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Tetracam Multi Camera Array (MCA)
Installation and Operation

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Basic MCA Architecture

The MCA is an integrated system of multiple camera units, a common USB hub and a suite of software and firmware. The MCA is specifically designed for capture of multiple channels of narrow band spectral data. This manual is applicable to MCA units with a case serial number of 220301 and higher.

Before camera images can be retrieved and used you must install an application program and the camera specific USB driver.

Host software and USB driver installation:

On the CD shipped with the camera you will find application folders for PW2 and the optional SensorLink (if you purchased it).

If your computer does not have the Microsoft .NET 2.0 framework installed, the PixelWrench2 installer will try to open Microsoft.com and download a file called dotNetfx.exe. This is the installer for .NET 2.0. This file is also on the CD in the root directory where you can run it directly prior to installing PixelWrench2.

PixelWrench2
PixelWrench2 is a powerful image editing program with several tools specific to multi-spectral images and working with Tetracam ADC and MCA cameras.
Open the PW2 folder and run Setup.Exe. This will install PixelWrench2. See the PixelWrench2 online help for more information.

SensorLink
SensorLink is a GPS waypoint triggering application enabling camera triggering at pre-defined waypoints. It uses the same .NET 2.0 framework. Simply run Setup.exe in the SensorLink folder to install it. See the SensorLink online help for more information.

Connecting the camera:

Connect the USB cable from a working USB port on the computer to the connector labelled USB on the camera interconnect panel. Apply 12VDC with **Center Positive** polarity to the power connector. The small wall plug type power supply shipped with the camera is provided for this. The power cable supplied is clearly marked with the Positive and Negative lines, these should be connected to a clean 12VDC supply, a large capacity battery is preferred.

USB driver installation:

On Windows XP systems, the first time the camera is connected to a USB port, Windows will fire the *New Hardware Found* wizard. This will guide you through installation of the camera driver called SvStream.sys. The driver will be installed once for each camera in the system, for a 4 channel MCA you will see the dialog run 4 times.
Do not let Windows search for the driver. In every case select the option where you specify the name and location of the driver. The driver SvStream.sys and it's information file SvStream.inf will be copied to your Windows/System32/Drivers folder when you install either PixelWrench2 or SensorLink. When the driver installation wizard asks for a location browse to Windows/System32/Drivers.
When the driver has been installed for all four cameras you will be able to communicate with the camera.
In both PixelWrench2 and SensorLink, you are required to specify the camera type prior to accessing the camera. In PixelWrench2, on the Camera Toolbar, click the small down arrow on the top button (Status). Select MCA as your cameratype. This loads the correct DLL for use with the MCA.
See the PixelWrench2 online helpfile for further specifics on camera communications.

Camera Physical Layout and Interconnects

The MCA is an assembly four camera PCBs, a common sensor PCB carrying a four sensors, a sheet steel housing and a machined aluminum optical plate assembly. The front optical plate carries the four objective lenses in permanent alignment, the rear optical plate locates the bandpass filters and the sensor PCB. The individual sensor sizes are 1280 x 1024 pixels, ½" optical format. The image sensors are oriented to the same aspect as the camera housing, ie the long dimension of the sensor is in line with the long dimension of the housing. Mounting the camera long dimension parallel to the aircraft fuselage results in an image with the long axis parallel to the direction of flight. This allows for maximum overlap while maintaining the maximum usable image.

All the electrical interconnections for the camera are on one endpanel. The opposite endpanel has the CF card access door.

The interconnects provided are;

Video Out – configurable for NTSC or PAL
Trigger – Plug the supplied external trigger unit into this connector.
Power – The camera requires a 12VDC, center positive polarity supply capable of delivering 1.0 Amps continuous. The supplied power cable and wallplug type supply connect to this jack.
USB – The main USB I/O connector.
Multi I/O – This 17 pin connector is allocated to the Tetracam Videoviewer accessory. The Videoviewer features a 6" LCD display, control buttons for triggering, menu operations and power switching. It has it's own power supply, input for an external supply and input for a GPS receiver.
GPS In – A standard DB-9 connector allocated for connection of a GPS unit. The camera serial port is configured 4800 – 8 – N –1, the NMEA 0183 standard configuration. The camera firmware is designed to listen for the NMEA RMC sentence. If found, the entire sentence is written to the image status string (header) for extraction by application software.

The minimum number of interconnections is two, power and either trigger, USB or the Multi I/O cable. Connection of a video monitor is strongly suggested, it functions as an accurate viewfinder and serves to show the operating state of the camera.

CF card access – All images are written to Compact Flash cards, each camera unit carries it's own card. Access to the cards is thru the removable panel. Cards are formatted FAT32 and can be removed and read

on any host computer with a CF card reader. All data on the cards can be transferred over the USB port using the application software if desired.

Optics and Filters

The four camera channels are structured as a Master unit and three Slave units. The Master camera determines and sets the integration period and time for all the channels (when set to auto-exposure mode). The Master thus determines that all cameras will exposure for 3 milliseconds (for example). In practice, due to the sensor curves and the energy throughput of the bandpass filters, the actual exposure on each sensor is adjusted using the individual lens irises. The filters should be situated so that the Master camera is able to set an integration period (exposure time) that can be accomodated by all the filter / lens combinations. The default arrangment of filters is;
Master – Red band
Slave 1 – NIR band
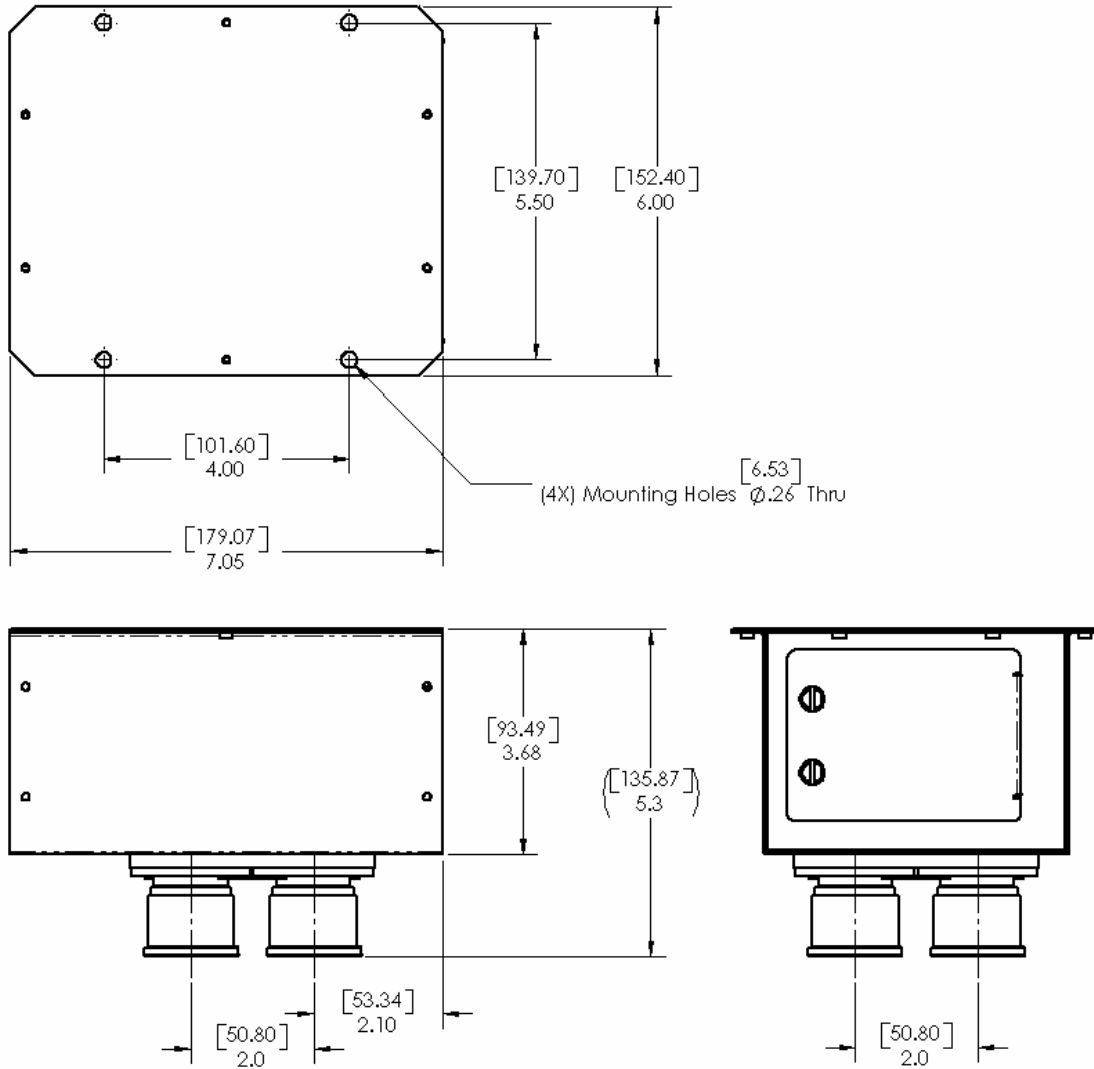Slave 2 – Green band
Slave 3 – Blue band
Fine adjustment of relative exposure on all four channels can be achieved by photographing a calibration standard such as a barium sulfate panel and making small adjustments to the lens irises. The aperture rings are spring loaded to prevent creep due to shock and vibration. Simply pull the spring away from the lens barrel to turn the aperture ring. To remove the front optical plate for filter replacement simply remove the

single ¼-28 nylock nut from the stud located at the center of the lens array. Note that the lens plate is located on two precision dowel pins. The lensplate has a hole on one side (the Master side) and a slot on the other side. Be sure to re-install the lensplate with the round hole next to the Master camera. The filters sit in small recesses in the rear optical plate, lightly held against the plate by foam washers located in matching recesses in the lensplate. Insure that the foam washers are in-place before reassembly. Run the ¼ -28 nut down to contact with the front optical plate but do not overtighten, just a snug fit is required. The lenses are pre-focussed at infinity and marked. Their position should not be changed or swapped. Each lens is mounted to an individual mountplate. Do not loosen the retaining screws on the round lensmount plates. This will affect the mechanical/optical alignment adversly.

Mounting the Camera

The four ¼" holes in the top flange of the camera housing are there to accept mounting bolts. It is always advisable to provide vibration isolation between the camera and aircraft. Additionally make sure to ground the camera housing to the mount. If the camera is mounted on non-conducting vibration isolators a ground strap should be provided. Dress and restrain all interconnect cables to prevent snagging or undue disturbance by propblast etc. The MCA camera housing and optics are not weatherproof. If the camera is mounted externally, weather protection should be provided.

It is the user's responsibility to insure that the camera is properly and safely mounted and is in conformance with any applicable aviation regulations.

Using the MCA Camera System

Simple Un-tethered Operation
The MCA is designed specifically for aerial photography and to that end, it's basic operation is simple. Although very extensive camera management operations can be done in flight, basic image capture is no more complex that pressing a button. When power is applied to the camera it will initialize itself and come ready in less than 2 seconds. Simply press and release the trigger button. The LED will turn red briefly indicating camera busy. When the LED returns to green and then off the camera is ready to capture again. This "mode" allows the camera to calculate a new exposure time between images.
To initiate *burst capture* simply press and hold the trigger button. The camera will calculate the exposure to be used for all the shots in the sequence and begin capturing frames at the burst capture rate of 1.3 frames per second until the memory buffers are full. The buffer contents are continually written to Compact Flash so when sufficient buffer space is free, another image will be captured. This continues until the trigger button is released. If a video display is connected to video-out it will freeze during image capture and slow significantly during image compression (writing out the memory buffers), this serves as another indication of the camera ready/busy state.
If a GPS unit configured to speak NMEA RMC is connected to the camera, it's output will be recorded in each image header.

Tethered Operation
Tethered means connected to and communicating with a host computer. While tethered operation provides management and control features not available otherwise, it requires a portable computer and an application program. The MCA ships with PixelWrench2 which has a full camera host interface built in. Camera statusing, setup, triggering, an on-screen viewfinder function, and file transfer operations are all available from PixelWrench2.
SensorLink and Tracker also provide manual or automated tethered operation, triggering the camera at geographical waypoints read from a user prepared list.
Camera Selection – In normal use, the Master camera is selected. "Selected" means it receives all host communications and commands. To select the Master, click the Setup button on the Camera Toolbar. The initial setup dialog has a selection box, click on MCA Master and close the dialog. This configures the MCA to react to normal commands like Trigger, SetExposure etc. The Master camera is automatically selected at camera power-up.
If a video display is connected to the camera it will continue to function in tethered mode.
Be aware that video out and auto-exposure is disabled in tethered mode. To determine correct exposure run the viewfinder function and adjust the scrollbar to achieve the right exposure or set a pre-determined exposure time on the set-exposure dialog.

Note:
The user is advised not to trigger more than one picture at a time when connected to USB.
If a *burst mode* capture was executed in un-tethered configuration, wait until burst operations are completely finished before plugging the camera in and opening the port.
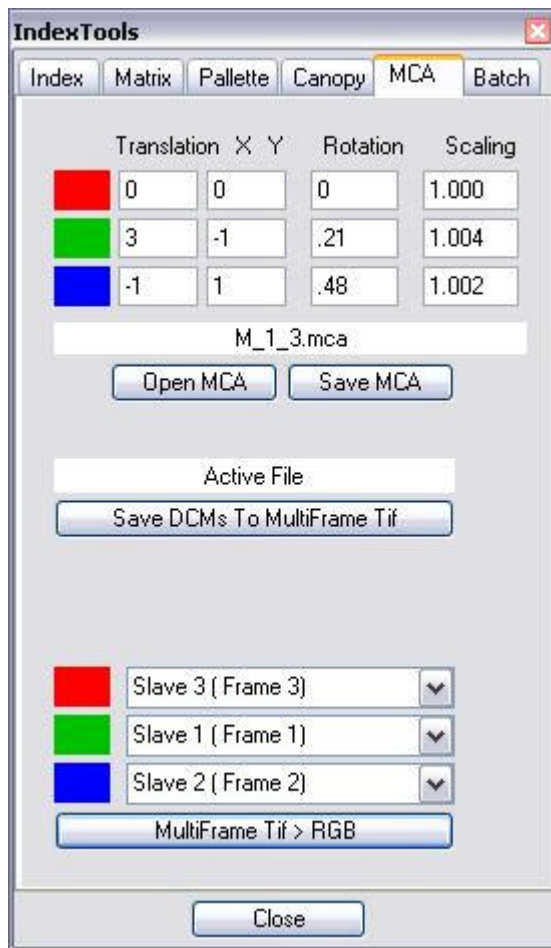
See the PixelWrench2, SensorLink or Tracker helpfiles for more specific information on tethered camera operation.

Tetracam Videoviewer Operation
Connection to the Tetracam Videoviewer is simple, just attach the cable supplied with the Videoviewer to the Multi I/O connector on the camera. Controls on the Videoviewer allow manual triggering of the camera and access to the camera menu system.

Managing and Pre-processing MCA Images
MCA Specific Features in PixelWrench2

 The MCA system creates an individual losslessly compressed image file for each channel (camera) in the system. These images are always accessible individually but the real power of the MCA system is in the ability to accurately combine and register the channels for further analysis. PixelWrench2 offers all the tools needed for management of MCA images located on the MCA page of the IndexTools form.

 There are four ways to retrieve images from the MCA;

1. Remove each CF card from the camera and copy it's contents to a folder on your computer.
2. In PixelWrench2; open the camera toolbar then click *Open Camera*. The camera inventory screen will appear with thumbnails of all the images. Set the source bitplane combo-boxes, select an image (or images) then click *Load.* The image(s) will be extracted from the individual camera units, combined into an RGB dib and displayed on screen. These images will not be registered (bitplane aligned).
3. In PixelWrench2, use the Open Camera button to invoke the camera inventory screen, select an image (or images) and click the *XFR Files* button (upper left corner of dialog). A folder browser will appear allowing selection of a target folder. All the individual DCM or RAW files from all the camera units will be written to that folder.

4. In PixelWrench2; open the camera toolbar and simply click the *XFR Files* button. A similar folder browser will appear allowing selection of a target folder. All the individual DCM or RAW files from all the camera units will be written to the designated folder.

Converting DCM or RAW sets

Individual image files in the format *.DCM *.RAW can be combined to single MultiFrame TIF files arranged with the Master and Slave cameras in ascending order from frame zero. The file naming convention for DCM files is TTCxyyyy.DCM. (or .RAW)
The fourth (x) character of the filename indicates the camera channel, 0 = Master, 1 = Slave 1 etc.
The fifth through ninth (yyyy) characters indicate the image number. A matched set consists of one file from the master and each slave unit for any given image number.
Use the *Save DCMs To MultiFrame Tif* button to allow navigation to the folder containing the matched sets of DCM files. A MultiFrame TIF file will be written to the same folder for each set of DCMs.
To view the individual frames for a MultiFrame TIF, use the PageUp and PageDown keys.

Extracting RGB images from MultiFrame TIFs

To create a 24bit (RGB) image from any three camera channels stored in a MultiFrame TIF, simply open the TIF file, select the channels to be extracted (and the color used to display the channel) and click the *MultiFrame Tif > RGB* button. A new imageform will appear with the selected channels displayed. This image will display the individual channels in registered form that can now be processed for extraction of NDVI etc. The image metadata stores a record of the camera channel used on each color bitplane.

Registering Bitplanes

The group of twelve edit boxes at the top of the MCA page allows entry of all the parameters needed to translate, rotate and scale any combination of bitplanes. The first two columns control X and Y translation of each bitplane, the third column controls rotation, the last column controls scaling.
Once a set of values are determined, they can be saved to a simple disk file for later use (*.mca file). You will need to derive and save an mca file for each combination of camera channels you use.

Translation – A positive value moves that bitplane right or down, a negative value moves left or up.
Rotation – Rotates the entire bitplane, positive values rotate clockwise, negative values rotate counter-clockwise. Rotation is required to account for mechanical misalignment of the CMOS sensor focalplanes. This value will not change over the life of the camera.
Scaling – Values greater than 1.000 scale up, values less than 1.000 scale down. Scaling is required to compensate for the small variations in optical magnification from one lens to another. This value will only change if the lenses are changed of if major changes are made to the choice of filter passband for that channel.

Both Rotation and Scaling use bi-cubic interpolation when re-mapping the image.

Deriving the Registration Values

*You will find example *.mca files in your PixelWrench2 application folder. These can be loaded and used immediately without following the procedure below. The naming convention used reflects the camera channel in it's respective RGB position, ie M_1_2 means Master = Red, Slave 1 = G, Slave 2 = B.*

Only two bitplanes of any three will ever require adjustment. One bitplane is treated as a reference with the remaining two brought into registration with it. Note that on the figure of the MCA page, the Red bitplane is the reference, the G and B planes are adjusted to match it. The following steps outline a simple method for determining all the needed values.

1. Create a MultiFrame TIF of an image that shows distinct and easily identifiable details over most of the image. An aerial shot of a town or airport is perfect.
2. Open the MultiFrame TIF. It will open displaying frame 0. This is the image from the Master camera.
3. Move your cursor to a distinct point at the far left of the image, about halfway up, a road-crossing, a particular rooftop etc.

4. Press and hold the L key and move your cursor to another distinct point at the far right, again, about halfway up the edge. A line will appear as you drag the cursor. The length and angle of the line is indicated on the main statusbar at the lower edge of the PixelWrench2 application window. Note the length (in pixels) and angle of the line.

5. Move to the next frame on the TIF file (PageUp) and repeat step 4 using the exact same image features. Repeat this step for all frames in the TIF file.
Using the Master image angle and linelength values as a reference, calculate the differences from the Master values to each of the Slaves.
  For example;
    Master angle = 0.25 degrees
    Slave 1 angle = 0.73 degrees
    Rotation needed to register Slave 1 to Master = -0.48 degrees.
    Master linelength = 909 pixels
    Slave 1 linelength = 905 pixels
    Scaling needed to match Slave 1 to Master = 909 / 905 = 1.0044

6. Type the resulting values for Slaves 1 and 2 into the Green and Blue row Rotation and Scaling boxes. Leave all Translation boxes set to 0.

7. On the Index page, select ImageType R G B in the combobox.

8. On the MCA page, extract an RGB image from the TIF file. For simplicity, extract the Master (on Red), Slave 1 (on Green) and Slave2 (on Blue). Set the comboboxes then click *MultiFrame Tif > RGB*.

9. The new imageform will appear with the G and B bitplanes on the RGB image rotated and scaled using the values you input.

10. On the Index page, in the topmost combobox, now select Red Channel and click *Execute*, repeat this, selecting Green Channel and Blue Channel.

11. You will now have monochrome images of the Red, Green and Blue channels from the color image. These monochrome images were created after the rotation and scaling operations and will directly show the required translation values for each bitplane.

12. Select the Red Channel image. Move your cursor to a distinct, identifiable point near the center of the image, the corner of a particular rooftop etc. Note the X and Y pixel coordinates of the cursor. These are displayed at the far left of the PW2 main statusbar.

13. Select the Green Channel image and locate the same feature in the image and again note the cursor location, x and y. Repeat this step on the Blue Channel image.

14. Using the master as a reference (like for the rotation and scaling) subtract the Master X and Y pixel values from each Slave image, the resulting number will be small, only 3 or 4 pixels and can be positive or negative. Enter the resulting values into the Translation X and Y boxes for the Green and Blue bitplanes.

15. Select the original MultiFrame Tif once again and click the *MultiFrame Tif > RGB* button. The resulting RGB image should show perfect registration.

16. Save the registration values to an *.mca file by clicking *Save MCA*.

Specifications

SXGA (1280 x 1024) 1.3megapixel CMOS sensor, 1 per channel.
25mm standard spectrometer filter, behind lens, 1 per channel
Image storage to CompactFlash in Tetracam DCM lossless format.
C-mount system compatible with thousands of available lenses.
(supplied with 8.5 mm lenses)
USB interface
Multipin I/O connector for use with Tetracam Videoviewer accessory.
Steel Enclosure

Image Capture
Capacity: Approx. 1mB per image, limited only by CF card size.
Rate: Single Shot – Capture to end of compression and write: 3.5 sec.
               Burst Mode – 1.3 frames per second until buffer full.

Inputs
12 VDC @ 1A
Rs-232 dedicated to capture of NMEA GPS sentences
External Trigger

Outputs
Realtime NTSC or PAL Video for both viewfinder and menu operations

Data Interface
USB 1.1

Dimensions
7 x 6 x 4 in. (179 x 153 x 101mm) without lenses (4 channel configuration)
Weight 4 lb. (1.8 kg) in 4 channel configuration