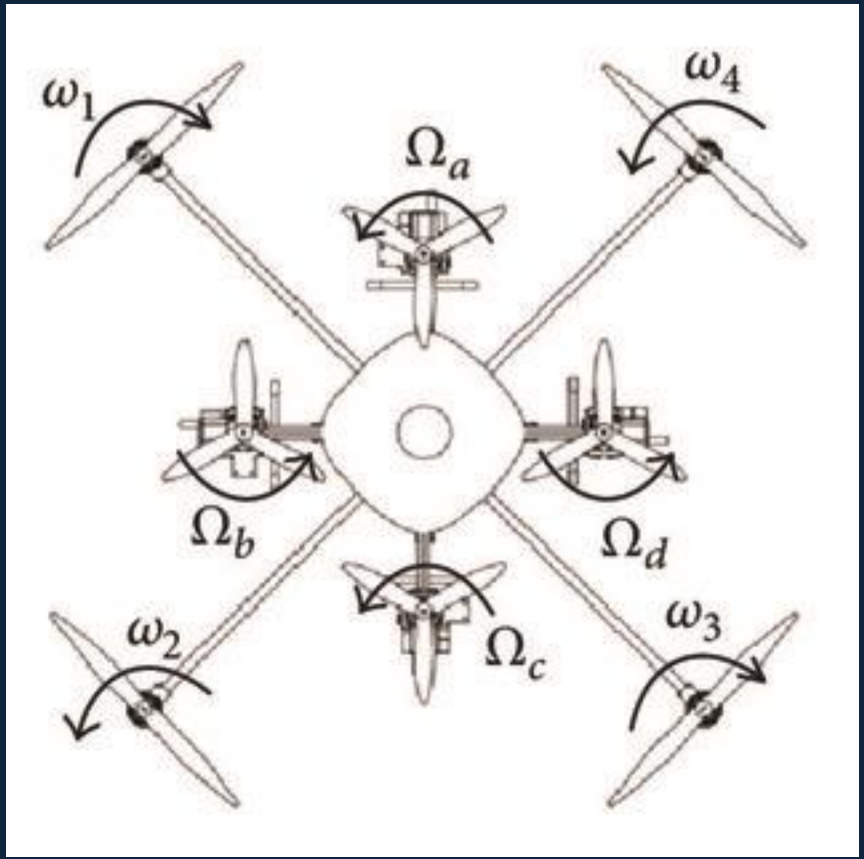
You would then compare this CoG position to the allowable limits in the RPAS's flight manual to ensure it's within safe operating parameters.

Note: The specific calculation methods and CoG limits will vary depending on the RPAS type and manufacturer's guidelines

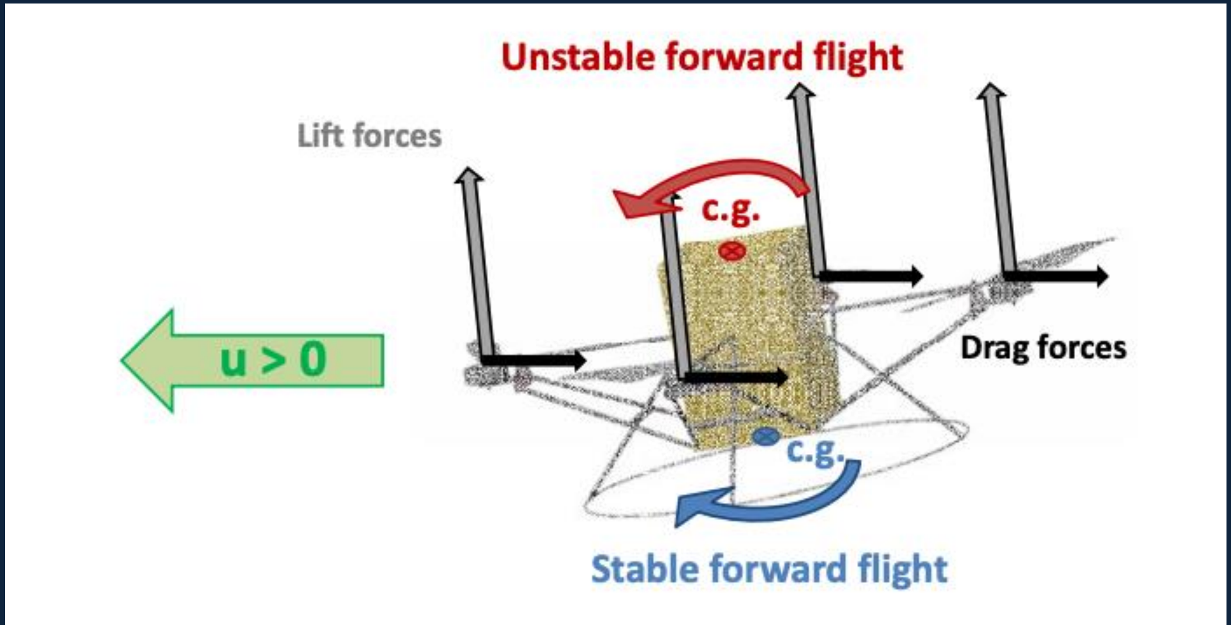
Circular envelope" multirotor, vertical lift concept and tolerable deviation from center of gravity.

In the context of multirotor drones, "circular envelope" refers to a constraint or limit on the drone's flight path, typically within a circular area. This concept is used in various applications, including flight envelope protection, navigation, and terrain mapping.

The vertical lift concept generally refers to any mechanism or vehicle that can lift objects or people vertically, often without the need for horizontal movement



The tolerable deviation from the center of gravity for a drone is a specific range determined by the drone's manufacturer and is crucial for maintaining flight stability and performance. A deviation outside this range can lead to issues with controllability and even potential flight failure.



- **Acceptable Limits:**

- Manufacturers define acceptable CG ranges for their drones, which are often specified in their manuals or documentation. These limits consider factors like payload, battery weight, and other operational conditions.

Aircraft critical surface contamination

Contaminants like water, ice, and snow can significantly impact RPA flight safety and performance by affecting critical surfaces, sensors, and overall aircraft stability. The RPA pilot must understand how these contaminants can affect the RPA and its components.

•**Water:**

•Rain, moisture, and condensation can affect sensor readings, especially in static ports and pitot tubes, leading to inaccurate data.

•**Ice:**

•Frost, ice, or snow accumulation on wings, control surfaces, and other critical surfaces can alter airflow, reduce lift, increase drag, and affect stability.

•**Snow:**

•Heavy snow can increase weight, create surface roughness, and potentially overload wing structures.

How Contaminants Affect RPA Components:

- **Wings:**
- Ice and snow accumulation on the wings can reduce their ability to generate lift, increase drag, and potentially cause structural damage.
- **Control Surfaces:**
- Contaminants on ailerons, elevators, and rudders can disrupt control inputs and make the RPA harder to maneuver.
- **Sensors:**
- Contamination of static ports, pitot tubes, and other sensor orifices can lead to inaccurate readings from instruments like airspeed indicators, altimeters, and attitude indicators.
- **Engines:**
- Ice and snow can enter engine intakes, causing damage or reducing performance.
- **Structural Integrity:**
- Accumulation of ice and snow can increase weight and stress on aircraft components, potentially leading to structural failure.

Overall Flight Impact:

- **Reduced Lift:**
- Ice and snow on wings and control surfaces can significantly reduce the amount of lift generated.
- **Increased Drag:**
- Contaminants create a rougher surface, leading to increased drag and fuel consumption.
- **Altered Flight Characteristics:**
- Contamination can change the aircraft's stall speed, pitching moments, and overall handling characteristics.
- **Reduced Visibility:**
- Ice and snow can obscure views through windows and reduce visibility.
- **Increased Risk of Failure:**
- Structural damage or component failure due to contamination can lead to a catastrophic flight event.

To effectively convert and compare altitude reports (ATC, pilot, and RPA), it's essential to understand the different reference frames and their respective units. ATC and pilot reports are typically provided in Altitude Above Mean Sea Level (AMSL), while RPA reports often use Altitude Above Ground Level (AGL).The maximum altitude for RPA in Canada is 400 feet AGL.

- **Comparing Altitudes:**
- When comparing ATC reports with RPA reports, it's crucial to be aware of the reference frame (AMSL or AGL). If comparing AMSL and AGL, you'll need to subtract the ground elevation to get the AGL equivalent of the ATC altitude.

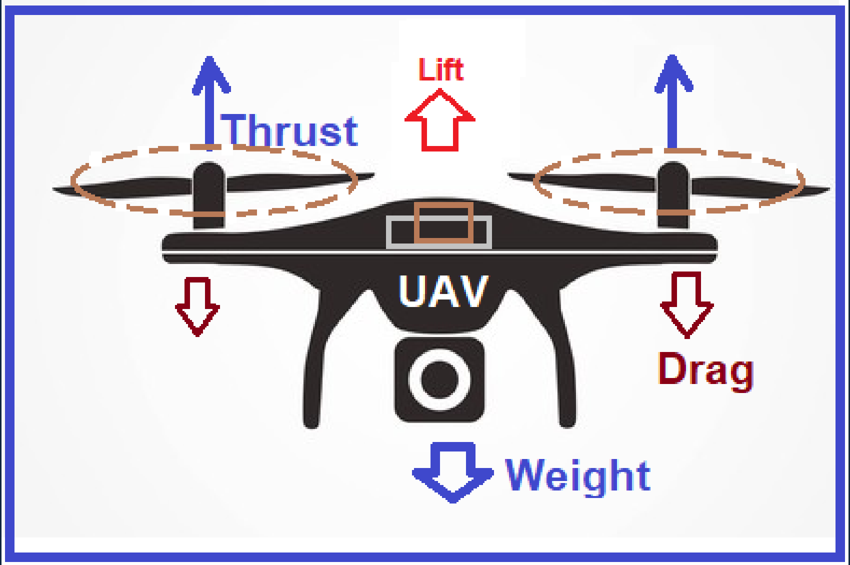
Example:

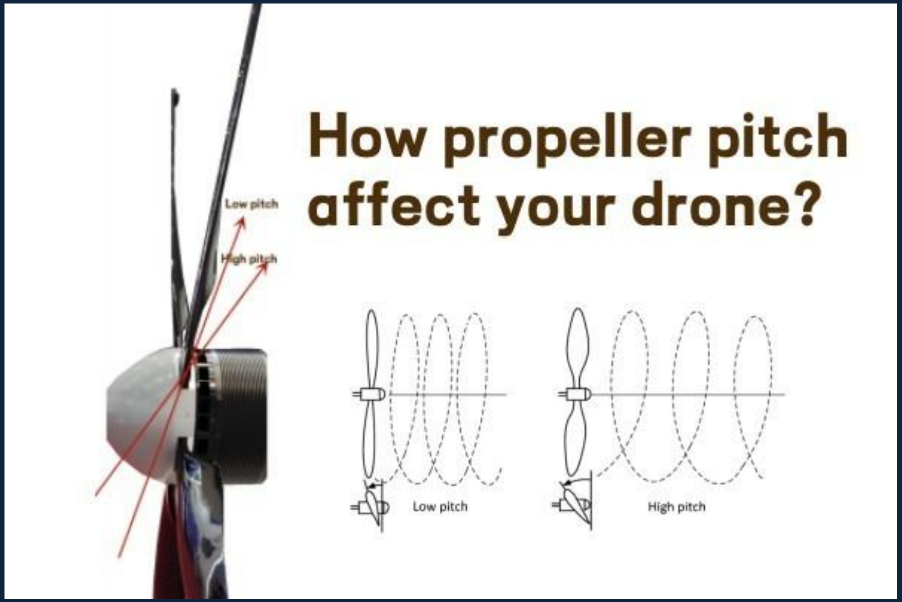
- **ATC Report:** "Aircraft is at 3,000 feet AMSL".
- **RPA Altitude:** "RPA is at 2,000 feet AGL".
- **Ground Elevation:** The ground elevation at the RPA's location is 1,000 feet.
- **Comparison:**
    - The aircraft is higher than the RPA (3,000 feet AMSL > 2,000 feet AGL).
    - The aircraft's AGL equivalent is 3,000 - 1,000 = 2,000 feet, which is the same as the RPA's altitude.

Theory of Flight

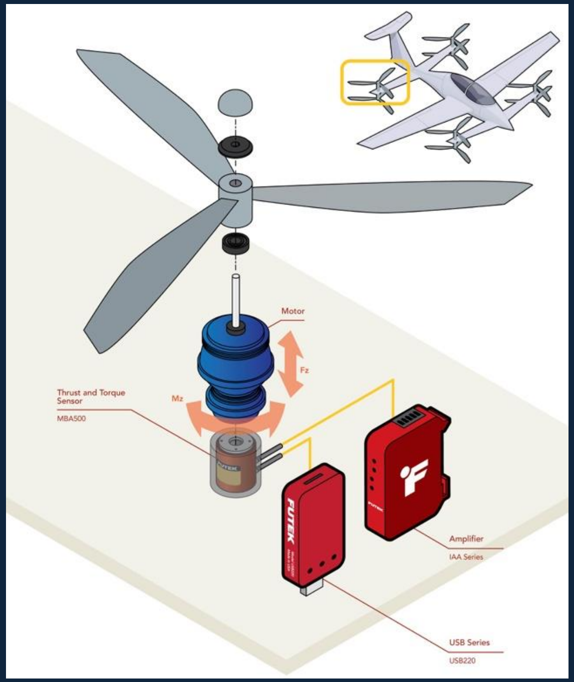
Lift in drones is produced through various mechanisms, depending on the drone type. Fixed-wing drones generate lift through aerodynamic principles, similar to airplanes, while multi-rotor drones utilize propellers to push air downwards, creating an upward thrust. Hybrid drones combine these methods, offering the advantages of both fixed-wing and rotor-based designs.

Propeller pitch significantly impacts a drone's power usage and performance. Higher pitch propellers, which move more air with each rotation, create more thrust and are better suited for speed and agility, but they also require more power and are less efficient. Lower pitch propellers, which generate less thrust, are more efficient and suitable for longer flights and smooth, controlled maneuver





A propeller on a drone creates thrust by pushing air downwards, generating an upward reaction force according to Newton's third law. The propeller blades are shaped like airfoils and rotate, accelerating the airflow around them. This acceleration creates a pressure differential, with higher pressure on the bottom side of the blade and lower pressure on the top, resulting in an upward force.



Staying within the manufacturer's center of gravity (CG) limits is crucial for drone stability because it directly impacts the aircraft's handling and flight characteristics. A properly positioned CG ensures the drone can maintain stable flight, respond to pilot inputs, and recover from maneuvers, making it safer and easier to fly.

•**Stability:**

•The CG is the point at which the drone's weight is concentrated. A CG that is too far forward or aft can make the drone unstable in pitch (nose-up/down) or roll (left/right).

•**Control:**

•An out-of-range CG can make the drone difficult to control, especially during maneuvers or turbulence.

•**Performance:**

•Incorrect CG positioning can also affect the drone's performance, such as its ability to climb, maintain altitude, and handle gusts of wind.

•**Safety:**

•An unstable drone can be difficult to control, increasing the risk of accidents or crashes.

•**Manufacturer Limits:**

•The manufacturer's CG limits are determined through rigorous testing and are designed to ensure the drone's optimal performance and safety.

Radiotelephony

- **Drone Pilot Certificate:**
- You'll need a drone pilot certificate, which you can obtain by passing an online exam and potentially completing ground school through a flight school.

- **Restricted Operator Certificate - Aeronautical (ROC-A):**
- This certificate is specifically for operating radios in the aeronautical frequency range, which is used by aircraft and drones.
- **Age Requirement:**
- You must be at least 14 years old to obtain a drone pilot certificate for basic operations.

- **Carry the Certificate:**
- You must carry your drone pilot certificate with you when flying.

- **ROC-A Requirements:**
- To obtain an ROC-A, you'll need to pass an exam administered by an accredited examiner. You can find examiners and information on the exam on the Innovation, Science and Economic Development Canada website.

In uncontrolled airspace, pilots are responsible for maintaining situational awareness and communicating their intentions to other aircraft via radio. This is typically done through a system of self-announcing, where pilots regularly broadcast their position, altitude, and intentions. Key radio procedures include listening before transmitting to avoid interference, using clear and concise language, and reporting position changes.

Communication equipment for the planned operation.

Ground crewmember radios and communications

Several factors and conditions can affect different communication forms. For radio and cellphone communication, environmental factors like terrain, buildings, and weather play a significant role. Text-based communication, on the other hand, can be affected by the absence of visual and auditory cues, leading to misunderstandings. Visual signals are impacted by visibility, distance, and the presence of obstacles.

- **Environmental Factors:**
- **Terrain and Topography:** The lay of the land can influence radio wave propagation.
- **Buildings and Obstacles:** Structures can block or reflect radio waves, creating areas of weaker signal.
- **Weather:** Rain, snow, and other weather conditions can affect signal strength and range.

- **Technical Factors:**
- **Transmitting Power:** Higher power outputs can increase signal strength.
- **Antenna Quality and Height:** The antenna is crucial for transmitting and receiving signals.
- **Frequency and Wavelength:** Lower frequencies typically have longer wavelengths and can travel farther.
- **Interference:** Other devices and signals can interfere with radio and cellphone communication.
- **Digital vs. Analog:** Different transmission technologies have varying strengths and weaknesses.

- **Network Coverage:**
- Adequate network coverage is essential for reliable cellphone communication.

Text Communication:
- **Lack of Non-Verbal Cues:** The absence of visual and auditory cues in text messages can lead to misinterpretations.
- **Misunderstandings:** It can be easy to mistake sarcasm or humor for rudeness in text.

The Low-Level Complexity 1 (BVLOS) is all about RISK MANAGEMENT. As you have seen through this course a variety of conditions can arise that could cause you to lose your RPA or worse cause an accident Even in low population density's. Assumption is always the enemy of safety ! Smart RPAS pilots are the ones to pay attention to every detail of the intended mission and have put in place proper risk mitigation processes to ensure a safe flight.

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