UAV Systems in Industry

Pilot Handbook

Applied Topics in Geography: UAV Ground School

Instructor: Matthew Johnson

Student Name: _____

Contact Information

M3 Aerial Productions Inc.

Phone:
(204)800-0220
1-866-814-4855

Email:
m3aerial@gmail.com

@M3Aerial

Instructor Bio:

Matthew Johnson, B.PE., B.A., B.Ed

Matthew Johnson has lived in Winnipeg, Manitoba for most of his life. He attended the University of Manitoba where he obtained a Bachelors of Physical Education, Bachelors of Arts in Geography, and a Bachelors of Education. He joined the Canadian Armed Forces Primary Reserves in 2008 as a Health Care Administration Officer in the 17 Field Ambulance. He currently holds the rank of Captain.

Matthew became a high school teacher in 2012, first working in St. Claude, Manitoba, where he taught mathematics, science, physical education and agriculture. In 2015, Matthew founded M3 Aerial Productions.

Originally, M3 Aerial primarily provided aerial photography for media productions. In 2016, the company branched into precision agriculture, operating both fixed-wing and multi-rotor UAVs to gather crop health and elevation data for producers. The company launched its UAV Pilot Ground School Course in November 2016, and offers training courses across Canada. Matthew introduced the Elmwood High School Drone Club in the fall of 2016, where he teaught students everything contained in this course, and more!

Matthew is married, and has two amazing children, Olivia and Magnus who inspire and motivate him daily.

Table of Contents

Course Outline

This in-class portion of the course is an intensive learning experience which guides students through the steps required to become successful, compliant, safe and efficient commercial UAV pilots. The course will be conducted as per the following schedule (all times are in Central Time):

Topic of Instruction
Course Introduction / House-keeping
Introduction to UAV Systems
UAV Operation Basics
Operational Safety Considerations
Rules & Regulations Overview
Introduction to NAV CANADA
Introduction to Meteorology
Introduction to the SFOC
Introduction to Insurance
Equipment and Processing
Introduction to Radio Procedure
Interpreting Aeronautical Charts / CFS
Maintenance and Record Keeping
Introduction to Mission Planning
Mission Planning Rehearsal
Scenario Analysis
Closing

Upon successful completion of the online final exam, **to a minimum standard of 60%,** course candidates will receive a certificate of completion issued by M3 Aerial Productions, confirming their achievement.

The certificate of completion document can be cited in the candidate's SFOC application, and insurance forms to fulfil the knowledge requirements set by Transport Canada.

Lets Begin!

Introduction to Unmanned Air Vehicles

Official UAV Terminology

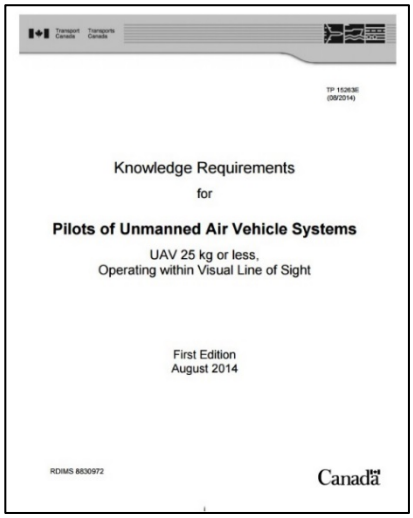
In Canada, the legally accepted name by Transport Canada is:

"Unmanned Air Vehicle" (UAV)

Common alternative names for "drones" include:

- Unmanned Aerial System (UAS)
- Unmanned Aerial Vehicle (also UAV)
- Remotely Piloted Aircraft (RPA) or Vehicle (RPV)

These names are often used interchangeably.



Knowledge Requirements
for
Pilots of Unmanned Air Vehicle Systems
UAV 25 kg or less,
Operating within Visual Line of Sight

First Edition
August 2014

Canada

UAV Applications

- Agriculture
- Construction
- Mining
- Infrastructure Inspections
  - Building
  - Pipeline
  - Hydro line
  - Bridge
  - Roads
- Cinematography
- Surveying
- Forestry
- Conservation
- Policing
- Firefighting
- Search and Rescue
- Education
- Military

Advantages of UAVs

- Speed: On-demand service; Quickly deployed; relatively low operation durations
- Efficiency: Gather multiple data outputs simultaneously
- Low cost: Require less maintenance than alternative methods (aircraft, ground vehicles); rechargeable batteries
- Safety: Can enter environments that are dangerous to human life
- Precision: Capable of gathering extremely high resolution imagery and accurate data
- Quality: Ultra-high resolution
- Versatile: Some types are multifunctional, and adaptable to numerous situations

The Growing UAV Industry

Various agencies have completed market assessments, predicting the growth of the UAV industry in general as anywhere from $5.6B to $127B within the next 5 years. Due to widespread interest in personal UAVs and commercial opportunities, the industry has exploded in the last couple of years.

Hand-launchable fixed-wing UAVs are becoming more common as the auto-pilot technology progresses

The rate of growth has been exceedingly high, and as such, new market predictions and forecasts are frequently presented. It is expected that the UAV industry will continue to grow at an exponential rate for several years.

Because of this, governments across the globe are slow with the enactment of laws and regulations. The UAV industry is still considered to be in its early stages.

Working Types of UAVs

This section could end up taking up quite a bit of space. We could have included ultra-light (micro) and heavy-duty caliber UAVs, but we've slimmed down to common commercial, and consumer-grade categories.

1) Fixed wing UAV
2) Multi-rotor UAV
3) Hybrid Rotor-wing UAV (VTOL: Vertical Takeoff and Landing)

Sentera Phoenix

FireFLY6 PRO (VTOL)

DJI Inspire 1

Types of UAVs: Pros vs. Cons

Body Type	Advantages	Disadvantages	Typical Uses	Price ($ CAD)
Multi-Rotor: **DJI Phantom series** **Sentera Omni**	• Versatility • Quick setup time • VTOL and hover flight • Good camera control • Can operate in a confined area • Great maneuverability for inspections	• Shorter flight times • Poor payload-to-flight time ratio • More motors → single motor-failure can cause a crash • Less able to fight wind	• Aerial Photography and Video • Aerial Inspection	**$800-15000**

Fixed-Wing:
 	
Sentera Phoenix 2
 	
eBee SQ, Plus
 	
AgEagle Rx60, Rx48
	• Long battery endurance
	• Simple design
	• Hand launchable
	• Light weight
	• Natural gliding ability without power
	• Energy efficient design
	• Can cover greater area
	  o Faster flight speeds
	  o Can fly at a higher altitude, therefore wider sight lines
	• Less moving parts
	• Less affected by wind
	• Can be used with gas engines
	  o Much longer flight times
		• Size can make it difficult to transport
		• Cannot hover in one spot
		• Launching and landing is more complicated
		• Higher cost
		• Difficult to fly manually
		• "Crash land" on most or all flights (belly landing)
			• Large-scale aerial mapping,
			• Pipeline and Power line inspection
				$5000-50000+

Hybrid (VTOL) **FireFLY6 PRO**	• VTOL • Accessibility • Long endurance flight • "The best of both worlds"	• Wind tolerance in hover mode during hover stage	• Drone delivery (Amazon.com) • Large-scale mapping	**$8000+**

Types of Sensors

- RGB: Red/Green/Blue – standard colour camera
- Near-infrared: plant growth
- Multispectral / Hyperspectral
- LiDAR (Light Detection And Ranging)
- Infrared Thermal
  - o Agriculture
  - o Firefighting / SAR
  - o Mining
  - o Construction / Inspections

MicaSense Sequoia Multispectral

Sentera Dual-Sensor NIR / RGB

Most commercial UAV come with standard RGB cameras, ranging from 8-20 MP

Confirm Your Knowledge

1. **Five advantages of using fixed-wing UAVs:**

   ⇒

   ⇒

   ⇒

   ⇒

   ⇒

2. **Four applications of UAVs in industry:**

   ⇒

   ⇒

   ⇒

   ⇒

3. **Three body types of UAVs:**

   ⇒

   ⇒

   ⇒

4. **Two types of sensors that capture NIR light:**

   ⇒

   ⇒

5. **One major disadvantage to using multi-rotor UAVs:**

   ⇒

Discussion:

Where do you see the UAV industry heading in the next 2-5 years?

Final Thought!

"There's a way to do it better. Find it!" – Thomas Edison

UAV Operation Basics

Understanding the basics, and practicing manoeuvers will allow you to develop the confidence required to operate a UAV safely.

Components of an Unmanned Aircraft

Small civilian and commercial use UAVs have no “life-critical systems,” and can thus be built out of lighter materials.

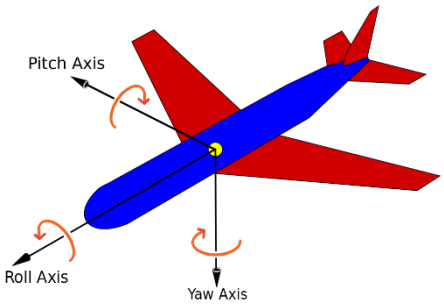
A UAV typically consists of the following components:

- *Body*
  - Usually plastic, foam, aluminum, or carbon fiber/composite
  - Includes wings, flaps, arms/legs, tail, etc.
- *Power supply*
  - Small UAVs typically use lithium-polymer batteries (Li-Po), while larger vehicles rely on conventional combustion engines.
  - Hydrogen fuel cell technology is advancing quickly and will soon be used to power small UAVs for exponentially longer time frames than what is currently available.
- *Computer | Flight controller*
  - The onboard system hardware for small UAVs is often called the Flight Controller (FC), Flight Controller Board (FCB), or Autopilot.
- *IMU: Inertial Measurement Unit*
  - Detects the current rate of acceleration (using accelerometers), and detects changes in rotational attributes like pitch, roll, and yaw (using gyroscopes).
  - Works in conjunction with the GPS unit
- *GPS / GLONASS*
  - Global Positioning System / Global Navigation Satellite System (*Russian*)
  - Provides geolocation and time information to a receiver onboard the aircraft which can be used to “geo-tag” images with their specific spatial data.
- *Actuators | ESC | Servos*
  - Responsible for moving / controlling the rotary systems.
  - Electronic Speed Controller vary an electric motor’s speed, direction, and brakes.
  - Servomotors allow precision control of parts that require positional feedback, such as the flaps and aelevons on a fixed-wing UAV.
- *Pitot Tube*
  - An air-speed calculation tool that connects to the IMU to provide feedback.

Understanding "Attitude"

Attitude is the orientation of the aircraft relative to the horizon of the Earth. The parameters of measurement are the amount of angular rotation (Euler angles) around the 3-axes of the aircraft:

- *Roll*: acting about the longitudinal axis, positive with the starboard (right) wing down
- *Pitch*: acting about an axis perpendicular to the longitudinal plane of symmetry, positive with the nose up
- *Yaw*: acting about the vertical body axis, positive with the nose to starboard



Modes of Operation

UAVs can typically have three modes of operation:

- Manual (GPS Assisted)
- Manual (Attitude)
- Autonomous

Manual (GPS Assisted mode)

- GPS can maintain position in a hover (multi-rotor), OR, can maintain a circular loiter pattern (fixed-wing)
- If pilot loses physical control of the ground-station, the UAV will remain where it was when the controls were released.

Manual (Attitude mode)

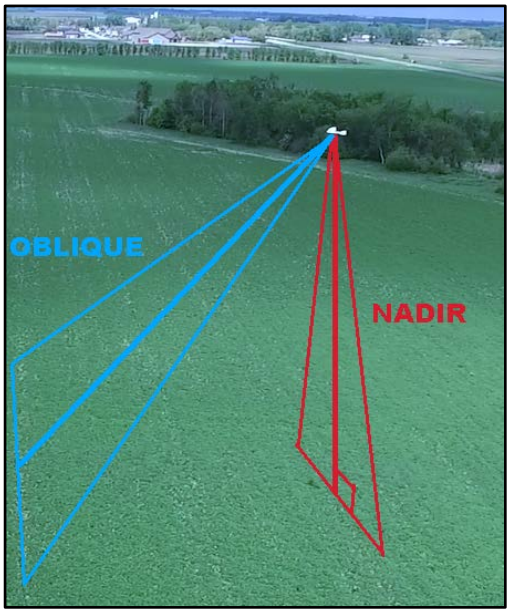
- No GPS assist means that the UAV will drift with the wind. Very small air currents can cause the drone to drift off its position.
- Great for smooth photography

Autonomous

- Pre-programmed flights allow the UAV to complete operations without the pilot-in-command (PIC) being involved.
- Reliant on GPS and IMU to maintain its course in windy situations.
- UAVs are often capable of safely landing autonomously, however it is a good idea to take over/assist control at that point.
- Some systems allow Autonomous-assisted, where the PIC can slightly adjust course while remaining in Autonomous mode.

Image Orientation

- *NADIR*: Images that are taken straight down from a vertical perspective.
  - Best used for 2D mapping (creating geo-rectified orthomosaics)
  - Least amount of image distortion
  - Shortest path to the ground = highest resolution
  - Highest amount of image overlap
- *Oblique*: Images that are taken at an angle of depression between 40-70º
  - Some sensors use this (SlantRange)
  - Higher quality 3D rendering (captures the sides of objects/buildings)
  - More precise metrics (volume and spatial calculations) when included with NADIR images for orthomosaics

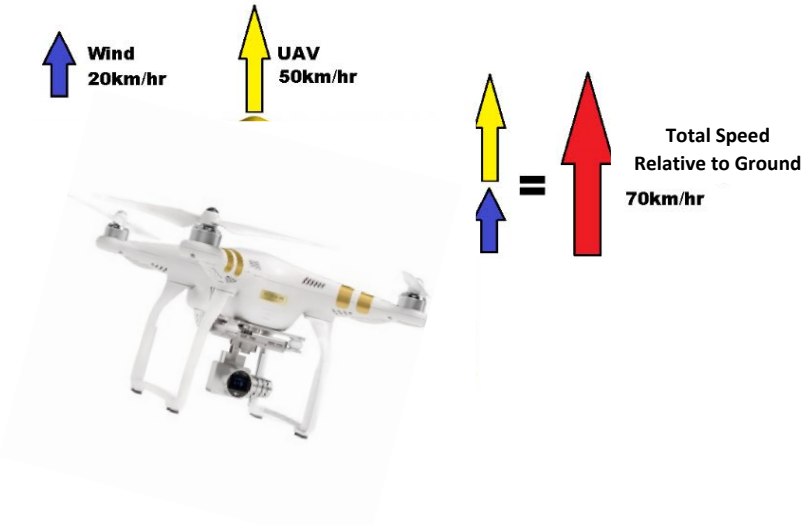


Understanding Vectors

A basic concept in physics, vectors describe a movement that consists of both direction and magnitude.

A UAV operating in *Attitude Mode* will be subject to vector math.

If a UAV can fly at a max speed of 50km/hr and the wind is blowing 20km/hr from the stern, the vectors will add together and the UAV could reach speeds up to 70km/hr. This could result in a highly dangerous situation!



GPS Assisted Mode is good at adjusting for vectors to prevent drift, but at full throttle with a tailwind, the UAV will likely exceed its maximum tested (and approved) speeds. This would violate the terms of the SFOC, and also would nullify insurance coverage in case of an accident.

Confirm Your Knowledge

6. **Five components of a UAV:**

   ⇒

   ⇒

   ⇒

   ⇒

   ⇒

7. **Four benefits of NADIR imagery:**

   ⇒

   ⇒

   ⇒

   ⇒

8. **Three mechanisms of angular motion comprising Attitude:**

   ⇒

   ⇒

   ⇒

9. **Two types of image orientation:**

   ⇒

   ⇒

10. **One function of the IMU:**

   ⇒

Discussion:

Why is it important for a pilot-in-command to understand the characteristics, functions and components of a UAV?

Final Thought!

"Risk comes from not knowing what you're doing" – Warren Buffet

Operational Safety Considerations

UAVs are susceptible to a myriad of failures due to various complications with the system. The following tables describe various types of complications, their characteristics, and actions that can be taken to avoid problems.

Weather Related Equipment Complications

Type	Reason	Description	Solution
Weather Related	Heat	• May cause video brown-out (missing video) • May cause overloaded IMU • May cause battery failure • May cause operator fatigue (heat stress, sun stroke) • Often max operating temp is 40-45ºC	• Store UAV and batteries in relatively cool (18-22ºC) place until flight • Heat is the enemy of LiPo batteries (never charge a recently used, warm battery) • Monitor temperature in flight apps (if able) • Limit use to shorter periods than normal • Stay hydrated, wear sunscreen, stay in shade (if possible *NOT **too** close to trees or structures)
	Cold	• Cold slows down chemical reactions inside batteries, resulting in shorter duration and unpredictable loss in power. • Low battery output in telemetry device • LCD displays can freeze • Deterioration in operator finger dexterity/reaction time.	• Store UAV and batteries in relatively warm (18-22ºC) place until just before flight • Limit use to shorter periods than normal to prevent battery from getting cold • Use a battery-warmer device, and/or insulators • Warm up controller and telemetry device between flights inside vehicle or building • Wear gloves that maintain a good sense of proprioception (touch)
	Moisture	• Fog/mist may cause short circuit or damage motors • Decrease in visual clarity	• Never fly in any amount of precipitation • Take **extra precautions** (thorough site inspection, extra visual observers, decreased flight radius/altitude) • Delay/abort mission.
	Dust	• May damage motors • Builds up in tight spaces • Decreases joint movement • Decrease in visual clarity	• Keep pressurized air in equipment kit to clean motors and electronic components between flights • Wear eye protection (encasing safety glasses) if required • Decrease flight radius/altitude • Delay/abort mission
	Wind	• May cause fly-aways if too windy • Decrease in visual clarity • Thermals caused by changes in temperature (often over water) • Can affect battery usage by increasing workload	• Know the wind limits of operation set in your SFOC (they are likely far less than the limits of the UAV) • Wear eye protection if required • Do not operate at low altitude (<5 ft) near water

Mechanical Equipment Complications

Type	Reason	Description	Solution
Mechanical Failures	Accumulated Stress Failure (wear & tear)	• Small cracks can lead to catastrophic failure • Deterioration in motor efficiency	• Perform a thorough inspection after any hard landings, and at regular intervals throughout the operational season • Adhere to maintenance schedules set in operational manuals (at a **minimum**)
	Sudden Failure	• Collisions • Crash landings	• Avoid flying in areas with high bird activity • Avoid flying near structures, or near airports (and only with clearance from ATC (Air Traffic Control) and/or ACC (Area Control Centre) • **Practice** evasive actions/manoeuvers ahead of time, so that control is not lost in the "heat of the moment"

Electronic Equipment Complications

Type	Reason	Description	Solution
Electronics Failures	Short Circuits	• Moisture can lead to short circuits • LiPo batteries are relatively unstable • May be damaged if transported in checked luggage on an airplane • A battery that falls from a height of more than a few inches could be critically damaged internally	• Perform a thorough inspection after hard landings/ at regular intervals throughout the operational season • Adhere to maintenance schedules set in operational manuals (at a **minimum**) • Store batteries in fire-proof LiPo bags, or ammo can (if long term storage), not the case • Special protocol must be taken when transporting LiPo batteries on a plane • Wait for 20-30 minutes after dropping lithium batteries before transport, and do not use them again
	Electro-magnetic Interference (EMI)	• Geophysical EMI – changes in Earth surface composition may result in changes in EMI radiation • Structural EMI - High powered transmission lines/towers, and other high energy structures • Hardware EMI – sensors can emit EMI that can interfere with other UAV components (GPS, autopilot, etc.)	• Calibrate UAV after every location change (greater than ~200 ft) • Calibrate IMU a few times per season, and after periods of storage • Avoid operating near high-power transmission lines and other high energy structures • Avoid operating near railway tracks or bridges • Test new hardware thoroughly (low level flights) before any full-scale operations.
	Radio Signal Strength Interference (RSSI)	• Satellite dishes, radio towers, and other radio-controlled devices may cause RSS interference • Increased distance from ground station results loss in RSS.	• Avoid flying near radio towers, wind mills, and large satellite dishes • Test aircraft responsiveness at an increasing distance (from ground station) before full-scale operations

Human-Error Related Complications

Type	Reason	Description	Solution
Human Error	Battery Connection Loss	• Moisture, if not avoided properly, can lead to short circuit battery connections • Battery may not be correctly seated, resulting in disconnection and sudden loss of power	• Perform a thorough inspection after any hard landings, and at regular intervals throughout the operational season • Adhere to maintenance schedules set in operational manuals (at a **minimum**) • Store batteries in fire-proof LiPo bags, or ammo can (if long term storage), not the case
	Operator Negligence / Weariness	• Making poor decisions (operating in inclement weather, under the influence, fatigue, etc.) • Deterioration of dexterity / reaction time • Compromised situational awareness	• Every flight is the most important flight, so take every precaution, every time! • Remember: if you cause an accident, you will not be covered by insurance if you are found to have voided the conditions of your SFOC • Avoid distractions when operating as PIC

Environmental Complications

Type	Reason	Description	Solution
Physical Environment	Desert	• Excessive heat and dust • Sun blindness	• See Weather section for dust and heat • Wear polarized sun glasses
	Mountains / Hills	• Changing topography may cause disorientation	• Slow down flight in areas where the ground level altitude changes drastically • Ensure highest point of land
	Forest	• GPS doesn't penetrate canopy very well • Difficult to maintain visual contact with drone	• Only operate in areas with 50ft radius of obstruction-free space
	Sea	• Orthomosaics don't stitch well	• Avoid creating orthomosaics of water as the stitching just doesn't work properly
	Lakes	• Changes in thermal air masses between land and water • Sun glare off water	• Be mindful of potential thermals, and avoid flying near ground level when travelling towards bodies of water • Difficult to avoid sun glare on water, all depends on the time of day, and angle of the sun based on the subject.
	Sun	• Glare in lens • Temporarily blinding • Reflects off objects	• Use tinted lenses and polarized sun glasses to protect from UV light radiation. • Avoid operating while directly facing the sun – move to a better vantage point with a less direct view of the sun • Early-morning sun is great for photography

Confirm Your Knowledge

11. **Five types of UAV failures:**

    ⇒

    ⇒

    ⇒

    ⇒

    ⇒

12. **Four effects of cold weather on UAV operation:**

    ⇒

    ⇒

    ⇒

    ⇒

13. **Three sources of electromagnetic interference:**

    ⇒

    ⇒

    ⇒

14. **Two ways dust can negatively affect UAV operation:**

    ⇒

    ⇒

15. **One way to ensure safe battery management:**

    ⇒

Discussion:

Why is it important to be aware of the various causes and characteristics of UAV complications?

Final Thought!

"An ounce of prevention is worth a pound of regret" – Benjamin Franklin

Rules and Regulations Overview

In December 2016, Transport Canada released some updates to some of the regulations, specifically for the SFOC Exemption. They are constantly considering new/updated regulations, in fact, in February 22, 2018 there will be a plenary council meeting hosted by CARAC (Canadian Aviation Regulation Advisory Council) regarding upcoming UAV regulatory changes.

The ultimate goal of Transport Canada is to address the safety requirements, growing popularity and economic importance of UAVs, and to integrate them safely into Canadian airspace.

The Golden Rule

There are many subtle nuances between the limitations of recreational flight, commercial flight under exemption, and commercial flight under an SFOC (Special Flight Operation Certificate). One universal concept between them all is:

The Golden Rule

DO NOT put aircraft at risk, fly where you are not allowed to, or endanger anyone's safety!

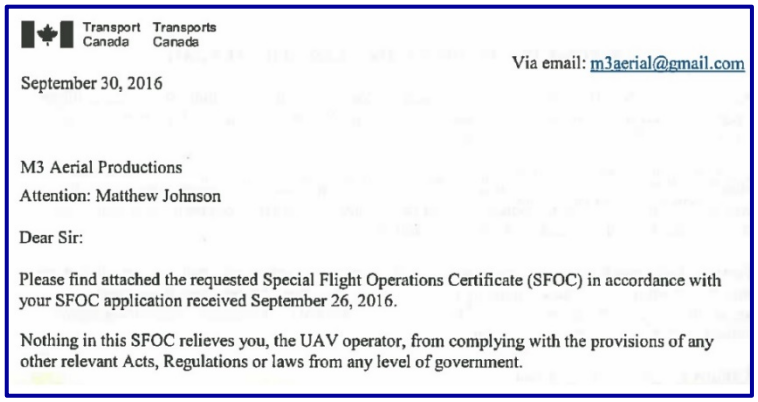
Special Flight Operation Certificate (SFOC)

"Nothing in the SFOC …relieves you, the UAV Certificate Holder, from complying with the provisions of any other relevant Acts, Regulations or laws or from any level of government." (see screenshot below)

Transports Canada Transport Canada

The SFOC is a document detailing the characteristics, limitations, and risk mitigation procedures for the commercial operation of a UAV. It can usually allow the Certificate Holder to operate in areas that may otherwise be restricted to recreational flight, or who operate under the SFOC exemption (more on the exemption to follow).

The entire rational for the SFOC process is to ensure that the applicants, professional users of UAVs, fully understand **every** aspect of their operation; where they can operate, when, how high they can fly, and for what purpose.


Transport Canada Transports Canada

Via email: m3aerial@gmail.com

September 30, 2016

M3 Aerial Productions
Attention: Matthew Johnson

Dear Sir:

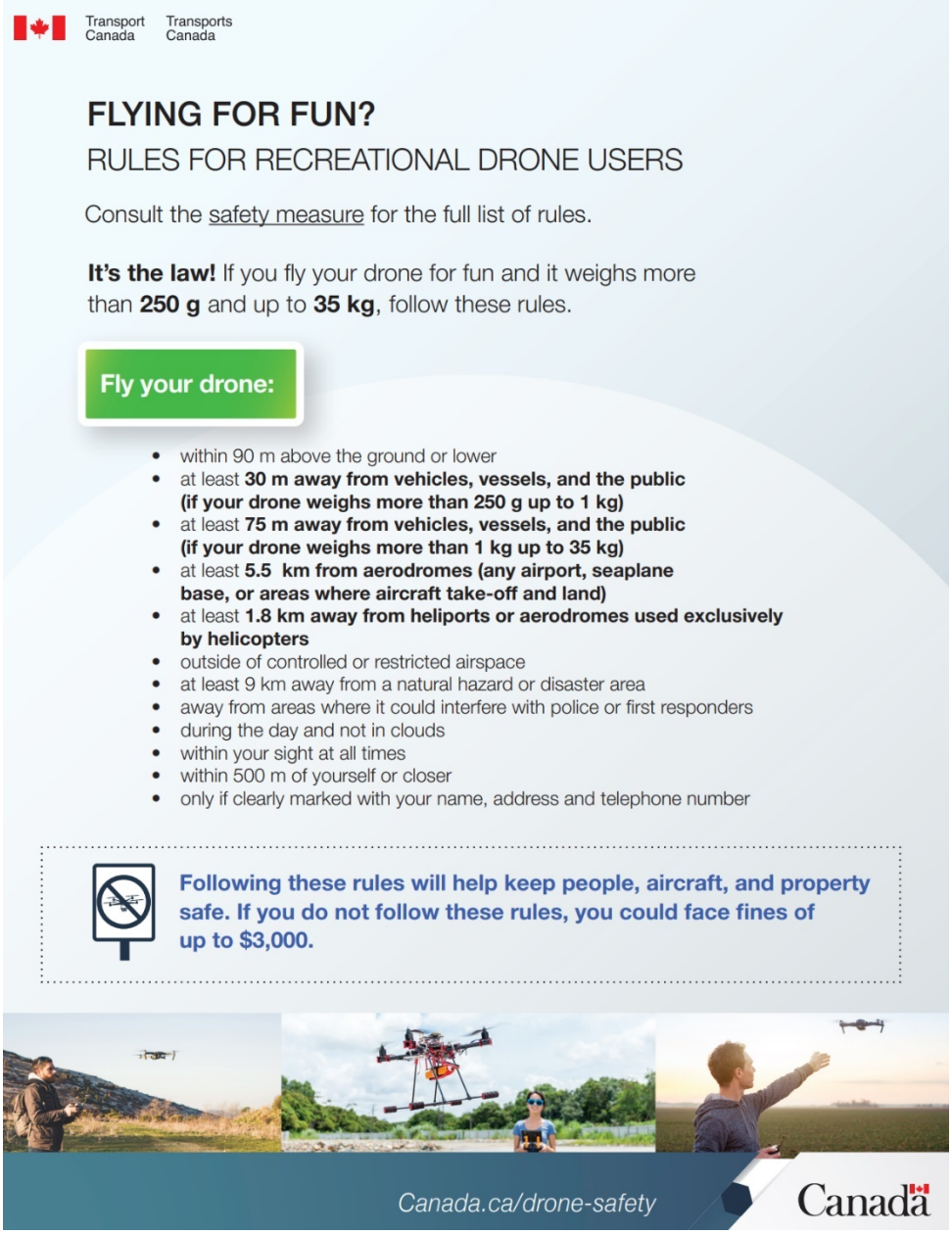
Please find attached the requested Special Flight Operations Certificate (SFOC) in accordance with your SFOC application received September 26, 2016.

Nothing in this SFOC relieves you, the UAV operator, from complying with the provisions of any other relevant Acts, Regulations or laws from any level of government.

Flying A Drone Recreationally?

As of March 16th, 2017, it has officially been made illegal to operate your “drone” in various hazardous locations without proper authorization from Transport Canada – essentially, you require an SFOC for most city-based UAV activities.

The following document outlines the new laws for recreational drone users:



Transport Canada Transports Canada

FLYING FOR FUN?

RULES FOR RECREATIONAL DRONE USERS

Consult the safety measure for the full list of rules.

It’s the law! If you fly your drone for fun and it weighs more than **250 g** and up to **35 kg**, follow these rules.

Fly your drone:

- within 90 m above the ground or lower
- at least **30 m away from vehicles, vessels, and the public (if your drone weighs more than 250 g up to 1 kg)**
- at least **75 m away from vehicles, vessels, and the public (if your drone weighs more than 1 kg up to 35 kg)**
- at least **5.5 km from aerodromes (any airport, seaplane base, or areas where aircraft take-off and land)**
- at least **1.8 km away from heliports or aerodromes used exclusively by helicopters**
- outside of controlled or restricted airspace
- at least 9 km away from a natural hazard or disaster area
- away from areas where it could interfere with police or first responders
- during the day and not in clouds
- within your sight at all times
- within 500 m of yourself or closer
- only if clearly marked with your name, address and telephone number

Following these rules will help keep people, aircraft, and property safe. If you do not follow these rules, you could face fines of up to $3,000.

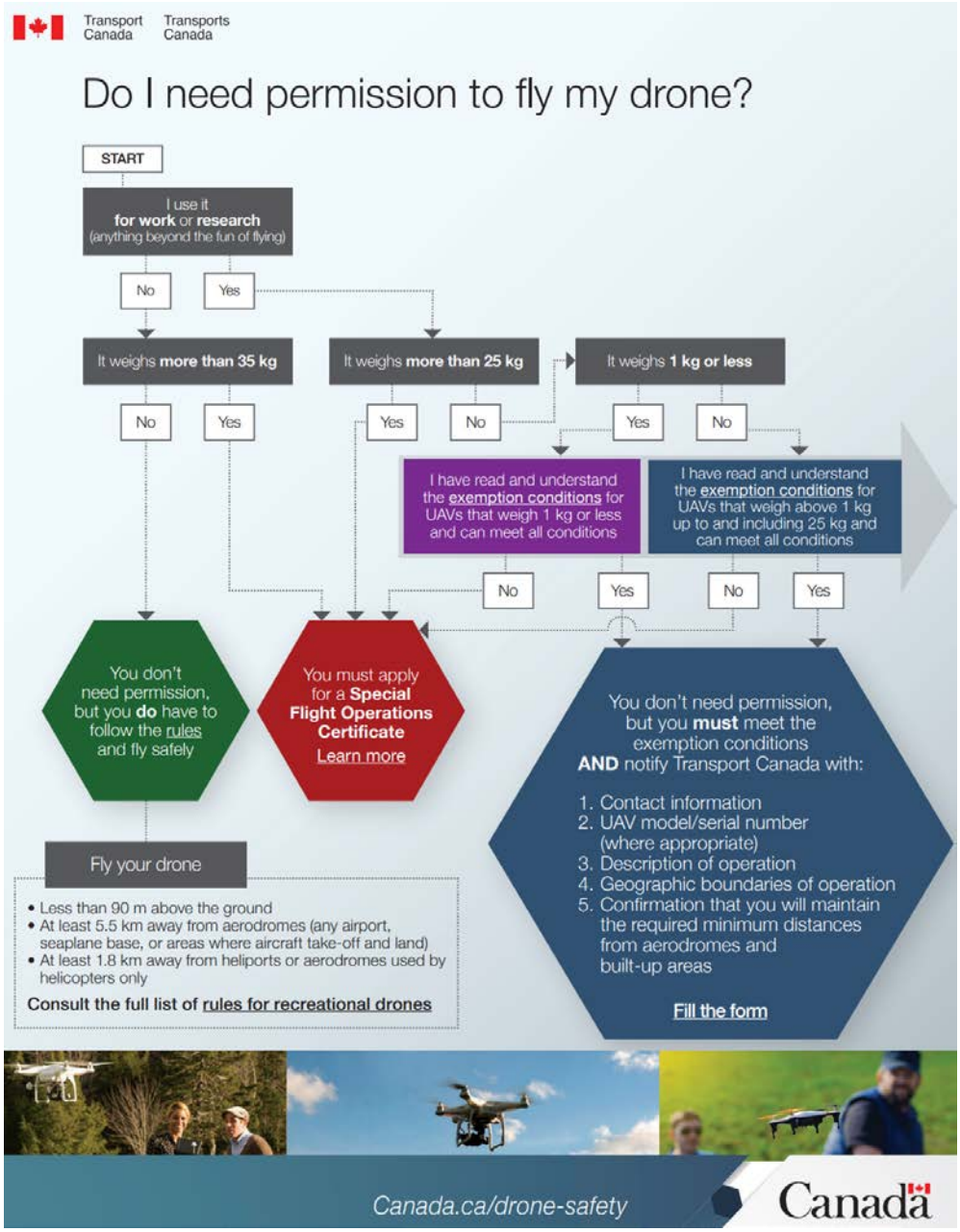
Canada.ca/drone-safety

Canada

https://tinyurl.com/yay74dso

Operating Under Exemption

Two exemptions allow non-recreational operators to conduct lower risk operation in more remote areas without the need to apply for an SFOC. To operate under an exemption, you must meet all safety conditions outlined in either the "Exemption for UAVs that weigh one kg or less" <u>or</u> "…one kg up to and including 25 kg".



https://tinyurl.com/yc79zy3l

The Exemptions

Exemption from Sections 602.41 and 603.66 (requirements for an SFOC) of the Canadian Aviation Regulations can be found on the Transport Canada website. This exemption does not apply to operations of model aircraft, autonomous UAV or operations by a foreign UAV operator, and specifically focuses on operators of UAV in the 1kg-25kg class (most common) for commercial operations.

The Exemption can be found at the following link: (http://tinyurl.com/j5rrvy9)

General Conditions of the Exemption

- Do not pose a risk to aviation safety
- Do not operate in a reckless or negligent manner, endangering the life or property of any person
- Must be over 18 years of age, or over 16 years of age and conducting research under supervision
- Must have liability insurance of no less than $100,000
- Do not operate if suffering from fatigue or other condition affecting performance of their duties
- Do not operate UAV with 8 hours after consuming alcohol, or while using any drug that impairs the persons faculties
- Must be familiar with the relevant aeronautical information before commencing the operation
- Must obtain permission (written) from the owners(s) of the property on which a UAV will launch or land from
- Must perform a site survey to confirm safe operations can be conducted
- Cease operations if the safety of any person or property is in jeopardy
- *Must have on hand a copy of the following documents:
    - The exemption - (http://tinyurl.com/j5rrvy9)
    - Proof of liability insurance coverage
    - Name, address and telephone number of the UAV operator
    - A copy of the UAV system operating limitations
    - Evidence of completion of a pilot ground school program (NEW)
- All the previous documents must be produced immediately if requested by a peace officer, police officer, or Transport Canada inspector
- Must follow all other relevant Acts, Regulations or laws from any level of government.

Flight Conditions of the Exemption

- Must maintain continuous, unaided visual contact with the UAV
- Do not operate the UAV further than one-half (1/2) nautical mile from the pilot (NEW)
- Do not use a First-Person View (FPV) device
- Do not use Visual observers to extend the operational area
- Do not operate more than one UAV at any one time
- Must always give way to manned aircraft
- Must operate during daylight hours only
- Must operate below 300 ft above ground level (AGL)
- Must operate only in Class G airspace
- Do not operate within 5 nautical miles of a forest fire area
- Do not operate in restricted airspace
- Must operate at least 5 nautical miles away from the center of an aerodrome
- Must operate at least 3 nautical miles from a built-up area

- Must operate at least 500ft from any building, structure, vehicle, vessel, animal or person unless they are the subject of the work and only persons inherent to the operation are present (NEW)
- Do not operate over an open-air assembly of persons
- Must operate with visual meteorological conditions, clear of cloud, with at least 2 miles of visibility
- Must always be able to take immediate active control of the UAV
- Must establish and follow procedures for lost-link, loss of control, emergency contact procedures, landing/recovering, contacting air traffic services, and the individuals named for each of those procedures.
- Must confirm that no radio frequency interference to the UAV is present prior to and during flight
- Do not terminate flight if it is unsafe to do so
- Do not operate in icing conditions/within operating limitations stated by the manufacturer
- Do not use a portable electronic device at the control station of the UAV where it may impair the functioning of the systems or equipment
- Do not launch a UAV if explosive, corrosive, bio-hazard or laser payloads, or any payloads that can be jettisoned, dispersed or dropped are carried onboard
- Must have a hand-held fire extinguisher of a type suitable for extinguishing fires that are likely to occur (*for Lithium batteries, Class D fire extinguisher/sandbag*)
- Must remain clear of take-off, approach and landing routes of manned aircraft
- Must advise the appropriate air traffic service unit(s) immediately if at any time, the UAV enters controlled airspace

Pilot Training and Reporting Conditions

- The pilot operating a UAV system shall have **successfully completed a pilot ground school** program that provides instruction on the following subject areas:
    - Airspace classification and structure
    - Meteorological and NOTAM reporting services
    - Interpretation of aeronautical charts and the Canada Flight Supplement
    - Applicable content of the Canadian Aviation Regulations
- Must ensure UAV is in a fit and safe state for flight, and any maintenance, disassembly-assembly or servicing is performed according to the manufacturer's specifications *(modifications)*
- Must not have an emergency locator transmitter (ELT)
- Shall **notify the Minister in writing, within 10 working days of a new or updated operation** of the following:
    - Their name, address, telephone number and e-mail
    - Model of the UAV(s) being operated including serial number(s), where appropriate
    - Type of work being conducted
    - Geographic boundaries/areas of the operation
    - Confirmation the exemption has been read/understood; that flights will only be conducted in Class G airspace, at the applicable distance from aerodromes and built-up areas (http://tinyurl.com/gs55ero)

Breaking the Rules

If an operator doesn't meet a single condition in the exemption, they will no longer qualify to fly under the exemption and must apply for an SFOC.

If an operator flies a UAV without an SFOC **and should have one**, Transport Canada can issue fines up to $5,000 for a person and up to $25,000 for a corporation.

If an operator does not follow the requirements of their SFOC, Transport Canada can issues fines of up to $3,000 for a person and up to $15,000 for a corporation

Common "No Drone Zones"

Certain areas are assessed as being higher risk, due to either hazards to public health and safety, disruption of the peace, or national differences in regulations:

- *Aerodromes*: remain clear (5.5 km) of aerodromes (unless you have specifically communicated with NAVCANADA and Transport Canada).

- *National Parks:* Unless specifically authorized in an SFOC, UAVs (and other aircraft) should not be operated in these areas below 2000 ft AGL.

- *Outside Canada:* rules for UAV operation are different in the United States (and other countries). Check the aviation regulations before you fly in other countries.

- *Indoors:* if you want to fly within a structure where people are present (e.g, at a sporting event, trade show, or demonstration), you must apply for an SFOC.
  - You *do not* need an SFOC to fly indoors when only the UAV crew or people directly participating in the operation are present.

The National Research Council of Canada has created an interactive map to help UAV operators identify areas where UAV operations may be restricted to SFOC holders.

The UAV Site Selection Tool: **https://tinyurl.com/mmuutfr**

Canadian Aviation Regulation Advisory Council (CARAC)

CARAC has been part of the Civil Aviation rulemaking process since 1993.

- Assess and recommend potential regulatory changes
- Changes are made through cooperative activities
  - Working groups
  - Plenary council meetings
- Joint undertaking of government and the aviation community
- Sends out updates, alerts, and notices about proposed changes, or new regulations that are being developed
- Provides a medium to become involved!

Contact CARAC to inquire about joining:
carrac@tc.gc.ca

*(the extra "r" is **not** a typo)*

Confirm Your Knowledge

16. **Five documents to have on hand when operating under Exemption:**

    ⇒

    ⇒

    ⇒

    ⇒

    ⇒

17. **Four common "No Drone Zones":**

    ⇒

    ⇒

    ⇒

    ⇒

18. **Three Flight Conditions of the Exemption:**

    ⇒

    ⇒

    ⇒

19. **Two reasons Transport Canada may issue fines:**

    ⇒

    ⇒

20. **One Golden Rule:**

    ⇒

Discussion:

Why should someone go through the hassle of getting an SFOC?

Final Thought!

"You are remembered for the rules you break" – General Douglas Macarthur

Introduction to NAV CANADA

Transport Canada is responsible for issuing SFOCs and granting you the authority to operate UAVs per the specified conditions, but they do not track individual operations.

Responsibilities of NAV CANADA

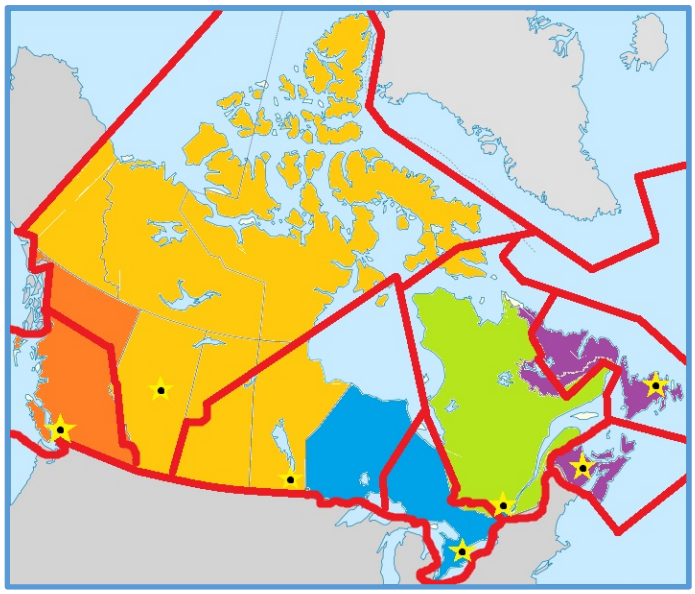
NAV CANADA is the company that owns and operates Canada's civil air navigation services (ANS).

Their ***services*** include:

- Air traffic control (ATC)
- Flight information
- Weather briefings
- Aeronautical information services
- Airport Advisory services
- Electronic aids to navigation

Their ***facilities*** include:

- Area control centres (ACC)
- Airport Traffic Service (ATS)
- Flight service stations (FSS)
- Flight information centres (FIC)
- Flight information region (FIR)



NAV Canada FIRs over Transport Canada Regions

Communicating with NAV CANADA

NAV CANADA has a FIC in Winnipeg, where Flight Service Specialists interpret meteorological information to provide weather briefings and advisories, and communicate directly with the ATC.

UAV coordination is very important to the safety of the flying public. You must notify the appropriate ATS agencies and issue appropriate notices (NOTAMs) as necessary.

You must provide the Unit Operations Specialist (UOS) with the following information:

- Contact info
- SFOC File #, ATS #, and RDIMS #
- GPS location of the operation
- Radius (nautical miles: NM) of flight
- Altitude
- Date/time of the operation
- Description of the UAV (type, wingspan, weight, colour)

Contact the Winnipeg FIC:
wpgaccuos@navcanada.ca or call (**204)-983-0304**

Notice To Airmen (NOTAMs)

A NOTAM is a notice containing information concerning the establishment, conditions, or change in any aeronautical facility, service, procedure or hazard.

The purpose of a NOTAM is to distribute information in advance of an operation to notify others of the area's activity. The NOTAM must be filed in sufficient time to take any required action.

A NOTAM should be filed at least 5 hours, but generally not more than 48 hours prior to an operation, and you will need to have the following information on hand:

- *GPS coordinates* (in degrees). Example: 49º54'39.6"N 97º05'47.8"W
- *Time* and *Duration* of operation
- *Altitude* and *Radius*
- *Wingspan*, *Weight*, and *Colour* of UAV
- Name of person or company filing

To file a NOTAM: Call the relevant FIC Contact:

Gander: 709-651-5207
Montreal: 514-633-2883
Toronto: 905-676-4609
Winnipeg: 204-983-0304
Edmonton: 780-890-8488
Vancouver: 250-765-4023
Or, call the NAV CANADA National Ops Center: 1-866-651-9053 or 613-563-5626

FIC / UOS Operation Request Example Email (this is not a NOTAM)

Good day,

I am requesting to fly multirotor UAV VLOS over a rural field to gather aerial imagery:

SFOC File Number: 5233-11-112
SFOC ATS: 15-16-00034343
SFOC RDIMS: 18643635

GPS Dec: 47.9110, -99.0966 (this is used with the UOS)
GPS Deg: 49º54'39.6"N 99º05'47.7"W (this is used when filing a NOTAM)

Date: 23 Nov 2017
Time: 0900-1230 CST

Altitude: 400 ft
Radius of flight: 1500 ft

-M3 Aerial Productions

Confirm Your Knowledge

21. **Five points to include in a NOTAM:**

    ⇒

    ⇒

    ⇒

    ⇒

    ⇒

22. **Four NAV CANADA facility types (with abbreviations):**

    ⇒

    ⇒

    ⇒

    ⇒

23. **Three services provided by NAV CANADA:**

    ⇒

    ⇒

    ⇒

24. **Two definitions of FIC and FIR:**

    ⇒

    ⇒

25. **One accepted format for GPS coordinates when filing a NOTAM:**

    ⇒

Discussion:

Why is it important to maintain strong communications with NAV CANADA when planning and executing a UAV operation?

Final Thought!

"*The biggest problem with communication is the illusion that it has taken place*"
– George Bernard Shaw

Introduction to Meteorology

A pilot must check the current, and forecasted weather conditions, as part of the pre-operation, and pre-flight phases. Since meteorological conditions are highly variable, a pilot must also understand the contributing, and resultant factors of the immediate meteorological conditions.

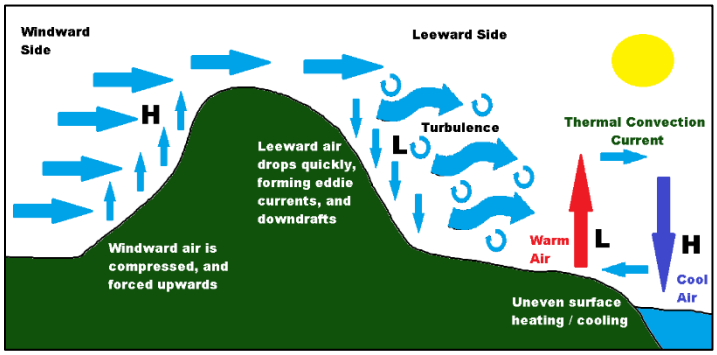
Pressure, Wind and Turbulence

Also known as barometric, or simply "air pressure," it's the cumulative force of the air in the atmosphere upon the surface of the Earth. Air (a gas) is a fluid, like water, and though we perceive it as weightless, it has mass. A column of air extending from sea-level to the edge of the atmosphere exerts a measurable force of 14.7 pounds per square inch (psi), or 101.325 kilopascals, also known as 1 standard atmosphere.

Major changes in air pressure are caused primarily by unequal absorption of the Sun's energy by the surface of the Earth. Air flows from high pressure to low pressure areas in the form of wind. When this happens, the air may become unstable, resulting in turbulence

There are four mechanisms that cause turbulence:

- *Convection:* Land and water warm and cool at different rates, thus during the day, land warms faster, causing air above the land to rise quickly, lowering the air pressure above the land. Cooler, high pressure air over the water blows in to take the place of the low-pressure air above the land. A downdraft, or "pulling" effect towards the water results as air from above rushes down to replace the air over the water.
- *Mechanical:* As air flows over terrain contours such as buildings, hills, mountains, trees and other obstacles, it becomes turbulent and unstable. Eddies and downdrafts result in similar "pulling" effects where air can suddenly drop over obstacles.



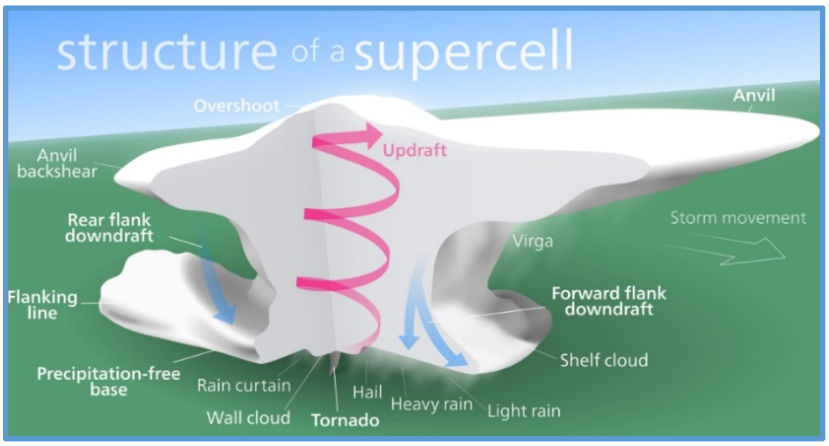
Wind and air pressure changes due to temperature and topographical changes in the Earth's surface. "H" indicates

- *Orographic:* Air flowing over mountains creates waves of unstable air on the leeward side.
- *Wind Shear:* A rapid change in wind speed over short horizontal distances, drastically affecting lift of an aircraft.

Wind speeds are lower at ground level due to friction with Earth's surface, and thus high wind on the ground often means potentially dangerous conditions above. ***Operations should never occur when wind exceeds specifications set by the manufacturer.***

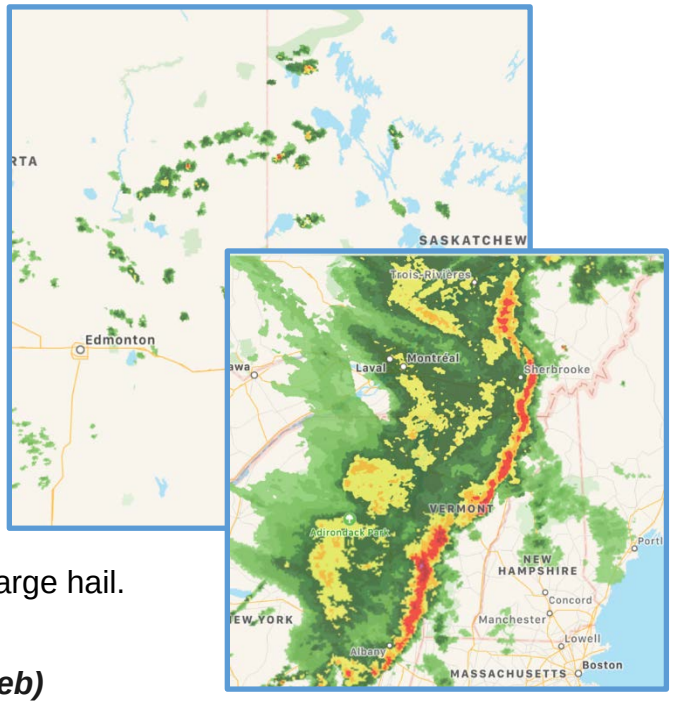
Also, remember to consider **vectors** (see Page 9) when determining how fast a UAV may be capable of operating in high wind conditions.

Thunderstorms



When moist, unstable air rises quickly due to surface heating or increases in elevation, a thunderstorm may develop. The UAV pilot must be very aware of thunderstorm conditions, as they are often preceded in the "*cumulus*" phase by strong updrafts, accompanied by turbulence and unpredictable wind currents (*wind shear*) which can increase the risk of a fly-away. Thunderstorms can often be seen far away as *tall, puffy cumuliform clouds*.

There are **four main types of thunderstorms** that you may encounter while mission planning, or in the field:



1) *Single Cell:* develop quickly on warm, humid days; common and relatively weak, but may be severe enough to produce hail and ***microbursts*** (sudden intense downward winds, lasting 5-15 min)
2) *Multi Cell (Cluster):* large areas; move in unpredictable patterns
3) *Squall Line:* narrow band of severe thunderstorms; develops on or ahead of a cold front in moist, unstable air
4) *Supercell:* long-lived storm capable of producing tornado conditions, and large hail.

Excellent UAV Weather Apps:
UAV Forecast, AeroWeather, SpotWx (web)

Icing and Precipitation

Icing occurs in temperatures between 5º and -20ºC, when air containing droplets of super-cooled liquid water freezes upon contact with an object. If this happens, a UAV may experience

- Decreased thrust
- Decreased lift
- Increased weight
- Increased drag.

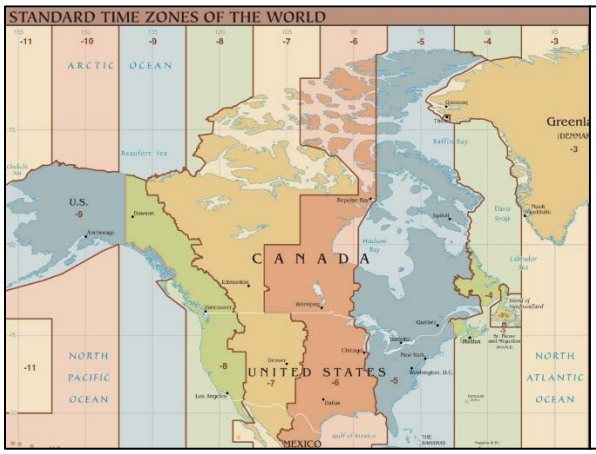
Precipitation generally occurs due to one of three physiographic processes:

1) *Orographic*: as warm, moist air is forced up by topographical changes in elevation, it can condense as it cools (*adiabatic rate*), forming water droplets.
2) *Convectional*: common on the Prairies and Ontario; heating of the Earth's surface causes air to rise rapidly, eventually cooling and condensing.
3) *Cyclonic*: also known as "frontal" precipitation; occurs when the leading edge of a warm moist air mass meets a cool (dense) and dry air mass, forcing it upwards, where it cools and condenses.

Time Zones and Daylight Savings

Time zones trend along the lines of longitude, however they often stray from their path to accommodate for provincial, state, federal, cultural, and geographic demarcations. It is important to understand where the time zones change over across the country..

In Canada, DST (daylight savings time) usually begins on the 2nd Sunday in March, and ends on the 1st Sunday in November. During DST, the time zones shift forward an hour towards GMT (ie. Central Standard Time -6:00 becomes Central Daylight Time -5:00).



<u> IMPORTANT NOTE **</u>**

Time may be provided in **"Z" (Zulu)** time, which is Greenwich Mean Time (GMT) or "Coordinated Universal Time" (UCT), the time from which every time zone in the world is based on.

You must be able to quickly convert from GMT to your local time.

Example:

Atlantic Daylight Time (ADT) is UCT -3:00
Central Daylight Time (CDT) is UCT -5:00

Sunrise & Sunset

Part of the mission planning process should see the operator noting the sunrise and sunset time, if the operation takes place around those times of the day. Canada is situated so far north, that we experience an extremely long summer solstice, the longest day (in terms of sunlight hours) of the year.

Jun 21

Nautical Twilight Start:	2:30
Civil Twilight Start:	3:36
Sunrise:	4:20
Local Noon:	12:31
Sunset:	20:41
Civil Twilight End:	21:25
Nautical Twilight End:	22:31

Sunlight affects how images turn out. Often, for photography, some of the nicest pictures can be taken as the sun is just above the horizon, as the atmosphere works as a filter that creates amazing shades of red, yellow and blue.

Sometimes, the lack of direct sunlight can affect the quality of data obtained by remote sensors. For example, NIR sensors should be used within3-5 hours of solar noon, depending on the time of year. Flying before or after these times could potentially cause artifacts in the data (errors).

Lastly, Transport Canada restricts operations to between official Sunrise/Sunset without “Night Flights” on an SFOC.

Decoding Weather Data

NAV CANADA presents information in both alphanumeric or graphical form. Both require some level of interpretation as abbreviations are often used to communicate a great amount of information in a small space. The following link directs you to the NAV CANADA Aviation Weather Website:

http://tinyurl.com/mmyxczh

METAR CYBR 010200Z 31014KT 15SM SCT080 BKN240 M20/M25 A3008 RMK AC3CI2 SLP233=		
METAR	**LOCATION** **CYBR - BRANDON MUNICIPALITY/MB**	**DATE - TIME** 01 FEBRUARY 2018 - 0200 UTC
WIND 310 TRUE @ 14 KNOTS	**VISIBILITY** 15 STAT. MILES	**RUNWAY VISUAL RANGE**
WEATHER	**CLOUDINESS** SCATTERED CLOUDS (3/8 - 4/8) 8000 FT BROKEN CLOUDS (5/8 - 7/8) 24000 FT	**TEMP / DEWPOINT** -20 C / -25 C
ALTIMETER 30.08 IN HG	**RECENT WEATHER**	**WIND SHEAR**

Confirm Your Knowledge

26. Five time zones in Canada:

⇒

⇒

⇒

⇒

⇒

27. Four types of thunderstorms:

⇒

⇒

⇒

⇒

28. Three processes of precipitation:

⇒

⇒

⇒

29. Two mechanisms of turbulence that can result in a downward "pulling" effect:

⇒

⇒

30. One characteristic of clouds that are precursors to thunderstorms:

⇒

Discussion: When should you first consider ending an operation due to weather-related circumstances?

Final Thought!

"Climate is what we expect. Weather is what we get" – Mark Twain

Introduction to the SFOC

Transport Canada is a government department responsible for developing regulations, policies and programs. It promotes safe, secure, efficient and environmentally-responsible transportation.

Transport Canada reports to Parliament and Canadians through the Minister of Transport, *The Honourable Marc Garneau*.

Minister of Transport
The Honourable Marc Garneau
marc.garneau@parl.gc.ca

Transport Canada Regions

Canada is divided into five regions, as follows:

- *Pacific Region*: only British Columbia
- *Prairie Northern Region*: Alberta, Saskatchewan, Manitoba, Northwest Territories, Nunavut, and Yukon Territory
- *Ontario Region*: only Ontario
- *Quebec Region*: only Quebec
- *Atlantic Canada Region*: New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland

Types of SFOCs Issued

Loathed by some, and embraced by others, the Special Flight Operations Certificate is a requirement for any person who wants to operate a UAV commercially. You must submit a completed SFOC application for review before getting issued an SFOC.

According to Section 603.66 of the Canadian Aviation Regulations (CARs):

"No person shall conduct a [UAV] flight operation unless the person complies with the provisions of a special flight operations certificate"

The act of flying a drone for any other purpose "but the fun of flying," is what Transport Canada stipulates as a commercial purpose.

There are two types of SFOC: Compliant and Restricted. As of April 6th, 2017, there is now an official National SFOC application form (this is revolutionary, as the previous system required different applications to be filled out, with different criteria, for each of the Transport Canada regions!).

Transport Canada Transports Canada

Application for a Special Flight Operations Certificate (SFOC) for the Operation of an Unmanned Air Vehicle (UAV) System in Canadian Airspace

When you are ready to submit your completed SFOC, send it to:

pnrspecialflightops@tc.gc.ca

You will receive a notice that it is being processed. It should take between 3-12 weeks.

You will get a hard copy of your SFOC, as well as electronic copy sent to you that you must bring with you during operations.

The SFOC Process

If you have determined that you do not fall under the blanket exemption, issued by Transport Canada, you will need to apply for an SFOC. You need to do some reading about the process in order to get a full understanding of the requirements. This course will provide you with a good chunk of what you need to know, but you should read the following documents [or excerpts] before launching your business operations.

- Transport Canada: Staff Instruction (SI) No. 623-001 – Review and Processing of an Application for a Special Flight Operations Certificate for the Operation of an Unmanned Air Vehicle (UAV) System
- Advisory Circular: Guidance Material for Operating UAVs under and Exemption
- Section 602.41 and 623.65 of the CARs (Unmanned Air Vehicles)

It is a complicated process, and is time consuming! But it is necessary to ensure that UAV operators take their positions seriously. Knowing the rules is the first step to following them.

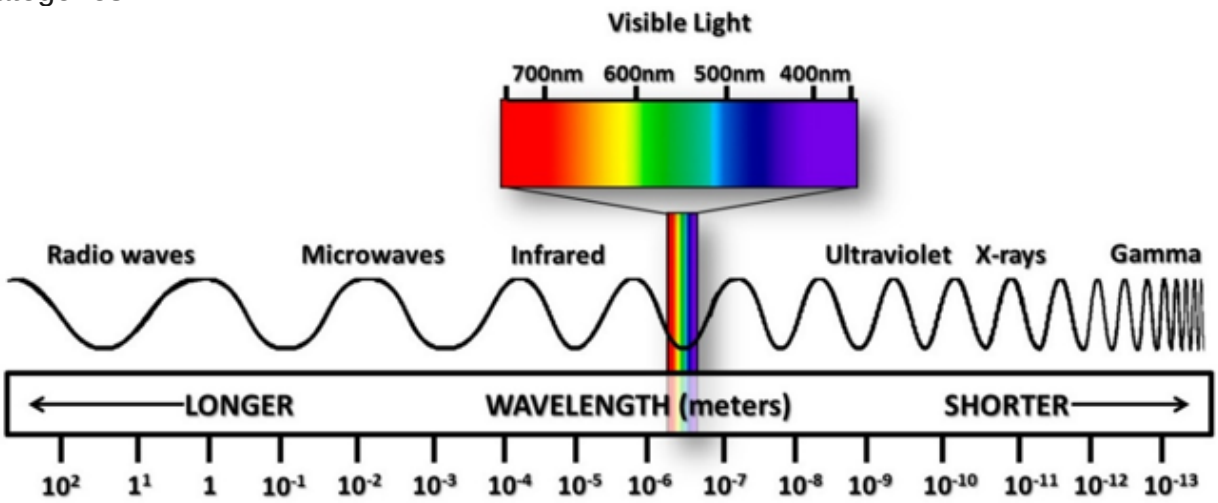
You will have some time during this course to get started on your SFOC, and receive feedback and consultation as you develop your plan.

Equipment and Processing

You need the right tool for the job. Sometimes you'll require a fixed-wing (e.g., if you're mapping a large quarry or a half section or more), and sometimes a multi-rotor (e.g., if you're taking pictures of a construction site at regular intervals). But you will always need some other camera or sensor as payload, otherwise you're just flying for fun!

Foundations of Remote Sensing

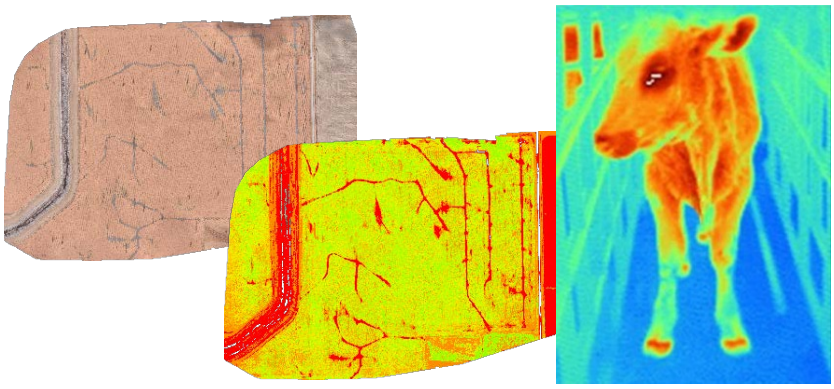
Electromagnetic radiation (EMR) can be classified by wavelength into a spectrum of categories:



EMR travels at the speed of light, and when it encounters an object, the radiation will either be absorbed, reflected, or transmitted through the object. Remote sensors are designed to detect the amount of reflected radiation.

Different sensors are calibrated to capture different sections of the electromagnetic spectrum (EMS). Remote sensors can be broken into several categories, based on the applications of their data:

- Thermal infrared
- Near infrared
- LiDAR
- Multispectral
- Hyperspectral



Applications of Remote Sensors

Every tool in the remote sensing toolbox has a unique purpose. The following table describes some applications, characteristics, benefits/drawbacks of remote sensors:

Sensor Type	Applications	Characteristics	Pros	Cons
Visible (RGB)	• Photography • Mapping for industry	• Most commonly used sensor	• Best used in conjunction with other sensors	• File size • GSD (ground sample distance)
Thermal Infrared	• Firefighting • Scene mtmt • Hotspots • Agriculture • Geology • Solar panel and building inspections	• Invisible to human eyes, but can be felt as heat as intensity increases • Detects radiant surface temperatures, not internal	• Valuable across many applications • Able to collect data at night • Complements other remote sensing data	• Heavier than other remote sensors • Require constant cooling • Very complex • High amounts of data to process
Near-infrared	• Agriculture • Normalized Difference Vegetation Index (NDVI)	• Plant pigments do not absorb energy in this region • Significant differences between plant species based on leaf structure • NDVI values range from 0 to 1 where healthy plants have a higher value	• Accurate detection of small changes in vegetation type, density, distribution, and health • Relatively easy to process • Output is easily understood	• Clouds detract • Many species of plants with unique values of reflectance • Complex map • Limited applications in remote sensing • Requires **ground-truthing**
LiDAR	• Digital Elevation Models (DEM) • Forest planning and mgmt. • Mining • Glacier monitoring • Architecture	• Light Detection And Ranging • Uses a laser pulses to measure ranges (variable distances) • Consist of a laser, a scanner, and a GPS receiver • Two types • Topographic • Bathymetric (green light – penetrates water)	• Extremely precise • Can penetrate vegetation to gather Earth surface topography data • Fast and accurate • Higher data density (doesn't rely on camera resolution)	• Lasers are not permitted on UAVs, unless given special permission from TC. • High-quality sensors can cost over $100k • May be less accurate with wet surfaces (light diffusion)
Multi-spectral / Hyper-spectral	• Mining • Agriculture • Soil typing • Moisture content(SWIR)	• Allows detection of specific EMS ranges • Main difference: is the number of bands and how narrow the bands are	• Can discern between mineral types • Can include all previous types	• Difficult to process (many inputs) • Requires training to understand

Commonly Used Remote Sensors

Here is a product / price breakdown of some of the commonly used sensors for UAV remote sensing:

SONY A6000 Hi-Res DSLR used with older UAV models

~$900 CAD

DJI Z3 Optical Zooming Camera

~$1250 CAD

DJI X5 Hi-Res Camera compatible with DJI Inspire

~$3500 CAD

MicaSense Parrot Sequoia Multispectral Sensor

~$5400 CAD

Sentera NDVI Sensor for DJI Inspire and Phantom

~$2700 CAD

MicaSense Parrot RedEdge Multispectral Sensor

~$8000 CAD

SlantRange (oblique) Multispectral Sensor

~$5500 CAD

Propeller Aeropoints GPS-enabled GCPs

~$10000 CAD

FLIR Zenmuse XT Thermal IR Sensor for DJI Inspire and Matrice series' UAVs

~$9000-$17000

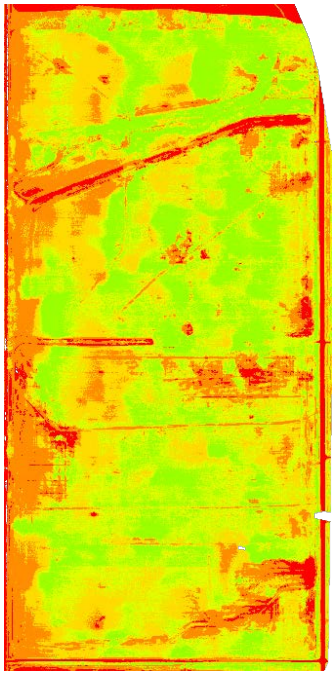
Tracking System

The Marco Polo Tracker is a very small tracking device, weighing only **12 grams**, and is a good idea to attach to any UAV system. It comes with a handheld tracking sensor that can detect signals from up to 2 miles away. It costs around $350.

Data Processing Platforms

There are several options for processing UAV imagery. Some options are integrated with certain UAV or sensor brands. Costs vary. Some companies charge for monthly subscriptions, and some charge based on usage.

• *Pix4D:* PC-based o $350 / mo o $3500 / yr o $8700 to own	• ***Sentera FieldAgent:* PC / Cloud** o **$29 / mo** o **1 YR FREE with purchase of Sentera sensor.**
• *Botlink:* Cloud-based o $150 / mo o $1500 / yr	• *Maps Made Easy:* Cloud-based o App costs $13.99 o $150 (~5000 ac) o $425 (~16000 ac)
• *DroneDeploy:* Cloud-based o $100 / mo (pro) o $300 / mo (bus)	• *Propeller Platform: Cloud-based* o $230-460 per survey o 15 / 50 / 100 / or 240 site packages avail



320 ac NDVI ortho stitch completed using Botlink

Processing Outputs

Orthomosaic data collected via several platforms, and stitched using one of several of the above (or other) options, can be processed in several formats. Different formats are required for different objectives.

- *JPEG*: Most common compression of data, gives a pretty good tradeoff between storage size and image quality
- *TIFF:* Image storage type that supports image-manipulation as in GIS (Geographic Information Systems) software applications
- *GeoTIFF*: Allows georeferencing information to be embedded within a TIFF file via GPS unit, to synch what an image with the exact coordinates it was taken
- *Shapefile*: A collection of files (.shp, .shx, and .dbf) that tracks and attaches geometric vector information to an image. Translates well with GIS and Agri-softwares, such as FarmWorks, and SMS Basic.

Confirm Your Knowledge

31. **Five applications of LiDAR:**

⇒

⇒

⇒

⇒

⇒

32. **Four sensors that gather NIR data:**

⇒

⇒

⇒

⇒

33. **Three applications of thermal infrared imagery:**

⇒

⇒

⇒

34. **Two types of file-outputs commonly used during data processing:**

⇒

⇒

35. **One primary application of near-infrared data used in remote sensing:**

⇒

Discussion: Is there a perfect sensor? What about a drone? Is there a perfect software?

Final Thought!

"Spoken word was the first technology by which man was able to let go of his environment in order to grasp it in a new way." – Marshall McLuhan

Introduction to Insurance

UAV Liability Insurance

Any person conducting any aviation related activities must possess no less than $100,000 in liability coverage pertaining to the operation of the UAV. Most general, commercial or professional liability insurance policies do not cover aviation related activities.

UAV operators must ensure they possess insurance that covers third party liability for aviation-related activities prior to operating under either exemption or an SFOC.

This innsurance covers many types of accidents, including:

- Third Party legal liability
- Premises liability
- Fire legal liability
- Personal injury
- Coverage for pilot and ground crew

Depending on the type and cost of your equipment, you may want to consider Physical Damage Insurance.

Insurance Costs

Liability Insurance

A commercial insurance policy for the minimum requirement of liability coverage can depend on the type of equipment that you are using and can range from $500-800.

Levels of coverage start at $100,000 (minimum), and step up incrementally to $500,000, $1,000,000, $2,000,000 and $5,000,000. Once again, depending on your equipment, prices can vary for these rates anywhere from $400-2000.

- Example of claim: Bodily injury and property damage following an impact with persons or third-party property

Physical Damage Insurance

Unless you are using very expensive equipment, it may be difficult to justify acquiring physical damage insurance. It can start at $1500 and go up substantially from there.

- Example of claim: Loss of operator control of the UAV; electro-mechanical / component failure; or operator error resulting in total loss

Introduction to Radio Procedure

Radio Communications

Part of the SFOC application process requires applicants to possess a Restricted Operator Certificate with Aeronautical Qualification (ROC-A).

The ROC-A is required by operators of radiotelephone equipment on board aircraft and at aeronautical land (fixed and mobile) radio stations using aeronautical mobile frequencies.

In most operational situations, you will be required to have in possession a VHF (Very High Frequency) Air Band Transceiver to establish two-way radio communications with nearby air traffic in case of emergency (eg. flyaway, rogue drone, etc.).

ICOM IC-A6
Allows for simple (one-handed) operation
~$400

You must **complete an examination** conducted by an Industry Canada accredited source. The following companies offer ROC-A examinations around the Manitoba area:

Brandon Flying Club: (204)728-7691
Harv's Air Service (Winnipeg): (204)339-6186

Radio Operators Certificate (ROC-A)

The exam can take anywhere from 15 minutes to an hour. It focuses on the following subject areas:

- Regulations
- Priorities of communications →
- Privacy of Communications
- Control of Communications
- Superfluous Communications
- False Distress Signals

Priorities of Communications

1. Distress
2. Urgency
3. Radio direction-finding
4. Flight safety
5. Meteorological inquiries
6. Flight regularity
7. UN Charter
8. Government messages
9. Service communications

Phonetic Alphabet

The International Telecommunications Union Standard Phonetic Alphabet is universally recognized in aviation.

A: Alpha	*F: Foxtrot*	*K: Kilo*	*P: Papa*	*U: Uniform*
B: Bravo	*G: Golf*	*L: Lima*	*Q: Quebec*	*V: Victor*
C: Charlie	*H: Hotel*	*M: Mike*	*R: Romeo*	*W: Whisky*
D: Delta	*I: India*	*N: November*	*S: Sierra*	*X: X-Ray*
E: Echo	*J: Juliet*	*O: Oscar*	*T: Tango*	*Y: Yankee*
				Z: Zulu

Operating Procedures

It is important to use the radio in an appropriate and responsible manner, and consider:

- Speech Transmission Techniques (proper pronunciation, clarity, speed/rhythm)
- Time and Date (twenty-four hour clock system as four figures)
  Example: 1:45 p.m. is expressed as “one, three, four, five” (1345 hrs)
- Phonetic Alphabet (Alpha, Bravo, Charlie, Delta, Echo, etc.)
- Transmission of Numbers (121.5 should be spoken: “one two one decimal five”)
- Procedural Words and Phrases (**do not say** slang such as “ok,” “ten-four,” “over and out,” “breaker, breaker,” “come in please!.” etc.
- Radio calling procedures / Radio Checks / Call signs

Emergency & Urgency Communications

- Most of this category is reserved for manned aircraft, but is important to look over
- If an emergency to life or limb occurs in a remote setting and cell communication is impossible, it may be useful to broadcast on your VHF radio (despite limited reach)

Aeronautical Terms, Procedural Words and Phrases,& Frequency Assignments

- See *M3 Aerial Member Content: Study Guide for ROC-A*

Crop dusters are not always monitoring the radio so you should **contact their airstrips** before you fly.

Standards of Good Practice

The following practices are recommended by NAV CANADA to make communications easier for yourself as well as the receiver:

- **Listen** on the frequency before speaking to avoid making a call while another aircraft is also transmitting
- **Think** about and plan what you are going to say before beginning transmission
- After pressing the push-to-talk button, a slight **pause** before and after speaking ensures your entire transmission will be heard, and not cut off
- Use a normal, conversational tone and volume of speech
- **Brevity:** Keep calls brief using concise, standard phraseology
- **Slow:** Speak slower than normal conversation and remember that the information being relayed may need to be written down
- **Three:** Only transmit three ideas (phrases, information, instructions) at once
- **Operational:** Only operational transmissions (i.e. avoid general conversation)

Confirm Your Knowledge

36. **Five top priorities of communication:**

⇒

⇒

⇒

⇒

⇒

37. **Four standards of good practice (one word each):**

⇒

⇒

⇒

⇒

38. **Three procedural phrases NOT to say over the radio:**

⇒

⇒

⇒

39. **Two locations to write the ROC-A:**

⇒

⇒

40. **One example of a VHF Air Band Transceiver model:**

⇒

Discussion: Why is it important to keep radio transmissions as concise as possible?

Final Thought!

"I don't think there's one thing I've said on the radio that would have been found indecent or obscene!" – Howard Stern

Interpreting Aeronautical Charts / Canada Flight Supplement (CFS)

Aeronautical Charts are used by pilots for flight planning and navigation. With these charts and other tools, pilots can determine:

- Their position
- Safe altitude
- Best route
- Navigational aids
- Emergency landing areas
- Radio frequencies
- Air space boundaries, and more!

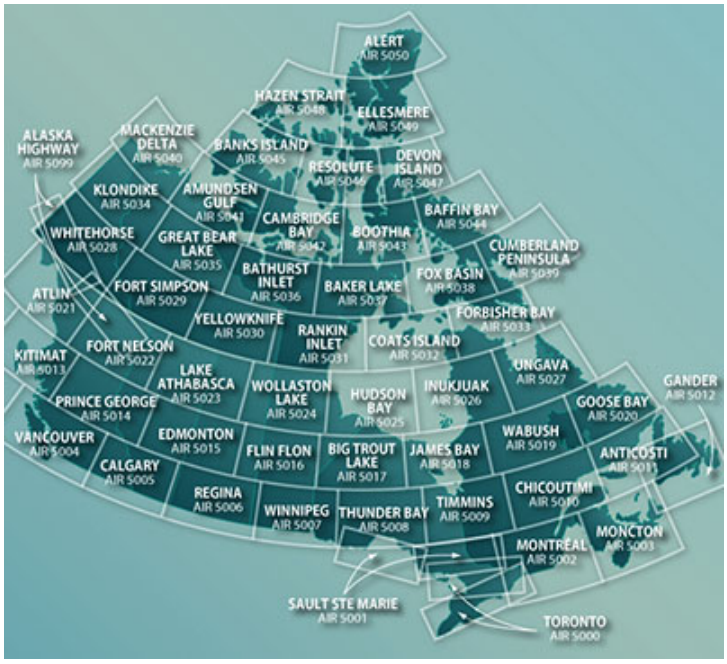
VFR Navigation Charts (VNC)

Used by VFR (Visual Flight Rules) pilots on flights at low to medium altitudes and at low to medium airspeeds.

The chart displays aeronautical information and sufficient topographic detail to facilitate air navigation. There are 52 charts in the series.

A quick online resource when VFR Charts are not available is the following link to Airport Nav Finder:

airportnavfinder.com
skyvector.com



Canada Flight Supplement (CFS)

A joint civil/military publication issued every 56 days. It contains information on all Canadian land and some water aerodromes and is used as a reference for the planning and safe conduct of air operations. It is published and produced by NAV CANADA's Aeronautical Information Services.

NOTAMs may amend or cancel the information in the CFS, therefore the NOTAM must be consulted to ensure that current information is used for flight operations

Other useful information contained in the CFS includes:

- VFR Chart Symbols Legend
- Temperature and unit conversions
- Phonetic and Morse alphabet
- List of contacts for all FICs

Classification of Air Space

Class "A" Airspace

- Controlled high level airspace
- 18,000ft ASL (Above Sea Level)
- IFR (Instrument Flight Rules) Only

Class "B" Airspace

- Controlled airspace
- 12,500-18,000ft ASL

Class "C" Airspace

- Controlled airspace
- VFR ops require clearance to enter
- Control zones and associated terminal areas (usually 10 nautical miles from center of large airports)

Class "D" Airspace

- Controlled airspace
- VFR flights must establish two-way communication with ATC

Class "E" Airspace

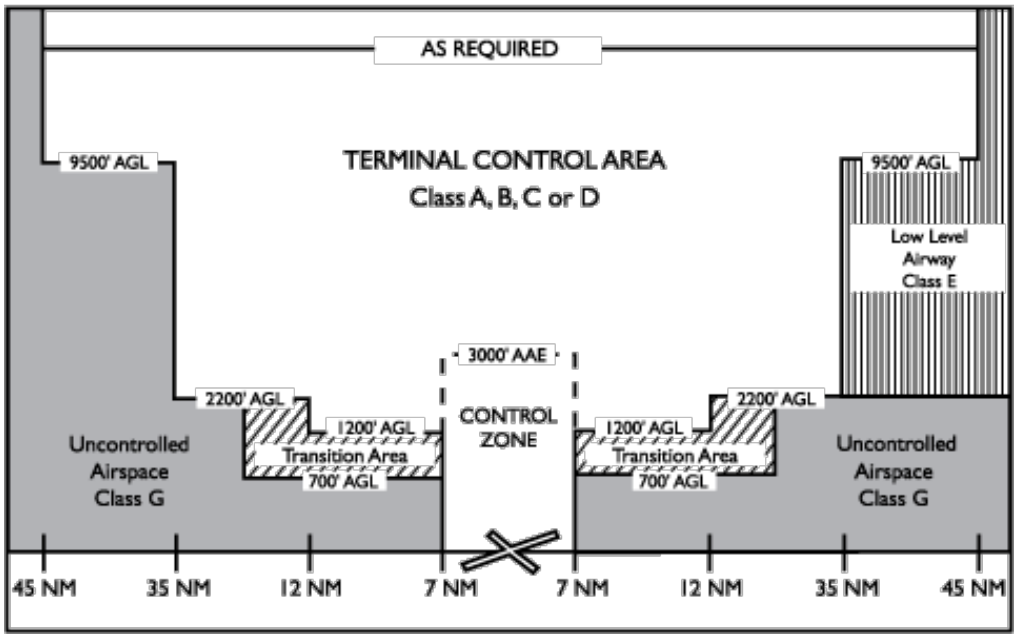
- High level controlled airspace, and low level airways
- Transition areas or control zones without an operating control tower (can't be A,B,C, or D)

Class "F" Airspace

- Restricted "special use" airspace, military ops or danger areas
- Can be controlled, uncontrolled or both

Class "G" Airspace

- Uncontrolled airspace
- ATC is not usually available
- Any aircraft may fly in Class G airspace



Canadian Airspace Classification Chart

Confirm Your Knowledge

41. **Five classifications of controlled airspace:**

⇒

⇒

⇒

⇒

⇒

42. **Four uses of Aeronautical Charts for pilots:**

⇒

⇒

⇒

⇒

43. **Three characteristics of Class G airspace:**

⇒

⇒

⇒

44. **Two characteristics of Class D airspace:**

⇒

⇒

45. **One definition of VFR:**

⇒

Discussion: Why should a UAV operator know how to read charts meant for manned aircraft?

Final Thought!

"No flying machine will ever fly from New York to Paris." – Orville Wright

Maintenance and Record Keeping

To ensure that your aircraft continues to offer optimal performance, and to ensure flight safety, it is a requirement by Transport Canada that your UAV aircraft be maintained and logs be kept.

Section 6.26 of (SI) No. 623-001 states that UAV operators shall maintain records of their flight operations to include the following information:

- Flight records (location, date, times, crew, aircraft type, etc.)
- Total flight hours accumulated per aircraft
- Pilot(s) flight hours (day, month, year)

Airworthy Condition

Section 5.1 of the (SI) No. 623-001 indicates that the UAV operator is responsible for ensuring that the UAV system is in an airworthy condition prior to conducting flight operations.

This airworthy condition includes at a minimum:

- The UAV has been **maintained** in accordance with the manufacturer's specified maintenance program and schedule
- That any **directives** issued by the manufacturer are completed (ie. Updating firmware, switching out a part, etc.)
- All **modifications** and repairs are carried out in accordance with the manufacturer's instructions
- No unapproved modifications may be carried out
- All equipment is **serviceable**

There is a gap in the market availability of certified UAV repair facilities. If your UAV becomes damaged, you may need to send it away for repair.

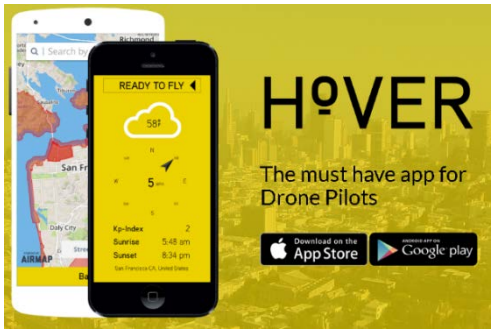
Most DJI products do not come with a warranty that covers operator error. If repairs or modifications are made by *the operator*, the insurance may become void in the case of an accident. This should be determined prior to getting the insurance policy.

Regular maintenance **is** something that you can complete per manufacturer guidelines.

Flight / Maintenance Logs

If you are flying drones commercially, you can track flights the “traditional” way, or the “modern” way:

- Hard copy – a log book that doesn’t rely on a battery
- Electronic – apps that track some, or all your flight data



With all the metrics that you can track using electronic log books, we advise using this method over hand-written notes simply due to time and space constraints.

Some apps that track flight data are free for the user, and some are paid. Here is a short list of apps that we use:

- Map Pilot for DJI ($13.99)
- DJI GO (FREE!)
- Hover (FREE!)
- Drone Deploy (FREE!)

It is important to keep track of standard maintenance.

Battery Maintenance

Lithium polymer (LiPo) batteries are the preferred power sources for most UAVs as they offer high discharge rates and a high-energy storage/weight ratio. These batteries are highly volatile, however, and the following guidelines need to be followed when charging/using LiPos:

- Airplane transport through carry-on in clear baggies for each battery
- Charge batteries in a fire-resistant charging bag / ammo can
- Use only approved charger and compatible batteries
- Ensure cell count is correctly set on your charger
- Cells should be within 0.1V of each other, and may need to be balanced
- NEVER charge batteries unattended, and always charge on a safe surface
- Do not puncture the cell
- Do not drop a battery from a height of more than a few inches
    - If you crash your UAV, do not use the battery again (and be careful with the battery – observe the battery for 20-30 minutes before transport)
- Keep a bucket of sand nearby to extinguish fires. Water only makes it worse!
- Store batteries at 30-50% for long periods of time
- Don’t let batteries sit unused for more than 2 months without a charge cycle

Confirm Your Knowledge

46. **Five battery maintenance guidelines:**

⇒

⇒

⇒

⇒

⇒

47. **Four characteristics of an airworthy condition:**

⇒

⇒

⇒

⇒

48. **Three records that a UAV pilot must maintain:**

⇒

⇒

⇒

49. **Two <u>free</u> electronic flight logging apps:**

⇒

⇒

50. **One type of battery used in UAVs:**

⇒

Discussion: What could happen if you ignored your maintenance schedule?

<u>Final Thought!</u>

"I bought some batteries, but they weren't included" – Steven Wright

Introduction to Mission Planning

In this section of the course, you will learn the procedures that are required to operate a UAV safely, in urban, rural, and remote settings.

Importance of Mission Planning

When an operation is planned, it is set forth with **intent**. The purpose of the SFOC is to ensure that UAV operators are flying with intent. Whether the operation is for training, research, data collection for a client, or just for leisure; the operator must have a plan before launching.

- Planning highlights the purpose of the activity, and identifies objectives clearly
- Planning minimizes uncertainties
- Planning facilitates co-ordination
- Planning facilitates control

Map Analysis

Like military missions, a UAV operation should start with a map analysis. First, look at the area using Google Earth, a powerful (and FREE!) program offered by Google.

Google Earth allows you to access highly detailed ground base maps, and overlay them with metrics like distance, area, and volumetric measurements and graphics.

Winnipeg Goldeye's playoff run photography operation

Operation Sequence

As was previously mentioned in the *"Introduction to NAV CANADA"* section, you need to coordinate with the appropriate NAV CANADA representative prior to all operations. In the Winnipeg FIR, that position is currently filled by Derek Yakielashek. He is responsible for coordinating every UAV operation within the Winnipeg FIR.

The following sequence of steps should be taken to coordinate properly with NAV CANADA and ensure safe and efficient UAV operations:

Step 1: **Identify the parameters** of your operation(s)

Step 2: **Communicate** the operation parameters with the NAV CANADA

Step 3: If flight is authorized, you may need to **file a NOTAM** with the FIC (and follow any other specified guidelines set for the operation)

Step 4: Complete **pre-operation checks** (charging batteries, etc.)

Step 5: Perform **on-site analysis**

Step 6: **Alert FIC** of mission launch (if specified in the flight authorization)

Step 7: Complete **pre-flight checks**

Step 8: Complete UAV **operation** within the parameters of your SFOC, and your flight parameters as communicated to NAV CANADA

- Failing to adhere to "*Step 7*" may result in the insurance being void in the case of an accident

Step 9: **Alert the FIC** following the end of operations, and in the case of any accidents or mishaps (if specified in the flight authorization)

Step 10: Complete **post-flight checks**

Flight Planning Software

In most cases, you will be using a flight planning software that operates on either an iOS or Android device. Flight planning software varies in capabilities, but most offer autonomous route programming. Some apps that work well for mapping and autonomous operations are as follows:

- Map Pilot / Maps Made Easy
- DJI GO
- DroneDeploy
- AgVault
- senseFly eMotion

Confirm Your Knowledge

51. **Five flight planning software options:**

⇒

⇒

⇒

⇒

⇒

52. **Four benefits of planning:**

⇒

⇒

⇒

⇒

53. **Three types of checks (checklists) to observe for each operation:**

⇒

⇒

⇒

54. **Two reasons to contact the FIC during an operation:**

⇒

⇒

55. **One extremely valuable flight planning tool available online to everyone:**

⇒

Discussion: Why is it important to fly with intent?

Final Thought!

"Plan for your work today and every day, then work for your plan" – Margaret Thatcher

Mission Planning Rehearsal

Situation: You have been approached by a group of farmers who wish to have their crops imaged with NDVI. There are 3 farmers owning adjacent land, however, one piece of land is within Class C airspace. They have asked if you can provide the data within a week, and if not, what is the soonest you could?

Using the Operation Sequence from the *Intro to Mission Planning* section, fill in what you would do, what numbers you would call, who you would contact and when, what information you would need, etc. for each of the steps below:

Step 1:

Step 2:

Step 3:

Step 4:

Step 5:

Step 6:

Step 7:

Step 8:

Step 9:

Step 10:

Scenario Analysis

Scenario 1:

You receive a call from a customer who tells you their media company is filming a scene for a movie, and they need an aerial shot of the MB Legislature Building. What are some things you will need to consider when determining if this is possible?

_____

_____

_____

_____

Scenario 2:

You receive an email on Monday evening asking if you can provide aerial photography services for a homestead located at the GPS Coordinate: 49.91797, -97.32224. Determine which Class of airspace this location falls within. The client would like the job completed by Wednesday morning. What do you tell them?

_____

_____

_____

_____

Scenario 3:

You have arrived at a client's field to perform some aerial crop analysis. Shortly after launch, you notice a low-flying aircraft – likely a crop duster. Describe steps you might take in this situation.

_____

_____

_____

_____

Scenario 4:

You've been flying for about half an hour when you notice it is starting to drizzle rain. You only have about 10% of your mission left to complete. What do you do?

_____

_____

_____

_____

Scenario 5:

You are contacted by a client who needs some aerial photos taken of his cottage sometime in the next week. When you check the meteorological report, it appears that a cold snap is forecasted for the next 10 days with temperatures never climbing above -10°C. What do you do?

_____

_____

_____

_____

Scenario 6:

You're photographing a clients' homestead and they ask if you can get a shot of their driveway from the other side of the busy highway. What are some factors that you must consider?

_____

_____

_____

_____

Scenario 7:

You have driven two hours to get to a clients' rock quarry to take some imagery. The wind has picked up substantially since you left this morning and is now gusting to over 40kph. You have a Phantom 3 Professional with a maximum operating wind speed of 10 m/s. What are you going to do in this situation in order to operate legally, and within the conditions of the Exemption for UAV between 1kg-25kg.

Scenario 8:

It's a really hot day! You have been driving on the highway for a couple hours with the UAV case in the box of the truck. When you arrive to your destination, you begin prepping for flight, but you notice the batteries are quite warm to the touch. What do you do?

Scenario 9:

Your cousin asks you to film her wedding with your UAV. Once there, you see a huge crowd is in attendance for the outdoor wedding. What must you consider before flying?

Suggested Travel Kit List

There are several pieces of equipment that Transport Canada requires UAV operators to have on hand, including documents, safety, and communications equipment. The following list of items are recommended to include in a "Travel Kit" that is brought on every operation. Several *Operational Kit* and *Safety Kit* items are mandatory.

Space has been left to add extras that are mission-specific to your operations.

Operator Personal Kit

1. High visibility vest
2. Sun screen
3. Mosquito repellant
4. Sun glasses
5. Hat
6. Bottled water
7. MRE (meal ready to eat)
8. Snacks
9. _____
10. _____
11. _____

**** Operational Kit ****

12. Copy of your SFOC or the Exemption (or both!)
13. Proof of insurance
14. Proof of ground school training
15. UAV system manual
16. Radio Operators Certificate
17. Air-band Transceiver
18. Canadian Flight Supplement
19. Terminal Area Charts
20. Staff Instruction
21. Mobile battery charging unit
22. RCA Auxiliary Plug Adaptor
23. Flight Logs
24. Cobra walkie-talkie radios
25. Spare parts and batteries
26. Radio frequency detector
27. Satellite communicator
28. _____
29. _____

Miscellaneous Kit

29. Bungee cords
30. Para cord/rope
31. Tow strap
32. Zip ties
33. Danger zone / Caution tape
34. Phone charging cord
35. USB charging bay
36. White Tarp
37. 5L gas can
38. Gas electric generator
39. Extension cord
40. Extendable ladder
41. Stool
42. Foldable table
43. Posts
44. Replacement parts (props, etc)
45. _____
46. _____

Safety Kit

47. Flashing light beacon
48. Air horn
49. Flash light
50. Class ABC fire extinguisher
51. Sandbag
52. Medical kit
53. Aluminum survival bag
54. Chemical ice packs
55. Pylons / cones
56. _____
57. _____
58. _____

Checklists

The following checklist will be performed by the responsible Operations Manager / PIC prior to the start of any flight operations. These are not necessarily all in chronological order of completion:

Pre-Operation Checklist

- O Gather operation details from client
- O Perform site survey and review onsite planning with client
- O Create and file SFOC (if required)
- O Verify SFOC approval and rework as needed
- O Perform operational site analysis
- O Create mission plan
- O Finalize proposed operation dates and alternate dates
- O Review final operation plans with client
- O Communicate operational parameters with NAV CANADA
- O Prepare equipment and aircraft for operation – full review and check of all gear and aircraft check
- O Charge batteries, controller, tracking devices (Marco Polo), sensors, tablets/phones, radio, etc.
- O File NOTAM with local ATC (if required)
- O Check weather leading several days in advance, leading up to, and on the day of operation
- O Check in with client before travel to site for any last-minute changes in operational plans

Pre-Flight Checklist

- O Wear safety vests at all times during the operations
- O Arrive on site and secure staging and takeoff/landing areas
- O Setup and check flight gear
- O Perform aircraft inspection and ensure all systems are configured properly and fully operational, and all batteries have been charged within the last 24-36 hours
- O Check for any recent NOTAMs
- O Check that area is secure and free of animals, persons, and vehicles
- O Ensure that all vehicles and passers-by are the beyond minimum distance away from the takeoff area.
- O Check weather conditions are within defined safe parameters

- O Notify bystanders of the flight plan
- O Visually inspect aircraft for any damage or structural issues
- O Calibrate aircraft internal compass
- O Check weather RADAR for any cell activity near your vicinity
- O Verify control transmitter is fully charged and correct aircraft selected, and all switches and controls are in proper neutral position
- O Ensure visual observers and flight crew are briefed of all operational information
- O Place aircraft in clear, level, and safe takeoff defined areas, clear of obstacles and any foreign object debris
- O Verify flight batteries are fully charged and stable
- O Camera is fully charged and turned ON
- O Camera is securely fastened to the gimbal or inside the UAVs fuselage
- O Power aircraft and verify flight control connections and battery levels
- O Are the motors twitching or have sluggish response?
- O Fixed wing UAV can be switched to different flight modes with correct flight mode indications in from the aircraft or flight controller
- O No initialization errors flagged by the autopilot
- O GPS link has been established (check for green flashing light on the LED module for multirotor UAVs)
- O Flight plan successfully uploaded to the software (if required) for the fixed wing UAVs
- O Check that wind speed (and gusting speeds) are below operating limits of the UAV
- O Verify radio-interference is within acceptable limits.
- O Communicate with NAV CANADA to alert them of operation starting in 15 minutes, if a NOTAM was required, and when operating in Class C or D airspace.
- O Verify maximum height are set for operational requirements
- O Verify geofence limits
- O Verify takeoff and flight area is clear
- O Announce takeoff to bystanders / and or client or associates
- O For multirotor UAVs, takeoff and hover 10-15 feet above ground for a final visual and audio inspection of the UAV
- O Engage rotor engines and perform takeoff.
- O Perform active-flight tests:
  - Are the motors running smoothly and evenly?
  - Any unexpected vibrations? Sounds?
- O Is the UAV responding to control inputs as it should?
- O Begin flight

Post-flight Checklist

- O **Inspect the UAV for any visual damage to control surfaces, propellers, motors, camera, etc.**
- O **Check photos/video from camera to make sure that the desired shots/footage had been captured.**
- O **In Class C, D and E Airspace, contact the ATS unit for the area to advise of the end of operations.**
- O **In Class G Airspace, make a general broadcast of the conclusion of operations.**
- O **Place used batteries in case with arrows pointing down for charging at a later time.**
- O **Following an operation, a debriefing and After Action Report will be conducted amongst all involved parties as a future reference**

Aborted or Delayed Takeoff / Launch

The following situations will result in aborted or delayed launch procedures:

- **Inclement weather**
- **Unexpected situation on the ground level (disruptive person, animal, vehicle, etc.)**
- **Contact from ATC advising against the mission**

Procedures for aborted launch are as follows:

- **Pilot will immediately notify crew via means**
- **Pilot will immediately notify bystanders**
- **Pilot will power down aircraft and remove from the situation**

In-Flight Procedures

- **Maintain visual contact with the UAV at all times (i.e. Do NOT fly behind structures, tall trees etc. at any point if you would lose sight of the UAV even momentarily**
- **Continuously monitor the UAV's altitude, distance from home base, separation from nearby hazards (e.g. trees) and remaining battery power**
- **Maintain a close eye on any bystanders/passers-by, making sure that they keep the required separation distance from the UAV takeoff and landing area.**

Landing & Recovery Procedures

- **Ensure that all bystanders/passers-by are the required separation distance from the UAV landing area. After landing, initiate motor shut-off sequence, unplug the main power to the UAV, and turn off the camera and RC transmitter.**

Notes

Course Feedback Form

This is an anonymous feedback form. If you would like to provide this as a testimonial, simply write your name at the top. Please fill it out to let us know how we did, so that we can improve the course for next time! Be honest and deliberate with your answers.

For the following section, please read the statements and circle a response based on your agreement with the statement. Use the scale below:

1 = Strongly Disagree 2 = Disagree 3 = No Opinion
4 = Agree 5 = Strongly Agree

1.	Lectures, discussion and activities were relevant to course objectives	1 - - 2 - - 3 - - 4 - - 5
2.	Instructor displayed a thorough knowledge of the subject matter	1 - - 2 - - 3 - - 4 - - 5
3.	The course was organized and skillfully prepared	1 - - 2 - - 3 - - 4 - - 5
4.	Instructor presented material at an appropriate pace	1 - - 2 - - 3 - - 4 - - 5
5.	Instructor emphasized important points	1 - - 2 - - 3 - - 4 - - 5
6.	The instructor remained clear, engaging, and on topic during the lectures	1 - - 2 - - 3 - - 4 - - 5
7.	There were sufficient and well timed breaks throughout the course	1 - - 2 - - 3 - - 4 - - 5
8.	Refreshments provided were satisfying and appropriate	1 - - 2 - - 3 - - 4 - - 5
9.	The presentation style of the course was easy to follow and understand	1 - - 2 - - 3 - - 4 - - 5
10.	Information covered in this course was what you had anticipated, and fulfilled your expectations	1 - - 2 - - 3 - - 4 - - 5

If you answered 2 or 1 to any of the above questions, could you please briefly explain how we were not able to meet or exceed your expectations?

_____

_____

Tell us briefly your overall impression of this course:

_____

_____

What is one thing you believe we could improve upon for next time?

_____

_____

Thank you for choosing M3 Aerial Productions! We'd love to hear from you on Twitter @M3Aerial