Image Acquisition for 3-D Mapping with DJI Phantom 3 Pro

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Contents

Overview

This series of manuals are intended to facilitate the safe use and teaching of unmanned aerial systems (UAS) to a wide variety of programs and teaching areas at BCIT. The ubiquitous and positively disruptive nature of UAS make them an excellent additional tool for the collection of spatially accurate data including photos and videos in a variety of applications. From Geomatics to Forestry and from Marketing to Forensics, UAS are quickly becoming indispensable due to their rapid deployment capability, ability to provide a unique perspective in difficult to reach areas and safely gather a rich data set in a short amount of time.

The demand for data captured by UAS is increasing at BCIT across the province and in fact around the globe. These manuals aim to rapidly and effectively transfer knowledge to those who are interested in leveraging this technology in their specific fields of interest and expertise. The manuals are divided into main categories; **Image Acquisition** and **Image Processing**. The Image Acquisition manuals are platform and sensor package-specific with the goal of being able to pick a specific UAS and camera combination and fly a pre-programmed, semi-autonomous mission in order to gather a specific set of images or videos. The Image Processing manuals can be used as standalone or as a follow-on from the Image Acqusition manuals. These focus on the most effective photogrammetric processing techniques in Agisoft Photoscan Professional given the specific data set and image type. Each of the Image Processing manuals is accompanied by a sample data set that provides a complete walk-through of the processing steps or they can be used to generate a variety of different 3-D mapping products using a user-supplied images.

Preface

This series of manuals are intended to facilitate the safe use and teaching of unmanned aerial systems (UAS) to a wide variety of programs and teaching areas at BCIT. The ubiquitous and positively disruptive nature of UAS make them an excellent additional tool for the collection of spatially accurate data including photos and videos in a variety of applications. From Geomatics to Forestry and from Marketing to Forensics, UAS are quickly becoming indispensable due to their rapid deployment capability, ability to provide a unique perspective in difficult to reach areas and safely gather a rich data set in a short amount of time.

The demand for data captured by UAS is increasing at BCIT across the province and in fact around the globe. These manuals aim to rapidly and effectively transfer knowledge to those who are interested in leveraging this technology in their specific fields of interest and expertise. The manuals are divided into two main categories; **Image Acquisition** and **Image Processing**. The Image Acquisition manuals are vehicle- and sensor-specific with the goal of being able to pick a specific unmanned aerial vehicle and sensor combination and fly a pre-programmed, semi-autonomous mission in order to gather a specific set of images or videos. The Image Processing manuals can be used as standalone or as a follow-on from the Image Acquisition manuals. These focus on the most effective photogrammetric processing techniques in Agisoft Photoscan Professional given the specific data set and image type. Each of the Image Processing manuals is accompanied by a sample data set that provides a complete walk-through of the processing steps or they can be used to generate a variety of different 3-D mapping products using a user-supplied images.

Part 1 - Preparing UAS for Image Acquisition

Overview

This manual guides you through the steps of preparing and flying the **DJI Phantom 3 Professional** unmanned aerial system (UAS) for photogrammetric image acquisition for the purpose of creating 3-D maps. Possible 3-D map products may include;

- sparse and dense point cloud
- 3-D textured mesh surface
- digital surface model (DSM)
- true orthophoto mosaic

The following manual Parts provide guidance for each step of the process;

- Pre-Operations
- Image Acquisition
- Post-Operations

Following image acquisition, the manual ***Processing UAS Photogrammetric Images in Agisoft Photoscan Professional*** can then be used to generate the 3-D map products listed above using Agisoft Photoscan Professional software.

Part 2 - Preoperations

Overview

This Part outlines the steps of performing preoperations in the lab prior to flying the image acquisition mission. This is a critical aspect of operations during which the UAS is prepared to safely and efficiently carry out the mission. All hardware and software components are tested and configured prior to heading out to the field in order to ensure safety and mission success.

Chapters included in this Part are;

- Component Inspection
- Preoperations
- Packing up UAS

Ideally, preoperations are carried out at least one day prior to flying the mission in order to allow sufficient time to charge batteries, update the firmware, software and applications and address any minor technical concerns.

Chapter 2.1 - Component Check

Overview

The UAS you will be flying may not have been used recently and thus it is imperative to assess its airworthiness and potential to safely and efficiently carry out the intended mission. The first step is to ensure that all mission-critical components are in the case and to visually assess their condition. If any component is deemed to be not airworthy, damaged, broken, unsafe or otherwise not functioning correctly, the System Maintainer, Chief Instructor Pilot, or Chief Payload Operator must be notified immediately prior to proceeding with the mission.

Component Inspection

For the DJI Phantom 3 Professional, the following items must first be verified and examined;

- Phantom 3 Professional UAS with camera and gimbal – *Check camera lens for any scratches. Remove safety bracket by gently sliding it off and ensure gimbal is secured to aircraft.*

A Vimeo element has been excluded from this version of the text. You can view it online here: https://pressbooks.bccampus.ca/phantom3pro/?p=25

DJI Phantom 3 Professional UAS

- MicroSD Card – *Access the slot as shown below to make sure the MicroSD card is installed.*

Close up of MicroSD Card on DJI Phantom 3 Professional

- Controller – *Press power button once to check battery level (charge if less than 100%), test flight controls and ensure that phone/tablet holder is secured properly and that the tilt adjustment screw is not too loose (tighten with flat-head screw driver if necessary).*

Phantom 3 Professional Controller

- Batteries – *Press power button on each battery to check battery level and charge if less than 100%. Check battery contacts for any debris or corrosion. Clean with a cloth or fine-grained sandpaper if necessary.*

DJI Phantom 3 Battery

- Propellers – *Inspect each propeller (including any spares) for*

cracks, chips or other damage. Damaged propellers should never be used.

DJI Phantom 3 Propellers

- Charger – *Ensure that the UAS battery and controller charger and all associated cables are present and working.*

DJI Phantom 3 Professional Charger

- iPad and charger with cable – *Check battery level (charge if not 100%) and switch on (use passcode 4679) to test function.*

iPad with Charger & Cable

If all of the above components are present and in what is deemed to be in good working order, the next step is to assemble the UAS and ensure all the components are working correctly together.

Chapter 2.2 - Assembling & Testing UAS

Overview

In the previous chapter, it was verified that all required components are present and in good visual order. In this section, all of the components are assembled and tested for proper functionality in the lab in preparation for mission planning.

Preoperations

Before proceeding, it is very important to ensure that the protective camera and gimbal bracket has been removed. If the UAS is powered on with the bracket in place, it may seriously damage the gimbal motors.

To attach the propellers, note the silver and black center markings and match them up with the sliver and black dots on the motor centers. Also note the direction in which the sliver and black propellers are tightened.

DJI Phantom 3 Professional propellers and markings

DJI Phantom 3 Professional with propellers attached

Power on the iPad and use passcode 4679 to log in.

Check for Updates
1. Check if iOS requires an update and proceed with update if necessary.
2. Check if the DJI GO and Pix4Dcapture apps require an update and proceed with updates if necessary.

Power on the the controller by pressing the power button and then holding down the power button until all the white lights illuminate. Now insert a fully charged battery in the aft slot of the UAS by sliding it in with the correct orientation of contacts until it firmly clicks in place. Ensure that the battery cannot be removed without squeezing both tabs on the top and bottom of the battery.

Power on the UAS by pressing the power button once then holding it down until all the green lights illuminate on the battery. Verify that the green light on the controller is illuminated and that the rear indicator lights on the UAS are blinking green.

Attach the iPad to the controller and plug in the USB cable as shown below

DJI Phantom 3 Controller with iPad

In the iPad, enter the **UAV** folder and open the **DJI GO** app. On the welcome page, tap **Camera** at the bottom. Within a few seconds the UAS will connect to the controller and this will be reflected in the **DJI GO** app. If the UAS does connect with the controller after a few seconds, power cycle (turn off then on) the controller and UAS using the sequence above.

The first screen you will see is the one shown below. This screen provides important information about the status of the UAS and it is critical that this information is reviewed carefully prior to each mission. In the example below, the **Radio Channel Quality** is **Poor** indicating strong interference with other sources of radio signals such as WiFi routers, 2.4 or 5.8GHz phones or radios, etc. This is typical of an indoor environment.
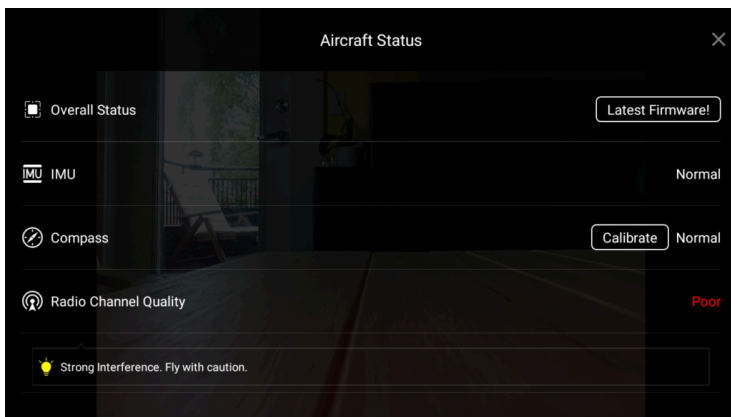

Status screen of the DJI GO app.

<table>
<tr><td align="center">**Check for Updates**</td></tr>
<tr><td>Check the **Overall Status** to make sure that that the **latest firmware** is installed. If not, tap **Update Firmware** and follow the instructions.</td></tr>
</table>

Tap the X in the top right of the status screen to close it once it has been carefully reviewed. The **DJI GO** app shows the view through the camera on the UAS as the main screen. This view reflects either the view of the still camera for taking photos, the video camera for recording video clips or the map.
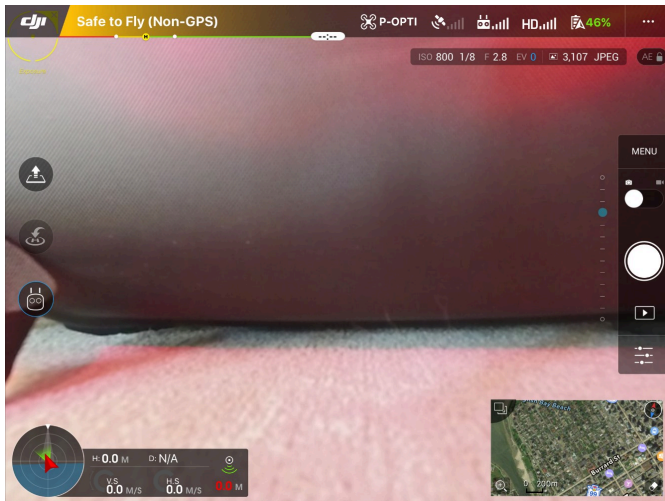
Sample screenshot of DJI GO app

Along the right side of the screen, the toggle between photos and video is at the top, followed by manual or auto mode settings, then the shutter release button (for both photo and video), photo/video playback button and advanced camera settings at the bottom. Camera angle is indicated along the left side of the toolbar.

Along the top of the screen, there is an indication of the flight mode that the UAS is currently in (the sample shows that the UAS is in non-GPS mode because no satellites are visible indoors). To the right of this are symbols showing the flight mode of the UAS (currently in P-OPTI mode), the number of GPS satellites locked on (none), the signal quality between controller and UAS (high), the quality of the video feed from the camera on the UAS to the controller (high), the battery level of the UAS (46%) and access to menu

settings (… symbol). Below the main bar is a read out of the camera settings including ISO, shutter speed, f-stop, exposure value (EV), number of frames remaining and auto-exposure lock status.

Along the left side of the screen, the top button is used to launch the UAS, second button from the top updates the Return-To-Home point (GPS lock to at least eight satellites is required) and the bottom button access the advanced flight modes.

Along the bottom of the screen, on the left side is the UAS telemetry cluster. The direction and flight path of the UAS are shown along with the height (H:), distance (D:), vertical speed (VS) and horizontal speed (HS) of the UAS and distance of the UAS to nearest obstacle. The bottom right of the screen shows either the map or camera view which can be toggled by tapping it.

Once all the settings in **DJI GO** have been verified, switch off the app by double-clicking the Home button to access the fast app switcher and flick the **DJI GO** app up and off the screen. This must be done before proceeding to the next step.

From the **UAV** folder on the iPad Home screen, launch the **Pix4Dcapture** app. Tap **Settings** in the top toolbar and verify that the **Drone** and **Camera** are set to **DJI Phantom 3 Professional**. Check that **Units** are set to **Meter** and that the **Auto download images when mission ends** option is switched **off**. Tap **Close** to return to the home screen.

Tap **Project List,** tap **Project 00022** and tap **Open**. You should should see a view similar to one below.
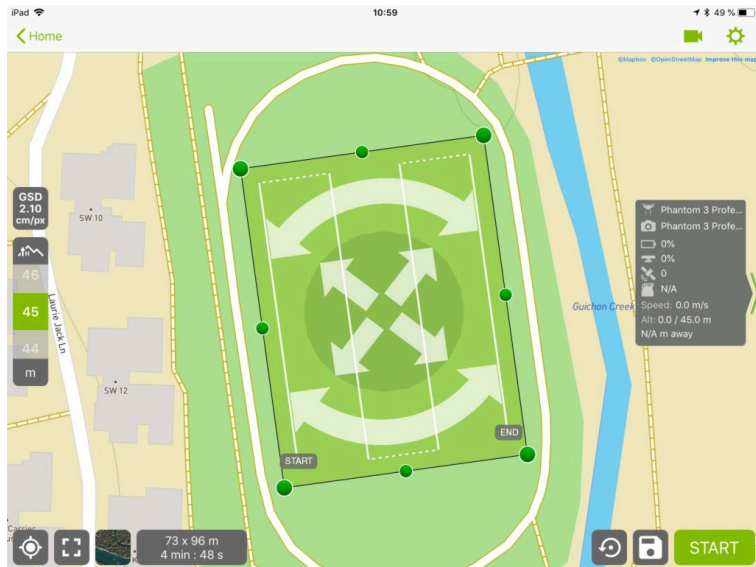
Pix4Dcapture mission planning screen

The main view shows the planned mission area in green overlaid onto a map or satellite view. The mission area can be resized (green grab handles), rotated (two curved arrows) or re-positioned (four directional arrow in the center).

Along the top of the screen, starting from the left side, there is a **Home** arrow to navigate back to the previous screen, a **Camera** icon to switch between map view (the current view) and camera view, and **Gear** icon (settings).

Along the left side of the screen, starting from the top, is the ground sampling distance (GSD) and the flying height adjustment scale.

Along the bottom of the screen, starting from the left, is the re-center on current position icon, the re-center on mission area icon, a toggle between map and satellite view, a read out of the mission area dimensions and estimated flight time, a reset mission area icon, save mission icon, and the start mission button.

Along the right side of the screen is the status pane showing the name of the UAS and the camera, percent battery remaining on the UAS, percent battery remaining on the Controller, number of satellites acquired, remaining capacity of MicroSD memory card, UAS speed, altitude and distance from Controller.

Tap the **Gear** icon (**Settings**) to verify mission settings as per the screenshot below.
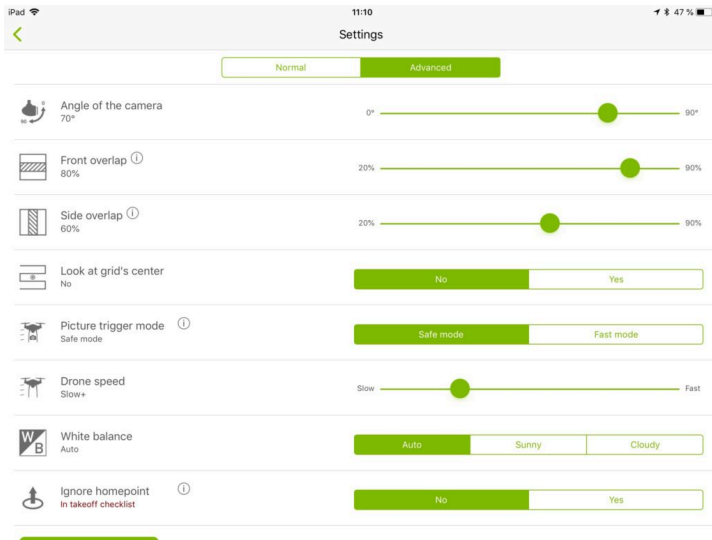
Setting options in Pix4Dcapture

Tap the **Gear** icon to close the settings menu.

Packing Up UAS

All of the preoperational checks are now complete. Follow the steps below to pack up the UAS and prepare it for an image capture mission.

> 1. Power off the UAS by pressing the power button on the battery once followed by a long press until the green indicator lights are off.

> 2. Remove the battery from the UAS by squeezing the top and bottom buttons on the battery and sliding it out. Connect the battery to the charger if fewer than four indicator lights are displayed.

> 3. Power off the Controller by pressing the power button on the battery once followed by a long press until the white indicator lights are off. Connect the charger if fewer than four indicator lights are displayed.

> 4. Power down the iPad (fully off, not sleep mode), unplug the USB cable and connect the charger if battery is less than 90%.

> 5. Remove the propellers and store them in the protective pouch.

> 6. Replace the protective camera gimbal bracket by sliding it on as shown in the video below.

A Vimeo element has been excluded from this version of the text. You can view it online here: https://pressbooks.bccampus.ca/phantom3pro/?p=33

Once all batteries have been fully charged, store the Controller, iPad, charger, propellers, battery, and UAS back in the case and secure the safety   strap.

Part 3 - UAS Operations

Overview

This Part outlines the steps of safely carrying out the pre-programmed image acquisition mission.

Specific sections included in this Part are;

- Operational Briefing
- Pre-Flight Operations
- Flight Operations
- Post-Flight Operations

A safely completed image acquisition mission results in a high quality image data set which can subsequently be used to create accurate, 3-D map products such as point clouds, 3-D mesh surfaces, digital surface models as well as orthophotos.

Chapter 3.1 - Flight Operations

Overview

At this point, all of the preoperational checks have been completed including batteries charged, software and operating system updated, UAS, Controller and intelligent flight battery firmware checked and updated and all mission-critical elements verified for flight worthiness. This chapter takes place outdoors and on location where the image acquisition mission will take place.

Operational Briefing

Be aware that a minimum of two individuals are required to conduct any UAS mission; a pilot-in-command (PIC) and a safety spotter. Additional personnel may be needed as ground access control crew according the specific mission safety and security plan. Safety spotters and ground access control crew *must* be briefed on their roles and responsibilities prior to heading to the field.

A weather check must be performed in order to verify the following minimum operational parameters;

- Visibility at least 2 statute miles (3.2km)
- Winds less than 30km/h
- Ceiling at least 1,000ft
- Temperature above 0 deg Celsius
- No icing conditions

Notice to Airmen (NOTAM's) must also be checked to ensure no conflicts with any other manned or unmanned air operations.

Prior to heading to the mission area, make sure to have with you the following items;

- UAS case with all mission-critical components packed safely inside
- Weather-clothing and footware
- Valid Transport Canada-approved Special Flight Operations Certificate, Certificate of Completion of UAV Ground School, valid

insurance certificate, valid radio operators certificate (if required), current MAAC membership (if required), current Flying Club membership (if required), pre-flight and emergency checklist(s)

- High visibility safety vest
- Protective eyewear (sunglasses are fine)
- Safety cones, signs and flagging tape (if required)
- Two-way radios
- Hand-held anemometer (if available)
- Foldable landing pad

Pre-Flight Operations

Once on site, visually double check the weather conditions. If a hand-held anemometer is available, verify wind velocity and direction. Inspect the proposed take-off landing site to make sure it is clear of any debris and obstacles. Check the proposed mission area to ensure that the planned mission height is sufficiently above any structures or obstacles.

Set up safety cones around the take-off area and deploy the safety spotter and any ground access control personnel to their pre-defined positions. Test two-way radio communication and only rely on cell phone communication as a back up.

Set up the landing pad and unpack the UAS as per the instructions in the previous chapter. Once the UAS and associated components (Controller and iPad) are switched on and connected, proceed to the next section.

Flight Operations

In order to consistently log all UAS flights, locate and launch the **UAV Logbook** app and tap **Quickstart** to start logging the mission.
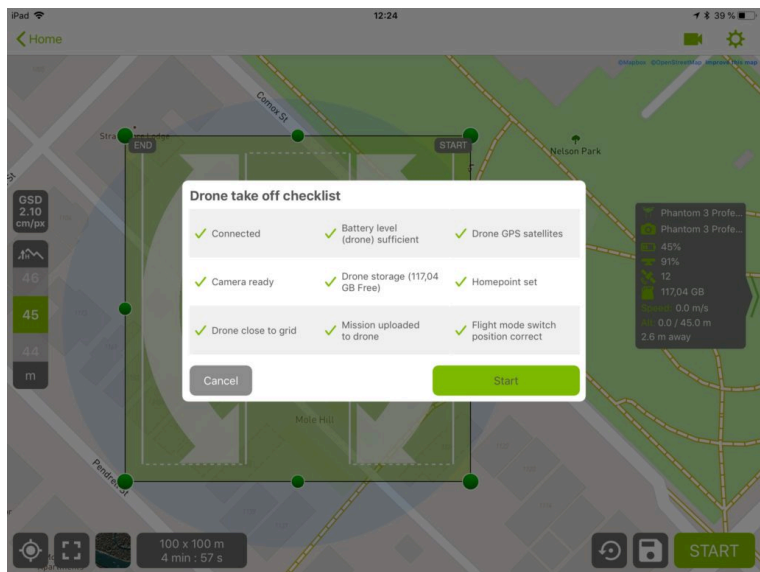
At this point check that the rear green indicator lights on the UAS is blinking, the green indicator light on the Controller is solid green and the Pix4Dcapture app is open with the appropriate mission as per the screenshot below.
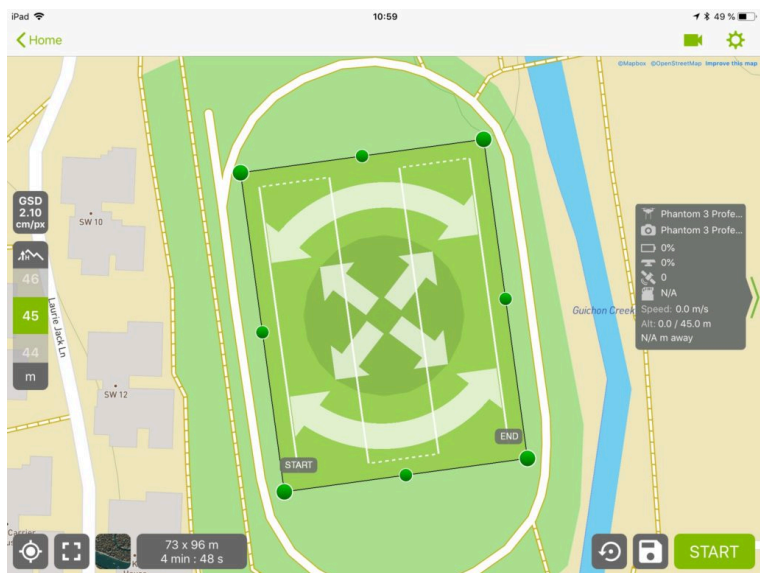
Pix4Dcapture mission planning screen

Tap **Start** and verify connection with the drone then tap **Next>**.

Pix4Dcapture take-off checklist

Pix4D Capture verifies all mission-critical parameters via the check list above. Conduct one last visual assessment of the take-off zone, announce loudly and over the two-way radio "**TAKE OFF!**" and tap **Start**. The UAS will immediately take-off and proceed to the first way point.

As the mission now proceeds semi-automatically, the main task for the PIC is to maintain visual contact with the UAS at all times and to ensure that the mission is proceeding at the correct altitude, heading in the correct direction along the pre-programmed route and that the camera is being triggered at the desired interval. The main role of the safety spotter during the mission is to maintain visual contact with the UAS and immediately notify the PIC of any hazards or departures from the pre-programmed flight (e.g. fly away or sudden loss of power/control).

During flight, the camera view can be checked by tapping the camera icon in the upper right which opens a small window which can be expanded by tapping the icon in the bottom left of the window. Exposure can be manually adjusted by rolling the dial accessible by the right index finger on the controller.

Once the image acquisition mission is complete, the UAS will climb to the pre-determined fly-home altitude and return to the take-off spot for automated landing. The main task for PIC is to maintain visual contact with the UAS to ensure there are no obstacles or structures in the path of the UAS as it returns home. Once the UAS begins to descend, the PIC will announce loudly and over the two-way radio "**LANDING!**" and perform a quick visual inspection to ensure the landing zone is clear.

Alternate Landing Zone
If, for whatever reason, the primary landing zone becomes obstructed and the UAS cannot be safely landed there, the PIC will announce loudly and over the two-way radio "**ALTERNATE LANDING ZONE!**" and proceed to guide the UAS to a safe landing in the alternate location.

The UAS will automatically attempt to land where it took off from, but due to GPS errors, this may vary by up to 5m. Thus, the PIC should gently manually guide the UAS as it descends to ensure it lands in the correct spot on the landing pad.

Post-Flight Operations

Once the UAS is safely on the ground and the engines have been shut down, the PIC should perform a quick assessment of the continued airworthiness of the UAS by checking the following;

- Condition of propellers (any nicks or cracks)
- Temperature of motors (check for excessive heat)
- Temperature of battery (does it feel too hot to touch?)
- Condition of the lens (does it need to be cleaned?)

Once the PIC has verified further airworthiness of the UAS, they have two options depending on mission requirements;

> 1. Complete the mission and proceed to pack up the UAS for transport back to the office, or;
>
> 2. Turn around the UAS for another flight.

UAS Turn-around

The PIC will notify the safety spotter and ground access control crew (if present) that the UAS is being turned around and to standby for further instructions.

It is strongly advisable to check the image quality on a laptop by removing the memory card from the UAS and inserting it into a compatible MicroSD memory card adapter. This allows for a better means of assessing image quality than can be done on the iPad in the Pix4Dcapture app. Images should be checked for correct number of frames, exposure, focus and presence of any motion blur. Should any aspect of image quality not be to the expected standard, the PIC must make the decision whether to re-fly the mission or not.

If the next flight is short enough to be carried out using the same battery, the PIC will follow the steps outlined in the Pre-Flight Operations section. If a battery swap or recharge is required, the UAS will need to be powered off and a fresh battery inserted. Controller and iPad battery status should also be checked along with the remaining capacity of the memory card.

Complete Mission

Prior to ending flight operations, it is strongly advisable to check the image quality on a laptop by removing the memory card from the UAS and inserting it into a compatible MicroSD memory card adapter. This allows for a better means of assessing image quality than can be done on the iPad in the Pix4Dcapture app. Images should be checked for correct number of frames, exposure, focus and presence of any motion blur. Should any aspect of image

quality not be to the expected standard, the PIC must make the decision whether to re-fly the mission or not.

Once the images are deemed to be of sufficient quality, the PIC will notify the safety spotter and ground access crew (if present) that the mission is complete and to rendezvous at the landing or alternate landing zone.

Switch to the **UAV Logbook** app and enter in as much of the pertinent information as possible referring to the sample screenshot below.

Sample of UAV Logbook app

With the mission complete, follow the steps in the Packing Up UAS section and proceed back to the office for the Operational Debrief.

Overview

Once the mission is flown and images safely acquired, the next step is to head back to the office for an operational debrief. The main purpose is to verify that the mission proceeded according to plan and that the correct data set was acquired. Equally important are the things didn't go quite as planned in order to improve the safety and efficiency of the operation in the future.

Assessing Mission Success

There a number of factors determining mission success;

- Safety
- Image quality
- Communication
- Efficiency

Safety

Safety is of utmost importance because it directly affects the ability to carryout subsequent missions. This is why it is imperative that all UAS operations are conducted with safety first and foremost in mind. Safety itself can be evaluated based on a number of criteria such as equipment, personnel, property and the public. It is worthwhile to discuss any areas where safety may have been compromised and where it can be improved.

Image Quality

The main goal of a photogrammetric image acquisition mission is to safely and efficiently collect the correct number of high quality images for subsequent processing. Thus, even though a mission may have been deemed successful from a safety standpoint, it could be a failure if the right number of quality

images are not captured. Any areas or procedures that may have compromised capture of quality images, should be evaluated.

For example, the effect of manual versus automatic photo capture settings in DJI GO app may result in images that are too dark, over exposed or blurry. Also using JPG versus RAW image format can affect post-processing steps. Images with insufficient overlap, taken at an altitude that is too high to see objects of interest or where the ground isn't clearly visible due to trees, shadows or other obstructions may negatively affect the outcome of a mapping project.

Communication

Communication between the PIC and team should not be underestimated. If the PIC does not clearly communicate what they are presently doing and their next intentions, the safety spotter and possible ground access control crew may be left wondering what stage the operation is at. Simple, frequent updates as to what is happening with the UAS will help the ground crew understand what they should be doing at any given moment.

This becomes even more important when the ground access control crew is managing access to the flight area. It is helpful to brief the crew when to expect communication and what is expected of them at each stage of the operation.

Mission Efficiency

Efficiency of the operation cannot take priority over safety, image quality or communication and yet it can definitely affect mission success. If the mission cannot be completed in the allotted time or at a certain time during the day, it can result in mission failure. For example, if a planned daytime flight cannot be organized with sufficient time before sunset, it will have to be aborted. Rapidly changing or deteriorating weather conditions can also cause inefficiently planned or executed missions to be grounded. Sometimes equipment issues will require re-flights (e.g. blurry images due to improperly focusing camera) or a software app becomes unresponsive.

One of the main benefits of post-operational debriefs is to improve safety, ensure quality image, improve communications and raise the level of efficiency of future UAS operations.

Post-Operational Debrief

Once the UAS and crew are back in the lab or office, the UAS and components need to be removed from the case and cleaned of any debris (dust or grass). Batteries need to be connected to chargers and images downloaded to a workstation from the memory card. Any equipment issues need to be documented in the **UAV Logbook** app under the correct mission.

Once the data have been downloaded and verified, the memory card should be formatted in preparation for the next mission and inserted back into the UAS slot. When the flight batteries, Controller and iPad have been fully recharged, all components need to be securely placed back in the case and the case returned to the safe storage area.

Official DJI Phantom 3 Professional website for manuals, documents, firmware updates, software and drivers

Official DJI GO app website

Official Pix4Dcapture website