
Airborne User Manual

Release 9.2

Resonon

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INTRODUCTION

The Hyperspectral Airborne Remote Sensing System is a compact, high fidelity, digital imaging spectrometer for airborne applications. The system consists of a Pika imaging spectrometer, a flight computer, a GPS/IMU, an optional downwelling irradiance sensor, an optional external USB LCD display, **Spectronon** data analysis software, and the **ResononGroundStation** software.

This user manual covers the installation and use of the hardware and software. Topics covered in this manual include:

- Installing the spectral imaging hardware
- Installing and configuring the **ResononGroundStation** software
- Configuring the Airborne Spectral Imaging System
- Flight operations, data download, georectification

Users can also visit the [Resonon Blog](#) for further material on hyperspectral imaging.

1.1 Data Modes

Airborne hyperspectral data from the Resonon imaging system can be utilized in three forms, as summarized below.

Raw data: This data is spectrally calibrated but contains the instrument response and illumination functions. This is the least useful form, as the spectral curves do not have real units or real physical meaning.

Radiance: The flight computer can acquire raw data for later processing or it can process the data to radiance as it is collected. The mode of collection can be selected in the *Imager Tab*. If radiance mode is selected, the appropriate calibration file must be uploaded to the flight computer. This file is also necessary for post processing to radiance using the radiance conversion plugin in **Spectronon**.

The radiance data form does not include the instrument response function. Additionally, it has the advantage of possessing real units and physical meaning.

Reflectance: In reflectance mode, both the instrument and illumination functions are removed. This leaves the data in absolute reflectance. Data can be converted to reflectance with one of four ways:

- **White reference that spans the FOV:** Data can be processed to reflectance with a calibration against a reflection standard that spans the entire FOV of the instrument. This is often impractical for airborne systems, but does have the advantage of not requiring processing to radiance. The highest quality reflection standard is Spectralon, but Teflon is acceptable for many applications.

Note: Teflon needs to be sanded with 100 grit sandpaper on an orbital sander to eliminate any specular properties).

This calibration is done with the *Record Correction Cube* feature, as described later in this document. It is important to note that reflectivity values are only accurate if the solar illumination (clouds, sun angle, etc) does not change between the collection of the correction cube and the collection of datacubes. Data can be converted to reflectance using **Spectronon**'s *Reflectance from Raw Data and Spectrally Flat Reference Cube* plugin.

- **Known spectral reference in scene:** The spectrum of a reference object in the scene can be used to correct the data to reflectivity. The reference spectrum must be known and in a tab or space delimited file, then use the *Reflectance from Radiance Data and Measured Reference Spectrum* plugin in **Spectronon** to convert the data. The data also must first be converted to units of radiance in order to correct for spatial variation of the instrument. This method can be the most accurate but is also not practical for some applications.
- **Downwelling Irradiance sensor:** The most convenient method for converting data to reflectance is to use a downwelling irradiance sensor. This sensor records the solar spectral irradiance during flight. This data is used, along with radiometric calibration files supplied by Resonon for both the spectral imager and downwelling sensor, in the *Reflectance From Raw Data and Downwelling Irradiance Spectrum* plugin for **Spectronon**. If data is converted to radiance onboard the flight computer, it can later be converted to reflectivity with the *Reflectance from Radiance Data and Downwelling Irradiance Spectrum* plugin.
- **Atmospheric Correction:** Data can be converted to reflectance data with the use of atmospheric correction algorithms such as FLAASH (Fast Line of Sight Atmospheric Analysis of Spectral Hypercubes). Please contact Resonon for more information.

INSTALLATION

2.1 System Hardware

The Hyperspectral Airborne Remote Sensing System includes:

- Pika imaging spectrometer. This may be:
 - Pika L VNIR USB3 or GigE spectrometer
 - Pika XC2 VNIR USB3 spectrometer
 - Pika IR, IR+, IR-L, or IR-L+ GigE spectrometer
 - Pika UV USB3 spectrometer
- Resonon flight computer
- USB-C SSD hard disk
- GPS/IMU
- Downwelling irradiance sensor (optional)
- External USB LCD display (optional)

Resonon provides the **ResononGroundStation** software to connect to and configure the flight computer. This requires a computer with:

- Windows
- 512MB of RAM

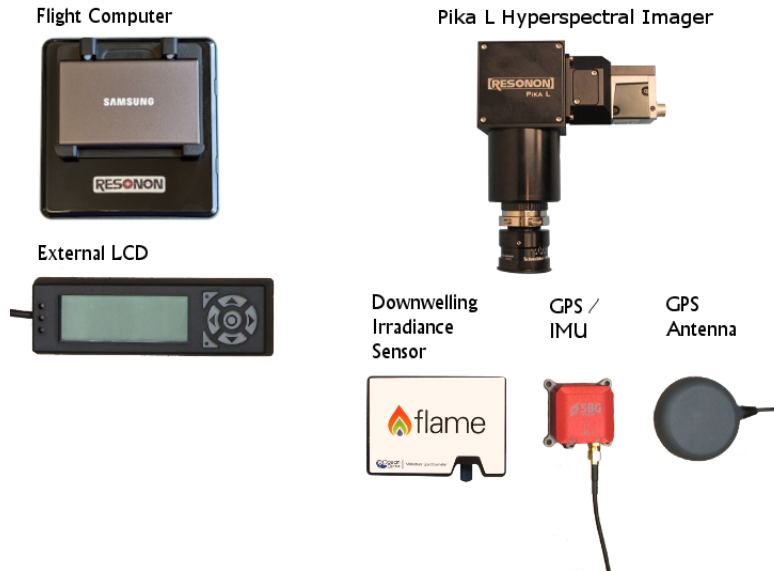


Fig. 2.1: Standard system components



Fig. 2.2: Pika IR imager

2.2 Installing the Hardware

The spectral imaging hardware should be mounted in the airframe with the following considerations:

2.2.1 Installing the Spectral Imager

- The Pika should be sighted straight down (nadir). The Resonon logo on the instrument should face either left or right relative to the direction of flight. The Pika should be square with respect to the GPS/IMU system (there should be zero angle in pitch, roll, and yaw between the two) as well as to the axis of the aircraft.
- The Pika should be mounted in a manner to reduce high frequency vibrations, but rigidly to low frequency vibrations with respect to the GPS/IMU.
- Do not attempt to adjust aperture (F#) of the Pika or the radiometric calibration will be void.

Connecting the Pika L and Pika XC2 USB3 imagers

- Pika L, Pika XC2, and Pika UV USB3 imagers connect to any USB3 port on the flight computer.
- An error will display in the ground station if the imager is connected to a USB2 port, as shown in Fig. 2.3.

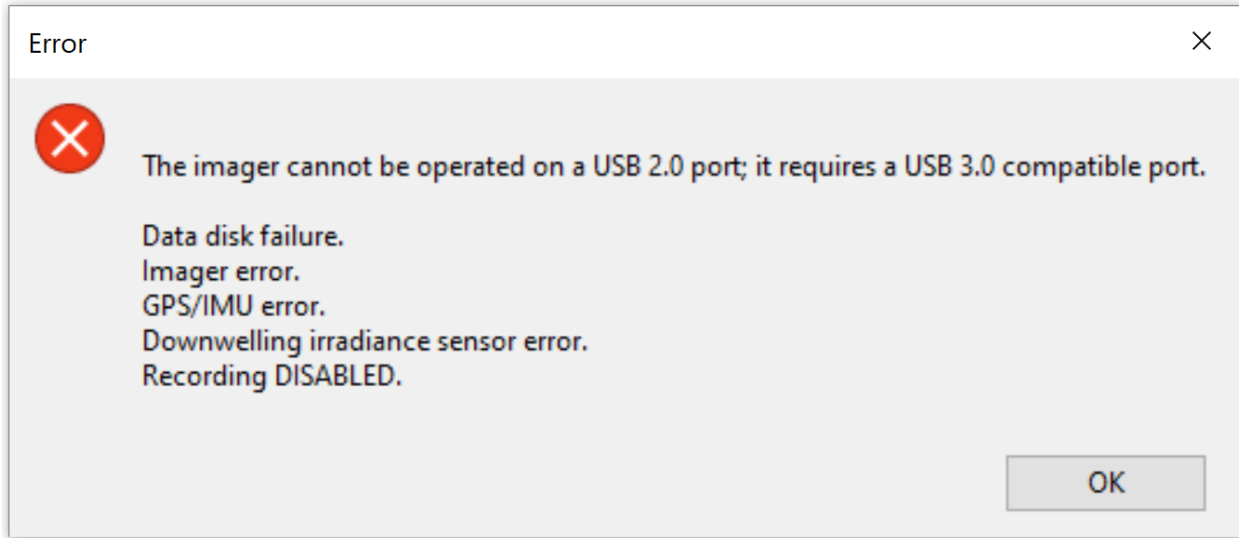


Fig. 2.3: Error displayed by ground station when Pika L or PIKA XC2 imagers are connected to a USB2 port

Connecting the Pika IR imager

- Connect the Pika IR Ethernet port to the Ethernet port on the flight computer.

2.2.2 Installing the GPS/IMU

- If mounting the Ellipse separately (not using a Resonon mounting system) it needs to be mounted rigidly with one of its axes square/parallel to the body of the imager. The orientation needs to then be configured in the **sbgCenter** software. In the case of a complete package such as the gimbal caddy or VIP, the Ellipse orientation may already have been configured but should be verified. Small angular misalignment can be entered into the *Alignment & Lever Arms* section of the SBG software, as discussed below. There are alignment holes in the base of the Ellipse that can be used to align the unit to reference pins. See the Ellipse user manual for the location of these holes.
- The unit should be vibration isolated, if possible, but in the same inertial frame as the Pika (ideally both the Ellipse and Pika are vibration mounted from the airframe). The GPS antenna should be screwed into the appropriate SMA terminal, and the antenna itself should be mounted with a clear view of the sky. Use brass screws to mount the unit. The unit should be positioned as far away from any potential source of magnetic interference as possible.
- If using a dual antenna system, both the *Primary Lever Arm* (distance from IMU to Antenna 1) and the *Secondary Lever Arm* (distance from IMU to Antenna 2) must be entered. See section below on dual antenna systems.
- GPS reception is sensitive to electromagnetic interference (EMI). The GPS antenna should be placed as far as possible away from radios, other GPS antennas, the flight computer, spark plugs, or any other potential source of EMI. Try to avoid running the GPS antenna parallel to other wires or cables for much distance. Do not bend the GPS cable excessively. A ground plane under the antenna helps significantly. Connect the GPS antenna to the GPS/IMU unit.

- Avoid looping the GPS cable. This might require shortening the cable by cutting it to length and re-connectorizing with a SMA connector. Alternatively, connectorized GPS antenna can be purchased along with the appropriate length SMA coax cable. SBG recommends the Tallysman TW7972 for the Ellipse N and the Maxtena M7HCT-A-SMA for the Ellipse D.
- For the Ellipse D, the further the antennas are positioned from each other, the better the heading accuracy. See the chart below:

Separation	RMS Error
2.0 m	0.15 deg
1.0 m	0.3 deg
0.5 m	0.6 deg
0.25 m	1.5 deg

- Connect the Ellipse USB cable to any of the USB ports of the flight computer.

Note: The Ellipse must be configured with proper lever arm settings corresponding to the physical installation. Single-antenna units also require a magnetometer calibration. Instructions to complete these steps in the **ResononGroundStation** software are given in [Section 3.6: GPS/IMU Tab](#).

2.2.3 Considerations if using system on gimbal

- The yaw axis of the gimbal should be locked to the rotation of the aircraft and not allowed to rotate independently.
- The system should be in its operating position (spectral imager pointing nadir) at power up for the system to properly align.

2.2.4 Initializing the GPS/IMU

- The system should be in its operating position (GPS/IMU in configured flight orientation) and have a clear view of the sky at power up. For dual antenna systems, minimize any opportunity for GPS signal reflections off of buildings or other objects.
- The Ellipse N should be flown at a velocity of at least 15 km/h (10 mph) before collecting data, which can happen at slower speeds.
- Flying in some patterns (left and right turns, accelerations, zig-zags, figure 8s, etc) before collecting data helps with the attitude accuracy. The Ellipse N also requires occasional accelerations or turns in order to maintain best performance.

2.2.5 Installing the Flight Computer

- The flight computer needs airflow—do not completely enclose the unit or block airflow around it.
- Keep power cables to the flight computer as short as possible. The unit draws a substantial amount of current at boot—long cables or wires of too small a gauge can prevent the computer from booting.
- The external USB LCD display is used to diagnose any errors with the system. It is optional. If it is used, connect it to a USB port of the flight computer.

Note: The external LCD can be connected and disconnected at will while the flight computer is running.

- Connect the SDDs drive to any USB-C port on the flight computer using the included cable.

2.2.6 Installing the Downwelling Irradiance Sensor

- The optional downwelling irradiance sensor's fiber input needs to be mounted straight-up with a clear, unobstructed view of the sky. Do not excessively bend the optical fiber. The downwelling sensor CANNOT be placed under plexiglass/polycarbonate, as it is not transparent in the NIR spectral range. Ideally, the fiber head is exposed to direct light, as even glass effects the signal.
- Connect the sensor to the flight computer via USB.

2.2.7 Connecting Power

Once all components are installed, provide power to all components of the system (Pika, flight computer, and GPS/IMU), paying close attention to min/max voltages and current requirements.

Device	Voltage	Power
Flight Computer	12-24V	40W peak, 10W operating
Pika IR (+), IR-L (+)	11-30V	5W
Pika L-GigE	12-24V	2.8W

2.3 Installing and Connecting the Ground Station Software

The **ResononGroundStation** software is easily installed with the provided installer. Please uninstall older versions of the **ResononGroundStation** before installing newer versions, then double click the installer and follow the instructions.

The **ResononGroundStation** can also be found at our [download site](#), under *Airborne* → *Airborne ground station software*. *Make sure to install the ground station version that matches your flightcode version.*

2.4 Data Disk File System

Current flight computer systems format the data disk with the Windows exFAT file system. No special drivers are needed to read the data disk from a Windows computer. This applies to systems which were originally shipped with firmware version 6.0 or later.

USING THE HYPERSPECTRAL AIRBORNE REMOTE SENSING SYSTEM

3.1 Powering Up the Flight Computer

If using a laptop or external LCD to monitor the system, connect these devices to the system and then power the system on. The laptop connects to the flight computer with the supplied USB to USB null modem cable. The external LCD connects to a USB port of the flight computer.

Power up the system. The unit should remain stationary for a few minutes while the GPS/IMU acquires satellites and initializes. If the external LCD is connected to the flight computer it will display the Resonon logo while the computer is starting up. It will display system information once the flight computer software is running. Confirm that all systems are operational in the external LCD (Fig. 3.1).

It is preferred not to turn off power to the system without shutting it down with the *Shutdown* button on the *Computer Tab* of the **ResononGroundStation** software (Fig. 3.18).



Fig. 3.1: External LCD

3.2 Launching the Software and Connecting to the Flight Computer

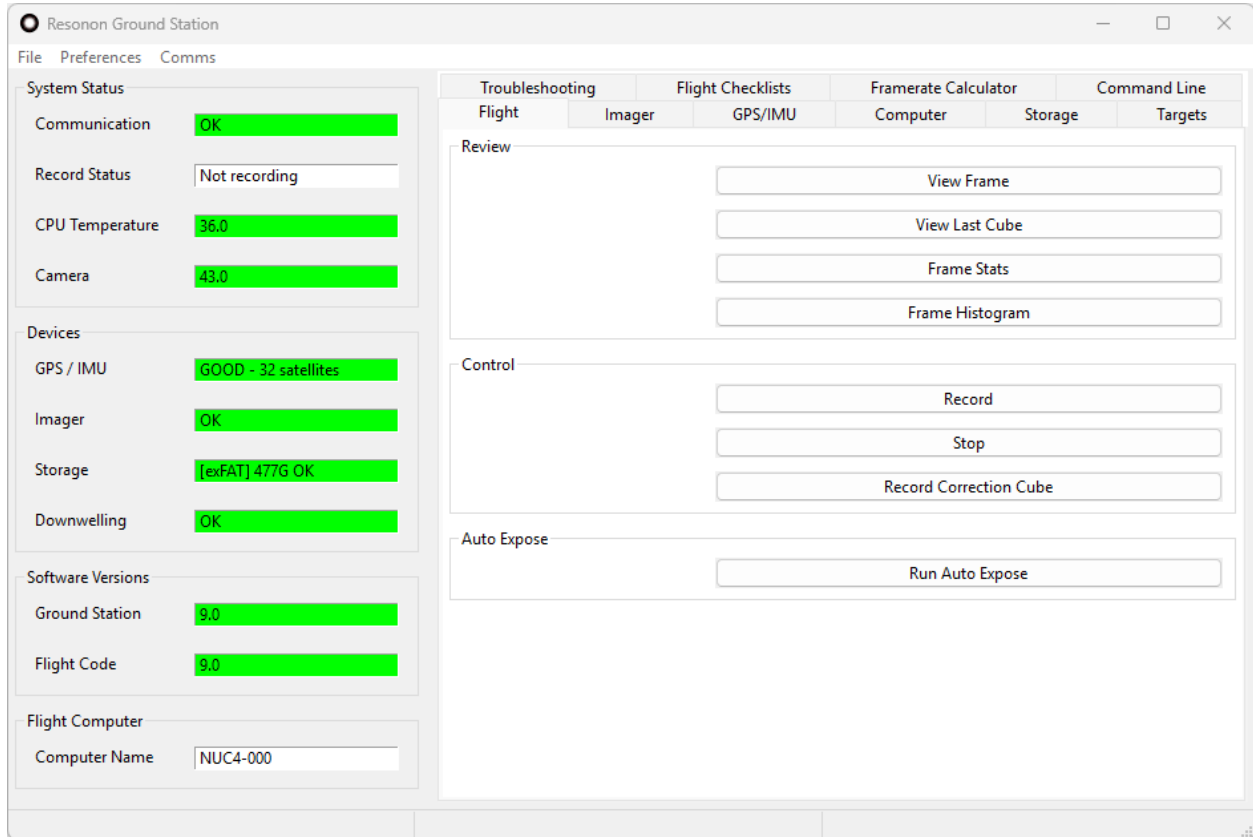


Fig. 3.2: **ResononGroundStation** software

The **ResononGroundStation** software communicates with the airborne system directly through the USB to USB null modem cable.

1. Use the supplied USB to USB null modem cable to connect the laptop to the flight computer.
2. Launch the **ResononGroundStation** software. The software will automatically attempt to connect to the flight computer over the last COM port used, or COM1 on first run. If the serial port does not exist no connection is attempted.
 - If the COM port setting is not correct, simply select the correct port from the *Comms* menu item. The system attempts to connect immediately. See Fig. 3.3.
 - If the correct COM port is not available in the *Comms* menu, refresh the list by selecting *Comms* → *Refresh*
3. The connection dialog appears with the message *Pinging flight computer*. When the connection is established and the flight computer has transmitted it's system status to the ground station, the dialog will display *Success* and then disappear. See Fig. 3.4.

If the connection is not successful,

1. The system may still be starting. In this case the external LCD displays the Resonon logo. Simply wait for the system to finish starting (the LCD displays system information).
2. Press *Ping Flight Computer* to send a new status request to the flight computer.

3. Review your COM port settings. You must select the COM port that your computer assigned to the USB to USB null modem cable.

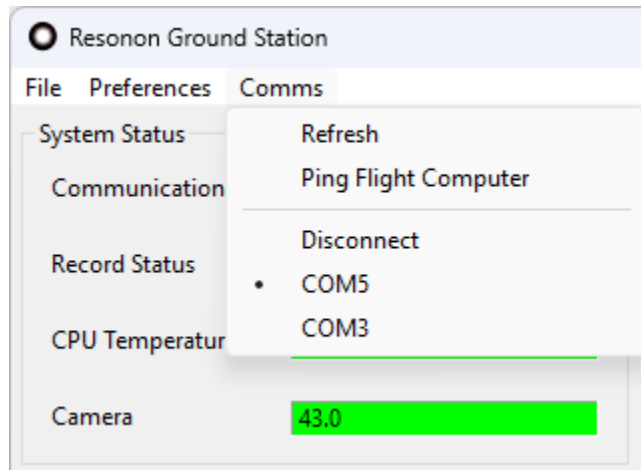


Fig. 3.3: COM port menu

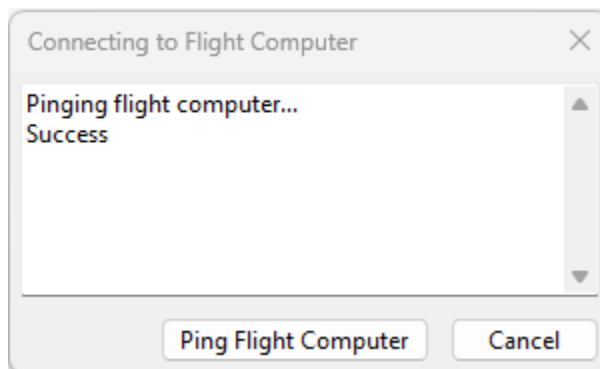


Fig. 3.4: The **ResononGroundStation** Connection Dialog

3.3 Status Panel

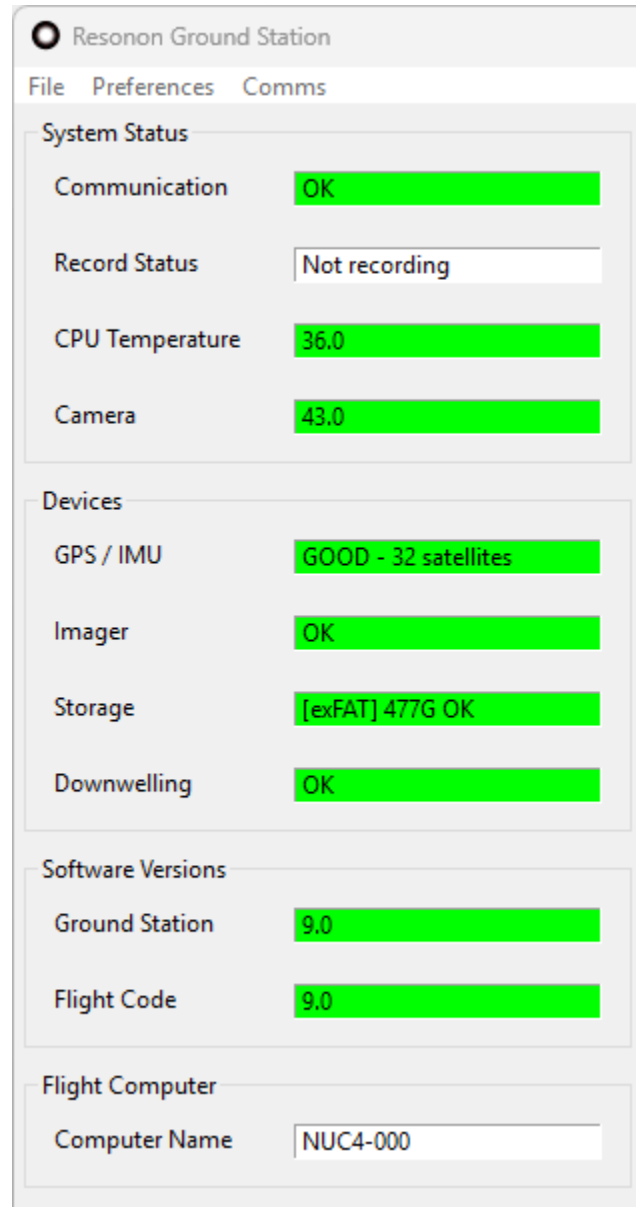


Fig. 3.5: The Status Panel

The *Status Panel* (Fig. 3.5) is always visible on the left side of the main window and displays useful information regarding the status of the system.

System Status section: Shows overall system status.

Communication: Shows status of ground station-flight computer communications. Possible values are:

- **OK on a green background:** The software is in communication with the flight computer.
- **Waiting on flight computer on an orange background:** The ground station has not heard from the flight computer recently. This will happen if the communication cable is disconnected from the

flight computer to begin a flight. Communication resumes when the cable is reconnected.

- **Error - Check software versions on a red background:** There has been an error processing status from the flight computer. Check the software versions reported at the bottom of the *Status Panel*.

Record Status: Shows overall status and is mirrored on the LCD display. Possible values are:

- **Not recording on a white background:** The system is ready to record.
- **A target name on a green background:** The system is currently recording.
- **DISABLED on a red background:** There is a device or system error preventing recording. See [Section 5.8: Troubleshooting](#) for information on procedures in this case.

CPU Temperature: The CPU temperature reported by the flight computer operating system. **If this value is 50 degrees C or greater (usually a result of exposure to sunlight while imaging), immediately shutdown the flight computer and move it to a cooler (shaded or indoor) area.**

Camera Temperature: The camera temperature reported by its internal firmware. **If this value is 60 degrees C or greater (usually a result of exposure to sunlight while imaging), immediately unplug the imager and move it to a cooler (shaded or indoor) area.**

Devices section: Shows status of the various hardware devices, to be used as quick visual confirmation that the system is operating properly. This information is mirrored on the external LCD, if it is connected. The operator should check all fields in this section at startup. See [Section 5.8: Troubleshooting](#) for information on procedures if any of these sections are marked *Fail* in red.

GPS/IMU: Shows the status of the GPS/IMU unit. This field is mirrored on the LCD display. See [Section 3.6: GPS/IMU Tab](#) for more information.

- **ACQUIRING GPS on an orange background:** The GPS/IMU unit has not yet acquired a sufficient number of satellite signals.
- **INITIALIZING NAVIGATION on an orange background:** The GPS/IMU is receiving data from nine (9) or more satellites, and is initializing the kalman filter; it cannot yet interpolate position between GPS readings.
- **GOOD - XX satellites on a green background:** The GPS/IMU can interpolate position and attitude at 200 Hz with a high degree of accuracy.

Imager: Shows imager status. This field is mirrored on the the LCD display.

Storage: Shows the data disk filesystem type, free space and status. This field is mirrored on the LCD display. As an example, the field might show *[exFAT] 991G OK* on a green background to show it is using the Windows exFAT file system, has 991 GB of free disk space and is ready to record.

Note: If the field starts with *[exFAT]* the data disk may be read directly from a Windows computer.

If the field starts with *[ext4]* then additional drivers will be required to read the disk on a Windows computer. See [Section 5.8.4: Legacy System Data Disk](#) for more information.

See [Section 3.8: Storage Tab](#) for more information.

Downwelling: Shows the status of the downwelling irradiance sensor. This field is mirrored on the LCD display. The downwelling irradiance sensor is optional and the system will operate normally without it.

The *Software Versions* section shows the running ground station software and flight computer firmware versions. These version should be kept in sync.

Ground Station: Shows the ground station software version and should be green. If the ground station and flight code versions are not compatible this field reports both the installed and the required ground station software versions on a red background. See [Section 5.2: Updating Firmware](#) in this case.

Flight Code: Shows the current flight computer firmware version and should be green. If the ground station and flight computer software versions are not compatible this field is orange. See [Section 5.2: Updating Firmware](#) in this case.

The *Flight Computer* section shows information about the flight computer itself.

Computer Name: A unique name assigned to the flight computer by Resonon. It is helpful to supply this name when requesting support.

3.4 Flight Tab

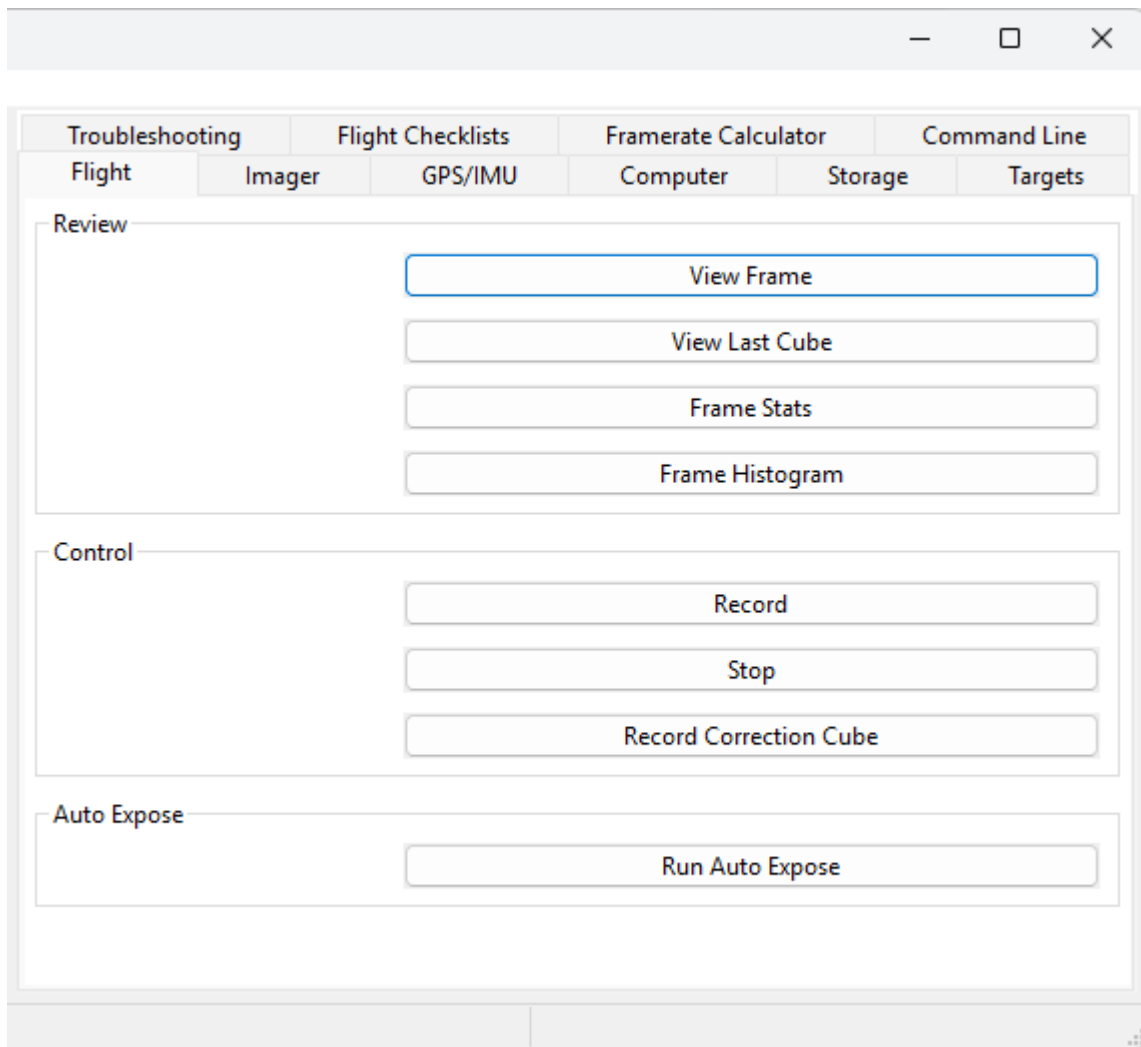


Fig. 3.6: The Flight Tab

The *Flight Tab* (Fig. 3.6) groups functions that may be useful during flight under a single tab.

View Frame: Requests and displays a raw imager data frame. It is rarely used in normal operation. It can provide the operator with feedback regarding the exposure settings, but is much harder to interpret than the Histogram function.

View Last Cube: Requests and displays a preview image of the last cube recorded.

Frame Stats: Requests and displays the minimum pixel value, maximum pixel value, and average values for a new frame of data, intended to assist in confirming exposure settings.

Frame Histogram: Requests and displays a histogram of a new imager frame. The histogram feature is likely the most useful for determining if the correct exposure settings are used. Interpreting this histogram is the same as any digital image histogram; the height of the bars show the number of pixels for each brightness level.

Record: Forces the system to record a datacube. It will record continuously until the *Stop* button is pressed. This allows the operator to record data over an area outside of the defined target areas (discussed in [Section 3.9: Targets Tab](#)).

Stop: Stops manual recording.

Record Correction Cube: Collects a correction cube for use with post-processing data correction. The cube collected in this step is used to remove the instrument response as well as the illumination function and leave the data in absolute reflectance (more info on post-processing can be found in [Section 3.16: Post Processing Data with Spectronon](#)). Before using this function, place a reflectance standard in the field of view of the imager and in a manner such that the standard is fully illuminated by the sun (no shadows). Use *Auto Expose* to determine the gain settings, and then record a correction cube. This cube will be in the flight's root folder and named to reflect its purpose.

Run Auto Expose: Manually runs the auto exposure routine.

Note: Autoexpose will not run while between successive recordings inside a target area unless *Preferences* → *Auto Expose Interval* → *Every Datacube* is selected.

In very large target areas with *Preferences* → *Auto Expose Interval* → *Outside Target Area* selected, drastic changes in conditions will impact the data.

3.5 Imager Tab

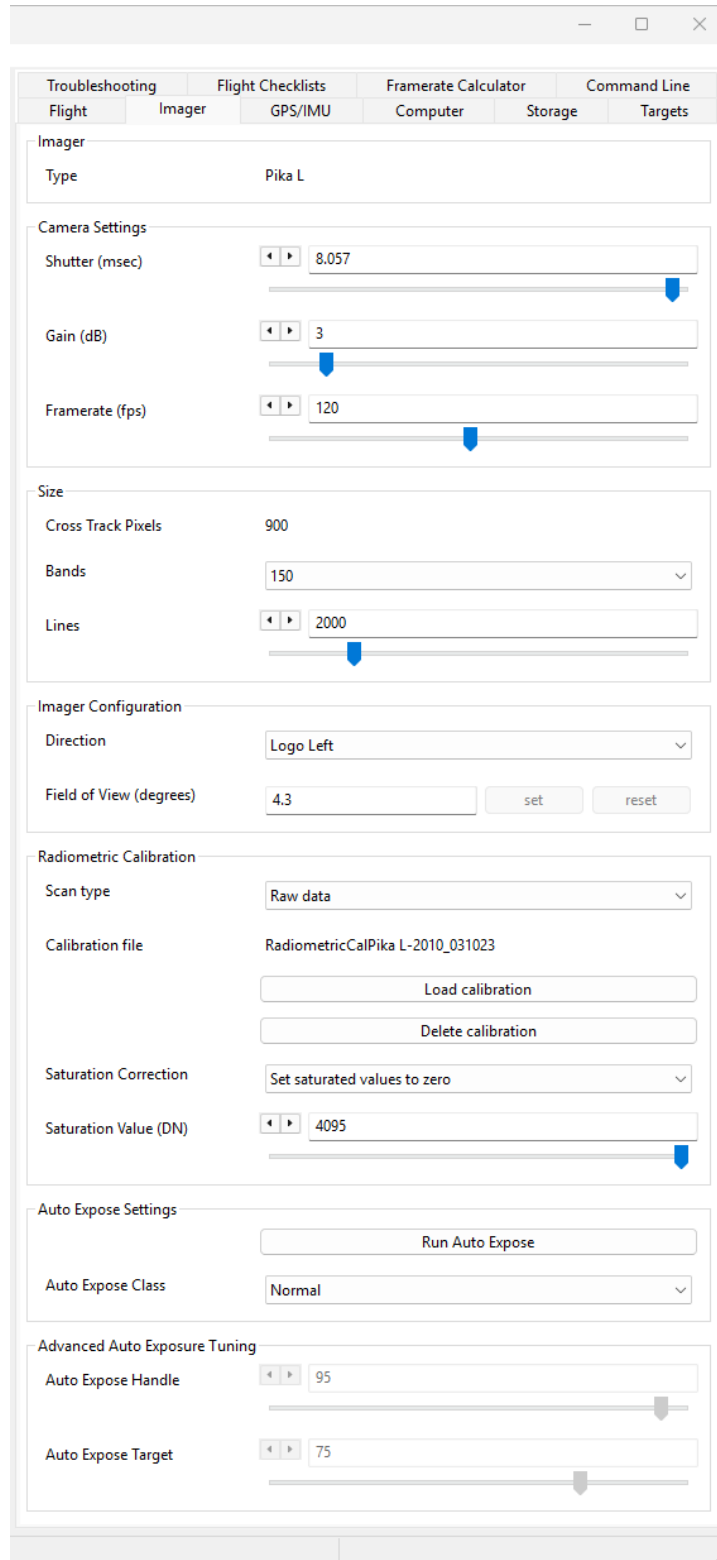


Fig. 3.7: The Imager Tab

The *Imager Tab* (Fig. 3.7) contains the settings relevant to the spectral imager. The tab title reflects the actual imager type in use by the flight computer (Pika L, Pika IR, IR+ IR-L, or IR-L+, Pika XC2, Pika UV).

Imager status is shown in the Section 3.3: *Status Panel as Imager* (see Fig. 3.5).

Shutter: Sets and displays the shutter setting of the imager in milliseconds. Autoexpose will adjust the shutter upward in preference to adding gain. If there is not enough light available (as shown by the *Frame Histogram* button Fig. 3.6), you may need to decrease the frame rate to allow longer exposure times.

Gain: This sets the gain of the imager. If autoexpose is used it is not necessary to manually change the gain settings. It should be noted that excessively high gain settings add noise to the images. Autoexpose will decrease the gain in preference to decreasing the shutter setting. If autoexpose is setting the gain above zero, consider decreasing the frame rate to allow for longer exposure times.

Note: The Pika IR, IR+, IR-L, and IR-L+ imagers do not support a *gain* setting. When using these imagers, the gain control will not appear.

Framerate: Sets the frame rate of the system, and with it the along-track spatial resolution. Use the **Framerate Calculator** tab or the **Airborne HSI Calculator** to determine optimum frame rate. Slower frames rates mean lower along-track spatial resolution, but better signal to noise ratios. If the autoexpose routine returns a *Not Enough Light* warning, or if it sets gain above zero, the framerate may be lowered to improve signal to noise ratios. Oversampling in the along track direction (using a higher frame rate than necessary for unit aspect ratio) will help compensate for flight instabilities. Depending on flight conditions such as wind and whether or not a gimbal is used, an aspect ratio of 2 or greater (as computed by the Airborne HSI calculator) is recommended.

Cross Track Pixels: Displays the fixed cross-track spatial resolution of the imager.

Bands: Sets the spectral resolution. Lower band numbers increase signal to noise ratios and result in smaller file sizes, but decrease spectral resolution.

Lines: Sets the length of each datacube recording in lines (camera frames).

Note: The recommended value is 2000. Individual datacube files can get very large if the number of lines is increased to the maximum value.

Direction: Sets the direction of the imager relative to the direction of flight. Set the parameter to Logo Right if the Resonon label side of the imager is facing the right (starboard) side of the plane and Logo Left is the Resonon label is facing the left (port).

Field of View: Set this to the actual field of view for your imager and lens. This value will be copied into the header data for each datacube that is collected. See *resonon.com* for the correct value for your imager and lens.

3.5.1 Radiometric Calibration

As of version 4.0 Resonon's airborne system can convert raw data to radiance in real time. A radiometric calibration (.icp) file supplied by Resonon is required.

Scan Type: This can be *Raw data* to record data with no processing, or *Radiance* to convert to and record radiance data on-the-fly. Without a radiometric calibration file only *Raw data* is available.

Calibration File: The radiometric calibration file which the system will use to record radiance data.

Load Calibration: Loads a radiometric calibration file from a USB thumb drive to activate the scan-to-radiance function.

Note: If you have more than 1 hyperspectral imager to be used with the airborne system, make sure the correct imager is connected to the flight computer when loading the calibration file. You may load separate calibration files for e.g. a Pika L and a Pika IR imager. The flight computer will assume the calibration file is to be used by the currently connected imager type.

Note: Only one calibration file per imager type is allowed. If a customer swaps between two imagers of the same type (both Pika L, for instance), the correct radiometric calibration must be loaded each time the imager is swapped.

Connect a USB thumb drive with the Resonon *.icp calibration file to the *flight computer*. A file selection dialog pops up, as in Fig. 3.8. Select the correct calibration file and click *OK*. On success the dialog in Fig. 3.9 is shown and *Scan Type* is changed to *Radiance*.

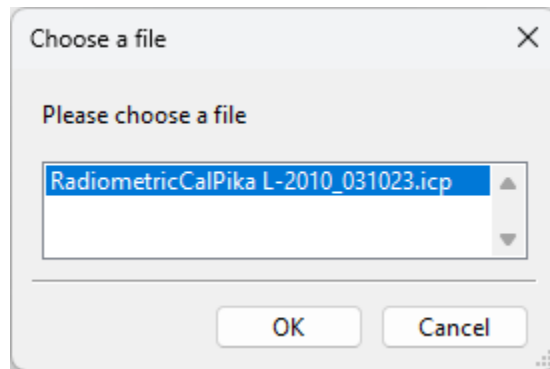


Fig. 3.8: Loading a radiometric calibration file

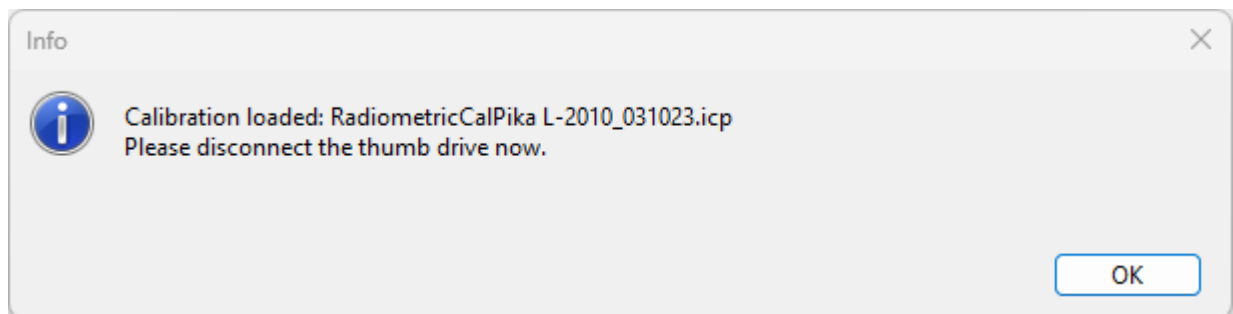


Fig. 3.9: Successfully loaded radiometric calibration

In the event that the error dialog in Fig. 3.10 is displayed, make sure that the USB thumb drive contains a *.icp file supplied by Resonon. Connect the thumb drive to the *flight computer*, not the ground station computer. Wait a few seconds to allow the flight computer to recognize the drive and try again.

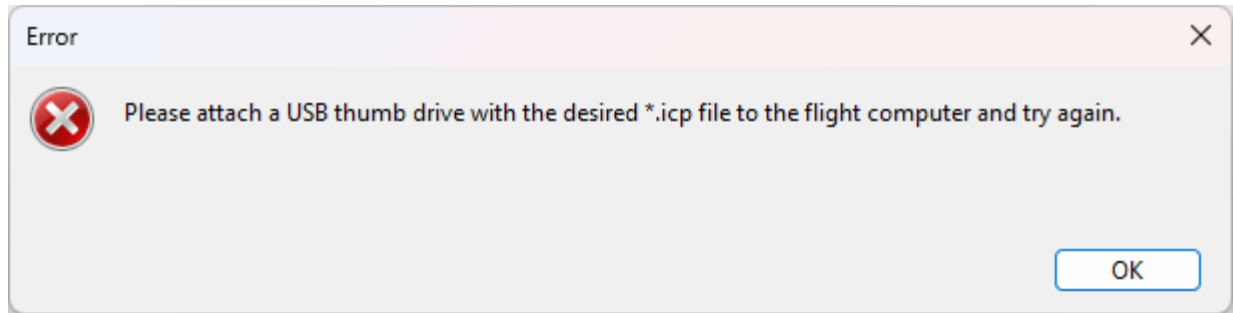


Fig. 3.10: Radiometric calibration error dialog

Delete calibration: Removes the calibration file for the currently attached imager type. A dialog is shown allowing you to continue or cancel. On calibration file removal *Scan Type* is changed to *Raw data*.

Saturation Correction: This can be *Set saturated values to zero* to zero out saturated data before being converted to radiance (recommended as it is difficult to detect saturation after radiance conversion otherwise), or *No saturation correction* to record radiance data with no further processing. This setting will be unavailable if the scan type *Raw data* is selected.

Saturation Value (DN): This sets the saturation value (in digital numbers) at which to zero out data; it defaults to the ceiling of the imager and can be set at any value up to this maximum. This setting will be unavailable if the scan type *Raw data* is selected or if the saturation correction is set to *No saturation correction*.

3.5.2 Auto Expose Settings

The *Auto Expose Class* selection fine tunes the autoexposure routine for a variety of imaging scenarios.

Normal: The most versatile and serves as a starting point for most applications.

Darker areas of Interest: For bright backgrounds with sparse areas of darker regions of interest (glacier background with sparse, dark pools of water of interest).

Bright Areas of Interest: For dark backgrounds with sparse areas of bright regions of interest (desert background with sparse, bright objects of interest).

Water: For imaging water or other scenes containing highly specular reflections (glare).

For custom settings, select the *Custom* item. The *Handle* and *Target* sliders will then become available. The *Handle* parameter determines which percentage brightness image pixel the autoexposure algorithm will try to force to the *Target* percentage value. For instance, a *Handle* setting of 98% and a *Target* setting of 90% will try to force the 98th percentage brightest image pixel to 90% of the maximum brightness value. This would then allow 2 percent of the image pixels to be brighter than 90% of the maximum value and be in risk of saturation, but also allow the majority of the scene to possess good signal to noise ratios. In the case of ocean imaging where a high percentage of glint is probable, a smaller *Handle* setting might be preferred. These settings can be adjusted fine-tuned by utilizing the *Frame Histogram* feature found in the *Flight Tab* (Fig. 3.6).

An illustration of the *Handle* and *Target* settings is shown in figures Fig. 3.11. Assume a *Handle* setting of 98%, and a *Target* of 90%. The imager grabs a frame and analyzes it. It finds the 98th percentile brightness value to be 3300 out of a maximum 4095 (12 bit resolution = 4095 DN), as shown on the left. This is 80% of the maximum. Thus, the exposure time is increased or more gain is added and another frame is grabbed and analyzed. This process repeats until the *Target* value of 90% is reached, as shown on the right.

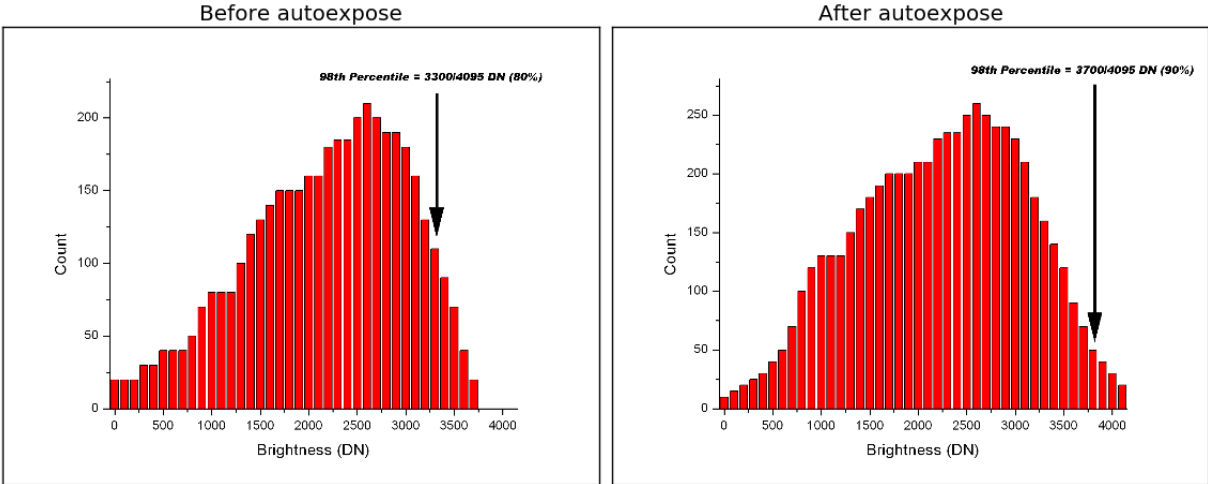


Fig. 3.11: Histogram

3.6 GPS/IMU Tab

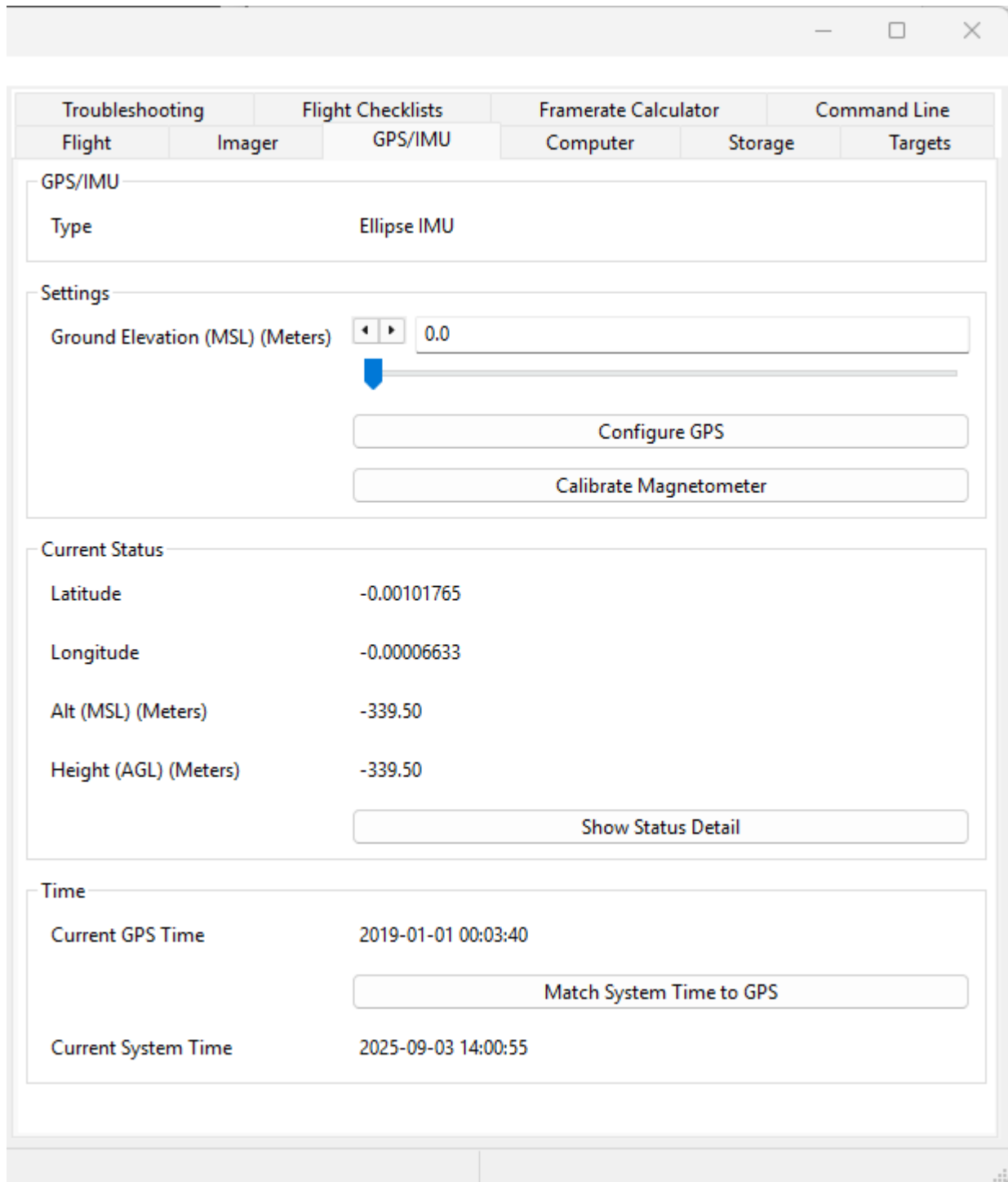


Fig. 3.12: The GPS/IMU Tab

The *GPS/IMU Tab* (Fig. 3.12) allows configuration of the GPS/IMU system and serves as a check to the proper operation.

Note: SBG Ellipse GPS/IMU units with firmware version 3.0 and later are supported by this software version.

Overall GPS/IMU status is shown in the *Status Panel* as *GPS/IMU* (see Fig. 3.5 in Section 3.3).

1. **GOOD - XX satellites on a green background:** The GPS/IMU is showing how many satellites it has acquired and has initialized the kalman filter for attitude and position interpolation. An Ellipse-D is ready for flight. An Ellipse-N is ready for flight provided a proper magnetic calibration has been done. See Section 3.6.2: *Ellipse GPS/IMU Magnetic Calibration* below.
2. **ACQUIRING GPS or INITIALIZING NAVIGATION on an orange background:** This status will not change to green until the system has aligned and is able to accurately compute its position and orientation at 200
3. **FAIL in red:** The system did not find the Ellipse or was unable to initialize it. Correct the problem and restart the flight computer.

Warning: The Ellipse orientation and antennae lever arms must be properly configured or data loss may result! If the status indicator will not leave *Acquiring GPS* it may be an indication that this has not been done. Configure the ellipse as detailed in See Section 3.6.1: *Ellipse GPS/IMU Configuration* below and make sure the unit is in this orientation during power up.

Warning: If using a single-antenna unit (Ellipse-N), a proper magnetometer calibration is mandatory. Even if the *GPS/IMU* status is *OK* the Ellipse-N will not track its position correctly without this calibration. Data loss can result! See Section 3.6.2: *Ellipse GPS/IMU Magnetic Calibration* below for details.

GPS/IMU Type: The GPS/IMU device type, usually “Ellipse IMU”.

Ground Elevation: The *Ground Elevation* must be set for proper operation. This is the mean sea level (MSL using EGM96 geoid) elevation of the ground. If set incorrectly, data may not be collected in the desired target regions.

Configure GPS: Configure the GPS/IMU unit. See Section 3.6.1: *Ellipse GPS/IMU Configuration*.

Calibrate Magnetometer: Begin a magnetometer calibration (Ellipse-N only). See Section 3.6.2: *Ellipse GPS/IMU Magnetic Calibration*.

Latitude: The current latitude.

Longitude: The current longitude.

Alt (MSL): The current altitude relative to mean sea level using EGM96 geoid.

Height (AGL): The current height relative to the set ground altitude.

Show Status Detail: Show detailed device status in a separate window. See Section 3.6.3: *Ellipse GPS/IMU Status Detail*.

Current GPS Time: The current GPS time as reported by the GPS.

Match System Time to GPS: Sets the flight computer clock to the time reported by the GPS and restarts the flight computer software. This should not normally be needed.

Current System Time: The system time according to the flight computer clock. This is set to UTC time and should match the GPS time.

3.6.1 Ellipse GPS/IMU Configuration

The ellipse must be told how it is physically installed in the system. This need be done only once after the system is initially installed or the physical installation is changed. This is done directly from the **ResononGroundStation** software, with the SBG unit connected directly to the flight computer. Click the *Configure GPS* button to bring up the GPS configuration dialog shown in Fig. 3.13.

Note: See Section 6.1: *Alternate Ellipse Configuration* in the appendix to complete these steps using **sbgCenter** instead.

Ellipse Physical Installation
✕

Motion Profile

Selected model ▾

Ellipse alignment in vehicle

<p>Device rough orientation</p> <p>X-Axis <input type="text" value="forward"/> ▾</p> <p>Y-Axis <input type="text" value="right"/> ▾</p> <p>Z-Axis <input type="text" value="down"/> ▾</p>	<p>Misalignment angles</p> <p>Roll <input type="text" value="0"/> °</p> <p>Pitch <input type="text" value="0"/> °</p> <p>Yaw <input type="text" value="0"/> °</p>
--	--

GPS Antenna

Primary Lever Arm (X,Y,Z) m

Secondary Lever Arm (X,Y,Z) m

Vehicle Center of Rotations (CoR)

Lever arm (X, Y, Z) m

Enter the primary lever arm FROM the Inertial Navigation System TO the vehicle Center of Rotations (CoR) for optimal performance.

Output Monitoring Point

Output (X, Y, Z) m

Enter the lever arm between the SBG unit and the lens of the Pika spectral imager.

Initial Position and Date

Latitude Altitude

Longitude UTC Date

Reload

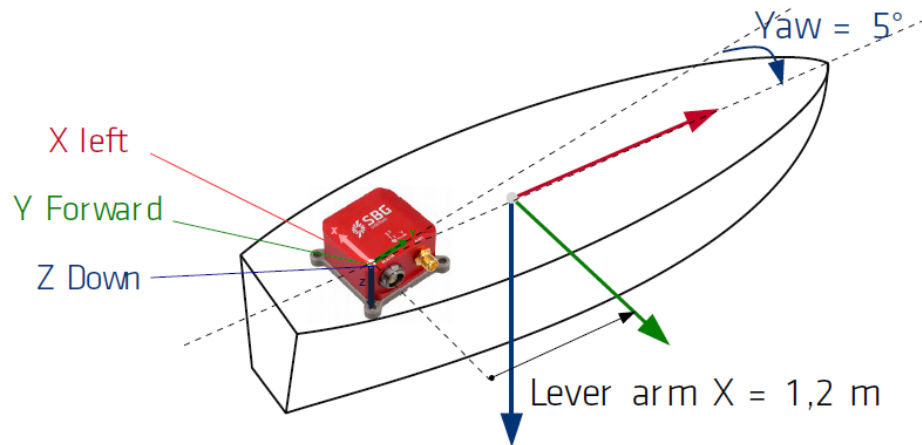
Apply

Close

Fig. 3.13: The GPS/IMU Configuration Dialog

- Select the appropriate *Motion Profile* for your vehicle, likely *uav*, *airplane* or *helicopter*.
- Configure the orientation of the SBG to match how it is mounted in the airframe. For example, if the X Axis label on the unit points to the right wing of the aircraft select X Axis = Right. As a reminder, the 'cross' icon on the Z axis label on top of the unit shows the tail end of an arrow. This icon shows the Z axis pointing down through the unit.
- Now enter the lever arm distances (X, Y, and Z) between the SBG unit and the GPS antenna. If using a dual-antennae unit, enter the secondary lever arm distances between the SBG unit and the second GPS antenna. These distances are measured from the SBG unit to the Pika lens, with positive X pointing forward, positive Y pointing right, and positive Z pointing down.

Note: Lever arm distances are entered in vehicle coordinates, meaning that X is forward, Y is right and Z is down regardless of how the the SBG unit is oriented.



- For optimal performance, enter the lever arm distances from the SBG unit to the vehicle center of rotation.
- Now enter the *Output Monitoring Point* lever arm distances from the SBG unit to the lens of the Pika spectral imager.
- The initial position and date need to be set before performing a magnetometer calibration on single-antenna SBG units (Ellipse-N). This is not required for dual-antenna units (Ellipse-D), which do not require a magnetometer calibration.
- Click *Apply* to validate the input and send the configuration data to the flight computer and SBG unit. If the system complains that any entry is invalid, correct the entry and click *Apply* again. Alternately, click *Reload* to clear your changes and display the settings currently saved to the SBG unit.
- Finally, click *Close* to reboot the SBG unit to use the new settings and dismiss the dialog.

3.6.2 Ellipse GPS/IMU Magnetic Calibration

This feature calibrates the Ellipse GPS/IMUs magnetometer after installation to compensate for any magnetic field interference.

Warning: A good in situ magnetometer calibration is **mandatory** for single antenna systems. If a good magnetometer calibration is not applied the GPS/IMU will not compute accurate position and attitude and can **severely compromise the data**.

Note: Please read the “Magnetic Calibration in Airborne Applications” document for a more detailed understanding of the magnetometer calibration requirements.

Note: If the Ellipse N unit is drone-mounted, review the video tutorial in the Resonon Library for [calibrating the Ellipse N magnetometer](#) and follow the instructions therein.

If performing a 2D magnetic calibration, enter the *Initial Position and Date* in the GPS/IMU Configuration dialog beforehand. See [Section 3.6.1: Ellipse GPS/IMU Configuration](#).

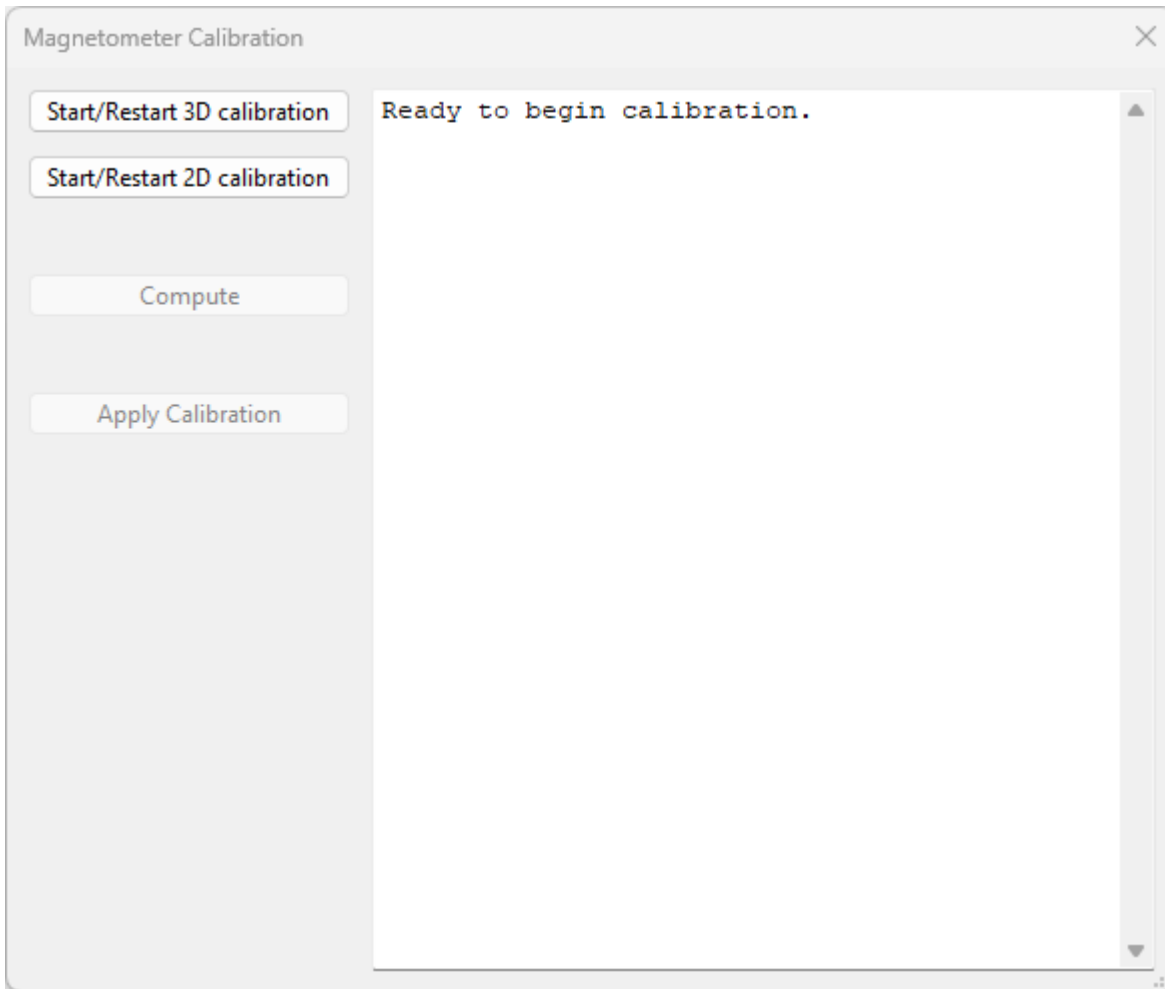


Fig. 3.14: Ellipse Magnetometer Calibration Window

1. To perform a calibration, first press the *Calibrate Magnetometer* button on the *GPS/IMU Tab* (Fig. 3.12). The Ellipse magnetometer calibration window appears (Fig. 3.14).
2. Press the *Start/Restart 3D calibration* or *Start/Restart 2D calibration* button.

The 3D calibration is the most accurate. See the “Magnetic Calibration in Airborne Applications” document for a recommended set of maneuvers to perform during a 3D calibration with a manned aircraft. With a UAV it may be possible to perform a 3D calibration on the ground. Make sure the UAV is at least 10m away from any metal structure.

The 2D horizontal calibration is less accurate and is best performed on the ground due to the need to keep the aircraft level. The aircraft will need to be rotated in a complete circle. Make sure the aircraft is at least 10m away from any metal structure.

3. Maneuver the aircraft as appropriate for the chosen calibration type.
4. Press the *Compute* button to compute the calibration results. Results are shown directly in the dialog.
5. The magnetometer may report that more data is needed. Simply continue executing maneuvers and try the calculation again. There is no need to click the “Start/Restart” buttons unless you wish to clear all collected data or change the calibration type.
6. Inspect the calibration results. A poor result may show warnings, or low quality or confidence indicators.

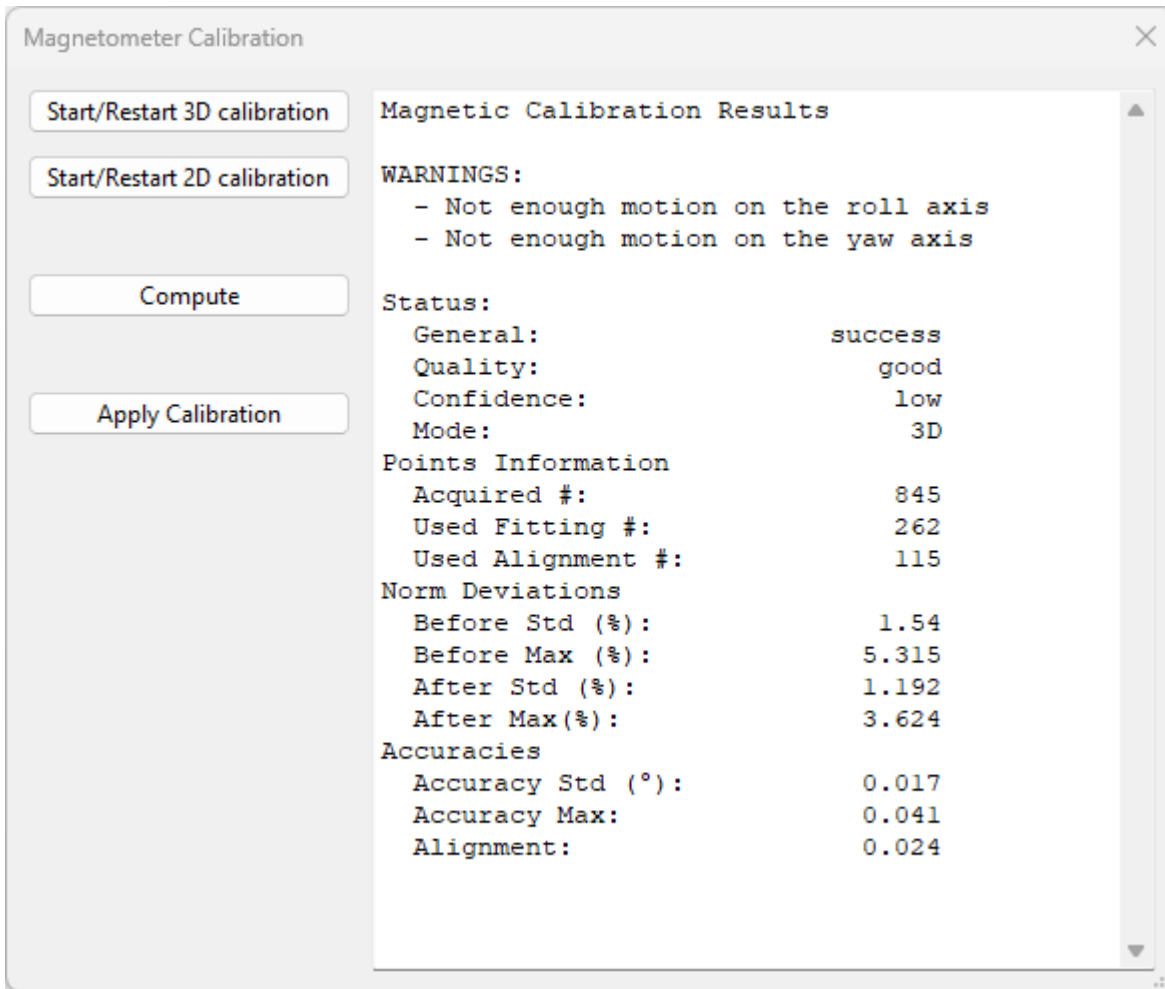


Fig. 3.15: A poor magnetometer result

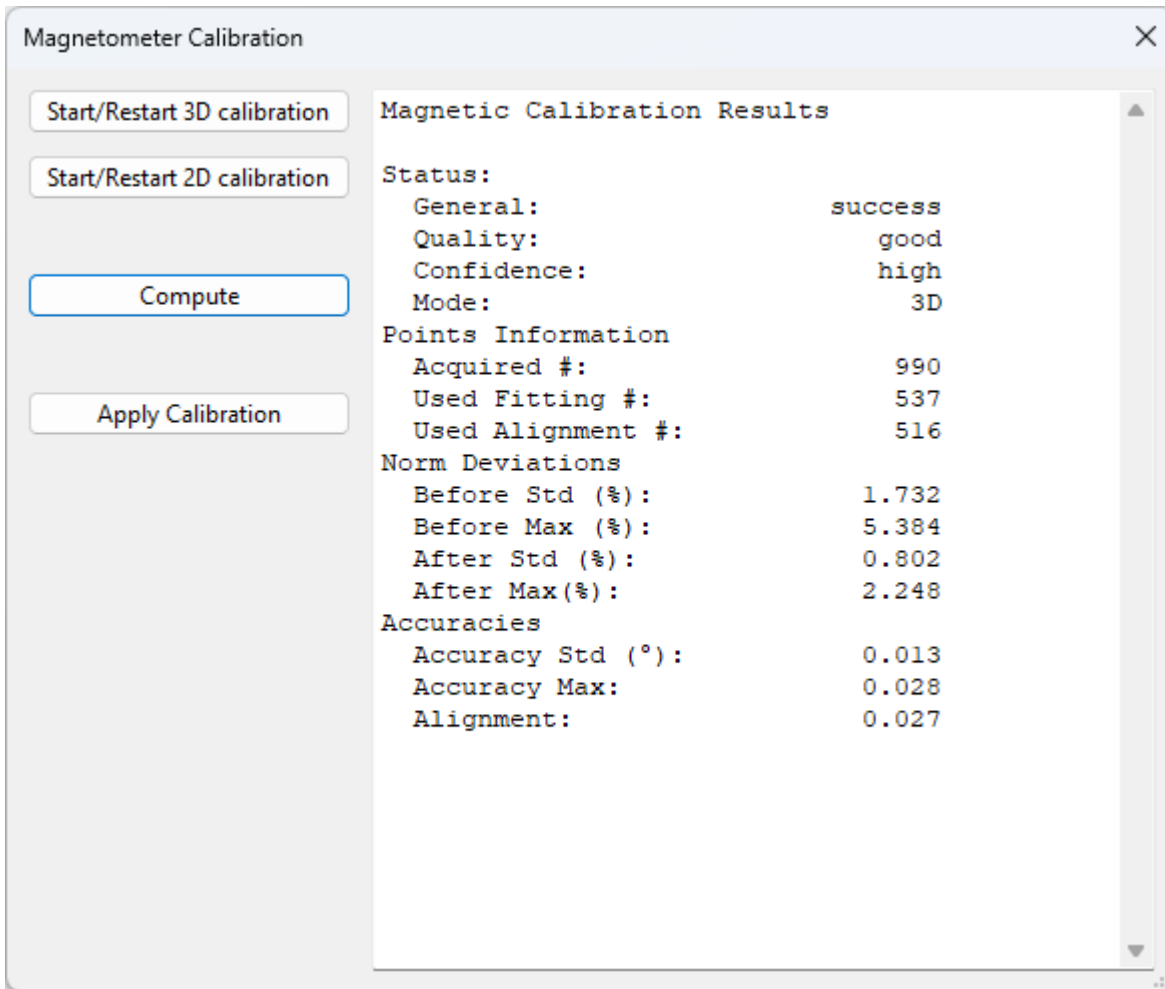


Fig. 3.16: A good magnetometer result

7. If no problems are reported, press the *Apply Calibration* button to apply the calibration. The dialog will confirm that the calibration has been applied.

Note: Once the *Apply Calibration* button is pressed the Ellipse will store the new calibration in non-volatile memory. The calibration does not need to be repeated on every flight unless sources of magnetic field interference are changed or the calibration is intentionally reset or overwritten.

8. When finished, dismiss the dialog to restart the SBG unit. Dismissing before clicking the *Apply Calibration* will leave the calibration data unchanged.

3.6.3 Ellipse GPS/IMU Status Detail

Click the *Show Status Detail* button to bring up a separate window with detailed information about the state of the GPS/IMU solution.

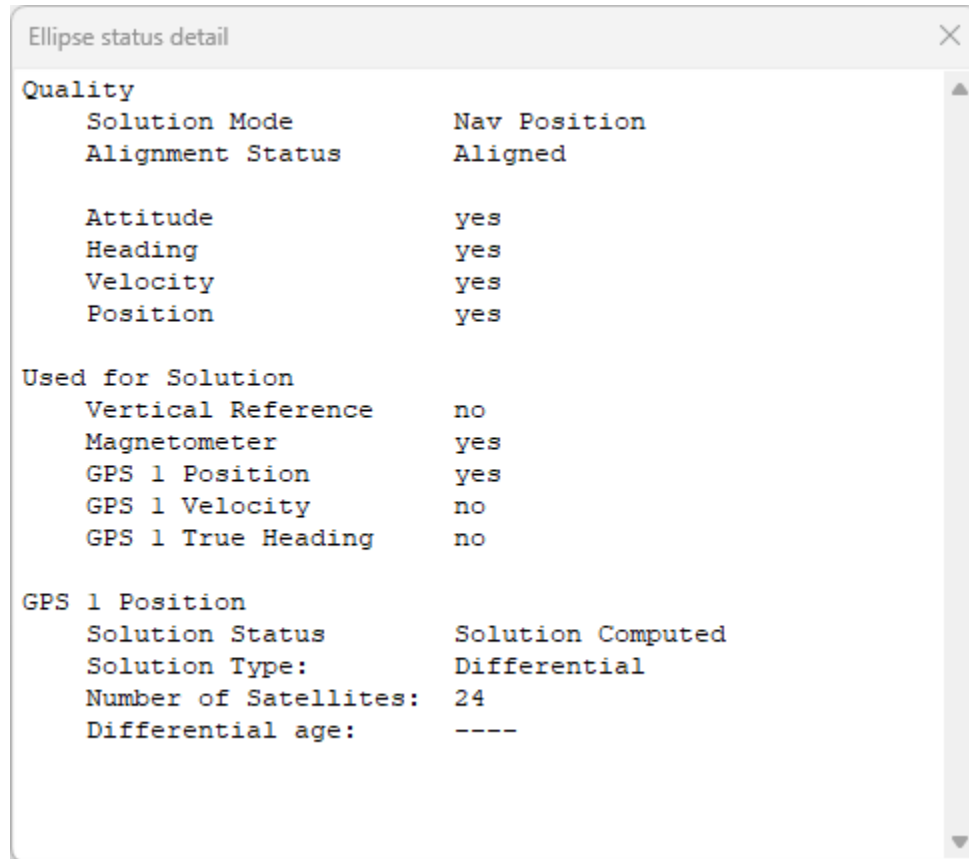


Fig. 3.17: Ellipse Status Detail Window

Pay particular attention to the *Solution Mode* at the top of the window. The software will not show the device is ready until this field reaches *Nav Position*. The meanings of each value are explained below.

- **Uninitialized:** The Kalman filter is not initialized and the returned data are all invalid.
- **Vertical Gyro:** The Kalman filter only relies on a vertical reference to compute roll and pitch angles. Heading and navigation data drift freely.
- **AHRS:** A heading reference is available, the Kalman filter provides full orientation but navigation data drift freely.
- **Nav Velocity:** The Kalman filter computes orientation and velocity. Position is freely integrated from velocity estimation.
- **Nav Position:** Nominal mode, the Kalman filter computes all parameters (attitude, velocity, position). Absolute position is provided.

3.7 Computer Tab

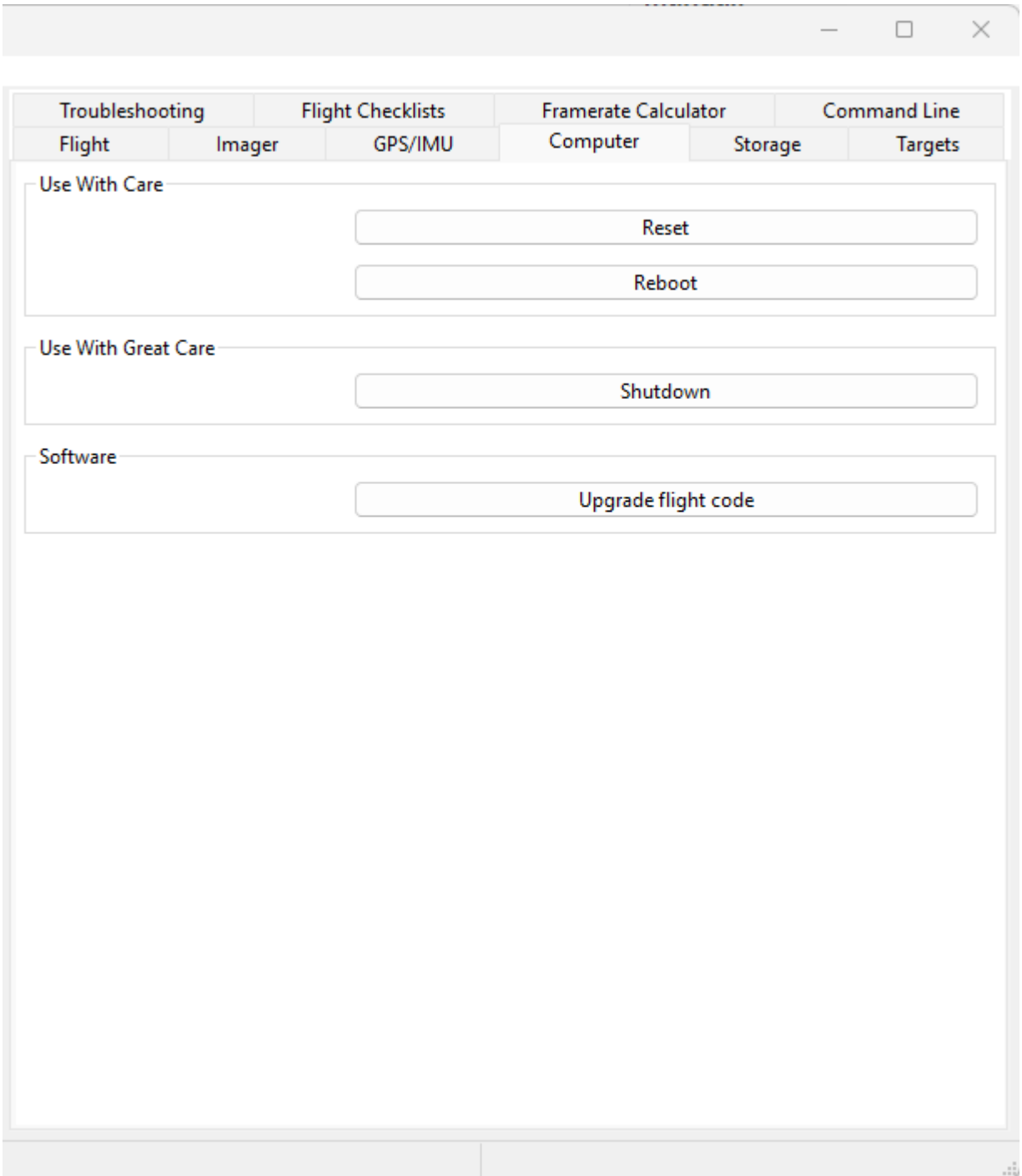


Fig. 3.18: The Computer Tab

The *Computer Tab* (Fig. 3.18) contains functions cleanly shutting down and for recovering a malfunctioning system.

Reset: Resets the embedded software. This may repair a partially crashed or unresponsive system. Use this when

asked to reset the flight computer, as when selecting a different imager type.

Reboot: Reboots the system. This may repair a partially crashed or unresponsive system.

Shutdown: Shuts the system down. It is best (but not necessary) to shut the system down before turning off power. Once a shutdown is executed you will need to disconnect and reapply power to the flight computer or press the flight computer power button to restart.

Upgrade flight code: Update the flight computer firmware. This should be done only on advice from Resonon. See [Section 5.2: Updating Firmware](#) for details.

3.8 Storage Tab

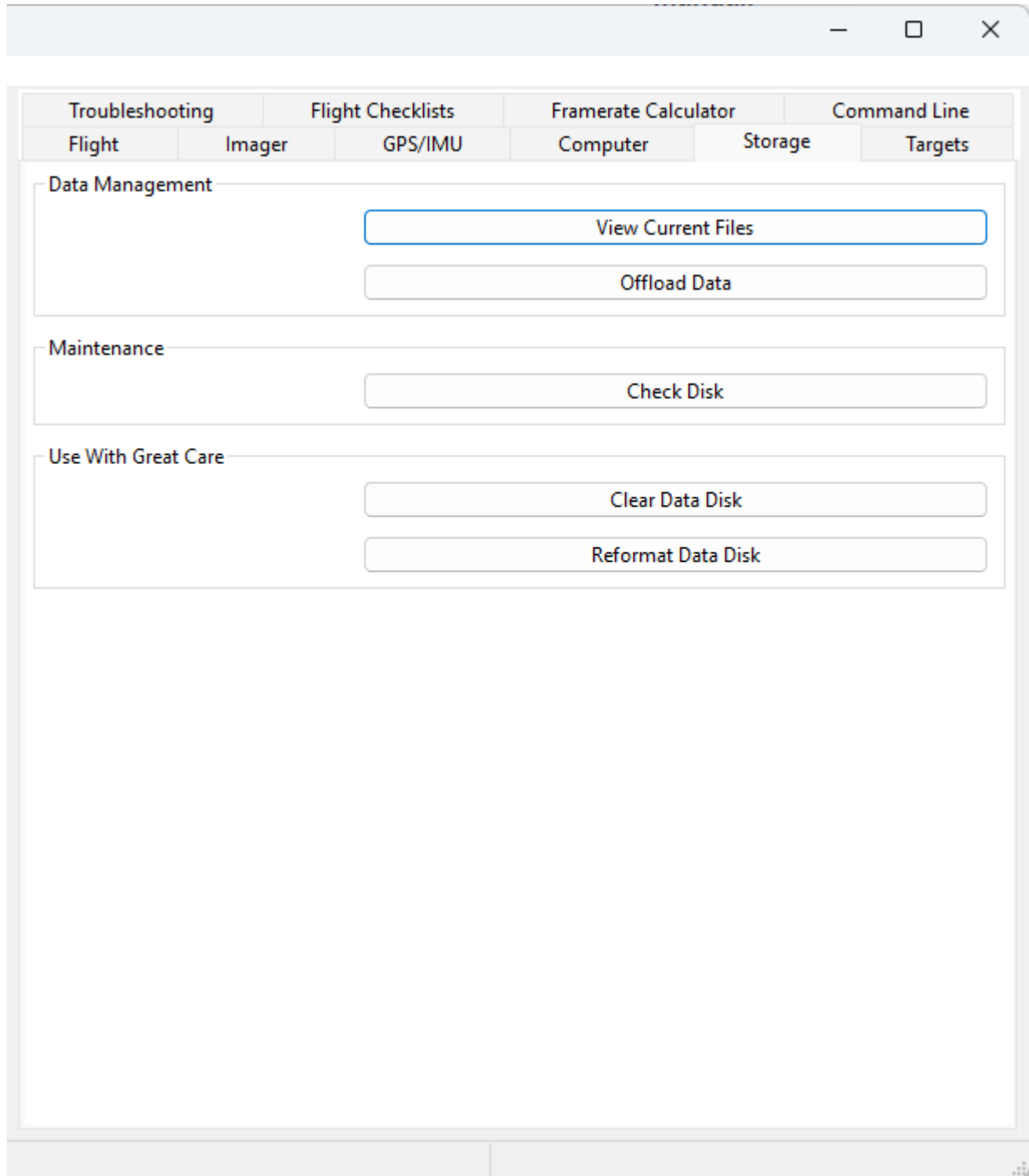


Fig. 3.19: The Storage Tab

The *Storage Tab* contains functions that affect the data written to the external SSD hard disk.

The overall status of the data disk is shown on the *Status Panel* as *Storage* (see Fig. 3.5 in Section 3.3). This field may

display:

- Filesystem type, disk space available and *OK* on a green background. The disk is ready to write data.
- Filesystem type, disk space available and *LOW* on an orange background. There is less than 15% disk space available for new files.
- Filesystem type, disk space available and *CRITICAL* on a red background. There is less than 5% disk space available for new files.
- *FAIL* on a red background. The disk was not found or there was an error writing to disk, possibly because the disk is full.

Note: If [exFAT] is displayed in the *Storage Tab* the data disk can be read by a Windows computer directly. If [ext4] is displayed additional drivers are required to read the disk from windows. See [Legacy System Data Disk](#) for more information.

View Current Files: Shows paths and sizes of all of the files and folders created for data recording, one folder per datacube.

Offload Data: This button is only used for transferring data to a external USB drive after the aircraft has landed, and is typically not used (instead, just shutdown the system and unplug the external SSD that contains the data). If using this function the external drive must be formatted as FAT32), and using a high end, high speed flash drive is encouraged.

To use, plug in the external drive and power it on. Wait 10-15 seconds for the flight computer to recognize the drive. Then press this button. A dialog is shown to walk you through the data transfer. Please do verify all data is copied to the USB drive before clearing the data disk! This method can be quite slow and is generally discouraged.

Check Disk: Performs a data disk check on the data disk filesystem. Errors reported on an exFAT filesystem should be repaired by a Windows computer. The flight computer will attempt to repair ext4 file systems itself. A disk check should be performed periodically, after a power loss while recording data, or if the system is reporting errors. It may also be prudent to perform after completed flights to prevent problems arising for the next flight.

Clear Data Disk: Deletes all of the spectral imaging data on the system. Do not delete data until you have offloaded it to your computer!

Reformat Data Disk: Completely reformats the data disk. All data will be lost. Do not reformat until you have offloaded all desired data to your computer! A message box is presented informing you that the disk format has begun. Please wait for a message dialog telling you that the format is finished, and then check that the *Data Disk* field is green and shows most of the disk space available.

3.9 Targets Tab

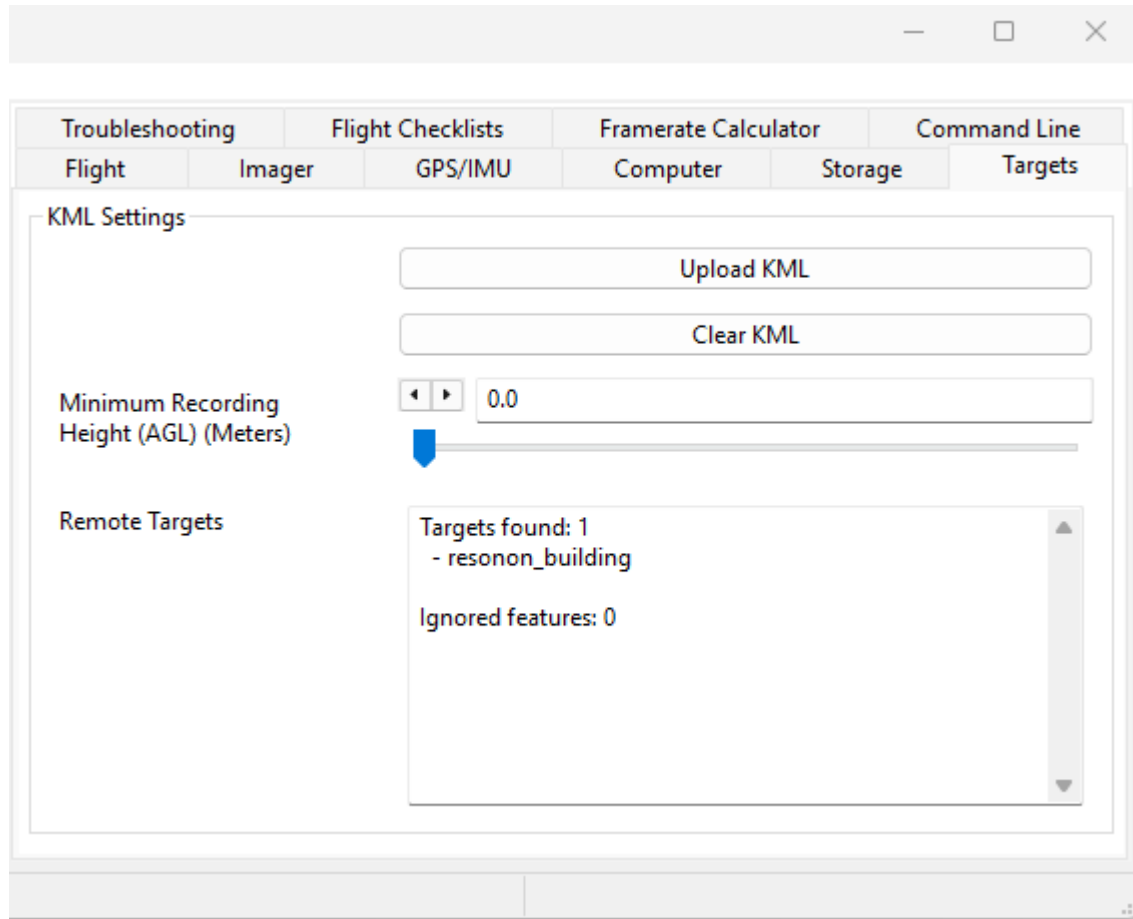


Fig. 3.20: The Targets Tab

The *Targets Tab* (Fig. 3.20) allows the operator to create, save, and upload target regions to the flight computer. These target regions define the areas over which the system will record data. When the aircraft enters a defined target area and is above the minimum height requirement, data recording is automatically started and ends when the aircraft leaves the target area. When data is recorded in a target region the name of the target region is reflected in the data folder name.

Note: In Fig. 3.20, the system's *Record Status* has changed from *Not Recording* to *resonon_building-3*, indicating the system is within the target KML file (*resonon_building.kml*) and is currently recording the third datacube from within that target area.

Target KML files are created in **Google Earth**. Only one target file can be uploaded at a time, but each target file may define multiple target areas.

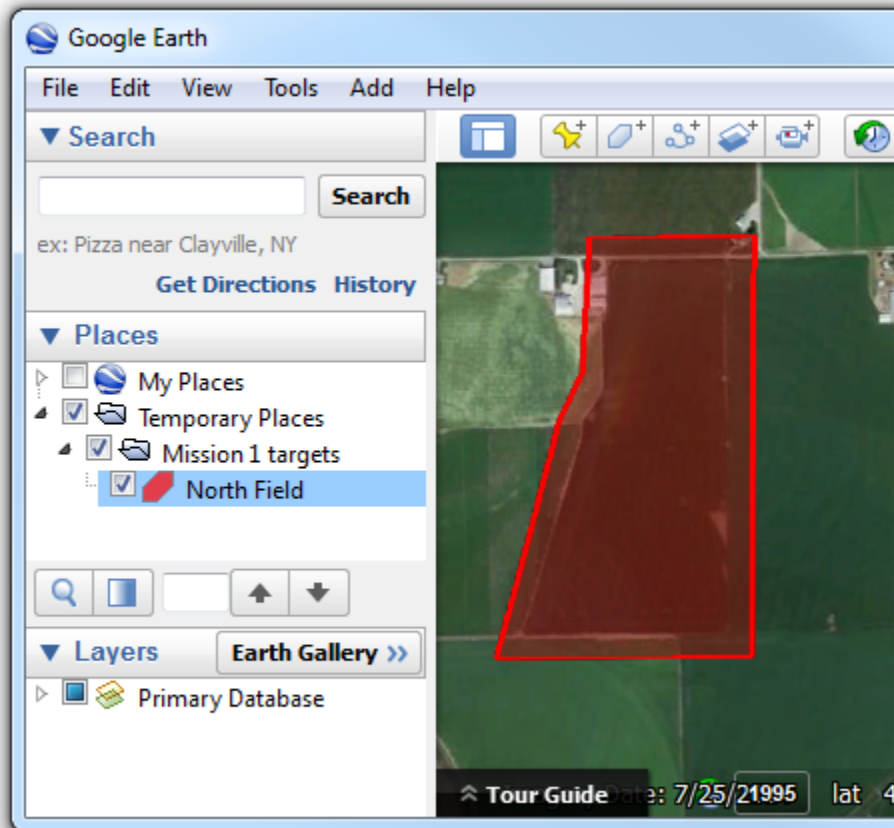


Fig. 3.21: KML target definitions in **Google Earth**

1. Use the *Add* → *Folder* option in **Google Earth** to create a folder. Give it an appropriate name.
2. Right click the new folder and select *Add* → *Polygon* to create a new polygon target inside the folder. The name you give the new target will be reflected in the folder names the flight computer creates for data recorded inside this target area.
3. Click points around the desired area to define a polygon (Fig. 3.21). Polygon fill colors, border widths, etc. are customizable in **Google Earth** and have no effect on the flight computer.

Note: Arbitrary target shapes are supported with KML target areas. However, it is preferable to minimize the size and complexity of the individual targets. Thus, when creating polygon targets, Resonon recommends that you click individual points around the target area rather than dragging the mouse between those points. The continuous curves created by dragging are both harder for the user to draw precisely and generate much larger files.

4. Continue creating more targets in the same folder if desired.
5. Right click on the folder and select *Save Place As*. Use the drop down option to select KML as the format (KMZ is not supported) and save to an appropriate location on your computer. Make sure to save the folder you created, which will include all of the contained targets in the KML file.
6. Upload the KML target file using to the flight computer using the **ResononGroundStation Upload KML** button shown in Fig. 3.20. A file dialog will be presented allowing you to select your saved KML file.

7. Examine the *Remote Targets* section of the *Targets Tab* (Fig. 3.20). Verify each target you defined is listed under *Targets found*. If a target is not shown, or if a target is listed under *Ignored features*, something is wrong with the uploaded target file. Fix it in **Google Earth** and try again. Features may be ignored if they were created as paths or points rather than polygons, for example.

To clear these targets from the system, either upload a new KML target file or use the *Clear KML* button.

3.10 Troubleshooting Tab

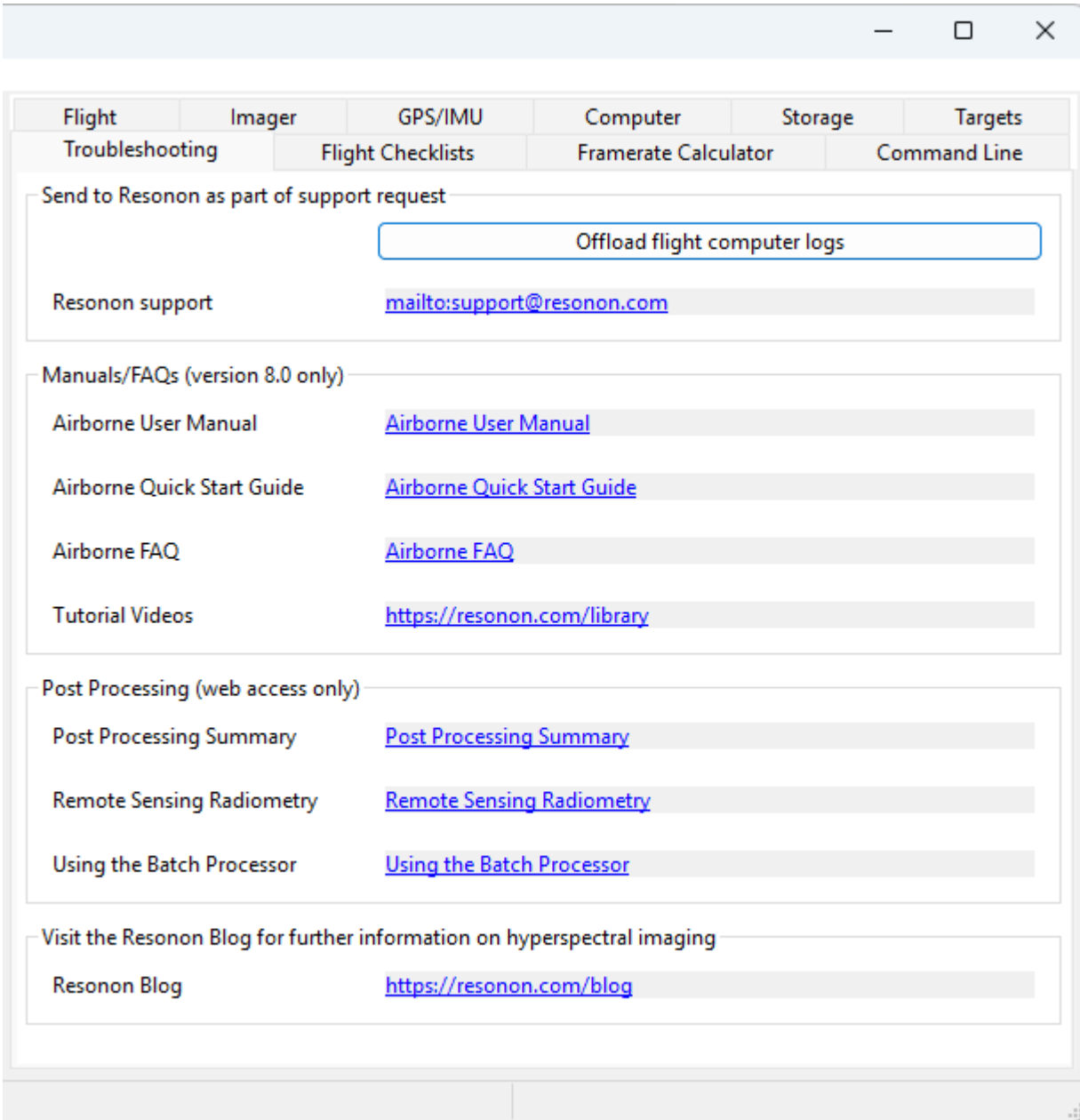


Fig. 3.22: The Troubleshooting Tab

The *Troubleshooting Tab* Fig. 3.22 is designed to provide easy access to all of Resonon's documentation and tutorials on the airborne system and make it easier for user's to diagnose problems as they arise. The tab also allows for users to extract the flight computer's logs, which can then be sent to Resonon's support team if further assistance is needed.

Note: The .zip file produced by the *Offload flight computer logs* button should always be sent as part of a support request.

Offload flight computer logs: Gather flight computer logs and settings for use by Resonon to evaluate and diagnose system performance.

Resonon Support: Send an email to Resonon's support team.

Airborne User Manual: A link to a local version this manual; the user manual covers the installation and use of the hardware and software.

Airborne Quick Start Guide: A link to a local version this guide; the instructions therein outline the most critical steps for successfully setting up and using Resonon's airborne system.

Airborne FAQ: A link to a local version this FAQ; commonly asked questions about the operation of airborne system, all of which should be reviewed as part of the initial setup of the system and before data collection begins.

Tutorial Videos: A series of tutorial videos covering different aspects of airborne hyperspectral imaging, including calibrating the magnetometer on the Ellipse N, a common procedure for drone-mounted airborne systems.

Post Processing Summary: Learn how to convert digital numbers to radiance or reflectance, implement a boresight correction and georectify data.

Remote Sensing Radiometry: An introduction to the radiometric nomenclature used by Resonon.

Using the Batch Processor: Choose any number of datacubes and apply post processing steps to execute sequentially on each, including batch radiance and reflectance conversion and georectification.

Resonon Blog: A series of articles detailing the many aspects of hyperspectral imaging, with a focus on Resonon's benchtop, outdoor and airborne systems.

3.11 Flight Checklists Tab

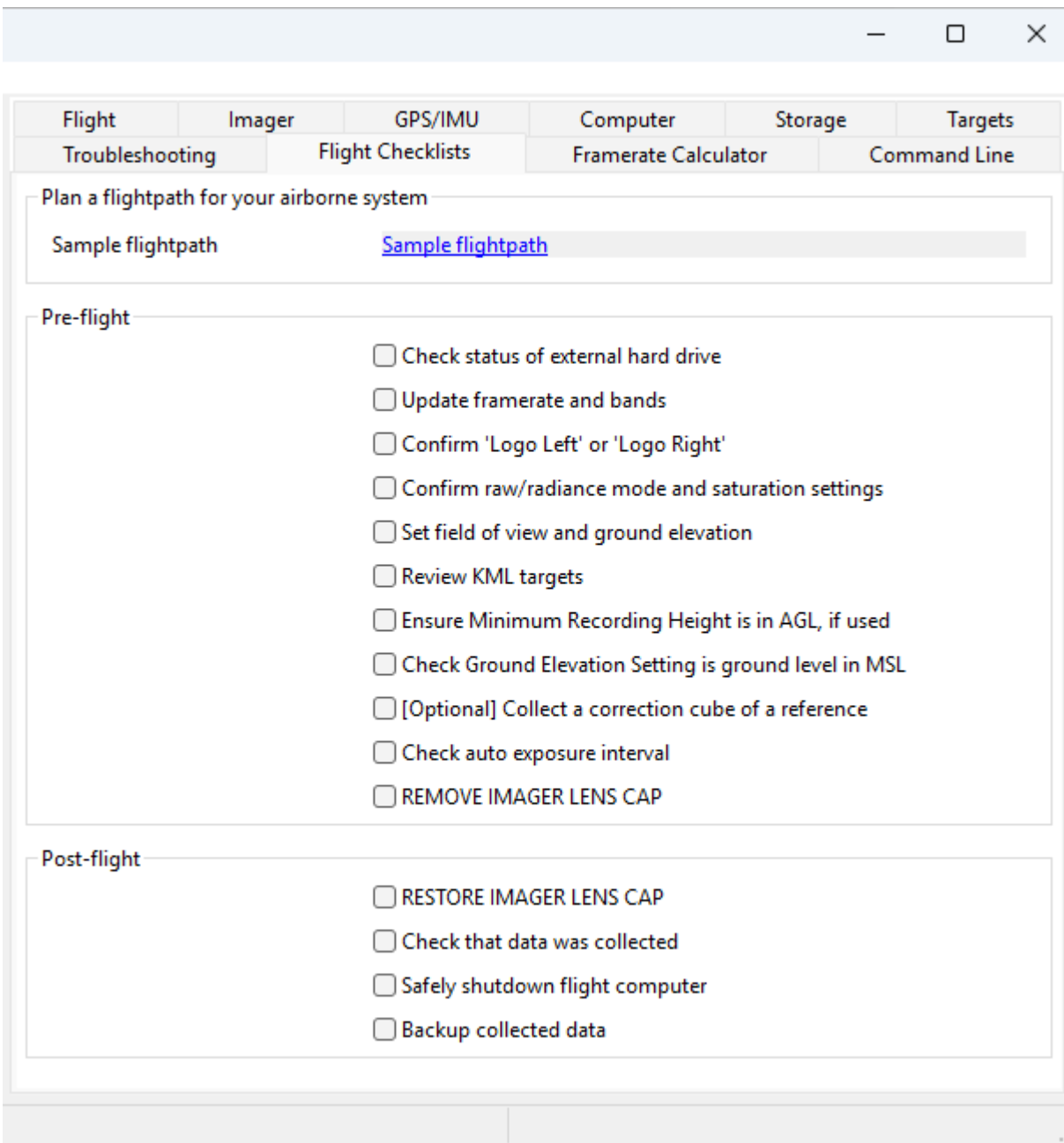


Fig. 3.23: The Flight Checklists Tab

The *The Flight Checklists Tab* Fig. 3.23 provides a series of steps for users to progress through immediately before and after a flight to minimize the chance of data not being collected or lost. Note that the checkboxes are not connected to other parts of the ground station; they serve only as visual and tactile reminders that the noted steps have been done.

Note: The tooltips for each checkbox provide additional guidance on the steps needed to complete each item in the

checklist.

The checklist also features a direct link to [Section 4.1: *Flightpath Planning*](#) to encourage best practices when planning a data collection campaign with the airborne system.

3.12 Framerate Calculator

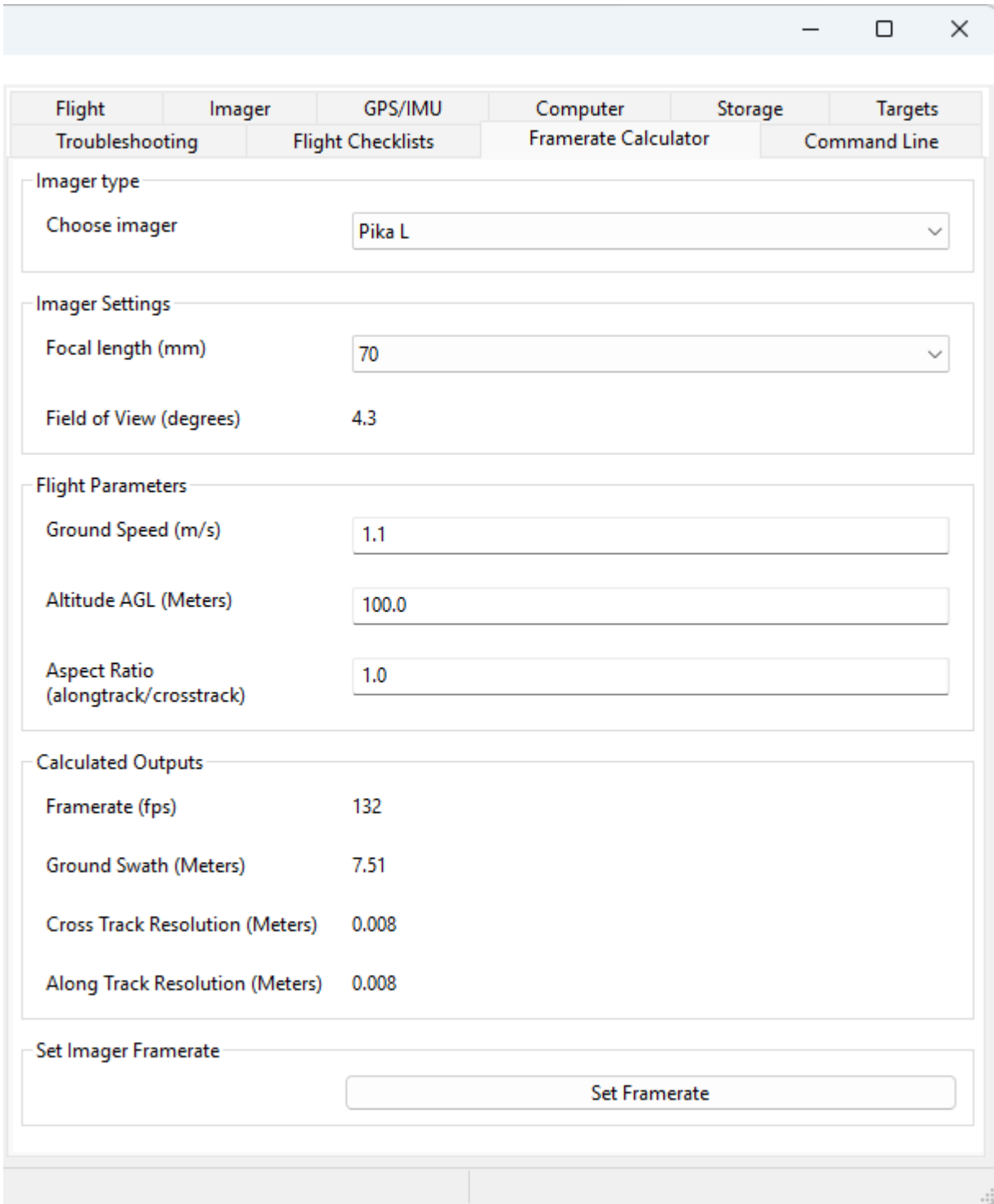


Fig. 3.24: The Framerate Calculator Tab

The *Framerate Calculator Tab* Fig. 3.24 is a stripped down version of the full **Airborne HSI Calculator** which allows a user to determine the square pixel framerate needed for an imaging campaign, given an imager, a lens, and the aircraft's ground speed and altitude AGL. It also outputs the ground swath in the cross track direction to allow the user to calculate the percent overlap of each pass over the target area.

Note: The framerate calculator can be used even when an imager isn't attached as an additional flight planning aide.

Choose imager: Select the imager for which you would like to calculate the square pixel framerate. If an imager is attached, it will be automatically selected.

Focal length: The focal length of your objective lens. This list only includes objective lenses provided by Resonon for a given imager.

Field of view: The field of view of the selected objective lens for the selected imager.

Ground Speed: The ground speed of the aircraft on which the imager is mounted.

Altitude AGL: The estimated altitude of the imager, which is usually well approximated by the altitude of the aircraft on which the imager is mounted.

Aspect Ratio (alongtrack/crosstrack) The desired output aspect ratio, usually 1.0. Change this to over/under sample in the along track. The framerate will be calculated to achieve this aspect ratio.

Framerate: The calculated framerate to achieve the set aspect ratio, given the imager settings and flight parameters; an orange background indicates a framerate higher than the imager's maximum framerate.

Ground Swath: The length of ground imaged in the cross track direction, assuming a flat Earth and a level aircraft.

Set Framerate: This button sets the connected imager's framerate to the calculated framerate. A command is sent to the flight computer and is reflected in the Framerate setting in the *Imager Tab*.

3.13 Command Line

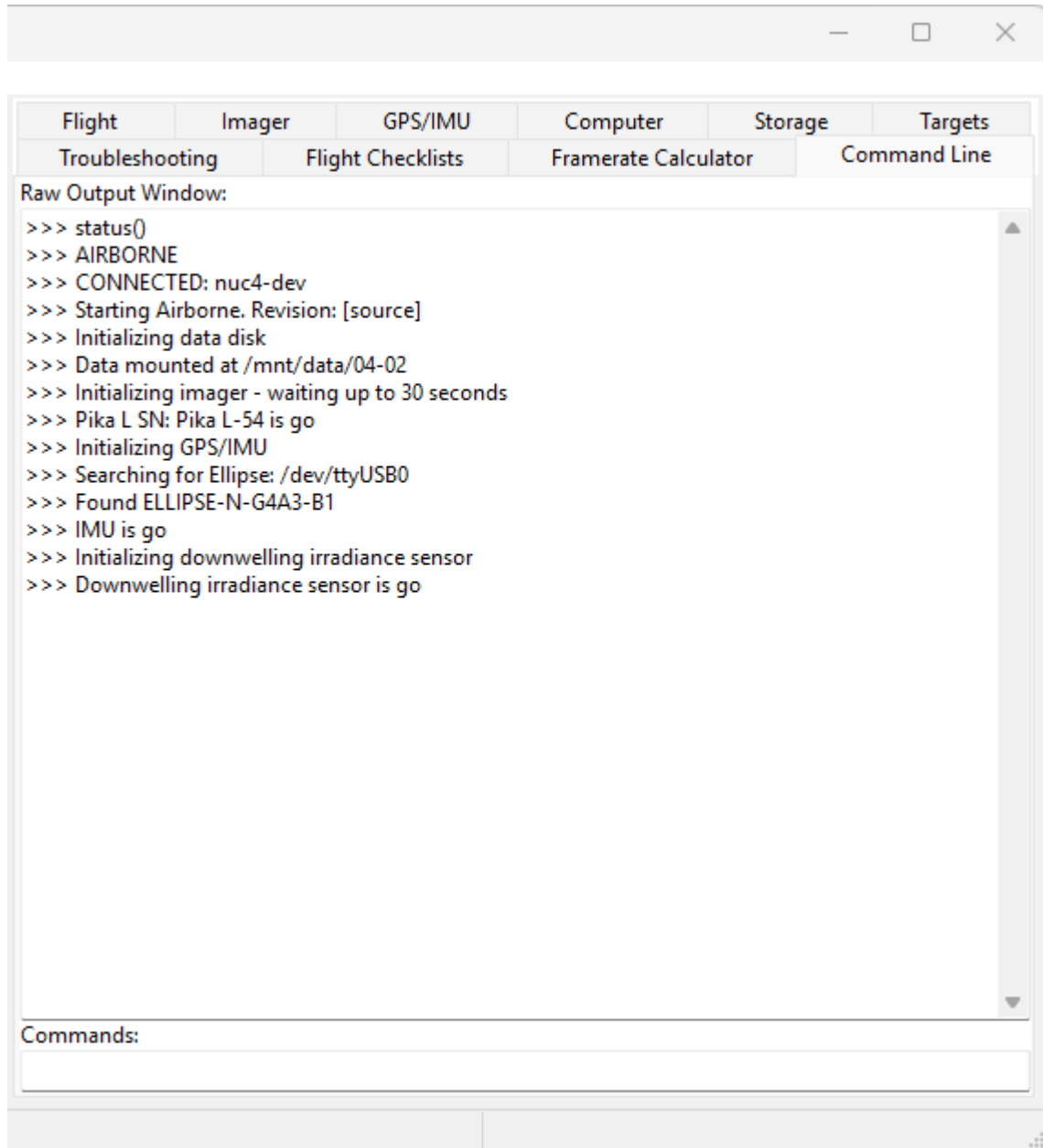


Fig. 3.25: The Command Line Tab

The *Command Line Tab* Fig. 3.25 contains an output window of messages to and from the flight computer, as well as an input window for manually sending messages to the flight computer. Please see [Section 5: Advanced Operation](#) for a description.

3.14 Menu Items

3.14.1 File

File → **About Ground Station**: Displays the version of the **ResononGroundStation** software.

File → **Exit**: Exits the **ResononGroundStation** software. This does *not* shut down the flight computer. Use the **Computer Tab** (Fig. 3.18) to do that.

3.14.2 Preferences

Preferences → **Downwelling Irradiance**: If the system will not be using a downwelling irradiance sensor (single point spectrometer) select *Disabled* to prevent downwelling irradiance sensor error warnings on startup. Select *Enabled* to re-enable the downwelling irradiance sensor.

Preferences → **Units**: Changes the **ResononGroundStation** software to use metric or imperial units. In both cases the flight computer stores values in metric units. The **ResononGroundStation** software converts to imperial units as necessary. Metric units is the preferred setting.

Preferences → **Auto Exposure Interval**: Determines when the flight computer runs the image autoexpose procedure. The flight computer will not run autoexpose while it is actually recording data.

The options are:

- **Every Datacube**: The flight computer will run autoexposure immediately before recording each datacube. **This is the recommended setting.**
- **Outside Target Area**: The flight computer triggers autoexposure once per second when outside of target areas. Autoexposure will not run while inside any target area above the *Min Height* setting. This setting should be used if there is a concern about data holidays (gaps between successive recordings inside a target area) if the lighting changes while the unit is recording.
- **Never**: The flight computer will not run autoexposure automatically. This is not recommended.

Preferences → **View Output In Separate Window**: Moves the **Command Line Tab** to a separate window to enable viewing up/down messages and ground station controls side-by-side.

3.14.3 Comms

Comms → **Refresh**: Refreshes the list of available COM ports. Click this if you connected the flight computer USB communication cable to the ground station computer after the software was started.

Comms → **Ping Flight Computer**: Manually open the connection dialog Fig. 3.4 and attempt to reconnect to the ground station on the selected serial port. This is done automatically when selecting a serial port. See Section 3.2: *Launching the Software and Connecting to the Flight Computer*.

Comms → **Disconnect**: Close the connection to the flight computer.

Comms → **COMx**: Each detected serial port is listed in the menu. Select the correct port to open a connection to the flight computer. See Section 3.2: *Launching the Software and Connecting to the Flight Computer*.

3.15 Transferring Data

The fastest way to transfer data is to:

1. Shut down the flight computer
2. Unplug the SSD drive.
3. Plug the SSD drive into computer.
4. Copy data from the drive to your computer.

Note: Systems which originally shipped with firmware prior to 6.0 write data to a Linux ext4 file system. Use **Disk Internals** or **Ext2Fsd** to read the drive and copy data. See the section *Legacy System Data Disk* for more information.

The second alternative is to plug in an external USB drive, formatted as FAT32, to a USB port of the flight computer and press the *Offload Data* button in the *Storage Tab*. This method can be quite slow.

3.16 Post Processing Data with Spectronon

Spectronon, Resonon's free spectral image analysis software, can be used to process airborne data from arbitrary units to radiance or reflectivity. There are a variety of **Spectronon** plugins available for each conversion.

Radiance:

1. With **Spectronon**, open the airborne datacube to convert.
2. Right click on the datacube to convert in the resource tree in the right hand side of the main **Spectronon** window. Select *New Cube* → *Correct* → *Radiance from Raw Data*.
3. In the resulting window, select the name of the radiometric calibration pack ('.icp' extension), then press *OK*. The resulting cube will be in units of microflicks (1 microwatt per steradian per square centimeter of surface per micrometer of span in wavelength).

Reflectance via downwelling data: Data can be converted to reflectivity using the optional downwelling irradiance sensor via the following steps.

1. Open the airborne datacube to convert.
2. Optionally, open the downwelling irradiance spectrum to be used. The plugin can also automatically use the downwelling spectrum in the airborne datacube folder for Resonon calibrated downwelling sensors.
3. Right click on the datacube to convert in the resource tree in the right hand side of the main **Spectronon** window. Select *New Cube* → *Correct* → *Reflectance from Raw Data with Downwelling Irradiance Spectrum* (or *Reflectance from Radiance Data with Downwelling Irradiance Spectrum*, depending).
4. If the downwelling sensor was radiometrically calibrated by Resonon, select *Resonon Calibrated* and the appropriate DCP calibration file in the *Downwelling Calibration* field.
5. If a third party sensor is to be used, select the units the sensor outputs in the drop down menu and the downwelling spectrum from the sensor.
6. By default, the plugin will correct for dark current using the ICP and DCP calibration files (for Resonon calibrated systems). If it is preferred to use a previously measured dark current during the correction, unselect the *Auto Remove Dark Noise* and choose the measured dark current cube or spectrum.
7. If you have a reflectance standard (such as a tarp) in a scene, you can use the data from the tarp in addition to the downwelling data to better correct the data. The creation of these correlation coefficients is described further below in this manual. Once created, you can select this correlation coefficient vector after selecting

the *Use Correlation Coefficients* checkbox and then selecting the previously created correlation coefficient spectrum.

8. Press *OK*. The resulting cube will be in reflectivity on a scale of 0 to 1, 0-10,000, or 0-bit depth depending on preferences.

The downwelling sensor can be operated on the ground for short flights around a local area. This option saves weight while adding minimal complexity. To do this, collect data with the downwelling sensor using Ocean Optics software. The cosine corrector should pointing up with a clear, hemispherical view of the sky. Save the spectra, and use the *Open Spectrum* option in **Spectronon** to import the data. This spectrum can now be used in the above procedure.

Creating correlation coefficients for use with downwelling irradiance data:

1. Open a datacube containing the reference standard.
2. Convert this cube to reflectance using the *Reflectance from Raw Data and Downwelling Irradiance Spectrum* (or *Reflectance from Radiance Data and Downwelling Irradiance Spectrum*).
3. Use the selection tools to create a ROI of the tarp. Right-click and select *Create Correlation Coefficients*.
4. Select the file containing the measured reflectance of your standard.
5. Use this spectrum in the either of the *Reflectance from Downwelling Irradiance* plugins to better control for calibration uncertainty in the conversion process.

Reflectance via in scene reference spectrum: If there is an object in the scene of measured reflectivity, it can be used to convert the data to reflectivity via the following steps.

1. Convert data to units of radiance using the *Radiance from Raw* plugin.
2. Select ROI of object of known reflectivity and create a Mean Spectrum.
3. Select *New Cube* → *Correct* → *Reflectivity from Radiance Data with Measured Reference Spectrum*.
4. Press the *Measured Reflectivity* button and select the file containing the reflectivity measurements. This file should be a tab or space delimited, with wavelength units in nanometers.
5. Press *OK*

If the reflectivity of the reference is spectrally flat over the wavelength range of interest, you do not need to use a measured reflectivity file. Instead, you can use the *Correct from Reflectivity from Radiance Data and Spectrally Flat Reference Spectrum* plugin, as follows:

1. Convert data to units of radiance using the *Radiance from Raw Data* plugin.
2. Select ROI of object of known reflectivity and create a mean spectrum.
3. Select *New Cube* → *Correct* → *Reflectivity from Radiance Data and Spectrally Flat Reference Spectrum*.
4. Enter in the reflectivity (0-1) of the reference material.
5. Press *OK*

Export to KML: **Spectronon** supports exported processed spectral image cubes to KML format data.

1. Open a **georectified** datacube, as generated by **Spectronon**'s *Georectify Airborne Datacube* plugin.
2. Process the data using the normal analysis tools of **Spectronon**.
3. Select the resultant image and use *Export Image as KML*. Note: In order for the background pixels (the buffer areas around the spectral image data used to make the image square) transparent in the KML, they must be black in the image. You may have to use various filters (*Invert*, *Stretch*, *Threshold*, etc) in order to make the buffer pixels black before exporting to KML.

Batch Processor: Spectronon's *Batch Processor* automates the processing of multiple datacubes with a simple GUI interface. See the **Spectronon** user manual for details. If using the *Georectify Airborne Datacube* plugin with the *Batch Processor*, please note that the saved location of some of the output products (.kml,.tiff,) are designated in the plugin dialog window, and the saved location of the georectified datacube is designated in the *Batch Processor* dialog window.

3.17 Using the Georectify Spectronon Plugin

Note: The **Georectification Plugin** software is easily installed with the provided installer. Please double click the installer and follow the instructions, after which you will be able to geo-correct airborne images.

The **Georectification Plugin** can also be found at our [download site](#), under *Airborne* → *Airborne Utility Software*. If you have not purchased a full airborne system, you will need to purchase the georectification software separately; please contact [Resonon's support team](#) to request access to the plugin. Please include your account username and your imager serial number in your email.

1. Launch **Spectronon**.
2. Open the datacube to geo-correct. If units of radiance or reflectivity are desired, these operations should be performed first as the conversion to radiance is not possible after georectification.
3. The plugin needs to know the ground elevation of the image area. This can be done using the assumption of a flat area at a known elevation (MSL using the EGM96 geoid) or by using a digital elevation map (DEM). If

using a DEM file instead of a flat earth elevation, uncheck the *Use Flat Earth Elev* checkbox and select the DEM file to use. DEM formats supported by GDAL (www.gdal.org) are supported by this plugin. If using a flat earth elevation, enter the value in meters of the ground elevation. In general, the resolution and accuracy of freely available DEMs such as SRTM is not sufficient for low altitude flights and a flat earth elevation should be used instead. The DEM should be in MSL using the EGM96 geoid.

4. Enter the FOV of the instrument/objective lens combination. A chart is shown below.
5. Enter the desired resolution (in meters) of the end products. The *Calculated Resolution* numbers (cross track, along track) provide a minimum value, but typically a larger number is used to account for aircraft instabilities, etc, and avoid large amounts of interpolation.
6. The ‘Override heading with course’ option may be used if the magnetometer data (source of heading data) is bad. This option will not perform with yaw gimbals or in crosswinds.
7. By default, all output products except for the datacube will be saved in the source folder. If this is not the desired behavior, unselect the *Save Products in Source Folder* and select another folder. Note: When using the *Batch Processor* with this plugin, output products will still be saved according to this preference. Datacubes generated by this plugin follow the saving preference selected in the *Batch Processor*.
8. Select the desired output data products. The swath outline simply shows the out line of the imager FOV. Please note that only the full datacube will show up in the **Spectronon** file tree, all other products are generated and saved without any visible indication.
9. Select the desired interpolation option for both the images and datacube, if applicable. The *morphological* interpolation method is the fastest. Interpolating full datacubes can be slow.
10. If you have multiple renders of a datacube open, you can choose which render you would like to use for KML/GeoTIFF. You can also choose to apply a stretch or not. Renders are not shown by name, rather by *rend0*, *rend1*, etc, in the order they were created in. You must match up the order of the render desired by looking in the **Spectronon** file tree.
11. If there is a known time offset between the imager and GPS/IMU, enter the value (in seconds) in the *Sync Offset* field. This value is typically left at 0.
12. Enter any known angular offsets (in degrees) between the imager and GPS/IMU in the appropriate fields. Read [Section 3.17.1: Biases](#) below for more information.
13. If you would like to only georectify a portion of a datacube, check the *Crop Cube to Start/End Lines* and enter starting and ending line numbers. Care must be utilized if using this feature in the *Batch Processor* as cubes may have different numbers of lines.
14. Press *OK*.

The table below lists the FOV of Resonon imagers with different objective lenses. This information is necessary for the georectification software. It is not exact and may have to be adjusted for your particular imager.

Focal Length [mm]	70	50	23	17	12	8	6
Pika L FOV [deg]	4.3	6.0	13.1	17.6	24.8	36.5	47.5
Pika L IFOV [mrad]	0.21	0.24	0.52	0.71	1.00	1.50	2.00

Focal Length [mm]	70	50	23	17	12	8
Pika XC2 FOV [deg]	7.7	10.7	23.1	30.8	42.7	60.8
Pika XC2 IFOV [mrad]	0.17	0.24	0.52	0.71	1.00	1.5

Focal Length [mm]	100	75	50	25	6.0
Pika IR, IR-L FOV [deg]	5.5	7.3	11	21.7	77.3
Pika IR, IR-L IFOV [mrad]	0.30	0.40	0.60	1.20	5.00

Focal Length [mm]	60	24
Pika UV FOV [deg]	8.4	20.5
Pika UV IFOV [mrad]	0.40	1.00

3.17.1 Biases

Despite tight machining tolerances, angular misalignments on the order of tenths of a degree can exist between the IMU and the imager's coordinate systems. For context, a tenth of a degree misalignment in pitch or roll leads to a 17 cm systematic error in location when the system is flying 100 meters above ground. The boresight angles should be determined if/whenever a new imager or IMU is swapped out of the airborne system.

Biases can be estimated visually or computed more precisely with the boresight correction tool built into Spectronon. To estimate biases visually, fly the system over a fiducial landmark from multiple directions and georectify the data. Any offsets of the geocorrected images versus the fiducial are a combination of GPS error (if not using RTK) and bias. Try to eliminate the effects of GPS error by looking at the same image taken from different flight directions. Then measure the remaining offset as a distance, then convert to angle with simple geometry and knowledge of aircraft height. These angles are measured from the GPS/IMU to the imager, following the following sign convention: Right wing up is positive roll, nose up is positive pitch, and clockwise looking down is positive yaw. The effect on the georectified image is the following: Positive roll bias shifts image to left (direction of flight is forward). Positive pitch bias shifts image back (again relative to flight direction). Positive yaw bias rotates lines counterclockwise. To determine which direction the aircraft is flying from the georectified image, use the plugin to generate a swath outline KML and open it. The green line represents the beginning of the datacube.

Directions for measuring biases with the boresight correction tool are detailed in the section below.

There can be a small time offset needed in the *Sync offset* field, typically between 0 and -.05 for non-triggered systems. This offset can be determined by looking at higher frequency roll effects and determining if the GPS/IMU data is ahead or behind the image data.

3.17.2 Boresight Correction Tool

The boresight tool allows users to correct for the boresight misalignment, thereby achieving the highest possible geolocation accuracy. Bear in mind that boresight angle determination depends on very precise GPS data, making RTK-assisted data acquisition essential.

Requirements

1. At a minimum, the boresight correction operation requires the acquisition of an image that contains at least two Ground Control Points (GCPs), one near the center of the imager's field of view, and one near the edge of the imager's field of view. In practice, a single GCP can be used, as long as a flight path is chosen to image that GCP multiple times, including instances where it appears near the center and on the edge of the imager's field of view.
2. GCP coordinates should be measured using survey grade equipment using the WGS84 spheroid. Google Earth coordinates are not typically reliable for this purpose.
3. Ideally, measure the GCP locations directly with the (RTK-assisted) airborne system to avoid convoluting GPS error and boresight misalignment.

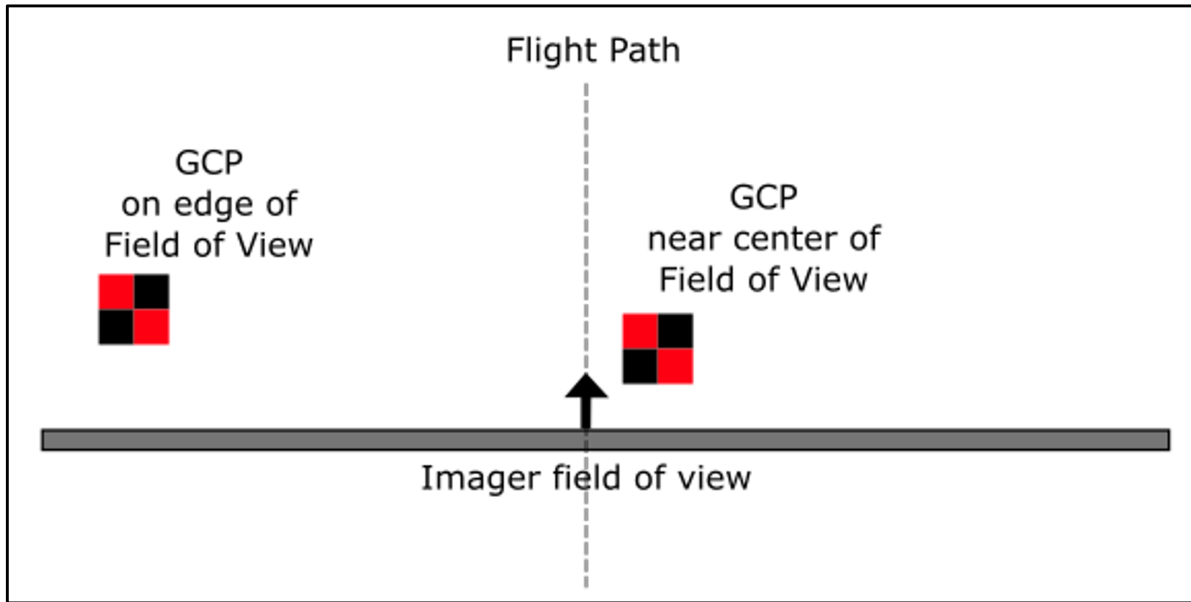


Fig. 3.26: Flight path and GCP configuration that meets the minimum requirement (low precision).

Note that the boresight correction tool will utilize every instance of a GCP as it is being imaged, which is why a redundant flight path over one (or several) GCPs yields the boresight angles with higher precision.

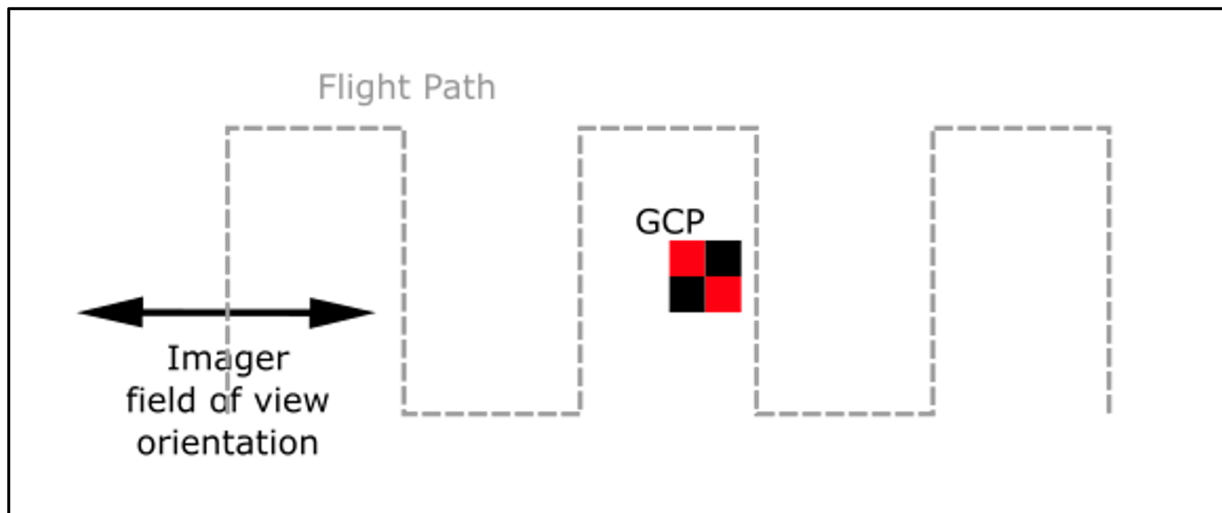
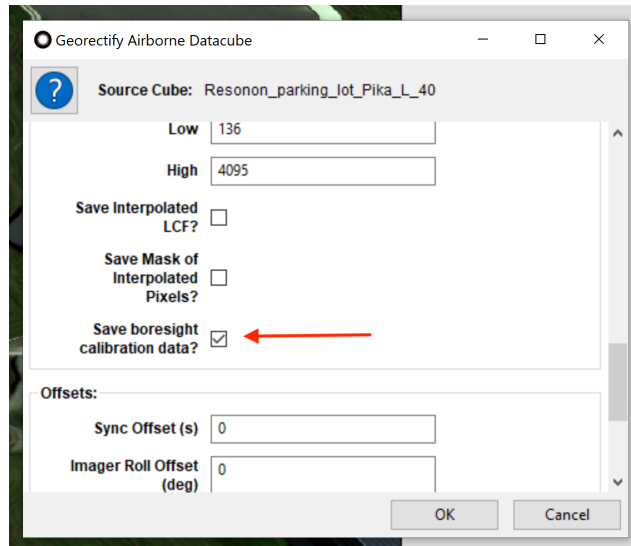


Fig. 3.27: Possible flight path and GCP configuration that effectively utilizes six GCP measurements, producing boresight correction angles with higher precision.

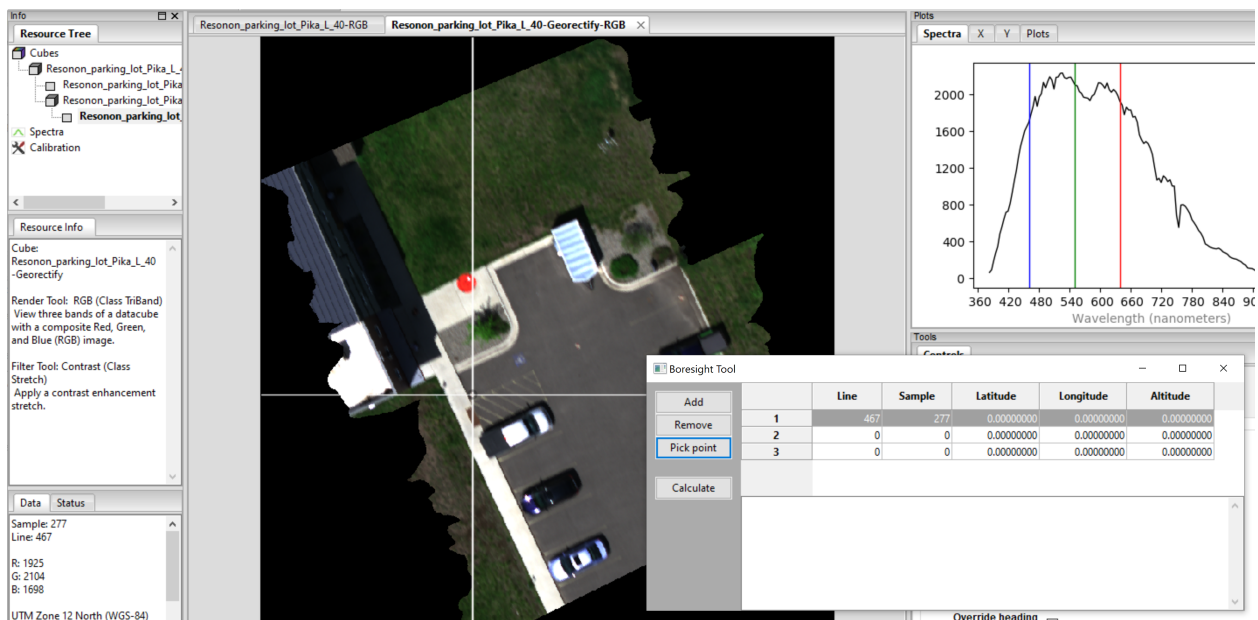
Method

1. Establish one or several GCPs in the field.
2. Measure and record the GCP coordinates with the help of the RTK GPS from a known point or other precise surveying techniques.

3. Record an image with a flight as per recommended above.
4. Open the airborne image into Spectronon as per usual.
5. Perform the standard georectification, being sure to check the Save Interpolated LCF? and Save boresight calibration data? boxes. As a reminder, select the datacube in the Resource Tree, then use the menu to select Datacube, New Cube, Correct, Georectify Airborne Datacube.

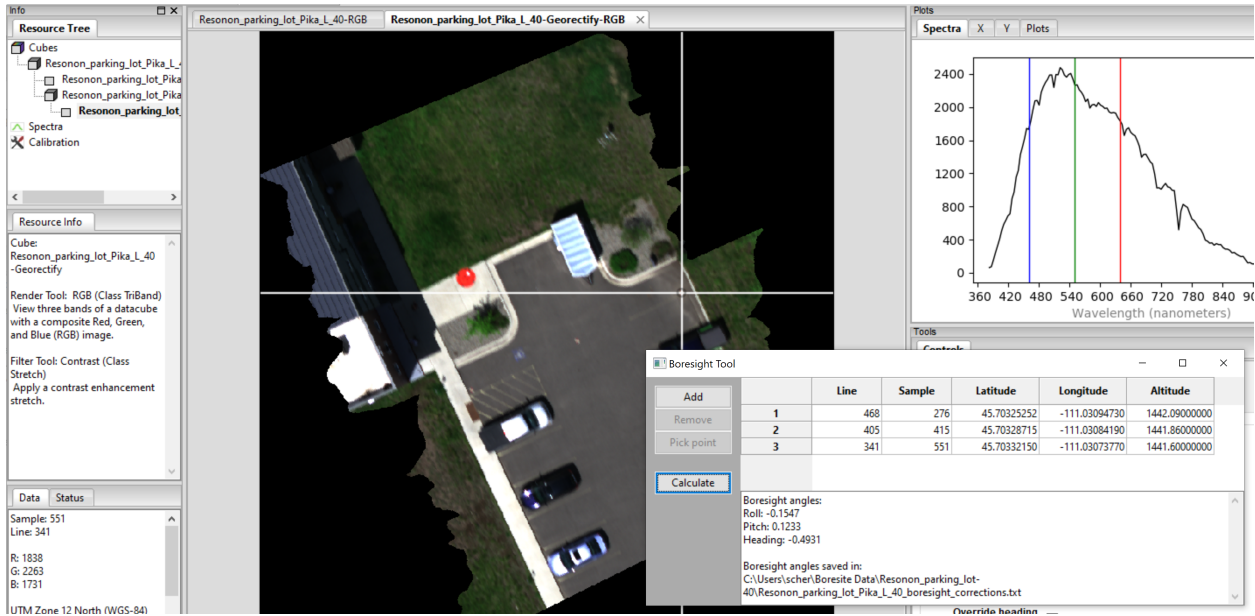


1. Once the georectified image appears, use the Spectronon menu to select Image, Airborne Boresight Tool...
2. In the dialog window, click Add to add a line for each GCP.
3. Click on the number (1, 2, or 3...) at the left of the line to select that line.
4. Click on Pick point in the vertical menu on the left side of the dialog window

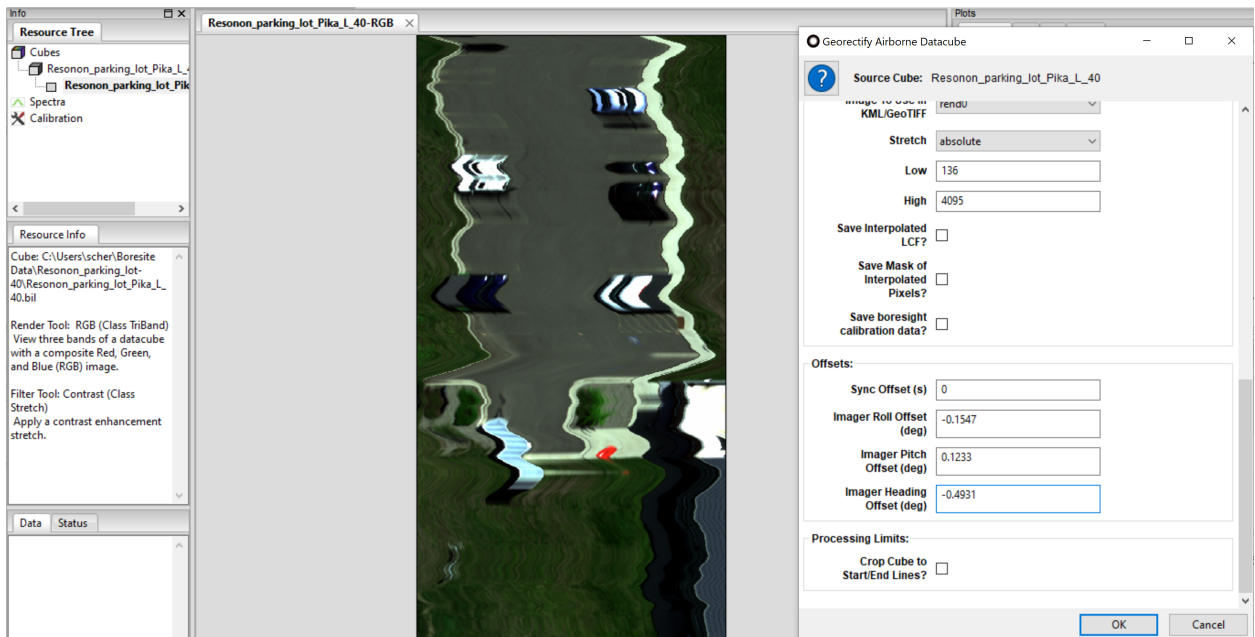


1. Use the Inspection Tool of the top tool bar to select the location of the GCP in the image. This will automatically populate the Line and Sample columns with the correct values

2. Manually enter the Latitude (in degrees), Longitude (in degrees), and Altitude (in meters) of that GCP as previously measured with the RTK.
3. Repeat steps 4 through 8 for each GCP.
4. Click Calculate on the left in the dialog window
5. The boresight correction angles will appear below the lines in the dialog window and also saved in the stated location.



1. You have now determined the correct georectification angles for your imager/IMU system. Use those angles for all future georectification procedures when precise geolocation is required, as per the instructions below.
2. To apply the boresight angles in the Georectify Airborne Datacube plugin, enter the boresight angles under Imager Roll Offset (deg), Imager Pitch Offset (deg), and Imager Heading Offset (deg).



3.18 Using the Mosaic Tool

The *Mosaic Tool* can be used to combine multiple georectified data sets into a single source. Due to the processing time required, and the size of the resultant file, it is recommended to only use the *Mosaic Tool* for GeoTiffs and not full datacubes. It should also be noted that the *Mosaic Tool* merges files based only on geolocation, and that no feature matching or blending is used.

1. Select *File* → *Mosaic Tool*
2. Use the *Add*, *Add Folder*, or *Recursive Add Folder* to select the input files.
3. Select a name and path for the output file.
4. Press *OK*.

OPERATION SUMMARY AND CHECKLIST

4.1 Flightpath Planning

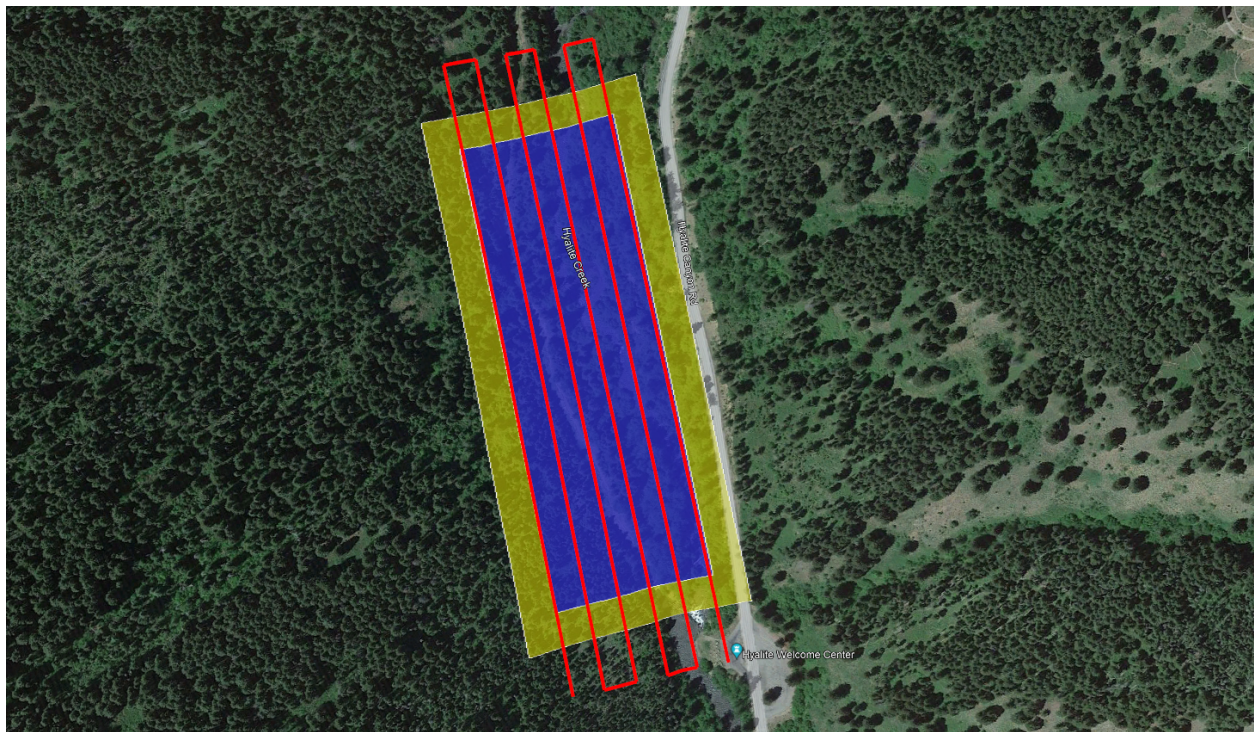


Fig. 4.1: A sample flightpath of a drone-mounted hyperspectral imager. The blue, yellow, and red represent the target area to be imaged, the target KML, and the aircraft flightpath, respectively.

Setting a correct flightpath for Resonon's airborne system is a critical step in successfully gathering hyperspectral datacubes from a drone- or airplane-mounted imager. In particular, the flightpath must both go over the target area to be imaged **and** fly within the target KML so the datacubes are collected in the first place.

The above hyperspectral flightpath Fig. 4.1 is an example of the target area to be imaged (blue), the Google Earth KML (yellow), and a drone flightpath (red). In particular, notice that the target KML is larger than the area to be imaged, and the flightpath is such that the drone will fly into and out of the target KML.

The flightpath design is to overcome the inherent inconsistency in the three different coordinate maps involved: Google Earth's coordinate system, the drone's coordinate system, and the imager's GPS/IMU unit's coordinate system. At-

tempting to make KML targets and flight plans that overlap precisely will often result in data not being collected, especially at the edges of the target area.

Instead, it is highly recommended that the target KML be larger than the target area, with the drone flying into and out of the target KML with a large degree of clearance. This will ensure that the entire target area is imaged (in fact, likely oversampled).

Lastly, note that the start and end of the flightpath are positioned such that the aircraft can return to its starting position without going through the target KML. This is not necessary, but will reduce the amount of inadvertently collected data, especially on drone-mounted imagers.

4.2 Mission Setup

1. Upload the target KML.
2. Set *Framerate* and *Bands* settings. Record test cubes to ensure the flight computer can handle the data rate.
3. Set *AutoExposure Class* and *Interval*.
4. Perform *Check Disk* function for routine maintenance

4.3 Pre Flight

Normal pre-flight operations are summarized below. Please see the preceding section for more details on these operations.

1. Power up system.
2. Launch **ResononGroundStation** software.
3. Verify all systems are operational.
4. Delete existing data.
5. Check that the system time matches GPS time. If necessary, match the system time to GPS time.
6. Set *Ground Elevation* if using target area *Min Height* setting
7. Optionally, autoexpose on a white reference and collect a correction cube.

4.4 Flight

1. Perform magnetic calibration, if necessary. This only needs to be done once as long as the plane and installation do not change. It is also not necessary for dual antennae GPS/IMUs.
2. If using a dual antenna GPS like the Ellipse D, you should fly a figure 8 or zig zag pattern to help the system lock in on heading.
3. If using an Ellipse N, allow the aircraft to exceed 15 km/h (~5 m/s) for good alignment. Data collection can happen at slower speeds.
4. Perform autoexposure, if necessary.
5. Confirm collection of datacubes while in target areas.
6. Optionally, shut down system (via *Shutdown* button) for return flight.

4.5 Post Flight

1. Shut down flight computer.
2. Remove data drive and offload data using dock/cable.
3. Convert data to radiance or absolute reflectance. Optionally classify/analyze data.
4. Geo-rectify data with **Spectronon**'s *Georectify Airborne Datacube* plugin.
5. Classify/analyze data.

4.6 Data Files and Structure

The top level data folder is named by date. Inside of the data folder are folders named by target polygon name and number. Inside of these folders are the .bip, .hdr, .lcf, and .times files. A description of all data files follows.

Per Image Files:

- ***.bil** The hyperspectral raw image data
- ***bil.hdr** The header file for the raw image data
- ***.bil.times** Lists the timestamps for each frame in the HSI file. In future versions, This data may be included in the *.hdr file under the var name "line time stamps"
- ***.lcf** Contains the actual location data pulled from the GPS/IMU during the cube recording.
- ***_path.kml** Map of where imager recording did and did not occur (red and blue, respectively) in a Google Earth readable file.

4.7 Keys to Obtaining Quality Data

- Collect data under cloudless skies or uniformly cloudy conditions between 10 am and 2 pm.
- Use the largest spatial and spectral binning appropriate for the application
- If the system is operating at non-zero gain, signal to noise ratios can be improved by slowing down the frame rate to the slowest rate appropriate for the application
- A high quality correction cube will improve data fidelity (if using). Make sure there are no shadows or glare present when recording this cube.
- The GPS/IMU's attitude solution is less accurate after turns. When creating a flight plan, allow the aircraft to travel straight for a short time before entering areas to be recorded. This increases the accuracy of the georectification. The Ellipse N needs occasional accelerations or turns for optimal performance.
- If autoexposure returns a *Not Enough Light* warning, the frame rate can be turned down (smaller FPS setting). This will increase the integration time of the system, allowing more light to enter. Decreasing the frame rate will decrease the along-track spatial resolution: if this is not desirable, the system can still be flown after a *Not Enough Light* warning, but the images may be dark and/or noisy. Alternatively, the aperture of the Pika's objective lens can be adjusted. Please contact Resonon for consultation on this procedure.
- The use of ground tarps for reflectivity reference will always be more accurate than the use of downwelling irradiance data.

Warning: Adjusting the Pika's aperture setting will void the radiometric calibration. Contact Resonon before adjusting this setting.

4.8 Recalibration Services

Resonon recommends a yearly schedule for wavelength and radiometric calibration for best performance, or immediately after rough handling. Please contact us for a quote and instructions.

ADVANCED OPERATION

5.1 Sending Special Commands to the Flight Computer

Many of the following sections require sending special commands to the flight computer. This is done through the **ResononGroundStation** software via serial cable. With the system running, navigate to the *Command Line Tab*. Click in the command-line box at the bottom of the window and type your command. Press <enter> to send the command to the flight computer. For example:

```
getVersion()
```

The command and any response from the flight computer command interpreter appear in the *Raw Output Window* above:

```
>>> getVersion()  
<<< Revision: 7.10
```

5.2 Updating Firmware

The firmware of the spectral imaging system can be updated via USB thumb drive.

Warning: Updating flight computer code should only be done under the request and guidance of Resonon personnel.

1. Determine your flight computer generation from the Name setting in the ground station, as shown in Fig. 5.1, which is the number directly after 'NUC.'

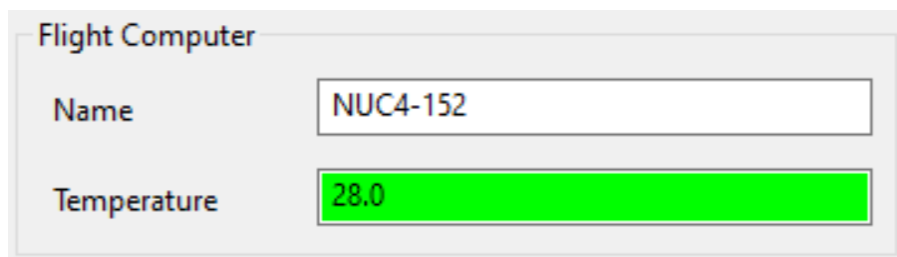


Fig. 5.1: An example of the ground station Name setting when connected to a NUC Generation 4 flight computer



Fig. 5.4: Older Flight Computers - NUC Generations 1, 2

3. Create an account at downloads.resonon.com.
4. Resonon personnel must enable your account enabled to view and download airborne software. Please provide your account username when you contact us.
5. Download the new firmware from downloads.resonon.com. It should be found under:
 - Airborne → Current NUC flight computer software and documentation*
 Pay attention to download NUC generation 2, 3 or 4 firmware as appropriate for your system.
6. Also download the matching **ResononGroundStation** code (same version number as the firmware file).
7. Copy the firmware file to a USB thumb drive.
8. Before powering up the flight computer, make sure there is a free USB port. You may unplug the imager, GPS/IMU, singlepoint spectrometer or LCD display to free up a port. *Do not connect the USB thumb drive yet!*
9. Power up the flight computer and connect with the **ResononGroundStation** software.
10. On the advice of Resonon staff, click *Upgrade flight code* on the **ResononGroundStation Computer Tab** (Fig. 3.18).
11. When a dialog pops up asking for a USB drive with the desired *.enc file, attach the thumb drive to the *flight computer* (not the ground station computer), wait a moment and click *OK*.
12. Select the firmware file in the next dialog, and click *OK*. The *Flight Code Version* status field turns orange and says *Reboot required*. The *Ground Station Version* status field turns orange and says *Upgrade required*.
13. When prompted, remove the thumb drive and either shut down or reboot the flight computer from the *Computer Tab* (Fig. 3.18). A reset is not enough.
14. Close and uninstall the current **ResononGroundStation** program. Install the new **ResononGroundStation** version.
15. When the ground station version matches the flight code version, the version status fields turn green again.

Note: If the ground station fails to connect to the flight computer, verify that the correct COM port is selected in the *Comms* menu.

5.3 Pairing a GPS/IMU with a Flight Computer

To change which type of GPS/IMU the flight computer is paired with, enter one of the following commands:

```
setImu('Ellipse')
setImu('Novatel')
```

5.4 Pairing/Unpairing a Downwelling Irradiance Sensor with a Flight Computer

If a downwelling irradiance sensor is not being used, the system will boot faster if the flight computer is instructed not to attempt to connect. For **ResononGroundStation** versions 4.4 and above the downwelling sensor can be disabled or re-enabled through the *Preferences* → *Downwelling Irradiance* menu.

5.5 Reformatting Disks

For system errors that can't be repaired by Windows [exFAT filesystems] or the **ResononGroundStation** *Check Disk* function [exFAT or ext4 filesystems], it may be necessary to reformat the external hard disk. This will erase all previous data collected by the flight computer.

A data disk can be reformatted by clicking *Reformat Data Disk* on the *Storage Tab* (see [Section 3.8](#)). This can take some time for large disks.

The *Reformat Data Disk* button can also be used to format an additional SSD SATA data disk. The choice of SSD disk is important to system performance. Please consult Resonon for disk drive model recommendations.

5.6 Changing Default Cube Length

By default, the airborne system breaks datacubes into ~2000 lines. This value can be changed by typing the following into the *Commands* field:

```
setCubeSize(size)
```

5.7 Exposure Sync Pulse

The Pika L and Pika XC2 imagers can be configured to output a timing signal on one of the general purpose I/O lines at the back of the camera. By default the signal transitions from high to low at the start of exposure and low to high at the end of exposure. This can be inverted.

This feature can only be configured from the *Command Line Tab*.

Enabling sync pulse:

```
camera.preferences.setitem('syncPulse', True)
```

Disabling the sync pulse:

```
camera.preferences.setitem('syncPulse', False)
```

Inverting the sync pulse:

```
camera.preferences.setitem('syncPulseInvert', True)
```

Default sync pulse:

```
camera.preferences.setitem('syncPulseInvert', False)
```

5.8 Troubleshooting

5.8.1 System Checks

- **Imager Fail:** Cannot find spectral imaging unit. Reset. Reboot. Check cabling.
- **IMU Fail:** Cannot find GPS/IMU. Check port settings and cabling. Confirm proper GPS/IMU firmware and configuration.
- **Storage:** Verify the SSD disk is connected and restart. Perform *Check Disk*. If errors are reported for an exFAT filesystem, attempt a repair from Windows. The flight computer will attempt to repair ext4 filesystems itself. If this does not solve the problem, try reformatting the data disk. See the discussion in [Section 3.8: Storage Tab](#) for more information.
- **Downwelling Irradiance Fail:** Shut down the flight computer and unplug power. Check cabling. Wait 10-15 seconds and power back up.

5.8.2 Data problems

- **Saturated Data:** Use the Custom Autoexposure class and turn down the *Handle* setting from the current value.
- **Dark Data:** Use the *Custom* autoexposure class and turn up the *Handle* setting from the current value.
- **Noisy Data:** Lower the *Framerate* setting. This will decrease along-track spatial resolution. Alternatively, the aperture of the objective lens may be increased. Please contact Resonon regarding before adjusting the aperture.
- **GPS Latitude and Longitude are incorrect:** Reposition GPS antenna away from any potential sources of EMI. The Ellipse GPS may not show the correct position until it's status changes from *initializing* to *OK*.

- **Poor Geo-rectification performance:** Have aircraft fly straight and level before entering target area, which allows the GPS/IMU to settle. Also, check GPS reception and reposition antenna if necessary.

5.8.3 Flight Computer Logs

When contacting Resonon with concerns about system performance, it is helpful to provide Resonon with system settings and logs. On the *Computer Tab*, click the *Offload flight computer logs* button. The dialog shown in Fig. 5.5. Attach a USB drive to the flight computer and click *begin*. After a successful download the dialog informs you that you may remove the USB drive, as in Fig. 5.6. Please provide the file called “airborne_logs.zip” to Resonon.

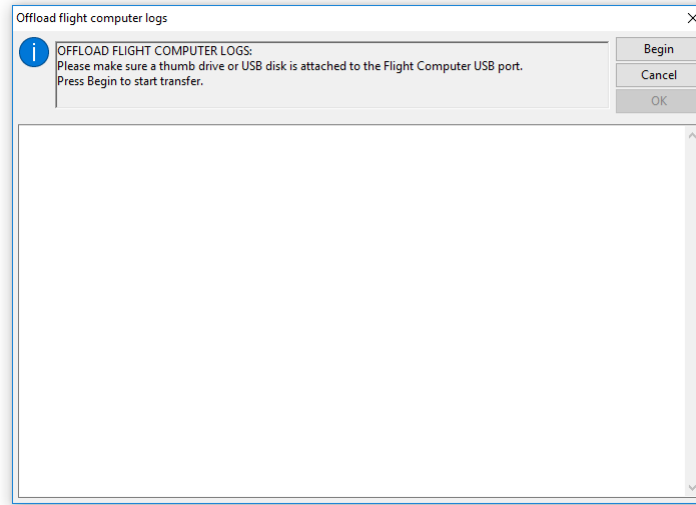


Fig. 5.5: The offload logs dialog

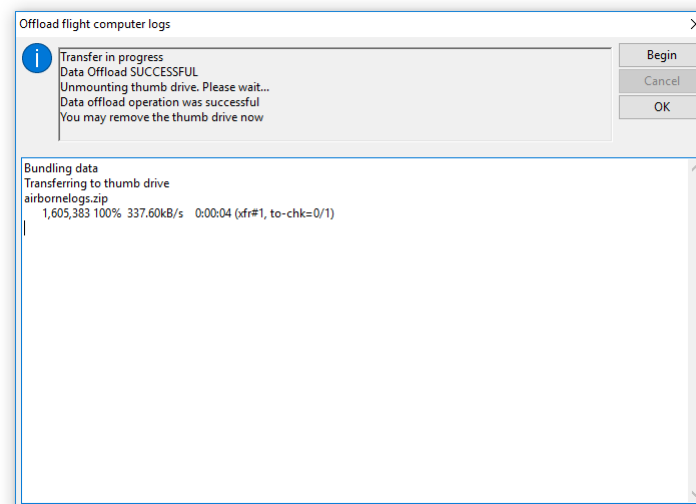


Fig. 5.6: The offload logs dialog after writing airborne_logs.zip

5.8.4 Legacy System Data Disk

Systems shipped with software versions prior to 6.0 do not support the Windows exFAT file system even after upgrading firmware in the field. The external solid state drive that the data is collected on is formatted as Ext4, which Windows does not natively support. Therefore drivers are needed. There are a few options (**Paragon**, **Ext2Explore**), but the **Disk Internals Linux Reader** or **Ext2Fsd** drivers seem to be the best.

For **Disk Internals**:

1. Download the software at <https://www.diskinternals.com/linux-reader/>
2. Plug the drive into your computer and launch the software.
3. Find the drive labeled as mnt/data, and copy the desired data from there.

For **Ext2Fsd**:

1. Download the driver from <http://www.ext2fsd.com> and install. A reboot is necessary.
2. Plug the drive into your computer and launch **Ext2Fsd**.
3. Find the drive labeled as Ext4. If no volume letter has been assigned, right click on the drive entry. Select *Change Drive Letter*.
4. Select *Add*, and then *Automatic Mount*. Select *Ok*.
5. The drive should be available in Windows for normal file transfer.

Note: Legacy systems which have been sent back to Resonon for upgrade may have exFAT support installed. In this case additional drivers may no longer be necessary.

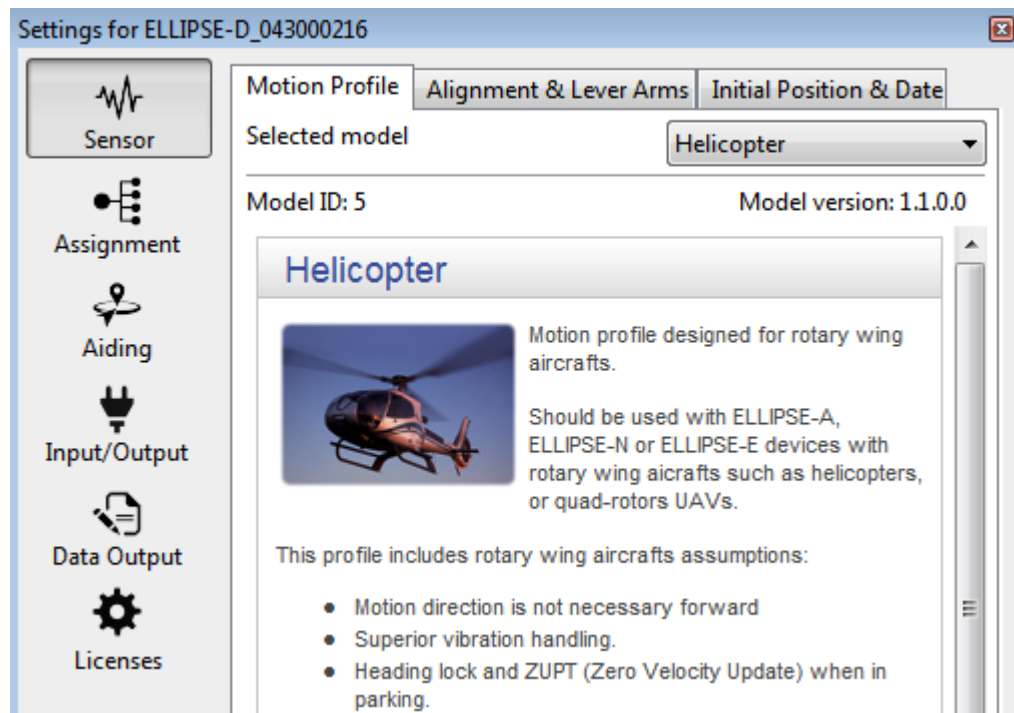
APPENDIX: SBGCENTER

6.1 Alternate Ellipse Configuration

With the introduction of the Ellipse GPS/IMU firmware version 3.x, all necessary configuration can be done from the Resonon ground station software. This section details alternate instructions using SBG's **spgCenter** software.

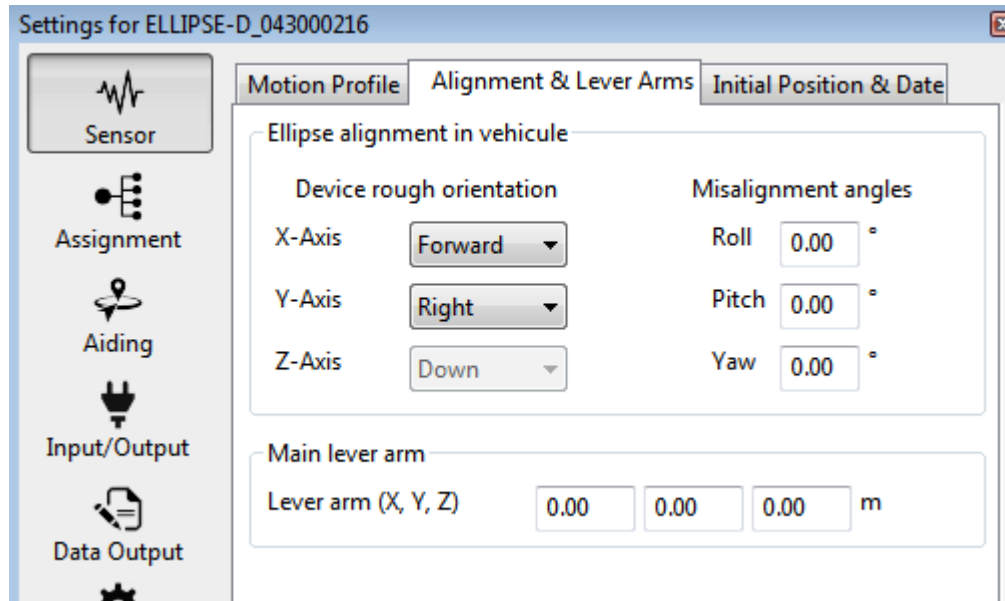
6.1.1 Configuring the Ellipse N/D

- Connect the Ellipse to a Windows computer with **sbgCenter** installed.
- Launch the software and press the *Connect/Disconnect* button. Press *Refresh* and connect to the attached device.
- Press the *Configure* button.
- In the *Sensor* page and *Motion Profile* tab, select *Multi-Rotor*, *Helicopter* or *Airplane* depending on your vehicle.



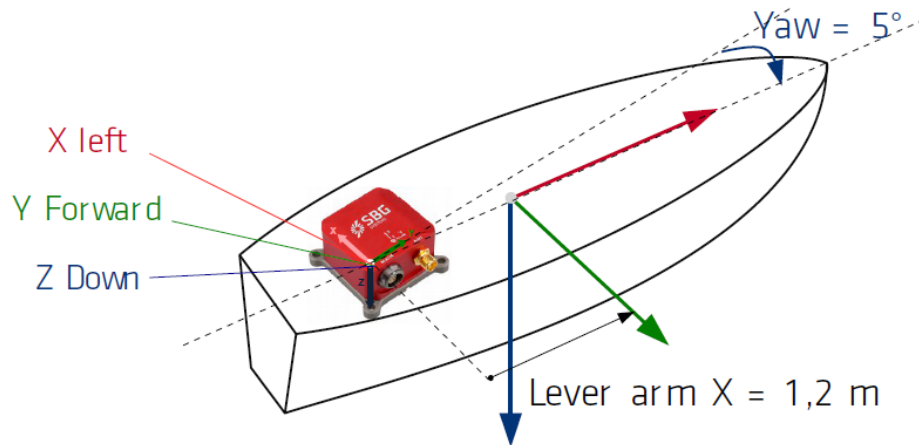
- In *Alignment and Lever Arms*, configure the orientation of the SBG to match how it is mounted in the airframe. For example, if the X Axis label on the unit points to the right wing of the aircraft, select *X Axis = Right*. As a

reminder, the ‘cross’ icon of the Z axis label on top of the unit shows the tail end of an arrow. This icon shows the Z axis pointing down through the unit.



- Now enter the distances (X, Y, and Z) between the SBG unit and the lens of the Pika spectral imager. These distances are measured from the SBG unit to the Pika lens, with positive X pointing forward, positive Y pointing right, and positive Z pointing down.

Note: Lever arm distances are entered in vehicle coordinates, meaning that X is forward, Y is right and Z is down regardless of how the the SBG unit is oriented.

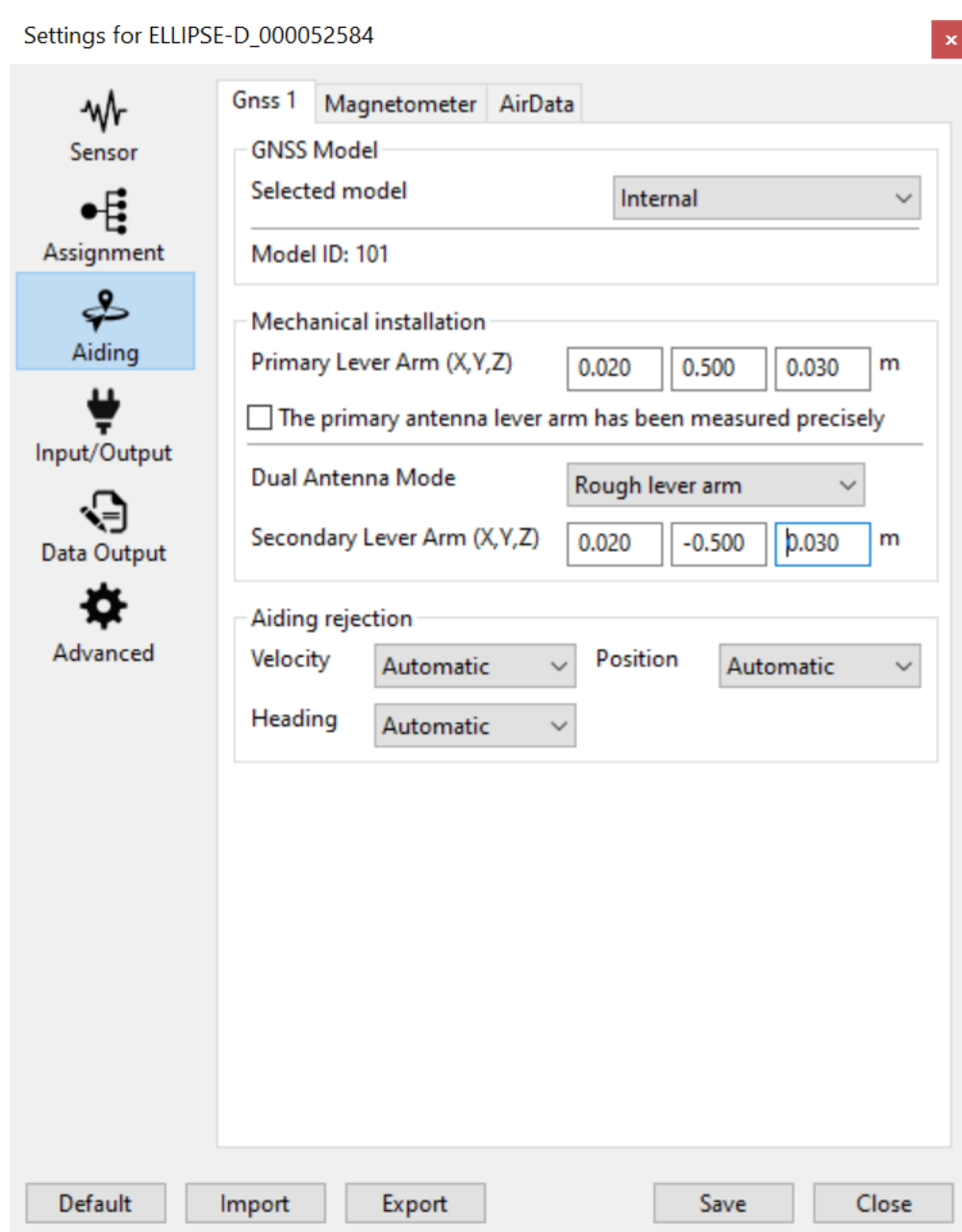


- In the *Aiding* page and *Gnss1* tab, enter in the lever arm between the SBG device and center of GPS antenna. Again, positive X is pointing forward, positive Y is pointing right, and positive Z is pointing down. If using a dual antenna system, the *Primary Lever Arm* distance is form the IMU to antenna 1, while the *Secondary Lever Arm* is from the IMU to antenna 2. Both measurements are in aircraft coordinates.

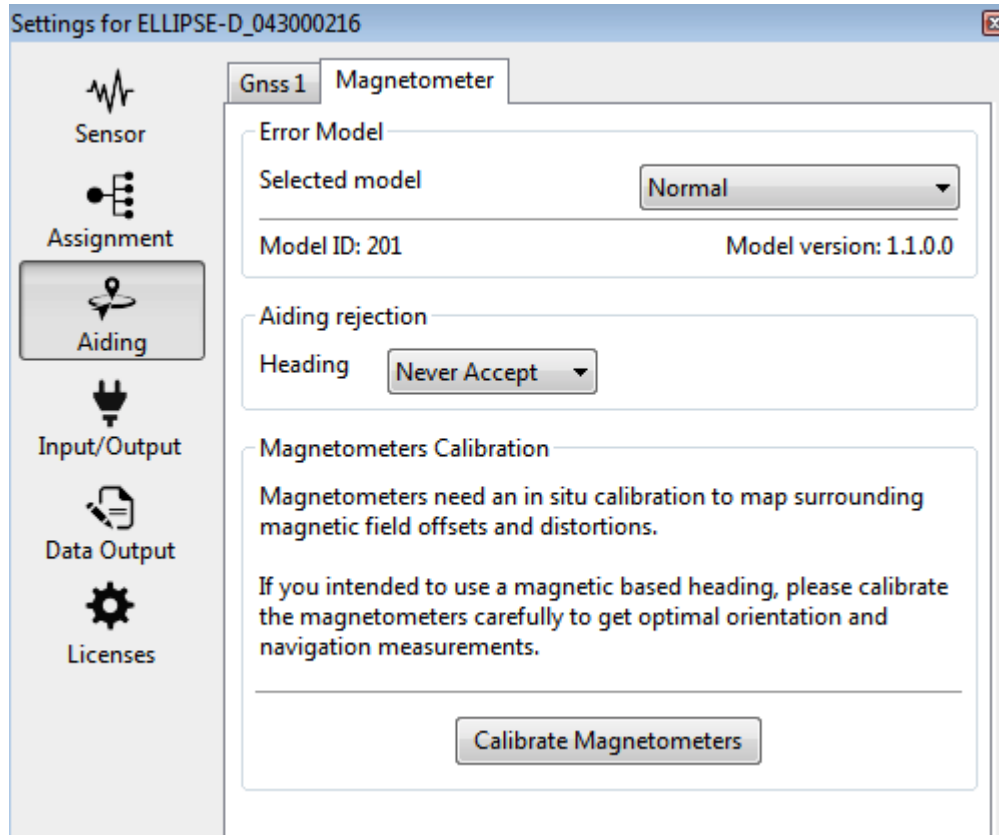
Note: Lever arm distances are entered in vehicle coordinates, meaning that X is forward, Y is right and Z is down regardless of how the the SBG unit is oriented. These distances need to be measured

to within 5 cm.

- If the primary arm distance is measured to within a centimeter (highly recommended), select the checkbox stating as such.

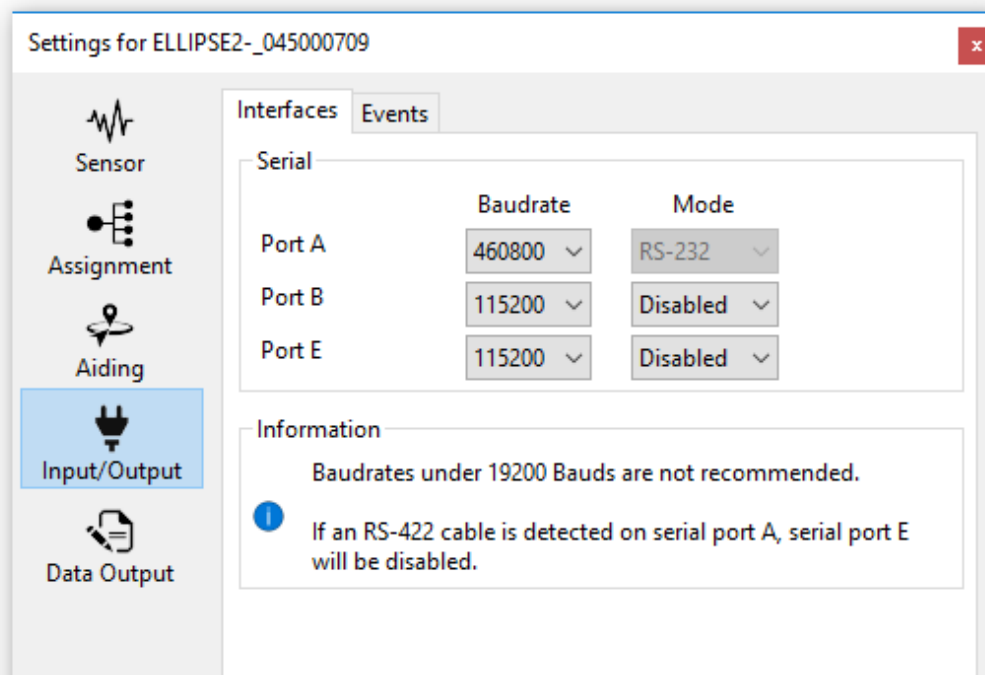


- In the *Magnetometer* tab of the *Aiding* section, set the *Aiding rejection* to *Automatic* if using the Ellipse N or to *Never Accept* if using the Ellipse D (dual antenna).



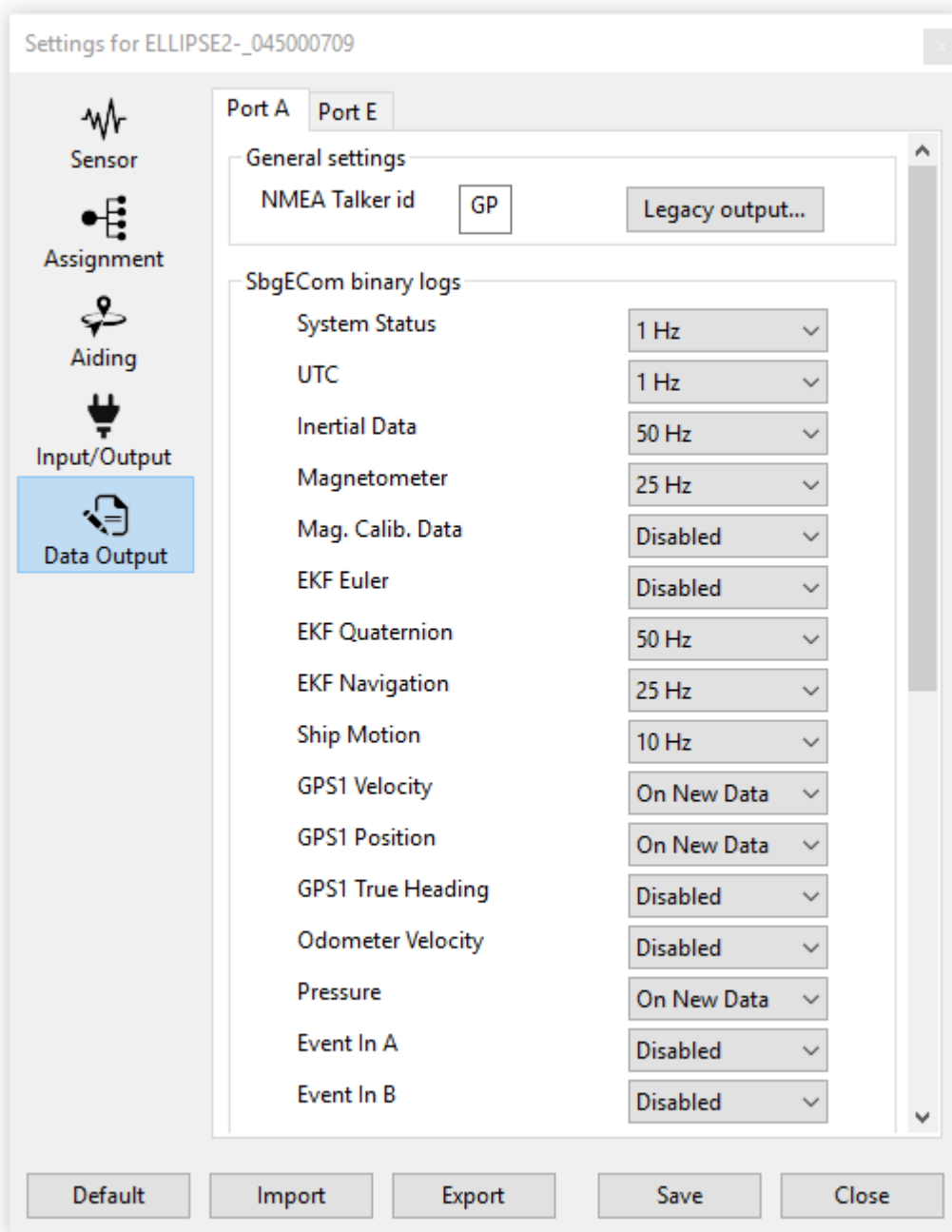
- If using the Ellipse N, the magnetometer must be calibrated before use. See the section below.
- In the *Input/Output* page *Interfaces* tab, set the *Port A Baudrate* to 460800.

Warning: If the *Port A Baudrate* is set to any value other than 921600, 460800 (preferred) or 115200, the flight computer will not communicate with the SBG unit.



- Do not change any other settings or the flight computer may not be able to communicate with the device or the output data might be erroneous.
- Save settings and exit.
- For more information, please read the Ellipse Configuration using **sbgCenter** user manual.

Note: If using the **sbgCenter** software to monitor GPS reception, you must set the Port A log settings to their default levels, as shown below. They do not need to be set back before connecting to the airborne system.



6.1.2 Magnetometer Calibration

If you are not using a dual antenna system, the magnetometer must be calibrated before data collection as well. This can be performed on the ground, or preferably, in the air. This procedure can be performed with the **sbgCenter**, or if in the air, with the **ResononGroundStation** software. It has been Resonon's experience that a 2D calibration is difficult to perform in the air due to the need to keep the wings level. A 3D calibration is preferable for accuracy reasons and should be performed if possible.

Review the video tutorial in the Resonon Library for [calibrating the Ellipse N magnetometer](#) to calibrate a drone-mounted Ellipse N unit. See the Magnetic Calibration section of Ellipse Operating Handbook - Use in Airborne Applications (in the Ellipse Documentation) document for further instructions on performing these calibrations.

If using the **ResononGroundStation** software, please see [Section 3.6.2: Ellipse GPS/IMU Magnetic Calibration](#) in the Operation chapter of this manual.

If using the **sbgCenter** software, please see the Magnetic Calibration section of Ellipse Operating Handbook - Use in Airborne Applications (in the Ellipse Documentation) document for instructions.

If performing a 2D magnetic calibration, enter the *Initial Position & Date* in the *Sensor* setup tab. For UAV use, the system can be spun on a flat, non-ferrous table to assist in the 2D calibration.

<p>Warning: Do not change any of the <i>Input/Output</i> or <i>Data Output</i> settings while using the sbgCenter.</p>
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