
Tetracam Auk 3 User's Guide



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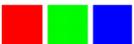
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Introduction

This User's Guide contains general information about Tetracam's Agricultural Wireless Camera 3 (AWC 3 or Auk 3) imaging systems covering installation, operation, options and accessories, warranties, and technical support. The information is specific to firmware version 1.63.

Tetracam's Auk 3 is an updated version of the company's previously-manufactured ADC products. The Auk 3 is faster than earlier systems and offers superior features and programmability, such as color processing and vegetation index extraction during a mission. It has a quad core processor and can capture images as fast as two images per second.

The Auk also features a new web browser based user interface accessible by way of the camera's Wi-Fi hotspot. Images and other data can also be moved in and out of the camera over the Wi-Fi interface; thus the name Agricultural Wireless Camera (AWC).

The system uses a NIR-Red-Green (NIR/R/G) sensor. Images are 2 Mpix (megapixels) in normal mode. There is also an optional mode (slower) that captures images at 8 Mpix. The wireless link can be used to transfer data to a host PC. The camera image folder shows up as a shared network folder (Samba).

Upward looking light sensors record the intensity of radiation at the time a picture is taken, a feature that is highly valuable for increased accuracy in remote sensing.

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 a installation CD or flash drive.



Quick Start Instructions

This section contains basic information needed to connect and use the Auk 3 or AWC 3 (Agricultural Wireless Camera 3). The Auk 3 is a wireless, Linux-based, NIR/R/G multi-spectral camera designed for vegetation analysis. A 6 to 24 VDC 3W minimum power source is required for power input. The controller is a powerful quad core system and along with the camera module is housed in a protective enclosure appropriate for outdoor use. An ILS (incident light sensor) is attached to the housing to increase remote sensing accuracy and is operating whenever the camera is powered up. Mount the ILS so that the white diffuser is positioned with a clear view of the sky.

To begin using the Auk 3 camera, attach the provided 6 pin power adapter cable to the camera. Make sure to align the arrows on the 6 pin plugs and press gently until the connectors lock together. To remove the 6 pin cable, gently pull the connector shell on the adapter cable to release the connector lock and then remove the cable. Do not attempt to twist or rotate the cable in the cable housing as damage to the cable connections may occur.

Connect the provided 12 VDC power supply to the AC wall outlet and plug the 12 VDC power cable into the 6 pin power adapter cable on the camera. The LED indicator on the camera will turn green when power is connected, and will then turn to orange during camera initialization. When the LED is green again, the Auk 3 camera is initialized and ready to operate. This process typically takes from 60 to 90 seconds to complete.

To access the camera's web browser interface, connect it to a Wi-Fi enabled device, such as a PC, tablet, or smartphone. Open the Wi-Fi network settings on your device and search for the Auk 3 camera's Wi-Fi hotspot, indicated by the following hostname: AUK3XXXX, where XXXX represents the last four digits of your camera serial number. Once you have successfully connected to the Auk 3 Wi-Fi hotspot, open up a web browser on your device. In the web browser URL navigation field enter 192.168.1XX.1, where XX is the last two digits of your camera serial number. You should now see the AWC controls page appear in your browser. Only Google Chrome and Mozilla Firefox browsers are currently supported.

Take a picture with the web browser interface by pressing the Trigger button. You may also take a picture by pressing and quickly releasing the white button on the Auk 3 housing. The status LED will turn red and will change back to green when the picture has been saved. See a live video feed of the sensor by pressing the Live View button. Click the Review button to return to the Review page. Review mode is the recommended screen for operating the Auk 3 unless live video is needed.



By clicking the Settings button, you can change the camera operation. Useful functions in the Camera Settings page include Capture Mode, Auto Capture Delay, Index Extractions, ILS Adjustments, and Disable Raw Data options. See help details by pressing the Help button next to each item. Save changes to the settings by clicking the Save Changes button. Click Back to return to the previous page.

After you've taken a few pictures, click the Refresh button to see the complete list of images in the camera. Click on the drop down list that contains image file names and select an image. The selected image will now be displayed. If Index Extractions are enabled, you will also be able to click the drop down list below the image display area of the page to select and view one of the index extractions defined in the Edit Veg. Index page.

Using a Windows PC, you can directly access the files in the Auk 3 by connecting with the Samba file sharing service that runs in the camera. Open the Windows File Explorer and type \\192.168.1XX.1 where XX represents the last two digits of your camera serial number. TTCAUK should come up as a network folder. Opening TTCAUK will provide access to images, settings, log files, extractions, and the DOCS folder.

In order to be processed and analyzed, the original images saved by the camera in the AUKJPGS folder must be converted to RAW format using PixelWrench2. Under the PW2 File menu, use the Convert Auk Jpeg to RAW function. To process multiple images, use the Convert Auk Jpeg to RAW function found in the Batch tab of the IndexTools form. IndexTools can be launched from the "Index Tools" selection under the View menu, or by right clicking in the PixelWrench2 active window and selecting "Index Tools". Refer to PixelWrench Help in the Help menu for detailed instructions.

As mentioned above, if the Index Extractions setting is enabled the Auk 3 has the capability to internally process and save images to TIF format under the EXTRACTIONS folder. Most common would be to enable the RGB Extractions in the Edit Veg. Index page to process and save NIR/R/G rendered images. Vegetation index extractions such as NDVI can also be created and saved in TIF format if those extraction types are enabled. Although camera performance and file storage space will be reduced, processing images in the camera can greatly simplify the data collection and management of images captured by the system.

There is a protective cover installed over the Auk 3 micro SD card. This micro SD card contains the Auk 3 system as well as stored images, settings, and log files. It is highly recommended to not remove this micro SD card under normal use, as there are multiple partitions on this micro SD card that will not be recognized properly on a Windows PC. To access images, settings, and log files, please use Samba as directed in the previous paragraphs.



There is a folder called DOCS located in TTCAUK, accessible via Samba. The DOCS folder contains this document as well as other documents and software. Please note that if you use the Format Disk function in the Auk 3 web browser interface, this folder will be permanently lost. The documents and software in the DOCS folder are also provided in a Tetracam CD.

The Auk 3 has Ethernet and USB ports. A protective cover is installed over both the Ethernet and USB connectors. For certain uses such as testing or hard-wired only installs, it may be necessary to use the Ethernet connection instead of Wi-Fi. To access the Ethernet connector remove the protective cover from the Ethernet connector and USB port by gently sliding the cover until it is clear of the guides on the camera body. Plug an Ethernet cable into the camera Ethernet connector to allow the Auk 3 to communicate on a network via DHCP, and connect power to the Auk 3. Once you have looked up the private IP address assigned to the Auk 3, you can access the Auk 3 web browser interface and Samba using this new IP address as well as the IP address associated with the Wi-Fi hotspot. A typical Ethernet IP address may be something like 192.168.1.XX, where XX are the two digits assigned by your modem or router.

The Auk 3 USB port is intended only for use with an optional USB type GPS. If a GPS has been provided by Tetracam, before installing the GPS, make sure the Auk 3 is powered down. As noted above, slide and remove the protective cover to expose the Ethernet connector and USB port. Install the GPS into the USB port. You may now power on the Auk 3. When the GPS blinks a blue LED, it has obtained a GPS location fix, and will transmit position data to the Auk 3. The GPS data is visible in the Auk 3 through the Auk 3 web browser interface, log files, and image metadata.

To power down the Auk 3 system from the web browser interface, select the Shutdown button. You may also power down the system by holding down the white button on the Auk 3 housing until the LED blinks red and green rapidly; upon witnessing this, release the white button. The Auk 3 LED will turn red, orange, and then green. At this point, green indicates it is safe to unplug power from the system.

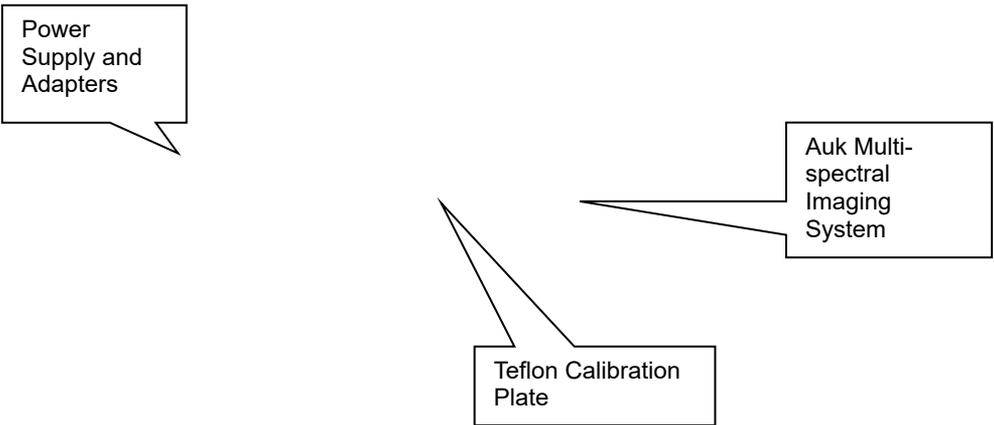


Unpacking The Box

Your new Auk multi-spectral imaging system is shipped with a variety of items to facilitate integrating the camera into a system:

- An Auk digital still camera
- A CD-ROM or flash drive with the installation software and documentation supporting the camera
- An AC power adapter and power input cable
- A white Teflon calibration plate
- A DC power adapter

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



Product Description

Becoming Familiar With Your Auk System

The Auk 3 is enclosed by a protective housing that has an Ethernet female connector accessible, an LED, mounting fixture, and a 6 pin multifunction connector. The Auk comes with an incident light sensor (ILS) provided by a cable on the Auk housing.

A single multifunction interface connector carries a serial port for GPS data, an image capture input, a capture sync output, power, and ground. The serial port is fully RS232 compatible with signals that swing +/- 5V, so that long connections can be used. The camera automatically listens for GPS NMEA strings on the serial input, and collects them so that location data can be added to the images as they are taken.

The picture taking input is expected to be normally high, with a low pulse of a few milliseconds when a picture is needed. The capture is timed from the trailing edge of the pulse.

The sync output switches from high to low at the beginning of integration, and back to high when the file save cycle is complete.

Power input can be any DC power supply from 6 to 24 volts. Current input is 200mA at 12VDC.

The Auk can be configured by way of the user interface for auto capture. There are two auto capture methods.

1. Trigger on GPS offset in meters
2. Trigger continuously with an intervening delay.

The maximum reliable capture rate for the unit is one frame per second. Approximately two frames per second may be captured when no capture delay is set.

Auk images are captured to the system memory card. The standard card capacity is 16 GB of images. Very large cards (64GB, 128GB) can be supported, but they should be configured at the factory. Preparing a memory card with a correct Linux system implementation in the field is a complex operation.

The Auk 3 system memory card has a protective cover. It is generally highly suggested to never remove this micro SD card in normal use. The reason for this is that the partitions that the micro SD card contains are not easily accessible using a Windows PC.

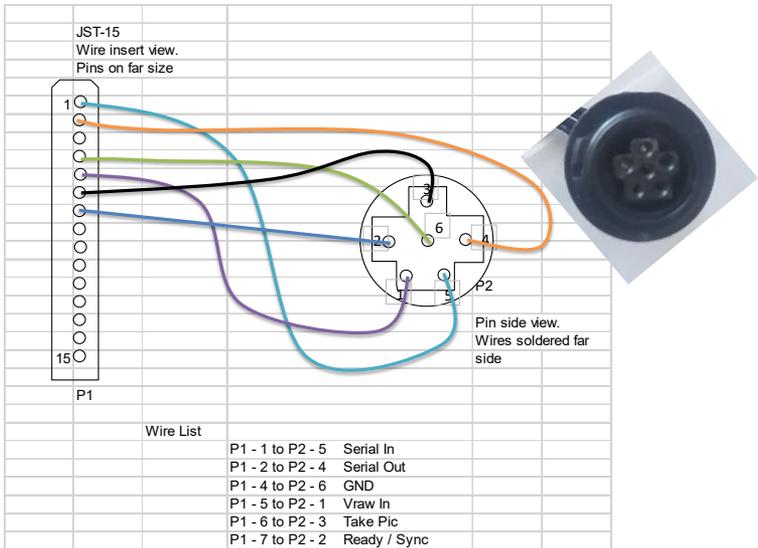


Two types of image files are saved by the Auk. The JPG files contain the raw data captured by the camera, and reside in the ttcawk/AUKJPGS folder. Images containing color processed results are TIF files located in the ttcawk/EXTRACTIONS folder. File names are based on a 'TC' prefix, and number of the sequence in which the picture was taken. Thus, a JPG file might be named TCR00012.JPG, and the TIF extraction file associated with it would be TCX00012.TIF.

Hardware Overview

The Auk system hardware is housed within a rugged plastic assembly. The Auk is designed for use in manned and unmanned aerial photographic missions. In the air, system operation can be controlled with commands implemented with the RS232 console port; over the wireless interface using a smartphone, tablet, or laptop; or by discrete control lines.

The Auk is controlled wirelessly in order to take a picture or start a continuous capture sequence. 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 detects a shutdown action.



Multifunction Interface Port – This small round connector provides an RS232 serial port and 12V power for external GPS or ILS attachments. A mating connector and cable are provided with the unit for integration into a hosting system.

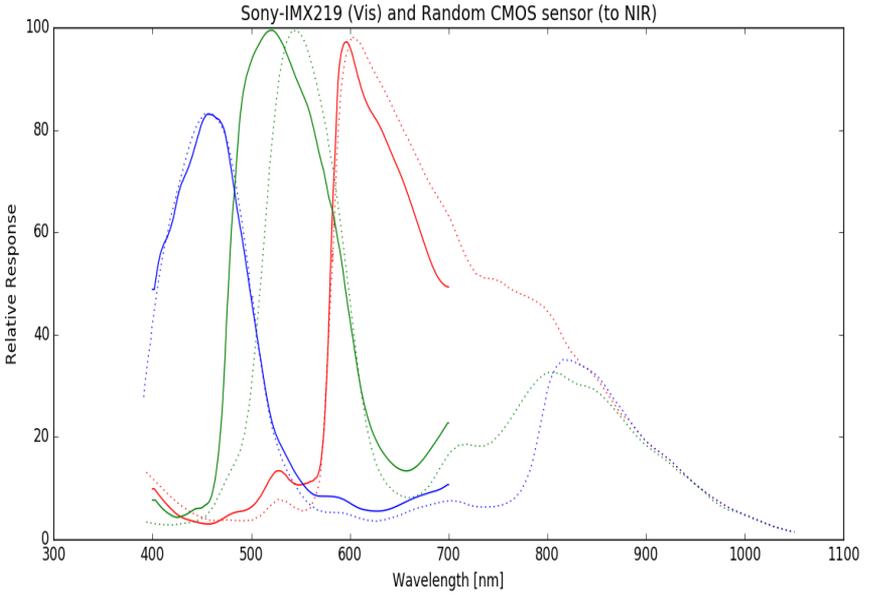
USB Connector – The USB 2.0 connector is located on the side of the unit, protected by a sliding cover. This connector is provided for the optional GPS that may be provided by Tetracam. When the Auk is powered down, plug in the GPS after removing the sliding cover. The sliding cover may be carefully removed by pressing on the leftmost or rightmost arrows to the left or to the right, respectively. Power up the Auk when the GPS is seated firmly in the USB port. When the GPS has a fix, it will blink with a blue LED. GPS data is then recorded in image metadata, logs, and web browser interface updates.

Auk Optical Configuration (Lens, Filters and Sensor)

Each Auk optical channel consists of a lens, a spectrometric filter and a CMOS optical sensor. The lens focuses visible or near-infrared radiation through the filter and on to a 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 1640 X 1232 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.



The graph below shows the relative efficiency of the Auk CMOS sensor for different bands of visible and NIR light. The NIR response band in gray is the same for each of the red, green and blue bands when there is no blocking filter. The NIR response shown is empirically derived, and should not be used for precise calculations.



System Setup

There are many configuration options for a Auk camera. The camera ships from the factory configured for the following:

- English language
- Triggered at 1 or more captures per second
- False RGB color, and NDVI processing enabled
- 115200 baud GPS/IMU input
- Landscape aircraft mount
- Normal Resolution (1640 X 1232) acquisition
- Logging disabled
- 16 bit TIFF file format for extraction, JPG for raw capture
- Auto-exposure average algorithm

The system can be reconfigured as needed using the browser interface on a smartphone, tablet, laptop, or desktop computer. The settings are changed by way of a set of option boxes which are clearly labeled and associated with help files. The Auk is set up as a Wi-Fi hotspot that will show up in the Wi-Fi menu for the device with the browser as AUK3XXXX where XXXX are the last 4 digits of the serial number.

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 JPG images from which they are derived have the same numeric file attribute, and are found in the AUKJPGS folder.

Using the Browser 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:

Startup 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 can be performed. If there were RGB/NIR light sensors, they are reported in colored bars, as well as number of pictures, time, revision information and clock ticks.



The Auk in flight is filling the image review menu. An image is selected from the dropdown box (TCA00002.JPG) and displayed by using the control buttons (Fwd, Back, Display Image, etc.). Metadata attached to the image can be viewed by selecting View Metadata.

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Agricultural Wireless Camera (AWC) Controls

Take Picture	Erase Pictures	Set Date/Time	Array Calibration	Live View
Edit Veg. Index	Shutdown	Format Disk	Edit Schedule	Edit Settings

PICTURE COUNT: 8
UTC TIME: Thu Oct 5 18:44:42 2017
METADATA: NO GPS
PICTURES LEFT: 5413
SYSTEM: Camera App: 1.11 Disk Size:15368M Linux 4.9.24+
BACKGROUND PROCESS:Background Task Idle

RED 1478 GRN 1444 BLU 795 NR 4913

TCA00002.JPG Refresh List Display Image Delete Image

Refresh the list to make sure recent files are added.
The selected file can be displayed below or deleted.

Fwd Back View Metadata Download Image



View: Jpeg Preview Data



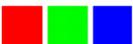
The Settings Form

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. Help files are also provided for each entry.

Setting	Current Value	Help Link
Code Version	111	--HELP--
Serial Number	270001	--HELP--
Metadata Format	GPS NMEA	--HELP--
Console Serial Baud	115200	--HELP--
UTC Time Offset	-7	--HELP--
Camera Mount	LANDSCAPE	--HELP--
Next Image Index	2	--HELP--
Language	ENGLISH	--HELP--
Auto Capture Delay (ms)	1000	--HELP--
Image Dimensions	HALF SIZE	--HELP--
Capture Mode	TRIGGERED	--HELP--
GPS Trg. Offset (m)	100	--HELP--
ILS Sensitivity	0	--HELP--
Enable Logging	LOGGING OFF	--HELP--
Index Extractions	PERFORM EXTRACTIONS	--HELP--
Adjust for Reflectance	ON	--HELP--
Fixed Exposure	0	--HELP--
Auto Exp. Method	CENTER AVERAGE	--HELP--

The Band Ratio / RGB Calculations Form

The camera maintains a file named "indices.txt" which directs the post processing of a captured image. Up to 8 post processing operations can be selected. In practice, one or two are usually enough. Post processing is not completely necessary. PixelWrench2 is able to do processing after the images have been copied from the camera, if desired.



All operations are performed on the Red, Green, and NIR bands, which are the only bands captured in the images.

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Setup Extractions

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

Current Index Form

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

Index ID	Palette File
RGB	default
NDVI	Becks.icp
NDVI	Grays.icp
OFF	Becks.icp
OFF	default

Different palettes can be assigned to the index extractions. The palettes are created and saved in PixelWrench2. A palette has to be copied to the camera folder PALETTES in the shared folder "ttcauk" for it to become visible to the edit box controls here.

The results of the calculations are saved as a multi plane TIFF file in the EXTRACTIVE folder in the image disk partition.

If the setting "Disable Raw Data" is true, a plane with raw data is appended at the end of the index extractions. With this setting the JPG file will contain only the jpeg image preview.

Palette Scaling

It is useful to apply the selected palette only a range of NDVI values in the extraction. By default the palette is applied to all pixels: 128 to 255. This has the desirable effect of using up colors just for index values that are interesting. Notably, the NDVI range is 0 to 255 (-1.0 to +1.0), but vegetation only has values between 128 and 255. (0 to 1.0).



The NDVI extraction will scale the palette to a range of pixel values of interest. The scaling is controlled in two places. First, for palette files that have no scaling values, the range is adjustable in the camera settings using the upper and lower “Palette Limit” options.

Some palette files have two scaling values at the end. If these values exist, they are always used to scale the palette instead of the values in the settings.

Pixels outside of the scaled range are rendered as monochrome.

ILS Adjustments

ILS adjustments can be performed (or disabled) when the band ratio false color images are created in the camera. Choosing “Reflectance” processing will cause the ILS values to be used to change each pixel in the image to a brightness proportional to the percent of downwelling radiation it reflects. If an object, for example, reflects 50% of the downwelling energy, the brightness of that image (for 8 bit pixels) will be set to 128. ($128 / 256 = .50$)

Choosing “Color Balance” processing will result in the image being adjusted for changes in the color of the downwelling radiation, eliminating the need for a calibration picture. If NIR radiation is weak because of cloud cover, the camera will automatically adjust the NDVI calculations so the values are accurate.

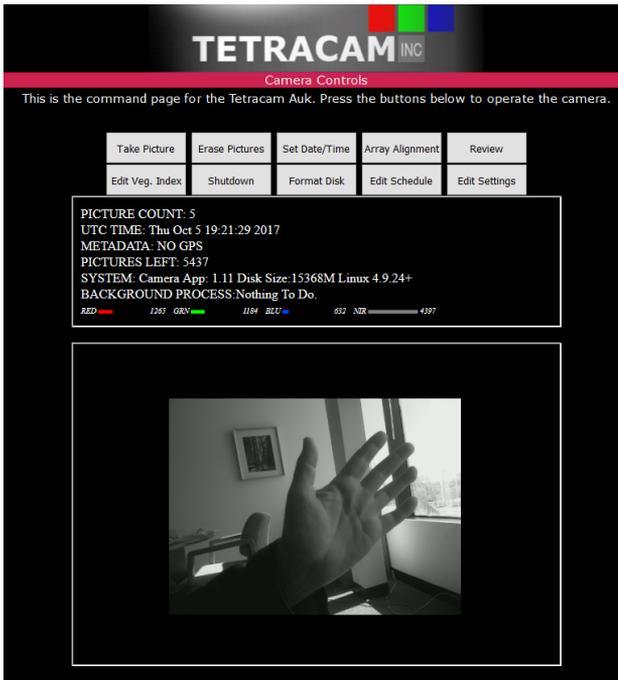
“Color Balance” ILS processing is not sensitive to changes in attitude or position of the aircraft; the amplitude of the ILS signal is used in the calculation. Only the relative differences in NIR, RED, and GREEN bands are used to correct the color prior to NDVI extraction.

“Reflectance” ILS processing IS sensitive to changes in attitude or position of the camera. The exact amplitude of downwelling radiation is needed to correctly calculate the percent of light reflected. Reflectance adjustments require that all pictures be taken without any significant pitch or roll changes in the aircraft.

The Live View Screen

This page allows the user to view a live feed from the camera. 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 startup page.





The live view screen and startup screen have certain controls in common:

1. The image save partition on the memory card can be formatted
2. All of the captured images in the camera can be deleted
3. A system shutdown can be started, in preparation for power removal

All of these operations require confirmation: "Are you sure?"

The Clock Setup page

This form allows the system clock in the camera to be set to any desired time: UTC or local. Normally the time kept in the camera is UTC time. The time is part of the image metadata, and UTC is the most transportable time representation. If local time is set, it may not match the time reported by GPS receivers, which is also included in metadata.

Year	2017 ▾	October ▾	Month
Day	5 ▾	19 ▾	Hour
Minutes	26 ▾	2 ▾	seconds
Save New Time		Back	

GPS Option Installation and Use

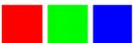
The Auk will capture and append the most recent GPS/IMU position data to each image as it is taken. The following requirements apply: The GPS receiver must be configured to output the standard NMEA RMC and/or GGA sentences. The default output protocol for NMEA sentences is 115200 baud, 8 data bits, 1 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 115200:8:1: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 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 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 of the image partition. If there is a pre-existing CURRENT.LOG file, the file is moved to the image folder (ttcauk/AUKJPGS) and renamed according to the system UTC time, seconds, at the time the file is saved.

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 PixelWrench2 to manage image and GPS log files.



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 1 millisecond ticks. The count 104 means that the CLK record was written 1.040 seconds after power on

CLK 00000000104 Date/Time: 10/22/2009 15:15:01

GPS 00000002006 00217 \$GPRMC,192254.00,A,2942.79012,N,08223.30667,W,0.0,0.0,0.0,221009,03.3,W,A*0B

GPS 00000002064 00217 \$GPRMC,192254.00,A,2942.79012,N,08223.30667,W,0.0,0.0,0.0,221009,03.3,W,A*0B
\$GPGGA,192255.00,2942.79047,N,08223.30663,W,1,04,2.58,00040,M,-031,M,,*5D

IMG 00000003049 00218

GPS 00000003102 00218 \$GPRMC,192302.00,A,2942.79461,N,08223.30899,W,0.0,0.0,0.0,221009,03.3,W,A*0B

GPS 000003280 00219 \$GPRMC,192302.00,A,2942.79461,N,08223.30899,W,0.0,0.0,0.0,221009,03.3,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.



You can use PixelWrench2 to manage image and GPS log files. See the PixelWrench Help file and the [PixelWrench2 User Guide](#) for more information on how PixelWrench2 uses the distilled log files to refine the embedded GPS data in each image. The latest edition of PixelWrench2 available at www.tetracam.com/PWversion.htm

Triggering the Auk at Specific GPS Coordinates

There are several ways to trigger the Auk 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 6 pin multifunction connector. A compatible cable and signal breakout connector are provided to simplify connection. The third method is to toggle the external Take Picture line when the controlling device reaches a desired GPS trigger point.



Capturing and Processing Auk Images

The Calibration Image

In order for the Auk system to capture accurate reflectance 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 or 22 to 24 percent reflectance target 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



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 above 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.

The camera is calibrated once at the factory, and this calibration in conjunction with ILS “Color Balance” processing eliminates the need for recalibration in the field. If the camera is recalibrated, the new calibration will also work for the “Color Balance” algorithms.

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 Auk 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 micro SD card EXT4 partition. Tetracam recommends always using the built-in Auk browser interface function to format this part of the micro SD card prior to each mission. This guarantees that the card will not be fragmented, and image save times will be optimal.

Managing Auk Images in PixelWrench2

Upon landing, images may be transferred from the Auk system to the host computer. With the camera powered on, connect the camera directly to a host computer with the Samba interface. Files can be dragged to and from the disk, and PixelWrench2 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, PixelWrench2 can do this quickly, using its built-in batch functions. Read the PixelWrench2 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 Auk, the user can simply transfer the multi-page TIF extraction files to the PC and view the results with PixelWrench2. Some mosaic building software may be able to use the Auk images as-is to immediately produce a mosaic image of the mission.

The Auk is configured for wireless access to all images, logs, and settings files. This happens through the Samba interface. Using a Windows 10 PC, access all of these files using Samba by following this procedure:

1. Connect to the Auk Wi-Fi hotspot using your PC Wi-Fi settings. It should be indicated by AUK3XXXX, where XXXX is the last four digits of your Auk camera serial number.
2. Open a Windows File Explorer.
3. Enter \\192.168.1XX.1, where XX is the last two digits of your Auk camera serial number.

4. Open TTCAUK.
5. All the images, logs, and settings should be accessible from TTCAUK. A DOCS folder is also present that contains all of the files that are on the Tetracam CD. Note that the DOCS folder will no longer be present after the Format Disk function has been used once from the Auk web browser interface.

Handling IMU and GPS Data

Pixelwrench has built into it the code to recognize either IMU data or GPS data, and create interpolated positions in the final TIF image files. The GPS and IMU strings can be found in both the log file and raw image metadata.

GPS strings are in standard GPS NMEA format as described at:

https://en.wikipedia.org/wiki/NMEA_0183.

IMU data is encoded as a variant of GPS strings beginning with the lead in identifier \$MAV. The comma separated fields in the \$MAV messages are interpreted by position according to the following list. The items in the list are expressed as decimal integers and floats, but are shown below descriptively:

```
/* integer values */
$MAV,
boot timestamp,
gps latitude
gps longitude,
gps altitude,
gps relative altitude,
gps X speed (lat)
gps Y speed (lon),
gps X speed (alt)
gps heading,
gps attitude timestamp,

/* floating point values */
imu roll,
imu pitch,
imu yaw,
imu rollspeed,
imu pitchspeed,
imu yawspeed,
```

Values that are not supported by the installed hardware (no GPS?, no autopilot?) are set to 0.



\$MAV messages are produced by the PixAuk autopilot interface, or from synthesizing a message from an attached camera IMU or GPS.

PC Software Overview

PixelWrench2

The installation CD included with your Auk system contains PixelWrench2 as well as other utilities, files, and documentation that are helpful for setting up and operating your system. PixelWrench2 is a powerful image editing program that is included with each Auk 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 Auk JPG and multi-page TIFs, 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. PixelWrench2 translates the Auk formats into other standard image file types. (BMP, JPG, TIF, PNG etc.)

Many of the PixelWrench2 batch processes can also be performed in the camera by configuring background processing to generate the desired band ratios and false color images.

PixelWrench2 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 access to the Samba interface can be used to retrieve pictures from the Auk 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 PixelWrench2 setup files are located on the installation CD. In order to install PixelWrench2, run the file “setup.exe” located in the PixelWrench2 folder either directly from the CD or after copying the PixelWrench2 folder to your PC.

The default installation target is this:

“C:\Program Files\Tetracam\PixelWrench2”

Please read the PixelWrench2 help file for further information.

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

The [PixelWrench Update page](#) at the Tetracam website has the most up-to-date version of PixelWrench2; please refer to it periodically for the latest updates.

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 Auk 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.

Incident Light Sensor (ILS)

The Auk ILS is built into the unit. The sensors are provided from a cable attached to the Auk 3 housing. These sensors should have an unobstructed view of the sky when the unit is in use.



The values (Red, Green, Blue, NIR) from these sensors are appended to each image as metadata which can later be used by PixelWrench2 to calculate the true reflectance or color balance of the subject plants, and compensate for reduced NIR when calculating NDVIs. NIR radiation varies with cloud cover, season, and time of day, so the use of the ILS data allows operation of the Auk in a wider time window.

Advanced Topics

Logging into the Auk Linux Operating System

The camera operating system is a version of Debian 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 using PuTTY must be done during the camera boot cycle. After networking is started, and the Apache web server is 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 GNU 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. When logging in via SSH, the user is prompted for a username and password; it is recommended to log in as ttcuser to avoid interfering with the camera application and to ensure straight-forward system administration when it is needed. PuTTY is recommended as a good 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; it is also useful when debugging, since it allows the opportunity to start aukmain manually by the command `'sudo ./aukmain'`.

A PuTTY and Xming installation files for Windows are included on the Auk 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.

Updating the Auk System Files Using Auk Update

When updates are made to the Auk system files, the changes are distributed by Auk_V0XXX files, where XXX is the firmware version. The process to update the Auk with a Windows 10 PC is as follows:

1. Power up the Auk and wait until it has a green LED and its Wi-Fi hotspot is accessible.
2. Extract the ZIP to receive the AUKUPDATE.tar.gz file.
3. Connect to the Auk via Samba as described in the [Managing Auk Images in PixelWrench2](#) section.
4. Place the AUKUPDATE.tar.gz file onto the root of TTCAUK.
5. Close the File Explorer window.
6. Power off the Auk.
7. Power on the Auk, and when the LED is green, the Auk should be updated.

Stopping the Camera Application (aukmain)

If the camera application, aukmain, ever closes, it is restarted automatically by a parent process called aukstart. In order to terminate the camera process so that a new aukstart can be installed, or to eliminate the camera application overhead, the aukstart 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 aukmain to be stopped without restarting.

Camera Control Files

The aukmain 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 FAT32 partition of the micro SD card when it is mounted or formatted, and they are updated with changes when aukmain exits.

Image Capture Partition Organization

The mount point for the image capture disk partition is /home/tetracam/TTCAUK. The control files referenced in the previous paragraph will also exist in this folder. Subfolders under TTCAUK contain the results of the camera application:

TTCAUK/AUKJPGS holds captured raw images in modified JPG format.

TTCAUK/PALETTES holds the palette files known to the system. New palette files may be generated using PixelWrench2.

TTCAUK/EXTRACTIONS holds the vegetation index images extracted in background processing during a mission. These files are multi-page TIFs.

The image disk partition is best reformatted using the web browser interface button. The filesystem is set as EXT4 without journaling for best possible save times and compatibility with Windows operating systems using Samba.

Host Interface Packages for Microsoft Windows:

PuTTY remote terminal utility

XMing X Windows client

WinSCP file transfer utility

Once these packages are installed on the Microsoft Windows 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 Auk cameras; it depends on the last two digits of the camera serial number. The IP address can easily be determined from the Auk control tablet; it is the same as the http homepage. The Windows host must have a working Wi-Fi interface in order to connect to the camera's Wi-Fi hotspot.

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 SSH login via Wi-Fi. When launching PuTTY with the camera IP address as the target using SSH via Wi-Fi, the user should log in as “ttcuser” for the most convenient experience, since it won’t interfere with the camera application activity. When using the serial port, connect by the COM port to which the camera serial interface is connected, and that will bring up a login prompt after the Auk boots up; however, it is necessary to strike a key after boot up to abort the startup of the aukmain process. Once aborted, the serial port will present a GNU Bash shell logged in as the user tetracam, in which case the user may start aukmain manually by entering ‘sudo ./aukmain’.

To use software with a GUI, the user must be logged in with PuTTY over the Wi-Fi SSH 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 Auk. It is as fast an interface as the USB2 connection. In situations where physical connection is difficult, it may be the preferred way for downloading pictures from the camera. PixelWrench2 interfaces directly to the Auk over the wireless link and the USB2 connection. The shared folder “ttcauk” appears as a shared network folder over the USB2 network, or the Wi-Fi network. The same is true for Icaros OneButton and Agisoft PhotoScan mosaic building utilities: they can operate directly from the USB2 or Wi-Fi link.

Image File Formats

The Auk system uses a modified version of the JPG standard for storing image data. The raw data are appended to the JPG data. The JPG header for each file contains many extensions (EXIF, GPS) and private tags that contain metadata that can help with image post processing.

The camera can perform vegetation index extractions and false color RGB renderings after a raw image is captured. These renderings are saved in a multi-page TIF, 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 800 ms. For 16 bit files, 1000 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 image file system.

<ESC>T

Take a picture and save the image to the image partition.

<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.

Support Info

Your Auk 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		
Typical Application	Aerial remote sensing of vegetation	
System Hardware	Rugged plastic housing single system trigger / start button. Multi-pin I/O connector for use with accessories or testing System CD with PixelWrench software 12 VDC external power supply Interface cable (unterminated on one end) Built-in ILS sensors White Teflon calibration plate	
System Inputs	Power (see below) Wi-Fi shared folder read/write RS232 serial (NMEA GPS sentences),	
System Outputs	Wi-Fi data from apache2 http server viewable with any web browser Samba to access images, settings, and logs	
System Software	PixelWrench2 is included with each purchase of a Auk. Full featured Debian Linux operating system with SSH, Samba, and HTTP servers.	
Commonly Ordered Options Available from Tetracam	USB GPS Ground Calibration Targets Full Icaros OneButton mosaicking software license	



Specifications (Continued)

Specification	Description/Value	Remarks
Physical		
Weight		
Dimensions (mm)	ILS / CPU box: Sensor Box	
Environmental	<i>Temperature</i> 0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 104 degrees Fahrenheit) <i>Humidity</i> Less than 85% relative humidity, non-condensing	Note: the camera will operate outside of the recommended environmental range, however performance may be degraded.
Power		
Voltage Input	+ 9 VDC to + 24 VDC Center Positive	
Current Draw at 12V:	200 ma typical	
Sensor		
Description	2 Mpix sensor operated at 1/2 resolution (1640 X 1232)	
Sensitivity	~420 nm to ~ 950 nm	
Dimensions	4.6mm diagonal	
Pixel Size	1.2 microns	

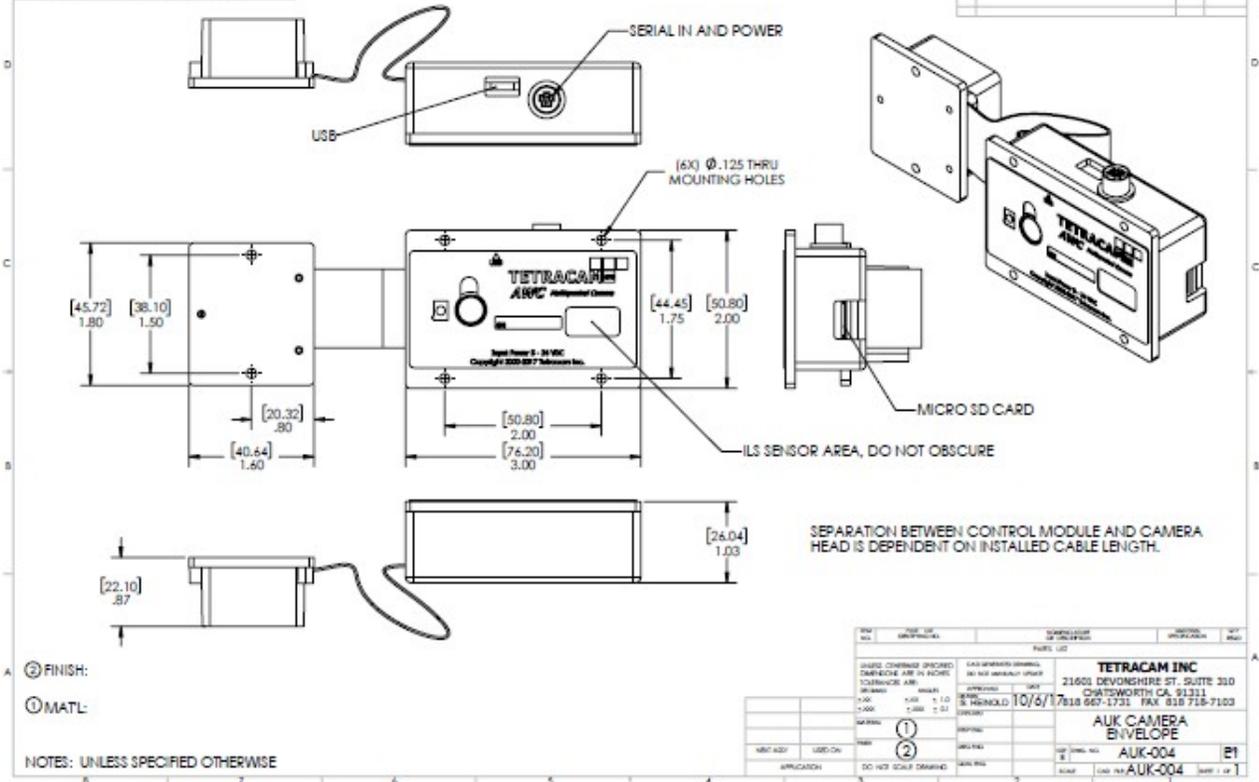
Specifications (Continued)

Specification	Description/Value	Remarks
Filters		
Filters	RGB bayer with blue blocking.	Blue pixels see only NIR
Lens		
Focal Length	3.04 mm fixed lens	
Aperture	F2.0	
Specification	Description/Value	Remarks
Images		
Horizontal Angle of View	59.7 degrees	
Vertical Angle of View	58.3 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, host PC trigger via Wi-Fi browser interface, or RS232 serial.	
Image Exposure time	Auto or menu-selectable in μ sec.	
Default Image Dimensions	1640 X 1232 pixels (2 MPel)	Auk image size may be adjusted to a high resolution image size of 3280 X 2464. Not Recommended
Default Image Storage	Images are stored in a dedicated EXT4 partition in modified JPG format.	
Native Image File Formats	16 bit multi-page TIF for index extractions (no compression) Modified JPG for raw data. Full of half size image capture	Other file formats can be generated by using Pixelwrench2 as a converter, or built in Linux (Imagemagick) conversion routines in the camera
Image Capacity	JPG size: 2.7MB per image	8000 pictures in 16 GB FAT32 partition. 2000 images in high resolution mode.
Image Capture Rate (Single Shot)	1000ms (1 per second) without background processing	



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REV.	DESCRIPTION	DATE	APPROVED



SEPARATION BETWEEN CONTROL MODULE AND CAMERA HEAD IS DEPENDENT ON INSTALLED CABLE LENGTH.

REV.	TOP OF DRAWING	DATE	DESCRIPTION	BY	CHKD.

REV.	TOP OF DRAWING	DATE	DESCRIPTION	BY	CHKD.

REV.	TOP OF DRAWING	DATE	DESCRIPTION	BY	CHKD.

REV.	TOP OF DRAWING	DATE	DESCRIPTION	BY	CHKD.

Weight:



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