It's a Bird! It's a Plane! It's a Frog Drone!

Testing the use and feasibility of using Unmanned Aerial Vehicles (UAV) to survey and monitor for amphibian egg laying.

Prepared for:
Oregon Spotted Frog Recovery Program
Fraser Valley Conservancy

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Project Goals

Oregon spotted frogs as a critically endangered and very cryptic species. Both the individuals and their eggs are challenging to find in the complex and fragile shallow water wetland in which they live. This project attempts to assess the feasibility of using Unmanned Aerial Vehicles (UAV's) to survey sensitive areas for amphibian egg masses. Surveying by foot or boat in sensitive habitats can cause damage as well as have decreased efficiency due to the surveyors' line of sight. Being able to survey the area at close range from above may have advantages over feet on the ground surveys, at least in the initial exploratory phase.

This project will look at the effective parameters for these aerial surveys, their ability to detect egg masses as well as the tools needed for data collection.

Permits

Flying unmanned aircraft (UAV) in Canada, under the authority of Transport Canada, focuses on safety and privacy. This requires following the *Canadian Aviation Regulations*, criminal code and local regulations. The recent popularity of UAV's means that there is little local regulation, though this may be forthcoming so being up to date of future changes in necessary.

Transport Canada lists these basic Do's and Don'ts for AUAV operation:

Do

- Only fly your aircraft during daylight and in good weather (not in clouds or fog).
- Always keep your aircraft in sight, where you can see it with your own eyes – not only through an on-board camera, monitor or smartphone.
- Make sure your aircraft is safe for flight before takeoff. Ask yourself, for example, are the batteries fully charged? Is it too cold to fly?
- Know if you need permission to fly and when to apply for a Special Flight Operations Certificate
- Respect the privacy of others – avoid flying over private property or taking photos or videos without permission.

Don't fly:

- Closer than 9 km from any airport, heliport, or aerodrome.
- Higher than 90 meters from above the ground.
- Closer than 150 meters from people, animals, buildings, structures, or vehicles.
- In populated areas or near large groups of people, including sporting events, concerts, festivals, and firework shows.
- Near moving vehicles, avoid highways, bridges, and busy streets or anywhere you could endanger or distract drivers.

- Within restricted airspace, including near or over military bases, prisons, and forest fires.
- Anywhere you may interfere with first responders

To fly a UAV legally, you need to follow strict safety conditions outlined in an exemption (Figure 2) or apply for permission from Transport Canada.

> If your aircraft weighs **2 kg or less** and you can meet the safety conditions in the **Transport Canada exemption** for UAVs that weigh less than 2 kg or less, you don't need to request permission to fly.

Using a UAV Phantom for research requires the pilot of situation to meet the exemption requirements in Figure 2.

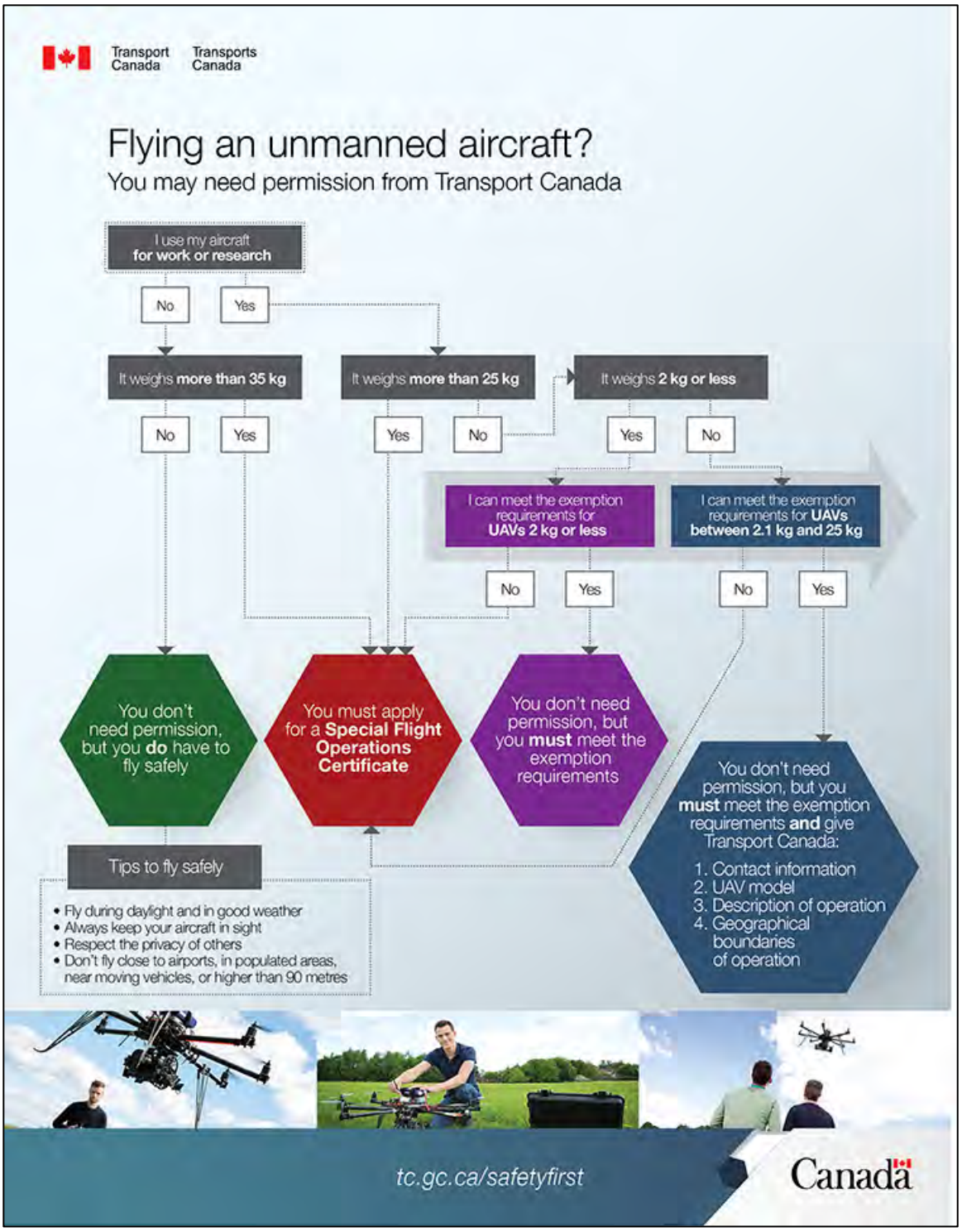


Figure 1: Drone flow chart, UAV under 2kg requires meeting exemption requirements in Figure 2 to fly without permission.

Figure 2: Exemption requirements in the right column are required for the use of a DJI Phantom for research purposes in BC.

The exemptions are common sense flying safety and are met with proper planning. More specific information can be found here: http://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-600-2135.html

It is important to gain the permission of specific landowners (private, municipal etc.) specifically with dates you will be using the UAV over their land. This both allows the landowner to be informed and also in the case of publically accessible areas such as parks, allows them to prepare for potential influx of questions and concerns from the public. Wearing a high vis vest while operating within view of the public helps to make you more approachable to ask questions and helps to ensure those who will not approach you that your presence is permitted. UAV's attract attention, be prepared for a crowd if operating in areas with public access!

Flying Weather

DJI Phantoms are not weather proof. The manufacturer states that they should not be operated in rain or fog. We found this to be the case in our trial and saw jumpy flight patterns and a decrease in hover ability when flown in heavy fog. Prolonged use in heavy fog, or rain, would likely have resulted in the loss of the UAV. For our projects we will be flying very low which allows the water surface to be visible even in fairly heavy fog, flying in fog does decrease your ability to keep the vehicle in sight as well as orient the UAV via the video feed.

On exposure to light fog or rain the mission should be discontinued and warming and drying of the UAV should prevent permanent damage. Experienced pilots who have had a crash directly into water have been able to recover their craft and its functionality by removing the battery and placing the unit in dry rice.

Time of day

Flying during hours when we are able to see clearly and the blue tint of morning has dissipated works best for viewing images on the camera. The camera sees what we see, it does not have an internal light or flash, so you will not get a better image than that which you can see.

The best time of day to use the UAV to result in the best images is approximately 1 hour after sunrise to one our before sunset.

Sun and the use of Filters

The sun can play havoc with clear video and image capture. Using the UAV correctly can help decrease glare and increase the quality of images.

When operating in bright sunlight the angle of the camera can be adjusted to decrease glare. Using the camera pointed directly down will eliminate glare at all times of day except when the sun is directly overhead, which is rarely a problem during the OSF breeding season. To eliminate glare when using the camera at a non-vertical angle it is best to keep the sun

behind the direction the camera is facing. Depending on the direction of the survey this may require flying the UAV "backwards" with the camera recording the area just behind the flight path.

There is no polarized filter accessory currently available for the DJI Phantom. UAV operators have posted a process for constructing one using aftermarket filters and the supplied lens cap for the camera. The link to the forum post on the subject is here:

http://www.phantompilots.com/viewtopic.php?f=27&t=30996&p=313511&hilit=polarized+filter#p313511

This method has been used to create a polarized filter for the OSF, which can be used if needed.

Temperature

Like all things electronic, temperature can affect the use of a UAV. It is unlikely that during the course of project work (during the egg laying period) temperatures will ever be too high as to impact the operation of the UAV. Flying in extreme hot temperatures can be detrimental to battery life and longevity. Effects of cool temperatures are less detrimental to operation and not likely to be a problem in BC's climate.

Warm battery temperature can cause some issues in the programming of the parameters for flight, while the UAV is attached to the computer. If this is the situation the software will alert the user to remove the battery and allow for cooling before continuing.

Wind speed

Flying in wind can be difficult even for advanced pilots. Staying low, as we will for our purposes, helps to decrease the effects of wind. The DJI Phantom does have active GPS control which decreases the effect of wind and allows for stable movement and video/pictures as well as increased control in slightly windy environments. This is however, only possible when GPS is active and available. If the number of available satellites drops below 6 the GPS functionality is lost and the UAV becomes very difficult to control, even in slight winds. Satellite availability should always be monitored with specific attention paid in windy and higher risk situations. Flying should be seriously reconsidered in wind speeds over 10-15 km/hr.

Batteries- how to use, store and charge effectively

Batteries are the power of the program and the bane of a pilot's existence. In order to use your batteries effectively, keep them working at their maximum and for their longest possible life span we need to ensure their care. Pamper your batteries.

Batteries last, under operation in the UAV, for approximately 20 minutes each. It is recommended that you follow closely the warnings in the operating apps, of returning the UAV to the operator at approximately 20% operating power remaining. Always keep in

mind the power needed to return and to descend. Loss of power over water may result in the loss of the craft.

Tips for battery charging:

- Always have the battery off when putting it in/out of the UAV or when plugging it in to charge
- If the battery is already charged 75% or more and the charge is needed to be "topped up" the battery must be turned on then plugged into the charger
- If the battery is less than 75% charged it should be kept off when in the charger
- While charging the level indicator lights will flash at the charging level
- Once charged the battery will turn off, batteries should not be left charging unattended, even with this smart battery functionality
- Every 20 times the battery is charged it needs to be completely drained. Battery charge number can be found in the diagnostics when the UAV is attached to the computer (for DJI batteries only). For ease I have put a sticker on each battery to record the number of charges since last complete discharge. Leaving the battery in the UAV and on can do complete discharge. Do not completely drain the battery by flying.
- You can quickly check battery level by pushing the battery on/off button and reading the green indicator bars. Pressing this button resets the 10-day discharge functionality (see below). Resetting this functionality multiple times can decrease the battery longevity.
- If left charged >10 days the batteries will auto discharge to 50% to save the battery life as part of the "smart" functionality. Because of this always check battery levels pre-flight.
- Keep batteries stored in the cool place, not the fridge
- Using anti corrosion liquid on the battery terminals will extend their life
- Do not fly with a damaged battery. The main way to observe a damaged battery is to look for swelling of the battery within the battery cage

Tips for battery use in UAV:

- Ensure battery is properly seated in the UAV by pushing it firmly and squarely into the compartment
- The battery on/off switch functions as the UAV on/off control
- Press the on/off button once quickly followed by once holding it down until the green lights flash. If the battery is in the UAV the greeting beeps will let you know power is supplied
- Only use the DJI Phantom batteries for data transfer (when hooked to computer). Aftermarket batteries do not communicate with the software (currently) and their stats will not be displayed.

Wi-Fi

The Wi-Fi link is your connection to the camera viewing capability and communication between the UAV and your tablet/smart phone. Operation of the UAV and functionality of the camera will be maintained if Wi-Fi signal is lost. Control of the camera via the dial on the controller is maintained, but you will not be able to see the image on your device.

In order to maintain proper Wi-Fi functionality it is best to have all other devices capable of receiving a Wi-Fi signal turned off, otherwise they may commandeer the Wi-Fi signal and result in the loss of the signal availability to your tablet/smartphone.

There is Wi-Fi signal icon on all associated apps, including third party. The Wi-Fi module takes a long time to charge, up to 8 hours, however it can be kept charged, with no need to discharge.

Your UAV Speaks- beeps and lights

I have printed and laminated a list of LED Flight indicators for the DJI Phantom. The UAV has a distinct greeting chime (produced without speakers!) to let you know that it is receiving power. The light patterns will indicate that the UAV is ready to fly and whether or not GPS is available.

Software needed

In order to set up or change the functions on the DJI Phantom you need to install the DJI Win Drive Installer (Windows), Phantom Vision 2+ Assistant Software (Mac or PC), and the Phantom RC Assistant Software (MAC or PC). Software downloads as well as manuals can be found here:

http://www.dji.com/product/phantom-2-vision-plus/download

> CAUTION: be sure to delay downloading recent updates until 1-2 weeks after their release. Updates are often buggy, delaying updates allows others to work out these bugs. Also ensure that the updates actually provide increased functionality you are looking for, often they are only applicable to US applications (i.e. restricted airspace updates for US cities)

DJI also has available an app for tablet or smart phone which is useful for collecting images and controlling the camera. This app can be downloaded at the link above. The functionality of this app for data collection is limited (i.e. it can not collect tracks) and is not likely to be updated. For more effective apps please see section “Apps to use for data collection” for a review of the currently available third party

Prepping for flight

The drone for the OSF program has been programmed for basic functionality as per above. Any changes to this information should be done before going out into the field via connection to computer and software.

Pre-flight Checklist

1. Ensure charges. This includes not only your batteries but also the controller and Wi-Fi. Each of these components requires separate charging. Wi-Fi can take up to 8 hours to charge from dead.
2. Propellers. Check for damage to edges, de-threading. Ensure the propellers are attached correctly (grey to grey, black to black). Spin tighten them, do not over tighten by hand. Spin motors gently by hand, they should have clicks you can feel but shouldn't bind.
3. Check landing gear for breaks or loosening.
4. Micro SD. Ensure it is in and has sufficient memory. Use only Class 10 SD cards.
5. Check the round rubber gimble cushions for wear.
6. Remove gimble/camera lock and lens cap (if not utilizing the polarized filter).
7. Check battery condition for connections and swelling.
8. Ensure the battery audio alert on your tablet/phone is on high.
9. Place battery in UAV straight and forcefully, make sure it fits well.
10. Ensure both silver toggle switches on the controller are switched up.
11. Ensure compass is calibrated if needed, see below.

Compass calibration

The compass needs to be calibrated when you travel more than 80km from the last flight location (last calibration). When calibrating the compass be sure to stand away from large metal objects (cars, cell towers, electricity towers, buildings with rebar etc.). Compass calibration ensures good control and decreases fly aways. A good rule of thumb is to do a quick calibration each time you fly.

There are directions on page 25 of the Phantom Manual and a video of the process can be viewed here:

https://www.youtube.com/watch?v=t2hfclQAjcM

If the compass needs to be calibrated you may see what is known as the "toilet bowl effect" where the UAV when left to hover circles and descends slightly.

Flying - General

Take off procedure

1. Ensure silver toggle switches are up
2. Turn on controller
3. Turn on Wi-Fi
4. Turn on battery (one tap then a second tap and hold), hear chime

5. Check for green flashing lights under UAV to ensure GPS lock
6. Check satellite lock, ensure 7 or more satellites
7. Start sticks down and to the center to start blades (see below), release sticks

8. Left stick up fairly strong to get UAV into air without tipping.

Flying for frogs - specifics learned

Flying elevation

The best height for flying the UAV over water appeared to be **approximately 3m or 10 feet**. At this height you can cover a fair swath of ground, about 5-8m across if you have the camera facing directly down. To cover a larger area or at and angle to decrease glare adjust camera to an angle between 180 and 150 degrees or increase height. If is often difficult to tell height from the camera view on your device. This view gives the impression that objects are closer than they are. You should be careful to have a visual of your UAV when flying over grasses, as depth perception through the camera is difficult.

Also note that the altitude functionality of the apps can be misleading. Apps appear read altitude from sea level so calibrate yourself to the appropriate height for your site. This is easy to do by getting you UAV to hover at your desired height and note the height displayed on your device as the target flying height.

Flying pattern

Because of the tendency of the UAV to fly in straight lines completing a relatively straight grid pattern by hand is relatively easy with some practice. Maintaining control of the craft by hand is recommended over a pre determined/programmed flight pattern. This allows for easy diversion to investigate an area and for less time to be spent in the programming process.

Pre-programmed flights work well for sites that are already well known. While pre-programmed flights do allow the operator to regain control of the craft, they do increase the risk of crashing into impediments. It would be challenging to program a flight path

around such varying and dynamic environments as we see in the field. There are apps that are working on the ability to "redo" a complex flight path that has been flown by hand on a previous mission. This may be more useful than the office programmed ability. However it will not take into account changes in the environment since the previous mission or dynamic structures (moving branches or newly downed logs). New updates to UAV software and versions anticipate "collision avoidance" functionality, however the release date of this or the exact specifications are unknown.

Field of vision

Field of vision is greater than if surveying by foot. The direct downward angle of the camera allows for better visualization of the waters surface and likely less chance of missing egg masses that are just on the other side of vegetation that would otherwise impede the survey. Because of the angle of view the distance between passes over a suitable area is increased and thus the over all time for the survey of an area will be less. Care must be taken to not increase the field of vision so much (by flying too high) that the chances of seeing egg masses are decreased.

Using a smaller device such as a smart phone over a tablet increases the clarity of the image seen in real time (the recorded image viewed on playback remains the same). If scanning for egg masses in real time I suggest using a smart phone over a tablet. Always record the image (video or stills) to ensure that you can go back and review footage. Sometimes the glare from the device screen makes seeing the image clearly in real time very difficult, particularly in bright sun. Going over the images on a laptop of computer later is useful in these cases.

Flight speed

A **suitable flight speed is between 1 and 2 m/s**. Slower than this still gives useful images and is good for capturing stills but is not very effective at covering significant area within battery life. Over 2m/s and the video footage becomes very difficult to differentiate on a smartphone. Increasing speed can be done at increased height, but with a loss of detail in the ability to see egg masses.

Video resolution

I found video resolution to be good for our purpose at any setting. Increasing the FPS (frames per second) to 30 decreases the ability to get good footage while panning and moving faster. Using an extremely high resolution or FPS can cause the Wi-Fi feed to become choppy, however recorded footage/still should not be affected. Using a Class 10 SD card ensures high read and write speed and better footage.

Range-line of sight, working radius

The range if the perimeter distance limits the UAV set during programming. Once the vehicle reaches this distance from home it will not go further even if instructed it will return to within the radius. For surveying purposes this is unlikely to be a factor as maintaining a visual on the craft is needed and the UAV is difficult to see at approximately 500m due to it size. To work large areas it is easier to move "home" so that you can

maintain a good visual on the UAV as well as the area you are covering. For example, large areas such as Pitt-Addington Marsh we moved our starting position around to get at different areas. Using the UAV to cover long (> 1km) distances to get to a site will decrease the availability of time to do the actual survey due to battery consumption, making this less feasible.

Pre-coding flight patterns- pros/cons-flight path considerations

Pre-coding flight plans is popular with enthusiasts however I do not know how effective it will be in surveying dynamic and changing environments. Pre-coded flight plans without ground trothing run the risk of hitting obstacles or having to fly so high that they are not gathering quality images. Flight plans that have been ground truthed may be more useful but would need to have been flown recently to account for vegetation growth and movement of obstacles etc. For example we would not want to fly a path we created in a complex environment one year previously, as vegetation may have changed height or trees fallen that are now new obstacles we did not take into account with our previous flight path. Also the accuracy of the GPS may result in the UAV flying closer to obstacles than on the original path.

Pre programmed flight paths may be useful for high altitude general aerial surveys. There may be level of personal preference regarding the use of programmed flight paths, however I found I like the constant ability to adjust the images I was collecting.

Feasibility of self-pilot/staffing

I found that using two people, a pilot and a person in charge of video control was the best option as it is difficult to adjust between the tasks. Once proficient I am sure a pilot who is also trained to look for animals/eggs/habitat features could conduct the work alone. There needs to be a level of confidence in the pilot to be able to "fly blind" and spend most of the time looking at the device screen, which is more challenging than you may think. The task becomes even more challenging when surveying an area with changing numbers of available satellites, as this is another aspect that needs to be monitored, to prevent loss of GPS.

Once the UAV is at a significant distance it becomes easier for the pilot to look at the device along with the surveyor as this allows them to tell the speed and elevation as well as the direction the camera is pointing.

When focusing on piloting, surveying, or both it is crucial to have your battery alert audio signal turned up. It is amazing how easy it is to get completely involved in your task and not notice the battery level creeping down.

Apps to use for data

There are many different apps to use for data collection. Many apps have overlapping functions or differing functionality, and new ones are being developed constantly by users (in fact we were downloading new apps daily on the way out to the field). The original app produced by DJI called the "DJI Vision" app has great basic functionality in terms of connecting to the UAV, capturing images and video. It does not however have any capacity

to record tracks, flight details or store/export these parameters. DJI is known for working on producing new UAV's and hardware, not for drastically updating their app so it is unlikely this will change in the immediate future. Apps produced by the UAV community work well and collect the data we are looking for; though some changes and updates are not currently available the anticipated updates are noted in the following.

Device to use

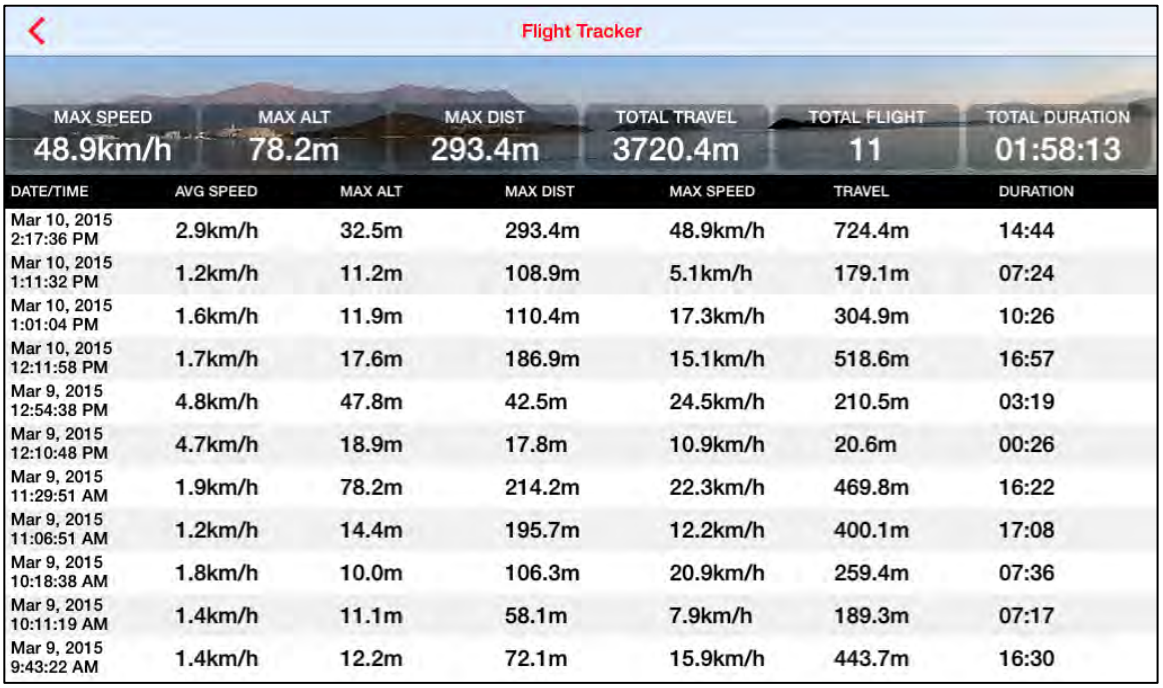
Most apps are optimised for a smaller screen (iPhones or similar sized android). It is possible to use the apps with larger devices (pad mini or small tablet) however the video will not be optimized on the device. The video will be recorded at higher quality for viewing later, but will not be optimized on the device at time of recording. Thus using a larger screen will not result in being able to see the image in real time recorded clearer.

MAC

The Most efficient app for use on Apple devices (pad mini or iPhone) is called "FPV Booster for Vision +" by Solomon Mobile Technology.

https://itunes.apple.com/ca/app/fpv-booster-for-vision+/id876413138?mt=8

This app allows normal camera functionality of video and stills and records all flight data and tracks. Figure __ shows the flight tracks recorded, Figure __ shows the flight path for one of the tracks.



DATE/TIME	AVG SPEED	MAX ALT	MAX DIST	MAX SPEED	TRAVEL	DURATION
Mar 10, 2015 2:17:36 PM	2.9km/h	32.5m	293.4m	48.9km/h	724.4m	14:44
Mar 10, 2015 1:11:32 PM	1.2km/h	11.2m	108.9m	5.1km/h	179.1m	07:24
Mar 10, 2015 1:01:04 PM	1.6km/h	11.9m	110.4m	17.3km/h	304.9m	10:26
Mar 10, 2015 12:11:58 PM	1.7km/h	17.6m	186.9m	15.1km/h	518.6m	16:57
Mar 9, 2015 12:54:38 PM	4.8km/h	47.8m	42.5m	24.5km/h	210.5m	03:19
Mar 9, 2015 12:10:48 PM	4.7km/h	18.9m	17.8m	10.9km/h	20.6m	00:26
Mar 9, 2015 11:29:51 AM	1.9km/h	78.2m	214.2m	22.3km/h	469.8m	16:22
Mar 9, 2015 11:06:51 AM	1.2km/h	14.4m	195.7m	12.2km/h	400.1m	17:08
Mar 9, 2015 10:18:38 AM	1.8km/h	10.0m	106.3m	20.9km/h	259.4m	07:36
Mar 9, 2015 10:11:19 AM	1.4km/h	11.1m	58.1m	7.9km/h	189.3m	07:17
Mar 9, 2015 9:43:22 AM	1.4km/h	12.2m	72.1m	15.9km/h	443.7m	16:30

Figure 3: PFV flight tracks recorded show all general flight info.

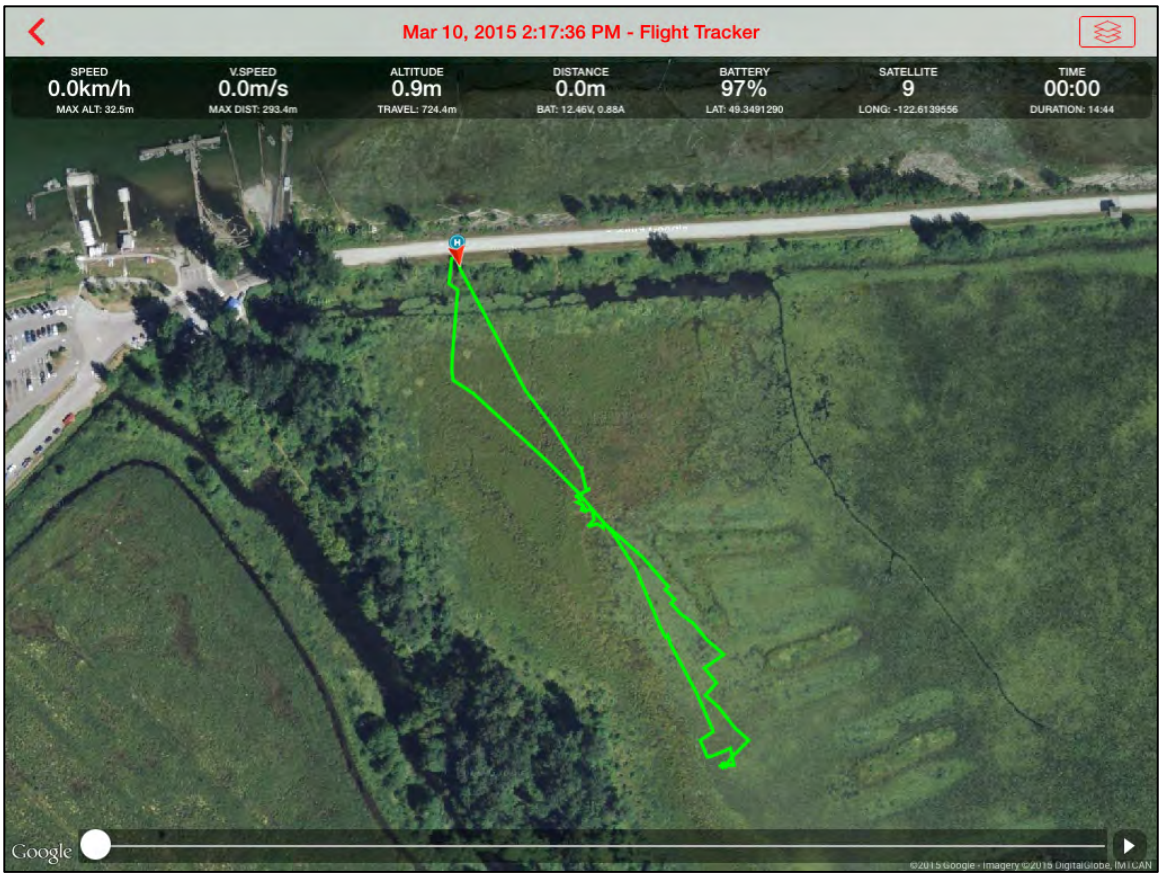


Figure 4: the flight track for the first flight listed in Figure 3. This app also has a function for play back simulation of your flight were the red directional arrow follows the flight path and the corresponding flight details change accordingly in corresponding time.

For the FPV app you need to purchase the app, the camera function, and the tracks function. The camera and tracks functions are both in-app purchases.

<u>Basic camera functions are as follows (not consistent between apps):</u>

- Two taps with one finger takes photo
- Two taps with two fingers starts/stops the video
- Settings menu, one finger swipe left
- Camera tilt up/down, Slower-> swipe down shorter and hold
- Camera tilt up/down, Faster-> swipe down longer and hold
- Demo of progressive tilting: https://www.youtube.com/watch?v=9xSfHabCewY&feature=youtu.be

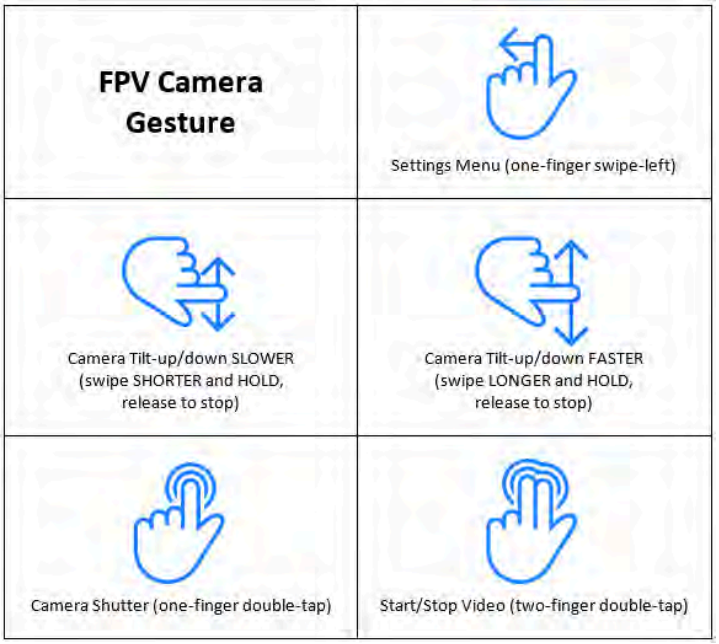


Figure 5: Gesture graphic for the FPV flight app. Apps can differ in their functionality in this respect. For ease of use it is recommended that one app be used consistently.

Google Map is a key component in FPV Camera for flying with both FPV and navigation map. There are 2 simple ways of caching Google Map in advance for offline use, in case you don't have Internet access in the field.

1. Open "Find my Phantom" function with Internet access. Tap the "my location" geolocator box in the lower right to scan to your location. You may then scan to the area of interest and zoom in/out to cache maps. It helps to be as close as possible to your survey location while still having GPS signal to do this.
2. Open the Camera function and "full map". Swipe left to show settings menu >FPV settings>Navigation mode>Full Map. Then as above zoom in and out/pan to cache maps.

When opening the app on a device that also has DJI Vision app installed, you need to make sure the DJI Vision app is completely off as it will grab the Wi-Fi signal preferentially. Otherwise, you may see "Phantom Connection Broken" and "Video Signal Lost" messages shown on FPV Camera screen.

<u>Other useful features of the app:</u>

- Set auto recording to start and stop video automatically with each mission
- Tilt gain, allows to control the gimbal tilting speed
- Vertical speed indicator
- Tap red arrow to display the tracks data during flight
- You can set the battery warning level to your specific comfort level through settings

Camera settings (through settings menu in Camera function):

- Adjust photo size to preference
- ISO is a measurement of the amount of light collected (in olden times it referred to the ability of the film to react to light). Low ISO is best for high light, high ISO best for low light.
- Adjust white balance for conditions (this will remove the blue tint on the images)
- Recording resolution, 1920x18080 25p worked will for me, higher FPS resulted in a choppy image on the device screen.
- Adjust photo format

Things to look out for:

- Disable DJI Vision app (as above)
- If the app crashes video recording timer and flight timer may not be correct

Extracting data

Currently at time of writing there is no way to extract the data from this app. There are updates currently being done to allow the exportation of the tracks and flight data.

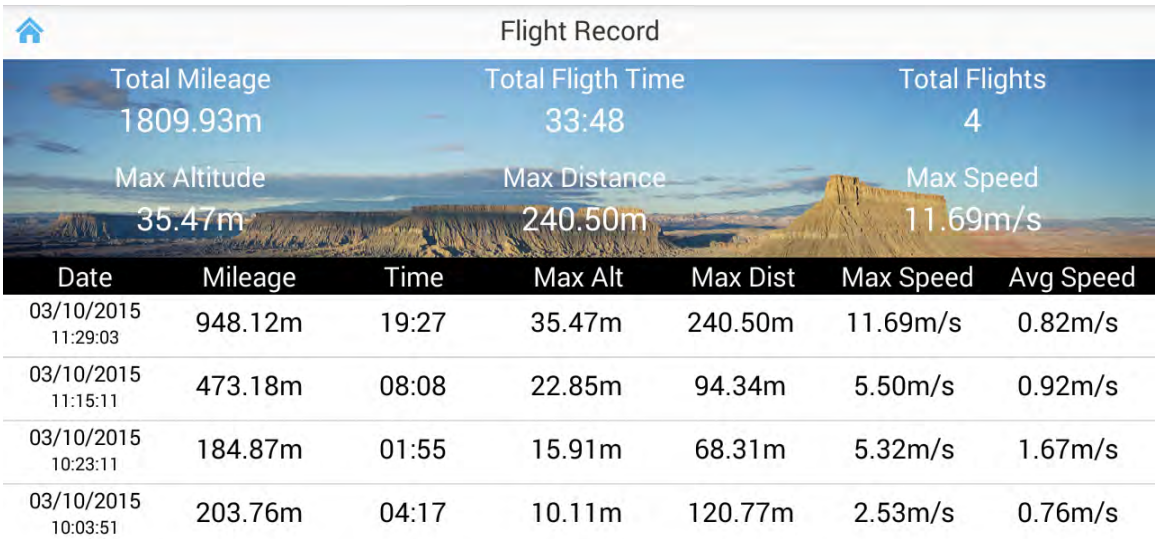
Demos and Features here:

https://www.facebook.com/notes/fpv-booster/flight-tracker-new-features/547242492045228

Android

The most useful app for use with Android devices is the Vision Pilot app by taco-rc.com, available at the Google Play store. This app has a similar functionality to the Apple app and presents the material in much the same way. You access the tracks of your recorded flights from the camera screen using the  button on the top left corner. This will access the list of flights, similar to the Apple app, as seen in Figure 5.

To view maps offline you can cache them by accessing the area maps you will be using and zooming in and out before leaving cellular service.



Date	Mileage	Time	Max Alt	Max Dist	Max Speed	Avg Speed
03/10/2015 11:29:03	948.12m	19:27	35.47m	240.50m	11.69m/s	0.82m/s
03/10/2015 11:15:11	473.18m	08:08	22.85m	94.34m	5.50m/s	0.92m/s
03/10/2015 10:23:11	184.87m	01:55	15.91m	68.31m	5.32m/s	1.67m/s
03/10/2015 10:03:51	203.76m	04:17	10.11m	120.77m	2.53m/s	0.76m/s

Figure 6: Flight records can be selected from this list, as in the FPV app, to bring up the flight path data as well as display the flight path details and playback.

Figure 7: The flight path is recorded on the Flight Record screen which allows play back with simultaneous flight parameters for the recorded flight changing in the top bar. You can visualize your projected flight path on Satellite, Hybrid or standard maps.

Exporting data

The functionality to export the tracks and data from this app was released on March 14, 2015. To download the tracks you use Dashware and follow the most up to date information found here:

https://www.facebook.com/notes/vision-pilot/how-to-import-vision-pilot-flight-log-to-dashware/1638085329758508

Programming the brains of the UAV

Much of the programing of the UAV is done upon initial set up, which has already been completed for the project UAV. Below are highlighted some specific important points of the Phantom Assistant interface that will be useful for setting functions, battery management, and calibration.

Battery Info

Battery info can be checked by inserting the battery into the UAV and attaching the UAV to the computer using the data transfer cable (be sure to attach to the UAV and not the gimble/camera port used for downloading pictures). Under the heading Battery Information you can get the manufacturers details on battery capacity as well as some additional information. The Percentage Charge indicates the current battery charge. Percentage Life indicates the life of the battery in general over its entire useful life. Discharging times indicate the total number of times the battery has been charged over its life. This is useful information to know in order to keep track of the number of charges and maintain the battery correctly by completely discharging every 20 charges. Battery information only works for DJI batteries, not aftermarket batteries, thus these batteries will not be able to give a read out of this information. This is where the stickers on the individual batteries where number of charges is noted becomes invaluable. Without this we would not be able to know the charge count on aftermarket batteries. For consistency I have put a charge count sticker on all batteries, including the DJI batteries, so that we do not need to connect them to the UAV in order to check the charge count.

Under Cell Voltage, we can monitor the status of each cell in the battery. The voltage read out for each cell should be approximately the same. Failure of a cell will result in a significantly different number for that cell here and will point towards possible failure of the battery.

We also want to ensure that the Return to Home box is checked for the low battery warning.

This screen also reminds us to fully discharge the battery every 20 charges and gives detailed information on how to do so.

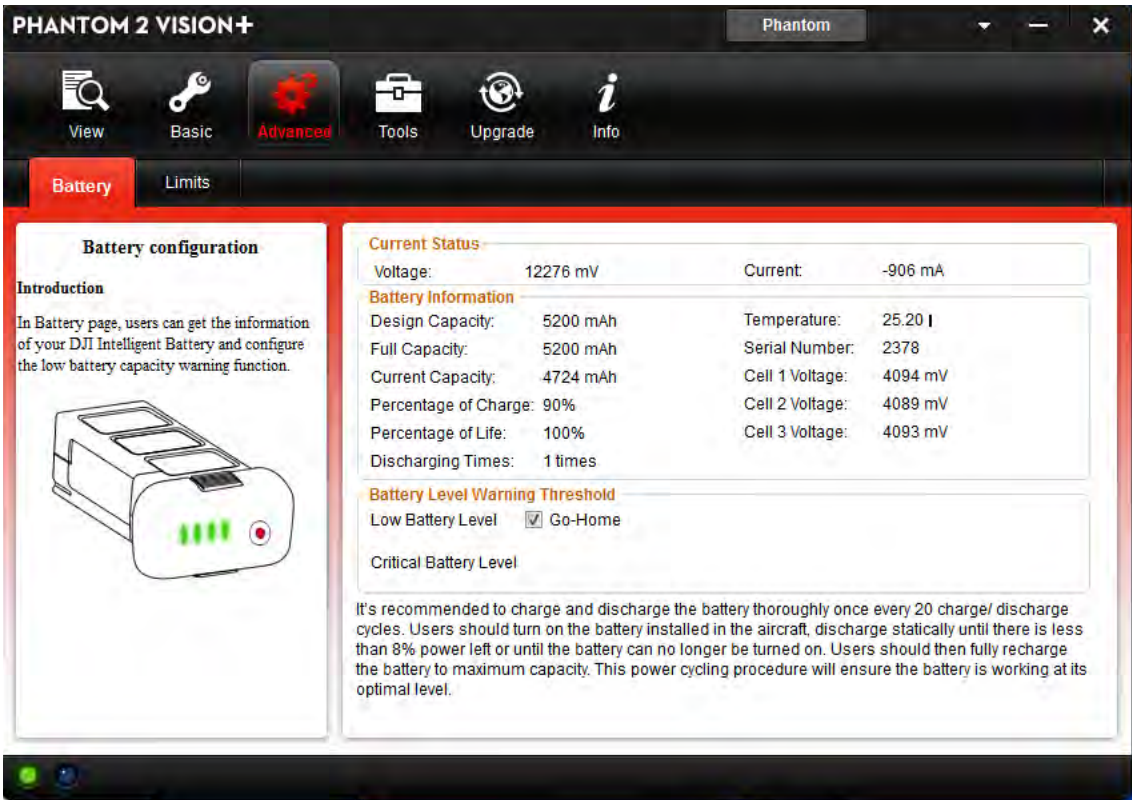


Figure 8: Battery info screen in Phantom Assistant software.

Calibrate Sticks

Calibrating the sticks usually only needs to be done after maintenance or servicing. When this screen is active we need to look for all bars under Command Sticks Calibration to be centered and green. As well we should see the bar X1 centered and green, this indicates the wheel on the remote is also calibrated, which controls the camera tilt when a Wi-Fi device is not enabled.

We also want to ensure the Upgrade Version radio button is highlighted under Transmitter Version to indicate the model of our controller.

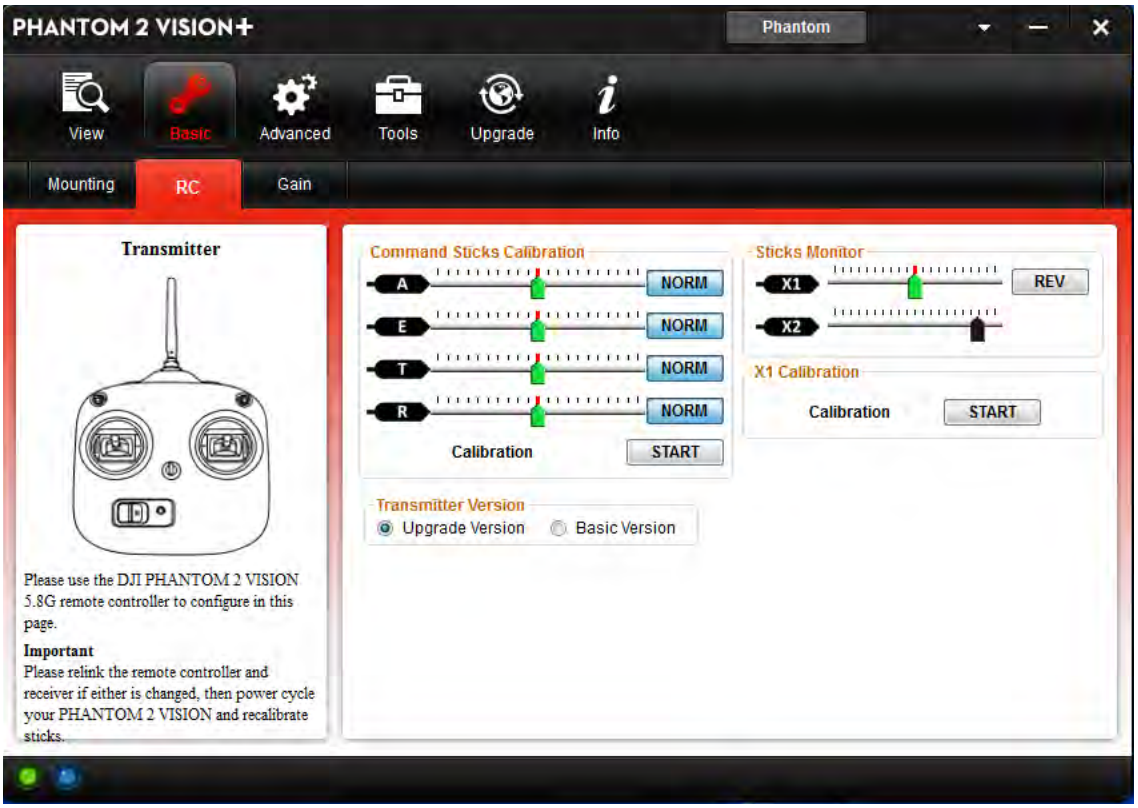


Figure 9: Sticks calibration of remote control, Phantom Assistant Software.

Check for Upgrades

Checking for upgrades on this screen allows us to see which components of the system have updates available. Upgrades are available to the main controller, GPS systems, the receiver, the internal software, and the battery. All updates are also available on the DJI site, with details on their specifications and any potential changes or improvements. It is recommended that these specifics be checked before updating. Often when updates are new they have glitches, waiting before updating allows the hobby community to trouble shoot the errors (which they love to do) and DJI to make any changes. Checking the details of the update allows you to ensure the updates are increasing the functionality in a suitable way. Many updates are made based on the US market (i.e. restricted zones over the Whitehouse) and are not needed for our application, with the risk of introducing changes that may be counter to our needs.

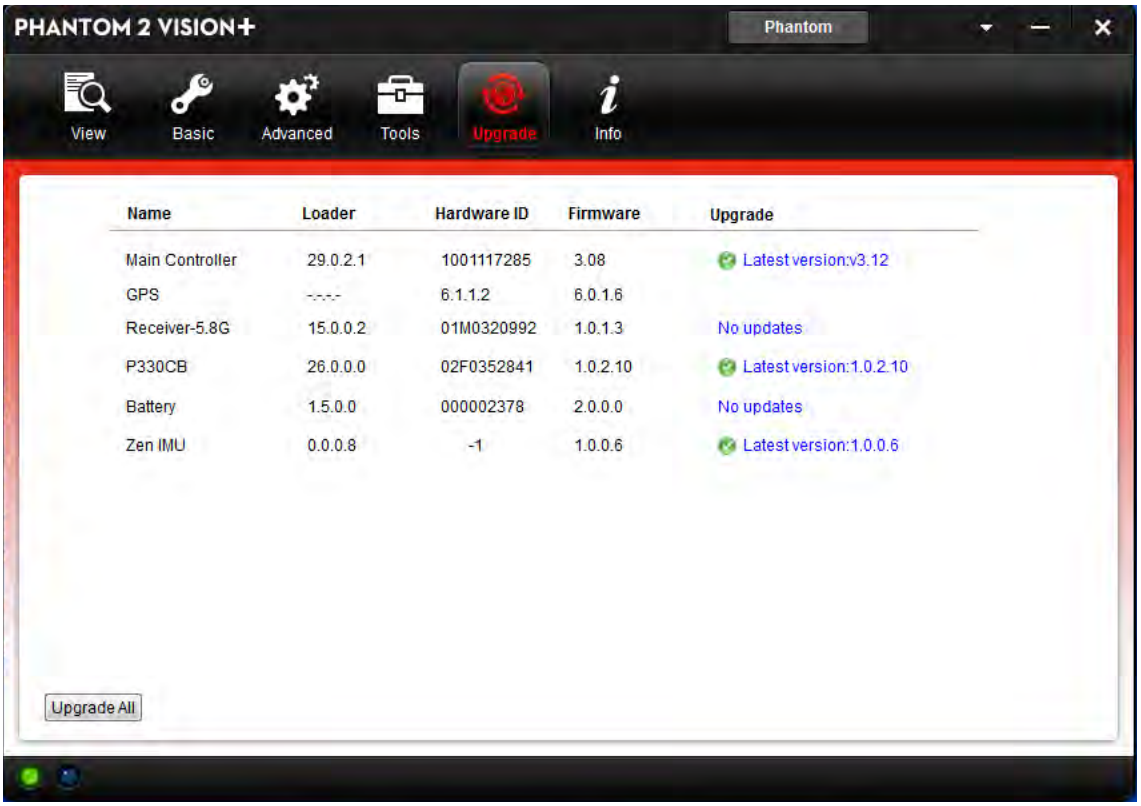


Figure 10: List of available updates for all components of the Phantom UAV.

Set limits- like any good parent

Setting the limits of the UAV is essential to maintain control and functionality, particularly to prevent fly-always and allow for the return-to-home functions to engage properly.

Units of measurement are set with the radio buttons at the top of the limits tab. The OSF drone is set to meters.

The distance limits set a maximum distance, vertically and horizontally, that the UAV will be able to fly away from home base. This distance can be adjusted for your specific flying situation. Keep in mind if the UAV approaches these limits it will simply go no further, like it is bouncing off an invisible wall. This functionality, as well as the go-home functionality, is lost when GPS signals drop bellow 6.

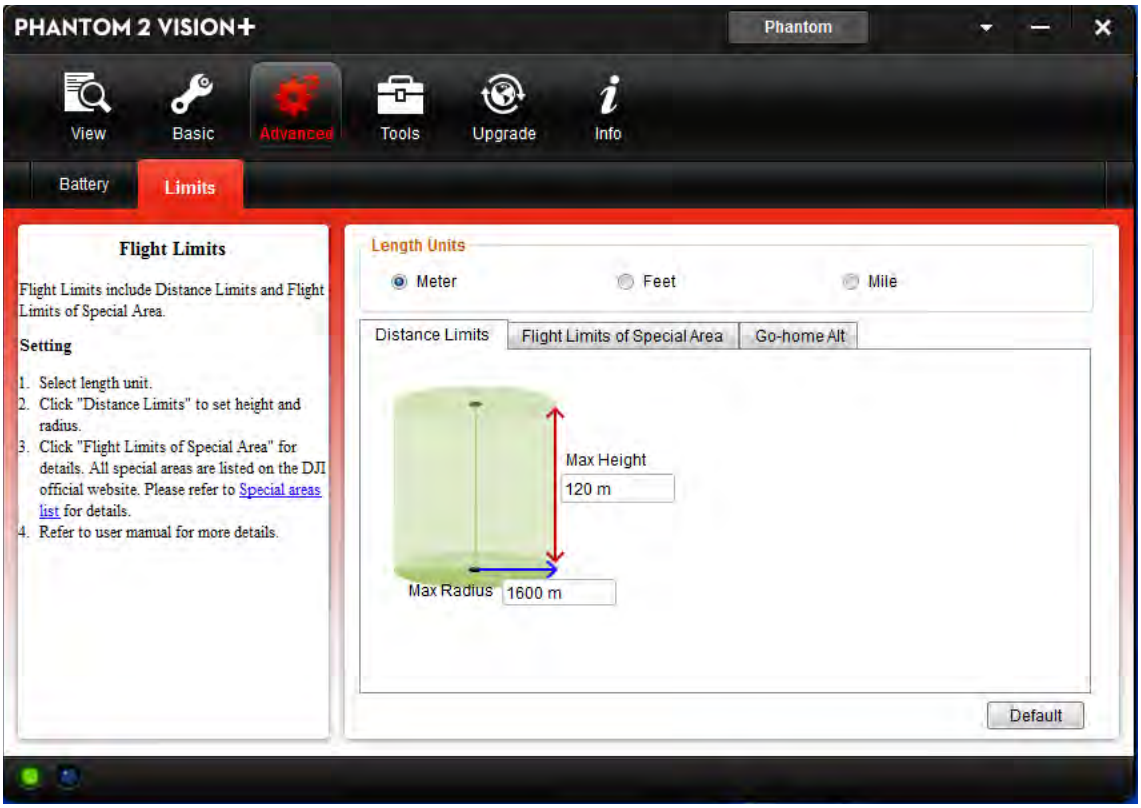


Figure 11: Setting flight limits on Phantom UAV.

Limits also can be set for the Go-Home altitude. This altitude should be set high enough to avoid any overhead obstructions and clear any obstacles that may be between the UAV and the home station (where you took off). For example this would need to clear any trees etc. If the go-home function is triggered the UAV will rise to this pre programmed altitude, travel horizontally to the home point and descend. It needs to have a clear path to do this, since if you aren't able to regain control it will crash into any obstacles.

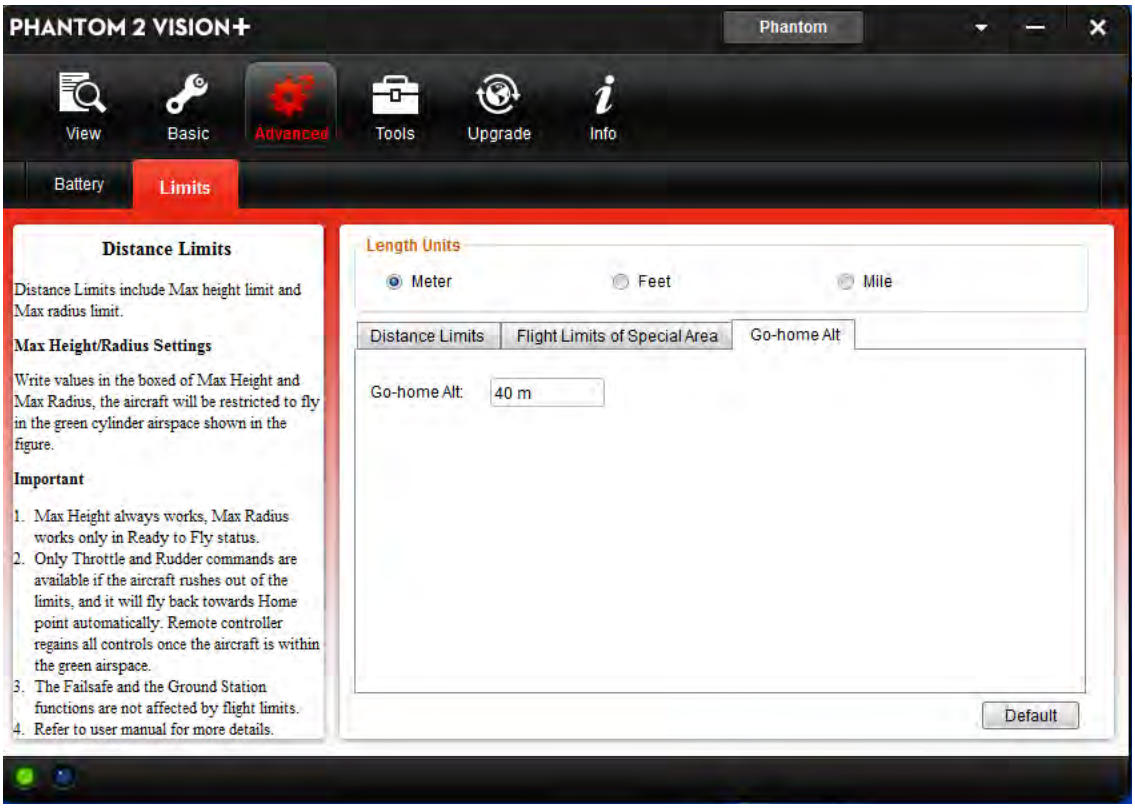


Figure 12: Setting the Go-home function.

Results

The image quality produced by the DJI Phantom 2+ is very high for both stills and video. For the best results we need to ensure that the camera settings are correct for the light conditions as well as that our technique for flying optimizes our chance for obtaining quality images.

The camera on the UAV is set to capture images and tilt controlled via a third party app. The image quality produced is high, though not as high as the GoPro option. The major detractor of the GoPro option is that you loose all ability to control the angle of the camera and stop/start video, switch between video and stills and make adjustments to camera settings as soon as you leave the ground. The GoPro option does not have Wi-Fi control capacity, as a result the settings you have when you launch your UAV are the settings you have until you get the unit back in hand. That being said the difference between the two systems, in terms of image quality is very minor and not likely to make a difference I application unless you are capturing images for movie production purposes, in which case there are specific UAV's for this purpose.

Below are some examples of the stills collected during the feasibility study.

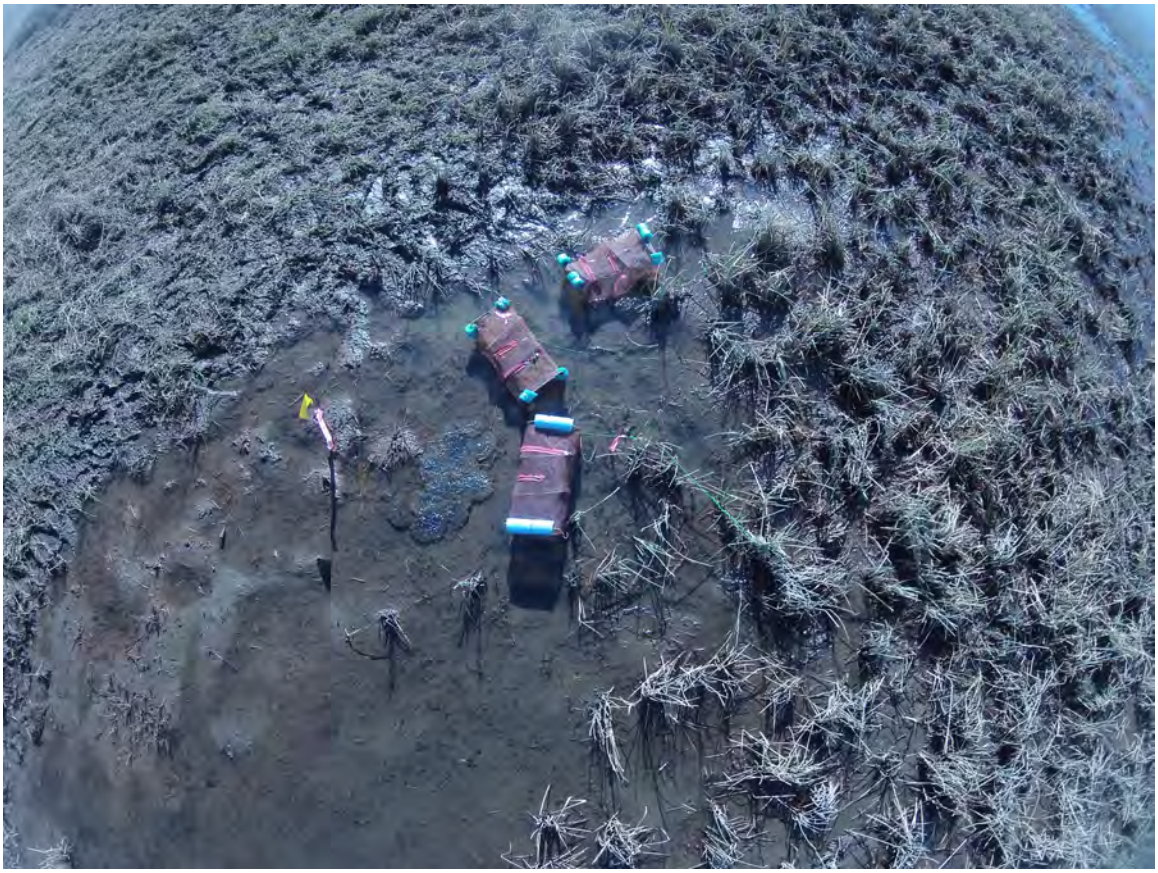


Figure 13: Clearly visible is a cluster of Oregon Spotted Frog egg masses. This image is at approximately 10 feet, with camera settings for high light and low ISO.

Figure 14: Eggs are still visible in this photograph, however distance (>20ft) and angle of this shot make it less than optimal. In addition the camera settings for low light result in the blue tint seen on this image.

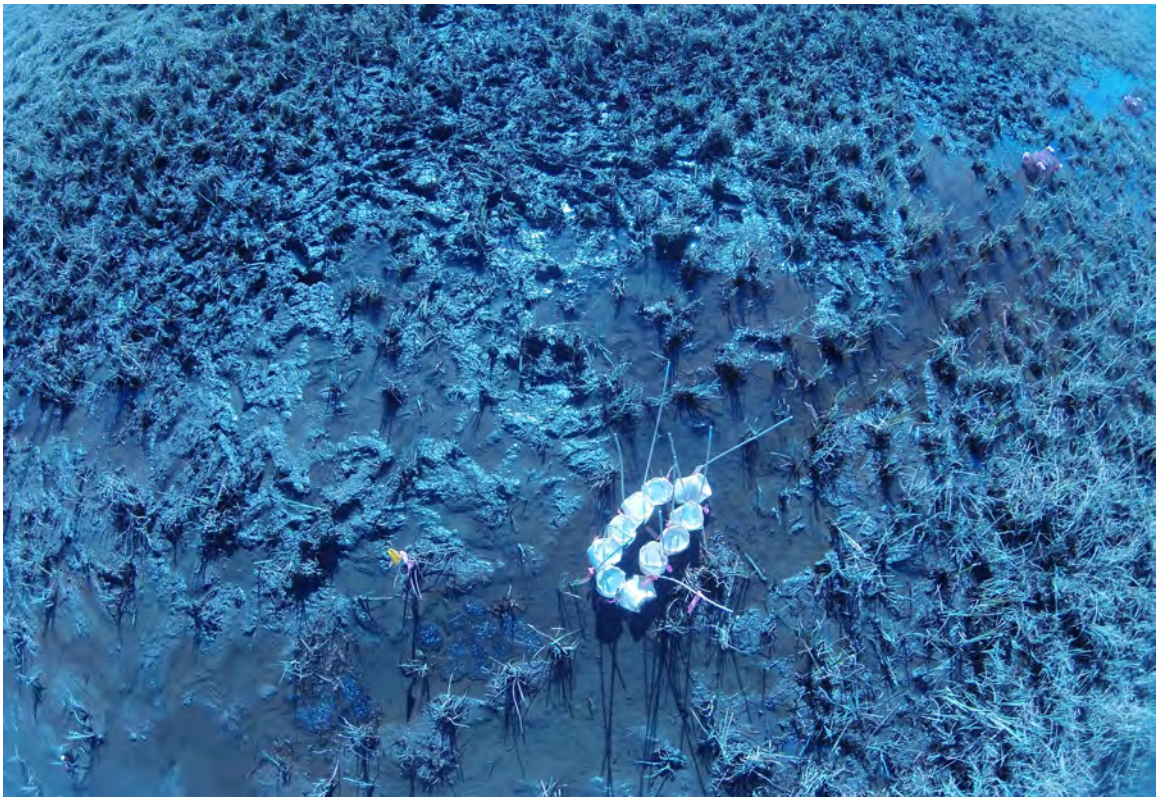


Figure 15: A reasonable camera angle and distance in this shot show eggs still visible but emphasizes the need for correct camera settings to get the best images.

Figure 16: Camera angle on this image shows how areas further from the camera are obscured with glare. Adding the polarized filter would help this, as would increasing the camera angle.

Figure 17: When pointed directly down (increased angle) with correct camera setting we are able to see through water much easier, even without a polarized lens. Camera settings for the right amount of light allow for increased contrast between eggs and background.

Figure 18: This image has proper camera settings however it could be taken at a closer range, particularly for the complexity of the terrain. Eggs in this image are not visible at this height.

Figure 19: This image with appropriate camera settings allows for egg masses to be clearly visible. While this area is quite open, more complicated or grassy habitat would require a closer image.

Figure 20: this image shows the adjustment of the camera angle to decrease glare. Also present is prop-wash, where the movement of the props disturbs the water surface. Egg masses along this shoreline would be clearly visible if present.

Project Equipment/Costs

Currently the UAV market is expanding rapidly. DJI and their Phantom line of UAV's are the leader, by far, in this technology. However, DJI is based in China with very little effective online or offline support services. The UAV enthusiast community, organized online through forums, is an invaluable resource. You will find you are very unlikely to have been this first one with a specific issue or question. The most useful online forum is www.phantompilots.com; this site deals only with DJI Phantoms, in their various incarnations. If you have general RC aviation questions there are many additional forums available, however they deal with all forms of RC aviation (helicopters and planes in addition to UAV's and quad copters) so you have to give very specific information to get an appropriate response.

Within North America there are very few sales and repair centers for DJI products. Within the Fraser Valley we are fortunate to have one such sales and repair center, Flying Cameras in Chilliwack. We have found this company to be very helpful and their prices comparable with the online market.

Prices will continue to come down as UAV's become more popular for research, commercial, and hobby applications. In addition to the UAV itself, there are some accessories that make your flying safer and more efficient:

- Prop guards- it is recommended that prop guards be used during flying. While they make a small difference in reaction of the drone they serve a much more valuable purpose than this detraction. Prop guards will help protect the props and motors from damage if the UAV is toppled, most likely to happen during take off and landing. The prop guards may also help to protect the machine in the case of a minor crash.

  Prop guards could also prevent the props from becoming entangled causing a crash.

  Prop guards are screwed into each arm of the UAV with special extended bolts. Be careful to keep track of the UAV's original small bolts in order to be able to use the machine without prop guards. Keep in mind that the UAV will not fit into the carrying case with prop guards attached.

- Additional batteries- since battery life is limiting having additional batteries charged and ready for use will maximize survey time and efficiency. Charging in a vehicle, via a car charger, is not always the most effective solution and should be reserved for emergencies only. Additional batteries are readily purchased, either from DJI or aftermarket manufacturers such as the Limefuel 5400 mAh. After market batteries do not currently share information with DJI software, though this may change. Limefuel also produces a long life battery (6000 mAh) that gives 25 minutes of flying time. This battery is very new to the market and not available at time of writing.
- Additional charger/Three-in-line charger- charging batteries takes time, additional chargers prove very helpful. There is also available a three-in-line charger (Smatree

SmaPow 3 channel charger) with three ports. This charger will sequentially charge three batteries, making mass battery charging more efficient.

- Additional SD cards- additional SD cards, class 10, allow you to quickly change out memory and can also stand as an image backup.
- Location beacon- a locator beacon, such as a Tracker device would be useful in the event of a fly away.
- Flotation/craft recovery device- attaching a large-scale floatation device, such as floatation pontoons voids the UAV warranty. A small-scale recovery device is a better option, such as a Getter-back, fishing rod recovery float that will deploy in a few feet of water allowing you to recover a craft that has sunk.
- Backpack style case- a backpack style case is ideal for transporting your UAV and gear safely. Personal preference decides, however backpack style is more effective that briefcase if you are accessing remote locations.

Summary of equipment for our project:

Item	**Cost CAD (conversions from USD noted)**
Phantom Vision 2+	$1689.00
Battery (DJI)	$168.99
Batteries (Limefuel)	$119.00 (from USD)
Charger	$50.00 (from USD)
Backpack	$259.00
Prop guards	$22.00

Conclusions

Using the UAV to search for and monitor amphibian breeding is likely to be a very useful tool. During the course of the work we were able to capture some high quality stills and video of the habitats including some footage of OSF egg masses.

The ability to cover a large amount of area, while decreasing disturbance and ensuring full coverage are benefits of this method. Viewing areas from above decreases the number of passes to effectively cover an area and allows visualization of both sides of barriers.

While this method will not replace ground truthing for egg mass number (we can not tell if egg masses are overlapping), egg survival, or determine species in questionable cases, it will be valuable as a tool in other respects. For example this type of monitoring and surveying would work well for checking known breeding sites at the start of egg laying

season, checking on the status of known nests, general surveying of large areas, surveying of detailed areas followed up by ground truthing, surveying of habitat, as well as checking large stretches of linear ditch systems.

Applications for this technology in the broader conservation community are extensive and exciting. We look forward to seeing where this work will lead, not only for Oregon Spotted Frog, but also for other species and conservation work.