AIRBORNE SPECTRAL IMAGING SYSTEM

User Manual

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Introduction

The Resonon Airborne Spectral Imaging System is a compact, high fidelity, digital imaging spectrometer for airborne applications. The system consists of a Pika II imaging spectrometer, a Payload Control and Data Acquisition (P-CAQ) computer, optional downwelling irradiance sensor, and ground station software.

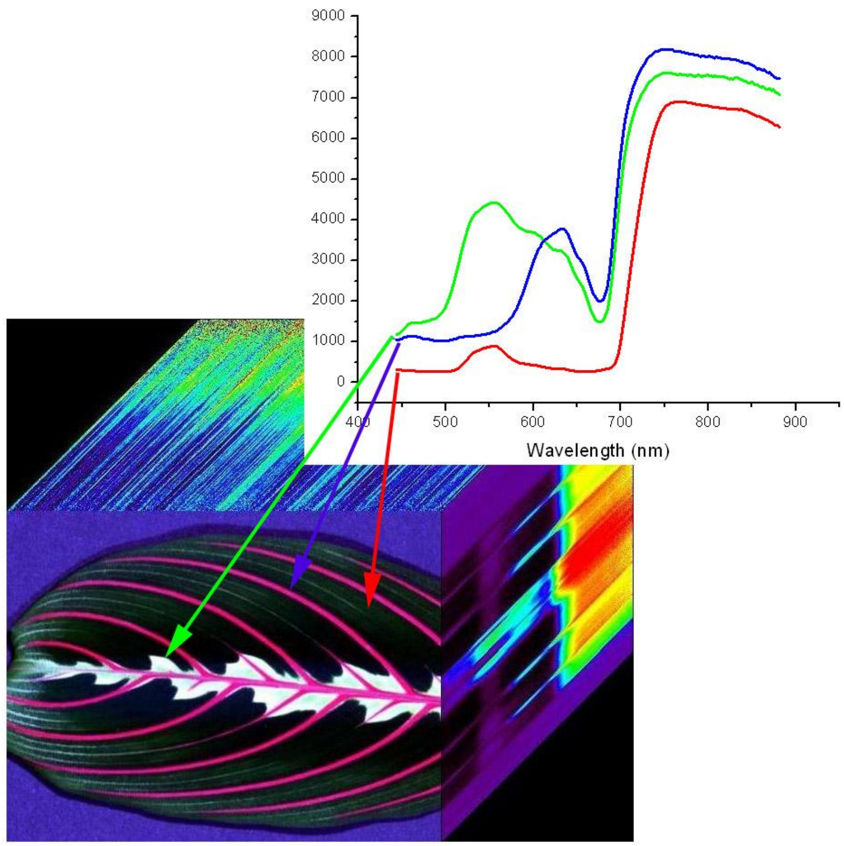
This User Manual covers the installation and use of the hardware and software.

Topics covered in this manual:

- *Installing the Spectral Imaging Hardware*
- *Installing and Configuring the Ground Station Software*
- *Configuring the Airborne Spectral Imaging System*
- *Flight Operations, Data Download, Georectification*

Brief Introduction to Hyperspectral Data

Hyperspectral Imaging, or imaging spectroscopy, refers to the creation of a digital image containing very high spectral (color) resolution. Each spatial point (pixel) in a hyperspectral image represents a continuous curve of incoming light intensity versus wavelength. The data can also be interpreted as a stack of images, with each layer in the stack representing the scene at different wavelengths.



Data Modes

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

Raw data:

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

Radiance:

The data can be post-processed to radiance. This requires the imager to be specially calibrated by Resonon at the desired aperture. This data form does not include the instrument response function. It has the advantage of possessing real units and physical meaning. If you have the calibrated radiance cube provided by Resonon, post-flight correction can be performed by using the Radiance Conversion tool in Spectronon.

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 pre or post flight: Data can be processed to Reflectance with a quick calibration against a reflection standard, pre or post flight. The highest quality reflection standard is Spectralon, but Teflon is acceptable for many applications (Note: Teflon needs to be sanded to eliminate any specular properties. Scotchbrite ™ on an orbital sander works well). This calibration is done with the Record Correction Cube feature, as described later in this document. It is important to note that Reflection 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 Correct from Cube plugin.

- White reference in scene: Once the data is in radiance, the spectrum of a white reference in the scene can be used to correct the rest of the cube. Please contact Resonon for details concerning this technique.

- Downwelling Irradiance sensor: The recommended method for converting data to Reflectance is to use a Downwelling Irradiance sensor. This sensor records the solar spectrum 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 Conversion plugin for Spectronon.

- 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

Requirements

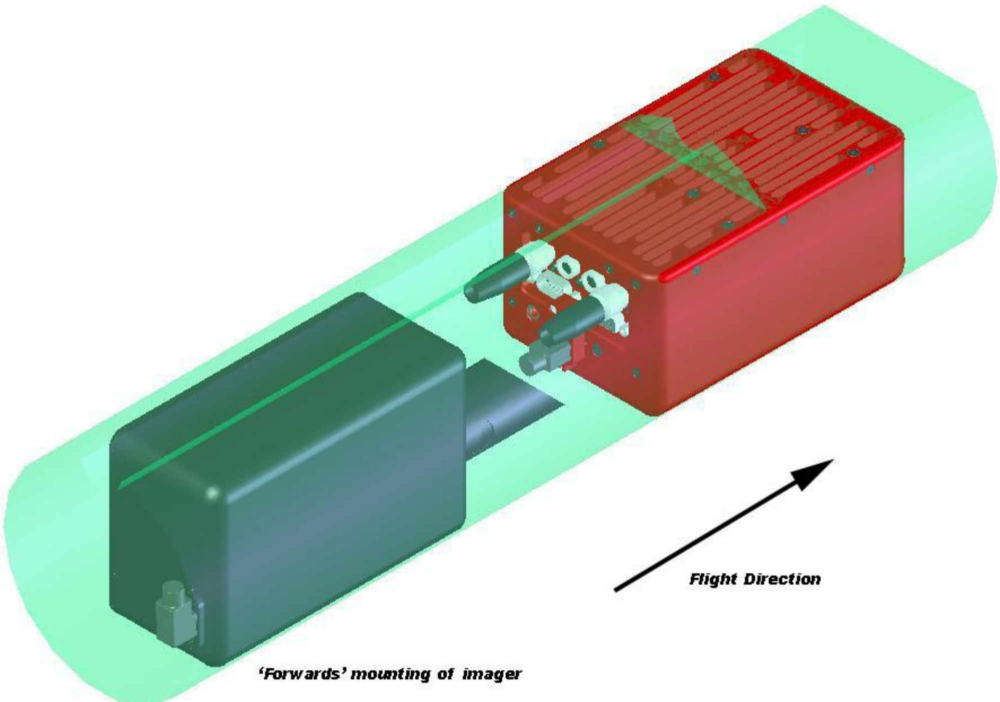
- Windows® XP Service Pack 2 or Windows 7
- 512MB of RAM
- Serial Port or USB→Serial Adapter
- Optional Virtual Serial Port software
- Optional Null Modem Serial Cable

Installing the Hardware

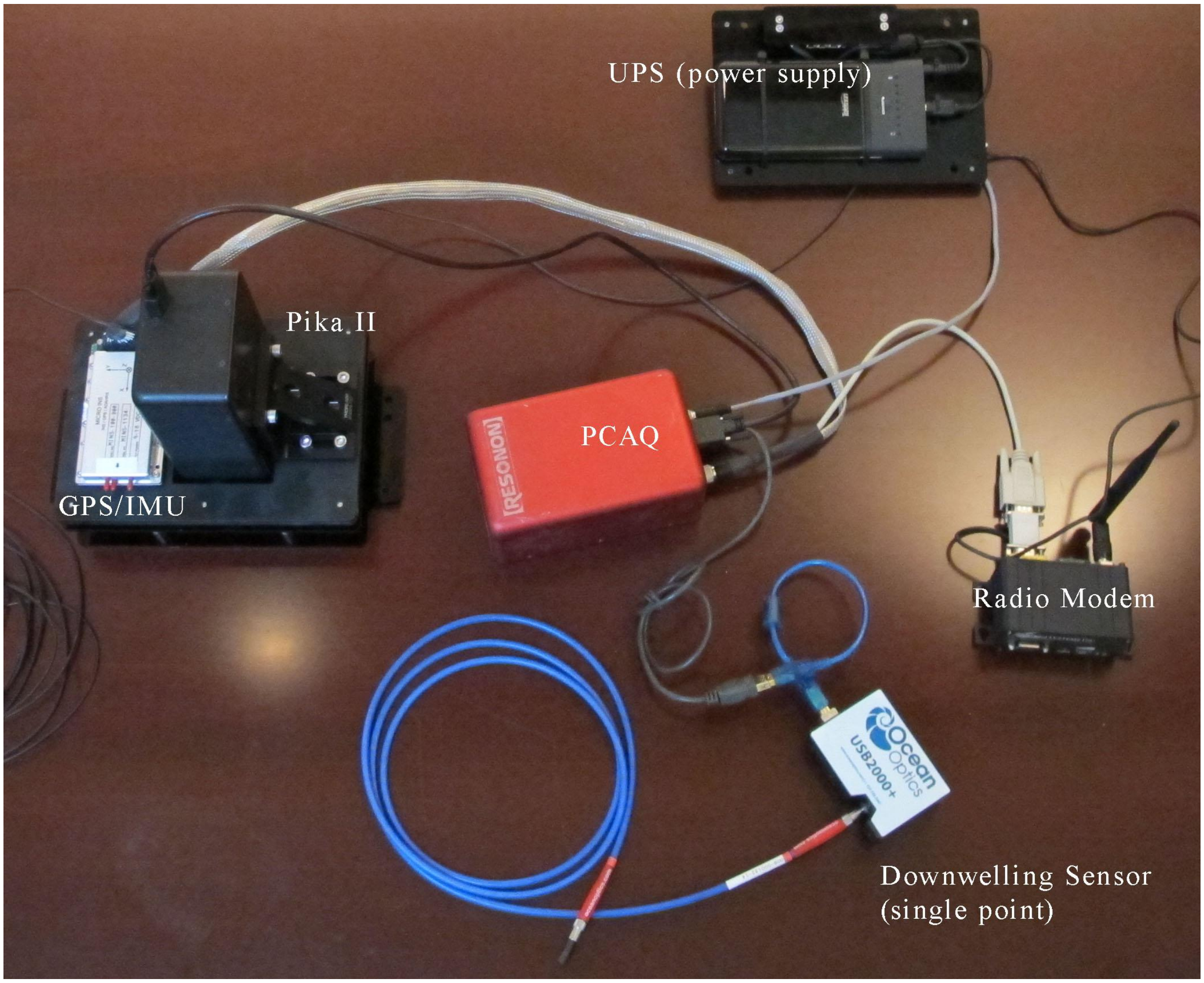
The Spectral Imaging hardware should be mounted in the airframe with the following considerations:

- The Pika II should be sighted straight down through the airframe, preferable with a protective window. If the Pika II has a turning mirror mounted, the ‘cone’ of the turning mirror can face forwards or backwards relative to the direction of flight. The Pika II should be square with respect to the GPS/IMU system (there should be zero angle in pitch, roll, and yaw between the two).
- The Pika II should be mounted in a manner to reduce high frequency vibrations, but rigidly to low frequency vibrations with respect to the GPS/IMU.
- The P-CAQ should have adequate air flow over its base or be mounted to a larger heat sink.
- The Pika II is connected to the P-CAQ via the Firewire 800 cable. Only screw-lock Firewire cables should be used.
- The Comm (GPS/IMU → P-CAQ) and Power (12-20V) connections are the only other connections necessary for flight. If a downwelling irradiance sensor is used, this needs to be connected to the P-CAQ's USB port. Additionally, the USB connection is used to offload the data. If the P-CAQ is mounted in a manner that makes access to this port difficult, the USB connection cable should be used to make access to the USB port easier.
- The optional downwelling irradiance sensor's fiber input needs to be mounted straight-up with a clear, unobstructed view of the sky.

An example of the hardware installed in a cylindrical fuselage is shown below. The necessary connections are shown but the cabling has been omitted.



Below shows a typical configuration of the system, with the option downwelling irradiance sensor and optional radio modem downlink, as well as the uninterruptible power supply. This configuration utilizes the Athena GPS/IMU. The Piccolo configuration utilizes a radio modem built into the Piccolo. It is recommended that the Downwelling sensor be plugged into a USB hub (not pictured) that is powered off of the 5V output of the UPS.



Configuring the Piccolo

First, the Piccolo must be configured properly. Using the Piccolo Command Center software, configure the Piccolo for the following Payload settings:

Com 4: 9600, Payload pass through
Com 5: 57600, Comms no flow control

Additionally, confirm that the Piccolo is mounted in the same orientation as it is configured for in the Command Center software.

Configuring/Mounting the Micro INS

For manned systems using an Rockwell Collins Micro INS, the system will need no configuration. The unit needs to be mounted with the labeled Z arrow pointed nadir and the X arrow pointed in the direction of flight. The edges of the Micro INS should be as parallel as possible with the airframe, and the Pika II. It should be vibration isolated, if possible, but in the same inertial frame as the Pika II. The GPS antenna should be screwed into the appropriate SMA terminal on the Micro INS, and the antenna itself should be mounted with a clear view of the sky. The red caps covering the S (static) and ALT (altitude) ports should be removed prior to use. The cap on the P (pitot) port can be left on unless a pitot tube input is available.

Microhard Radio Modem

If the optional Microhard radio modems are used to communicate between the PCAQ and the ground station computer, a null modem connector must be used between the PCAQ and the Microhard radio.

Optional UPS

A Uninterruptible Power Supply (UPS) is available as an option for manned aircraft. This system accepts voltages from 5-28 V and converts to ~15V for the Resonon system. Additionally, it contains a small battery that will power the system for a brief moment if the incoming power is interrupted. To use this system, wire the incoming power (from the aircraft) to the In+ and In- screw terminals. The PCAQ , Mircohard radio, and GPS/IMU power leads are then wired to the Out+ and Out- screw terminals. Be careful not to reverse polarity. The UPS has a small On/Off switch located on its front face. This switch should be turned off when the system is not in use. The charge state of the backup battery can be accessed by pushing the narrow button on the top face. A wall plug power supply is included to be used as 'shore' power to the UPS when power is not available from the aircraft (such as bench testing).

Installing and Configuring the Ground Station Software (Piccolo)

The Ground Station software communicates to the airborne system through the Piccolo payload data link. This software can be run on the same computer as the Cloud Cap Piccolo Command Center software or on a separate computer. The connection can be made by attaching a computer directly to the Payload port of the Cloud Cap Portable Ground Station or by utilizing the Cloud Cap Payload Decoder utility. These options will be discussed in more detail below.

Installing Software

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

For Windows 7 users: After installing the Ground Station software right click the application icon, select Properties, go to Compatability Tab and then check "Run this program in compatability mode for Windows XP (Service Pack3).

Connecting to Ground Station

Same Computer (Recommended)
If the same computer is to be used for the Piccolo Command Center, two options are available:

1. (Recommended) Connect second serial port (or USB→Serial adapter) to the Payload port on the Portable Ground Station using a normal serial cable. The Resonon Ground Station software will utilize this serial port, so note the name of this port (COM1, COM2, etc). The baud rate of this connection is 9600.

2. Utilize a Virtual Com Port software package and create a bridged connection between to virtual ports. Use the Cloud Cap Payload Decoder (special Resonon version) software to pipe the payload data to one of these virtual ports. This is done by specifying the virtual port name in the batch script used to launch the Payload Decoder. The Resonon Ground Station software will then connect to the second, bridge port. The baud rate of these connections should be set at 57.6kb.

Two computers
If two computers are to be used, two options are similarly available.

1. (Recommended) Connect a serial port of the secondary computer to the Payload port of the Portable Ground Station using a normal serial cable. The Resonon Ground Station software will utilize this serial port, so note the name of this port (COM1, COM2, etc). The baud rate of this connection is 9600.

2. Connect a serial port of the secondary computer to a serial port on the computer running the Cloud Cap Piccolo Command Center using a Null Modem cable. Use the Cloud Cap Payload Decoder (special Resonon version) software to pipe the payload data to this port. This is done by specifying the port name in the batch script used to launch the Payload Decoder. The baud rate of this connection is 57.6kb.

Configuration File

To simplify the launching of the Ground Station software, a configuration file is available. Navigate Windows Explorer to Resonon Ground Station folder (by default is located in Program Files) and open the ‘usecom.txt’ file with a text editor. Change the port and baud settings to match your system setup. An example is shown below:

{'port': 'COM7', 'baud':9600}

Batch Scripts

To streamline the launching of the Ground Station software with the Payload Decoder software, it is best to create batch scripts. Examples are below:

(For Payload Decoder, save this line in a *.bat file. This pipes the payload data to COM6 at a baud rate of 57600. It assumes that the PSPayloadDecode executable is in the same folder or in the system Path.)

PSPayloadDecode.exe -P=6 -B=57600

(This batch script launches the Resonon Ground Station on COM5 at 57600)

cd C:\Program Files\ResononGroundStation
ResononGroundStation.exe -c COM5 -b 57600

Both scripts can be combined into one if necessary.

PSPayloadDecode.exe -P=6 -B=57600
cd C:\Program Files\ResononGroundStation
ResononGroundStation.exe -c COM5 -b 57600

Installing and Configuring the Ground Station Software (Micro INS)

The Ground Station software communicates to the airborne system through the Microhard data link or directly through a serial cable. These options will be discussed in more detail below.

Installing Software

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

For Windows 7 users: After installing the Ground Station software right click the application icon, select Properties, go to Compatability Tab and then check "Run this program in compatability mode for Windows XP (Service Pack3).
Connecting to Ground Station

<u>Microhard radios</u>

1. Make sure that the airborne radio is connected to the Comms port of the PCAQ using a normal serial cable and that the radio is properly powered.

2. Connect the second radio to the laptop serial port (or USB→Serial adapter) using a normal serial cable. The Resonon Ground Station software will utilize this serial port, so note the name of this port (COM1, COM2, etc). The baud rate of this connection is 9600.
3. Launch the Resonon Ground station software. The software will attempt to open the default port (COM1) at the default baud rate (9600). This will fail unless COM1 is the correct port. In the Comms menu item, set the correct port. After the port is opened successfully, then press Check Comms to send a verification message to the PCAQ.

<u>Direct connection</u>

1. Connect the the laptop serial port (or USB→Serial adapter) to the Comms port of the PCAQ using a normal serial cable. The Resonon Ground Station software will utilize this serial port, so note the name of this port (COM1, COM2, etc). The baud rate of this connection is 9600.
2. Launch the Resonon Ground station software. The software will attempt to open the default port (COM1) at the default baud rate (9600). This will fail unless COM1 is the correct port. In the Comms menu item, set the correct port. After the port is opened successfully, then press Check Comms to send a verification message to the PCAQ.

Configuration File

To simplify the launching of the Ground Station software, a configuration file is available. Navigate Windows Explorer to Resonon Ground Station folder (by default is located in Program Files) and open the 'usecom.txt' file with a text editor. Change the port and baud settings to match your system setup. An example is shown below:

{'port': 'COM7', 'baud':9600}

Using the Airborne Spectral Imaging System

Powering Up and Down

To turn on the system, first power up the Piccolo/MicroINS. Then power up the spectral imaging system. It is preferred not to turn off power to the system without shutting it down from the Ground Station software. Shutting down the system is covered later in this section.

Launching the Software

If using the Piccolo, launch the Piccolo Command Center and Payload Decoder software (if necessary), then launch the Resonon Ground Station software. If using the MicroINS, just launch the Resonon Ground Station. Initially, the controls will not be available. Once the imaging system is online and communicating, the controls will be available. If you receive the message 'Did not get Ping reply', there is a communication failure between the imaging system and the ground station software. It is likely that the system is still starting. However, it may be due to a serial port setup error. Navigate to the Comms menu (described below), and try to reconnect on the correct serial port and baud rate. If this does not work, check the settings of the Piccolo Payload ports and the port settings of the Payload Decoder as well.

Note: If it appears that the software successfully connected to the imaging system but the controls are still not available, select the Check Comms item in the Comms menu list.

Refresh Button

The Resonon Ground Station software only requests information from the PCAQ when the Refresh button is pressed. Use this button to query the PCAQ for the most recent status and setting information. If the PCAQ is actively acquiring a datacube, the refresh function may take some time to return.

Home Tab

The Home tab displays useful information regarding the status of the system, data previews, and manual recording options.

The **Summary** section shows the most important status components of the system, to be used as quick visual confirmation that the system is operating properly. The operator should check all fields in this section at startup. See the Troubleshooting section for information on procedures if any of these sections are marked *Fail.*

View Frame: The function will request and display the last frame of raw data. This function 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: This function will request and display a highly compressed, greyscale preview of the last cube recorded.

Frame Stats: This function will request and display the minimum pixel value, maximum pixel value, and average values for the last frame of data, intended to assist in confirming exposure settings.

View Histogram: This function will request and display a histogram of the last frame of data. 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 (brightness scale: 0-4095)

Note: *To download a preview of the last frame and last cube, the signal strength of the Piccolo/Radio Modem connection must be high. If the signal strength is low (low Signal To Noise ratio), the command will timeout before the preview download can be completed.*

The Control section provides manual control over data recording. or stop data collection in defined areas. This section also contains the Record Correction Cube button. This process will be described below.

Record: This button will force 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 the Targets Tab section). This button is also used to record test cubes during configuration to ensure that the system can keep up with the data bandwidth.

Stop: Stops the collection of datacubes, whether the recording was started manually or because the aircraft is inside of a defined target region. If this function is used to stop the collection of data within a target region, collection will begin again once the aircraft is back inside a target region.

Record Correction Cube: This button allows the collection of 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 Chapter Four).

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 AutoExposure 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.

Imager Tab

This tab contains the settings relevant to the Spectral Imager.

Shutter: This sets and displays the shutter percentage of the imager. If AutoExpose is used, it is not necessary to manually change the shutter settings. It should also be noted that if the shutter is not set at 100% that the ground area is effectively sub-sampled, instead of averaged. If the scene is too bright for a given frame rate and at zero gain, the frame rate can be increased or the f/# can be increased as an alternative to altering shutter percentage. Use the Resonon Airborne Calculator to determine how sub-sampling will effect the data.

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.

Framerate: This sets the framerate of the system, and with it along-track spatial resolution. Use the Resonon Airborne Calculator to determine optimum frame rate. Slower frames rates mean lower along-track spatial resolution, but better signal to noise ratios. If the AutoExposue routine returns a "Not Enough Light" warning, the framerate may be lowered to improve signal to noise ratios. Alternatively, the aperture of the objective lens can be increased. Please contact Resonon regarding this procedure. It is possible to set the framerate faster than the P-CAQ can keep up with for a given number of cross-track pixels and spectral bands. If the P-CAQ can not keep up with the data flow, it will produce a warning to the Ground Station software and quit recording. It is therefor necessary to record test cubes after changing framerates and/or resolution settings to be sure that the P-CAQ will properly record data.

Recommended framerates for spatial and band settings:

640 cross-track by 120 bands: Framerate < 80
640 cross-track by 80 bands: Framerate < 120
640 cross-track by 60 bands: Frame < 135
320 cross-track by any number of bands: Framerate < 135

Cross Track Pixels: This sets the cross-track spatial resolution. Use the Resonon Airborne Calculator to determine optimum cross track pixels (normally 320 for UAV operations). Smaller numbers mean lower cross-track spatial resolution, but increases signal to noise ratios and produces smaller data files. It is important to note that the system can be configured for framerates that it cannot keep up with. Be sure to test frame rate settings prior to flight. To do this, start a cube recording using the manual button and allow it to record for ~30 seconds. Then stop the cube recording. In the output window, look at the message the PCAQ has returned. In the message is the frame rate achieved.

Bands: This sets the spectral resolution. This parameter is 80 for normal operation. Lower band numbers increases signal to noise ratios and results in smaller file sizes, but decreases spectral resolution. Large settings in both spatial and spectral resolution may limit the maximum FPS of the system.

Imager Direction: This parameter sets the direction of the imager relative to the direction of flight. If the 'nose cone' of the imager points in the direction of flight, this parameter is set to Cone Forward. If the imager does not have a nose cone, set the parameter to Cone Forward if the Resonon label side of the imager is facing the starboard side of the plane.

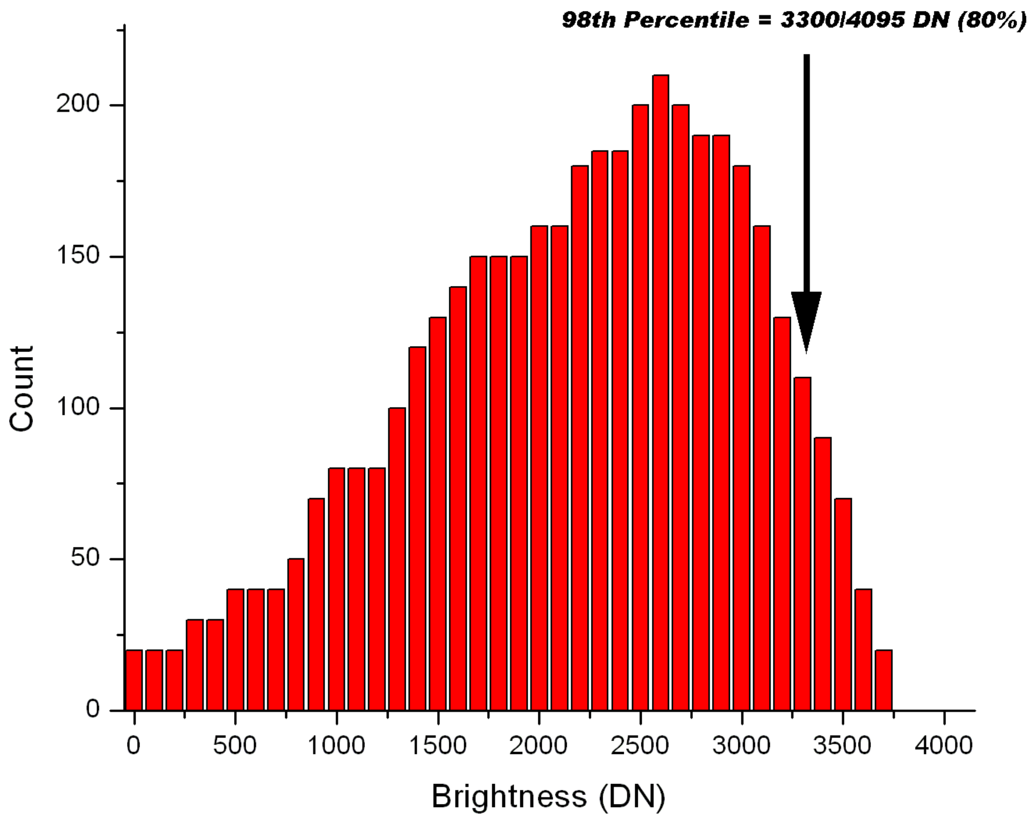
Auto Expose: The Auto Expose class selection fine tunes the autoexposure routine for a variety of imaging scenarios. 'Normal' is the most versatile and serves as a starting point for most applications. 'Darker areas of Interest' is for bright backgrounds with sparse areas of darker regions of interest (glacier background with sparse, dark pools of water of interest). 'Bright Areas of Interest' is for dark backgrounds with sparse areas of bright regions of interest (desert background with sparse, bright objects of interest). 'Water' is for imaging water or other scenes containing highly specular reflections (glare).

It is important to note that Autoexpose will not run while recording a data cube, so that while in very large target areas, drastic changes in conditions will impact the data.

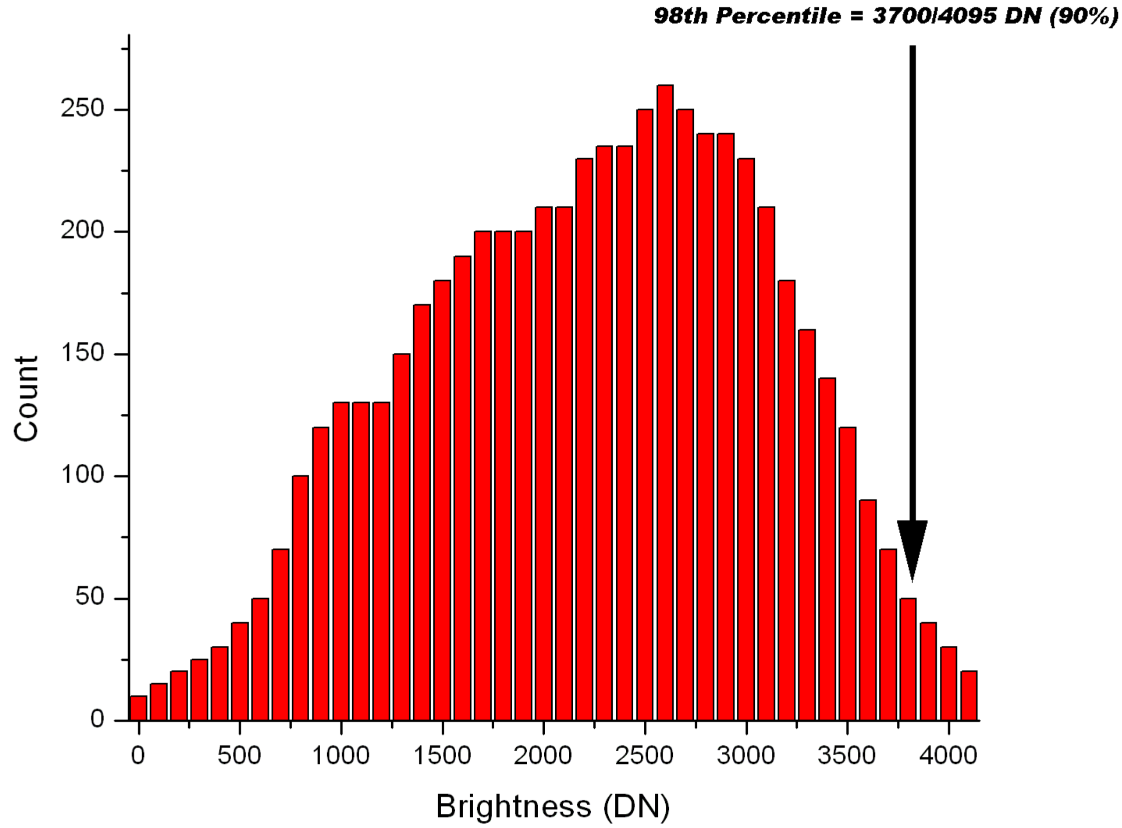
For custom settings, select the Custom item. The Handle and Target sliders will then become available. A description of setting these parameters is below:

The Handle parameter determines the 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 98^{th} 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 posses 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 Data Tab.

An illustration of the Handle and Target settings is shown below.



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). This is 80% of the maximum. Thus, more gain is added and another frame is grabbed and analyzed. This process repeats until the Target value of 90% is reached (below).



GPS/IMU Tab

The GPS/IMU tab shows the information relevant to the GPS/IMU system and serves as a check to the proper operation of the GPS/IMU system.

The Ground Altitude must be set for proper operation. This altitude is the MSL altitude of the ground. If set incorrectly, data may not be collected in the desired Target regions and geo-rectification will not be accurate.

At boot, the PCAQ will attempt to set the system time to the GPS time reported by the GPS/IMU. If the GPS had not acquired satellites at the time of boot, the system time will be wrong. Press the Set System Time to GPS Time to sync the two times.

Computer Tab

Along with displaying the temperature of the CPU and the amount of disk space remaining, the Computer Tab also contains functions for recovering a malfunctioning system.

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

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.

Storage Tab

View Current Files: This button will show all of the data files on the internal solid state drive.

Offload Data: This button is only used for transferring data to the external USB drive after the aircraft has landed. To use, plug in the external drive and power it on. Wait 15-20 seconds for the PCAQ to recognize the drive. Then press this button. When the files have been transferred, a message will appear in the output window showing the files that have been successfully transferred. Depending on the amount of data collected, this may take some time.

Check Disk: This function will perform a system check and disk maintenance. It should be performed periodically, after a power loss while recording data, or if the system is reported 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 successful transfer of data to an external USB drive has been confirmed.

Targets Tab

The Target tab allows to create, save, and upload target regions to the flight computer. These Target regions define the areas for which the system will record data over.

To create a target, navigate to the Targets menu, and select New Target. Each field of the new target (Name, Lat., Long., etc) are editable by clicking in the field. Enter in the name, Latitude and Longitude in Decimal Degrees, a minimum AGL altitude, and a diameter. The system will collect data anytime it is in the circle defined by these parameters. The minimum altitude setting prevents the system from recording data while it is on the ground of the launch/landing zone, if the launch/landing area is within a Target region. Once a target file has been created, it can be saved locally for use later.

Once a target file has been created or loaded from a locally saved file, it needs to be uploaded to the PCAQ. This is accomplished through the Targets menu item Upload Local Targets. After the Refresh Now button is pressed, the Remote Target List should match the Local Target List.

A target list can be saved locally through the Targets menu item Save Target File or Save Target File As items.

To clear Remote targets, create a blank local target list and upload.

When data is recorded in a target region, the name of the target region is reflected in the data folder name.

Menu Items

The Command Line tab contains an output window of all messages from the PCAQ computer, as well as an input window for sending messages up. Please see Chapter 5 for a description.

Preferences:

Check Location Interval: This parameter is the rate at which the system checks its position to determine if the unit is within a Target area. For small target areas, an interval of 1 second might be best to insure the system images all of the area. For larger areas, a longer interval conserves CPU cycles and power use.

Status Refresh Interval: This sets the Refresh rate of the Ground Station Software, which is enabled by checking the Auto Refresh checkbox in the Status tab.

Auto Exposure Interval: Settings are normally saved on shutdown. However, pressing this button will save settings immediately.

View Output In Separate Window: Shows all up/down messages in a separate floating window for easy viewing.

Comms:

Connect: This button is used to try to reconnect to the serial port if the wrong port was specified in the batch file.

Check Comms: This button checks the communication between the Ground Station software and the PCAQ.

Baud Rate: Sets the baud rate of the connection. Use 9600 for direct connection to the Payload port of the ground station, 57600 for use with the Payload Decoder.

Comm Port: Sets the communication port.

Targets:

New Target File: Creates a new, blank local target file

Open Target File: Opens an existing local target file

Save Target File: Saves a target file locally

Save Target File As: Saves a target file locally

New Local Target: Creates a new target in the current local target file

Clear Local Targets: Clears the current target fields

Upload Local Targets: Uploads the current local target file to the PCAQ

Download Local Targets: Downloads the target file in the PCAQ to the local file

LED Codes

Normal:

Solid red: Power on and hardware initialization

Solid blue: Boot process beginning

Blue heartbeat: initializing software

Green heartbeat: Recording Data

Yellow flash*: Checking Location

Alternating aqua/purple: Normal run cycle

*when location check is every second, it is mostly yellow with short alternating aqua/purple bursts

Errors:

Fast red blink: Cannot find spectral imaging unit. Check cabling.

Fast blue blink: Cannot find Piccolo/MicroINS. Check port settings and cabling.

Operation Summary and Checklist

Mission Setup

1. Enter Target regions.
2. Set Framerate, Cross Track Pixels, and Bands settings. Record test cubes to ensure P-CAQ can handle data rate. If not, decrease frame rate, number of bands, or number of cross-track pixels.
3. Set AutoExposure Class and Interval.
4. Set Location Check Interval
5. Preform Check Disk function for routine maintenance

Pre Flight

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

1. Power up Piccolo/MicroINS, then power up imaging system.
2. Launch Payload Decoder, if necessary.
3. Launch Ground Station software.
4. Set Ground Level Altitude.
5. Delete existing data.
6. Optionally, AutoExpose on White Reference and Collect Correction Cube.

Flight (All operations are optional)

1. Perform AutoExposure, if necessary.
2. Confirm Collection of Datacubes while in Target Areas.
3. Check Histogram, confirm Exposure settings are correct.
4. Optionally, shut down system (via Shutdown button) for return flight.
5. If necessary, targets can be created, modified, or deleted.

Post Flight

1. Download Data to external USB drive.
2. Confirm successful data transfer; delete files from P-CAQ.
3. Optionally, perform Check Disk on the system and power down.
4. Optionally, convert data to radiance or absolute reflectance
5. Geo-rectify Data with Geo-Reg or Parge.

Please see the Spectronon User manual for information on correcting data for the instrument function and absolution reflectance.

Data Files and Structure

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

Per Flight Files:
*_sync.times -
There is one sync file per flight. It is a series of recorded values to correspond the timestamps coming from the Piccolo/MicroINS with the current system time used to stamp the individual image frames. This data is then used to synchronize the image and location data

Per Image Files:
*.bip -
The hyperspectral raw image data

*.bip.hdr -
The header file for the bip

*.bip.times -
Lists the timestamps for each frame in the HSI file. In future versions,
This data may be included in the *.bip.hdr file under the var name "line time stamps"

*.bip.lcf -
Contains the actual location data pulled from the Piccolo/MicroINS during the cube recording. The first column contains the time stamps. If you select to save the debug files, this data can be re-saved as a raw format datacube with one layer for each location data type. This file will be of type 'ins' with a corresponding 'ins.hdr'

Georectification Result Files:

*.igm -
The IGM file is a data cube of the same dimensions as the original BIP file, but with only 2 bands. The data in those bands is the Latitude and Longitude for each image pixel. This is used to create the GLT file. Once a GLT is made, this file can be deleted, but if you are trying different Grid Density Multiplier values, having this file will speed up that process.

*.igm.hdr -
IGM header file.

*.XV
The XV file is a georectified spectral image data cube which can be opened directly with ENVI.

*.xv.hdr
XV header file

*.kml -
Georectified version of the current rendering (True Color, NVDI, SAM, etc) for use in Google Earth or similar programs.

*.png -
Image used in the KML file

Keys to Obtaining Quality Data

- Collect data under cloudless skies or uniformly cloudy conditions between 10 am and 2 pm.
- The largest spatial and spectral binning necessary for the application
- If the system is operating at non-zero gain, signal to noise ratios can be improved by slowing done the frame rate to the slowest rate necessary for the application
- A high quality Correction Cube will improve data fidelity. Make sure there are no shadows or glare present when recording this cube.
- The Piccolo/MicroINS'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.
- If AutoExposure returns a "Not Enough Light" warning, the framerate can be turned down (smaller FPS setting). This will increase the integration time of the system, allowing more light to enter. Decreasing the framerate 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.

Post Processing Data with Spectronon

Spectronon, Resonon's free spectra image analysis software, can be used to process airborne data from arbitrary units to Radiance or Reflectivity.

Radiance:

1. With Spectronon, open the radiometric calibration datacube, as supplied by Resonon for your spectral imager.
2. Open the airborne datacube to convert.
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 -> Radiance Conversion.
4. In the resulting window, select the name of the radiance calibration cube, 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:
1. With Spectronon, open the radiometric calibration datacube, as supplied by Resonon for your spectral imager.
2. Open the airborne datacube to convert.
3. Open the radiometric calibration spectrum for the downwelling irradiance sensor, as supplied by Resonon.
4. Open the downwelling irradiance spectrum that is in the same folder as the airborne datacube.
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 Conversion.
4. In the resulting window, select the name of the radiance calibration cube for the imager, the downwelling irradiance spectrum, and the downwelling irradiance calibration spectrum, the then press OK. The resulting cube will be in Reflectivity on a scale of 0 to 1 (unitless).

Advanced

Updating Firmware

The firmware of the spectral imaging system can be updated via the Internet. This update should only be done under the request and guidance of Resonon personnel. To perform this update, use the provided Ethernet cable to connect the system to a DHCP enabled Internet connection. Then type: *updateSVN('name,'password")* replacing *name* with the username provided to you by Resonon. Press return. The number that is returned is the version number. Please confirm this number with the desired version number communicated by Resonon. The version number is also returned after sending *getVersion().*

After a successful update, reboot the system.

If update fails, type *getip()* into the command window. If this fails to return an IP address, try *ethdown()*, then *ethup().*

Note: Firewalls may prevent successful connection to the firmware server. Please ask your system administrator for assistance.

Pairing a Pika II with a PCAQ

In order to use a different Pika II than the original with the PCAQ (or after a disk reformat), the calibration numbers from the Pika II must be entered into the PCAQ. This is done though the Command window in the Overides tab. To enter in a slope (in this case, a value of 1.08), do:

setSlope(1.08)

followed by the Enter key. To set the intercepts (in this case, 400.12), enter:

setIntercept(400.12)

followed by the Enter key.

Reformatting Disks

For system errors that the Check Disk function does not fix, it may be necessary to reformat the disks. This should only be performed after consultation with Resonon personnel. Reformatting the disk will erase all data, settings, and targets, as well as the Pika II calibration. To restore the calibration, please see the above section, Pairing a Pika II with a PCAQ.

To reformat the disks, enter the following line into the Command window:

reformatDisk()

followed by the Enter key. The reformatting process can take many minutes and the system will appear unresponsive during that time. Do not shut off the system.

Uploading Error Logs

If the system is experiencing problems, Resonon personnel may request a system error log to assist in correcting the problem. To do this, connect the PCAQ to a DHCP enabled internet connection. Then type *uploadErrorLog()* followed by a Enter.

Changing Default Cube Length

By default, the airborne system breaks datacubes into ~2000 lines. When a cube nears 2000 lines, it is written to disk and a new cube is instantiated. This value can be changed by typing *setCubeSize(size)* into the Command field.

Troubleshooting

If any of the System checks show failure:

Imager Fail: Cannot find spectral imaging unit. Check cabling.

IMU Fail: Cannot find Piccolo/MicroINS. Check port settings and cabling.
Confirm proper Piccolo firmware.

LED Fail: Reboot PCAQ, or ignore. The LED is not a critical component. Battery voltage will also not be monitored in the event of a LED failure.

Storage: Preform Check Disk. If Check Disk does not solve the problem, follow the above directions to Reformat the disk. A Reformat will reset all settings.

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.