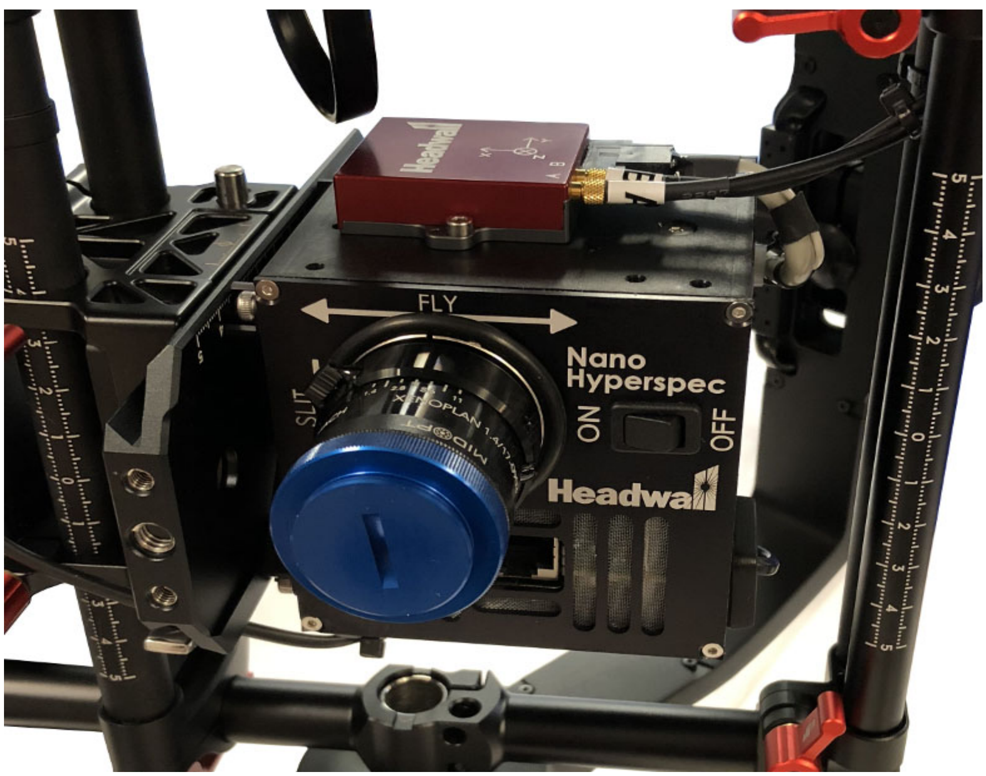
Headwall

NANO-HYPERSPEC® AIRBORNE PACKAGE



Operations Manual

CD-1543 Rev B

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DOCUMENT REVISION TRACKING

Table 1-1. Document Revisions

Date	Name	Page	Detail
6/2016	Chenevert	46	Added note about closing the live video and waterfall views to prevent GPS data drop. Added steps for remote trigger using GPIO functionality.
7/5/2016	Chenevert	1-14,15	Added detail about IMU connections. Added information about flight planning in that section of book. Included use of FOV calculator for planning and operations.
9/2016	Chenevert	1-3, 1-5	Added details for features, identified positioning of IMU so no interpretation by users, Updated for features added since last editing
5/2018	Chenevert	Cover	Change to updated image on gimbal. 1-5 added details for payload addition,
6/2018	Chenevert	Multi	Changed images for GPS trigger polygon function, updated kml import function
9/2018	Chenevert	Multi	Updated images for UgCS, polygon tools and detailed functions of airborne flight planning. Organized to follow the steps used by Headwall pilots
6/2019	Chenevert	Multi	Added section covering co-aligned unit

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Table of Contents

CHAPTER 1 NANO AIRBORNE PACKAGE OPERATION

The airborne package is a combination of hardware, consisting of the motion tracker, IMU and GPS antenna, and software that operates with the Nano-Hyperspec® (Nano). The airborne tracking software is integrated into the Hyperspec® III software installation and operation. The airborne package is used to plan and execute aerial data collection, and then seamlessly adjust the orthogonal perspective of data collected from manned or UAV flights.

The orthogonal adjustment is done within the SpectralView® application of Hyperspec® III. For the software to effectively manage and correct the data cube during the ortho-rectification process the initial position of the IMU needs to be set, so the correct orientation off-sets can be applied to the post processing algorithms. The IMU is set at the Headwall facility prior to shipping. All Nanos are flown and have data cubes orthorectified prior to shipping.

NOTE

If the customer is using an IMU purchased from a source other than Headwall they need to closely follow the directions of the IMU manufacturer. Additionally, the customer is responsible for developing the bore-sighting co-efficients for the assembled system.

The following is a list of the components that make up the standard airborne package covered in this section. The complete sensor system, as delivered, may have additional or alternative components, as ordered. These alternative components are identified in the system documentation enclosed with the unit. This chapter deals only with the Headwall IMU, GPS antenna and Nano combination airborne package. The Applanix IMU information is contained within that chapter of this manual.

1.1 NANO-HYPERSPEC® — AIRBORNE PACKAGE COMPONENTS

The Headwall Standard Airborne Package contains the following hardware components.

(1) Nano-Hyperspec® Unit

- (a) Nano-Hyperspec® sensor
- (b) Provided lens

(2) Airborne Package (GPS)

- (a) IMU, Headwall
- (b) Flash drive with Hyperspec® III software and Nano calibration data, sample flight data, manuals and supporting documentation
- (c) GPS Antennas
- (d) Antenna mounting hardware

(3) Cat 6 Cable, 5 ft.

The antennas for the Headwall IMU need to be mounted a minimum of a half meter apart, and have a clear view of the sky. When the airborne package is shipped with the UAV, the Nano and antennas are mounted onto the flight platform.

The Headwall IMU is mounted onto the Nano-Hyperspec® prior to, and during operations. The power to operate the supplied Headwall IMU comes through a connection with the Nano-Hyperspec®. Once powered and operating, the IMU will transmit the unit's GPS location and orientation, such as yaw, pitch or roll, to the Nano for inclusion into the data cube for the particular scan. For each performed scan, the Nano stores the data cube in the scan folder in its memory. Once the scanning is completed the file contents, the data cube, can be downloaded from the Nano to the identified and licensed computer, using the Transfer feature within Hyperspec®III.

AIRBORNE PACKAGE

The operation of the Nano-Hyperspec® unit is covered in the manual for that device. The Nano-Hyperspec® is identified within the individual components section of Airborne Operations for ease of instruction.

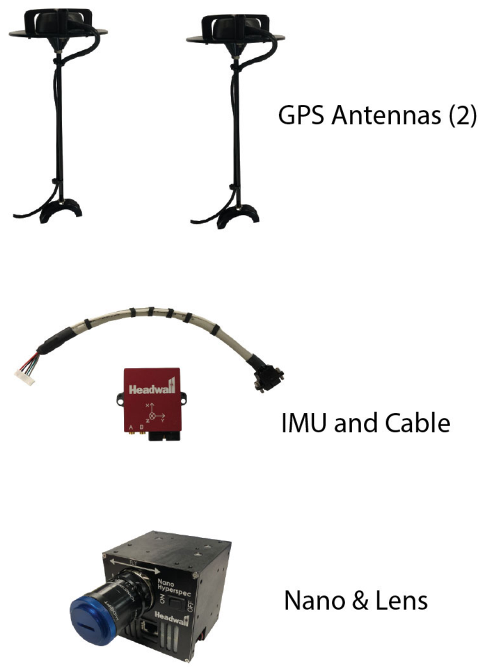

Figure 1-1. Nano-Hyperspec® — Airborne Package.

1.2 INDIVIDUAL COMPONENTS

1.2.1 Nano-Hyperspec®.

Figure 1-2. Nano-Hyperspec®, with Lens.

1.2.2 IMU.

The IMU weighs 58 grams. When mounted to the Nano-Hyperspec®, it sends positional data to the Nano for storage, and inclusion into the scan data file. The positional data from the unit is then used for ortho-rectification of the scan data within the SpectralView® application. The Headwall supplied cable, used to connect the IMU to the Nano, is the minimal length, to eliminate any interference.

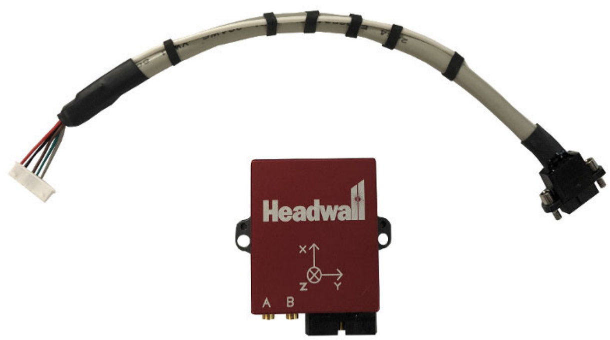

Figure 1-3. IMU

The software to operate the IMU and generate positional data is embedded within the device. The software to interpret the positional data is integrated into the Hyperspec® III software. During the system software loading and system set up process, the Nano-Hyperspec® and IMU units are configured to operate together. When ordered together this integration is done at the Headwall facility prior to shipping.

The IMU specifications are listed in the following table. The value CEP is (Circular Error Probability), defined as the radius of a circle centered on the true value that contains 50% of the actual GPS measurements. So a receiver with 1 meter CEP accuracy will be within one meter of the true measurement 50% of the time. The other 50% of the time the measurement will be in error by more than one meter.

Table 1-1. IMU Specifications

Parameter	Value
GPS Update Rate	4 Hz
Horizontal Accuracy Position SPS	2.5 m CEP
SBAS	2.0 m CEP
Vertical Accuracy Position SPS	5 m
Velocity accuracy	0.1 m/s @ 30 m/s
Start-up Time, Cold start	27 s
Re-acquisition	< 1 s
Tracking Sensitivity	-161 dBm
Timing Accuracy	30 ns RMS

Table 1-1. IMU Specifications

Parameter	Value
Maximum Altitude	18 km
Maximum Velocity	515 m/s
Max dynamics GPS	4 g

1.2.3 GPS Antennas.

The GPS antennas are used to define the initial location of the Nano-Hyperspec® unit once the IMU has been installed. Three types of IMU and antennas are presently available for Headwall remote sensing applications: Xsens, Headwall and Applanix APX-15. During flight, the GPS antenna captures the location of the system and sends that data to the IMU and Nano for inclusion into the overall flight data. Within the data capture folders two files identify the GPS data, the Frame Index file and the gpsMonitor file. To optimize results, the GPS antenna should be positioned a minimum of 50 cm apart on the drone. The GPS antenna positional information is also used for triggering the Nano for flying a remote triggered, pre-defined polygon pattern. Polygons and patterns are developed within the Hyperspec III® application to enable the user to set data collection parameters. The use of polygons and other patterns is found in Section, GPS Configuration and Polygons of this manual.

Figure 1-4. Headwall GPS Antenna.

1.3 IMU CONNECTION AND ORIENTATION, HEADWALL IMU.

The Headwall IMU has internally defined coordinate systems to identify the X, Y and Z coordinates. It also contains an internal magnetometer that can be disturbed when proximate to power cables which generate a flux field.

Figure 1-5. IMU Coordinates.

The coordinates, x,y,z, are shown in the previous figure and correspond to the local earth-fixed reference co-ordinate system. This coordinate system is defined as a right-handed, Cartesian co-ordinate system with:

a. X positive to the East (E).

b. Y positive to the North (N).

c. Z positive when pointing up (U).

The coordinate system is also known as ENU and is the standard in inertial navigation for aviation and geodetic applications. Note that it is possible to change the coordinate system with respect to the IMU using an alignment matrix or orientation reset. However, for this manual the default coordinate system will be used.

The IMU is mechanically attached to the Nano-Hyperspec® with the supplied mounting screws. The Nano has mounting holes on more than one surface of the unit. The IMU should be mechanically attached to the Nano as shown in the following figure. All units shipped as assemblies from Headwall have the IMU attached as shown.

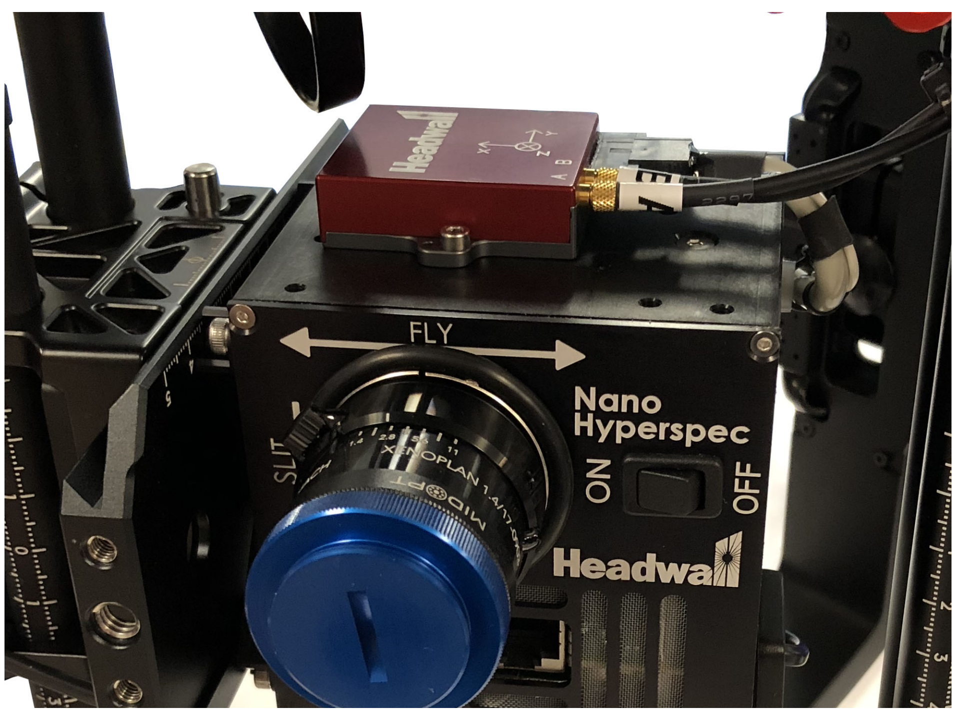

Figure 1-6. Headwall IMU on Nano, Gimbal Mount.

Note that the X direction of the IMU is in line with the flight direction of the sensor.

1.4 COMPONENT INTERCONNECTION

1.4.1 Nano Computer Connection.

To set the Nano for remote scanning, such as a drone or other remotely controlled platform:

(1) Connect one end of a Cat 6 cable to the Nano RJ-45 port and the other end to the computer operating Hyperspec®III. Open HyperSpec®III, then click the Capture button.

(2) Set the parameters for the flight, in the Capture panel, leave the Nano powered ON and disconnect the Cat 6 cable.

(3) Once the scan is complete, the data from the Nano-Hyperspec® needs to be downloaded to the operating computer for storage and analysis.

(4) Reconnect the Nano-Hyperspec® to the computer, with a Cat 6 cable to the RJ-45 port on the Nano-Hyperspec® and the other to the RJ-45 port of the operating computer. With the computer and Nano powered ON, open the Hyperspec® III application, open the Capture panel and click the **Stop** button.

(5) To transfer files from the Nano, select the **File Transfer** button on Hyperspec®III. Use the pop up and navigate to the desired capture folder. Once transfered, the files will be unpacked and saved. Detailed Hyperspec®III operational steps are found in the Hyperspec®III manual.

1.4.2 Power Connection.

The Nano-Hyperspec® uses 9.5 to 25 VDC power. Suggested power is 12 VDC. Connect the positive and negative leads to an appropriate power source. Insert the power connector into the Nano Power Connector location, identified the following figure. The connector pin out is shown in the following table. When the standard airborne package is shipped, the Nano power is configured through the gimbal battery.

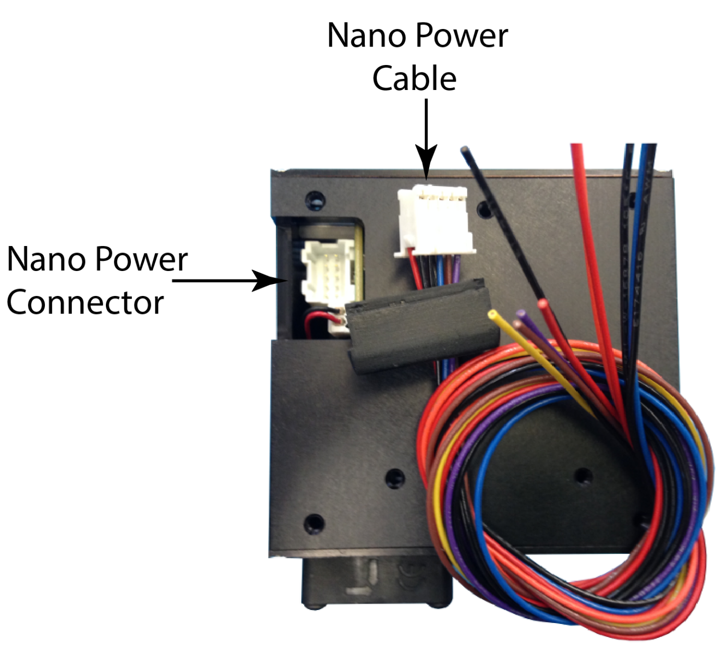

Figure 1-7. Nano Power Location.

The IMU receives the power from the Nano through the cable, supplied with the airborne package.

NOTE

Headwall recommends that users power OFF the Nano when changing batteries on remote control platforms. Not doing so may cause damage to the Headwall sensor or the replacement batteries,

The following table identifies the wires coming from the Nano power connector.

Table 1-2. Power Connector Pin Out

Pin #	Function	IO Format	Wire Color	Comments
1	Ground	Power	Black	
2	Voltage Input	Power	Red	Voltage Input Range +9.5V to +25V
3	Ground	Power	Black	
4	Voltage Input	Power	Red	Voltage Input Range +9.5V to +25V
5	Voltage Output	Power	Blue	Voltage output is +5V with a maximum current of 250mA
6	Voltage Output Return	Power	Black	
7	GPIO3	General Purpose IO	Brown	0 to 5V range
8	GPIO2	General Purpose IO	Yellow	0 to 5V range
9	GPIO1	General Purpose IO	Purple	0 to 5V range
10	GPIO0	General Purpose IO	Orange	0 to 5V range

1.4.3 IMU Data/Power Connection Xsens IMU.

The IMU, when shipped from Headwall, is attached to the Nano and should not be removed. The data cable connecting the Nano with the IMU is also attached and should remain connected. The following steps are provided for users who purchased the Nano Airborne package and plan to integrate the system with their own drone or scanning system.

a. Orient the Nano, with the IMU attached, so the Nano serial number label and cooling fan are facing forward, as in the following figure. The IMU data port is the white connector, as shown.

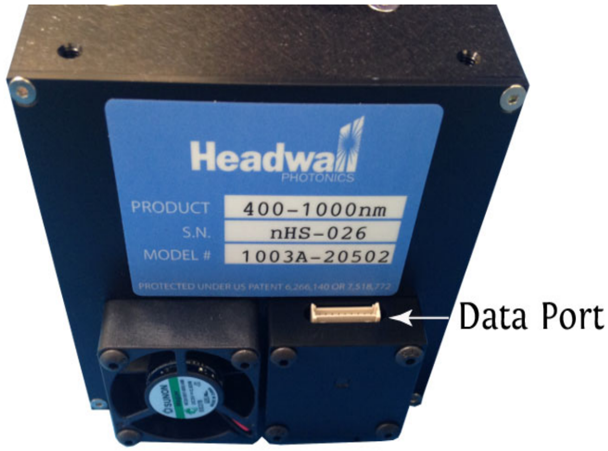

Figure 1-8. Nano-Hyperspec® Data Port View.

b. Remove the IMU cable from the airborne package.

c. Hold the data serial connector and orient it so the holes in the cable-end connector match the pins in the Nano data port connector.

d. Place the cable-end connector into place in the Nano data port connector and press down on connector edges until it is completely secure, as shown below.

Figure 1-9. Cable Connector secured in Nano Connector Housing.

e. Hold the IMU cable, take the LEMO connector and align the red dot on the LEMO connector to the red dot on the IMU connector, shown in Figure 1-10.

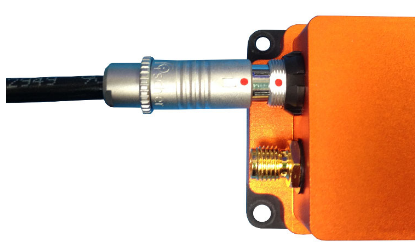

Figure 1-10. Align Red Dots, LEMO and IMU.

CAUTION

Do not twist the LEMO connector into the IMU connector. This will damage the pins and make the cable useless. The LEMO is a push-pull connector.

f. Hold the Nano in place and gently press the two connector pieces together until the connectors appear as below, Figure 1-11.

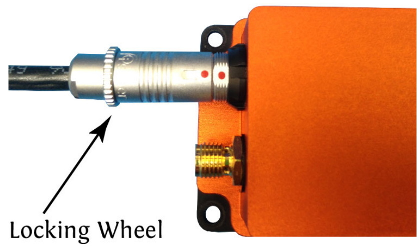

Figure 1-11. Secured LEMO-IMU Connectors.

g. Once the two halves are pressed together, turn the locking wheel clockwise until it stops. This secures the LEMO connector into place.

h. Secure the slack cable, if any.

1.4.4 IMU, GPS Connection.

a. Remove the GPS Antenna from the package.

Figure 1-12. GPS Antenna.

b. Take the motion tracker connector and align it with the gold connector on the IMU.

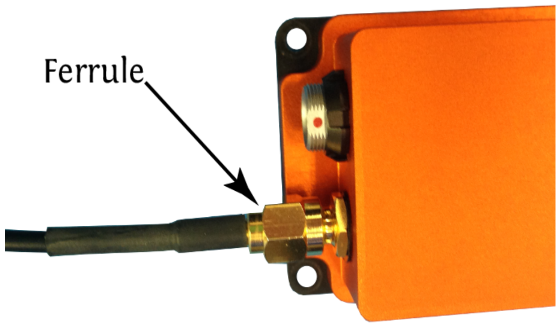

Figure 1-13. GPS to IMU Connection.

c. Once aligned, press the two halves together and turn the ferrule clockwise to secure the connector to the IMU.

d. Secure the GPS antenna to a location on the aerial platform and secure any excess cable. If the GPS antenna is used on a UAV body that is conductive material, such as aluminum, the GPS antenna performs best when mounted outside the body. For optimal results, it is suggested that the GPS antenna be located within 10cm of the IMU device, with a clear field of view of the sky.

1.5 CONFIRM NANO TO IMU CONNECTION

With the IMU/ GPS connected to the Nano, use the Cat 6 cable to connect the Nano to the computer that contains the Hyperspec® software.

Power ON the computer and then power ON the Nano. Wait for the Nano's LED to turn green. Open Hyperspec®III. The Log Dock should show blue letters. If red letters appear an error requires correction. There are two possible sources or errors: The first is identified as White and Dark references. These are minor errors and require the user to establish new references prior to operation. Follow the steps in the Hyperspec®III manual for this procedure. The second possible error may be the connection between the Nano and the GPS. If a GpsMonitor Command error occurs in the Log Dock, it indicates the Nano is not recognizing the IMU. The source can be either system configuration or a cable fault. To correct the configuration error perform the following steps:

(1) Click the **Settings** button in Hyperspec®III.

(2) Click the **Sensor** tab in the Settings window.

(3) Within the Sensor tab there is a section for **Devices**, one of which is the **GPS**.

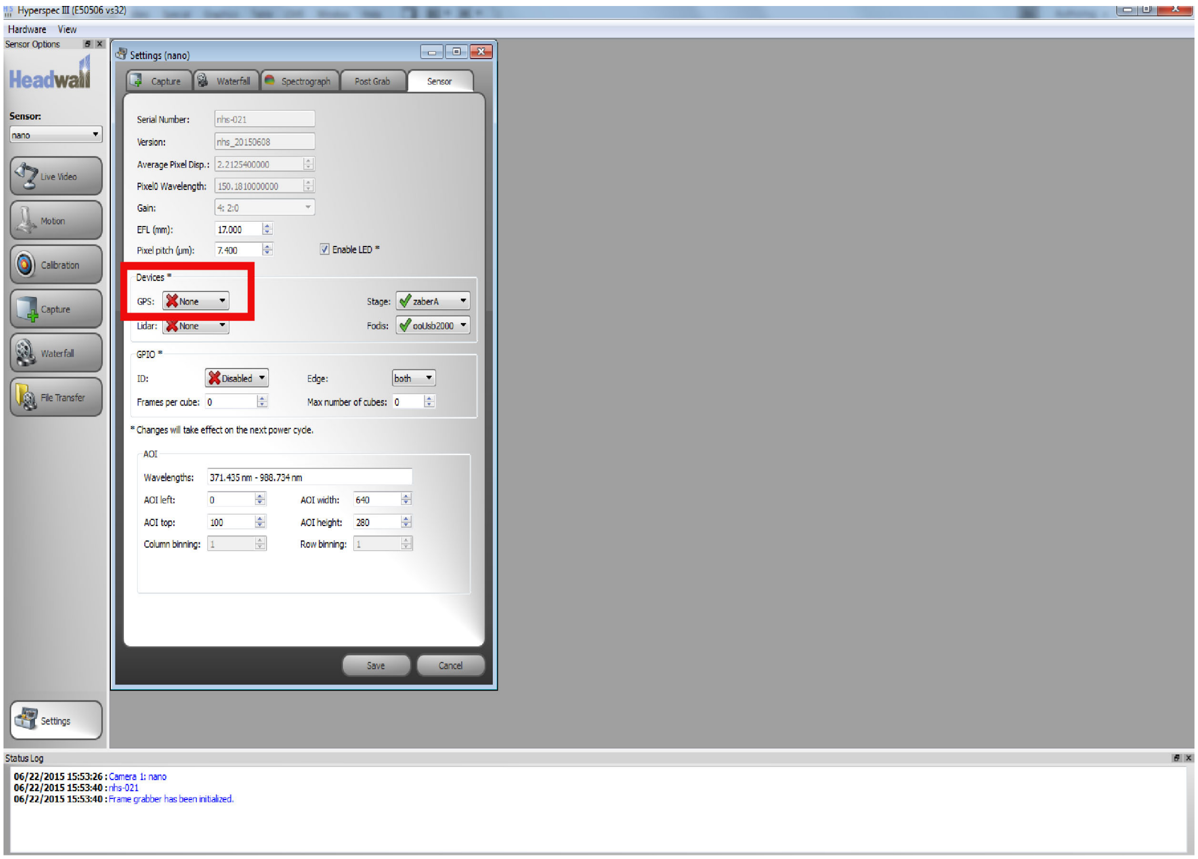

Figure 1-14. Identified GPS Selection.

(4) Click the GPS drop down, select the IMU that is attached to the Nano.

(5) Click the **Save** button and close and re-open Hyperspec®III.

The Log Dock should have no error messages if this was the source. If a red error message shows, check the cable connections, verifying they are both correct and firmly secured. If the cables are secure, there is a fault in one of them which needs to be replaced.

1.6 FLIGHT PLANNING

The Nano performs hyperspectral scanning, identified as push broom scans. This means that during the flights the sensor should always move in a forward facing direction. Moving in one direction, holding the sensor facing forward, side slipping and then reversing direction may capture raw scan data, while creating difficulty in post processing steps. This back and forward flight is not recommended.

There are two operational platforms to capture scans while in flight: manned and unmanned, UAS, aircraft. This section deals with UAS flights. When setting the flight plan for a UAV/UAS the best results can be gathered when all factors are considered in the pre-flight process.

The first step is planning for optimal atmospheric conditions. This generally means flights in the morning, before environmental heating generates wind and thermals in the scanning area. These can affect the UAS flight stability and subsequent scan clarity. Also, the topography is important, flights aimed at uniform terrain will yield better results that those including random, irregular elevations.

A second consideration is whether to use manual triggering or GPS/automatic triggering. The manual triggering is done through the UAS flight controller and the UAS power source sending a trigger signal to the Nano. To obtain a good scan, the operator needs to very accurately observe way-points, and scan only when they are reached. When scanning large areas, this may prove problematic through a combination of distance and visual accuracy. GPS triggering can be set using the Headwall Polygon tool. Headwall recommends using the polygon tool, http://www.headwallphotonics.com/polygon-tool, as a means of identifying the scan area and setting the GPS start and stop triggers for the Nano. This, coupled with preprogrammed, automatic flight, eliminates the operator variable in the scanning process, and generally leads to better results.

1.6.1 Setting Capture Options.

Connect the Nano, using the Cat 6 cable, to the computer with Hyperspec®III installed.

Power ON the computer, allow it to fully boot.

Open Hyperspec®III.

Power ON the Nano. Wait for the LED to glow green.

Check the Log Dock in Hyperspec®III and confirm the Nano is connected to the software.

Remove the lens cap from the Nano and click the Live Video button on the Button Dock. The result should be similar to the following figure.

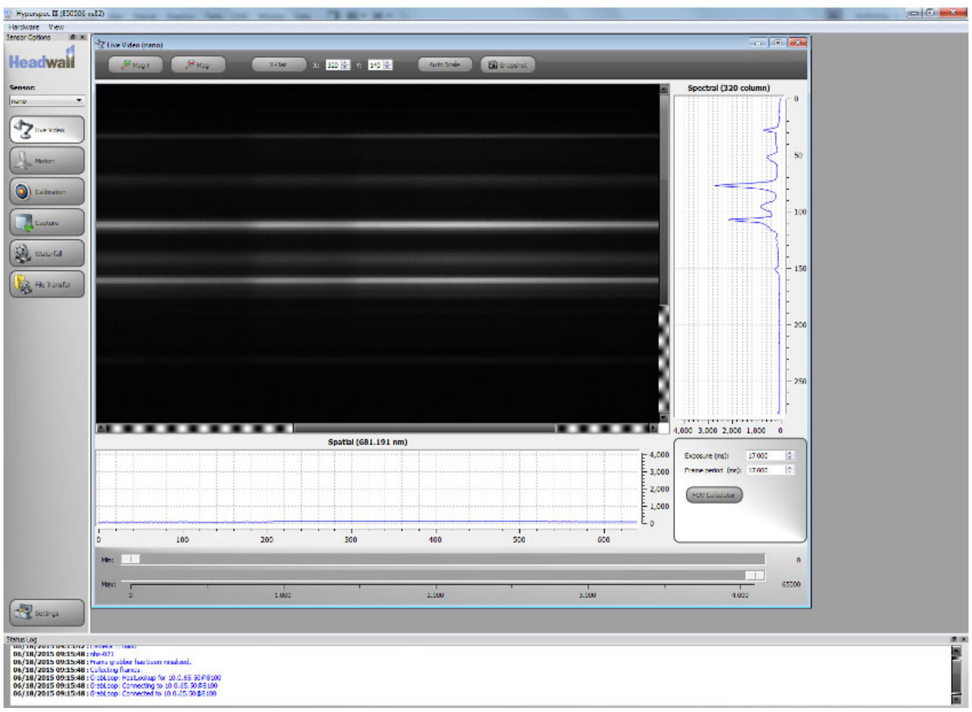

Figure 1-15. Nano, Connected to Computer.

Close the Live Video.

Click the Settings button, opening the Settings screen. Click the Sensor tab, shown in the following figure.

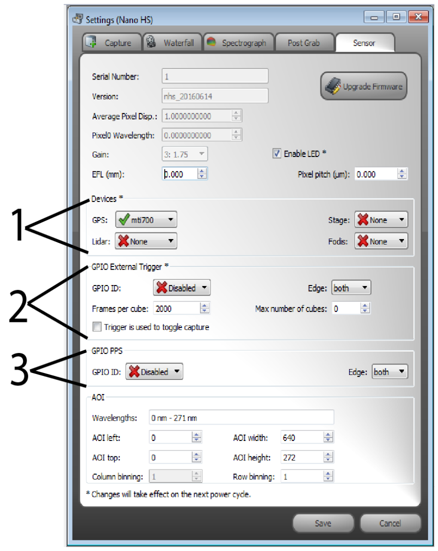

Figure 1-16. Settings, Sensor Tab.

The operational details for the numbered sections are in the following table. Verify the settings conform to the system configuration.

Table 1-3. Sensor Settings

Number	Function	Operational Settings
1	GPS	Drop down, select IMU used with Nano. This is necessary if the Nano will be used for aerial scanning.
	Lidar	Drop down, select Lidar used with Nano, if necessary
	Stage	Drop down, select Stage used with Nano, if necessary
	Fodis	Drop down, select Fodis used with Nano, if necessary
2	GPIO ID	Select wire used for trigger function, 0.170 is commonly used
	Edge	Defines reading of rising or falling edge or both
	Frames per Cube	Maximum Frames per scanned cube
	Max Cubes	Maximum cubes per scan
	Trigger to toggle capture	Check to enable external triggering, It is a toggle function, one pulse Start, next pulse Stop.
3	GPIO ID	Select wire used for trigger function, 0.170 is commonly used, used to define time stamp from IMU.
	Edge	Defines reading of rising or falling edge or both.

For most applications, using the Xsens IMU from Headwall, users can perform the manual triggering with the GPIO ID set for the IMU and the GPIO External Trigger selected. The External Trigger is used to toggle captures when the check box is selected, as shown in Figure 1-21. One pulse starts the capture, the second pulse stops the capture.

When using the Applanix IMU, the GPIO PPS needs to be identified. This will generate the time stamp for the IMU files. The GPIO ID in the GPIO PPS sections needs to be selected.

While the software ad system functionality allows for manual operation of the unit, users are strongly encouraged to develop UAS autonomous flight plans and use the GPS triggering function.

1.6.2 Capture Function.

When the UAS is set to fly autonomously, using the GPS triggering function, it is flying the polygon scanning method, and the Enable GPS Trigger in the Capture window needs to be selected.

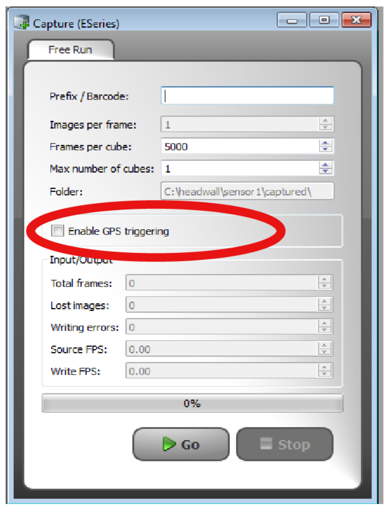

Figure 1-17. Nano Capture Window.

The result of using the GPS triggering is improved data scans and autonomous flights for the drones. When the platform flies outside the polygon boundary the capture stops, and the data cube is not influenced by the rotation and orientation maneuvers of the platform. The coordinates for the polygon can be saved in a text file. This allows for subsequent flights to be made over time, for the same area, by simply reloading the polygons from computer memory.

The data cubes are stored on the Nano during drone flights. Users should download the files after the collection/flight campaign ends. Retaining folders on the Nano can impact the sensor's performance, as the storage capacity is reduced.

Users should also maintain a naming convention for the various data cubes. The default naming is a date code, but a name convention for time and location makes reading, sorting and retrieval far easier.

CHAPTER 2 NANO-DJI MATRICE PRE-FLIGHT

NOTE

This chapter is specifically for customers using the Headwall Nano, integrated by Headwall with the DJI Matrice 600.

If the reader is using another UAS platform with the Nano, and needs only the information for operating the Nano and Hyperspec III®, please proceed to Chapter 2.

Users and pilots should follow local UAS flight rules and regulations.

It is strongly recommended that users planning to operate the Matrice 600 should read the entire UgCS manual and Matrice 600 manual before conducting a flight. Also, reading the Mission editor: flight execution section of the UgCS manual provides details for successfully executing a mission.

The tablet and laptop should be periodically checked for the presence of UgCS and DJI software updates. Both devices should be set to allow updates on a manual basis, not automatic. If updates are not present, connect the devices to the Internet, download and then install the applications. Users can verify if updates are available on a schedule. For the UgCS application, the license is supplied from Headwall, and is enclosed with the system documentation.

Before flying the Headwall Photonics, DJI Matrice and Nano units, the systems need to be examined for operational and safety consideration. This includes verifying the functionality and upload processes for the software used for directional and flight control, flight planning and UAV control. The gimbal should be checked for unrestricted movement.

NOTE

If the DJI and Nano system is shipped from Headwall with an integrated tablet and Nano, the UgCS software is installed and configured. UgCS needs to be installed on the customer's operational laptop.

2.1 SOFTWARE AND FIRMWARE UPDATES

The DJI and UgCS software have periodic updates and releases. Prior to planning the flight, check the DJI and UgCS websites for any critical updates.

DJI updates available at: http://www.dji.com/matrice600-pro/info#downloads

UgCS updates and downloads are available at: https://www.ugcs.com/en/page/download

2.1.1 DJI Software Installation Steps.

a. Download and install DJI Assistant 2 on the field operational computer.

(1) When the download completes, log into DJI Assistant 2 in the upper right corner. If needed, create a DJI account.

(2) Connect the laptop to the drone using the Micro-USB cable, supplied with the system, connecting under the status LED, rear indicator light for battery #4, on the drone.

(3) Power ON the DJI Matrice

(4) Using DJI Assistant 2, will be used to update drone firmware and available modules on the drone.

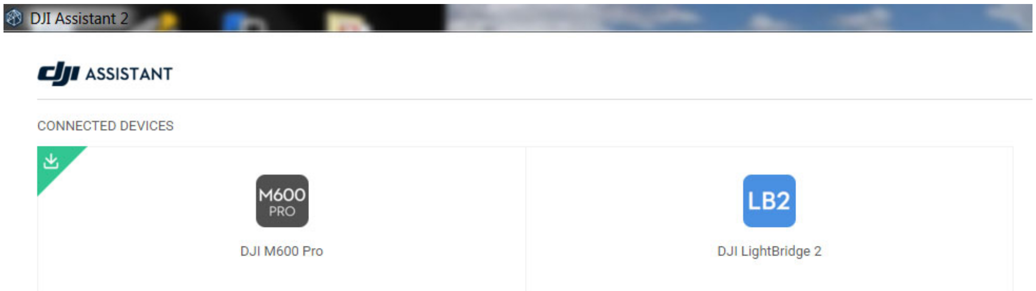

Figure 2-1. DJI Assistant.

(5) The left side menu is for firmware updates. Click **M600 Pro** icon.

(6) Remove propeller sleeves, lock the propeller arms in the deployed position and place the drone clear of obstructions and personnel, and then click **UPGRADE** on the main screen. Allow process to complete.

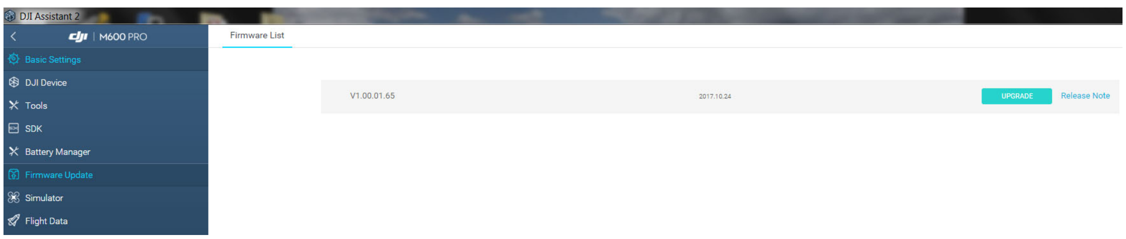

Figure 2-2. Firmware Upgrade

(7) When complete, return to main menu, **click** the **LightBridge** icon and allow any downloads to complete.

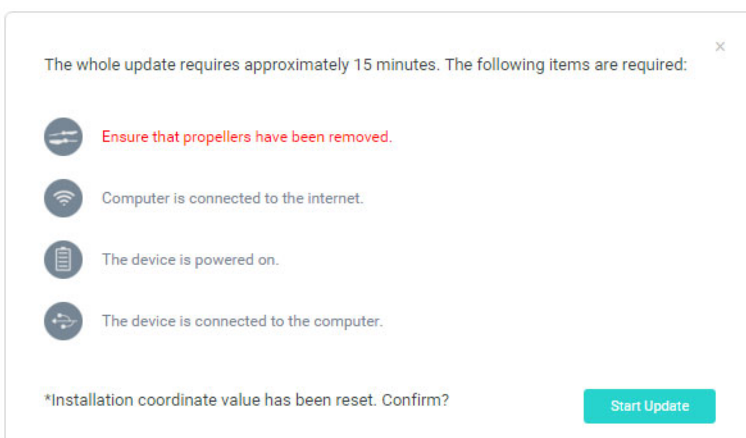

Figure 2-3. Download Notice.

b. Update DJI Go and UgCS to the latest versions from the Google Play store. This requires logging into the Google account.

(1) Connect the computer to the Internet.

(2) Launch DJI Go and re-login to your DJI account

c. Quit DJI Assistant 2.

d. Download and install the latest version of UgCS Desktop onto the operational laptop, from the UgCS website if not already done.

e. After the application starts, check for the latest version of UgCS are installed and operational.

2.2 FLIGHT PLANNING

This pre-flight process presumes the DJI Matrice 600 is operational and the UgCS and Hyperspec software are installed, updated and operational on the laptop computer used for flight planning and uploaded to the tablet for flight control. Also, the tablet should be operating to interconnect the laptop computer with the DJI Matrice 600. The tablet communicates between the laptop computer and Matrice through a wireless hot spot. This hotspot does not require Internet connection.

If the UgCS software is not installed on the operating laptop, download it from, https://www.ugcs.com/ and apply the included license. The first time the application is used, a demo mission will run. Users can watch this for instruction or click the **Menu Icon** and select **Remove Mission**.

(1) Open the UgCS application on the laptop. As illustrated below, zoom into your location. Alternatively, enter an address or GPS location into the Search area in the top right of the screen.

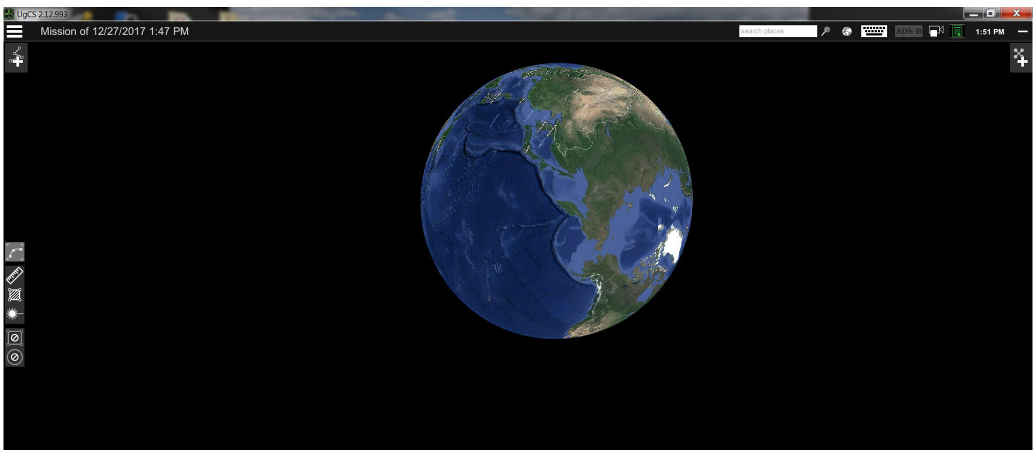

Figure 2-4. Initial UgCS View.

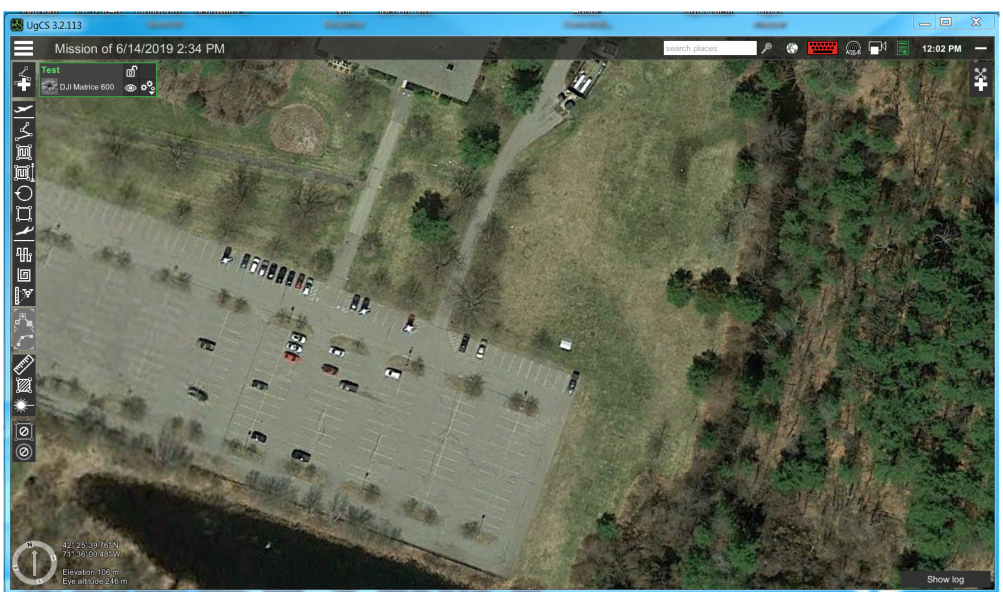

Figure 2-5. UgCS Opening Screen.

(2) The screen opened to the location, shows software controls along the top edge, with added functionality in the tool bar on the left of the page.

(3) Click **Main Menu** and then **License**. Confirm the UgCS license is activated. New shipments of the Headwall Airborne package include the UgCS license on the supplied flash drive.

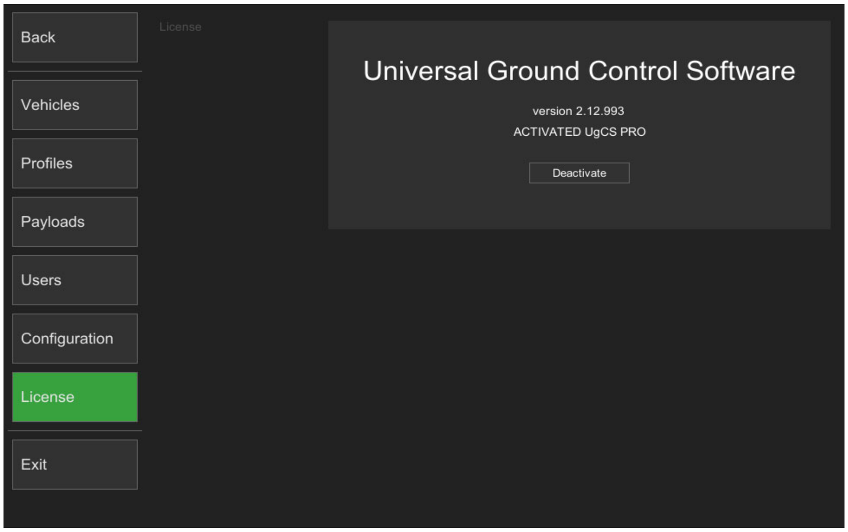

Figure 2-6. UgCS with Active License

(4) If the license is not activated, click the button, and enter the license number that was either purchased or supplied with the drone system.

(5) Once done, continue to the Sensor Set Up.

2.2.1 Sensor Set Up, UgCS.

The set up process is performed at the Headwall facility, if the fully integrated system is purchased. Users should follow the steps below as a learning opportunity in the event that additional lenses are purchased, or they are performing this process with their own integration.

(1) With the UgCS application opened, as shown above, click the **Menu** button, on the top left of the screen.

(2) Select **Main Menu**, as shown below.

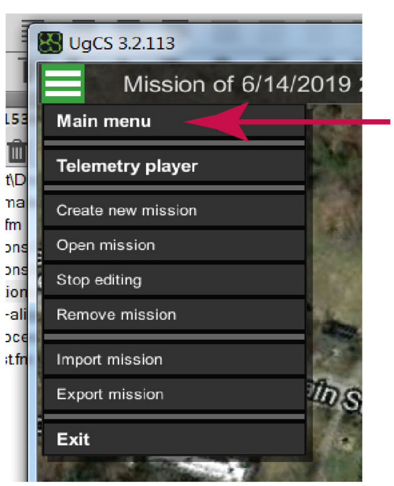

Figure 2-7. UgCS Main Menu Option.

(3) Click **Payloads**, then click **Create New** as shown in the following figure.

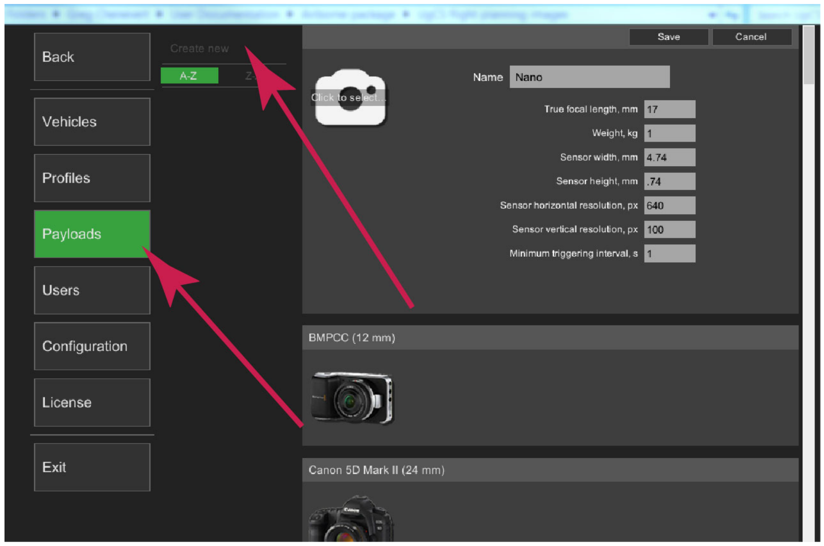

Figure 2-8. Payload, Create New.

(4) A panel opens that requires the user to enter all sensor data for the particular Nano.

In the following example, 17mm is the focal length. Enter the sensor Name, include the lens size for ready identification.

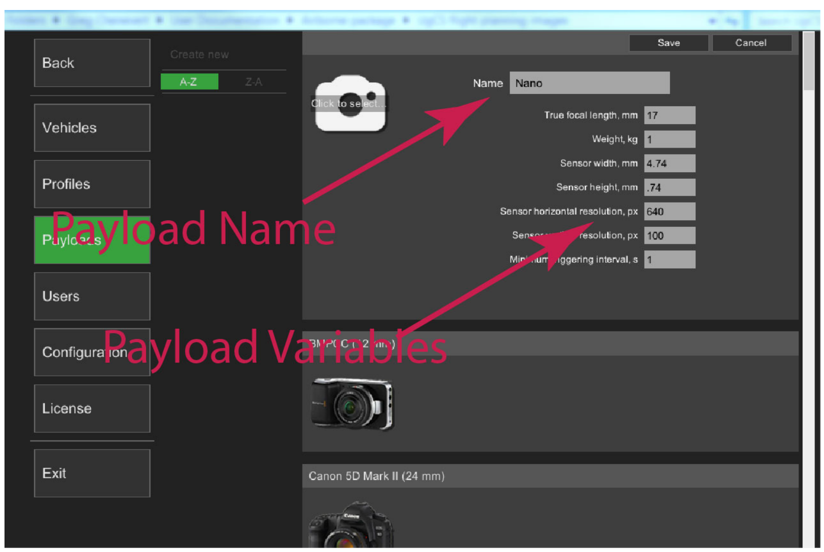

Figure 2-9. Sensor Specific Configuration.

Once the payload is named the data from the Nano needs to be input for the software to integrate into the correct altitude and speed calculations. The Nano data is found in the Certificate of Compliance, supplied with the unit. For all Nanos, the values are:

1 1 kg.

2 Width (slit width) 4.74 mm

3 Height 0.74 mm

4 Horizontal resolution (sensor size) 640 pixels

5 Vertical Resolution (size) 100 pixels

6 Minimum Triggering Interval 1 s.

7 Click **Save**.

The focal length is specific for the lens used. In the following example a 23 mm lens was used.

This concludes adding a payload to the available profiles on the Matrice.

Figure 2-10. Sensor Specific Data.

(5) Once the sensor values are saved, continue the following steps to add the sensor to the payload.

(6) On the main panel, click **Profiles** and select **DJI Matrice 600** and then click **Edit**.

(7) When the button becomes active, click, **Add**, which allows a new sensor to be added to the platform payload.

(8) Select **Nano XXmm,** in this example, Nano 23mm, from the opened list, and click **Select** and then click **Save.**

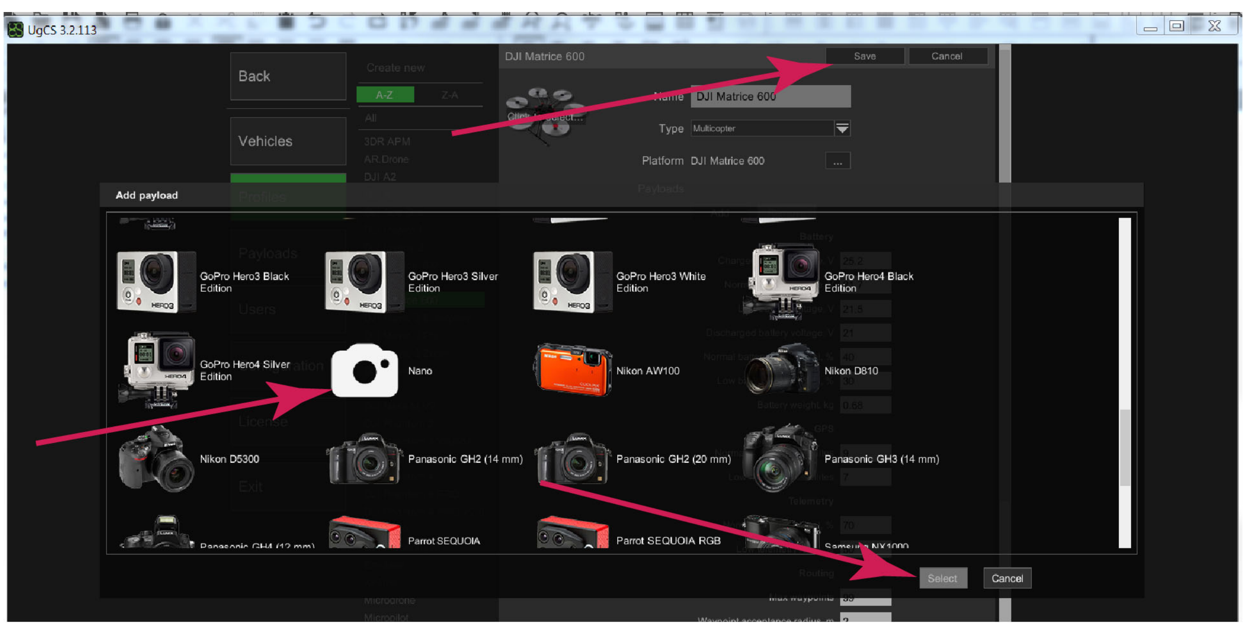

Figure 2-11. Final Nano Addition Steps.

(9) Click **Back** to return to the main screen. The next step is creating the flight plan. This will be the path, including altitude and speed, that the drone will fly for the scanning mission.

2.3 FLIGHT PLAN CREATION

(1) With the UgCS application opened, click the **Add new route** button, +, PLUS sign.

(a) Next, click **Create from scratch**.

(b) Click, **Next**.

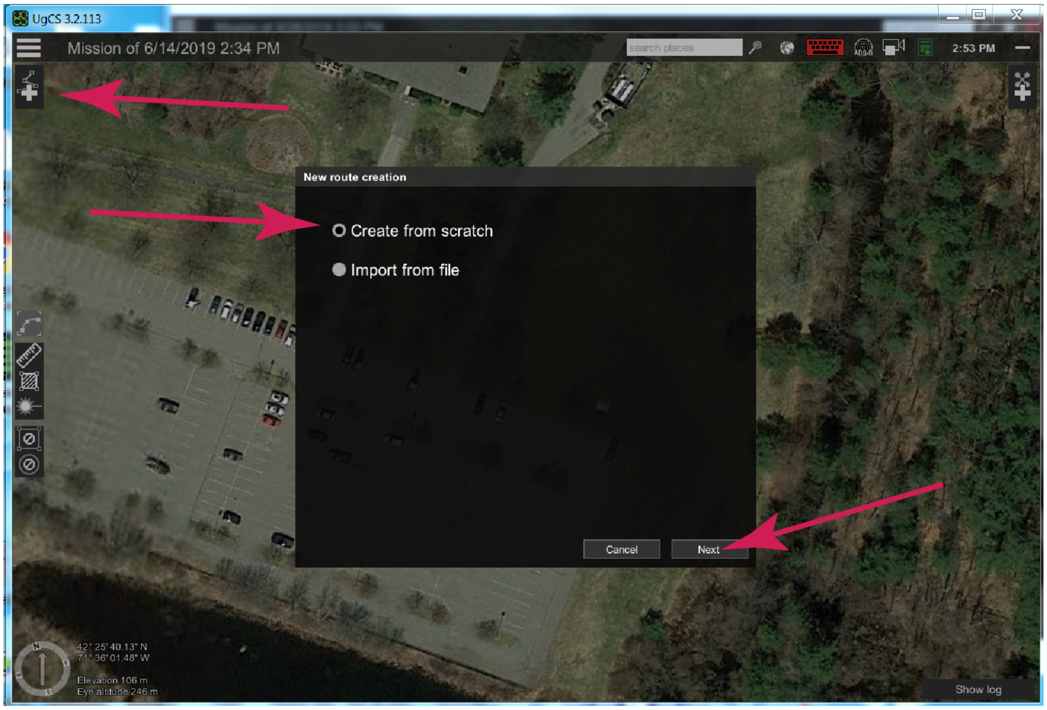

Figure 2-12. Initial Flight Plan.

(2) Select the planned UAS, **Matrice 600**.

(a) Give the new route a name for ease of identity or future reference. Flight plans can be saved and reloaded for faster future deployment.

(b) Click **Next**.

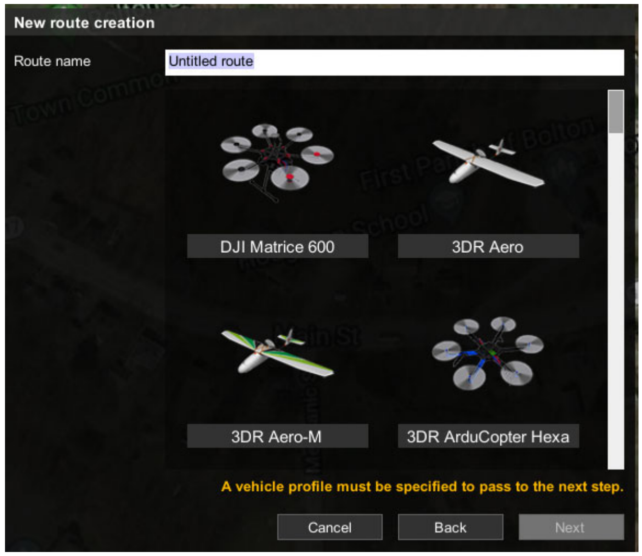

Figure 2-13. DJI Matrice Selection.

(3) Recommended route settings, for the next step are shown below. These include the Altitude mode and trajectory type. The return altitude is based upon having no obstructions taller than that defined height.

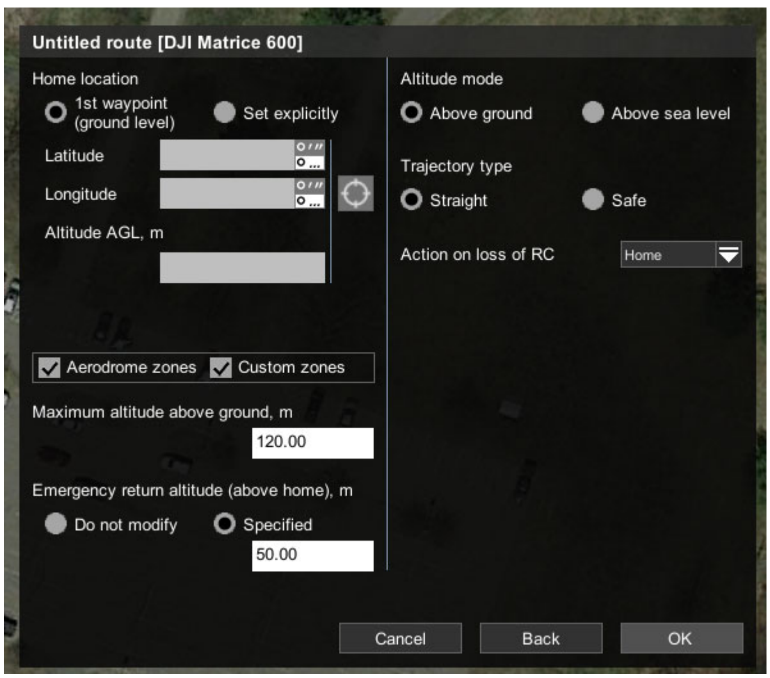

Figure 2-14. Defined Flight Route.

(4) Verify the settings and click **OK**.

(5) Select photogrammetry tool, the fourth button from the top on the left side of the screen. All flight planning with the Nano needs to use the photogrammetry tool for correct flight planning.

(a) Example values are shown below.

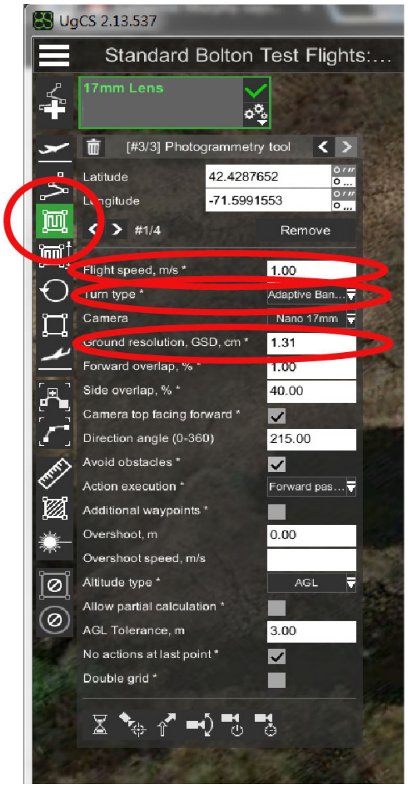

Figure 2-15. Photogrammetry, Speed, Bank, GSD.

(6) Explanation of Mission Plan, Step 1 fields.

(a) Flight Speed, m/s: The forward speed of the aircraft for the flight plan and while navigating to the first waypoint under autonomous flight. This value must be Calculated depending on altitude and integration time of the Nano-Hyperspec® sensor. The FOV calculator inside Hyperspec® III can be used to calculate flight speed for a given frame rate or vice-versa. Actual flight speeds of the Matrice may vary by up to 1 meter per second slower. This is a function of the DJI firmware.

NOTE

The DJI Matrice 600 will not fly slower than 1 m/sec.

(b) Turn type: Always select “Adaptive Bank Turn” for best results.

(c) Camera: Select the camera and lens combination that you will be using. The camera needs to be added in the Profiles section before you can select it (please see 'Camera Setup' step above).

(d) Ground resolution, GSD, cm: Pixel resolution of the sensor. Altitude is back calculated from this value and must be verified as a safe altitude for the given flight area.

(e) Forward overlap%: Set this to the minimum value of 1%.

(f) Side Overlap%: 40% is recommended to ensure full spatial coverage.

(g) Camera top facing forward: Leave this item checked.

(h) Direction angle (0-360): For a given flight plan it is typically best to select the angle that gives you the least number of flight lines. Direction is from due North, 0 degrees.

(i) Avoid obstacles: UGCS supports user defined obstacles. If this is selected the flight plan will be calculated to avoid these.

(j) Action execution: This is a method for triggering cameras which is not currently supported for the Ronin MX and our sensor. The selection does not matter.

(k) Additional waypoints: Leave this unchecked. Additional points will be created along the flight lines but usually results in more than 99 waypoints, which is the maximum allowed by the UgCS software.

(l) Overshoot speed, meters per second. If left blank, it will default to the selected flight speed.

(m) Overshoot, meters: This can be used to add additional length to the end of the flight lines. It is recommended that this be 1.5 to 2 times the FOV width.

(n) Altitude type: AGL, altitude is adjusted during the flight to keep a more uniform altitude above the ground. This option can give better results and based on the DEM for the area. Always use AGL as the altitude of reference.

(o) Allow partial calculation: Select this if the software is having issues calculating the full flight plan, especially if there are over 99 waypoints.

(p) AGL Tolerance: Determines how accurately the UAS will follow the terrain while using the AGL selection for Altitude Type.

(q) No actions at last point: We are not using actions so this does not matter.

(r) Double Grid: Do not use under most conditions, but possibly use with LiDAR. Contact Headwall for how this can apply to LiDAR flights.

2.3.1 UgCS Flight Paths and Flight Lines.

Developing the flight path in UgCS is done with the following steps.

(1) Add a minimum of 4 points to the ground. Double-click to drop a point and continue dropping points to create a polygon covering the area of interest.When done the last point, double click on the first point, closing the polygon and verifying the arrows at the base show. Alternatively, drop a point on the ground and drag over the top of the first point to close the path.

(2) The initial waypoint must be within 30 meters of the drone home or take off position. If it is not, add an initial flight leg from the take off point to the first way point. This can be done by using the button that is 8th down on the left, the Modifier button, which allows the insertion of a route segment before the current on. Once clicked, then click the top button, to enable the screen view to insert the segment.

(a) Waypoints are added by double clicking on the map. The polygon is closed by double clicking on the first point. Waypoints, to extend or change the polygon sides, can be adjusted by dragging after placement.

(b) The software will automatically calculate the flight plan, based on the sensor payload and photogrammetry data previously input to the software, once the polygon is completed. In the following figure, the yellow, round icon on the first line on the left panel, indicates the software is processing. When the icon becomes green, the process is complete and loaded.

Figure 2-16. Four Ground Points.

(3) Below is a properly configured flight plan. Note the flight starts with the left side flight line and ends with the right side flight line. The last flight line also points to the take off position, for effective battery use and avoids collecting unwanted data.

NOTE

Altitude should be checked manually by hovering the mouse over a given waypoint, as illustrated in the white rectangle in the following figure. Always verify that a safe altitude selected for the target area (and for each waypoint).

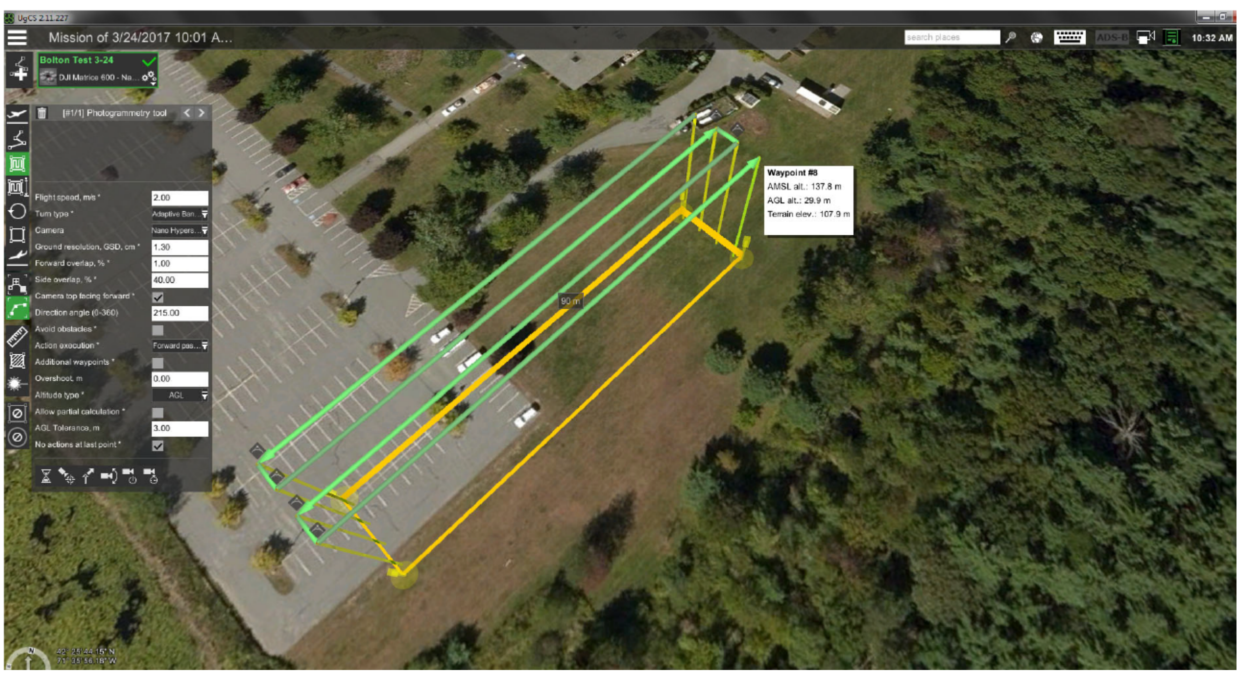

Figure 2-17. Properly Configured Flight Plan.

(4) The flight plan is now ready to be used or can be exported in the main menu for later use.

The number of flight lines is modified, increased or reduced, by changing the percent overlap, as well as altitude and the lens used with the Nano. Different lenses on a Nano can be added to the Camera section of the UgCS software and added to the Matrice 600 payload, as needed. The different lenses will have different fields of view.

The drone flight need to overshoot the capture area in order to make an adaptive bank that is not recorded by the sensor. Overshoot is controlled by the Overshoot value in UgCS, shown below. Note that both distance and speed are variables.

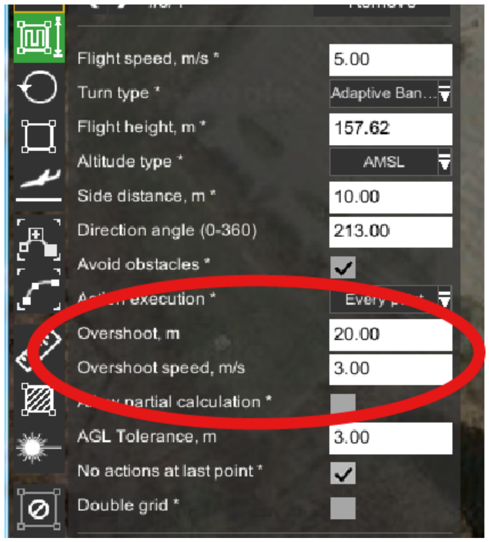

Figure 2-18. Overshoot Values, Distance and Speed.

Adding these overshoot values to the previous flight plan results in the modified plan, shown below. The overshoot automatically occurs at both ends of the flight lines.

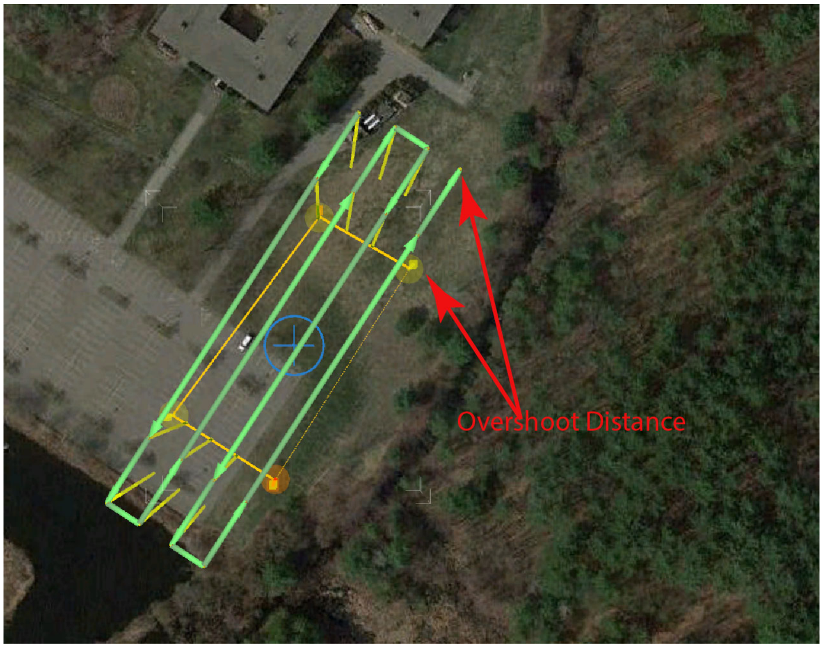

Figure 2-19. Overshoot Added to Flight Plan.

Verify the flight parameters by clicking the Parameters button in the Flight Route Panel, shown below.

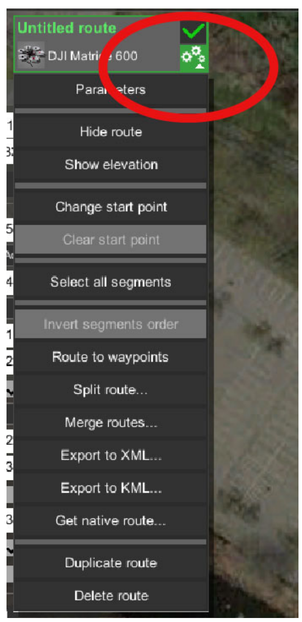

Figure 2-20. Parameters Panel.

The mission is saved by clicking the Main Menu icon and selecting the **Export Mission** option. For flying existing missions, from the Main Menu, select **Import Mission**. To save the individual routes, from the Flight Parameters, select **Export KML**.

Using the Headwall Polygon Tool, a triggering polygon can be developed within the flight area. The polygon, once accepted can then be exported in a kml format and imported into the UgCS for comparison to the flight plan. The optimal result occurs when the flight plan starts and stops outside the trigger polygon, and flies well beyond the perimeter of the triggering polygon.

Alternatively, the flight plan in UgCS can be exported as a kml file and then imported into the Headwall Polygon tool. When the capture polygon and UgCS flight polygon are overlaid on the Polygon tool the user can see the trigger points and confirm each is properly aligned.

2.3.1.1 Triggering Polygons.

To capture data during a remote operating mission HyperSpec III® uses GPS defined triggering polygons. Flights can use single or multiple polygons to perform remote data acquisition. The method for creating and loading these triggering polygons into the software and sensor are as follows.

(1) Open Hyperspec III ®, if not already opened. Connect the computer to the Internet, this allows access to the Headwall Polygon Tool.

(2) Click the GPS button on the Button Dock. The GPS pane opens, as shown below.

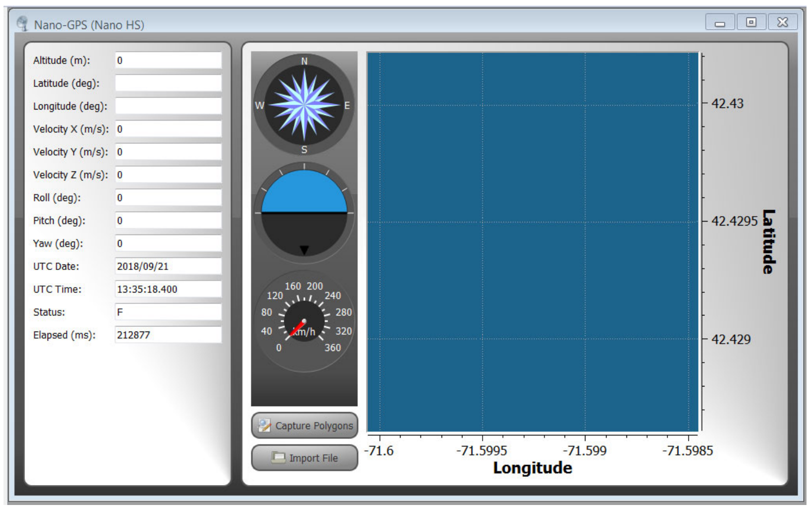

Figure 2-21. GPS Pane.

(3) Click the **Create Polygon** button, opening the Headwall Polygon Tool, shown below.

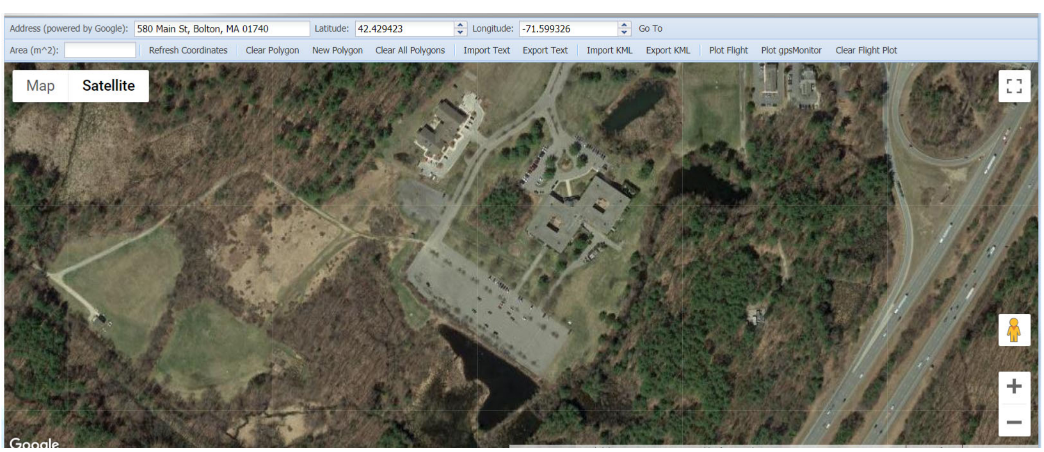

Figure 2-22. Opened Polygon Tool.

(a) On the top of the Polygon Tool, click **Clear all Polygons**.

(b) Identify the location you want to scan and enter the address or location into the top line values. Then click **Go To**.

(c) Bring the location into focus so the desired scanning area is detailed.

(d) Use the left mouse button to place a single location that starts defining your scan area.

(e) Place the points with left mouse clicks to complete the polygon. The points can be moved by left mouse clicking, then hold and drag any point.

(f) Additional polygons can be created by clicking the New Polygon button on the Polygon Tool. Single or multiple polygons are all saved as a single file.

(g) Once the process is done, the Polygon Toll should be similar to the following image.

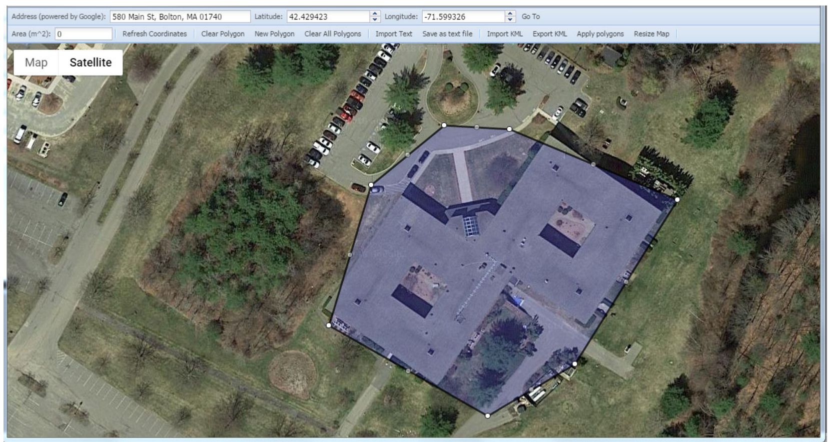

Figure 2-23. Finished Polygon.

(h) When the polygon is completed, export it to a location on the computer and name it accordingly.

(i) Close the Headwall Polygon Tool and return to the GPS Pane in Hyperspec III®.

(j) Disconnect from the Internet and close Hyperspec.

(k)

2.3.1.2 Upload Trigger Polygon to Nano.(l)

(4) Connect the laptop to the Nano, power ON the Nano and open Hyperspec LLL®. Confirm they are connected

(5) Click the GPS button on the Button Dock.

(6) One the GPS Pane, click **Import File**.

(7) Navigate to the location of the trigger polygons, such as the one just made.

(8) Select the desired polygon and click **Open**.

(9) The GPS Panel should appear similar to the following figure.

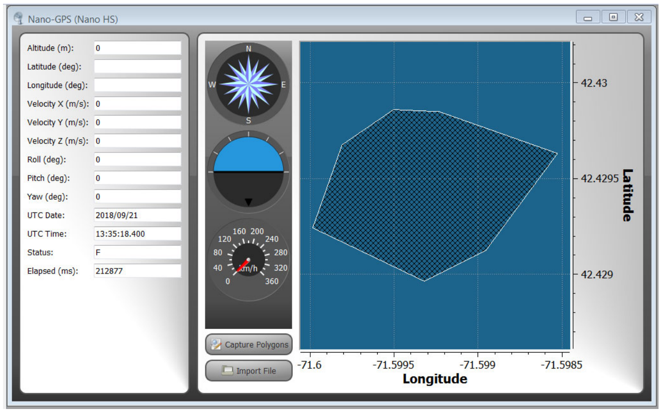

Figure 2-24. Populated GPS Panel.

(10) The addition of this polygon to Hyperspec also uploads the polygon to the Nano sensor.

(11) Close and re-open Hyperspec, open the GPS pane and confirm the polygon remains displayed in the panel, as above. The presence indicates it was successfully loaded to the Nano.

2.4 MISSION EXECUTION

It is recommended to read the entire UgCS manual for flight control, and the Matrice 600 manual, before conducting a flight. The "Mission editor: flight execution" section of the UgCS manual details executing a mission.

Below are the steps outlining a flight and hyperspectral data collection process. The steps should be performed in the order listed, and the user should wait for each to be completed before starting the next. This will avoid potential problems in communication between the laptop, controller and M600.

2.4.1 Power-up Sequence.

(a) Have an operational wireless hot spot. This device does not require Internet access. It is used to communicate between the laptop and the drone controller.

(b) Power **ON** Hot Spot device.

(c) Load fully charged batteries to the M600 and Ronin MX.

(d) Connect to M600 controller with the provided USB to Micro USB cable. Connect tablet to controller.

(e) First time start up should follow steps, 1 through 5, otherwise proceed to Step f.

1 For the first power ON and launch sequence, perform the following steps. These are for only the first time the system with the Applanix is powered. For systems operating for the second or subsequent times, proceed to Step f.

2 Launch DJI GO. Check for and address any errors or warnings.

3 Perform magnetic calibration if needed. For safety reasons and to optimize accuracy it is recommended that users perform magnetic calibration when traveling distances of 20 miles or more from the last calibration site.

4 High-Performance GPS users will also need to perform an additional magnetic calibration, detailed in the Applanix document; "APX/15 2D Magnetometer Calibration Instructions".

5 Exit and dismiss DJI GO from the application switcher.

(f) Power tablet, open tablet home screen and connect both laptop and tablet to the same wireless network.

(g) Power **ON** the M600, M600 controller and the Ronin gimbal.

(h) Select UgCS for DJI in the op-up on the tablet, then select **Just Once**. When the drone is connected, check that the UgCS icon on the tablet is green, this may take a few minutes. Verify the UgCS application on the laptop telemetry/PS and battery information from the drone is visible.

(i) Select UgCS for DJI in this window, and then select 'Just Once". When drone is connected, check that the UgCS icon on the tablet is green (this may take a couple minutes) and in UgCS on the laptop telemetry/GPS/battery/etc. info from the drone is visible

(j) Verify that all other devices, tablet, wireless hot spot and laptop computer, have an adequate level of charge.

(k) Upload a route onto tablet/drone from PC, with button on the middle right hand side of computer screen.

(l) Watch tablet screen upload percentage increase from 0-100%. If successful it will flash a green banner saying that the route has successfully been uploaded

(m) Power **ON** Nano-Hyperspec®. Wait for the front panel LED to be a steady green, 10 to 15 seconds.

2.4.2 Acquisition Setup.

At this time in the process, the tablet should be powered **ON**, as well as the Matrice 600 and Ronin gimbal. The tablet should show the UgCS home screen, and the wireless switch should be powered **ON** and operating with the tablet and drone.

(a) Connect the laptop to the Nano-Hyperspec® with an Ethernet cable and remove the lens cap.

(b) Launch Hyperspec® III.

2.4.2.1 Set Exposure and Collect Dark Reference.

(a) Use the "Live Video" window to determine the appropriate integration time, exposure and frame rate. Click **Live Video**.

(b) Remove the lens cap from the Nano and confirm the green LED is on.

(c) Rotate the gimbal so the Nano is angled and aimed at a reference target.

1 Place a white reference object in front of the lens, such that the white reference is fully illuminated. This is done by adjusting the reflective angle of the white target relative to the sun illumination into the sensor.

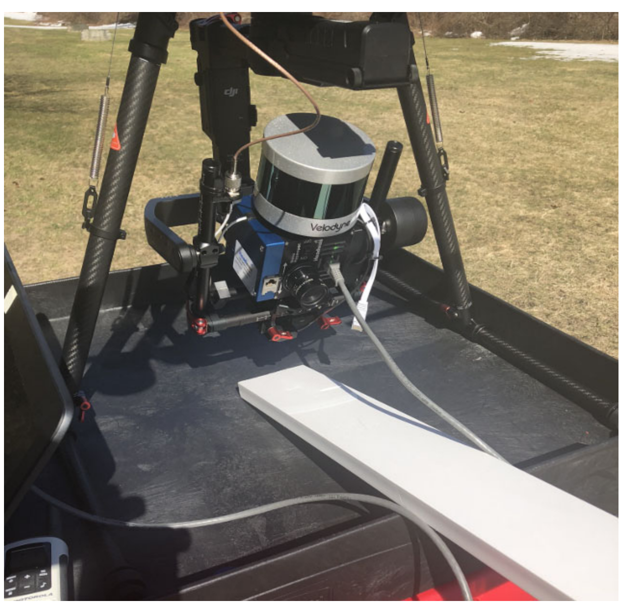

Figure 2-25. Nano Aimed at White Reflectance Target

2 Observe the Spectral intensity in the graph to the right of the live video window. The ideal range is 3000 to 3500 counts.

3 The exposure time may require adjustment, increases or decrease as conditions dictate. Adjust the “Exposure (ms)” until the maximum value in the intensity spectrum is ~3000 counts. Setting the exposure will in some instances automatically change the Frame Period.

4 Move and tilt the white reference with respect to the Sun’s location, to maximize the intensity spectrum. The resulting curve should cover approximately 75% of the chart to the right of the Live Video. After this process, the exposure time for the flight is set.

5

2.4.2.2 Calculate FOV.

The FOV calculator is used to determine the appropriate combination of flight speed, exposure time and frame period (frame period must be greater than or equal to the exposure time). Once the exposure is set, the FOV calculator can be used.

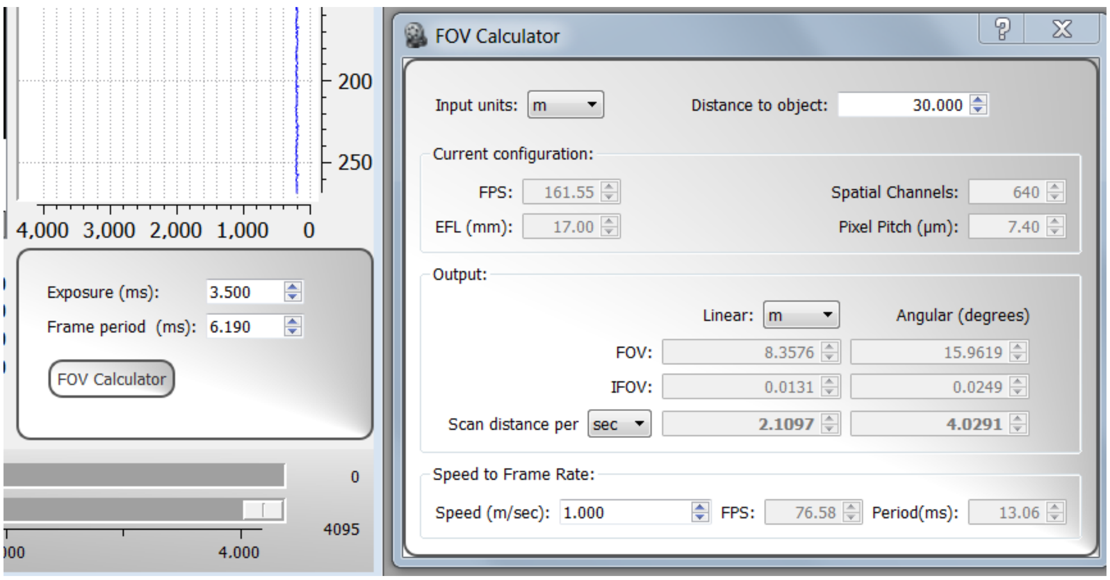

Figure 2-26. FOV Calculator.

As shown in the previous figure, with the exposure set at 3.5 ms and the frame rate at 6.190 ms, clicking the FOV Calculator button opens the pane to the right. The box at the top right, Distance to Target, is the planned flight altitude. Set this for the planned altitude AGL, for your flight. The result is the Speed, identified as Scan Distance per second. By default this is in meters. The FOV value is the scan width in meters. The IFOV is the resolution per pixel.

This example then indicates: at an exposure of 3.5 ms, flying at 30 meters altitude the drone should fly at 2.11 m/s. With these settings it will capture an 8.3 meter swath with a resolution of 1.3 cm per pixel.

The following is a second example, for clarification. The following figure shows an exposure of 20.5 ms and an opened FOV calculator showing a 30 meter flight altitude. Note the FOV and the resolution, IFOV. This set of conditions cannot be flown with the DJI Matrice, since it cannot fly slower than 1 m/s. The speed in this example is 0.637 m/s.

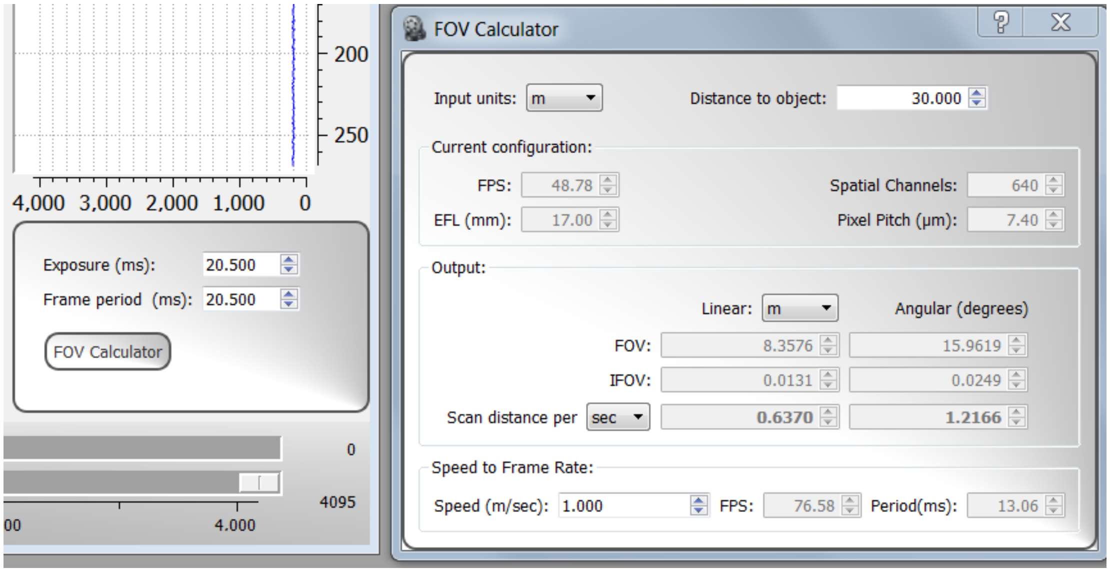

Figure 2-27. FOV Calculator 20.5 ms Exposure.

If the exposure is the maximum, and there is a need to fly this mission, there is a solution, shown in the following image.

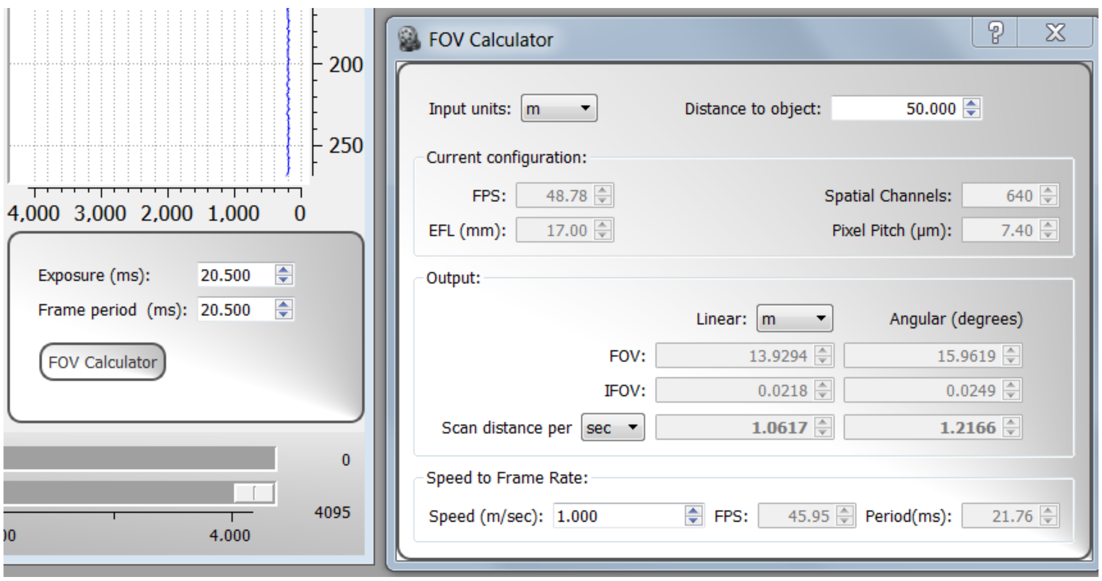

Figure 2-28. FOV Calculator 20.5 ms Exposure.

Note that the speed is now within operating range of the Matrice drone, 1 m/s. However to achieve this, the altitude was changed from the previous 30 meters to 50 meters. The scanned area width is now 13.9 meters and the IFOV is 2.18 cm compared to the prior 1.3 cm resolution.

A simplified approach is that the faster the exposure, i.e. low exposure times, the faster the drone can fly. Also, the higher the flight altitude, the faster the drone can fly.

In all cases the IFOV should equal the GSD value in UgCS. Please confirm this during your flight planning. And then enter the flight speed plus 1 meter per second to compensate for UgCS into the speed box in the flight planning software.

1. Place the lens cap, tightly over the lens.
2. Click the **Capture** button on the Button Dock, opening the panel shown below.

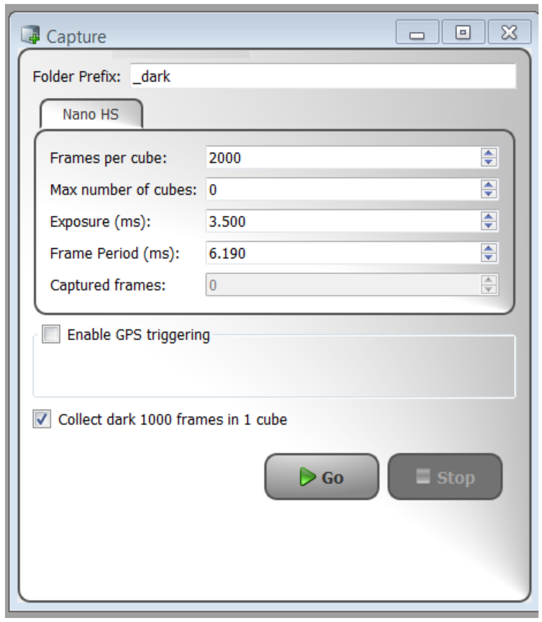

Figure 2-29. Capture Panel.

3 With the Capture panel open, label the capture, in the Folder Prefix line, as "dark reference_nhs-xxx" in the capture directory. This will be the dark reference used in the Reflectance post-processing of SpectralView.

4 Uncheck **Enable GPS Triggering**.

5 **Check** the Collect Dark Reference Collect 1000 Frames in 1 Cube check box, as shown below.

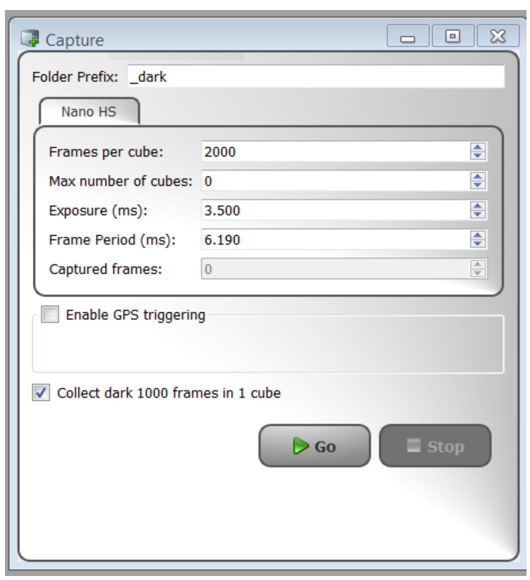

Figure 2-30. Dark Reference Collection.

6 Click **Go** and wait for the process to finish.

7 Verify the dark reference file was created in the Capture folder, C:\headwall\sensor1\capture, or img\captured if saving to the Nano memory

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Remove the lens cap, uncheck **Collect dark 1000 frames**, and select the **Enable GPS Triggering** check box. and close the Capture panel.

2.5 ACQUISITION STEPS

(1) Bring drone to desired take off location (an open area away from any buildings, trees, etc.)

(2) Set up the calibration tarp on a flat surface within the area of interest that you will be flying

(3) For best results, you may want to strategically place the tarp in an area coinciding with where your flight plan will directly pass over the tarp

(4) Stake the tarp down if needed

(5) Check that all the antenna mounts are in the upright / locked position and are sufficiently tight

(6) Check all other screws on the aircraft are sufficiently tight

(7) Fully extend the 6 arms, and fully lock into place with the red rotating clamps

(8) Remove the 6 wing covers and set aside

(9) Open all the blades so that the two blades per arm are in a straight line

(10) Check that all the blades are in good condition visually, and by running your fingers along the edges to look for nicks/cracks or other defects

(11) Insert 6 fully charged batteries

(12) Power on the drone by pressing the power indicator button on one of the batteries once and then pressing and holding again for 3 seconds, it will make a noise once it successfully powers on

(13) Hold the sensor in the Home position before powering ON the gimbal. Power on the Ronin MX gimbal by pressing once and then pressing and holding the power indicator button on Ronin MX battery for 3 seconds

(14) Make sure the Nano is switched to the ON position, and that its LEDs are lit and the fan is running

(15) Insert an Ethernet cable into the Nano, and the other into your computer

(16) Follow airborne manual for how to set up the Nano for capture (set exposure / frame period based on the light, import a polygon, check that the GPS is receiving signal, and begin capture)

(17) Once the Nano is collecting data, disconnect the Ethernet cable from the drone

(18) Move sufficiently away from the drone (at least 10ft)

(19) Connect your computer and the tablet to the same wireless Internet connection

(20) Make sure you have the UgCS application installed on the tablet, and your computer with an active license

(21) Close out of any applications on the tablet, and close UgCS on your computer if it is open

(22) Place the tablet into the mount on the RC

(23) Turn on the RC by pressing once and then pressing and holding the RC power button for 3 seconds

(24) Once the RC powers on, it will make a connection to the drone, and will prompt you to choose an application

(25) Select the option for UgCS, and select 'Just Once', and the application will launch

(26) Use the upper left rocker on the RC to rotate the gimbal so that the lens is looking straight down (rotate it as far as it will go, and it will stop when the lens is pointing nadir)

(27) Open UgCS on your computer, and if a proper connection is established, you will see the drone on the map, and you will be receiving live telemetry data

(28) Upload your desired flight plan to the drone by pressing the button in the upper middle of the UgCS application on the computer screen

(29) Watch the tablet to see if the route is received/uploaded

(30) If the upload is successful, you are ready to fly

2.5.1 Flight and Acquisition.

(a) In UgCS on the laptop ensure that the altitude and flight speed agree with the values previously noted in the Hyperspec III® FOV calculator. Adjust them if needed.

1 Speed; Enter the value from the FOV calculator results and add 1 meter/sec. to compensate for the DJI 1 meter speed adjustment

2 ALE; Adjust GSD, IFOV from FOV calculator

(b) Make sure the mode switch on the left shoulder of the remote controller is in the "F" position.

(c) On the laptop click the button to upload the flight plan to the M600.

(d) Watch on the tablet and ensure that the mission is uploaded successfully.

(e) Use the rocker on the left shoulder of the controller to rotate the Nano-Hyperspec® to nadir position until the gimbal reaches its stop. Ensuring the gimbal is always rotated to its stop will produce the most consistent results.

(f) If using high performance GPS, before taking off make sure the system is stationary for 5 minutes before flight.

(g) The M600 can now be taken off manually.

(h) If using APX-15 before starting the mission, the UAS must perform an initialization flight sequence

1 Once you take off fly forward in straight line for 10 sec at a maximum speed. Accelerate for 5-6 seconds, whatever your platform allows (accelerate from 0 to 10m/sec), decelerate come to the stop at the end of 10 sec line, turn a wide bank turn and come back to home position using the same approach accelerate and stop at home position.

2 Fly a figure 8, ensure the UAS is always flying forwards.

3 This procedure is necessary each time the APX-15 is power cycled.

(i) When ready start the mission.

(j) Once the mission is complete land the UAS manually or automatically.

(k) If using APX-15 leave the system stationary on the ground for 5 minutes with an unobstructed sky view.

(l) Connect the laptop to the Nano-Hyperspec® with an Ethernet cable.

(m) Wait for Hyperspec® III to reconnect to the Nano-Hyperspec.

(n) On the capture window click **Stop** once the button becomes active.

(o) All devices may now be powered off or the data can be downloaded.

2.5.2 Downloading of Data Files.

a. It is recommended to use the supplied cable to power the Nano-Hyperspec® or Ronin MX and Nano-Hyperspec® directly.

b. Connect the laptop to the Nano-Hyperspec® and open Hyperspec® III.

c. Click on the **File Transfer** button. The following pane opens.

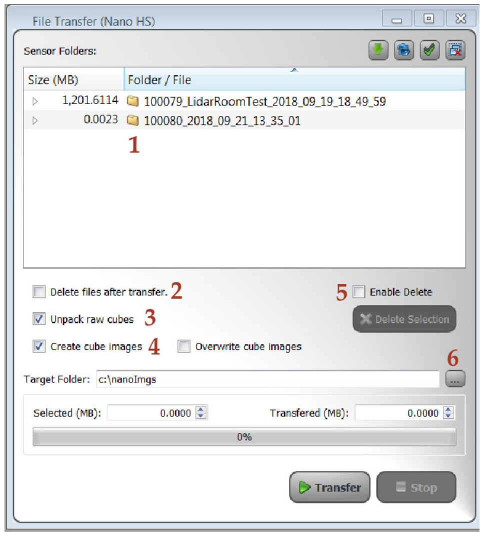

Figure 2-31. Nano File Transfer.

(1) Files in memory on the Nano.

(2) Delete files after transfer: Files will be deleted automatically after download. It is recommended to not use this function, for data security measures. Allows user to select one or more folders and delete without downloading

(3) Unpack Cubes: Files are compressed on the Nano-Hyperspec® this option performs decompression automatically during transfer.

(4) Create Cube Images: Creates a png file from the raw data.

(5) Enable Delete: Selecting specific files and clicking this check box, enables the Delete button, allowing users to delete the selected files.

(6) Select Storage Location: Users can navigate to the desired storage location for the files.

d. Select the files to download and click **Transfer**. The files are transferred to the identified computer location.

2.5.3 Additional Data for High-Performance GPS Users.

a. It is recommended to use the supplied cable to power the Nano-Hyperspec® or Ronin MX and Nano-Hyperspec® directly. This saves battery time, when after the flights, the system is returned to the bench and data is downloaded.

b. For consistent connectivity, it is recommended to have the Ethernet cable connected to the laptop and GPS prior to powering the Nano-Hyperspec®. Otherwise the network adapter of the GPS may not become active.

c. Navigate to 10.0.65.100 in a web browser. On the landing page login with the credentials "admin" and "password"

d. Navigate to data logging and follow the paths to the data files of interest.

e. The data files can be selected and downloaded through the web interface.

f. Alternatively, the data can be downloaded using the same credentials as above and an FTP client of your choosing.

g. These files will need to be processed into one or more SBET files using POSPac UAV before being used.

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CHAPTER 3 CO-ALIGNED UNIT

3.1 OVERVIEW

The Headwall co-aligned unit is a series of sensors and IMU housed within a single, integral housing. The unit contains a SWIR and VNIR sensor, an Applanix APX-15 and Hypercore. The system is capable of holding 430 GB on each of the data drives, one on the VNIR and the second on the integral Hypercore. The Hypercore is also connected to the Applanix so the flight data can be retained on either the SWIR or VNIR unit. The system can also be configured to operate and store LiDAR data to enable further detailed data analysis.

This document covers the physical configuration of the co-aligned unit, removal of data from the system and preparation for flight. The LiDAR is included.

3.2 CO-ALIGNED SYSTEM

Figure 3-1. Co-Aligned with LiDAR.

The above figure shows the co-aligned unit, with an integrated LiDAR mounted onto a UAV for aerial data collection. The unit is supplied with an integral dove-tail mount that connects with the UAV. The power and data connections for the co-aligned are found on the opposing side to that shown. The following figure shows the data and power connections, labeled for convenience.

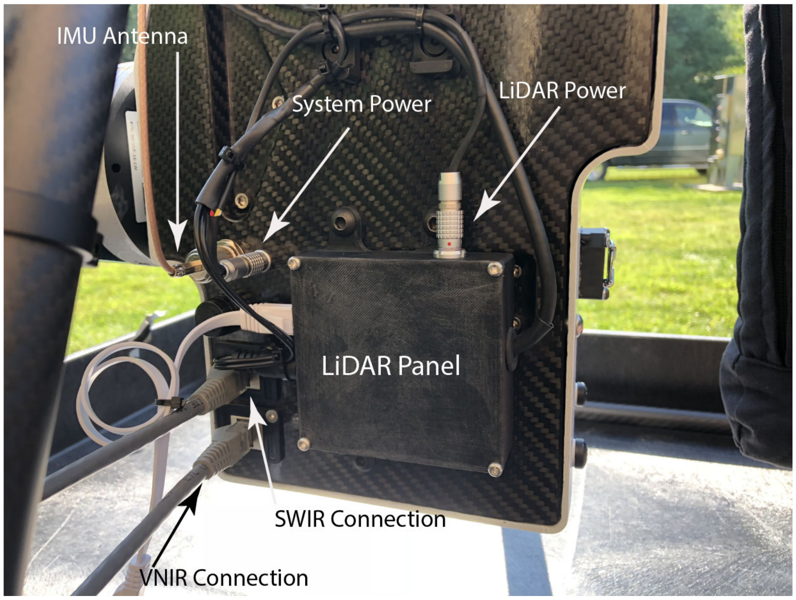

Figure 3-2. Labeled Co-Aligned Unit.

The VNIR and SWIR connections are routed through the adapter to the operating computer. The Applanix data is downloaded through the SWIR port using the IP address http://100.0.65.51:8080/.

3.3 SYSTEM OPERATION

The system contains two sensors with the respective sensors aligned to the same axis. As such, when developing a flight plan both sensors require configuration. An example of this is that the capture polygon that is used for GPS triggering needs to be loaded into both sensors. The configuration for data capture is done with Hyperspec III from the operating field computer.

Connect the operating computer, through the giga-bit switch to the co-aligned unit, as shown above. Confirm the Ipv4 adapter settings are set to a static IP of 10.0.65.30.

Power **ON** the operating computer and Co-aligned unit.

Start HyperSpec III and wait for the SWIR to come to operating temperature, indicated by the reduction in sound of the cooler. Once the cooler reaches operating temperature the HyperSpecIII log will show the SWIR connected.

The following figure shows the sensor selection option for HyperSpecIII. To change between sensors, use the drop down Sensor menu. The HC A640 is the HyperCore which goes with the SWIR, Nano HS is for the VNIR.

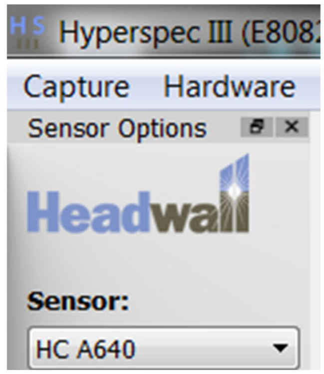

Figure 3-3. Sensor Selection, HyperSpec III.

When the two Live Video windows are open, use the exposure and FOV calculator to set the exposure for the available illumination. The purpose is to capture the data with square pixels in both sensors in a single flight. This is accomplished by first setting the exposure for each sensor and then matching the frame periods of the sensors. Also, the SWIR sensor pixels are twice the size of the VNIR sensor making the accuracy of frame periods important to match the data.

The SWIR sensor has an exposure range that is more limited than the VNIR. For this reason the SWIR should be the first sensor that the user sets the exposure period. Once set, then set the exposure of the VNIR, adjusting it to follow the guidelines identified in the HyperSpecIII manual. Once the VNIR exposure is set the frame periods for the VNIR and SWIR need to be set to identical values.

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CHAPTER 4 APPLANIX POST-PROCESSING

NOTE

This chapter is specifically for users who have captured hyperspectral data while using an Applanix APX-15 for geospatial IMU referencing.

4.1 APPLANIX DOWNLOAD.

During the capture process, using a Nano configured with an Applanix APX-15, the Nano will store hyperspectral data. The APX 15 has internal storage and will hold the positional data from the flight. Post flight, the user creates a folder within the associated hypercube data, and downloads the Applanix raw data into the folder. In the following figure it is a folder named APX, within the hyperspectral data folder. The best folder structure is similar to the following figure.

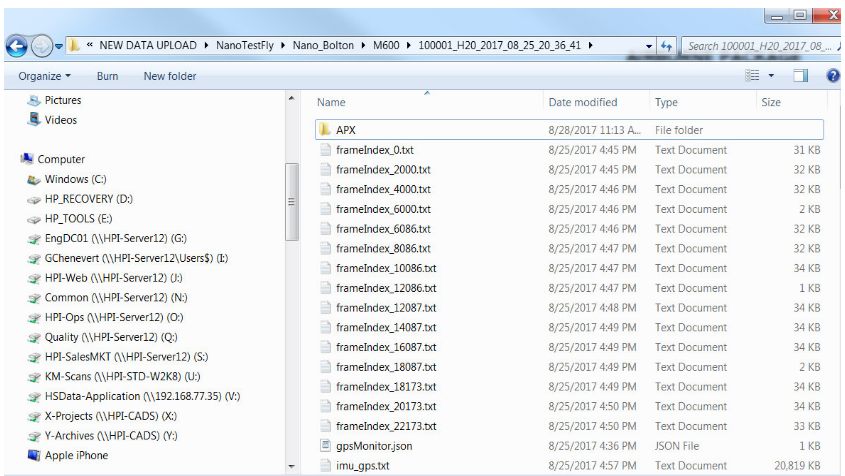

Figure 4-1. Hyperspectral Folder.

The Applanix files, *.T04 files, once downloaded, should be similar to the following figure.

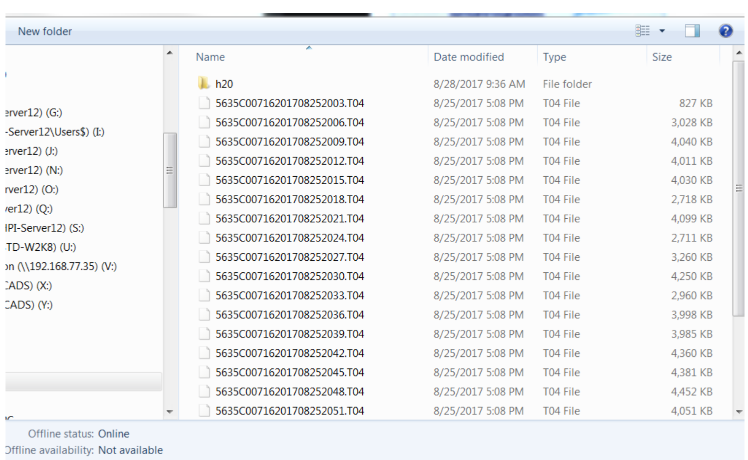

Figure 4-2. Applanix Data Folder.

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Power ON the APX-15, connect it to the computer used for post-flight data processing.

Set the computer network settings so the Applanix unit and computer are connected. The IP Address for the APX-15 is 10.0.65.100.

Open a browser, entering the IP address for the Applanix, User name = admin, password = password.

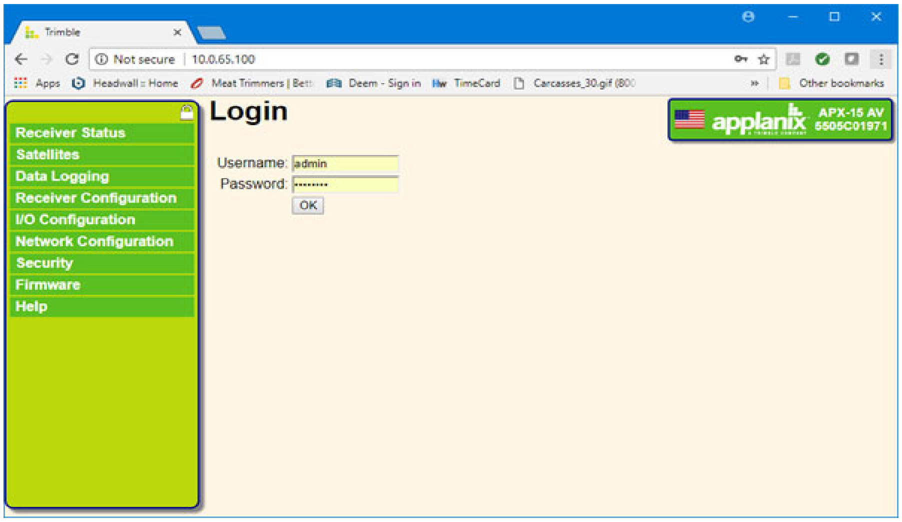

Figure 4-3. Applanix Login Page

Once the application opens, identify the directory where the flight data was stored.Choose "Parent Directory" to see files grouped by month.

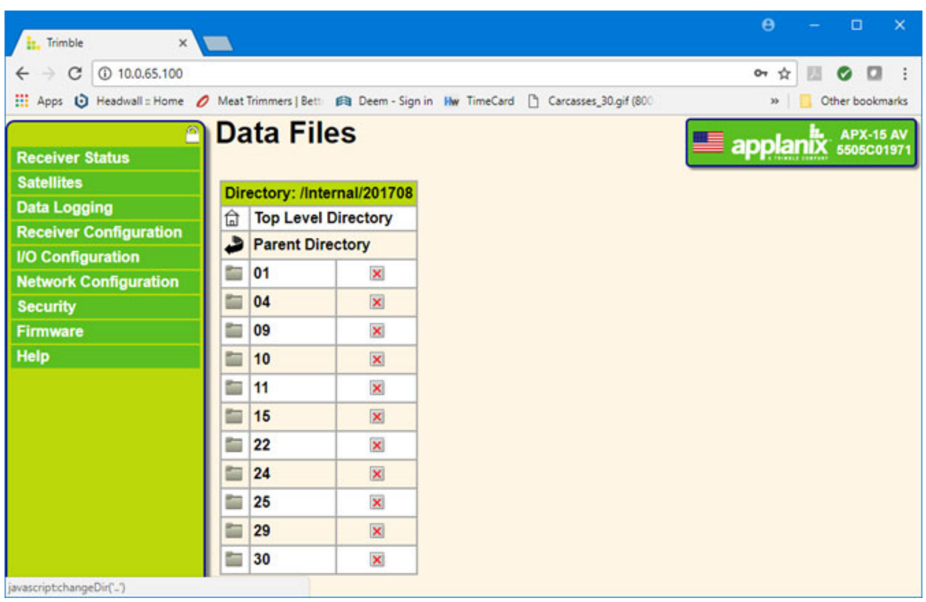

Figure 4-4. Data File Location

Expand the folder and confirm the files that are to be downloaded for the defined flight.

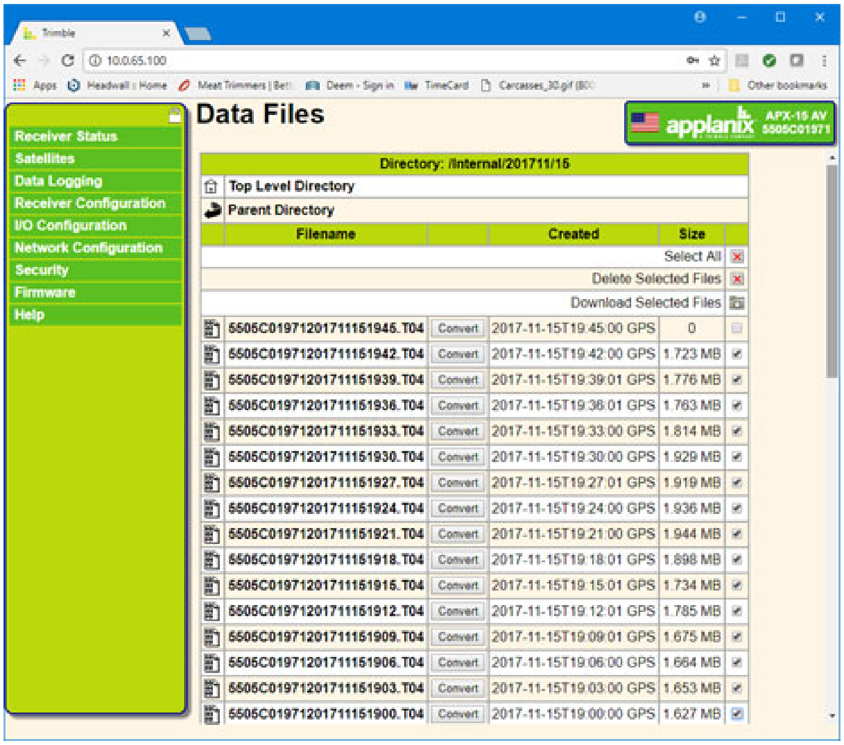

Figure 4-5. Data File Structure

When the data is selected, download into the previously created folder.

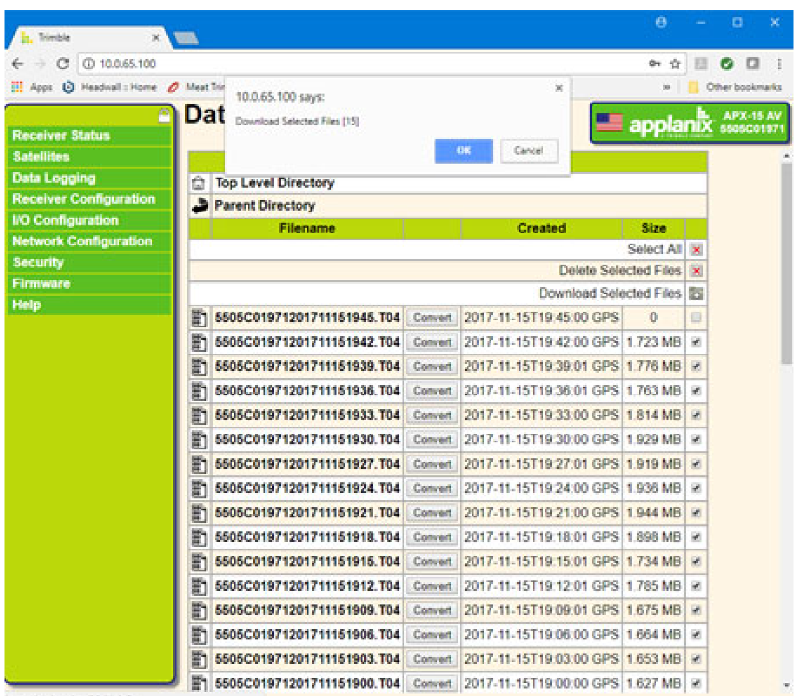

Figure 4-6. Download File Confirmation

Close browser window and disconnect the computer, power OFF the APX-15.

4.2 POSPAC FUNCTION.

Locate and launch the POSPac application, used with the Applanix.

Click **New Default Project** and then click **Import**, browse to the folder where the *.T04 files are located.

Select the T04 files that overlap the collected hyperspectral data and click **Import**. Allow the import process to complete.

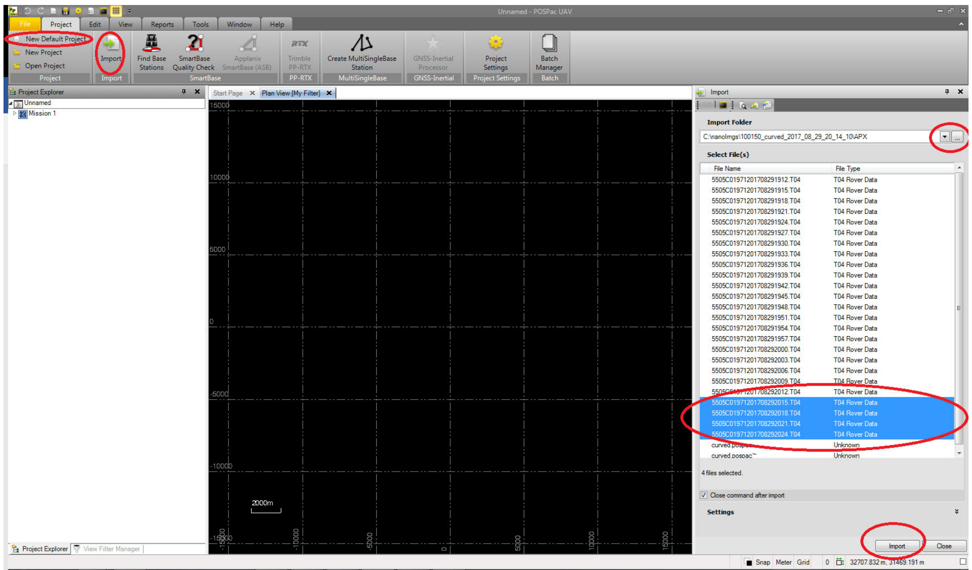

Figure 4-7. POSPac Application, New Project.

4.3 SINGLE BASE PROCESSING

The accuracy of the Applanix IMU arises from the relative accuracy developed from the relation of the hyperspectral collection flight to a particular base station. For orthorectification the accuracy of each pixel's placement is important to making the ortho image place accurately on for the collected scan.

With the POSpac application opened, click **Find Base Stations.**

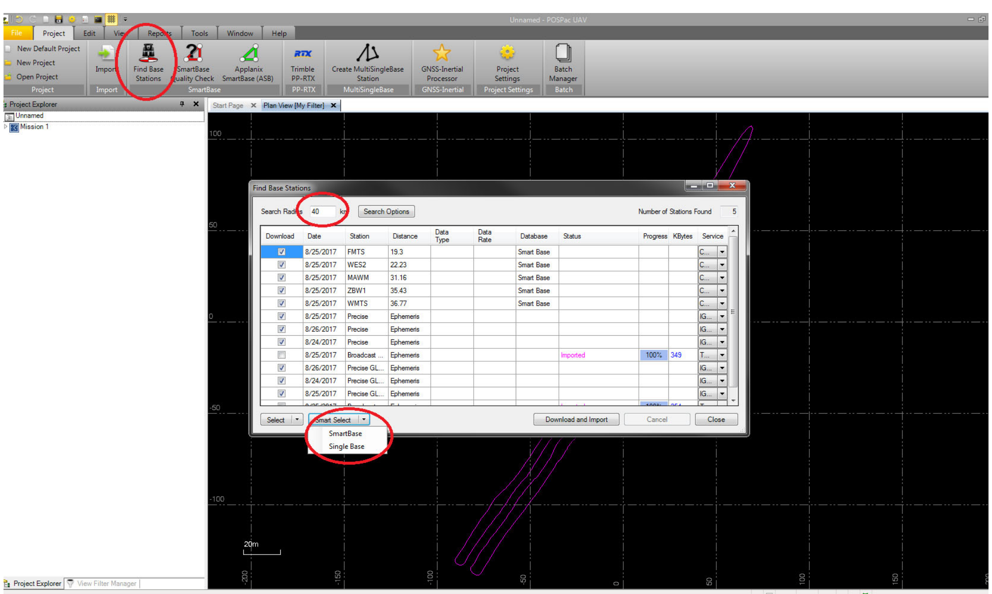

Figure 4-8. POSPac Selection Options.

If there is a base station within 40km from the flight location, click the **Smart Select** drop down and then **Single Base**. Wait for the import process to complete, and click **Close** when finished. Wait for the QC Processor to finish.

The GNSS QC Processor may fail with a message output. The failure can be from a corrupted t04 file or, more likely, an erroneous base station, as shown below.

Figure 4-9. POSPac Error Message.

If there is no Single Base station within 40km, then select **Smart Base**, the instructions for smart base are located at the end of the selection. The error above may be corrected by returning to the base station selection panel and choosing an alternative base station, as shown below.

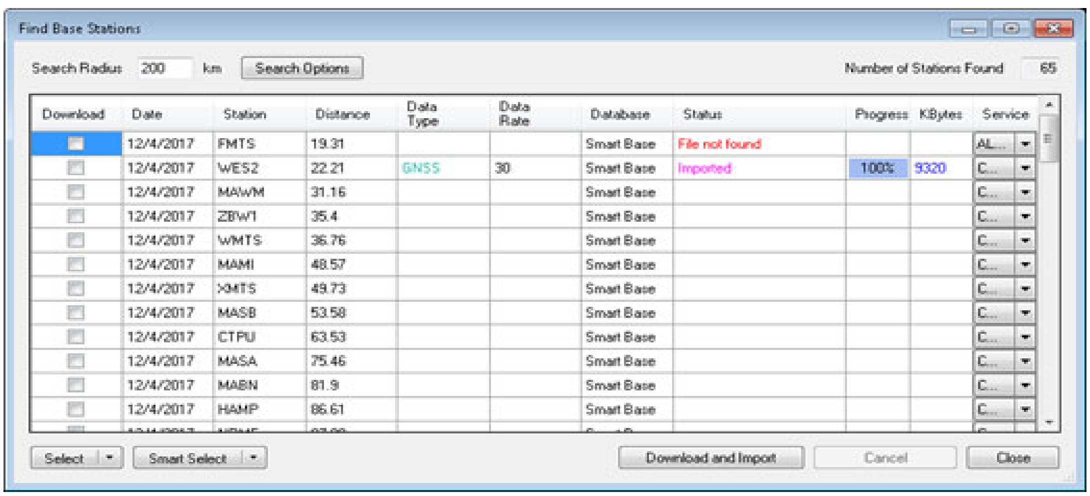

Figure 4-10. Base Station Panel.

The error came from selecting the WES2 station. Assuming there is a problem with this data point, select an alternative and then click the Download and Import. When the import successfully completes, the following Statistics pop-up opens, click **OK**. There should be minimal values for "Float Epoch" and "No Solution"

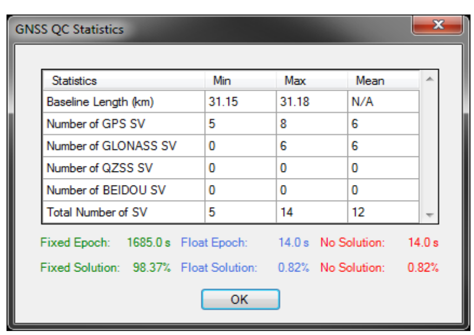

Figure 4-11. GNSS Statistics.

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With the application opened, select the **GNSS-Inertial Processor** button on the top line. Verify the GNSS Mode, as in the Settings view, is **In-Fusion Single Base**, circled on the right side of the following figure.

If using a gimbal, set Stabilized Mount to **Model**. If no gimbal is used, set Stabilized Mount to **None**. Verify that the base station is listed. If not locate it in the project explorer pane, right click on it and select **Set Base Station**.

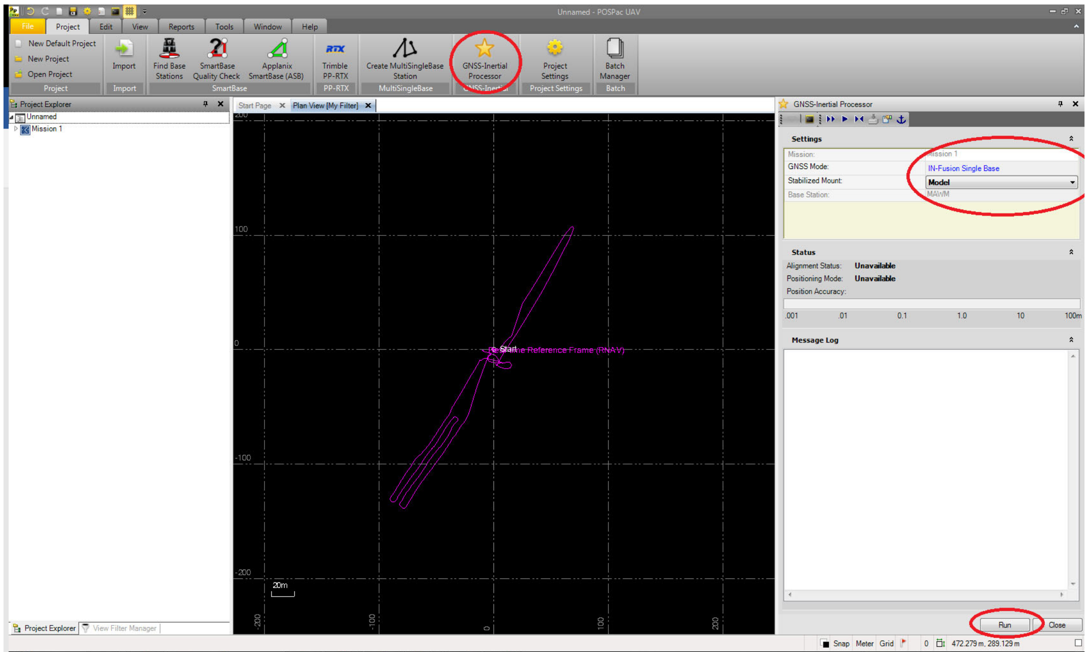

Figure 4-12. GNSS Inertial Processor.

Click **Run** and wait for processing to finish. Verify that the Post Processed trajectory, Green area in the following figure, includes the entire area where Hyperspectral data was collected.

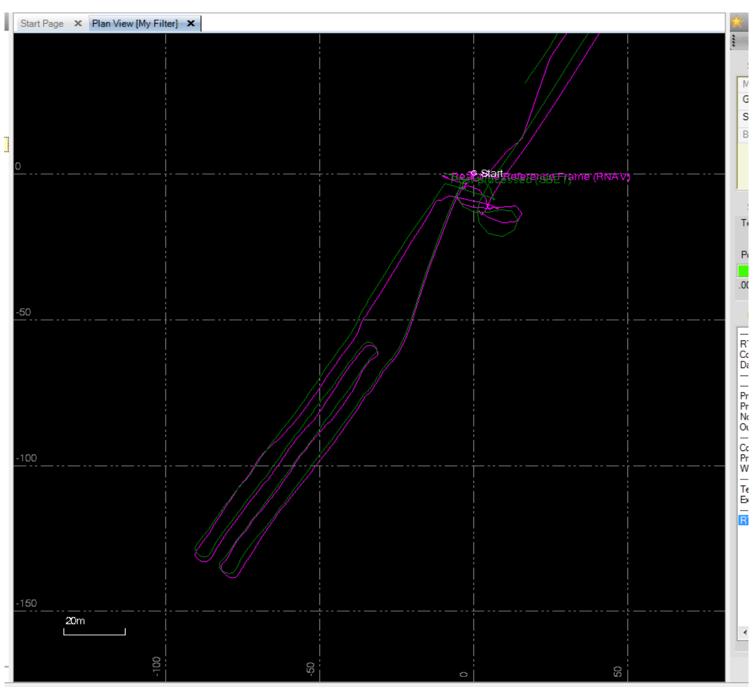

Figure 4-13. Post Processing Trajectory.

4.4 CREATE SBET FILE.

Click **Tools**, then click **Export**.

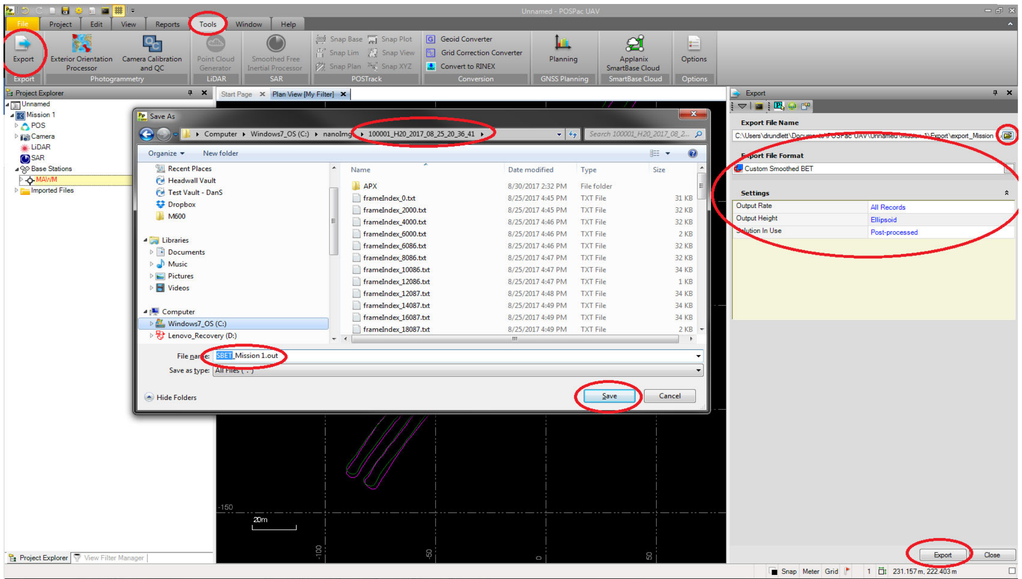

Figure 4-14. Create an OUT file.

Select **Custom Smoothed BET** from the format drop down. Confirm that **All Records**, **Ellipsoid** and **Post-processed** are selected.

The saved file must contain the string, SBET. Browse to the same folder where the hyperspectral data is located and make sure the file is named **SBET_Mission1.out**.

Click **Save** and then click **Export**.

APPENDIX 1 PRE-FLIGHT CHECKLIST

Table 5-1. DJI Matrice Pre-Flight Checklist

Pre-Flight Checklist			
Pilot in Command		FAA Reg No:	Date:
Person Manipulating Controls			Observer(s):
UAS Model:	Location		
Purpose of Flight:	Commercial:	Training:	Other
	UAS Pilot License:		
Flying in unrestricted airspace **Yes** **OR** **Have waiver for restricted space** **Yes**			
Complete all check list items in the order they are presented. If you cannot check off an item STOP and correct the problem before continuing.			

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
Pre-Flight Check					
1		Airspace	Verify location	Unrestricted airspace or flight authorized. Potential obstructions near flight path identified and accounted for.	

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
2		Weather	Visual	Visibility ≥ 3 miles/500 ft. below clouds Wind ≤ 15 mph, Precip. = None	
3		Laptop computer with CAT5e or CAT6 Ethernet port	Power and verify Ipv4 DNS settings	Setting correspond to those for system communication. Refer to manual for particular system requirements	
4		Tablet and connecting cable	Power tablet, Verify interconnect cable tablet to controller	Min. 50% battery power level. Cable connects tablet and controller	
5		Unpack UAS and payload	Unfold arms and propellers. Lock arms to the click with red lock device. Remove propeller covers and deploy the blades	.Inspect blade edges for cracks or defects. Arms should be fixed in place.	
6		Antenna Mounts,	Identify IMU Type	Headwall, Applanix, Other	
	6 A	Headwall antennas	Rotate upright and confirm lock.	Upright and locked positions, wires secured and not obstructing operations	
	6 B	Applanix	Secure antenna mast	Secure mast and antenna to mount atop the drone	
7		UAS Airframe & Props	Visual inspection of all surfaces.	No structural defects, missing parts visible. Red locks secured	
8		UAS Battery	Visual	Sufficient for planned flight, min 75% and at safe level and charge	
9		Payload; gimbal or hard mount, depending upon configuration	Unpack and attach to mounting hardware on drone	Payload mounted and secured	
10		Power connections to payload	Visual	Cable from gimbal/hard mount to sensor	

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
11		Controller Battery	Visual	Sufficient for planned flight, min 75%	
12		Gimbal Battery (if applicable)	Visual	Sufficient for planned flight, min 75%	
13		Gimbal Lock removed, if applicable. If hard mount, go to next step	Visual and manual that the hook and loop straps used for transport are removed	Removed and set aside	
14		Controller Power	Press once, release then press and hold for 3 sec.	ON light illuminated	
15		UAS Power	Select any drone battery. The round button, Press once, release and press and hold for 3 sec.	Round button lights red. 4 bar LED shows correct color, white	
16		Tablet, DJI GO Compass calibration	View Compass Calibration in DJI GO	Three bars small green in each. If not present perform compass calibration procedure steps from DJI GO.	
17		Connect sensor to powered ON laptop computer	Plug Ethernet cable from laptop to sensor RJ45 port	Connectors secure in place.	
18		Payload powered ON **NOTE:** **For specific payloads follow power on procedures specific to that system.**	Visual	LED indicators steady	
19		Open Hyperspec III	Click Icon	Hyperspec III opens. Hyperspec III log dock displays connection to sensor, blue text.	
20		Verify available data storage on payload	View status bar on left side of Hyperspec III	50% or greater available storage space	

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
21		IMU Powered and connected	Visual	GPS disk in bottom left of Hyperspec III colored yellow without satellite coverage (inside) and green when satellite communication	
22		LiDAR Powered	Visual, cable plugged into unit, if applicable	Laser output visible with Android cell phones if LIDAR not used, N/A	
23		Ethernet cable to laptop disconnected	Visual	No computer cable connected to front of Nano	
24		LiDAR cable connected to sensor	Visual	Ethernet cable connected from LiDAR to sensor Ethernet port	
25		Observer briefed	Oral confirmation	Present, briefed and ready.	
26		Flight limits set	Visual with software settings	Alt. <=120 meters, 400 ft.	
27		Flight mode set to F mode	Visual	Verify in software. Controller mode switch in “F” , display status GREEN - RTF	
28		Dark reference taken	Procedure from Airborne manual or specific payload procedures	Dark reference found in folder	
29		Lens ready for capture	Remove lens cap	Lens visually observable	
30		Sensor set to Capture	Procedure from Airborne manual or specific payload procedures	Capture panel opened, Start button grayed and Stop button active	
31		UAS placed in take off location	Manual	Clear for >=25ft. radius, no overhead obstructions	
	31 A	Applanix Calibration	If using Applanix IMU requires 5 minutes of non-flight stabilization	Time unit sitting in take off position	

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
	31 B	APX Calibration	Place powered drone in take-off position, let sit static for 1 minute	Visual	
	31 C	Flight APX Calibration	Manually rotate drone 3 times in one direction and 3 times in the opposite direction, each flight a minimum of 9 seconds duration.		
	31 D	Verify Calibration	Land drone after completing previous step.		
	31 E	Connect to Applanix	Connect computer to Applanix	Visual: Ethernet cable connected to device and computer	
	31 F	Nano or Micro SWIR	Open browser enter http:\\\10.0.65.100	Applanix login opens	
	31 G	Co-Aligned	Open browser enter http:\\\10.0.65.51:8080	Applanix login opens	
	31 H	Log In	enter username = admin, password = password	Data files page opens	
	31 I	Validate Calibration Date	Click on the GPS Status, then INS Status tabs, and check the bottom right corner to see the GPS calibration date.	Should read current date (in UTC), meaning the calibration was successful (if not, repeat this process)	
Motor Start Checklist					
1		Computer and tablet connected to same wireless connection	Visual	Open wireless connection on both devices and confirm connection	
2		Tablet clear	Visual	Tablet applications closed	
3		Computer ready	visual	Close UgCS on computer	

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
4		Tablet on Drone Controller	Visual	Secure tablet to controller	
6		Launch UgCS tab.	Visual confirmation		
7		Launch UgCS on laptop	Visual confirmation		
8		Drone Controller connected to drone and computer	Visual	Observe connection in computer screen UgCS	
9		Gimbal to Nadir, when flying a gimbal mounted sensor.	Use the upper left rocker on the controller to rotate the gimbal until it stops	Sensor to nadir	
10		Flight plan loaded	Visual: pressing the button in the right middle of the UgCS app on the computer screen and verify successful upload on tablet	Plan displays route plan upload	
Flight Checklist					
1		DJI UAV connected to UgCS software	Visual: Path and UAV shown.	Icon of drone following the flight path	
2		Drone operating under controlled conditions	Visual: check status	Directly observe the movement and stability of the UAV	
3		Calibration	Manual take off and flight pattern for calibration	Observe figure 8	
4		Applanix calibration, if applicable	Manual take off and flight pattern for calibration Refer to Airborne manual for Applanix flight directions.	Observe Applanix flight pattern and speed.	
Landing Checklist					

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
1		Stopped in correct location	Visual	Identify location on computer display. Identify the physical location.	
2		Manual control assumed for aircraft	Controller switch set to P	Control UAV	
3		Post flight calibration	Verify adequate battery left	Manual movement	
4		Landing gear dropped	Control flight through to landing gear.	Visual	
5		Securely landed	Decreased motor speed, lower motor sound.	Visual/audio	
6		Rotor blades stopped	Controller set to OFF. Rotors in fixed position	Visual	
7		Applanix resolution	Wait minimum of 5 minutes after landing before moving UAS	Visual	
8		Computer connected to sensor system.	Connect laptop to to Nano	Visual	
9		End hyperspectral capture process	Use Hyperspec to Stop capture	Visual	
10		Transfer Data	With Hyperspec III opened and connected to Nano. Click **Transfer** button select and transfer data.	Visual	
Post-Flight Checklist					
1		Data captured	Connect computer to Nano, verify a folder for the flight and the folder has contents	Visual	
2		Download data	Click **Transfer** button on Hyperspec III, select data and identify repository folder on computer	Visual	

Table 5-2. Operational Check UAS, Nano, Headwall IMU/GPS

Step:	Step:	Item	Procedure	Acceptable Condition	Verify
	A1	Connect to Applanix	Connect computer to Applanix	Visual: Ethernet cable connected to device and computer	
	A2	Nano or Micro SWIR	Open browser enter http:\\10.0.65.100	Applanix login opens	
	A3	Co-Aligned	Open browser enter http:\\10.0.65.51:8080	Applanix login opens	
	A4	Log In	enter username = admin, password = password	Data files page opens	
	A5	Select files	Use manual for details to identify specific files	Downloads to the computer Download directory	
	A6	Place files with scan data	Copy from Download directory	All T04 files in APX directory	
3		Stow rotors	Fold rotors to stow position.		
		Power Down Sequence	Press gimbal power button		
			Power OFF drone		
			Power OFF tablet		
			Power OFF controller		