
Tetracam RGB + 3 User Guide



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About This Manual

This User Guide contains general information about Tetracam's RGB + 3 imaging systems. The guide is intended to familiarize users with installation, operation, features and specifications, options and accessories, warranties, and technical support of these systems.

The purpose of this User Guide is:

1. To guide the user through the installation of the product and its supporting software.
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 7, Windows Vista, or Windows XP operating system. 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 installation CD.

Support Info

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

Technical Support:

Tel: 818 860 6814 (8 A.M. to 4 P.M. Pacific Standard Time)

Email: support@tetracam.com

Web: www.tetracam.com

Additional Resources

For additional information, visit <http://tetracam.com>





SECTION 1: INTRODUCTION

As the name suggests, a Multi-Camera Array consists of multiple cameras that are grouped into a common array and packaged in a single platform. Tetracam currently manufactures two types of Multi-Camera Arrays, the Micro-MCA (abbreviated μ -MCA) and the **RGB + 3**. These Multi-Camera Arrays are used for both ground and aerial remote sensing applications.

All cameras in a Multi-Camera Array are registered and synchronized so that each camera captures the same scene at the same instant in time. Each camera in the array is equipped with a separate imaging filter. Filters are specified by the customer for installation during manufacture between each camera's lens and its sensor. This enables each camera in the array to capture an image of the scene viewed at a different wavelength. In this way, Tetracam's MCAs may be used to identify unique spectral signatures that enable users to distinguish healthy from stressed vegetation, differentiate one plant species from another, discern ripe from unripe crops, extract vegetation indices such as NDVI or identify some other spectral property or properties possessed by the subject under study.

μ -MCA System Overview

Tetracam's μ -MCA is an updated version of the company's earlier Mini-MCA. The new system is smaller, lighter, faster and more feature-filled than the Mini-MCA. The μ -MCA is delivered with a faster USB interface (USB 2.0 rather than 1.1) and a larger default image memory (16 GB rather than 2 GB per camera). The system's faster interface



makes image transfer ten to forty times faster than the Mini-MCA. The larger image memory enables users to capture up to 12000 images during each imaging mission. This system also possesses control buttons for selecting system menu functions or triggering image capture, a 16-pin circular multi-IO connector, a video interface, serial interface, a connection to an electronic incident light sensor and a power input.

The μ -MCA is available in two sub-models, each with two sensor variations. The μ -MCA6 contains six digital cameras. The μ -MCA12 contains two side-by-side μ -MCA6 systems. Each sub-model may be ordered with all cameras equipped with either rolling shutter sensors or global snap sensors. At the time of order, users specify the filters to be included with their system. Filter values may range from ~450 nm up to ~1000 nm with rolling shutter sensors or from ~350 nm in the ultraviolet through the entire visible spectrum up to ~950 nm with global snap shutter sensors.



RGB + 3 System Overview

Tetracam's second Multiple Camera Array system is the RGB + 3. This system consists of four cameras that are each equipped with a fast global snap sensor. The camera in the upper right section of the system (as pictured at right) is normally equipped with a color sensor. The color sensor senses broad bands of red, green and blue visible light with the following approximate wavelengths: Red: 570 nm – 700 nm, Green: 480 nm – 550 nm and Blue: 400 nm – 470 nm. The remaining camera's sensors may be equipped with user-specified narrow band filters. Filter values may range from ~350 nm in the ultraviolet through the visible spectrum up to ~950 nm in the near-infrared.



RGB + 3 systems may be ordered with a fourth monochrome sensor with the same filter values as the other monochrome sensors substituted for the color sensor. This system is identified as a system is identified as a μ -MCA4 Snap. The RGB + 3 systems come standard with four 16 GB MicroSD cards, control buttons for selecting system menu functions or triggering image capture, a 16-pin HDMI multi-IO connector, a video interface, serial interface, USB 2.0 interface and a power input.

MCA Options and Accessories

All Tetracam Multi-Camera Arrays include PixelWrench2 software. This software enables users to configure system menus inside the cameras. It manages transfer and conversion of camera images, interpolation of GPS coordinates for each image and extraction of vegetation indices such as NDVI from the captured images. The software includes a number of other utilities helpful for remote sensing vegetation or planning sensing missions.

Common options available with all MCA systems include FirePoint GPS, UV lenses and filters, larger USB MicroSD cards, Six Pack MicroSD Memory Readers, Bluetooth Wireless Camera Interface, Camera Calibration Service, third-party mosaicking software, electronic-Incident Light Sensors (for μ -MCA only) and/or an HDMI breakout box (for RGB + 3 systems only).

Currently Manufactured Multi-Camera Array Systems

<u>Tetracam MCA System</u>	<u>Part Number</u>
μ -MCA 6	TTC-1064
μ -MCA 12	TTC-1065
μ -MCA 6 Snap	TTC-1074
μ -MCA 12 Snap	TTC-1075
RGB + 3	TTC-1087
μ -MCA 4 Snap (in RGB + 3 package)	TTC-1088



Section 2: RGB + 3 System Hardware

The RGB + 3 multi-spectral imaging system consists of four global snap cameras packaged in a single platform. All cameras take pictures at the same time with minimal registration errors between the images. These registration errors are corrected during factory alignment of the system. The .mca alignment file is supplied on a CD included with the unit.

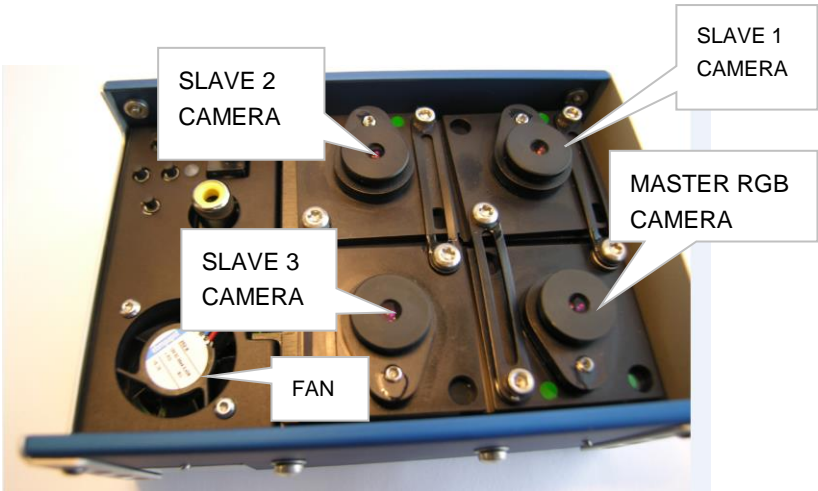
The system is also supplied with a .cpf file. The .cpf file adjusts the red, green and blue bands of the system's color sensor for operation in standard lighting conditions. The .cpf and .mca files should be loaded into PixelWrench2 when the system is initially received.



The fan-cooled RGB + 3 system is equipped with controls, indicators and IO connections that enable users to interact with the system on the ground or via remote command in the air. System Control buttons enable users to control camera configuration by an internal system menu or to manually trigger image capture. A Status LED glows red when the system is busy or green when the system is ready to capture images. An HDMI IO connector on the rear of the unit enables wired connection to signals that enable system menu navigation, GPS data transfer or video transmission. Additional discreet connectors are provided to transmit video from the unit, receive GPS data, power the unit, and access images via a fast USB 2.0 interface.



All cameras in the array are visible from the bottom of the unit. With the fan in the lower left corner of the platform, the camera in the right corner is designated as the MASTER camera. In RGB + 3 systems, this is the RGB color camera. The MASTER camera is responsible for synchronizing the other cameras (SLAVES), calculating exposure requirements, and logging GPS geo-referencing information.



Each camera in the array has its own file system and its own MicroSD image memory for saving images. The color sensor senses broad bands of red, green and blue visible light with the following approximate wavelengths: Red: 570 nm – 700 nm, Green: 480 nm – 550 nm and Blue: 400 nm – 470 nm. The remaining camera's sensors may be equipped with user-specified narrow band filters. Filter values may range from ~350 nm in the ultraviolet through the visible spectrum up to ~950 nm in the near-infrared. Filters are commercially available from companies such as Andover Corporation.

Images captured on the system's MicroSD cards are transferred to a host PC for processing by PixelWrench 2, the software that comes with the system, by removing and reading the MicroSD image memory cards, or by plugging in a USB cable to the USB Hub controller built into the unit.

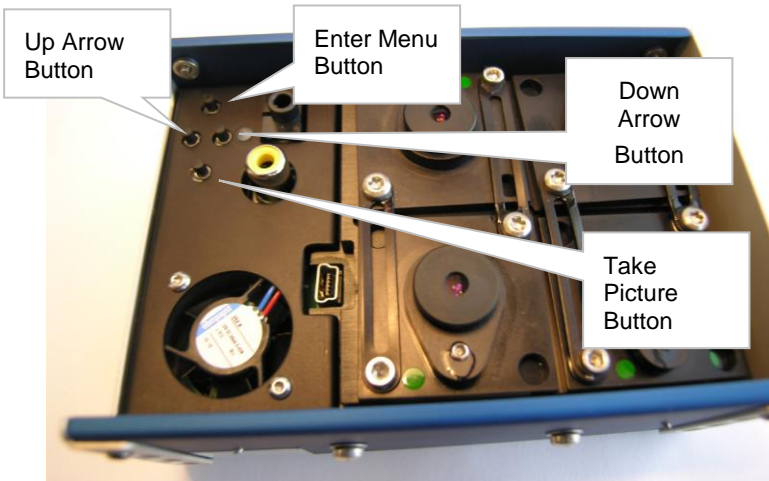


RGB + 3 Controls and Indicators

The RGB + 3 system hardware is housed within a rugged sheet metal assembly. The dimensions of the platform are 115 mm x 80.3 mm x 50 mm. Camera weight is 400 grams (0.88 pounds). The system is designed for use in aerial manned and unmanned aerial photographic missions or for operation in towers located on the ground. In the air, system operation is generally performed by remote commands but the unit contains System Control Buttons for testing and configuration on the ground.

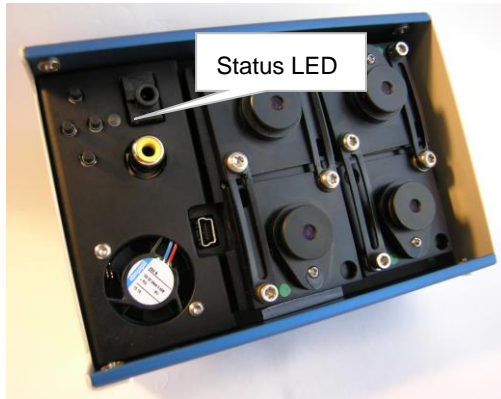
RGB + 3 System Control Buttons

The System Control Buttons are adjacent to the down-facing cameras and accessible from the bottom of the unit. The upper button enables the user to select a system menu choice. The button nearest edge of the camera enables users to move up through the system menu. The button to its right enables users to move down. The bottom button nearest to the fan enables users to manually take a picture or to initiate the auto timer to begin taking pictures at an interval pre-programmed in the system menu.



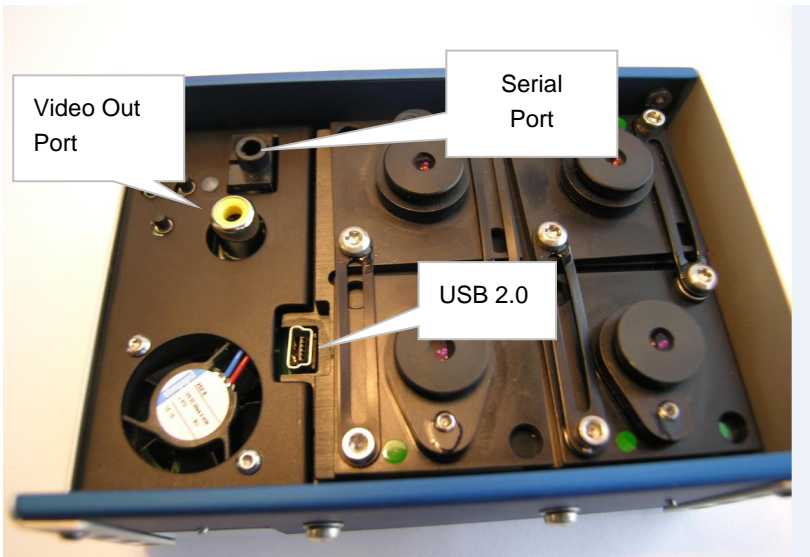
RGB + 3 Status LED Indicator

The Status LED Indicator is located in two positions in the RGB + 3 system. On the bottom of the unit, the LED is located just to the right of the Control Buttons. On the back of unit, the LED is located just to the right of the HDMI multi-IO connector. This 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.



RGB + 3 System Connectors

Serial Port – Two ports are located to the right of the System Control Buttons. To the immediate right of the buttons is the RS232 Serial port. This is used for connecting an optional GPS receiver or for sending serial commands to the camera from auxiliary devices such as a BlueTooth transmitter/receiver. The connector is a 3.5mm stereo phone with plug tip, ring and sleeve carrying camera receive, video transmit, and ground, respectively.



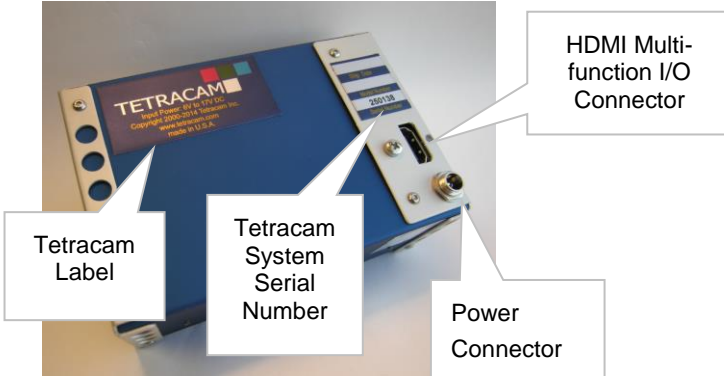
Video Out – Below the Serial Port is the video signal output. Video is output in NTSC format or, by special order, in PAL format. The Video Out Port is able to act as the Master camera's viewfinder, displaying the image in the view by the Master camera, or it is able to display the System Menu.

USB Connector – The USB 2.0 data connector is located between the fan and Slave Camera 3. 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.

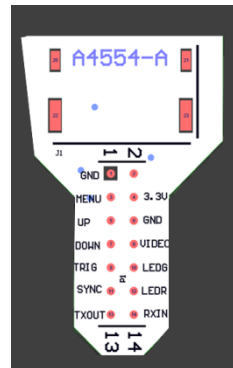


The back of the RGB + 3 unit contains the Tetracam system label with the system serial number as well as Power and HDMI connectors.

Power – The Power input is a round connector located on the lower right hand side of the RGB + 3 unit. The system 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 it can handle input voltages between +9.0 VDC and +14.7 VDC. The power connectors are center positive. The total current drawn by the unit at any moment depends upon its level of system activity (i.e., whether the system is capturing and saving an image or not). Typical current draw for this systems is 500 mA (approx.).



RGB + 3 Utility Cable – The 16-pin HDMI Multi-function I/O connector carries signals to enable viewing video, navigating the menu, taking pictures, and connecting GPS. RGB + 3 units are shipped with an 18 inch (45.72 cm) male to female HDMI cable and a key-shaped HDMI Breakout Connector board (see drawing at right). A female HDMI connector is soldered on the top of the key-shaped board. Together the cable and connector is identified as the RGB + 3 Utility Cable. Pins on the board are labeled to allow users to connect wires for remote connections to: GND (ground), MENU (menu select), 3.3 Volts, UP (move menu cursor up), DOWN (move menu cursor down), VIDEO (Video out), TRIG (remote trigger – connect ground to trigger), LEDG – (high when system is ready), LEDR – (high when system is busy), Sync (identifies the exact instant at which GPS spatial coordinates were captured), RXTN (carries the transmitted GPS coordinates into the RGB + 3 system), and TXOUT (acknowledges receipt of GPS signals).

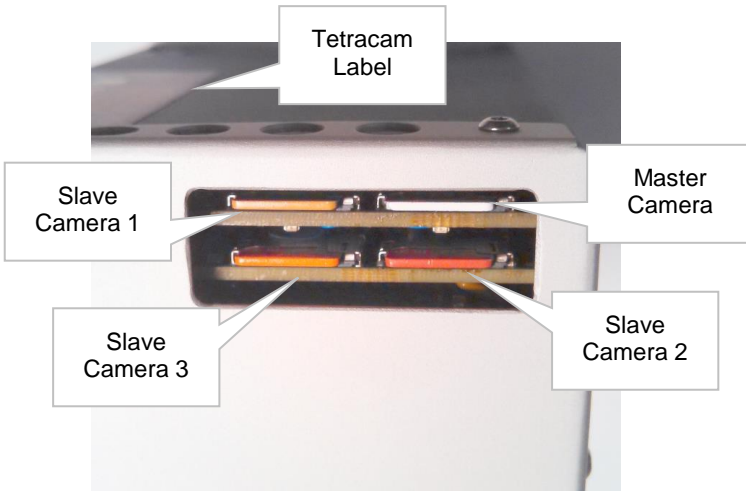


RGB + 3 Image Memories

The RGB + 3 employs one 16 GB MicroSD Card for each one of its four cameras. Viewing the Tetracam label on the back of the unit, the system's images memories are all accessible on the left side of the unit.



The image memory stores images in the system's native image file formats (DCM10, RAW10, RAW8 and RWS10). When images are transferred from each sensor to each image memory, the system's Status LED turns from green to red signaling that the system is busy and unable to capture additional images. The image memory also stores GPS coordinates that are streamed to the system from an optional external GPS receiver. Upon completion of each mission, the content of each image memory is transferred to the host computer for processing by PixelWrench2. Image memories from 512 MB to 32 GB may be used in place of the default 16 GB MicroSD card. The unit's power should be turned off when any memory card is replaced.



RGB + 3 Lenses, Filters and Sensors

Each RGB 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.



RGB + 3 Lenses

The RGB + 3 uses small miniature lenses with fixed apertures and focal lengths. Each channel of the RGB + 3 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.

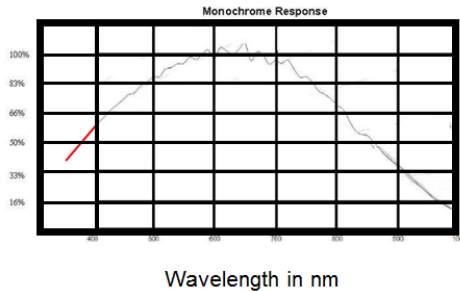
RGB + 3 Filters

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 vignetting. 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 customer may specify alternate or additional filters with their order. These may change the overall price of the system. Consult Tetracam's web site for the current list of standard filters for each system.

RGB + 3 Global Snap Sensors

The filters for RGB + 3 cameras with global snap sensors are specified at the time of order. The graph below shows the relative efficiency of the CMOS global snap sensor for different bands of ultraviolet, visible and NIR light. When it is installed at the factory, the filter with the highest photovoltaic efficiency (i.e., the filter nearest to 800 nm in the graph) is selected for insertion in the Master channel position. Each slave channel's exposure time is then set as a multiple of the Master channel exposure time.

Global Snap Sensor
Relative Sensitivity



The added sensitivity of global snap sensors wavelengths below the visible spectrum enables systems equipped with these sensors to view bands of radiation in the ultraviolet from approx. 350 nm to 400 nm. Systems equipped with these sensors are able to view floral patterns visible by bees or spot arc-ing in electrical power lines. Ultraviolet bands require special UV filters. Since glass lenses block UV radiation, sensing these bands also requires special lenses. UV lenses and filters are quoted at the time of order.

RGB + 3 Filter Replacement by Users

Users may replace filters in the field with standard 25mm spectrometer filters in order to re-task the system with the following limitations. 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 generally requires factory re-calibration of the unit. Contact Tetracam Technical Support for guidelines on customer re-calibration of the system or contact Tetracam Repair Depot to obtain a Return Material Authorization number to return the unit to Tetracam for re-calibration.



RGB + 3 Video Display (Optional)

The RGB + 3 system includes an optional 4.3 " Video Display. This is shipped with a + 12 VDC Video Power Adapter for powering the display and a 6' Video Cable for connecting the Video Display to the system's Video Out port. The red connector connects the Video Display to the Video Power Adapter. The monitor may be connected to the Video Out Port using either the yellow or white connectors. Connect the Video Display to view video output from the system's Master camera.



Section 3: Common Hardware Options

GPS Receiver

Tetracam supplies a pre-configured FirePoint 100 GPS receiver that provides the NEMA strings needed to reference captured images geographically. The unit comes with a cable wired correctly for the μ -MCA or RGB + 3 serial port, and has a separate 8V to 14V DC power connection. A 2mm plug and cable is shipped with the GPS unit to simplify installation. The GPS and camera ship from the factory configured for transferring data at a 4800 Baud rate.

Six Pack micro SD Card Reader

The Six Pack micro SD Card Reader is provided to facilitate transferring micro SD memory cards from a μ -MCA or RGB + 3 system after a mission is complete (and thereby, freeing the MCA for further remote sensing operations). The reader enables simultaneously linking six image memory cards to a host computer for processing by PixelWrench2.

When the Six Pack is populated with a set of cards from a mission, it looks exactly like the camera array to PixelWrench2, and all camera processing operations can proceed as if the host computer were connected to an MCA. Each Six Pack is provided with a two-amp 24 watt power supply. This delivers sufficient power to connect up to six micro SD memory cards simultaneously plus a seventh micro SD card that may be



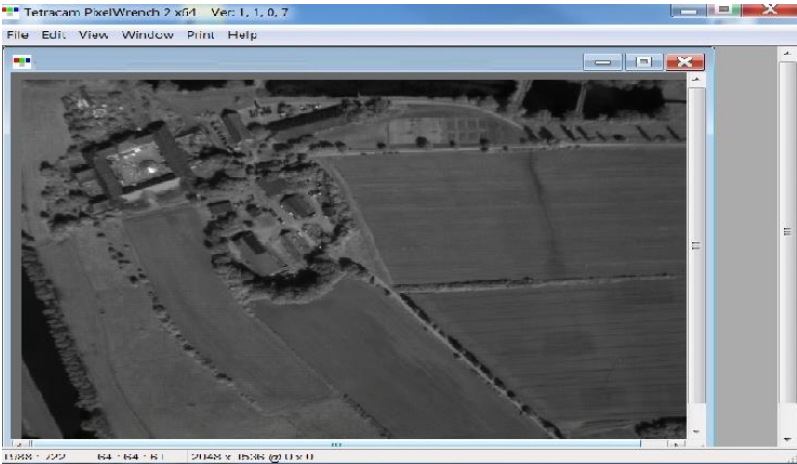
plugged into a Daisy-Chain socket on the side of the unit.

The Six Pack contains an extension socket for “Daisy Chaining” another Six Pack. This would be necessary when using two Six-Pack units with a μ -MCA12. The Daisy-chain Socket is also used if a μ -MCA has an ILS or e-ILS. The memory card from the ILS should be installed in the daisy chain connector using the single card SD reader that is included with the ILS unit.



Section 4: Software

The CD included with your system contains PixelWrench2 as well as other utilities, files and documentation that are helpful for setting up and operating your system. PixelWrench2 (PW2) is a powerful image editing program that is included with each *RGB + 3* system. This software runs on any IBM-compatible personal computer running Windows 7, Vista or XP operating system (see PC System Requirements for additional details). The licensed software includes tools specific to multi-spectral images.



PixelWrench2 oversees transfer of images from the system's image memories to the host computer. It provides tools for management of image sets, color processing of Tetracam RAW and DCM files, complex batch processing tools, extraction of several vegetation index and canopy segmentation images as well as a comprehensive suite of image editing tools. PixelWrench2 translates Tetracam's proprietary DCM10, RAW10 and RAW8 image files into standard image file types (BMP, JPEG, TIF, PNG etc.) PixelWrench2 includes various tools that support image processing operations. TifExport, for example, is a tool that converts μ -MCA images to multi-page TIF files of any page depth (usable by GIS applications) and enables users to view any combination of three bands as a single color image and view a histogram, pixel-wise spectral signature or metadata associated with that image.

The GPS Log Distiller in PW2 provides controls for setting all important camera operating parameters and creating and editing camera alarm files. Distiller provides a multi-threaded file transfer function for moving image and log files from the camera(s) to hard disk. Distiller also refines the camera-produced log files into compact *.GPS files and KML files useable with Google Earth.

PixelWrench2 also includes a Field of View 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.



Section 5: System Set Up

Unpacking Your System

Your new RGB+3 multi-spectral imaging system is packaged in a rugged plastic carrying case. This is what you should find in the case.

An RGB + 3 Multi-spectral Imaging System

A CDROM with PixelWrench2 and other software supporting the camera
Product and Accessory Documentation

A USB interconnection cable

A Control Cable

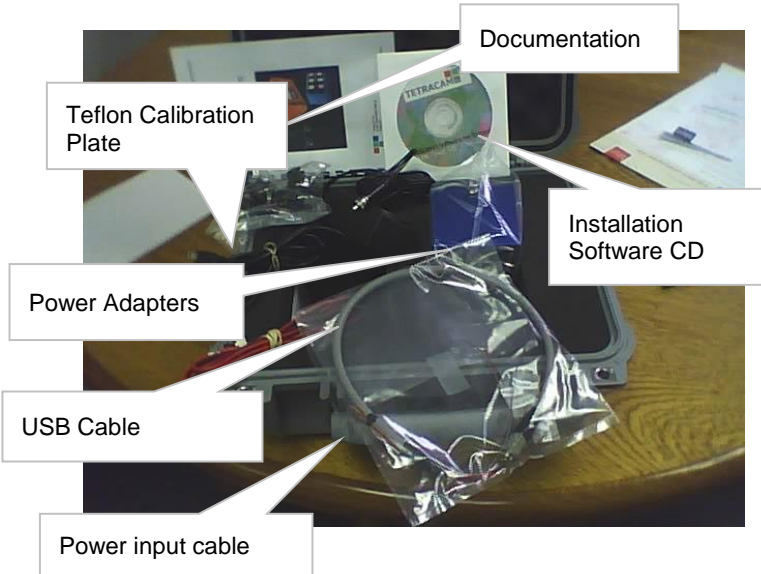
A 16 GB Secure Data Memory Card for each camera in the array

An AC Power Adapter and Power input cable

A White Teflon Calibration Plate

A 4.3 " Video Display with cable and Power Adapter (optional)

Your MCA comes with a one-year warranty against defects. You should send in the warranty card to register the camera and qualify for additional software and firmware updates.



PixelWrench2 Software Installation

Any IBM-compatible personal computer with a free USB serial jack can be used to retrieve pictures from the RGB + 3 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 7, Vista or XP operating system
- 512 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 10 GB or more free space

In order to install PW2, run the file Setup.exe located in the PW2 folder. The root folder of the CD also contains the image alignment file for your particular camera. Its name is xxxxxx_global. μ -MCA where xxxxxx represents your camera serial number.

If your computer does not have the Microsoft .NET 3.5 framework installed, the PixelWrench2 installer will try to open Microsoft.com and download a file called dotNetfx.exe. This is the installer for .NET 3.5. This file is also on the CD in the root directory where you can run it directly prior to installing PixelWrench2.



Quick Start Instructions

Install PixelWrench2 before connecting the camera to the computer. This program is needed to manage connections to the camera and to extract useful data from the sets of visible light and NIR images the camera captures.

Included on the CD that comes with all MCA systems is an *.mca file. By convention, the factory supplied file is named XXXXXXGlobal.mca (where XXXXXX = the camera serial number). This file contains X and Y translation, rotation and scaling values for each camera. Upon receipt of your system, load the .mca on the CD into the /Support file in PixelWrench2. To load the file into PixelWrench2, click on OPEN MCA under the MCA tab of in the Index Tools module. Once loaded, the software will use the loaded registration values for the system.

Included on the CD in an RGB + 3 system is a cpf file. Upon receipt of your system, load the .cpf on your CD into the /Support file in PixelWrench2. If the *Autoload cpf files by camera serial number* box is checked on the Matrix tab of Index Tools, PW2 will search the /Support folder for a *.cpf file with a name containing the serial number in the current image. This cpf file causes the software to automatically set image values appropriate for their camera in normal lighting conditions.

Connect the Video Display to the Video Display Power Adapter (12 V) and to the system's Video Port.

Connect the unit to a DC power source. The system will accept power input between 9.0 VDC and 14.7 VDC, such as power commonly available in vehicle power supplies.

As the system boots, observe it runs system diagnostic checks. During this time, the Status LED will be illuminated red indicating that the system is Busy and unable to capture images. When the Status LED changes to Green, the system is Ready to capture images.

Prior to beginning any mission, you should capture an image of the included Teflon Software Calibration Tile in the sunlight. This tile equally reflects visible and near-infrared radiation. Taking a picture of the tile prior to beginning a mission enables PixelWrench to adjust color ratios for variations in lighting.

Once your remote sensing mission is completed, view your images on a computer. To do this, you may remove the Image Memory cards and install them in a separate card reader, or plug the camera into the USB interface on your computer.

When connecting the MCA system to a computer's USB port, Windows will recognize the system as a USB Mass Storage Device. From PixelWrench2, you may open previews of the images on the memory card in the camera, and extract them for viewing and analysis. Consult the PixelWrench2 Help Menu for more detailed instructions. When finished, disconnect Power.



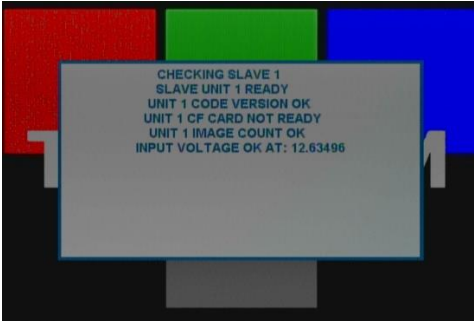


Section 6: Operation

In most cases, operation of the μ -MCA and RGB + 3 systems are identical. The operational controls pictured in the following section are illustrated using a μ -MCA. The operational instructions, however, apply to both the μ -MCA and RGB + 3 systems unless otherwise noted.

Viewing Your System's Video Output

Once the system is powered on, it enters a diagnostic mode in which the slave and master cameras in the system are checked for consistency and operability. You can view progress of the diagnostics by connecting the Video Display to your Video Out port. Included in the consistency checks are image count, memory card status and firmware revision. The results of each test cycle are displayed on the video output as they occur



Camera Control

There are buttons built into the camera to be used to setup and manually control the camera. Separate connectors are provided for Video out and RS232 communications. A trigger button is provided for manually taking pictures, or starting and stopping the continuous capture process.

Controlling the Viewfinder

In daylight conditions, a properly set exposure will produce a good viewfinder image so that NIR data is not over-exposed. Exposure can be set automatically by the camera, or can be entered as a fixed value. Once the viewfinder image is satisfactory, capture can be initiated with the TAKE PIC button on the controller. The Status LED will turn from green to red, indicating that the camera is busy capturing and saving the image. After a capture, the camera completes the compression and storage of the image and the status LED returns to green indicating the camera is ready.

More about the Viewfinder

The live viewfinder screen is the normal ready-state of the camera. From this state, the user may enter the menu system using the MENU / SELECT button, or capture images using the TAKE PIC button.

With an external video monitor connected to the camera's video out port, a live video image of what the camera "sees" will be shown on the screen.



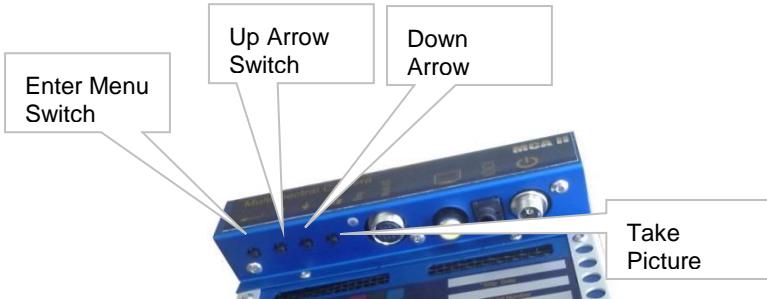
GPS Position – With a GPS receiver connected and communicating with the camera, position coordinates will be displayed. If the GPS receiver loses its signal lock, "WAITING FOR GPS" will be displayed in RED until it recovers its signal lock.

The live view screen is active until a still image is captured. Live view resumes when the image has been completely stored. If there is little or no time between pictures in continuous capture mode, the unit will not display video between captures. In either RAW or DCM format, the picture interval needs to be at least 4-6 seconds if a useful amount of video display between shots is required.



Using the Graphical User Interface

The camera configuration values can also be managed from the graphical user interface. The interface is accessed from the four buttons on the camera and viewed on the video display attached to the system's Video Out port.



Navigation begins when the enter key is pressed. The first screen shows icons for the setup screens that are available to the user. The icons start small (1/2 size) and get larger when one of them is selected with up and down arrow keys. In the illustration below, the tools setup icon has been chosen. This screen is used to delete images and format memory cards. These settings are preserved through power cycles. Pressing enter activates the tools screen.



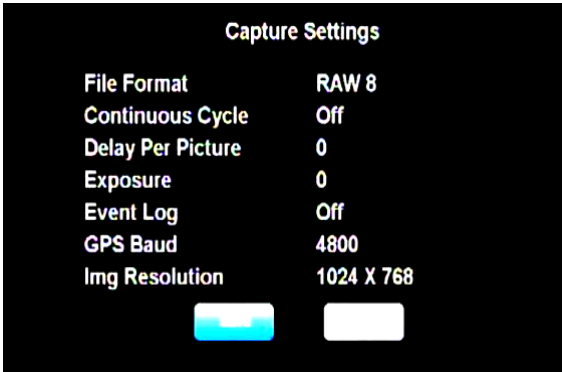
Inside the text screens, the enter button is used to move from field to field, and the up down arrow are used to change the value of a field. The picture taking switch is used to complete the operation. The only time that the changes made are saved is when the picture taking switch (Exit) is used and the SAVE button is selected.

When the Exit switch is pressed while viewing the icon screen, live view is resumed. The tool screen consists of four action buttons, each labeled with the appropriate action:



The Tools Icon provides an entry point for deleting images in the camera and restoring factory defaults. The selection dialog is presented on the right:

In the screen below, the capture icon has been selected, which brings up the Capture setup text screen. The values controlled here determine how the camera will take pictures on its mission.



File Format selects if picture data will be compressed, or saved as it comes out of the sensor (RAW) for speed.

Continuous capture mode causes the camera to continue to take pictures after a single button press, with a delay between them, as controlled by "Delay Per Picture"

Exposure allows the user to select a fixed exposure time for the mission, so that the brightness of different shots will not change as the subject changes. If a fixed exposure is not set, the camera's automatic exposure feature will calculate an optimum exposure for each shot.

The Event Log, discussed in an earlier section can be turned on and off in this setup screen.

The GPS baud can be one of 6 values: 4800, 9600, 19200, 38400, and 115200.

The camera can capture still images at reduced resolution to speed up the camera cycle time. Choose 2048 X 1536 for full resolution shots and 2+ second cycle time. Choose 1024 X 768 for half resolution and .8 second cycle time.

The camera has a real time clock which can be set from the user screen. Normally, it is better (more accurate) to allow the camera to set the clock from GPS messages, but when no GPS is available, or the GPS cannot be configured to emit the GGZDA string, manual setting can be carried out as shown in the example. As with all setup screens, enter navigates between fields, and up/down arrow changes the value. Pressing the shutter switch (exit) when the save button is selected makes the changes permanent.





The clock settings are standard except for the UTC offset field. Here the user enters the difference in hours between local time and UTC (Greenwich, U.K.). The default UTC value is pacific daylight time (Chatsworth, CA), or -8. Selecting the Info Icon results in a display of camera status: Available memory, picture inventory, and camera firmware revision.



Choosing an Image Format

The 10 Bit RAW file format provides the highest rate of capture, at about one picture per second. The speed depends in part on the features of the MicroSD card. For users who want to use less storage, the 8 bit RAW format is the next fastest.

The RAW files are quite large – 6 megabytes for the 10 bit format and 3 megabytes for the 8 bit format. Compression (DCM format) cuts the size of the files in half, but takes longer to capture. We therefore think of DCM compressed continuous mode as “low speed”.

Besides the smaller file size, another advantage of the DCM format is that the files contain previews that speed up the image access speed using PW2.

The RWS format is the fastest format for saving images captured by global snap sensors. These sensors output data in an irregular pixel order. Data is saved in that order to minimize the time required to save the file during image capture. PixelWrench2 is used to re-order the pixels during post-processing.

The table below shows the relative advantages and disadvantages of camera file formats. These apply to all modes of operation.

File Format	-----Advantages-----	-----Disadvantages-----
RAW 8 bit	Small storage space, faster cycles than DCM	Less dynamic range, no embedded previews
RAW 10 bit	Fastest cycle time and full dynamic range	Big files, no embedded previews
RWS 10 bit	Fastest format for saving images from cameras with global snap sensors	Images are stored in a format that requires re-ordering pixels during post-processing with PixelWrench2
DCM 10	Smallest file size with full dynamic range	Longest time between pictures (up to 3 seconds)



Configuring Continuous Capture Mode

The simplest way to map large areas with the MCA is to place the system in Continuous Capture mode with a delay that will ensure adequate overlap of adjacent images along the line of flight. The recommended image overlap is at least 75% frontal overlap along the line of flight and at least 60% side overlap (between adjacent flying tracks). You can use the FOV calculator in PixelWrench2 to determine the altitude above ground level (AGL) that you will need to fly your plane in order to attain the desired resolution and the best delay to set up between successive shots given your aircraft's airspeed.

Say you wanted to know how much detail your image would show when flying a UAV at 400 feet above the ground. The FOV calculator tells you that the field of view that each μ -MCA camera sees at 400' AGL is an area 75 meters (246 feet) wide by 67 meters (220 feet) high or, in other words, an area approximately equal to three rows of six standard tennis courts 23.78 meters (78.0 feet) long by 10.97 meters (36.0 feet) wide. It also tells you that the camera's resolution at that height is 66 mm (2.5 inches) per pixel or about the size of a standard tennis ball. If you wanted a different resolution you could use the FOV calculator to determine a different height AGL to fly your aircraft.

The MCA is able to capture one Raw 10 bit image every second. If the delay between pictures were set to one second then in order to obtain a 75% image overlap along the line of flight, the camera would have to be ready to take a new picture before it had traveled 25% of the distance into the new picture. Since the cameras are generally set up to capture images perpendicular to the line of flight of the aircraft, the overlap would be along the vertical axis of the image. So, in one second the aircraft would have to traverse no further than $\frac{1}{4}$ of the image height at 220 per second/4 (or 55 feet per second or 37.5 mph) in order to attain the required overlap. If it flew faster, it would pass the 75% overlap point before one second elapsed. If the aircraft flew slower then the Continuous Capture Delay setting would need to be set to a longer delay between pictures to attain the 75% overlap.



GPS Option Installation and Use

Your RGB + 3 will capture and append the most recent GPS data string to each image as it is taken. The following requirements apply; Your GPS receiver must be configured to output the standard NMEA RMC and/or GGA sentences. The default output protocol for NMEA sentences is 4800 baud, 8 data bits, 1 stop bit, no parity. Your receiver should allow you to configure it for RMC and/or GGA at 4800:8:1:N. If your GPS receiver can be configured for a higher Baud, you should take advantage of the feature, since it will make the GPS data more accurate since less time would be lost transferring the messages. The menu in the camera has an entry for the GPS Baud. There is also an advanced setup screen, accessible via Pixelwrench2 that save a higher baud rate.

The GGA sentence is emitted once 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 receiver.

The most recent GPS sentence sent to the camera will be appended to the image data file. You can view the GPS data in the image using Pixelwrench2. 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 10 milliseconds.

The camera also has two features you can turn on in the setup called GPS HEARTBEAT and GPS DISPLAY, which will toggle an indicator on the viewfinder screen each time it receives a new GPS sentence and will show the last GPS position received. This is useful to see that the camera is properly receiving GPS data.

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 LOG EVENTS is set to ON in the CAPTURE METHOD screen, 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 GPS receiver 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 root folder. If there is a pre-existing CURRENT.LOG file, the file is moved to the image folder (TTCMCA0 in the case of the μ -MCA master camera) and renamed according to the image numbers that were captured while the camera was last in operation. Only the master camera channel logs GPS data and image events.

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 00310034.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 and NULL. The NULL characters are hidden, and additional line feeds are added for clarity in the illustration.

Log files are much easier to manage if the camera is set up to operate in the USB Disk mode described earlier. The Log files are not directly accessible from Pixelwrench2 using the stream interface. When the camera shows up as a folder window on the desktop, as it does in USB Disk mode, the moving and deleting files is trivial.

You can use the GPS Distiller tool to manage image and GPS log files. See the PW2 help file for more information on how PW2 uses the distilled log files to refine the embedded GPS data in each image.



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 00000104 Date/Time: 10/22/2009 15:15:01
GPS 000002006 00217 $GPRMC,192254.00,A,2942.79012,N,08223.3066,W,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
GPS 000002064 00217 $GPRMC,192254.00,A,2942.79012,N,08223.3066,W,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
$GPGGA,192255.00,2942.79047,N,08223.30663,W,1,04,2.58,00040,M,-031,M,,*5D
IMG 000003049 00218
GPS 000003102 00218 $GPRMC,192302.00,A,2942.79461,N,08223.30899,W,000.00,000.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
GPS 000003280 00219 $GPRMC,192302.00,A,2942.79461,N,08223.30899,W,000.00,000.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
$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.

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 **RGB + 3** System with Aircraft

Mounting the unit

The RGB + 3 contains four mounting holes in the front and rear of the unit. These should be used to mount the system into manned or unmanned aircraft. The system should be isolated from vibration transferred to it from aircraft. The RGB + 3 does not contain its own power supply so power must be supplied from the aircraft by using the supplied Multi-I/O Control Cable.. Connect +9.0 VDC and +14.7 VDC and Ground to Pin 15 u (see 16-Pin Multi-I/O Connector Pin Outs next page). 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 RGB + 3 housing and optics are not weatherproof. If the camera is mounted externally, weather protection should be provided.

16-Pin Multi I/O Connector Pin Outs

The following describes the 15-pin functions of the Multi I/O connector:

- 1 –Power
- 2, 3, 4 & 5 – MENU/SELECT, UP, DOWN, and TAKE PIC buttons, respectively. Momentarily short to ground for button activation.
- 6 – power switch / external event trigger
- 7 – RS-232 Transmit (GPS)
- 8 – RS-232 Receive (GPS)
- 9 – Red LED: logic high when camera is busy
- 10 – Green LED: logic high when camera is on / idle
- 11 – (NC)
- 12, 13 – NTSC video signal and ground, respectively
- 14 – 3.3 V (logic high)
- 15 – Ground
- 16 – (NC)



Triggering the RGB + 3 at Specific GPS Coordinates

Images may be captured by the RGB + 3 system at specific locations using one of two methods. If the system contains an autopilot that has a programmable port then program the aircraft's autopilot with the waypoints where you want the system to capture images. Program the autopilot's port to momentarily output a low logic level (ground) as it reaches each waypoint. Connect the autopilot's port to Pin 5 (TAKE PIC) on the Multi-I/O Control Cable. At each waypoint, the grounded TAKE PIC signal line will trigger the system to capture images.

In order to record the GPS locations where images are captured connect an external GPS system such as Tetracam's 'plug and play' FirePoint 100 to the RGB + 3 by using the Multi-I/O Control Cable. Connect the GPS system's RS232 Transmit signal line to the RS232 Receive Pin (Pin 8). Connect the GPS system's RS232 Receive signal line to the RS232 Transmit Pin (Pin 7). Consult the previous section of GPS Option Installation regarding GPS configuration.

The RGB + 3 system may alternatively be triggered at specific locations by sending an <ESC> T command to the system via Pins 7 and 8 (RS232 Transmit and Receive) using the Multi-I/O Control Cable (see Tetracam RS232 Serial Control Commands ahead). This is the method that is employed Tetracam's Wireless Camera Interface. In this, an Android tablet or cell phone is inserted into the aircraft. The Android uses Tetracam's free S-Link App to calculate waypoints and the Android's own BlueTooth® interface to trigger the camera at each waypoint.



Capturing and Processing MCA Images

The Calibration Image

In order for the MCA 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 PixelWrench2 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 μ -MCA 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. Pix4D, for example, recommends a minimum of 75% forward overlap and 60% side overlap.

Images are captured on 16 GB MicroSD memory cards. One card is used for each of the system's optical channels. Tetracam recommends that the memory cards be formatted on a PC prior to a camera mission. They should be formatted as FAT32 cards with a 32KB cluster size for high performance. Care must be taken to maintain the label on the volume: TTCDISK[1-8], as it comes from the factory, during formatting on the PC. The volume information is used by PixelWrench2 to identify the device as a Tetracam camera, and identify the channels when it appears as a USB Disk. If desired, move lower resolution video images out of the system for display on a cabin flight monitor in manned aircraft or, with a supplementary video transmitter, you can send video down to a ground control station from an unmanned aircraft.

Managing and Processing RGB + 3 Images in PixelWrench2

Upon landing, images may be transferred from the MCA system to the host computer. There are two ways to retrieve images from the MCA:

1. Remove the card from the camera and copy its contents to a folder on your computer. The *.DCM and *.RAW files can then be opened directly in PixelWrench2.
2. Connect the camera directly to a host computer with a USB interface. The cameras will all show up, each as a separate USB disk device with a unique volume ID. Files can be dragged to and from the disks, and Pixelwrench2 can be used to open the files directly.

Tetracam supplies a multiple channel card reader accessory that allow up to 7 cards to be installed in a system over USB.

Read the PixelWrench2 Help file for a detailed description of this software and its use with Tetracam multi-spectral imaging systems.



Section 7: Programmer's Reference

File Formats

The MCA systems use proprietary formats for lossless data storage. DCM files are compressed using differential encoding and Huffman compression. RAW files are the array of captured pixel values with header and trailer information. The exact format of the file in 8 and 10 bit form is shown below.

10 Bit Raw File Format

The RAW file format contains both Header and trailer information. For values greater than 255, two bytes are used in little endian (Intel) configuration for header, trailer and pixel values.

Byte 0-3 Size of raw image in bytes – 32 bit value
Byte 4 Bits per pixel – 10 for this format
Byte 5 Format tag – 16 for RAW files
Bytes 6-7 Pixel Columns – 16 bit value. This is pixels not bytes
Bytes 8-9 Pixel Rows – 16 bit values

Bytes 12-(image size + 10) PIXEL DATA – 16 bit values

Bytes (image size + 10)-(EOF - 28) GPS data. \$GGA and \$RMC strings
Last 28 Bytes – ASCII exposure string formatted: "EXPOSURE:%08ld
uSeconds\n"

8 Bit Raw File Format

Byte 0-3 Size of raw image in bytes – 32 bit value
Byte 4 Bits per pixel – 8 for this format
Byte 5 Format tag – 16 for RAW files
Bytes 6-7 Pixel Columns – 16 bit value. This is pixels not bytes
Bytes 8-9 Pixel Rows – 16 bit values

Bytes 12-(image size + 10) PIXEL DATA – 8 bit values

Bytes (image size + 10)-(EOF - 28) GPS data. \$GGA and \$RMC strings
Last 28 Bytes – ASCII exposure string formatted: "EXPOSURE:%08ld
uSeconds\n"



10 Bit RWS File Format

The RWS file format contains both Header and trailer information. For values greater than 255, two bytes are used in little endian (Intel) configuration for header, trailer and pixel values.

Byte 0-3	Size of raw image in bytes – 32 bit value
Byte 4	Bits per pixel – 10 for this format
Byte 5	Format tag – 16 for RAW files
Bytes 6-7	Pixel Columns – 16 bit value. This is pixels not bytes
Bytes 8-9	Pixel Rows – 16 bit values

Bytes 12-(image size + 10) PIXEL DATA – 16 bit values

Bytes (image size + 10)-(EOF - 28) GPS data. \$GGA and \$RMC strings
Last 28 Bytes – ASCII exposure string formatted: "EXPOSURE:%08ld
uSeconds\n"

10 Bit DCM File Format

Byte 0-3	Size of image data, GPS data, and various tags in bytes – 32 bit value This value can be used to
----------	---

calculate

	a pointer to the JPG preview data
Byte 4	Bits per pixel – 12 for this format (2 padded)
Byte 5	Format tag – 16 for RAW files
Bytes 6-7	Pixel Columns – 16 bit value. This is pixels not bytes
Bytes 8-9	Pixel Rows – 16 bit values

Bytes 10-(data size + 10) DATA – 8 bit values

Bytes (data size+10)-EOF JPEG Preview image.

Looking backwards into the data encompassed by the size value in the header there are several fixed length fields, given below with their sizes.

GPS data – 1024 Bytes

Tags for temperature and clock ticks – 16 bytes

We do not recommend trying to process the DCM files with your own code. Contact Tetracam for assistance with sample 'C' source files if reading the DCM file data is absolutely necessary.



Tetracam RS232 Serial Control Commands

Camera serial port command strings consist of a lead-in character (ESC), 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).

<ESC>E

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

<ESC>T

Take a picture and save the image to SD card memory.

<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.





Section 8: MCA Specifications/Drawings

Specifications

Specification	Description/Value	Remarks
Basic		
Part Numbers	<ul style="list-style-type: none"> μ-MCA 6 TTC-1064 μ-MCA 12 TTC-1065 μ-MCA 6 Snap TTC-1074 μ-MCA 12 Snap TTC-1075 RGB + 3 TTC-1087 μ-MCA 4 Snap TTC-1088 (in RGB + 3 package) 	<ul style="list-style-type: none"> 6 monochrome channels 12 monochrome channels 6 monochrome channels 12 monochrome channels 1 color + 3 monochrome channels 4 monochrome channels
Typical Application	Aerial or ground remote sensing of vegetation	
System Hardware	<ul style="list-style-type: none"> Configurable Camera Array of 4, 6, or channels Rugged sheet metal system housing Four System Control Buttons: Menu E Menu Forward, Menu Backward, Take Picture Multi-pin I/O connector for use with accessories or testing ADC/MCA controller box & 6' Multi-I/O cable Replaceable filter for each lens Six slot memory card USB reader System CD with PixelWrench2 software USB Interconnection Cable 12 VDC external power supply Power Cord (un-terminated on one end) White Teflon Calibration Plate Rugged Pelican Carrying Case 	
System Inputs	<ul style="list-style-type: none"> Power (see below) USB 2.0 data connection, RS232 Serial (NMEA GPS sentences), 	
System Outputs	<ul style="list-style-type: none"> USB 2.0 data connection, Real time NTSC Video for viewfinder and menu operations, Remote Shutter (External Trigger) 	
System Software	PixelWrench2 is included with each purchase of a μ -MCA	
Commonly Ordered Options Available from Tetracam	<ul style="list-style-type: none"> FirePoint™ GPS Navigation System S-Link Android App and Wireless Camera Interface (MCA) Camera Calibration Service Ground Calibration Targets 	



Specifications (Continued)

Specification	Description/Value	Remarks
Physical		
Weight	<i>μ-MCA 6: 1.54 lbs. (700 g)</i> <i>μ-MCA 6 Snap: 1.54 lbs. (700 g)</i> <i>μ-MCA 12: 2.87 lbs. (1300 g)</i> <i>μ-MCA 12Snap: 2.87 lbs. (1300 g)</i> <i>RGB +3: 0.88 lbs. (400 g)</i> <i>μ-MCA 4: 0.88 lbs. (400 g)</i>	
Dimensions (mm)	<i>μ-MCA 4 Snap: 115 x 80.3 x 50</i> <i>μ-MCA 6: 131.4 x 78.3 x 87.6</i> <i>μ-MCA 12: 154.4 x 78.3 x 87.6</i> <i>RGB + 3 115 x 80.3 x 50</i>	
Environmental	<i>Temperature</i> <i>0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 104 degrees Fahrenheit)</i> <i>Humidity</i> <i>Less than 85% relative humidity, non-condensing</i>	Note: the camera will operate outside of the recommended environmental range, however performance may be degraded.
Power		
Voltage Input	+ 9 VDC to + 16.5 VDC Center Positive	
Current Draw at 12V:	RGB + 3: 500 ma typical μ-MCA 4 Snap: 500 ma typical μ-MCA 6: 820 ma typical μ-MCA 12: 1650 ma typical	
Sensor		
Description	1.3 mega-pixel CMOS sensor (1280 X 1024 pixels)	
Quantity per System	4, 6, or 12 per system	
Sensitivity	~450 nm to ~ 1000 nm	
Dimensions	6.66 mm x 5.32 mm	
Pixel Size	5.2 microns	



Specifications (Continued)

Specification	Description/Value	Remarks
Filters		
<p>Filters Standard with RGB + 3:</p>	<p>3 Broadband RGB filters on a single color sensor with the following approximate wavelengths: Red: 570 nm – 700 nm, Green: 480 nm – 550 nm and Blue: 400 nm – 470 nm.</p> <p>Plus three separate filters with values</p> <ul style="list-style-type: none"> - 680FS10-25 - 700FS10-25 - 800FS10-25 	<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. μ-MCA 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 for all systems upon request with quotation</p>
Lenses		
Focal Length	9.6 mm fixed lens	
Aperture	f/3.2	

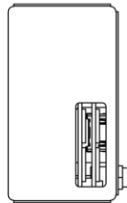
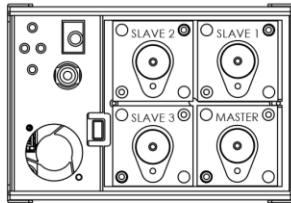
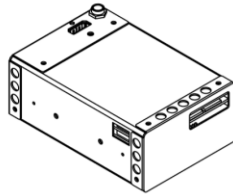
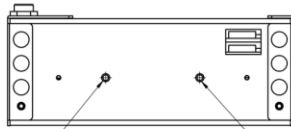


Specifications (Continued)

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 Release, Auto-Timer (Menu-settable), Remote Shutter Release (External Trigger), Computer Trigger via USB, or RS232 Serial Trigger	
Image Exposure time	Auto or menu-selectable in milliseconds	
Default Image Dimensions	1280 x 1024 pixels (1.3 MPel)	μ-MCA image size may be adjusted to an alternate image size (1024 x 768) via menu selection
Default Image Storage	Images with metadata are stored on 16 GB MicroSD cards (1 per channel) in Tetracam native file formats	10 bit RWS 10 bit RAW 10 bit DCM (with lossless compression)
Native Image File Formats	10 bit RWS 10 bit RAW 10 bit DCM (with lossless compression)	Native file formats may be converted via PixelWrench2 into common standard image file types such as BMP, JPEG, TIFF, PNG, etc.
Image Capacity	(DCM10) 0.9MB per image (RAW10) 2.6MB per image (RWS10) 1.3MB per image	Total capacity varies as DCM capacity is variable as compressibility is content dependent
Image Capture Rate (Single Shot)		
DCM10-Capture to end of cycle:	3.0 Seconds	
RAW10-Capture to ready:	2.0 Seconds	
RWS10-Capture to ready:	1.0 Second	



RGB + 3 Drawings



REV	DATE	DESCRIPTION	BY
1	08/11/03	REVISION	MS

NO.	QTY	DESCRIPTION	UNIT
		RGB + 3 CAMERA	





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