
Tetracam Macaw User's Guide



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Introduction

This User's Guide contains general information about Tetracam's Multi-Camera Array with Wi-Fi (MCAW or Macaw) imaging systems covering installation, operation, options and accessories, warranties, and technical support. The information is specific to firmware version 1.0.

Tetracam's Macaw is an updated version of the company's previously-manufactured mini and micro MCA products. The Macaw is faster than the earlier system and offers superior features and programmability. It is delivered with a faster USB interface (USB 3.0 rather than 1.1 or 2.0) and a larger image storage memory (256GB SATA SSD instead of multiple 16GB μ SD cards) The larger memory enables users to capture thousands of additional images during each imaging mission, and since all bands are stored in a single multi-page TIFF file, management of the captured images is greatly simplified. Like its earlier siblings, the Macaw is available in three sub-models. The Macaw-4 contains four digital cameras. The Macaw -6 contains six digital cameras. The Macaw-12 contains twelve digital cameras.

The Macaw also features a new web browser based user interface accessible by way of the camera's Wi-Fi hot spot interface.

Each system's digital cameras are organized in an array, with discrete filters installed in each camera in the array between the camera's lens and sensor. The primary use of this product is to capture spectroscopic signatures of vegetation, chemicals and geology using a set of filters tailored to the targeted substance.

The purpose of this document is:

1. To guide the user through the installation of the product and its supporting software on its target host system.
2. To describe the basic camera operating procedures.
3. To describe the interaction between the camera's interface software and the image editing and archiving software it may be used with.

This document assumes that the user is familiar with the operation of an IBM compatible personal computer running the Windows 10 or earlier Windows operating systems. The user should be familiar with the use of USB serial ports and USB disk devices, and with the use of spectroscopic signatures to identify materials of interest.

A PDF version of this manual is supplied on the Macaw control tablet and on the installation CD.



Quick Start Instructions

Connect the unit to a DC power source. The Macaw system will accept power input between 9.0 VDC and 18 VDC, such as power commonly available in vehicle power supplies. The status LED will turn green when the system has finished booting, and the camera application is running.

Install PixelWrench for Macaw. This program is used to manage connections to the camera and to extract useful data from the sets of visible light and NIR images the camera captures.

Apply power to the camera and wait for the status LED to turn green. Pressing the picture taking button will take one picture.

Images in the camera can be viewed with any web browser in a smartphone, tablet, or PC after connection to the camera Wi-Fi node is made. Use the Wi-Fi settings option in the tablet to select connection to the Macaw, which is typically macawNNNN where NNNN are the last four digits of the unit serial number.

The tablet computer that ships with the unit is already configured to show the Macaw as a bookmark in the browser. The tablet is already configured to start with the camera home page. The IP address for the Wi-Fi connection will be 192.168.1XX.1, where XX are the last two digits of the unit serial number. If the last two digits are 00, 1XX becomes 200.

To transfer your pictures to a computer you must perform a shutdown and remove DC power. Shutdown consists of holding the picture taking button until the LED blinks red, waiting until the LED turns orange, and removing power.

With power off, plug the camera into the USB interface on your computer. (The SATA SSD drive can also be removed and replaced, but viewing data on a removed drive will probably require rebooting your host computer, and there will be no significant speed improvement.)

When connecting the Macaw system to a computer's USB port, Windows will recognize the system as a USB Mass Storage Device. From PixelWrench for Macaw, you may open previews of the images on the hard drive in the camera, and extract them for viewing and analysis. Consult the PixelWrench Help Menu for more detailed instructions.

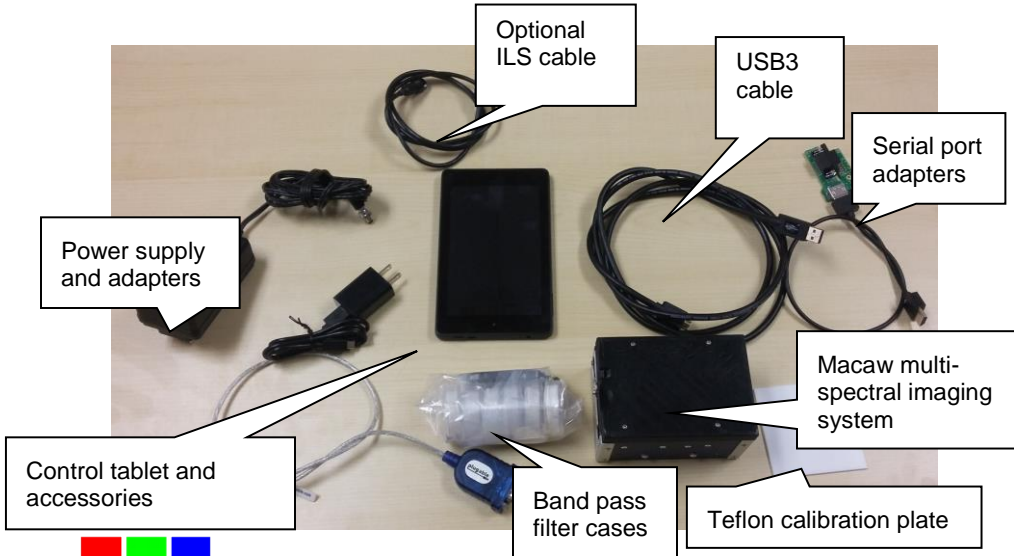


Unpacking The Box

Your new Macaw multi-spectral imaging system is packaged in a rugged plastic carrying case. This is what you should find in the case:

- A **Macaw** multi-spectral imaging system
- A CD-ROM with the installation software supporting the camera
- A USB3 interconnect cable
- A tablet computer set up to interface with the camera that contains installation software and documentation
- USB cable and power adapter for the tablet computer
- A SATA SSD storage device installed in the unit
- An AC power adapter and power input cable
- A white Teflon calibration plate
- 8 ½ by 11" neutral reflectance target (typically 22% to 24%)
- Serial port breakout and HDMI cable (for GPS or other serial devices).
- Console adapter (breakout with DB9 connector)
- A DC power cable
- eILS, Super ILS and cable (extra cost option)

Your Macaw comes with a one-year warranty against defects.



Control Tablet File Contents

The control tablet included with the Macaw contains necessary software and documentation. These files are located in the Documents folder of the tablet, which is accessible by pressing on the Docs button on the tablet's Home screen. NNNNNN refers to the Macaw serial number. The following is what the Documents folder contains:

- PixelWrench for Macaw setup files
- PuTTY setup file
- WinSCP setup file
- Xming setup file
- This Macaw Users Guide
- The Macaw Startup Sheet
- Webinar Series folder
- bandinfoNNNNNN.txt
- NNNNNN.txt

Many of these files can be opened from the tablet or PC, but the setup files can only be opened from a PC. To access the files from a PC, plug the provided USB cable into the tablet and then into your PC or vice versa. Note that you are not plugging in the USB3 cable; it is the other provided USB cable that you will be using.

Once you have plugged the tablet into your PC via USB, opening Windows File Explorer will allow you to see "Fire" under "Devices and Drives" as shown below:



Once you've opened "Fire", you will see "Internal Storage". Open "Internal Storage", and then you will see "Documents". Open the "Documents" folder, and you will see all of the files listed above.

By either copying these files from the tablet to your PC, or running the files directly from the tablet, you are able to use the files according to your needs.



Product Description

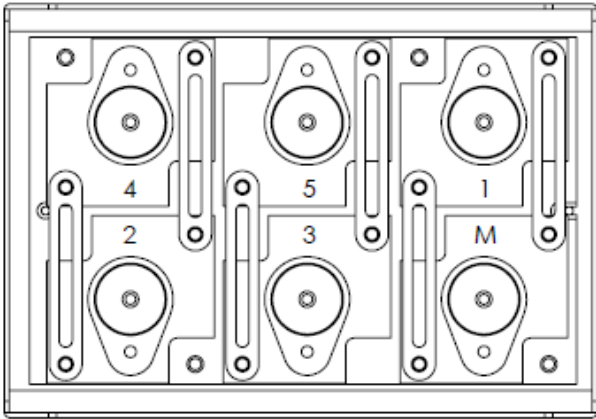
Becoming Familiar with your Macaw System

The Macaw multi-spectral imaging system consists of a set of digital still cameras compactly packaged and synchronized so they can all take pictures at the same time with only minor registration errors between images. These registration errors are corrected during factory alignment of the system. The alignment file is supplied on the tablet included with the unit, and is installed in the camera application folder /home/tetracam.

One of the cameras in the system is set up as the MASTER band. The master band is used to calculate exposure requirements and reference luminance for the rest of the system. The alignment and rotation of this sensor is the reference for the rest of the sensors in the system.

GPS/IMU/ILS metadata is collected continuously while the camera is in operation and inserted in the TIFF headers of the multi-page TIFF image files.

Control connectors are provided to allow the camera to be remotely triggered, and to provide connection to the external GPS/IMU. When the camera is within range, live video feeds can be seen on the control tablet for any of the bands.



6 Channel Macaw band Layout



Each camera has its own band pass filter – typically a spectroscope filter commercially available from companies like Andover or Sigma. A wide variety of band pass filters are available. Bandwidths of 10 nanometers and above will supply acceptable images. Narrower band pass filters (less than 10 nm) can produce some artifacts in the images. These may need to be corrected on the host PC using PixelWrench for Macaw supplied with the system. Band pass filters may be anywhere in the range of ~380 nm (near UV) to ~1000 nm (near infrared). The spectral response graph later in this document shows the working range of the sensors. A set of four, six or twelve standard filters is included with the unit. Alternate custom filters are available upon request with a quotation. There is also an option to add FLIR Tau2 sensors, either SWIR of Thermal, to the array.

Images can be transferred to a host PC by plugging in a USB cable to the USB 3.0 SATA disk controller built into the unit. A USB disk device will appear in the Explorer devices list.

An optional incident light sensor (ILS) module is available that includes an additional camera and matching filters for the set in the MCA. The ILS connects to the main assembly by way of a serial port, and passes luminance information merged with GPS and IMU information to the camera so these can be added to image metadata.

Hardware Overview

The Macaw system hardware is housed within a rugged sheet metal assembly. The Macaw is designed for use in aerial manned and unmanned aerial photographic missions. The unit weighs 5% less than prior models. In the air, system operation can be controlled with commands implemented with the RS232 console port, or by discrete control lines.

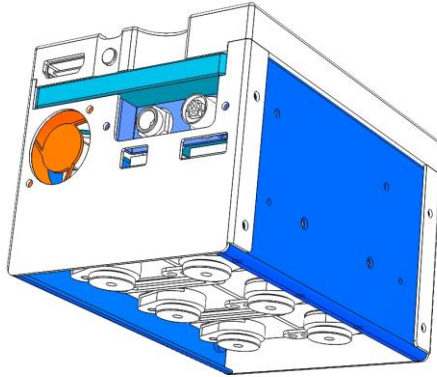
There is a single physical switch on the Macaw which is used to take a picture, or start a continuous capture sequence. The HDMI style system interface connector provides an RS232 serial input (Linux console stdin), a trigger line and a start/stop line.

The Status LED indicates whether the system is ready or not ready to take a new picture. When the Status LED is green, the system is ready to take a new picture. When the Status LED is red, the camera is busy capturing and saving images. After saving images, this LED returns to green indicating the camera is ready to capture a new picture. The Status LED is also made to blink when the unit is shutting down.

Two signal lines on the control connector provide external signaling. One provides a ready / not ready state, the other signals an image capture cycle, going high at the start of sensor capture, and low at the end of the file save operation.



Power – The right-most of the system connectors is the Macaw power supply input. The Macaw contains a switching power supply so it is able to handle a variety of voltage input levels. The unit runs nominally on +12 VDC external power but can handle input voltages between +9.0 VDC and +18 VDC. The power connector is center positive.

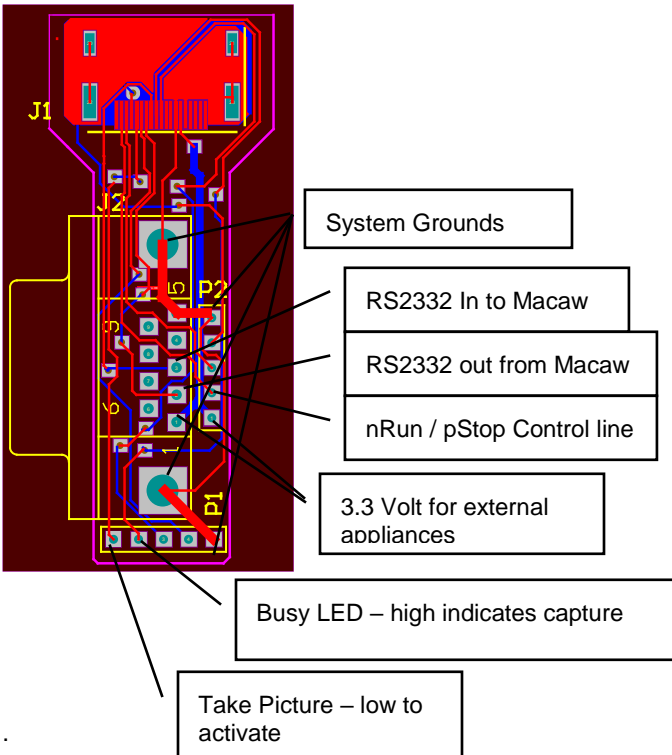


The total current drawn by the unit at any moment depends upon its model number and level of system activity (i.e., whether the system is capturing and saving an image or not). The Macaw-4 typically consumes 1 amp. The Macaw-6 typically consumes 1.5 amps. The Macaw-12 typically consumes 2.3 amps.



Multi-function I/O – This HDMI style connector carries signals to enable monitoring camera activity, taking pictures, and controlling the camera with serial port commands or control lines, or by connecting a GPS. The serial port is also the default Linux control console. Two breakout PCBs are provided with the camera. One has a DB9 connector which mates directly with a USB serial port adapter. The other is left bare, except for the HDMI connector so it can be used for wiring into a control system.

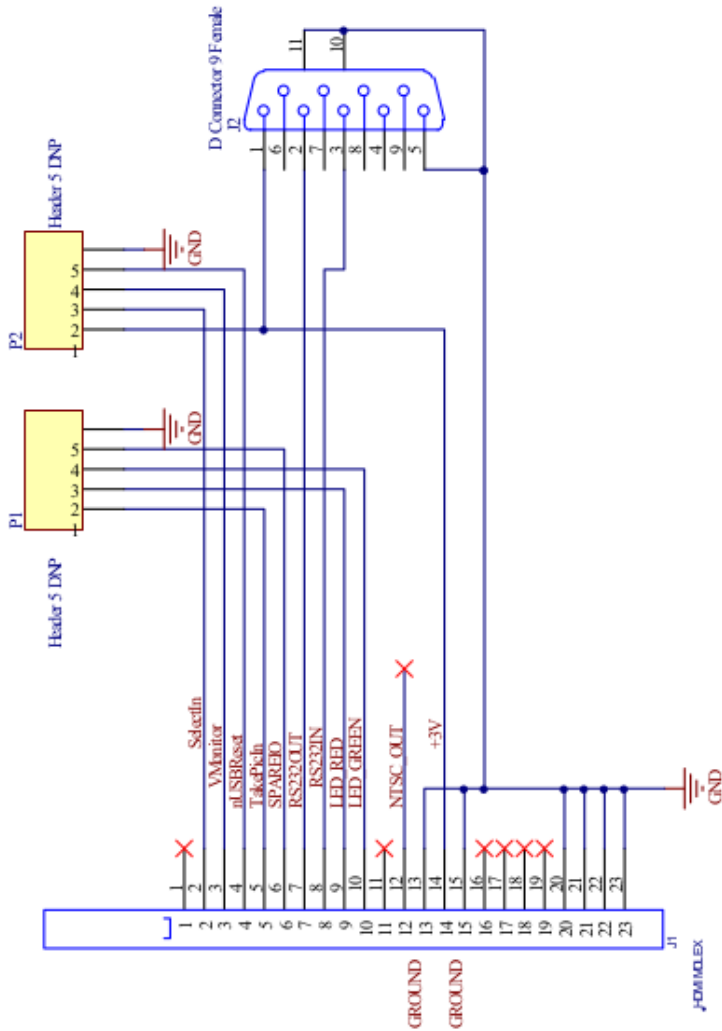
When this serial port is used for commands, there is a second port that can be used for GPS input. The second port is limited to 38400 baud, while the main console serial port can handle GPS NMEA strings at 115K baud.



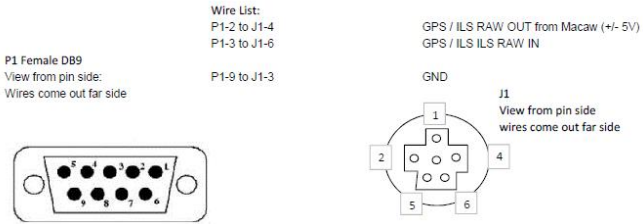
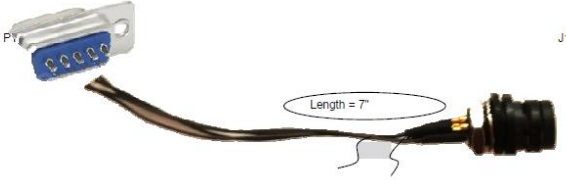
The user may wish to modify an HDMI cable, and not use the breakout PCB. In that case the HDMI wiring should follow the schematic on the next page:

In a simple situation, short between pin 1 and 5 on P1 to take a picture.





GPS / ILS Port – This small round connector provides an RS232 serial port and 12V power for external GPS or ILS attachments. Wiring for a typical serial port connection to a GPS with a DB9 connector is shown below. This diagram is for a DB9 female connector, with a male in the GPS. If the GPS connector is female, the pin ordering must be reversed.



USB Connector – The USB 3.0 data connector is located on the right side of the unit (to the right of the Power connector). This connector provides the path that is used to transfer images between the camera and a Windows-based host computer following completion of imaging missions. Visible on this side of the unit as well is the SATA SSD drive which contains all of the images captured during a mission.

The USB controller is only available when the camera is powered DOWN. The controller gets its power from the USB port, and needs for the SATA drive to be disconnected from the Linux system. If the system is powered down, there is no conflict.

The drive has a FAT32 format, and can be formatted in Windows, but it is better to format the drive from the control tablet, because the palettes and special control files are restored in an orderly way.

CAUTION: Disconnect USB before turning on and booting the camera.



Image Storage

The Macaw employs a single SATA SSD disk that is used as mission image memory. This storage device receives images in the system's multi-page TIFF file format as they are acquired during imaging missions. The TIFF header in this file format also stores GPS coordinates, ILS luminance data, and IMU orientation data that are streamed to the system from an optional external GPS device.

Additional image processes, such as vegetation index or RGB color image extractions can optionally be performed on the captured raw images as the file capture progresses. The SATA SSD is mounted under the `/home/tetracam/TTCMCAW` folder. Raw TIFF images are stored in `/home/tetracam/TTCMCAW/MCAWTIFS`, and extracted images are stored in `/home/tetracam/TTCMCAW/EXTRACTIONS`. See the console login section for more details on folder and file definitions.

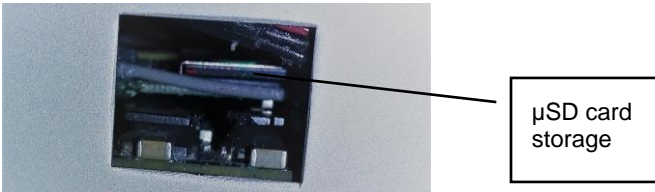
Several sizes of SATA SSD drives are available, starting at 168 GB, and extending to 2 Terabytes. The SATA SSD may be upgraded in the field. Always remember to re-format a new drive from the browser interface so that critical folders and control files will be present.

Linux Operating System Storage

The Macaw is equipped with an internal memory card that contains the Linux operating system, the executable programs required by the system, and data file backups for critical data. The memory card does not need to be removed or replaced in normal operation, but occasionally there may be comprehensive system updates that may require a new card. It is also possible that the card may fail in use.

A backup memory card is provided with the system in case of failure. This spare card may also be used to receive Linux image update files from a Tetracam web server. The memory card is 16GB in size, so copying can be very time consuming.

To replace the operating system storage, first remove the aluminum tape covering the access hole on the side of the camera opposite the connectors. Inside the opening, the edge of a micro SD card can be seen:



The socket for the card is a “press to release” style. Reach in with a small blunt object and press on the edge of card. The card will eject about 3mm when released. Using a tweezer or a pair of needle nosed pliers, reach in and pull the card out by the edge.

Insertion of a new card is done in reverse order: insert, then press into place.

Make sure to re-install the aluminum tape when the operation is completed so that the airflow design of the cooling system is not disrupted.

Macaw Optical Channels (Lenses, Filters and Sensors)

Each Macaw optical channel consists of a 9.6 mm lens, a spectrometric filter and a CMOS optical sensor. The lens focuses visible or near-infrared radiation through the filter and on to a 1.3 mega-pixel CMOS sensor. The filter limits the wavelengths that are able to pass through it to a specific band of electromagnetic radiation. The CMOS sensor accumulates electrons proportional to the amount of radiation impinging upon the sensor at each of its 1280 X 1024 pixel locations. The size of the photo-sites that form the wells for each pixel are very near the size of the near-infrared wavelengths that the sensors are optimized to capture. Each well is cleared of its electron contents immediately prior to image exposure. This ensures that each image has high spectral fidelity and low image noise.

Like previous versions of the MCA, the Macaw uses small miniature lenses with fixed apertures and focal lengths. Each channel of the Macaw is equipped with the same type of 9.6 mm focal length lens so the images can be merged with a minimum of error and distortion. For UV imaging, a fused silica lens is used which extends the imaging range into the near UV.

Each channel has a receptacle to hold the spectrometer filter in place immediately below the lens. Positioning the filters below the lens limits the angle that radiation enters the channel and inhibits image vignettes.

Filters may be obtained from a commercial supplier such as Andover. Tetracam supplies a standard set of filters with each system. These are selected for their relevance to remote sensing of vegetation. The Tetracam web site lists a wide assortment of available filters.

The Macaw filters are customer designated at the time of order. When they are installed at the factory, the filter that produces the greatest number of electrons in response to the radiation that it passes is selected as the Master filter. Each slave channel's exposure time is then set as a multiple of the Master exposure time.

The graph below shows the relative efficiency of the Macaw CMOS sensor for different bands of visible and NIR light. The filter with the highest photovoltaic efficiency (i.e., the filter nearest to ~790 nm in the graph) is selected for insertion in the Master channel position.

Spectral Response Curve

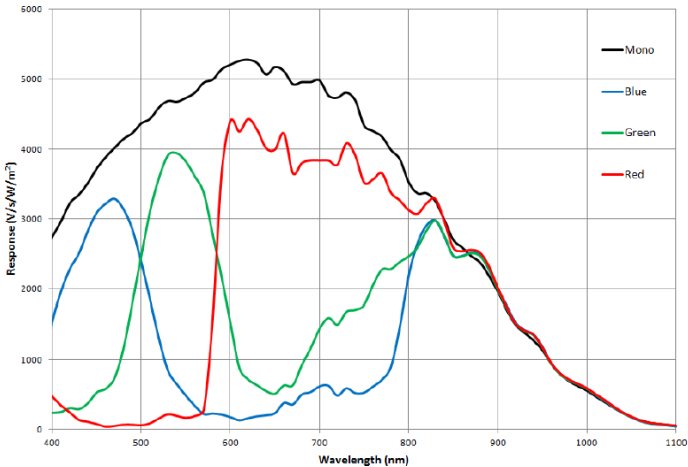


Figure 3. Spectral Response Curve for Mono and Color

Users may replace filters in the field with standard 25mm spectrometer filters in order to re-task the system with the following limitations. A new filter should only replace a filter that has a similar band pass wavelength. In the visible spectrum, replacing a filter with a new one that is within ± 100 nm of the original is acceptable. Beyond 700 nm replacement filters should be within ± 50 nm of the original.

Replacement of filters beyond this range generally requires factory re-calibration of the unit, primarily in the area of lens focus. Contact Tetracam Technical Support for guidelines on customer re-calibration of the system or to obtain a Return Material Authorization (RMA) number to return the unit to Tetracam for re-calibration.



System Setup

There are many configuration options for a Macaw camera, including modification of the camera application code in the field. The camera ships from the factory configured for the following:

- English language
- Continuous capture at 2 to 5 captures per second
- Background image alignment, false RGB color, and NDVI processing
- 38400 baud GPS/IMU/ILS input
- UTC time offset -7 (California!)
- 115K baud console/GPS/serial control input
- Landscape aircraft mount
- Full size image (1280 X 1024) acquisition
- Brief metadata logging
- 16 Bit TIFF file format
- Auto-exposure average algorithm
- No long term time lapse image acquisition

The system can be reconfigured as needed using the browser interface. A preconfigured tablet is shipped with each unit for this purpose. The settings are changed by way of a set of option boxes which are clearly labeled and associated with help files.

There is a band definition file (bandinfo.txt) which can be modified via the browser interface when filters are changed. The band definition file is presented in the browser interface when a vegetation index or RGB extraction is configured. It is useful to have band descriptions that reflect the filters actually installed in the unit when defining a band ratio imaging calculation. Where NNNNNN is the Macaw serial number, the bandinfoNNNNNN.txt file located on the control tablet is the same file as bandinfo.txt that is on the Macaw SATA drive and SD card; it is provided as such for convenience.

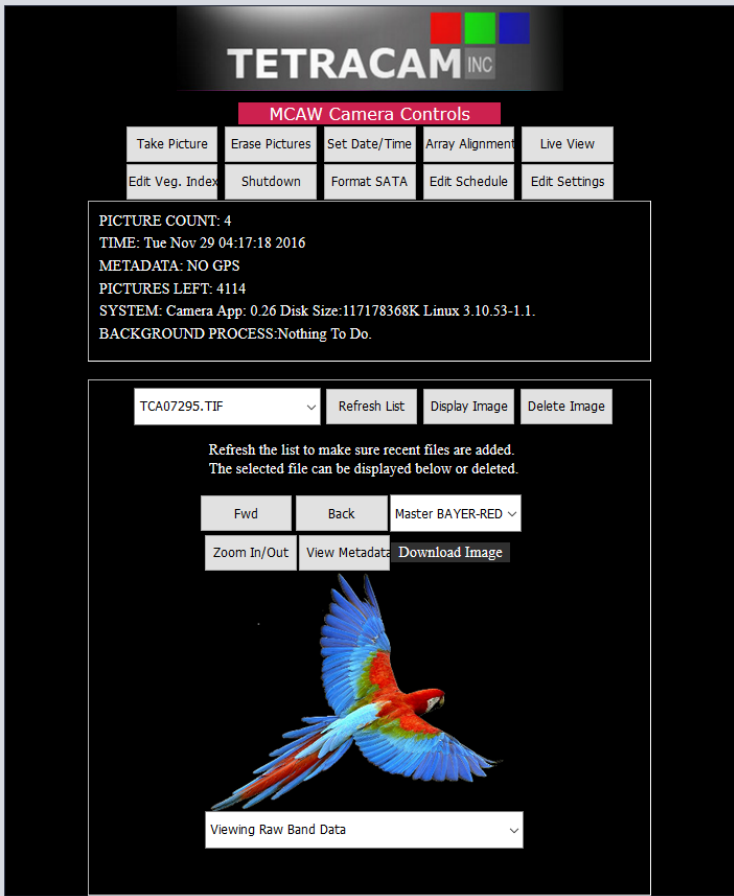
There is a background process definition file (indices.txt) which allows up to 8 band ratio / RGB calculations to be performed on each image that is captured. The calculated images are saved as a set in a multi-page TIFF image file in the EXTRACTIONS folder. The raw TIFF images from which they are derived have the same numeric file attribute, and are found in the MCAWTIFS folder.



Using the Browser User Interface

There are six browser screens that manage camera setup. Each is provided with help buttons to explain its use. The various screens, which are HTML pages resident in the camera in the /var/www/html/* folder, are these:


1. Basic Status Page



This page is used for basic camera operations, and to access other pages. Pictures can be taken and erased, captured images and band ratio calculations can be reviewed, and other basic operations performed.



2. The Settings Form


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Camera Settings

This is the user settings menu page for the Tetracam wMCA.

Current Settings Values

The current value of each setting is displayed in the edit boxes. Modify the values of interest, and when finished, Use the Save Changes button to update the values in the camera. The help link next to each value can be used to determine which values are appropriate for a particular setting.

Save ChangesBack

Code Version	26	--HELP--
Serial Number	200003	--HELP--
Metadata Format	GPS NMEA v	--HELP--
Console Serial Baud	115200 v	--HELP--
Field Of View Reduction	10	--HELP--
Auto Exposure Adjustment	0	--HELP--
Number of bands	10	--HELP--
UTC Time Offset	-7	--HELP--
Camera Mount	LANDSCAPE v	--HELP--
Next Image Index	7298	--HELP--
Language	ENGLISH v	--HELP--
Auto Capture Delay	500	--HELP--
Image Dimensions	FULL SIZE v	--HELP--
Capture Mode	GPS OFFSET v	--HELP--
ILS/GPS Baud	38400 v	--HELP--
GPS Trg. Offset (m)	50	--HELP--
Enable Logging	LOGGING BRIEF v	--HELP--
Align Planes	BG ALIGN AND EXTRACT v	--HELP--
Enable Mosaic Tiles	DISABLED v	--HELP--
File Format	16 BIT TIFF v	--HELP--
Fixed Exposure	0	--HELP--
Auto Exposure Method	CONTROL AVERAGE v	--HELP--

The settings form provides selection boxes and help file links for all camera settings. The settings only take effect when the 'Save Changes' button is pushed. Each entry is an option box which shows the available choices in a self-explanatory list.

3. The Band Descriptor/Alignment Page

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Array Alignment

This page allows adjustment of the camera array alignment data.

Current Alignment Values

The alignment values below are in units of pixels for x and y offsets, degrees for rotation, and scaling ratio without units. Make sure there is a copy of the original factory settings before changing and saving any of these values to the camera.

Unit	X Offset	Y Offset	Rotation	Scaling	Band ID	Vignette	Vig. Exp.	Vig. X	Vig. Y	Rel. Exp.
Master	0	0	0	1	BAYER-RED	0	1.2	0	0	100
Slave 1	0	0	0	1	BAYER-GRN	0	1.2	0	0	100
Slave 2	0	0	0	1	BAYER-BLU	0	1.2	0	0	100
Slave 3	-3	0	-0.1016	1.00342	490-10	0	1.2	0	0	100
Slave 4	5	0	0.1033	1.00427	550-10	0	1.2	0	0	100
Slave 5	-4	-2	-0.0731	1.00427	680-10	0	1.2	0	0	100
Slave 6	3	3	0.5108	0.99324	720-10	0	1.2	0	0	100
Slave 7	1	3	0.0331	0.99661	900-20	0	1.2	0	0	100
Slave 8	5	21	0.5881	0.9584	THERMAL	0	1.2	0	0	100
Slave 9	0	0	0	1	BAYER-RGB	0	1.2	0	0	100

This form is normally changed only when a filter is replaced. It contains the alignment values for each optical stack which should not be disturbed unless factory alignment tools are available to examine very small pixel displacements.



4. The Linux Cron Configuration Screen for Elapsed Time Shots

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Scheduled Image Capture

This page allows creation and modification of a picture taking schedule.

Image Capture Schedule

The table below holds Linux "Cron" style schedule entries. The schedule is specified in Minutes, Hours, Days, Months and Day of Week.

This is a machine generated file.
It should only be changed from the browser control window

Save Changes Back

Minutes	Hours	Day of Month	Month	Day of Week	Command
*/1	1	*	*	*	Disabled ▾
1	*/2	*	*	*	Disabled ▾
0	0	1	1	*	Disabled ▾
0	0	1	1	*	Disabled ▾

This screen is typically used for fixed camera installation where long term time lapse photography is useful.

5. The Band Ratio / RGB Calculations Form: indices.txt

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Setup Extractions

This page allows changes in the background vegetation index processing for the Macaw.

Current Index Form

The table below shows the vegetation index extraction operations that have been set up for background processing in the Macaw. Up to eight extractions can be configured. Any changes take effect when they are saved.

Save Changes Back

Index ID	-LONGEST-	-SHORTER-	-SHORTER-	-SHORTEST-	Palette File
RGB ▾	BAYER-RED ▾	BAYER-GRN ▾	BAYER-BLU ▾	* ▾	default ▾
NDVI ▾	900-20 ▾	680-10 ▾	* ▾	* ▾	example1.icp ▾
RGB ▾	680-10 ▾	550-10 ▾	490-10 ▾	* ▾	default ▾
RGB ▾	900-20 ▾	680-10 ▾	550-10 ▾	* ▾	default ▾
GARI ▾	900-20 ▾	680-10 ▾	550-10 ▾	490-10 ▾	IE_1.icp ▾
GARI-M ▾	900-20 ▾	680-10 ▾	550-10 ▾	490-10 ▾	default ▾
NDVI-M ▾	900-20 ▾	680-10 ▾	* ▾	* ▾	default ▾
OFF ▾	* ▾	* ▾	* ▾	* ▾	default ▾

6. The Live View Screen

TETRACAM INC

Camera Controls

This is the command page for the Tetracam wMCA. Press the buttons below to operate the camera.

Take Picture	Erase Pictures	Set Date/Time	Array Alignment	Review
Edit Veg. Index	Shutdown	Format SATA	Edit Schedule	Edit Settings

PICTURE COUNT: 6
UTC TIME: Fri Apr 7 15:27:23 2017
METADATA: NO GPS
PICTURES LEFT: 13727
SYSTEM: Camera App: 1.12 Disk Size:228864M Linux 3.10.53-macaw-006
BACKGROUND PROCESS:Nothing To Do.

SELECT A LIVE VIEW OPTION: Processed RGB 900-20 680-10 550-10 * default

This page allows the user to select a live feed from any camera in the array. It also allows all the basic camera control functions to be performed, as does the startup page. 'Review' button takes the user back to the basic status page.

There are several live view options in the drop down selection box. In the example, a view defined by an active entry in indices.txt has been selected. A correctly configured index extraction in the indices.txt definition file can be streamed as a live view. The colors are determined by the palette selection, where applicable. There are also choices for viewing individual camera bands.



GPS Option Installation and Use

Your Macaw will capture and append the most recent GPS/IMU position data to each image as it is taken. The following requirements apply: The GPS receiver must be configured to output the standard NMEA RMC and/or GGA sentences. The default output protocol for NMEA sentences is 38400 baud, 8 data bits, 1 stop bit, and no parity. The Tetracam GPS option is correctly configured. Any alternative receiver should allow you to configure it for RMC and/or GGA at 38400:8:1:N.

The GGA sentence is emitted once or twice per second and contains the following fields:

1. Time UTC
2. Latitude and Longitude
3. Fix quality
4. Number of satellites tracked
5. Horizontal dilution of position
6. Altitude in meters MS
7. Height above MSL

Attach the optional serial cable to the small serial connector (see the illustration in the Hardware Installation section of this manual). Attach the other end to the serial port of the GPS/IMU.

The most recent GPS position data sent to the camera will be appended to the image data file. You can view the GPS data in the image using a web browser, or with PixelWrench for Macaw. The camera firmware also supports an event, or position, logging system that will exactly place the GPS locations at the time pictures are taken, with a resolution of 1 millisecond.

The GPS messages are saved in each image as it is taken, and in the camera log file. Bad GPS sentences are not included in the log file unless logging is set to "verbose" mode in the capture setup screen.

Event Log File

When 'Enable Logging' is set to LOGGING BRIEF, the camera will maintain a file with a record of key events that can be used to accurately position the location at which the picture was taken. Generally, a Tetracam GPS/IMU unit is connected to the camera serial port that sends \$GGA... and \$RMC...position strings to the camera.

This feature is used most often with aerial photography, when the GPS point is directly below the camera, so that both the camera and the image are at the same coordinate.

When the option is enabled, the camera creates the file CURRENT.LOG on the memory card in the root folder. If there is a pre-existing CURRENT.LOG file, the file is moved to the image folder (TTCMCAW/MCATIFS/) and

renamed according to the image numbers that were captured while the camera was last in operation.

For example: If images 31, 32, 33, and 34 were captured, there will be event log records for each of those captures in the file. The file is scanned image capture records, and the smallest and largest image numbers found are used to compose a file name. In this case, the file would be renamed to 00031-00034.LOG. The first four characters of the new file name are the lowest image capture record in the file; the second four letters are the highest image capture record in the file.

A typical Event Log file is shown on the next page. Each line shown is one record in the file, terminated by a newline character. Additional line feeds are added for clarity in the illustration.

You can use PixelWrench for Macaw to manage image and GPS log files. See the PixelWrench Help file for more information on how PixelWrench for Macaw uses the distilled log files to refine the embedded GPS data in each image. The latest edition of PixelWrench for Macaw is available at www.tetracam.com/PWversion.htm



The CLK record is added when the camera powers up. It shows the camera date and time.

Every Record has a "Ticks" Field that shows the cameras internal clock count of 10 millisecond ticks. The count 104 means that the CLK record was written 1.040 seconds after power on.

CLK 000000000104 Date/Time: 10/22/2009 15:15:01

GPS 000000002006 00217 \$GPRMC,192254.00,A,2942.79012,N,08223.30667,W,000.0,000.0,221009,03.3,W,A*0B

GPS 000000002064 00217 \$GPRMC,192254.00,A,2942.79012,N,08223.30667,W,000.0,000.0,221009,03.3,W,A*0B
\$GPGGA,192255.00,2942.79047,N,08223.30663,W,1,04,2.58,00040,M,-031,M,,*5D

IMG 000000003049 00218

GPS 000000003102 00218 \$GPRMC,192302.00,A,2942.79461,N,08223.30899,W,000.0,000.0,221009,03.3,W,A*0B

GPS 000003280 00219 \$GPRMC,192302.00,A,2942.79461,N,08223.30899,W,000.0,000.0,221009,03.3,W,A*0B
\$GPGGA,192303.00,2942.79517,N,08223.30922,W,1,04,2.58,00062,M,-031,M,,*55

If a GPS is connected, an entry is made each time a GPS update string is received. Different GPS messages are concatenated as they come in

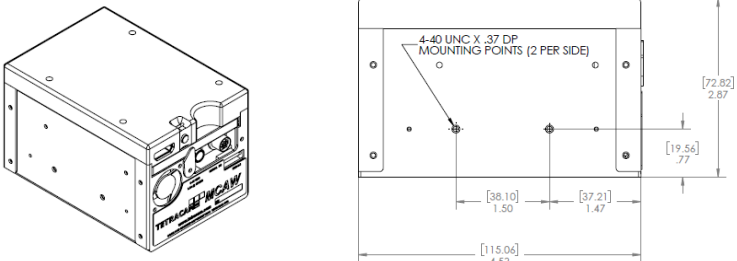
When a picture is taken, a record is written showing the system ticks at the end of integration. The camera can only do one thing at a time, so there will always be a system ticks offset between capturing a picture and the GPS messages. The actual position of the camera when the picture is captured can be approximated by interpolating between the two GPS messages using the system ticks.



Integrating the Macaw System with Aircraft

Mounting the unit

The Macaw contains four mounting holes in the front and rear of the unit (see drawing below). These should be used to mount the Macaw system into manned or unmanned aircraft. The system should be isolated from vibration transferred to it from aircraft. The Macaw does not contain its own power supply so power must be supplied from the aircraft by using the power cable fitted with the co-axial connector. Ensure that the cable is wired as center positive. In addition, the camera metal chassis should be grounded by connecting ground to one of the mounting screws. If the camera is mounted



on non-conducting vibration isolators then a ground strap should be provided. Dress and restrain all interconnect cables to prevent snagging or undue disturbance from propeller blast, etc. The Macaw housing and optics are not weatherproof. If the camera is mounted externally, weather protection should be provided.

Triggering the Macaw at Specific GPS Coordinates

There are several ways to trigger the Macaw with respect to GPS position. The first, and simplest, is to configure the camera for GPS offset capture, and enter the number of meters of separation between GPS points that should cause the trigger.

The second method is to use the console input to send trigger commands from an external controller that has a GPS input stream. The console serial port is wired to the 16 pin multifunction connector. A compatible cable and signal breakout board are provided to simplify connection. The console serial port can be connected to an external Bluetooth receiver that supports triggering from a Tetracam smartphone/tablet application.

The third method is to toggle the external Take Picture line when the controlling device reaches a desired GPS trigger point.



Capturing and Processing Macaw Images

The Calibration Image

In order for the Macaw system to capture accurate multi-spectral images it is necessary to obtain a reference calibration image prior to or during each imaging mission. Calibration consists of taking an image of the Teflon calibration tag under the same lighting conditions as the images under study. This image is used to teach the application software what the spectral balance of that day's sunlight is. The ratio of red/NIR or green/NIR is then applied as an offset to the calculation of the various vegetation indices. Note: if a calibration image is not taken within an hour or two of pictures in the field, the vegetation index calculations will not be very accurate, and the pictures may not be useful.



Place the calibration target on the ground, or hold it level with the ground, and photograph it. It need not fill the entire frame and it must not be overexposed. Make sure to avoid a direct reflection of the sun. The sample image on the left is of a properly exposed calibration target. When the pictures are imported to the host computer, the calibration image will be used to refine the vegetation index calculations.

In place of the Teflon Calibration Tag supplied with each system, you may also use Multi-spectral Ground Calibration Targets that provide a relatively flat response to incident radiation throughout the VIS-NIR wavelengths. These have that added advantage of acting as Ground Control Points for geo-referencing images.

Flying Aerial Imaging Missions

Typically, a user's initial concern at the start of an aerial imaging mission is the ground resolution they will need to achieve in order to identify the detail they require in their images. Use the FOV Calculator in PixelWrench for Macaw to determine the above ground level altitude you need to fly in order to obtain that resolution. You can also use this calculator to determine the airspeed you will need to fly in order to obtain sufficient frontal and side image overlap.

Aerial missions involve making successive passes back and forth across an area of interest usually in an east-west direction. This flight line ensures

consistency in orientation and sun angle. The orientation of images is generally at 90° to the flight lines. Images are generally captured at a nadir angle with the Macaw system pointing straight-down. Using the nadir angle minimizes occlusion of subject matter by hills or other intervening objects. In order to permit splicing multiple images together, vendors of mosaicking software recommend a high overlap percentage for adjacent images. Icaros OneButton, for example, recommends a minimum of 75% forward overlap and 60% side overlap.

Images are captured and saved to the SATA SSD. Tetracam recommends always using the built-in browser function to format the SATA drive prior to each mission. This guarantees that the drive will not be fragmented, and image save times will be optimal.

Managing Macaw Images in PixelWrench for Macaw

Upon landing, images may be transferred from the Macaw system to the host computer. With the camera powered off, connect the camera directly to a host computer with the USB interface. The camera will appear as a new USB disk device with a unique volume ID. Files can be dragged to and from the disk, and PixelWrench for Macaw can be used to open the files directly.

If band ratio and false color conversions have not already been performed by the camera during the mission, PixelWrench for Macaw can do this quickly, using its built in batch functions. Read the PixelWrench for Macaw help file for a detailed description of this software and its use with Tetracam multi-spectral imaging systems.

If these conversions have already been performed by the Macaw, the user can simply transfer the multi-page TIFF extraction files to the PC and view the results with PixelWrench for Macaw. Some mosaic building software may be able to use the Macaw images as-is to immediately produce a mosaic image of the mission.



PC Software Overview

PixelWrench for Macaw

The tablet and installation CD included with your system contains PixelWrench for Macaw as well as other utilities, files and documentation that are helpful for setting up and operating your system. PixelWrench for Macaw is a powerful image editing program that is included with each Macaw system. This software runs on any IBM-compatible personal computer running Windows 10 or earlier operating system (see PC System Requirements for additional details). The licensed software includes tools specific to multi-spectral images.



It provides tools for management of Macaw multi-page TIFFs, color processing of band data and complex batch processing tools for extraction of several vegetation indexes. The application includes a comprehensive suite of image editing tools. PixelWrench for Macaw translates the Macaw multi-page TIFF format into other standard image file types. (BMP, JPEG, TIFF, PNG etc.)

Many of the PixelWrench for Macaw batch processes can also be performed in the camera by configuring background processing to generate the desired band ratios and false color images.

PixelWrench for Macaw also includes a Field of View (FOV) Optical Calculator. This tool enables users to input camera parameters along with the distance from the camera to the subject in order to calculate variables including the observable field of view (FOV) in meters and the image resolution in millimeters per pixel. Additional variables including the required speed to fly to obtain a desired image overlap may also be calculated using this tool.

PC System Requirements

Any IBM-compatible personal computer with a free USB serial port can be used to retrieve pictures from the Macaw system. The unit produces sets of images synchronized for simultaneous capture. The images from the set can be displayed three channels at a time using RGB format for false color rendition. Each RGB rendering is about 3.9 Megabytes. You should select a computer with resources that can support manipulation of images that are this large. Our recommendations for a minimum configuration are:

- 1 GHz or better processor, Intel or AMD
- Windows 10 or earlier operating system
- 1 GB megabytes of SDRAM
- 24 bit color graphics adapter at 1024 x 768 or better resolution
- 1024 x 768 or higher display
- Large hard disk drive with 100 GB or more free space

Software Installation

Remember that the PixelWrench for Macaw setup files are located on the tablet in the Documents folder. In order to install PixelWrench for Macaw, run the file “setup.exe” located in the PixelWrench for Macaw folder either directly from the tablet or after copying the PixelWrench for Macaw folder to your PC. The default installation target is this:

“C:\Program Files (x86)\Tetracam Inc\PixelWrench for MCAW”

Where NNNNNN is the Macaw serial number, the control tablet contains a file named NNNNNN.txt. This is the file that must be used if you want to align multi-page TIFF image files using PixelWrench for Macaw. We highly recommend that you copy it to the Support subfolder under the application directory.

Please read the PixelWrench for Macaw help file for further information.

If your computer does not have the Microsoft .NET 3.5 framework installed, please be sure to use Windows Update to acquire it.



Options and Accessories

GPS Receiver

Tetracam offers a pre-configured GPS/IMU device that can provide the NMEA strings needed to reference the captured images geographically, and orientation data (pitch, roll, and yaw) that records any tilt in the optical axis. The unit comes with a cable wired correctly for the Macaw accessory serial port, and has a separate 8V to 15V DC power connection. A six-pin plug and cable is shipped with the GPS unit to make installation in the target system relatively simple. The GPS and camera ship from the factory configured for 115200 Baud on the console serial input and 38400 baud on secondary serial port input for the ILS or GPS.

Incident Light Sensor (ILS)

The Macaw ILS is an additional element that can be added to the GPS/IMU.

The ILS analyzes calibration images each that record the relative strength of down-welling radiation in each of the Macaw sensor bands, and sends metadata messages to be inserted into the TIFF image headers.



Advanced Topics

Logging into the Macaw Linux Operating System

The camera operating system is a version of Ubuntu Linux that supports multiple users. There are two user accounts already set up for use:

Login: tetracam
Password: z9g5ji

Login: ttcuser
Password z9g5ji

Logging in on the serial port console must be done during the camera boot cycle. After networking is started, and the apache web server launched, the startup script will launch a camera application, unless a key is hit within four seconds. Striking a key will result in the console being logged into a bash command shell as the user tetracam. An alternative (and better) way to log in is to use PuTTY and an SSH connection over the wireless interface. PuTTY is recommended as a good SSH terminal client for both the serial console and an SSH Wi-Fi login.

Preventing the launch of the camera application on the serial port is a good way to prepare the unit for an update. When the camera application runs, the executable file, cammain, cannot be rewritten or deleted.

A PuTTY and Xming installation files for Windows are included on the Macaw control tablet, and can be retrieved over a USB connection to the tablet. Xming allows the use of X11 graphical interfaces on the remote (Windows) host. More information is available below in the discussion of host interface software packages.

Stopping the Camera Application (cammain)

The camera application, cammain, is restarted automatically whenever it closes by a parent process, camstart. In order to terminate the camera process so that a new cammain can be installed, or to eliminate the camera application overhead, the camstart process must be identified and killed. a `'ps -gax | grep cam'` command will list all the processes, and a `kill -9 XXXX` command, where XXXX is the process id value for camstart, will terminate the parent and allow cammain to be stopped without restarting.



Camera Control Files

The cammain application and its browser interface use text files to configure the behavior of the application, and provide forms for the user to modify. There are four control files, and a palettes folder:

```
settings.txt
bandinfo.txt
indices.txt
ttcron
/home/tetracam/PALETTES
```

These files are permanently installed in the application home folder: /home/tetracam. They are copied to the SATA SSD drive when it is mounted or formatted, and they are updated with changes when cammain exits.

SATA SSD Organization

The mount point for the SATA SSD is /home/tetracam/TTCMCAW. The control files referenced in the previous paragraph will also exist in this folder. Subfolders under TTCMCAW contain the results of the camera application:

TTCMCAW/MCAWTIFS holds captured images in multi-page TIFF files.

TTCMCAW/PALETTES holds the palette files known to the system.

TTCMCAW/EXTRACTIONS holds the vegetation index images extracted in background processing during a mission.

The SATA SSD should be unmounted if it is to be removed from the system while power is on:

```
sudo umount /home/tetracam/TTCMCAW
```

The drive is best reformatted using the web browser interface button. The filesystem is set as FAT32 for best possible save times and compatibility with Windows operating systems over USB. Formatting with a different file system, such as ext4, will work, but camera cycle time will be much slower, and Windows may not recognize the file system type.

A script is provided for remounting the SATA drive with the correct file system attributes: /home/tetracam/mountmca.

Rebuilding the Camera Application

A complete development project for cammain is provided with the camera. The source and library files are contained in the folder /home/tcuser/lab. In order to invoke the eclipse development environment, an X windows client must be installed on the host computer to be used as an interface. As noted before, a version of Xming and PuTTY is resident on the Macaw control tablet for installation on a Windows computer.

Updating the Macaw

When changes are made to the Macaw camera application (cammain), the changes are distributed both as source code and binaries. Upgrading the binary files is much easier than rebuilding the code from source files.

To install a new camera binary and other updated files, connect the Macaw to a USB3 port on the host computer. The Macaw should be powered down before doing this. The USB3 port provides power for the SATA SSD and the USB disk bridge.

Create a new folder called MACAWUPDATE in the root folder of the SATA SSD. If you've received the Macaw update files in an archive, extract them to a folder somewhere on the host computer. Now, copy the Macaw update folder structure into the MACAWUPDATE folder. Unless otherwise noted, the folder structure likely consists of a folder called home and a folder called var. When you're finished with this, MACAWUPDATE should only contain the Macaw update folder structure.

Unplug the USB3 cable and apply power to the Macaw. When Linux is finished booting, the SATA SSD will be checked for new binaries and other files. When they are found, they are automatically copied to the correct destination (/home/tetracam). The original camera application file is renamed to cammain.old.

To observe the update procedure, connect via serial console to the Macaw using PuTTY.

The startup script will launch the new binary after the update is completed.

Host interface packages for Windows 10:

PuTTY remote terminal utility

XMing X Windows client

WinSCP file transfer utility

Once these packages are installed on the Windows 10 host, the user can



connect to the camera through its SCP/SSH server. This is done by configuring the packages with the IP address used by the camera Wi-Fi server: 192.168.1XX.1. XX will be different for different Macaw cameras. The IP address can be determined from the Macaw control tablet; it is the same as the http home page. The Windows 10 host must have a working Wi-Fi port which can be redirected to the camera hot spot.

Detailed information on PuTTY, Xming, and WinSCP can be found on the web. The most current versions of these utilities are available for download from their parent websites.

PuTTY is the most basic of the support utilities. It does not require Xming or WinSCP to operate, and can be used for both the serial port console connection and wireless login. Launching PuTTY with the camera IP address as the target, or the COM port to which the camera serial interface is connected will bring up a login prompt. The user should log in as "ttcuser" over Wi-Fi for doing software development. When using the serial port, it is necessary to strike a key after boot up to abort the startup of the cammain process. Once aborted, the serial port will present a bash shell logged in as the user tetracam.

To use software with a GUI, such as the Eclipse development environment or the GIMP image editor, the user must be logged in with PuTTY over the Wi-Fi link, and Xming must be running. PuTTY will not do X11 forwarding when the connection is a serial port.

WinSCP provides a Windows Explorer style of user interface for moving files back and forth between a host PC and the Macaw. It is not as fast an interface as the USB3 connection, but in situations where physical connection is difficult, it may be the preferred way for downloading pictures from the camera. PixelWrench for Macaw cannot interface directly to the Macaw over the wireless link. Instead, the USB3 connection allows the camera data to be accessed and processed without moving it to the host PC. The same is true for Icaros OneButton and Agisoft PhotoScan mosaic building utilities: they can operate directly from the USB3 link.

Starting the Camera Development Environment

If the Xming client is installed in the Windows 10 host, and the login is over a PuTTY Wi-Fi link, change to the /home/ttcuser/lab folder and type 'sudo eclipse'. Eclipse is preconfigured with the cammain project as the default workspace, and the project C/C++ perspective for the cammain project will be shown. Programming techniques in C are beyond the scope of this manual, but a brief discussion of the most likely source files for modification is in order:

cammain.c: The main thread which manages the control files, the SATA drive, and interaction between other threads in the application.



ttcsignals.c: This thread collects input from the browser interface, stdin, switches, and the ILS serial port, and determines what messages to send to cammain.

ttcbgtasks.c: This thread performs background image processing: image plane alignment, vegetation index extraction, and mosaic tile preparation.

ttcindexproc.c: The actual file I/O and calculations for band ratios are performed here.

Information on the use of the Eclipse IDE for program development is available online. Be sure to always launch with root privileges. This allows the program access to protected resources, such as the gpio pins and i2c interface device drivers, and certain camera configuration files

There is also a project for the Macaw web page in the project view. This allows access to the user interface pages and forms for customization with a text editor. Always "Open with" the text editor. Double clicking on a file will launch the internal Firefox web browser, which will render the file, but not allow it to be changed.

Image File Formats

The Macaw system uses a multi-page version of the TIFF standard for storing image data. The exact format of the file conforms to the TIFF standards, and can be opened by any TIFF reader, or program that supports the TIFF format, including PixelWrench2 and PixelWrench for Macaw. The TIFF header for each file contains many extensions (EXIF, GP) and private tags that contain metadata that can help with image post processing. The structure of the master header is contained in the file tiff.h under the development folder /home/tetracam/lab/ttclnclude.

This header, along with ttctypes.h, may be included in an external program that needs to resolve the metadata values in the TIFF files.

The camera can perform vegetation index extractions and false color RGB renderings after a raw image is captured. These renderings are also saved in a multi-page TIFF, but without much metadata.

Pixel data in the captured files can be either 8 or 16 bit. 16 bit data are more accurate, 8 bit data can be captured faster. Average capture times for 8 bit files is 100 ms. For 16 bit files, 200 ms.

Tetracam RS232 Serial Control Commands

Camera serial port command strings consist of a lead-in character (#), a command character (A – Z, a - z), and a number of numeric arguments. The numeric arguments are strings of Hex ASCII digits either 4 or 8 characters



long depending on the magnitude of the value (16 bit or 32 bit). Separators are not required between the argument values, or between the command character and an argument. Spaces can be used as separators if desired.

Below is a table of the command characters currently implemented, and a description of the responses to be expected from the camera. Arguments are shown as <ARG16> or <ARG32> depending on their magnitude (16 or 32 bits).

#E

Erase all Image files stored in the camera's file system.

<ESC>T

Take a picture and save the image to the SATA SDD.

<ESC>X<ARG16>

This command controls the camera exposure for the next image with the value in the argument. If the value is 0, the camera performs a light measurement operation, and calculates a reasonable exposure itself. Otherwise, the exposure is set to the number of milliseconds given in the argument.

Thermal Camera Option

The Macaw camera is available with one or two Flir Tau sensors added to the camera array. The thermal sensors are identified in the bandinfo.txt file as "THERMAL" bands. If there are two, the bands can be distinguished with an additional value: THERMAL1 and THERMAL2.



Data Sizes

The thermal camera sensor is organized 640 X 512. In the Macaw, the sensor output is automatically adjusted to fit the selected size of the visible band sensors. If 1280 X 1024 size is selected, the output image from the Tau sensor will automatically be scaled to 1280 X 1024 in the saved TIF image file.

If the visible band sensors are operated in half-size mode, the dimensions of the visible and thermal sensors are matched.

Thermal Data Pixel Values

The Flir Tau2 is operated in 14 bit parallel mode. The values are automatically scaled up to 16 bit data in the saved TIF file. In this mode, the thermal camera output will appear very “flat” when rendered. Most of the field of view will be within a narrow temperature band.

The Flir NTSC video output is made available on one or two RCA jacks on the side of the unit. The video output is enhanced by the Flir native camera controller to provide a pleasing image, with a full range of pixel values.

The Flir sensor is also supported over the Macaw wireless interface in “Live View” mode. The camera live view frames are also enhanced to provide a more pleasing range of output values, and will not look like the final captured image.

The thermal bands in a captured TIF file are completely linear, allowing temperatures to be calculated from the captured data.

Visible Band Only Operation

The thermal bands can be disabled by removing the “THERMAL” band entries from the bandinfo.txt file. The camera can operate at a higher capture speed (2 frames per second) without the overhead of syncing the Tau2 sensors to the visible band snap sensors. It takes about 400 ms to sync for a still capture when the thermal bands are enabled, slowing the capture rate to about one frame per second.

When the thermal bands are enabled, only 16 bit file format is recommended. Truncating the output to 8 bit data may completely eliminate the pixel values of interest in 14 bit space. If all of the data in the image is 64 counts or less, the truncated 8 bit image will be black.

PixelWrench for Macaw Thermal Processing

The linear data saved in the TIF files along with calibration data for each sensor (collected at Tetracam during test) is used by the PixelWrench for Macaw application to provide absolute temperature values for each pixel in the image. The temperatures calculated are accurate to +/- 10%.

Thermal band data can be combined with visible band data to create false color RGB images. The RGB rendering of each band is controlled by the



definitions in the indices.txt file, as described earlier.

System Power Changes

Each Tau2 thermal sensor adds about 250 ma of current draw at 12 volts DC. This is about 3 watts per camera. The power increase is always there, whether the thermal sensors are enabled or not.

Support Info

Your Macaw system comes with a one-year warranty against defects or hardware failures. For help with problems, contact

Technical Support:

Tel: +1-818-288-4489 (8 A.M. to 4 P.M. Pacific Standard Time)

Email: support@tetracam.com

Web: www.tetracam.com



Specifications

Specification	Description/Value	Remarks
Basic		
Part Numbers	Macaw 4: TTC1024 Macaw 4 Macaw 6: TTC1021 Macaw 6 Macaw-12: TTC1025 Macaw 12	4 multi-spectral Channels 6 multi-spectral Channels 12 multi-spectral Channels
Typical Application	Aerial remote sensing of vegetation	
System Hardware	Configurable camera array of 4, 6, or 12 channels Rugged sheet metal system housing single system trigger / start button. Multi-pin I/O connector for use with accessories or testing Replaceable filter for each lens System CD with PixelWrench software USB interconnection cable Macaw control tablet computer 12 VDC external power supply Power cord (un-terminated on one end) White Teflon calibration plate Rugged Pelican Carrying Case	
System Inputs	Power (see below) USB 3.0 data connection, RS232 serial (NMEA GPS sentences),	
System Outputs	USB 3.0 data connection, Wi-Fi data from apache2 http server viewable with any web browser	
System Software	PixelWrench for Macaw is included with each purchase of a Macaw. Full featured Ubuntu Linux operating system with SSH and HTTP servers. Eclipse development environment for camera software modifications	
Commonly Ordered Options Available from Tetracam	Macaw GPS/IMU Macaw GPS/IMU/ILS Ground Calibration Targets Full Icaros OneButton mosaicking software license	



Specifications (Continued)

Specification	Description/Value	Remarks
Physical		
Weight	Macaw 4: 1.3 lbs. (550 g) Macaw 6: 1.4 lbs. (600 g) Macaw 12: 2.5 lbs. (1100 g)	
Dimensions (mm)	Macaw 4: 131.4 x 78.3 x 87.6 Macaw 6: 131.4 x 78.3 x 87.6 Macaw-12: 154.4 x 78.3 x 87.6	
Environmental	<p><i>Temperature</i> 0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 104 degrees Fahrenheit)</p> <p><i>Humidity</i> Less than 85% relative humidity, non-condensing</p>	Note: the camera will operate outside of the recommended environmental range, however performance may be degraded.
Power		
Voltage Input	+ 9 VDC to + 18 VDC Center Positive	
Current Draw at 12V:	Macaw 4: 1500 ma typical Macaw 6: 1700 ma typical Macaw 12: 2500 ma typical	
Sensor		
Description	1.3 mega-pixel CMOS Snap sensor (1280 X 1024 pixels)	
Quantity per System	4, 6, or 12 per system	
Sensitivity	~380 nm to ~ 1000 nm	
Dimensions	6.66 mm x 5.32 mm	
Pixel Size	4.8 microns	



Specifications (Continued)

Specification	Description/Value	Remarks
Filters		
<p>Filters Standard with Macaw 4:</p> <p>Filters Standard with Macaw 6:</p> <p>Filters Standard with Macaw 12:</p>	<p>- 490FS10-25 - 550FS10-25 - 680FS10-25 - 800FS10-25</p> <p>- 490FS10-25 - 550FS10-25 - 680FS10-25 - 720FS10-25 - 800FS10-25 - 900FS20-25</p> <p>- 490FS10-25 - 520FS10-25 - 550FS10-25 - 570FS10-25 - 671FS10-25 - 680FS10-25 - 700FS10-25</p> <p>- 720FS10-25 - 800FS10-25 - 840FS10-25 - 900FS20-25 - 950FS40-25</p>	<p>Each system holds 4, 6, or 12 user-selectable field-changeable 25 mm standard narrowband spectrometer filters (1 per channel in bandwidth increments > 1 nm). Typical bandwidth increments equal 10 nm.</p> <p>Filters are identified by a part number. The first three digits in this identify the center wavelength in nm. The two digits following the "FS" indicate the bandwidth in nm. The two digits after the dash indicate the filter diameter in mm.</p> <p>Macaw filters are customer designated at the time of order. These are field-replaceable by the user with standard 25mm spectrometer filters in order to re-task the system with the following limitations. Since wavelength impacts focus, a replacement filter should only replace a filter that is near the wavelength of the filter originally installed in the system in that channel position. In the visible spectrum, replacing a filter with a new one that is within ±100 nm of the original is acceptable. Beyond 700 nm, replacement filters should be within ±50 nm of the original. Replacement of filters beyond this range requires factory re-focusing of the unit.</p> <p>Alternative band pass filters are available upon request with quotation.</p>
Lenses		
Focal Length	9.6 mm fixed lens	
Aperture	f/3.2	



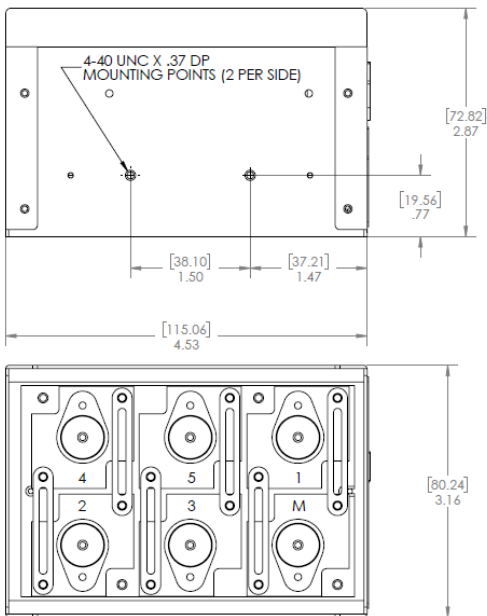
Specifications (Continued)

Specification	Description/Value	Remarks
Images		
Horizontal Angle of View	38.26 degrees	
Vertical Angle of View	30.97 degrees	
Default Depth of Field	-2 meters to infinity	
Image Triggering Mechanisms	Manual shutter switch, auto-timer (Menu-settable), GPS offset (menu settable), external trigger, external start/stop, computer trigger via wireless, or RS232 serial.	
Image Exposure time	Auto or menu-selectable in ms	
Default Image Dimensions	1280 x 1024 pixels (1.3 MPel)	Macaw image size may be adjusted to an alternate image size (640 x 512) via menu selection
Default Image Storage	Images are stored on a dedicated SATA SSD drive in either 16 bit TIFF format, or 8 bit TIFF format	
Native Image File Formats	16 or 8 bit multi-page TIFF (no compression) Full or half size image capture	Other file formats can be generated by using PixelWrench for Macaw as a converter, or built in Linux conversion routines in the camera
Image Capacity	Multi-page TIFF size: 2.6MB per band, times the number of bands. Typically 16 megabytes. 8 bit format is 8 megabytes	13000 pictures in 256 GB SATA SSD at full resolution and 16 bit TIFF format
Image Capture Rate (Single Shot)	500ms (2 per second) without background processing	

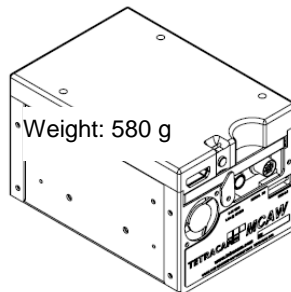
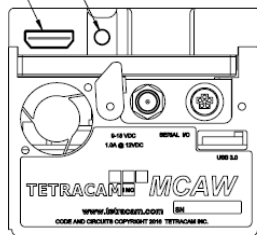


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Macaw -6 Dimensions



TRIGGER BUTTON / STATUS LED
SYSTEM CONNECTOR



REV.	REVISION DESCRIPTION	DATE	APPROVED

② FINISH:

① MATL:

NOTES: UNLESS SPECIFIED OTHERWISE

FORM NO.	PART OR IDENTIFYING NO.	SCHEDULE/CLASSIFICATION OF DESCRIPTION	MATERIAL SPECIFICATION	QTY REQD.
PARTS LIST				
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE AS SHOWN		CAD GENERATED DRAWING DO NOT MANUALLY UPDATE		
APPROVALS DATE		TETRACAM INC		
DRAWN BY S. HEINOLD 12/13/16		21601 DEVONSHIRE ST., SUITE 310 CHATSWORTH CA, 91311		
CHECKED BY		818 667-1731 FAX 818 718-7103		
MATERIAL ①		ENVELOPE, MCAW 6CH.		
NEXT ASSY USED ON ②		SEE DWG. NO. MCAW-019		
APPLICATION		1 of 1		

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