SharkEye ä SC-3

Remote & Autonomous Underwater Digital Camera System

Including SL-3 Rapid Fire LED Strobe and SBP-2 Battery Pack

Operator's and Technical Reference Manual

Version 2.96

Updated for use with SharkEye™ software and firmware version 2.96
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Desert Star Systems, LLC
3261 Imjin Road
Marina, CA 93933
(831) 384-8000
www.desertstar.com

1. Overview

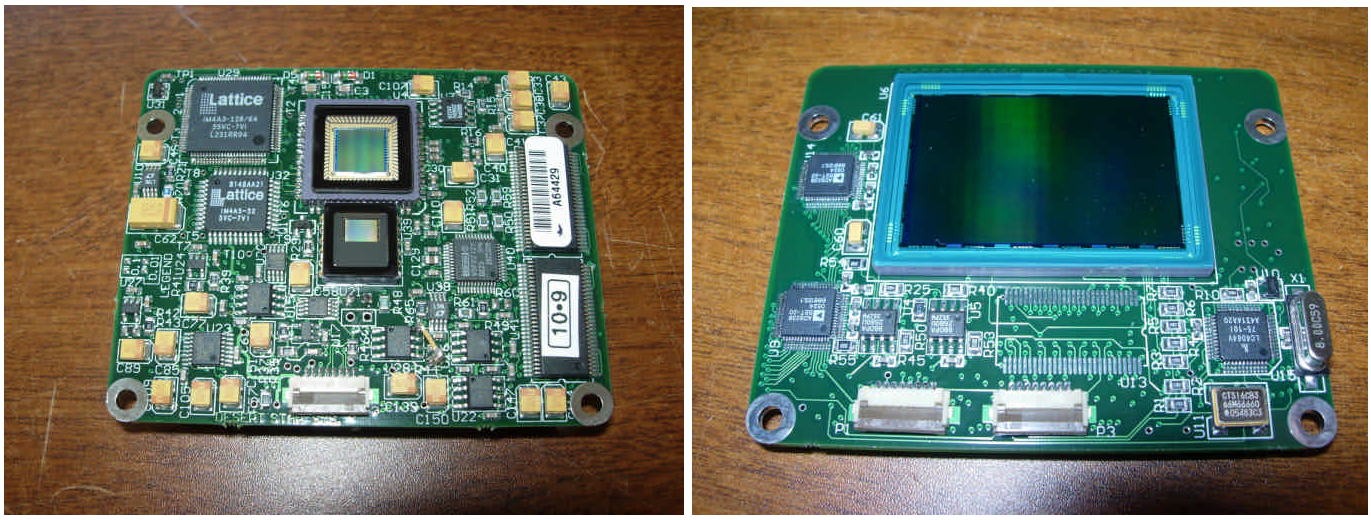
The SharkEye™ model SC-3 digital camera systems are designed specifically for remote and autonomous underwater operations. Typical applications include sea floor mapping with AUV/UUV, autonomous observation stations, drop cameras and high-quality inspection cameras for ROV.

The SC-3 camera system has these principal features:

Choice of Image Sensors

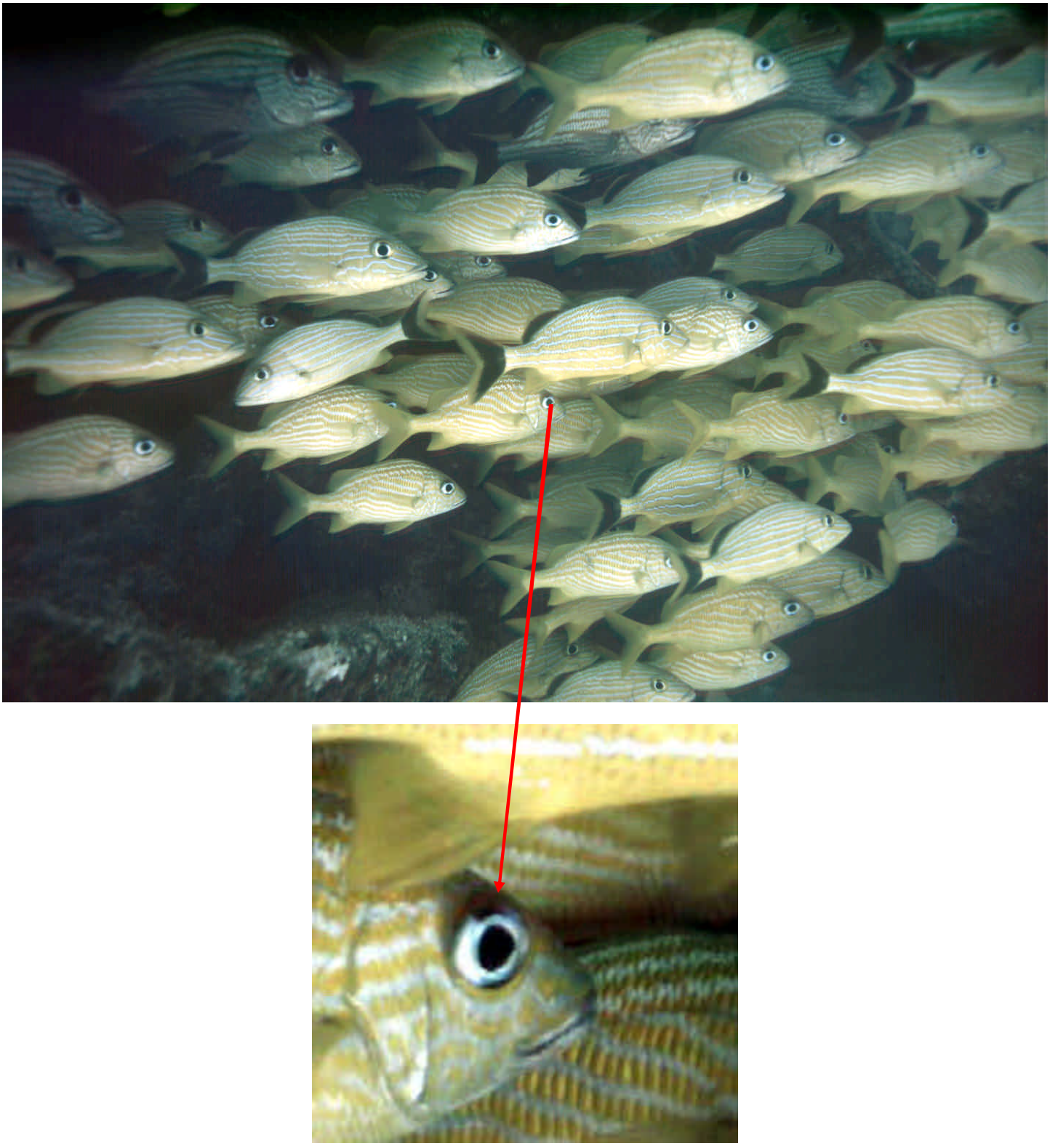
The SC-3 system has a replaceable image sensor module.

- The FISM-1 image sensor module includes two co-located sensors suitable for still and motion imagery. Either sensor is selected by rotating the lens adapter plate to align the C-mount lens with the desired sensor.
    - A high-quality / low-noise CDD with 1004x1004 pixel resolution is available in color or grayscale and provides high quality images when light conditions are above approx. 1 Lux
    - An electron multiplier CCD (EMCCD) is available for very low-light operations or in fast mapping operations where motion blur must be minimized. Resolution is 656 x 496 pixels, and the minimum practical illumination is 0.000125 Lux (125 microlux).
- The FISM-2 image sensor module hosts a 14 Megapixel CMOS sensor, available in color or grayscale. This sensor is designed for applications where a wide area must be observed with high resolution, but also for professional media purposes such as magazine photography and some IMAX and other movie applications.



FISM-1 dual sensor module incl. very low light Electron Multiplier CCD (left). FISM-2 14-Megapixel CMOS sensor module (right)

FISM-1 Images: Kodak KAI-1020 color CCD (left), Texas Instruments TC-253 Electron Multiplier CCD (right)



FISM-2: 14-Megapixel CMOS Sensor Images Large Areas with High Resolution

Note:
Due to the sensor size, SharkEye™ cameras equipped with the FISM-2 sensor module must use the Canon-EF lens mount. (Use of the FISM-2 with C-Mount lenses is not supported.)

Choice of Housings

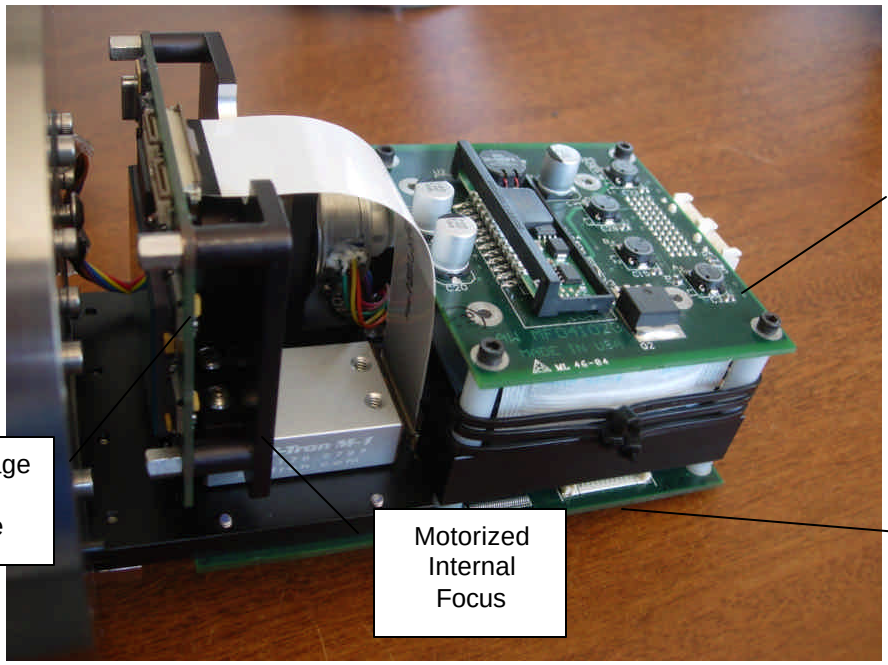
The SharkEye™ camera system is available in a selection of housings:

- The SC-3/300m version is the standard configuration. The rectangular aluminum housing is easy to mount and align, and supports operations to a depth of 300m.
- The SC-3/100m version is similar, but uses a Delrin plastic housing. Use it for extended immersion in shallow water where corrosion would be a concern with metal housings.
- The SC-3/1000m version is strengthened to support greater operating depths.
- The SC-3/4000m version is a cylindrical aluminum housing that supports use at depths up to 4000m.
- The SC-3/6000m version is manufactured from titanium. It is optimized for long-term immersion to the greatest depths.
- In addition to the standard housing, highly specialized custom versions are available as well. The picture below shows a camera with a rotating 45-degree mirror that was designed to enable observations in all directions from a drop camera.

Standard SharkEye™ Versions: 1000m C-Mount, 4000m C-mount, and 6000m titanium with Canon EF mount

Custom Housings: With 360º rotating mirror (left), with dome port (right)

Modular Design: All SharkEye™ Cameras have Exchangeable Lens Systems (C-Mount or Canon EF), Internal CF FLASH Storage Cards and both Firewire and RS-485 Data Interfaces.



Full Replaceable Electronics: The Image Sensor, Processor and Power Modules can be Replaced to Add New Capabilities to your Camera as they Become Available

Interchangeable Lenses and Choice of Lens Systems

All standard SharkEye™ SC-3 cameras feature an interchangeable lens system. Lenses are easily replaced between deployments by removing a lens hood and then changing the lens. SharkEye™ cameras support two lens systems:

- **C-Mount** lenses are used for the physically small sensors up to 25mm diagonal such as those on the FISM-1 image sensor module. C-Mount lenses are normally used in machine vision applications and a great variety is available. The lenses are physically compact and light sensitive ratings of F/1.4 or F/1.8 are the norm. Short focal lengths down to f=4.8mm produce a wide field of view and a great depth of field (distance range that will be in focus). In SC-3 cameras equipped with the dual-sensor FISM-1 image sensor module, an adapter plate is used to align the lens with either the KAI-1020 color sensor or the TC-253 low-light EMCCD.
- **Canon EF** lenses are supported primarily for use with large, high pixel-count sensors, such as the 14-Megapixel CMOS sensor on the FISM-2 module. These lenses produce an image of 45mm diameter to support such sensors. Canon EF lenses also have a motorized iris that can be controlled from the camera.

SharkEye™ SC-3/300m with lens hood removed and C-Mount lens

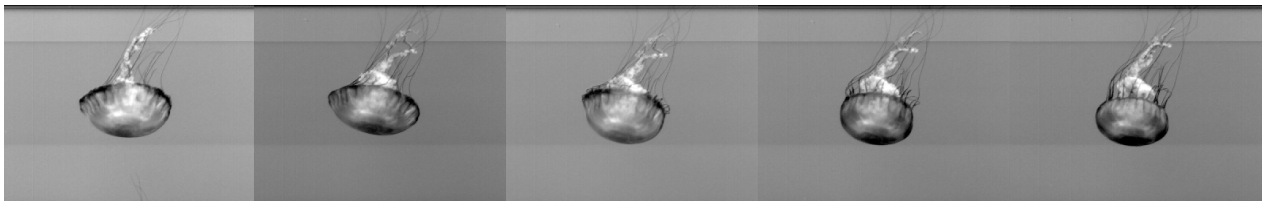
Internal Motorized Focus

SharkEye™ has a camera-internal motorized focus that is independent of the lens. This focus mechanism supports operation at extremely short distances, in some cases right down to the surface of the lens hood. As a result, the system can discern very fine detail down to the tens of micrometers. This is useful for industrial inspections and scientific work.

A weld inspection shows metal pitting

Digital Still and Motion Imagery

SharkEye™ cameras can operate in both 'still' and high repeat-rate 'motion imagery'. Motion imagery is designed to support sea floor mapping, where a high frame rate is required to image the sea floor with sufficient overlap between pictures, or for applications such as marine animal motion studies. Unlike in digital video cameras, images can be stored raw or individually compressed, so that each individual image yields the highest quality. Frame rates depend on the pixel count, compression method and storage device speed. The KAI-1020 sensor yields about 4 frames/sec when images are stored raw on the CF FLASH card. The TC-253 sensor operates at about 11 frames/sec under the same conditions.



Motion Sequence with the TC-253 EMCCD Low-Light Sensor

Storage Media

SharkEye™ cameras can transmit digital imagery life via their Firewire or RS-485 interface, but they can also store images internally. The SC-3 model includes an internal CF card slot. The camera is factory equipped with a 32GB FLASH card. In the RAW (best quality) image format, this is sufficient for about 16000 KAI-1020 images, 48000 TC-253 images or 1140 images taken with the IBIS4-14000 14 Megapixel image sensor. Selecting JPEG compression instead of RAW multiplies the number of images that can be stored approximately by a factor of approx. four.

Lighting Systems

Desert Star Systems offers the model SL-3 high-intensity LED strobe for use with the SharkEye™ camera. Using the latest LED engines (currently three Titan Turbo NT-54D0-0487), the SL-3 operates both in strobe and continuous modes. At 5500 Lumen, is sufficient for most applications.

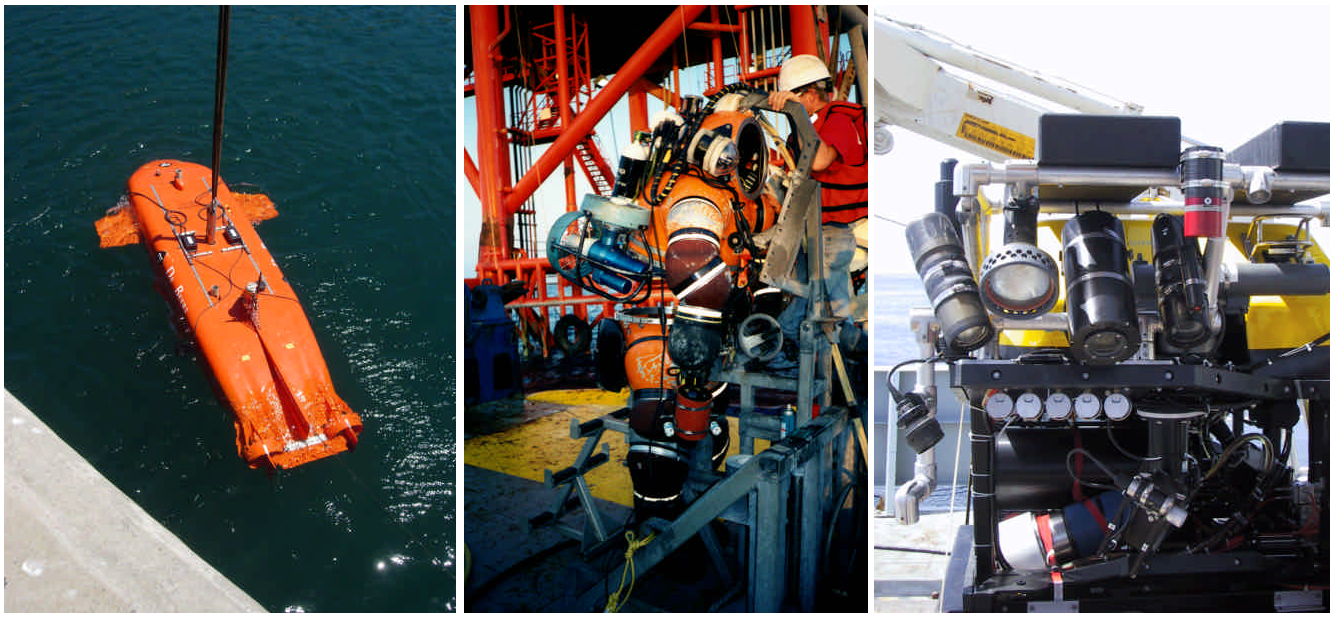
SharkEye™ cameras are also generally compatible with many other manufacturers' strobes, although a custom made adapter cable will be needed.

SL-3 Rapid-Fire LED strobe in 4000m depth rating configuration

Operating Modes

SharkEye™ cameras support three operating modes:

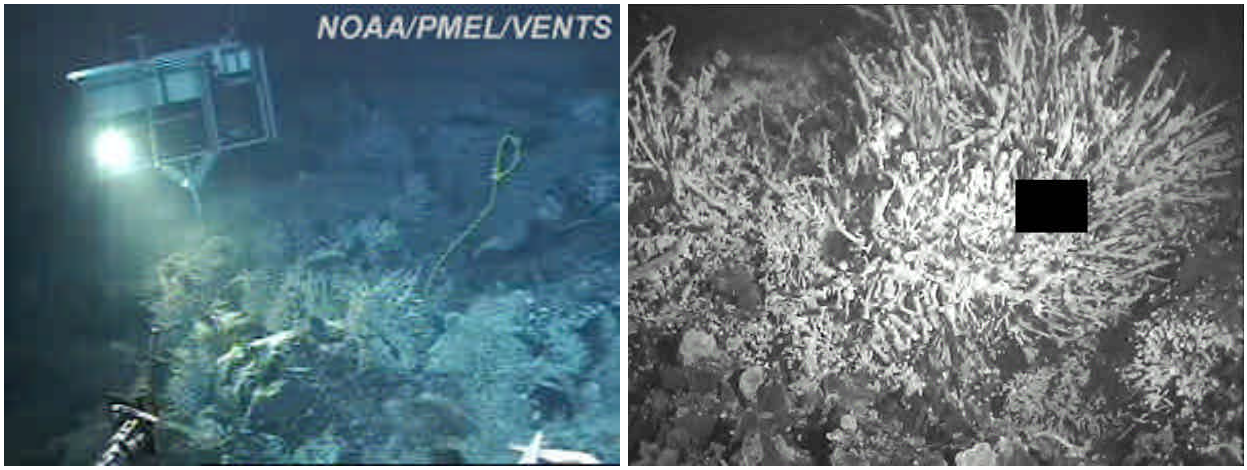
1. In **remote mode**, the camera is controlled via an umbilical by a PC at the surface. The RemoteCAM software is used. This operating mode is suitable for ROV, diver and drop-camera operations, where live imagery must be obtained at the surface.
2. In **autonomous mode**, the camera is configured to execute a pre-defined image acquisition schedule. The operator can define the number of images per acquisition, the interval between images in an acquisition and the time between acquisitions. The camera enters a low-power sleep mode between the image acquisitions. This mode is intended for autonomous observation stations, where a camera may operate over periods ranging from hours to over a year.
3. In **host controlled mode**, the camera functions are controlled by a host computer through either the RS-485 or the Firewire interface. Camera imagery may be sent to the host computer via these interfaces as well. This mode is intended primarily for AUV/UUV, but also some autonomous observation stations. The host controlled operation and image retrieval is in particular useful when there is a need to store a variety of observation data, including imagery, on a central storage device controlled by the host computer. Note that this mode requires custom engineering support.



Dual SharkEye™ cameras on an AUV (left), single atmosphere diving suit (center), ROV (right)

Stereographic Imaging, Acoustic/Satellite Imagery Transmission and Other Special Features

The SharkEye™ system is highly modular and does include a powerful processing system. It does support custom programming and can therefore assume highly specialized functions. One previously implemented capability is the tight synchronization of two cameras to obtain stereographic imaging for volumetric measurements. Another is image tiling and special compression to support image transmission from a NOAA deep ocean observatory via an acoustic and a GEOS satellite data link to shore. Special programming and features are available upon consultation with Desert Star Systems. Once an application has seen repeated demand and has reached a sufficient state of refinement, it may be added to the camera's standard feature set. This assures long-term support of the capability.



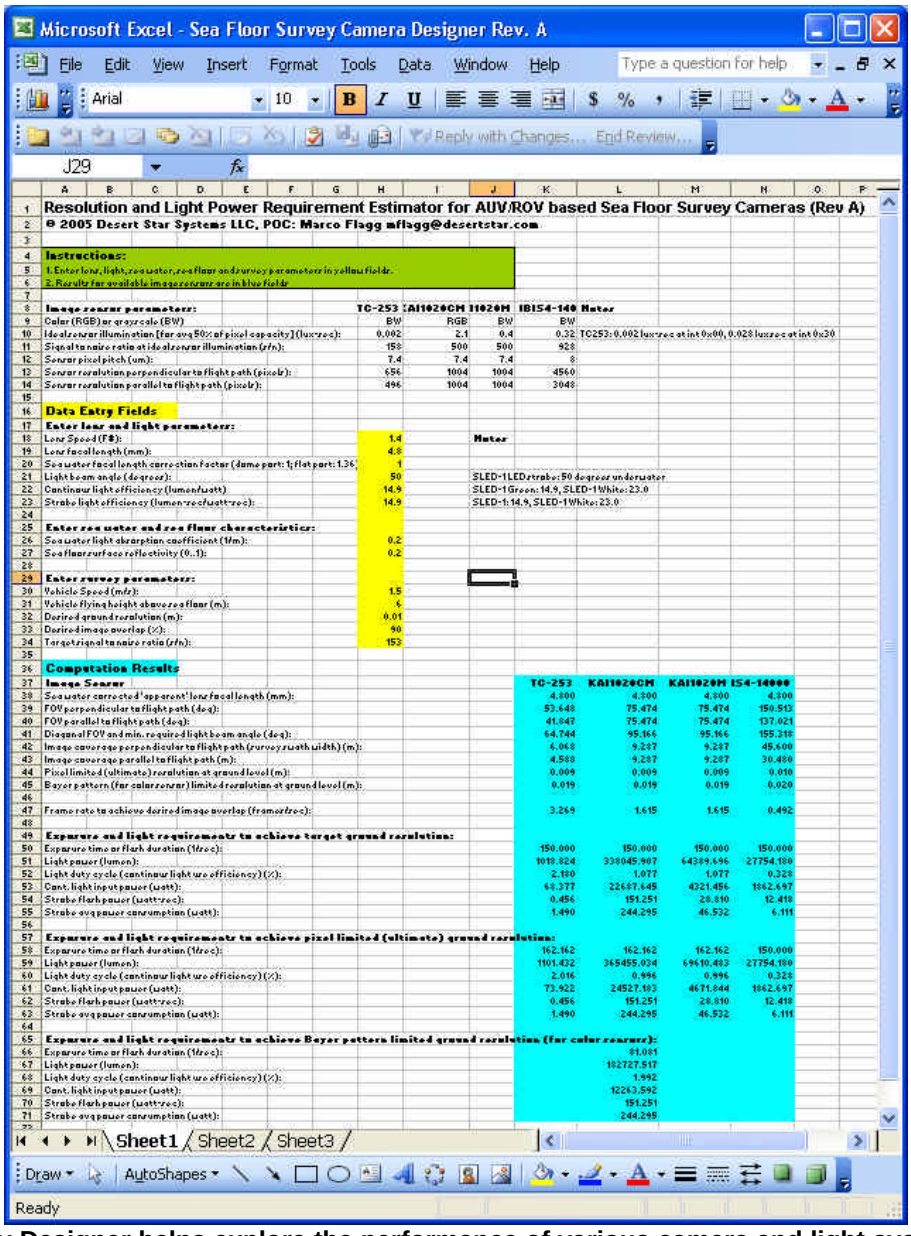
NOAA's NEMOnet autonomous observatory (left), and SharkEye™ picture of a tube worm colony with missing tile transmitted via an acoustic and a GEOS satellite link (right)

1.1. Camera Selection

The standard SharkEye™ camera is the model SC-3/300m with these features:

- 300m rated rectangular aluminum housing
- FISM-1 image sensor module with 1004x1004 pixel color CCD and 656x496 pixel low-light EMCCD
- C-Mount lens system, with rotating adapter plate for color or low light sensor selection
- Image storage 1 GB internal CF FLASH memory card
- RemoteCAM remote operation software

This model is suitable for most operations and it is described in this manual. Please contact Desert Star Systems if your application requires a different or a custom configuration. We will ensure that your camera has the appropriate sensor, lens, field of view, lighting system, storage capability and software for your application. You can also experiment with the Seafloor Survey Designer spreadsheet, which is available on our web site. This spreadsheet lets you play with a variety of parameters to explore lighting and lens requirements, frame update rates, motion blur control etc.



The Seafloor Survey Designer helps explore the performance of various camera and light system configurations

2. SharkEye™ System Components

Below is a list of standard SharkEye™ components. Most systems will come with all of the following. However, customized systems may be shipped without some of the standard components. For example a SharkEye™ not equipped with an external FireWire interface will not include the Firewire to AMP Connector Communication Adapter.

SharkEye™ Component List

- 1 ea. SharkEye™ SC-3 Digital Still Camera
- 1 ea. CON00306 5-pin dummy plug for the strobe connector
- 1 ea. CON00403 6-pin dummy plug for the umbilical connector
- 1 ea. CON00383 8-pin dummy plug for the multi-function connector
- 1 ea. CON00402 6-pin female whip (0.6m length) for splicing to a remote control umbilical
- 1 ea. FCBL-A Multi-Function Connector Adapter Cable
- 1 ea. FADM-485 'SeaLvel' RS-485 to USB converter
- 1 ea. ACDC-U Power Adapter/Charger
- 1 ea. LNS00013 4.8mm F/1.8 C-Mount lens or similar (lens delivery sometimes changes due to availability)
- 1 ea. Software Installation Disk including the RemoteCAM software and support utilities
- This manual

For SL-3 Strobe:

- 1 ea SharkEye™ SL-3 LED strobe
- 1 ea CBL00015 strobe power & control cable

For SBP-2 Battery Pack:

- 1 ea SBP-2 battery pack
- 1 ea CBL00017 8-pin battery cable (6-pin CBL00009 for special orders)

If a shipment is incomplete, please immediately contact Desert Star Systems. If you are missing any components required for system operation, obtain these components before proceeding.

Windows Computer for SharkEye™

In order to use SharkEye™, you will also need a Windows computer. SharkEye™ has been tested with Windows XP and Vista machines. Processing power and memory requirements are modest, so most machines will suffice. You will however need a Firewire (IEEE-1394) interface to retrieve image data from the camera. If your computer is not equipped with a Firewire port, adapter cards are available.

3. SharkEye™ Connectors and Controls

Multi-Function Connector

This connector is present on all versions of SharkEye. It is used for camera control (via RS232 or RS485), retrieval of image data (via Firewire), and supplying external power. The FCBL-A multi-function adapter connects here.

Bulkhead Connector: Subconn MCBH8F
Cable Connector: Subconn MCIL8M

1: Ground
2: RS485 TX/RX+
3: RS485 TX/RX-
4: FireWire TPA+
5: FireWire TPA-
6: FireWire TPB+
7: FireWire TPB-
8: External Power Input (+9V to +15V DC)

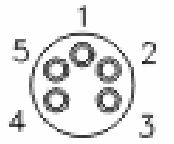
Umbilical Connector
Used primarily for remote operation of the SharkEye™ camera via RS-485, and remote power to the camera. Use the supplied 6-pin female whip (CON00402) to splice your system's umbilical to this connector. The RS485 interface is the same one as is available on the multi-function connector.

Bulkhead Connector: Subconn MCBH6M
Cable Connector: Subconn MCIL6F

1: Ground
2: RS485 TX/RX+
3: RS485 TX/RX-
4: External Power Input (+9V to +15V DC)
5: External Trigger Input (short to ground to trigger)
6: Available for special/custom functions (such as strobe trigger output)

Strobe Connector
Used for connecting to external strobe. Using appropriate cables, the strobe control is compatible with the SL-3 LED strobe and strobes made by other manufacturers.

Bulkhead Connector: Subconn MCBH5F
Cable Connector: Subconn MCIL5M



1: Ground
2: Strobe /TRIGGER (shorted to ground for fire the strobe. Strobe is lit as long as signal is shorted to ground)
3: Strobe /STROBE_ON (shorted to ground to switch strobe ON. SC-3 provides 7-sec startup time for cap charging)
4: Available for special or custom functions
5: Power Output for strobe (same as external power input on the two other connectors)

Power Switch
Flip this switch to the ON position to power the camera. In autonomous mode with sleep between acquisitions, setting the switch to ON starts the operation, but the camera will still power itself down for sleep. Switching this switch OFF stores current camera settings in FLASH memory, for basic remote operation using the external trigger input.

Status LED
The SharkEye™ status LED blinks when the camera is switched ON.

RESET Indent
There is also a magnetic camera RESET indent on the end-cap. Hold a magnet here to RESET the camera prior to enable firmware updates.

4. SharkEye™ Acessories

FCBL-A Multi-Function Cable
The multi-function cable, part # FCBL-A is used for maintenance, test and image download tasks. One end of the cable plugs into the 8-bit multi-function connector on SharkEye™ (see section 3.1.). The other end of the cable has three connectors:

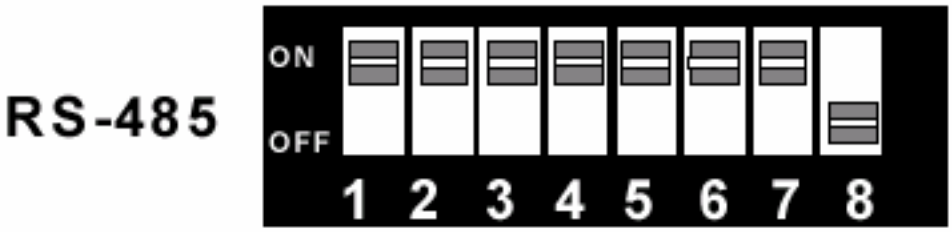
1. The Firewire (IEEE-1394) connector is available to download stored image data from the camera. A 6-pin to 4-pin adapater is provided so that the cable can be used with either standard or mini Firewire ports.
2. The power connector links to the part # ACDC-U external supply/battery charger. Use it for lab tests of the camera or to charge the internal battery in your camera.
3. The RCA connector links to the camera via the RS-485/USB adapter to the PC. It is available to test camera remote operations, to update the camera firmware and it can also be used to retrieve stored imagery from the camera at a speed slower than Firewire.

FADM-485 RS-485 to USB Communication Adapter

The SharkEye™ is shipped with a RS-485 to USB adapter. In remote operations, the adapter provides the link between the ROV umbilical and a USB port on your PC. A first test should be done by linking the camera via the FCBL-A multi-function cable and this adapter to your PC. The operations, the FCBL-A is then replaced with the umbilical twisted wire pair or RS-485 multiplexer connection between the surface control point and the ROV.

RS-485 to USB Converter

The Camera uses a 2-wire no-echo half-duplex communication protocol. The adapter is factory configured to use this protocol. The internal dip switches are set as shown:



The standard pin assignment for the adapter is described below.

PIN NUMBER	FUNCTION
7	Ground
3	TX/RX -
14	TX/RX +

ACDC-U Power Supply and Charger

SharkEye™ cameras are shipped with a 15V DC power supply (part # ACDC-U) suitable both for internal battery charging and test operations of the camera.

ACDC-U 15V DC Power Supply & Charger

4.1. SL-3 High Intensity LED Strobe

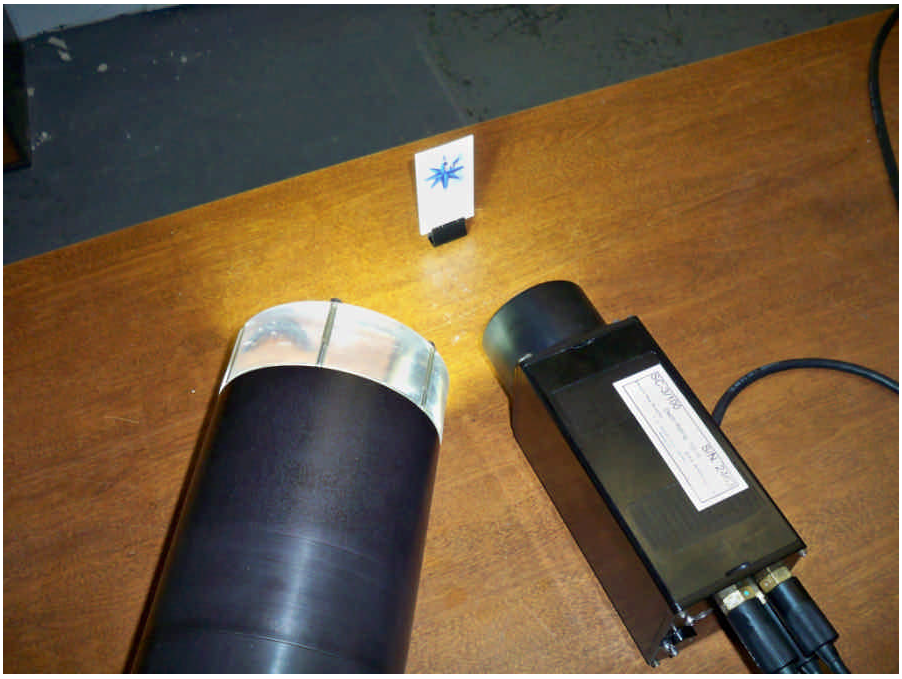
Desert Star Systems offers the model SL-3 high-intensity LED strobe for use with the SharkEye™ camera. Using the latest LED engines (currently three Titan Turbo NT-54D0-0487), the SL-3 operates both in strobe and continuous modes. At 5500 Lumen, is sufficient for most SharkEye™ applications.

SL-3 Strobe (4000m depth rated version)

The operation of the SL-3 strobe is simple. It is connected via a supplied 5-pin cable to the SC-3 camera. The SC-3 camera must be connected to external power, and that power is routed via the 5-pin cable to the strobe. The SC-3 camera automatically controls the strobe through a /TRIGGER signal and a /STROBE_ON signal. The /STROBE_ON input to the SL-3 strobe switches the strobe ON when shorted to ground. The strobe then starts charging it's capacitors, which provide the high power needed for illumination. Capacitor charging takes about six seconds if the capacitors are completely depleted. The camera fires the strobe by shorting the /TRIGGER signal to ground. The strobe stays lit as long as /TRIGGER is active. This means that the strobe can be operated in continuous mode by keeping /TRIGGER shorted. However, the strobe will be not as bright (estimated 25% of full brightness) in continuous mode, as the energy storage capacitors are depleted and then maintained by the capacitor charge current only.

SL-3 Strobe Operation

1. Connect the SL-3 strobe to the SC-3 camera using the supplied 5-pin cable (CBL00015)
2. Aim the strobe to light the camera's field of view. Typically, the strobe is some distance from the camera and points at about a 30 to 45 degree angle, in order to minimize backscatter.
3. Operate the camera. The strobe will fire whenever the camera is exposing an image. There is no explicit 'strobe selection' control in the control software. Instead, if you don't want to use the strobe, disconnect it. Make sure to seal any unused connector with a dummy plug.
4. Adjust the image brightness by changing the exposure time as needed.
5. For close distance (macro) shots, partially close the iris of the camera lens. This will provide a greater depth of field (greater distance range within which the image is in focus), and overall image quality will be better for most lenses. To compensate for the reduced light hitting the sensor, the exposure time needs to be longer. In general, make sure that the exposure time is not so long that motion blur will become a problem.

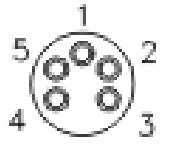


The strobe should point at about a 30 to 45 degree angle at the target, in order to minimize backscatter caused by particulates in the water. For close-up shots such as demonstrated here, partially close the camera lens iris in order to obtain a greater clear focus range (greater depth of field) and improve overall image quality

SL-3 Strobe Controls

The SL-3 strobe is equipped with a status LED and a connector for power & control. The strobe is powered and controlled by the camera. The status LED will light up when the camera switches the strobe ON. The pin assignment of the connector is as follows.

Bulkhead Connector: Subconn MCBH5F
Cable Connector: Subconn MCIL5M



1: Ground
2: Strobe /TRIGGER (shorted to ground for fire the strobe. Strobe is lit as long as signal is shorted to ground)
3: Strobe /STROBE_ON (shorted to ground to switch strobe ON. Capacitor charging may take up to 6 seconds)
4: Available for special or custom functions
5: Power input for strobe, +9V to +16V

Use cable CBL00015 to link the camera to the strobe. This cable is supplied with the strobe. Additional technical specifications for the strobe are available in the Specifications of this manual.

4.1. SBP-2 Submersible Battery Pack

Standard SharkEye™ cameras include a small internal battery pack (note: some cameras are delivered without that pack, in order to facilitate remote initialization of the camera by power cycling). However, an external power source is always needed when operating the SL-3 strobe, or when the required battery life exceeds the specification of the camera internal battery.

SBP-2 Submersible Battery Pack

The SBP-2 is a submersible battery pack that can be used to operate the camera. The battery pack provides 9000 mAh capacity at 9.6V nominal, which is generally sufficient for over 1000 strobe exposed images (see Specifications section of this manual for details). The depth rating of the standard SBP-2 is 1000 meters.

Battery Pack Operation

Connect the battery pack to the camera using the supplied cable. The standard is an 8-pin cable, part number CBL00017. Depending on your specific camera configuration, the battery pack may be equipped with a 6-pin connector and require cable CBL00009.

Battery Pack Charging

Connect the battery pack to the SharkEye ACDC-U charger via the supplied adapter cable. The battery pack will be trickle charged. If completely depleted, a full charge requires 24 hours. The charger can remain connected beyond that, as excess energy will be converted to heat at a rate low enough to not damage the batteries. While charging over a weekend is OK, we recommend against permanently leavi ng the pack permanently on charge.

SBP-2 battery pack connected to ACDC-U charger via FCBL-A adapter cable and 6-pin/8-pin converter

SBP-2 Connector Pin Assignment

For the standard 8-pin version:

Bulkhead Connector: Subconn MCBH8F
Cable Connector: Subconn MCIL8M

1: Ground
2-7: not used
8: Power output (+9.6V nominal) and charger input (+15V)

For special-order 6-pin version:

Bulkhead Connector: Subconn MCBH6F
Cable Connector: Subconn MCIL6M

1: Ground
2-3: not used
4: Power output (+9.6V nominal) and charger input (+15V)
5-6: not used

5. Operating the SharkEye™ Camera

Follow these steps to get the SharkEye™ ready for operation.

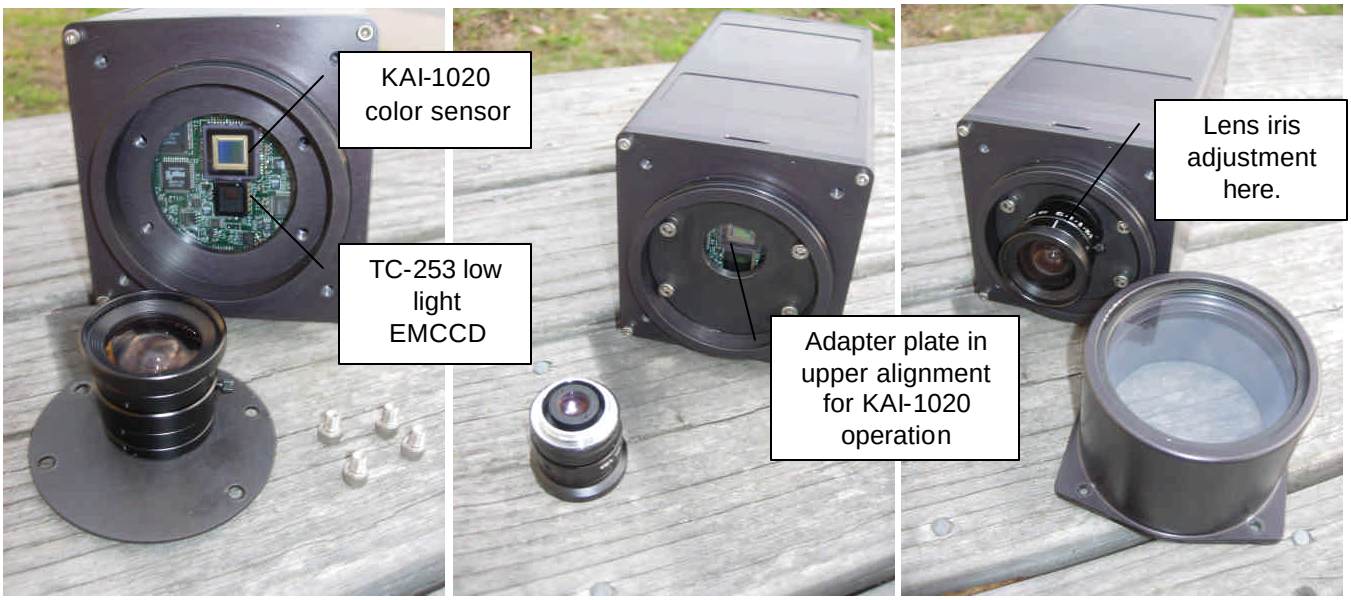
- Unpack the SharkEye™ and make sure you've got all the parts.
- Charge the internal battery if necessary.
- Change and adjust the lens as needed
- Connect the SharkEye™ to your computer directly (for test purposes) or via an umbilical.
- Optionally connect a strobe.
- Activate and test SharkEye™ on your desktop.
- Deploy for your actual mission.

Battery Charging

The SharkEye™ SC-3 battery whenever external power above about 13V is applied. Charging does not interfere with normal camera operation. However, to insure that the battery is fully charged, the recommend procedure is to charge the battery with the camera off. In applications where the camera is always powered externally, the battery may be of disadvantage. This is because it prevents a camera power cycle to achieve a full RESET, and the battery may also eventually (after several cycles) become damaged if the camera is not switched off by turning the power switch OFF after external power is disconnected. Therefore, on request Desert Star will remove the battery in your camera.

Lens Replacement and Adjustment

The SC-3 lens is accessible by removing the lens hood. Cameras equipped with C-mount lenses and the FISM-1 dual-sensor module also include a lens adapter plate. Rotate the plate to align either with the KAI-1020 color sensor or the TC-253 low-light sensor as required by your operation. The lens hood and the adapter plate are removed by loosening the four screws around the perimeter. Adjust the lens iris. An open iris (F/1.8 or F/1.4) passes most light, but focus is also most critical. Best image quality is obtained at around F/5.6 for most lenses. But F/5.6 requires ten times as much light as F/1.8!



Connecting the Camera to a Computer or Umbilical

Connecting the camera to your computer for test purposes is straightforward. Just link it via the FCBL-A multi-function adapter cable and the FADM-485 adapter to a USB port on your computer. For umbilical connection to a ROV, drop camera or similar system, use the supplied 6-pin female whip (CON00402) and splice at least the data lines (pins 2 and 3) to the umbilical. Wire such that the TX/RX+ connector on the camera connects to TX/RX+ on the FADM-485 on the top end, and the TX/RX- signal of the camera to the TX/RX- on the top end. In most cases, you will also connect power (pins 1 and 4). The nominal power is 12V DC is you do not intend to charge the camera internal battery, or 15V DC if the internal battery is to be charged as well. Camera power consumption depends on the mode of operation. Your supply should provide at least 2 Ampere in order to support all modes, battery charging and still have some margin of safety. If you are also powering the SLED-3 strobe through the umbilical, then your supply must support spikes up to 5 Ampere.

Connecting a Strobe

A strobe can be connected to the SharkEye™ camera through the strobe connector and supplied strobe cable. The strobe is powered through the SharkEye™ camera. For the SL-1 and SL-3 strobes, turn the power knob on the strobe to the on position. The LED on the strobe will stay on when it is ready to fire.

Activating the Camera

Switch the knob to the ON position to activate the camera. The LED should start to blink. If the camera is correctly connected to a PC running the RemoteCam or Image Retrieval software, that software should detect the camera.

The Status LED

Once the camera is active, observe the status LED. When first turned on the status LED will blink one second on one second off. This indicates that the camera is starting up. After a few seconds, the LED should settle into a pattern of one short blink every second. If you don't see this pattern, you should reset the camera. Refer to the following table.

During battery charging the status LED will emit a short blink once every 4 seconds, even if the switch is in the off position.

Status LED Pattern	Description
LED is OFF	The camera is OFF, the battery is dead or there is no external power connected.
LED is always ON	Not a valid blink pattern. A hardware problem may exist, the battery may be discharged.
Single short blink once per second	The camera is operating fine.
Fast short blink	The internal batteries are low and should be recharged.
1/2 sec ON, 1/2 sec OFF	The camera is starting up.
1/4 sec On, 4 sec OFF	The internal battery is charging.

SharkEye™ Blink Patterns

5.1. Camera Remote Operation with RemoteCam

The SharkEye™ camera can be remotely controlled from a Windows PC. The RemoteCam application provides the user interface for.

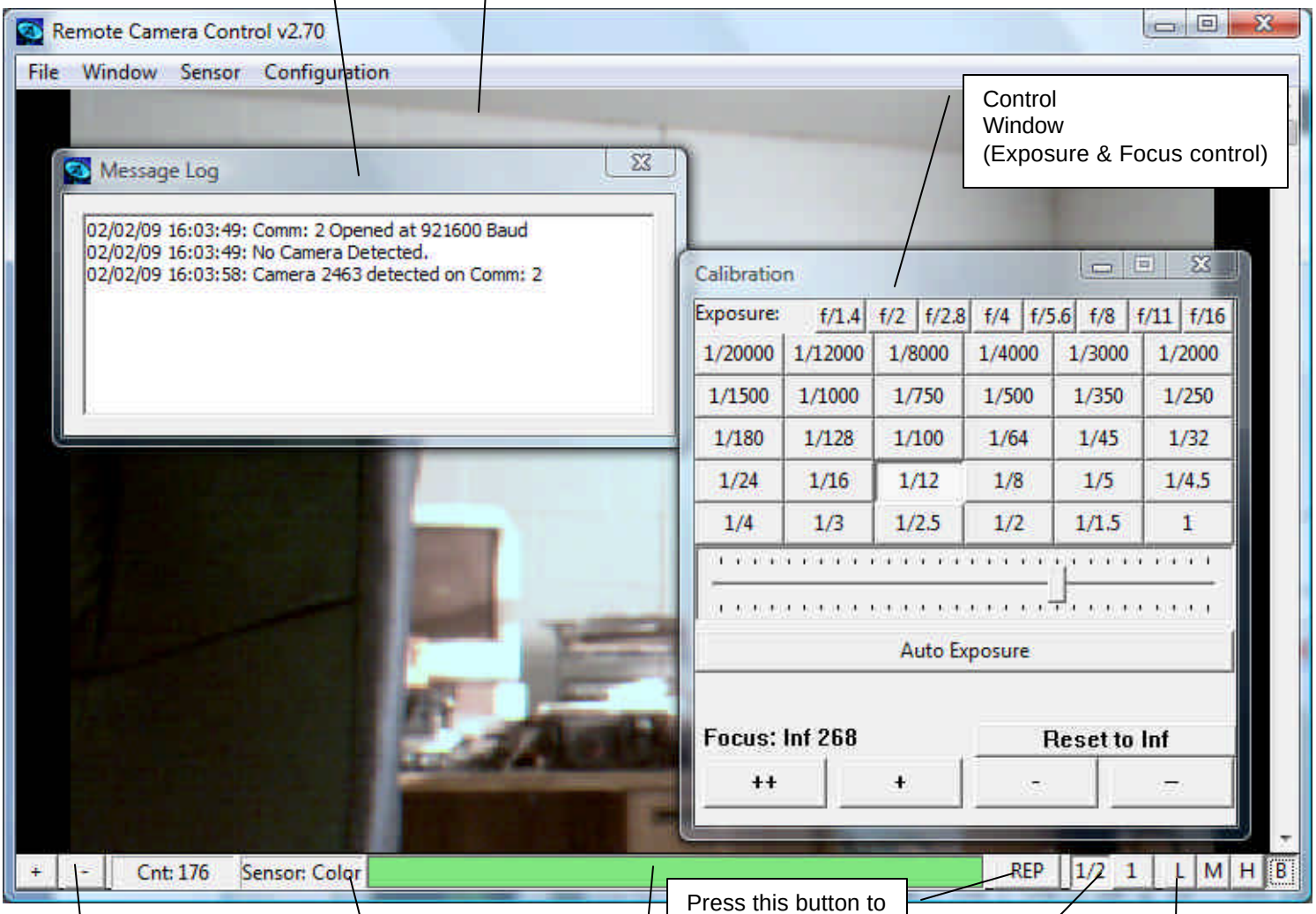
Select the RemoteCam application from the windows start menu. The application will start running and indicate that it is waiting for a connection. If the application cannot open the selected serial port an error message box will appear. You can select a different serial port to resolve this problem.

The RemoteCam™ application is shown below:

Image Acquisition Window:

- Left-click on this window to acquire and transmit another image to the surface.
- Right-click on this window to acquire a full-resolution image and store it in the on-camera FLASH or hard disk memory.

Message Window



Control Window (Exposure & Focus control)

Image download progress bar

Press this button to continuously acquire and transmit images.

Image Zoom

Image Sensor Type

Image Transfer Resolution

Image Quality Settings

Connecting the Camera to the PC using RemoteCam

The SharkEye™ camera uses RS-485 serial communication. The RS-485 standard provides robust data exchange at distances up to 1300 meters). An RS-485/USB converter (SeaLevel model P/N 2104) is provided to allow for the use of the SharkEye™ with a standard PC USB port. The converter can be used with either the multi-function or umbilical ports.

Once the camera is connected and the application has been started, turn on the SharkEye™ camera to establish a connection. The knob should be turned to the ON position. When the camera has been detected by the RemoteCam application, a message will appear in the message window.

The RemoteCam application will also connect to an attached camera if the camera is turned on when the application is started. The RemoteCam application only supports RS-485 Communication

When the application is started the software will attempt to open the last used serial port at the last used baud rate. If this port cannot be opened an error message will be shown. If no link is established, the wrong serial port may be in use or the baud rates on the PC and the camera do not match.

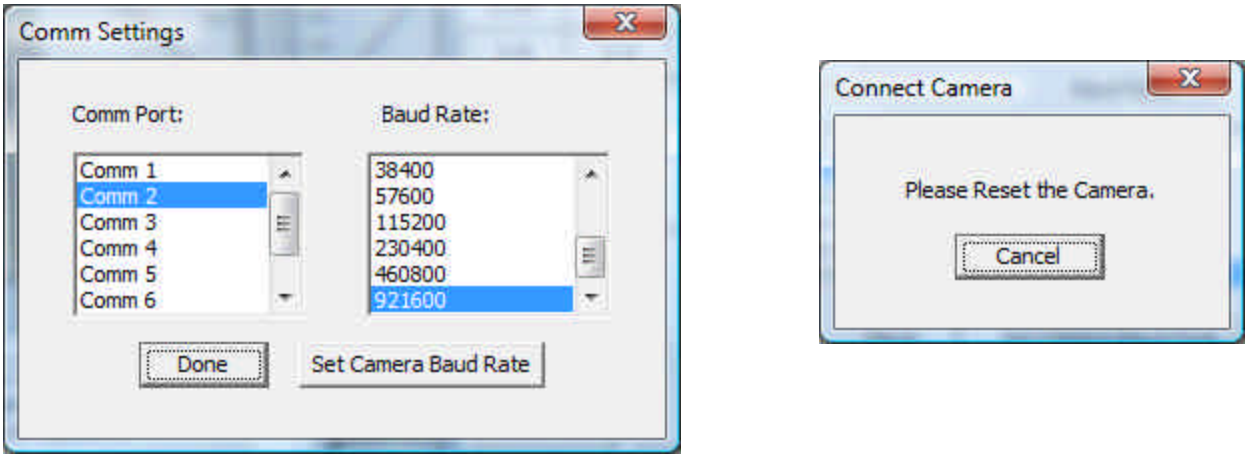
The camera is factory configured to use 921600 baud by default.

Changing the RS-485 Connection

The desired serial port can be selected from the Serial Configuration Window. Select ***Configuration/Serial Port*** from the main menu. The Serial Port Settings window will be displayed. Selected the desired serial port and baud rate.

Press the ***Set Camera Baud Rate*** Button to change the programmed baud rate on the camera. Flip the camera power switch to the OFF position, wait 5 seconds and then the ON position when the pop-up window appears. When the pop-up window disappears the new baud rate will have been programmed.

If you know the current Baud Rate setting of the camera (such as 921600 baud), and you simply want to instruct the PC to use that baud rate, just hit the ***Done*** button after selecting the baud rate. You might do this for example when starting to use a new PC with an already programmed camera.



Serial Port Selection Window (left) and pop-up window asking to power-cycle the camera

Image Sensor and Mode Selection

SharkEye™ can be outfitted with a choice of image sensor modules. **RemoteCAM** will auto-detect the sensors that are available on the connected camera. The image sensor type is indicated at the bottom of the **RemoteCAM** window. Most sensors have some mode selection options, which are accessible by clicking ***Sensor*** on the main menu.

For the FISM-1 image sensor module:

Color -> Daylight: Use of the KAI-1020 color CCD under 'daylight conditions', such as on land, in very shallow water (<3m) or in deeper water with artificial illumination. This mode uses auto white-balance to obtain good colors.

Color -> Underwater: Use of the KAI-1020 color CCD underwater (> 3m) with natural light. The red portion of the light spectrum is mostly absorbed at this depth, and the camera does not use white balance. The pictures will look mostly blue or green, but image noise will be much lower (smoother looking image).

Night Vision -> Twilight: This mode uses the TC-253 EMCCD night vision sensor. The image intensifier is at it's lowest (least sensitive) setting, requiring most light but also yielding the lowest image noise. Use this setting during twilight on land or in deeper but also clear waters.

Night Vision -> UW Bright: This unfortunate named mode uses the TC-253 EMCCD night vision sensor. The image intensifier is at it's medium setting, yielding a good compromise of sensitivity and image noise. Use this setting as the default underwater.

Night Vision -> UW Dark: This mode uses the TC-253 EMCCD night vision sensor. The image intensifier is at it's highest (most sensitive) setting, yielding best sensitivity but also noticeable image noise. Use this setting for darker underwater conditions.

For the FISM-2 image sensor module:

Panorama Mode: This mode shows the full field of view (full angle) of the image sensor, but the images are decimated to speed the transmission. The decimation is 4:1 in both the X and Y axis, meaning only every fourth pixel (strictly speaking every fourth pixel pair due to the Bayer color processing) is transmitted. This means, the RemoteCAM 'full resolution' provides an image of 1140H x 762V. This mode is used primarily to obtain control images that show the full view. Right-click on the RemoteCAM screen to save an image on the camera at the full sensor resolution of 4560H x 3048V.

Center Region Mode: This mode transmits only the center region of the full sensor image, but does so at the full pixel resolution. Just like in Panorama mode, the transmitted image is 1140H x 762V. Yet, because these are the center pixels, the image covers only ¼ of the full field of view both horizontal and vertical. This mode provides the best detail and should therefore be used for fine focusing. It also can serve as a digital zoom. Even if you are in this mode, a right-click on the RemoteCAM window will still save the full sized image (4560H x 3048V) on the camera.

As more FISM series image sensors become available, corresponding ***Sensor*** menu selections will be added to RemoteCAM.

Acquiring Images

Images are acquired by pressing the left mouse button when the cursor is anywhere in the Image Acquisition Window. The camera will acquire an image and the application will begin to download the image. The ***Image Download Progress Bar*** indicates the status of the image transfer to the PC. The image will be displayed when the progress bar reaches the end.

The ***REP*** button enables continuous image acquisition.

The image can be digitally zoomed in or out by using the **Image Zoom Control** buttons or by pressing the + or – keys on the PC keyboard when the Image Acquisition Window has keyboard focus (indicated by the highlighting of the Main Dialog Window's title bar.)

The Count Display at the bottom of the screen indicates the number of images currently stored on camera internal FLASH memory.

Image Transfer Resolution Control

Pressing the desired resolution button on the top of the screen can change the resolution of the image transferred to the PC. Resolutions can be set to 1/2 or full resolution. The lower the resolution the quicker the image can be uploaded to the PC.

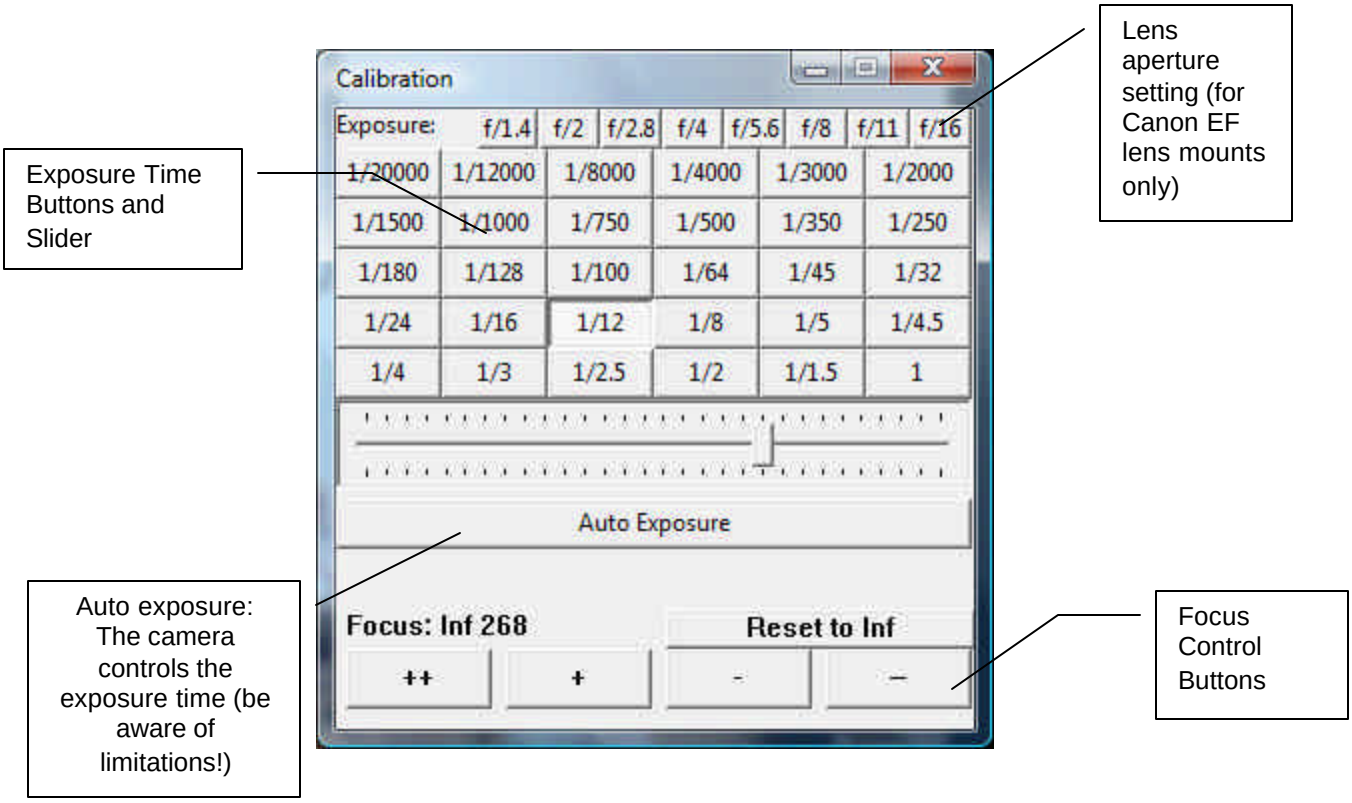
The other buttons set the JPEG compression factor.
L = **L**ow quality
M = **M**edium quality
H = **H**igh quality
B = **B**est quality

The lower the resolution the quicker the image can be uploaded to the PC.

NOTE: The camera will always save full resolution/full color images to its internal storage. The resolution controls only modify the size of the image uploaded to the PC.

Exposure Control

Exposure can be controlled via the Exposure setting controls on the Control Window.



The Exposure Time buttons or the slider can be used. Both controls have the same effect. Pressing the Auto Exposure Button enables auto exposure on the SharkEye™ camera. When auto exposure is enabled the Exposure Time slider and buttons are disabled. Auto exposure is based on the camera using the results of one image, to adjust the exposure for the next image. The auto exposure does have a number of limitations that you should be aware of:

- Auto exposure will only work if the scene illumination is similar for successive images. This may be the case when the camera is static, or when it is moving and images are acquired frequently.
- If the camera is expected to move a lot between successive images, or light conditions will have changed a lot, then the auto exposure will not work well. You should use manual exposure, or perhaps techniques such as controlling the brightness of the illumination based on an altimeter reading.
- When using a strobe and auto-exposure, then the camera will try to adjust the illumination by changing the length of the strobe trigger pulse. Some strobes use a constant pulse period, and have a brightness control instead. In these cases, SharkEye™ cannot control illumination and you should select manual exposure, with an exposure period that is somewhat longer than the strobe pulse.

The exposure window can be closed and then reopened by selecting ***Window/Control Window*** from the main menu.

Focus Control

Camera focus can be changed by pressing the **+** or **–** buttons at the bottom of the Control Window. The **+** button will move the focus point farther away from the camera and the **–** button will move it closer. The double **++** and the **--** will move the focus in increments 5 times larger than the **+** and **–** buttons.

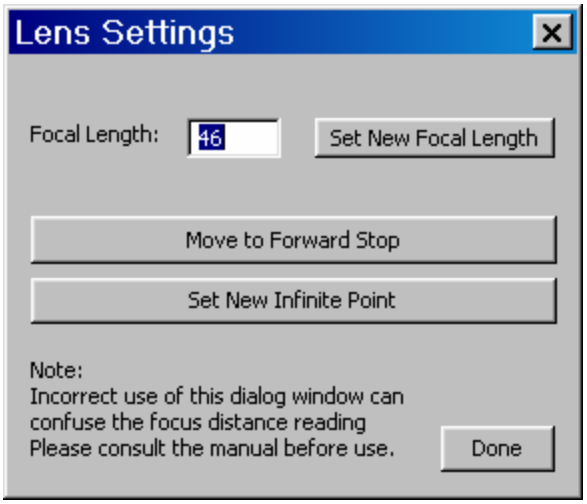
Note that the camera will only change the focus between image downloads. Due to the relatively long period for an image download (a few seconds up to a minute), the focus control can be a bit difficult. We recommend the following technique:

1. Open the lens iris all the way (smallest f number). This makes the focus most critical, and therefore also easiest to adjust. If your camera uses C-mount lenses, adjust the aperture ring on the lens. If you are using Canon-EF lenses, then use the aperture buttons in the exposure window (electronic control).
2. When calibrating focus in the air and the camera has a flat lens window, point the camera at a target that is about 70% of the anticipated underwater focus distance. When calibrating under water (preferred) or the camera has a dome lens port, point the camera at a target the same distance as the focus distance. The target should have both coarse and fine detail.
3. Start the focus process by selecting ½ resolution and **L**ow image quality setting at the bottom of the RemoteCAM™ window. This will provide fastest response. If your camera is equipped with the FISM-2 14 Megapixel sensor module, select ***Sensor -> Center Region*** on the RemoteCAM main menu. This will instruct the camera to send only the center portion of the image at full pixel resolution. This allows for a more precise focus.
4. Press the ***REP*** button and wait until you have gotten a few images. Notice their focus.
5. Now, hit the **- -** button or, or the **++** button once. This will adjust the focus for closer distance (**- -**) or greater distance (++). Wait until you get the re-focused image. Be careful to not become impatient here and wildly press the buttons. You can press the buttons at any time, but you will only see the result once the camera has acquired and then transmitted the next full image! So, take it slow until you get used to this. Pressing the buttons a lot will over-shoot the focus and you may get yourself really confused. Be also aware that the actual focus range of the mechanism is probably much larger than the focus range you need. Therefore, if the image is so blurred as to be unrecognizable, then the focus is much out of the useful range.
6. Once the focus is as good as you can tell, increase the image quality to **H**igh and then acquire some more pictures. Zoom in on the image somewhat by using the **+** button in the lower left corner of the window. The image transfer will now be slower, but you get a clearer picture. Do focus adjustments until the result is as good as you can get it.
7. Your focus should now be quite good already, and it is time for the final step. Select the full image transfer resolution (**1** button in the lower right corner), and do fine adjustments of the focus.
8. As the final step, set the lens aperture as desired. Closing the aperture down (larger f number) gives you a greater depth of field, meaning focus is less critical. It can also significantly improve image sharpness because the lens performs better. However, a closed down aperture also means you need more light to operate. In general, best image quality is obtained around f/5.6 to f/8. Often, this setting would require too much light and so you may operate at f/4 instead. For best sensitivity at some loss of detail, open the aperture all the way.

For most underwater photography, focus is adjusted once and then left in place, or it is adjusted rarely. Auto focus mechanisms are generally of limited use because they can easily be confused by floating particulates and backscatter in the water. The primary means for underwater focus control is to approach the target to the correct (focused) distance, and to set the lens aperture such that the target will be within the depth of field.

Obtaining a focus distance reading

SharkEye™ focus is operated by a stepper motor and a slide assembly that moves the sensor module inside the camera. I most cases, focusing is done visually, but SharkEye™ can also indicate a focus distance by tracking the motor position. Be aware that this mode is only practical in cameras that have an internal battery. The current position of the mechanism is stored in RAM memory and is lost each time power is removed from the camera.



To use this capability, you must first calibrate the mechanism for use with the lens mounted on the camera:

1. Point the camera at a distant target that defines the 'infinite' point. The target distance should be at least 200x the focal length of the lens, for example 10m for a 50mm lens.
2. If the lens has a focus ring, set it to infinite.
3. ***Select Configuration/Lens Settings*** from the main menu bar to pop up the lens setting dialog. Enter the new focal length (in mm) and press **Set New Focal Length**.
4. Now press the **Move to Forward Stop button**. This will move the internal focus all the way forward. (this takes about 10 Seconds).
5. Now start acquiring images and moving the focus back (using the – or – buttons)
6. When the image is in proper focus open the lens settings
7. Press the **Set New Infinite Point**.
8. The new infinite point is now set.

The camera will now indicate the focus distance as you change the focus. The focus distance is displayed to the left of the **Reset to Inf** button. The display will read Inf or Inf +# if the focus is moved to the set infinite point or beyond. Pressing the **Reset to Inf** button will move the focus to the infinite focus set point.

Saving Images

Images can be saved on the controlling PC or onboard the SharkEye™ camera. Images saved on the surface PC are at the resolution and quality setting that is selected on RemoteCAM. Images saved on the camera are always at the highest resolution and are currently always stored in in the .RAW file format, i.e. yielding the highest quality. (Future versions of RemoteCAM may support BTC or JPG compressed on-camera file storage to increase the number of images that can be stored).

The most common approach is to operate the remote communication link at a lower resolution and image quality, in order to boost the image update rate at the surface. If an image is worth saving, the operator saves its full resolution/quality copy on the camera, and retrieves these images after the mission is completed. Saving images transmitted via RemoteCAM meanwhile can serve as a means to make initial data available right away, while a mission is still in progress.

To save images on the surface PC:

- Select ***File/Save Image*** from the main menu bar to save the current image on the PC. A file browser will then pop-up, allowing the user to specify where to save the image. The image will be saved at the currently selected image transfer resolution.

- Selecting ***File/Save All Images*** from the main menu bar will cause all images acquired to be saved in the save image directory.

- The save image directory can be changed by selecting ***File/Set Save Directory*** from the main menu bar.

To save images on the camera:

- The current image can be saved on the camera's internal storage device by clicking the right mouse button when the cursor is anywhere in the Image Acquisition Window. The Images Stored on Camera Count indicator at the bottom of the window should increment. Currently the image is always stored at full color and resolution. Images stored on the camera can be retrieved using the Image Retrieval Application described below.

Recovering images stored on the camera is discussed in section 5.3 below.

Additional Function and Controls

The Message Log will report various status messages (such as serial ports opened and cameras detected). The window can be closed and then reopened by selecting ***Window/Message Log*** from the main menu.

5.2. Remote Operation with External Contact Trigger

SharkEye™ can be triggered by closure of an external contact switch. The switch must be connected to pins 5 (TRIGGER) and 1 (GROUND) of the six-pin umbilical connector. A picture is acquired and stored on the camera each time the switch is closed. The switch closure period must be 0.2 seconds or longer. The minimum interval is sensor specific and is about five seconds for the FISM-2 image sensor module and less than one second for the FISM-1 module.

Typical switches for underwater applications include a seafloor contact switch, a simple trigger that is operated from the surface (in many cases using a separate video camera to provide control images), or the control of the camera by a host computer such as on an autonomous vehicle (AUV/UUV) or on an instrument platform.

Because this type of operation has only limited or no performance feedback while an operation is in progress, it is very important to properly configure and then thoroughly test the camera system prior to operation. These instructions provide a guideline for the design of your SOP (Standard Operating Procedure):

Camera Connections and Power Supply

1. The trigger switch must be wired to pins 5 (TRIGGER) and 1 (GROUND) of the six-pin umbilical connector. A suitable whip is provided with the camera to manufacture the cable. A mechanical switch, a relay or an open drain/collector solid state switch are all suitable options. The switch can also be triggered by a TTL output of a microprocessor system. It has an input impedance of 10 kOhm, and a sink current of 0.5 mA or more is required for reliable operation. If left unconnected, you will see a bias voltage of +5V on the TRIGGER pin.

2. For shorter operations of typically two hours or less (depending on sensor selection and overall camera power consumption), the camera can be powered by its internal battery. For longer operations, external power should be used. +9V to +15V DC power should be connected to pins 4 (+) and 1 (-) of the six-pin umbilical connector. The power demand is about 0.4A to 1.2A depending on camera configuration (see specifications). The supply also has to support a brief initial power-on surge**. It is important to inspect the stability of your power supply during power-up and operation! Do this with a storage (digital) oscilloscope, rather than just a volt meter.**

3. Consider also ordering SharkEye™ without the internal battery installed, or request assistance in removing the battery. Removing the battery allows the camera to be power-cycles from the surface in order to RESET the camera. While SharkEye™ is very thoroughly tested and has multiple protective COP mechanisms, there is still a chance that a hang during operation could occur. This could for example happen due to erratic voltage (brown outs) on the external supply line or indeed due to a software bug. If the battery is removed, then the camera can be recovered from such a condition by switching external power OFF and ON again. No image data will be lost and operations can proceed.

4. Many operations will require a strobe or a continuous artificial source of illumination. SharkEye™ can control either type of device. The strobe or light control is normally connected to the 5-pin strobe connector. Pin 1 is ground. Pin 2 (TRIGGER) is shorted by SharkEye to ground to fire the strobe or switch on the illumination. Pin 3

(QUENCH) is shorted by SharkEye to ground at the end of the exposure period, at which time the switch on pin 2 is opened again. Light sources can be controlled by just the TRIGGER signal, or TRIGGER and QUENCH.

Camera Configuration

Feedback is limited during the dve, so the camera must be carefully configured and tested before operation. Camera configuration is done using the RemoteCAM utility, which is described in section 5.1. The concept is to set all parameters as desired, and then switch the camera power switch to the OFF position. At that moment, the camera will store all configuration information in its permanent FLASH memory and will now operate in this mode each time it is switched on. **Note that the camera power switch must be used to store configuration information. Just disconnecting external power from the camera, whether or not the camera is equipped with an internal battery, will not change the camera configuration!**

Sensor and mode selection:
In general, you can select any image sensor (the FISM-1 image sensor module has two image sensors) and sensor mode that is supported by your camera. However, an exception applies to the resolution and image file format (compression) selection.

- In Remote trigger mode, the camera will always store the images in the highest available resolution. If you are using the FISM-2 image sensor module, images will always be stored in the full 14 Megapixel format. This means that you can use RemoteCAM to calibrate the camera in any of the (faster) low resolution modes but still be assured that all stored images will be in the highest resolution.
- The camera stores all images in the raw (.RAW) format. This yields the best quality and most flexibility for image enhancement. The image quality selection in RemoteCAM therefore does not apply to images stored on the camera.

Focus:
Focus must be carefully adjusted. The camera does not have auto focus and will not change the focus during operation! Determine your approximate target distance, and adjust focus to that distance. Use the procedure in section 5.1. to adjust focus using RemoteCAM.

Iris:
Closing down the iris (using a larger f/ number) yields a wider depth of field, meaning a greater distance range will be in focus. Also, lenses generally yield the sharpest images around f/5.6 to f/8 even if they have a much more sensitive rating such as f/1.4. However, closing down each full fstop (such as f/2.8 to f/4 or f/4 to f/5.6 etc.) also doubles the light requirement. Therefore, iris setting is always a trade-off between good focus, best sharpness, available light and motion blur control. Some experimentation will be necessary and clearly each application has different requirements and priorities, but something around f/4.0 is a good starting point for your tests. Make adjustments based on the results of your initial tests.

The iris adjustment procedure depends on the lens mount of your camera:

- If equipped with a **C-Mount**, the lens adjustment is manually, by using the iris (aperture) ring on the lens.
- If equipped with a **Canon EF** mount, the iris is adjusted from RemoteCAM. Use the buttons at the top of the control window. Note that these buttons are always the same, independent of the attached lens and its rating. To open the iris all the way, you can check its f/ rating and hit the appropriate button, or just select f/1.4 which will open the iris for all lenses.

Please also see special iris instructions for strobe operation below.

Exposure Time and Mode:
You can select either auto exposure or a specific manual exposure time by pressing the appropriate button in the RemoteCAM control window. Auto exposure is recommended for ambient or continuous light exposed images, at least in static environments (the camera or the subject do not move or move slowly). Here, SharkEye will automatically adjust for light conditions. If there is fast movement, then auto exposure runs the risk of causing too much motion blur if light is low and therefore exposure is adjusted long. In that case, consider using manual exposure with a fixed exposure time. Set the exposure short enough as to not cause image data loss due to over-exposure and also short enough to keep motion blur within acceptable levels. When the subject is dark, the images will be under-exposed but can then be 'boosted' using Photoshop and similar software. This method does result in an increase of noise in the image, so well under-epxosed images may look noisy. However, the information necessary for your science or work may still be maintained.

Strobe Operation:
Strobe exposure is selected by setting the strobe slider to an amount other than zero. The slider only has a zero or non-zero function (it is still a slider for certain historical reasons and will be replaced by a check mark in future versions of RemoteCAM). When strobe exposure is selected, the camera will operate the TRIGGER and QUENCH lines to control the strobe (see discussion at the beginning of this section).

For variable pulse length strobes: When using industry standard xenon variable pulse length strobes, auto exposure should generally not be used. This is because the strobe illumination as a function of strobe pulse length is often very 'non-linear' and can cause erratic behavior in conjunction with our auto exposure algorithm. So, you should select a fixed exposure time. You can adjust the illumination by setting the exposure time. Keep in mind that most strobes are limited to pulse lengths of roughly 1/125 sec. Longer exposure times beyond this amount will not result in additional light from the strobe, but they can be used to fill in a distant background using ambient light.

For constant pulse length strobes: Another strobe type uses a constant pulse length, but the brightness of the strobe is regulated. SharkEye™ does not have a standard means to control the light output of a constant pulse length strobe. You may be able to control the strobe brightness by other means, such as using the output from an underwater altimeter to set the strobe brightness. SharkEye™. For a constant pulse length strobe, set the exposure time to be somewhat longer than the pulse of the strobe. This assures that all light is captured.

For continuous light sources and the Desert Star SL-3 LED strobe: SharkEye™ can also switch an external continuous light source ON and OFF. In most cases, the TRIGGER line would be used to activate the light sources through an appropriate power switching circuitry. You can use auto or manual exposure. For auto exposure, it is important that the light source lights up quite fast, such as within 1/1000 sec. If lighting up is slow, the auto exposure may not work correctly and should be tested first.

Special Notes for FISM-2 Operation With Strobe

The electronic shutter of the IBIS4-14000 CMOS image sensor on the FISM-2 module is a so-called 'rolling shutter'. Rolling shutters expose an image several rows of pixels at a time (exposure time is controlled by selecting how many rows the exposure window covers). This means, that the entire image is not exposed at once and therefore this mode is not suitable for strobe operation. Instead, SharkEye™ will use the sensor's full-frame exposure mode but loose the benefit of the electronic shutter. That means that light will still be collected by the sensor during the sensor read-out period, which is approx. 0.65 seconds. The camera will minimize unwanted light by closing the iris of the Canon EF lens during the read-out period. Please note the two implications of this approach:

1. For reliable operation, the iris must be set all the way open. This maximizes the difference between the amount of light that hits the sensor during the exposure period and then the read-out period.

2. Strobe exposure may not work when there is also much ambient (natural or continous) light. The iris of Canon EF lenses cannot be closed all the way, and so the light falling n the sensor during the read-out period can cause motion blur or over exposure.

Pre-Dive Test

Test the camera prior to the dive. Ideally this is done in water, such as when the host instrument is still at the surface. It can also be done in the air, such as when the host instrument is on deck. Try to obtain illumination, target reflectivity and target distance conditions similar to those underwater in order to get a good approximation. Then, shoot some images and make sure that both the camera and the light source operate OK. It is always advised to recover and inspect a few images to make sure everything is in working order. For example, you may find that the iris has been set incorrectly, that the remote trigger has failed to operate, that you have problems with the power supply or even that a protective lens end-cap is still attached!

Be aware that focusing is different in air than it is in water if your camera has a flat lens port. Underwater, targets will appear about 70% of the distance that they appear in air. So, for focus testing in air set the target at 70% of the distance that it will be in the water.

Dive Operation

During the dive, the camera will simply shoot an image every time the trigger input line is shorted to ground. You must make sure that the trigger pulse length is at least 0.2 seconds, but it can be longer. The minimum trigger interval depends on the sensor. It is about 5 seconds for the FISM-2 sensor module (IBIS4-14000 14MP sensor), and it is less than one

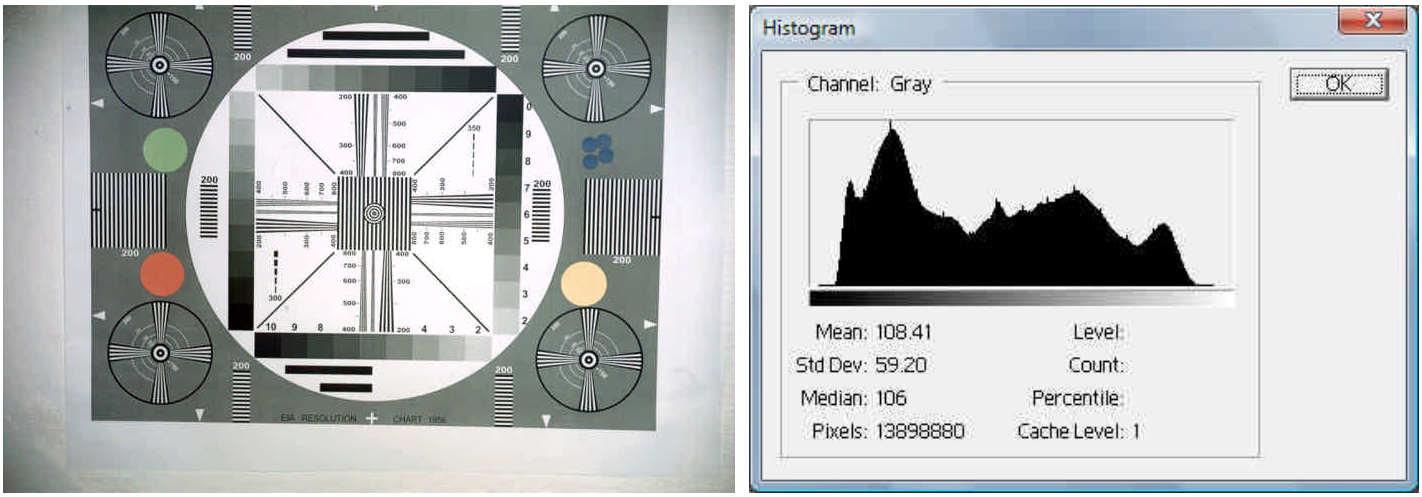
second for either of the sensors on the FISM-1. Triggering more frequently than the minimum period causes no harm, but the camera will ignore those trigger pulses.

It is also recommended to verify proper camera operation throughout your operation when possible. For systems that use a strobe equipped SharkEye™ in addition to a video feed, this can be done by watching for signs of the strobe flashing. If the camera experiences a hang or crash situation, possibly due to unstable power or a rarely occurring software bug that is not captured by the cameras 'computer operating properly' (COP) mechanism, execute a power cycle or camera RESET. Cameras without the internal battery installed can be power cycled simply by switching the external power off, then waiting five or more seconds, and switching power on again. If your camera does have the internal battery installed, the power cycle is not possible because the internal battery will keep powering the camera. In that case, a camera RESET is a possibility. The camera RESET signal can be factory-connected to a free connector pin. This is a custom modification and must be requested.

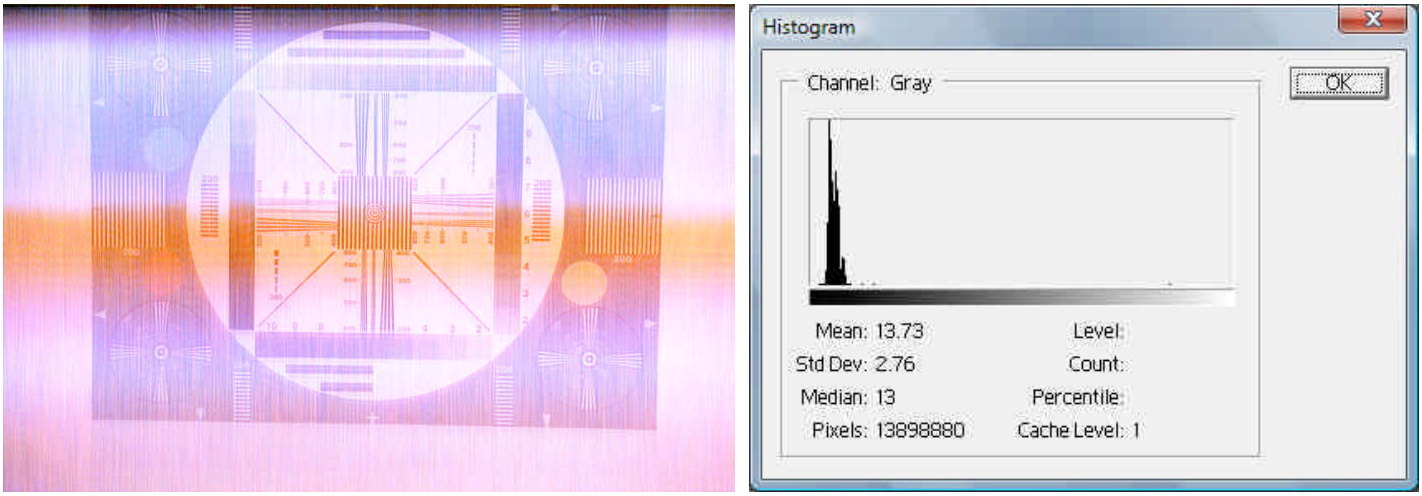
Image Recovery and Optimization for Subsequent Operations

Following the dive, recover the imagery using the Firewire (IEEE-1394) data link and the Image_Retrieval software. As an alternative, you can also recover the images using the RS-485 data link and the RemoteCAM software. However, this is much slower. Image retrieval is explained in section 5.4. Be also sure to erase the images on the camera internal storage card after the images are secured and inspected on your PC. This will free the memory for use in the next deployment.

Following the recovery, inspect the images and make adjustments depending on what you see. Too much motion blur for example requires a shorter exposure time. Not enough detail or contrast means that the target distance was too large for the water conditions. If you see much backscatter, move the strobe so that it does not illuminate the target directly from the camera view point etc.



A well exposed FISM-2 picture and its histogram (1/2.5 sec exposure)



The histogram shows that this picture is severely underexposed (1/100 sec exposure)

The pictures above show the impact of under exposing for images taken with the IBIS4-14000 14-Megapixel CMOS sensor on the FISM-2. The histogram (obtained with Photoshop) shows that the lower picture is significantly under exposed. In fact, the exposure time was 40 times shorter than in the top picture. Boosting the image does show the basic image features, but finer details are obscured by noise that here appears primarily as banding.

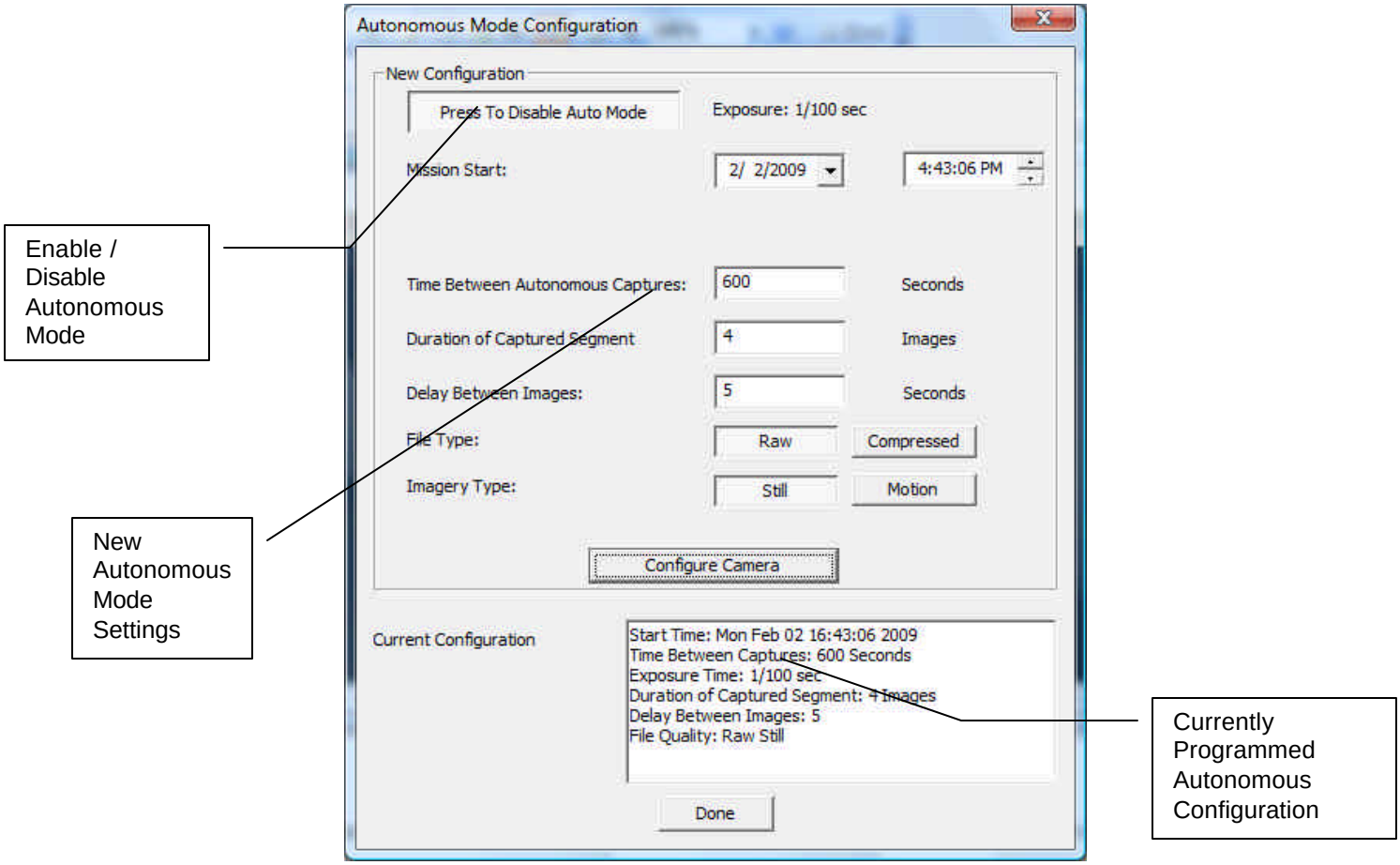
In this case, the following adjustment options should be considered:

1. Lengthen the exposure time (as in the top picture). This is an option for ambient or continuous light exposures. Be aware that motion blur may become a problem.
2. Use a stronger light source. This is a definitive and powerful technique, but stronger light is not necessarily available.
3. Open the lens iris or use a lens with a lower f/ rating. Be aware that this also reduces the depth of field, making focusing more critical.
4. Use a combination of the above factors plus some image boosting. The picture may not be as clean as the top example, but it may become useful.

5.3. Autonomous Camera Operation

SharkEye™ camera can be used in autonomous mode. Images can be captured according to a predefined acquisition schedule.

To define autonomous acquisition, first adjust the focus and exposure as appropriate (see ADVISE below for some limitations). Then, select ***Window/Autonomous Configuration*** from the main menu will display the ***Autonomous Mode Configuration*** dialog window:



The currently programmed autonomous mode configuration is displayed in the text box at the bottom of the window.

Programming an autonomous acquisition schedule

To program a new autonomous mode schedule, select the desired settings on this dialog. The exposure setting currently selected in the **Exposure Control** window is used as the exposure for autonomous mode. Press the ***Configure Camera*** button to download the new schedule to the camera.

Autonomous Acquisition Parameter	How to Use
Mission Start	Define when the acquisition schedule should start. This allows you to program and activate the camera, but start image acquisition (to save storage and battery power) only after a deployment time. The alternative and recommended method is to leave the automatic setting, which is 'now', in place. After programming, switch the camera OFF until the start of deployment.
Time Between Autonomous Captures	Specify the desired image acquisition interval, in seconds. Consider the storage and battery power limitations. The Specifications at the end of this manual provide guidance.
Duration of Captured Segment	The number of still images or seconds of motion imagery to acquire and record during each acquisition cycle. Still or motion image acquisition is selected through the Imagery Type button (see below). Acquiring multiple images per acquisition cycle can be used for example to obtain snippets of motion in periodic intervals, such as to observe fish behavior.
Delay Between Images	This field is only available for still images. It specifies how long the camera waits between successive still image acquisitions when more than one image is acquired per acquisition cycle. For example, in the above screen plot, a set of four images spaced five seconds between images is acquired once every 600 seconds. If you select motion instead of still imagery, the camera will acquire images as fast as it can.
File Type	Select **Raw** to store raw images, which have somewhat better quality or **Compressed** to store smaller JPG files on the camera. If you are recording only one image per image acquisition cycle, always select **Raw**. That is because the first compressed image in a sequence will always be black. The camera always uses exposure statistics from the previous image in a sequence to adjust the compression for the current image. The only option for motion imagery is **Compressed** images, which will be auto-selected when you choose motion imagery.
Imagery Type	**Still** images offer better quality, but **Motion** images are acquired more rapidly. The maximum frame rate for motion imagery is sensor specific. It is about four images per second for the KAI-1020, and about twelve images per second for the TC-253. Images will be acquired as the camera's maximum speed when you select **Motion** images. A typical use of **Motion** imagery is the study of the behavior and interaction of marine animals.

Activating Autonomous Image Acquisition

Once an autonomous schedule has been programmed, it will be activated each time the camera is switched on, and it does not detect a connection to RemoteCAM or Image_Retrieval via the RS-485 or Firewire ports. Switching the camera ON is normally done by flipping the power switch on the SC-3 to the ON position. An alternative method is available for special-order cameras that are shipped without an internal battery. Autonomous mode can be started by applying external power.

Special Advise for Autonomous Operation

1. Select **Raw** image format for autonomous operation when acquiring one image per acquisition cycle (as opposed to a sequence of images per acquisition cycle). This is because the first two or three compressed (JPG) images per sequence will not be correctly exposed.

2. Cameras without an internal battery can be switched between autonomous acquisition mode and RemoteCAM operation remotely by cycling remote power. However, the images will not have a correct time stamp after power cycling because the real-time clock looses power. Autonomous operation will continue to work.

3. Select fixed exposure as opposed to auto exposure when acquiring one or few images per acquisition cycle. Auto exposure requires data from previous images to adjust the exposure.

5.4. Image Retrieval

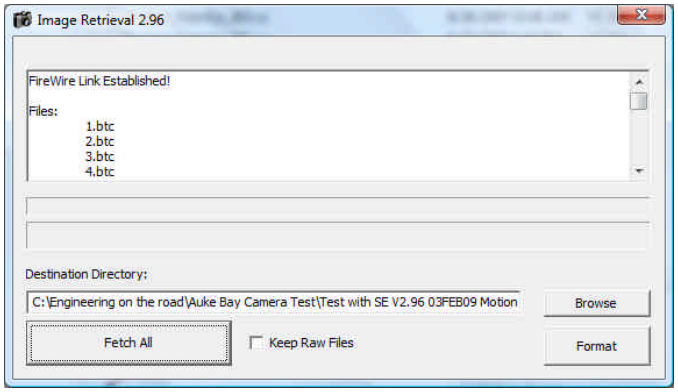
Images can be retrieved from SharkEye™ using either the Firewire (IEEE-1394) link or the RS-485 link via the supplied SeaLevel USB converter. The standard image retrieval method should be via Firewire, as this yields the best speed. Retrieval via RS-485/USB is available for umbilical based systems to recover at least some on-camera images while a dive is still in progress, and as a backup for the Firewire link.

Image Retrieval via Firewire (IEEE-1394)

Be prepared to connect the camera the PC as shown in the picture. The FCBL-A adapter cable links the camera to a Firewire port on the PC. The ACDC-U charger powers the camera. FCBL-A uses the standard six-pin Firewire connector, but we now also include an adapter so that the miniature 4-pin Firewire connector that is popular on many notebook computers can be used. If your computer does not have a Firewire port, then use one of the commonly available PC-Card or EXPRESS-Card Firewire adapters.

Follow this procedure:

1. Connect the FCBL-A adapter cable and the ACDC-U charger/power supply to the camera. Do not yet connect the cable to the PC Firewire port.
2. On the PC, launch the **Image_Retrieval** application.
3. Switch the camera ON and wait about 10 seconds for the camera to boot as indicated by a steady status LED blink pattern.
4. Only once the camera has booted up, connect the Firewire connector of the FCBL-A to the PC.
5. For first use, the PC will initialize the camera driver install. Go through that process, guiding the install wizard to the C:\Program Files\Desert Star Systems\FrogEye – SharkEye folder. This folder contains the driver software (vhpd1394 and desertstar1394), which the wizard will automatically use.
6. Following successful installation and connection, you will see the list of image files that are on the camera displayed in the Image Retrieval file list.
7. Select your desired destination folder for the image files by clicking on the ***Browse*** button.
8. Start the image retrieval process by clicking on the ***Fetch All*** button. It is recommended that you don't use your PC for other actions while image download is in progress. While multi-tasking in general works, some machines can get quite bogged down and we may have seen some download failures due to multi-tasking as well.
9. Image_Retrieval will automatically convert all files that are found on the camera to high-quality JPG for viewing. Check the ***Keep Raw Files*** check box if you also want to keep the original raw files on the PC. This can be useful for future file manipulation, but it does use more disk space and clutters up your image folders.
10. Once you have properly secured and inspected the files on your PC, click the ***Format*** button. The image memory on the camera will now be erased and is ready for the next operation.



The Image_Retrieval application before a link is established. A list of image files appears in the top white field once the link is established.

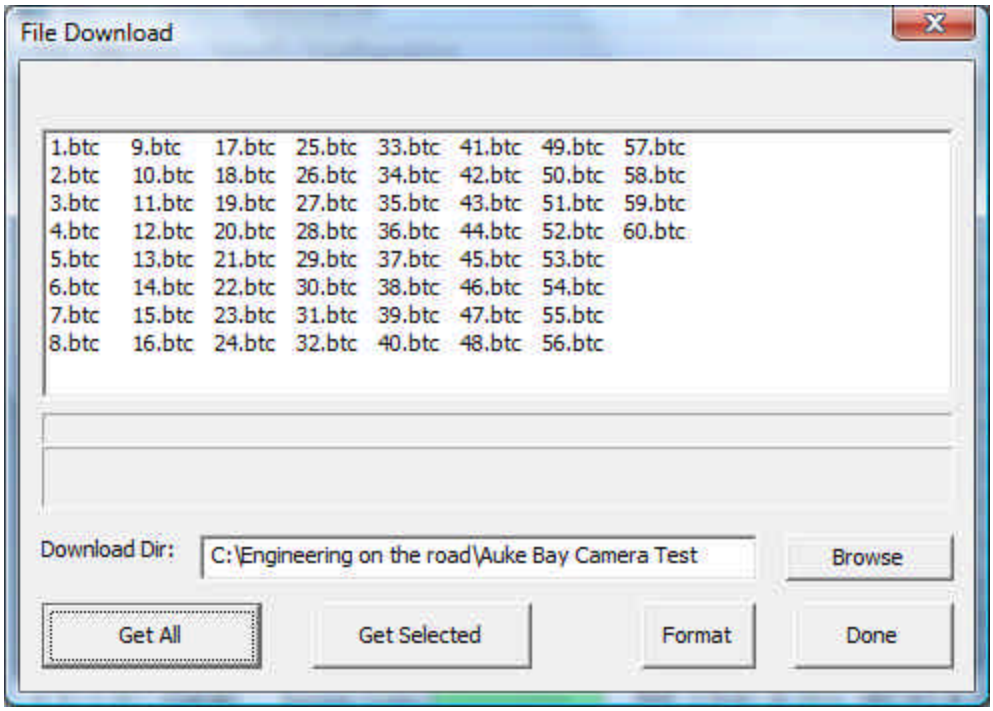
Image Retrieval via RS-485/USB

Connect the camera as shown in the picture. The FCBL-A adapter cable connects to the camera. The camera is powered by the ACDC-U battery charger / power module, which also connects to the FCBL-A. The connection to a USB port of the PC is via the SeaLevel 2104 RS-485/USB adapter.

Follow this procedure:

1. Prior to the first connection of the SeaLevel model 2104 adapter to the PC, make sure that the SeaLevel drivers are installed on your PC. The driver CD ROM is shipped with your camera, or you can also retrieve it from the SeaLevel web site here: http://www.sealevel.com/drivers.asp Download the SeaCOM Asynchronous Serial Driver and run the install package on your PC. (If you install the drivers only after first connecting the SeaLevel device, then your PC may get confused and you should consult a PC technician to get it straightened out again).
2. Once the drivers are installed, launch **RemoteCAM** and then switch the camera ON. The camera should now be detected. If not, then the communication baud rate of the PC and the camera may not be set the same. Use the procedure in section 5.1. to make this adjustment.
3. Images can be retrieved from the camera using the File download dialog in RemoteCAM. Select ***File/Download Images*** from the main menu to pop up the dialog. Continuous capture must be disabled while you are doing this (un-select the ***REP*** button at the bottom of the RemoteCAM main window).
4. A list of available image files will now appear. You can do the following:
    a. Click ***Browse*** to select the folder where you want the images to be stored.
    b. Select the desired images and click ***Get Selected*** to retrieve just these images. Image download speed is around 50 – 100 KByte/sec (if your camera baud rate is set to the fastest speed of 921600 baud), so down load can take a while and selecting necessary images is recommended.
    c. Click ***Get All*** to get all images.
    d. Click ***Format*** to erase the on-camera image memory.
    e. Click ***Done*** once you are done.

Progress bars are available to monitor the download progress. Note that RemoteCAM unlike Image_Retrieval will not convert .RAW or .BTC files to the viewable JPG format. This has to be done as a separate step, using ImageConvert.



The Image File Download Window in RemoteCAM

5.5. Image Conversion Using the ImageConvert Utility

Images are stored in SharkEye using the RAW and BTC file formats in addition to JPG. RAW and BTC files must be converted to JPG for viewing. This is done automatically by the Image_Retrieval software during download, but if images are retrieved via RemoteCAM, then conversion must be done as a separate step. This is done with **ImageConvert**.

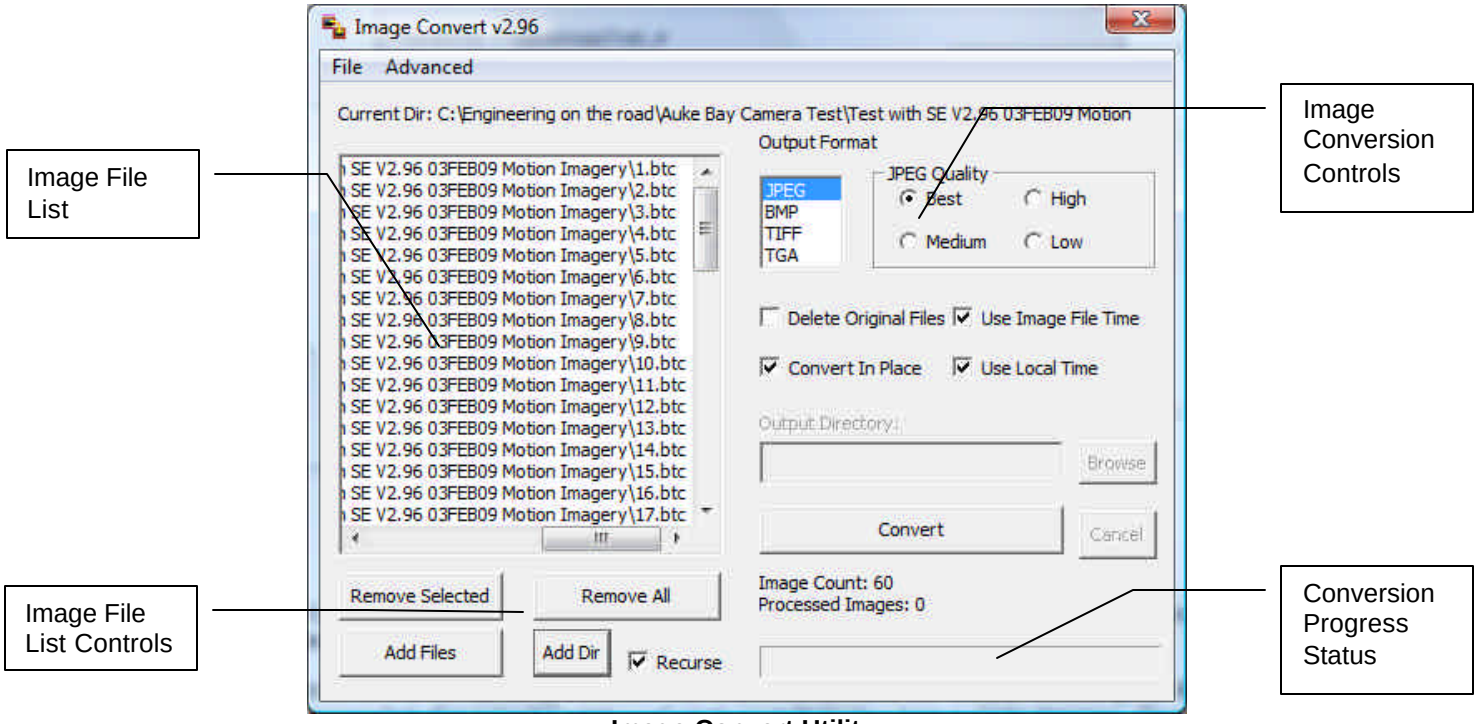


Image Convert Utility

The **Image File List** displays the list of files to be converted. Files in the list can be selected and removed by pressing the **Remove Selected Button**. Pressing **the Remove All** button removes all the files in the list.

Files can be added to the list by using the **Add Files** button or the **Add Dir** button. Pressing the **Add Files** button displays a file browser that allows for the addition of single or multiple files from a single directory. Pressing the **Add Dir** button displays a folder browser that allows for the addition of all the files in a directory. If the **Recurse** check box is selected all directories underneath the selected directory will be scanned for files to be added to the **Image File List**.

The **Output Format** and **Compression Quailty** (if JPEG was selected) can be selected prior to the start of image conversion. All images will be converted to the selected format.

If the **Delete Original Files** check box is selected the original images (*.raw, *.btc, etc.) will be deleted after they have been converted to a standard image format.

Select the **Use Image File Time** to append the time and date at which the image was acquired to the file name of the converted image. This time and date is stored in the header of the image file. If not selected, the file name of the converted image will be the same as the raw image, i.e. the image serial number. Select the **Use Local Time** if the time should be expressed in the local time zone, or do not select if you prefer GMT.

If the **Convert In Place** check box has been selected, the converted images will be written into the same location as the original images. If the check box is not selected, the converted images will be written to the location in the **Output Directory** box. Pressing the **Browse** button allows for the selection of a directory, or a directory name can be entered directly in the **Output Directory** box.

Press the **Convert** button to begin the image conversion process.

6. Camera System Maintenance

Normal underwater instrumentation maintenance procedures apply.

- Keep connectors clean and always terminated before submerging the camera.
- Apply some silicon O-ring grease to the connectors when dry.
- Keep the lens view port clean and protect from scratching.
- Rinse the camera in fresh water after use to minimize corrosion.

    - New software installations sometimes interfere with existing software. Test SharkEye™ after new software installations and BEFORE going offshore.

6.1. Upgrading Camera Firmware

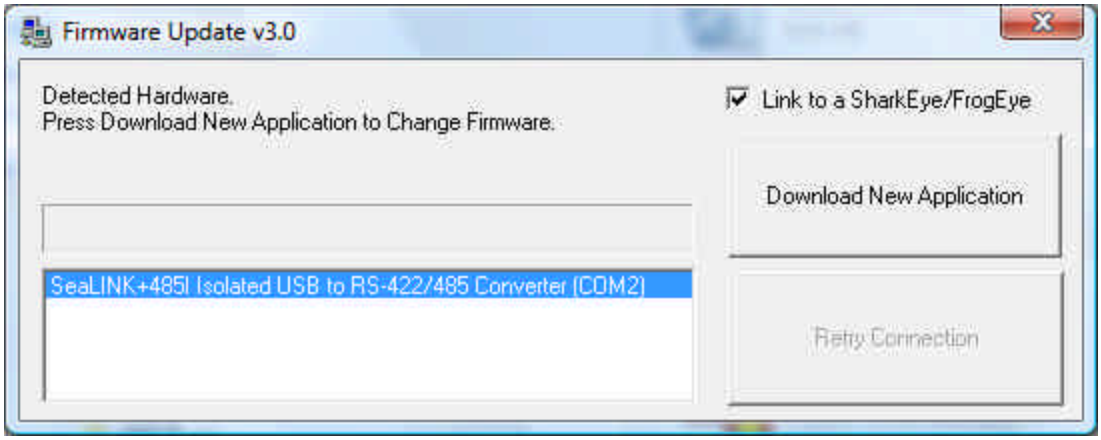
New firmware can be downloaded to the camera using the **Firmware Update** utility. Run **Firmware Update** and select the proper Comm port, connect the camera to the PC using the RS-485 connection (either through the umbilical connector or the multi-function connector) and turn on the camera. Make sure to select the **Link to SharkEye/FrogEye** check box, as this selects the correct baud rate. Next, it is necessary to disable the 'computer operating properly' (COP) mechanism of SharkEye™ for the period of the download. (If COP is running, then a supervisory processor in the camera will keep reseting the main DSP processor in an attempt to get normal imaging operation to start.) There are two means to disable the COP:

- For cameras without an internal battery, just flip the camera switch ON and then apply external power. The COP is switched off automatically after the first activation following the application of power.
- For cameras with an internal battery, switch the camera ON while holding a magnet to the round indent on the camera connector end-cap. Remove the magnet once the switch is flipped to the ON position.

The connection worked if you see the **Detected Hardware** message as in the picture below. You should hear the double-beep of Windows recognizing the link once. Wait about 30 seconds. If you hear the double-beep repeatedly, then the COP is still running and you need to repeat the above procedure.

Next, press the ***Download New Application*** button. A file browser will pop up. Select the new firmware (obtained from Desert Star Systems). The firmware will be a .vc file with a file name similar to this: sharkeye_fcbm1a_v274.vc The v274 is the version number (i.e. version 2.74).

Download will now proceed, as indicated by the progress bar. In case you get any data communication error messages, then your link has probably not be initialized correctly. Perhaps, the COP is still running after all. Repeat the procedure above.



The Firmware Update utility

7. Specifications

Mechanical Specifications

SharkEye Model	Housing Material	Size (mm)	Weight in air (g)	Weight in water
SC-3/100m (C-Mount)	Delrin Plastic	92W x 92H x 241L	2150g	~550g
SC-3/300m (C-Mount)	Aluminum	92W x 92H x 241L	3170g	~1570g
SC-3/1000m (C-Mount)	Aluminum	98W x 98H x 241L	~3800g	~2000g
SC-3/4000m (C-mount)	Aluminum	152D x 279L	7400g	~2400g
SC-3/6000m (C-Mount)	Titanium	152D x 304L	~11300g	~6300g
SC-3/6000m (Canon)	Titanium	152D x 365L	13600g	~7600g
SL-3/4000m strobe	Aluminum	152D x 241L	6300g	~1900g
SBP-2/1000m battery	Aluminum	76D x 349L	3620g	~2030g

Note: Weights marked by ~ are estimated. Other weights are measured to within 100g

Electrical and Power Specifications

External Power Supply: 9V-15V DC
Voltage requirement to enable internal battery charging: 13.5V-15V DC
SC-3 internal battery pack (battery specs per Sanyo data sheet, 2009): 8 x Sanyo HR-3U 'AA' NiMH Cells
9.6V nominal voltage
>= 2500mAh in SC-3 use
Fast charging in approx. 3 hrs

SBP-2 external battery pack (battery specs per Sanyo data sheet, 2009): 24 x Sanyo N-3000CR 'C' NiCd Cells
Three packs, wired in parallel, each
Consisting of eight cells in series
9.6V nominal voltage
9000 mAh nominal for SC-3 use
SBP-2 is trickle charged over 24h
Self discharge: Approx. 75% capacity
remaining after 3 months @ 20 deg C

Power Consumption:

With FISM-1 using KAI-1020 color sensor @ 12V DC supply:	Approx. 600 mA
With FISM-1 using TC-253 sensor @ 12V DC supply:	Approx. 700 mA
With FISM-1 using TC-253 and sensor cooler @ 12V DC supply:	Approx. 1200 mA
With FISM-2 using IBIS4-14000 sensor @ 12V DC supply:	Approx. 400 mA
SL-3 strobe while charging capacitors:	Approx. 3000 mA (6 sec for full charge)
Sleep mode:	Approx. 4 mA for SC-3 only
	Approx. 5 mA with SL-3 strobe
Start up current:	Up to 6A for < 0.1 second

Autonomous Battery Life (estimated numbers based on power consumption measurements and mfg battery capacity):

Time per wake-up cycle including first picture:	8 seconds
Internal battery, no strobe, KAI-1020 sensor, 10 minute interval:	Approx. 1000 images; 7 days
Internal battery, no strobe, KAI-1020 sensor, 60 minute interval:	Approx. 440 images; 18 days
SBP-2 battery, no strobe, KAI-1020 sensor, 10 minute interval:	Approx. 3600 images; 25 days
SBP-2 battery, no strobe, KAI-1020 sensor, 60 minute interval:	Approx. 1320 images; 64 days
SBP-2 battery, SL-3 strobe 1/30 sec, KAI-1020, 10 minute interval:	Approx. 2700 images; 19 days
SBP-2 battery, SL-3 strobe 1/30 sec, KAI-1020, 60 minute interval:	Approx. 990 images; 41 days
100 Ah car battery, SL-3 strobe 1/30 sec, KAI-1020, 10 minute interval:	Approx. 30000 images; 209 days
100 Ah car battery, SL-3 strobe 1/30 sec, KAI-1020, 60 minute interval:	Approx. 11000 images; 450 days

Other specifications are available on the SharkEye data sheet, available at www.desertstar.com

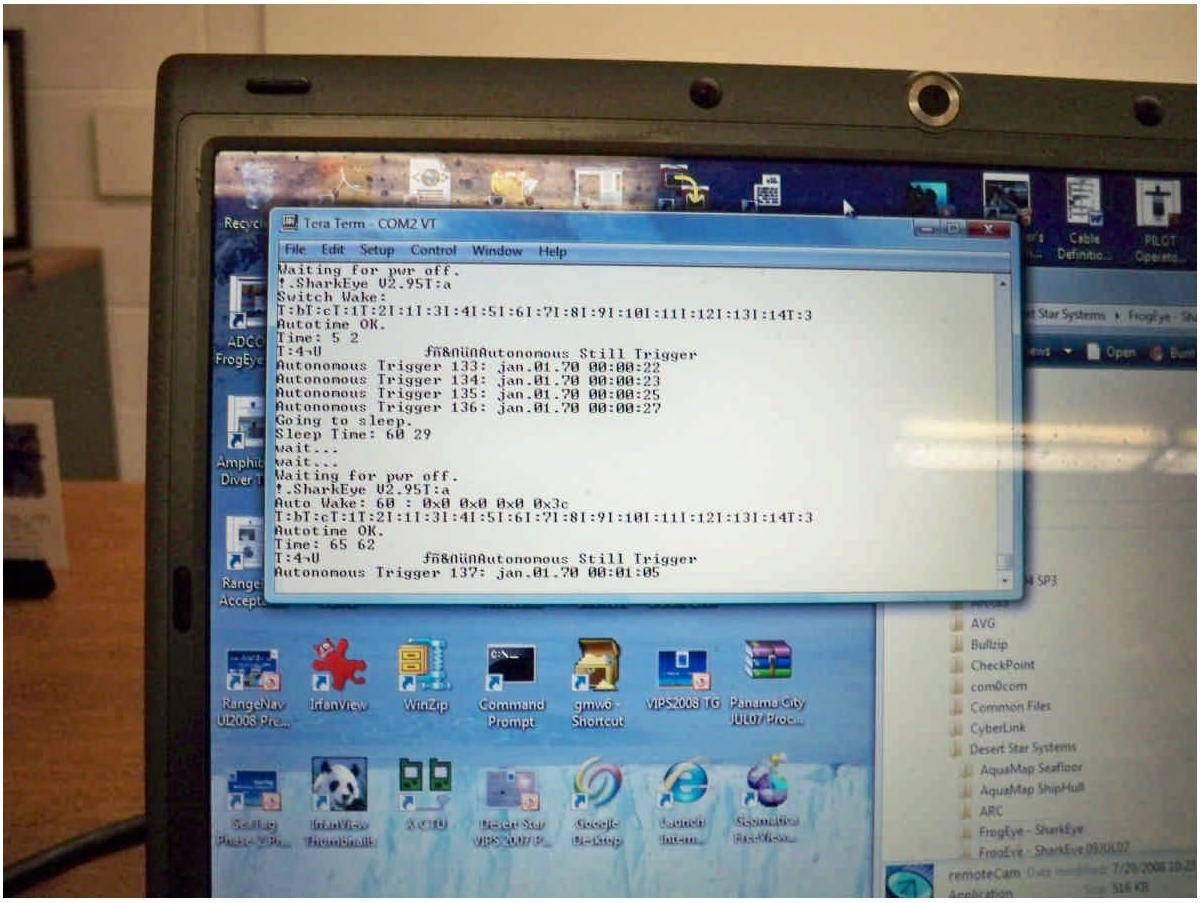
Image Storage

Storage Media:	CF FLASH Card
Storage Size:	Factory equipped with 32GB CF Card.
File size / Image files for 32 GB card:	
KAI-1020 sensor, RAW format:	2 MB / 16000 images
KAI-1020 sensor, JPG format:	~0.5 MB / 64000 images
KAI-1020 sensor, motion images (BTC):	~0.25 MB / 128000 images
TC-253 sensor, RAW format:	0.67 MB / 48000 images
TC-253 sensor, JPG format:	~0.17 MB / 192000 images
TC-253 sensor, motion images (BTC):	~0.085 MB / 384000 images
IBIS4-14000 sensor, RAW format:	28 MB / 1440 images
IBIS4-14000 sensor, JPG format:	JPG format is not supported for this sensor

Appendix A: Sample SC-3 SharkEye™ Camera Configurations

The following pictures show SharkEye™ camera system cabling and connections for various operating modes, such as control via umbilical from the surface, recovery of image data via the Firewire interface etc. It is intended as a visual reference guide to help you get started.

Autonomous Operation with Surface Power:
The camera is connected to the surface via the 50' umbilical cable. Power is from 110VAC via the supplied adapter (lower right), or a car battery using the supplied clips (next to power adapter). An image acquisition schedule is programmed into the camera using the RemoteCAM software, and the camera power switch is then set to ON for operations. The RCA umbilical connector for the RS-485 remote control interface can remain open (unused) while the camera is in autonomous mode.



Observing Autonomous Operations:

When in autonomous mode, the camera will sleep for a programmed time, then wake up to take one or a sequence of pictures before falling asleep again. When it is taking pictures, it is sending various information through its RS-485 remote control port, which can be monitored. Use a terminal program such as Hyperterm or Terraterm, and set the speed to 4800 Baud to monitor this traffic.

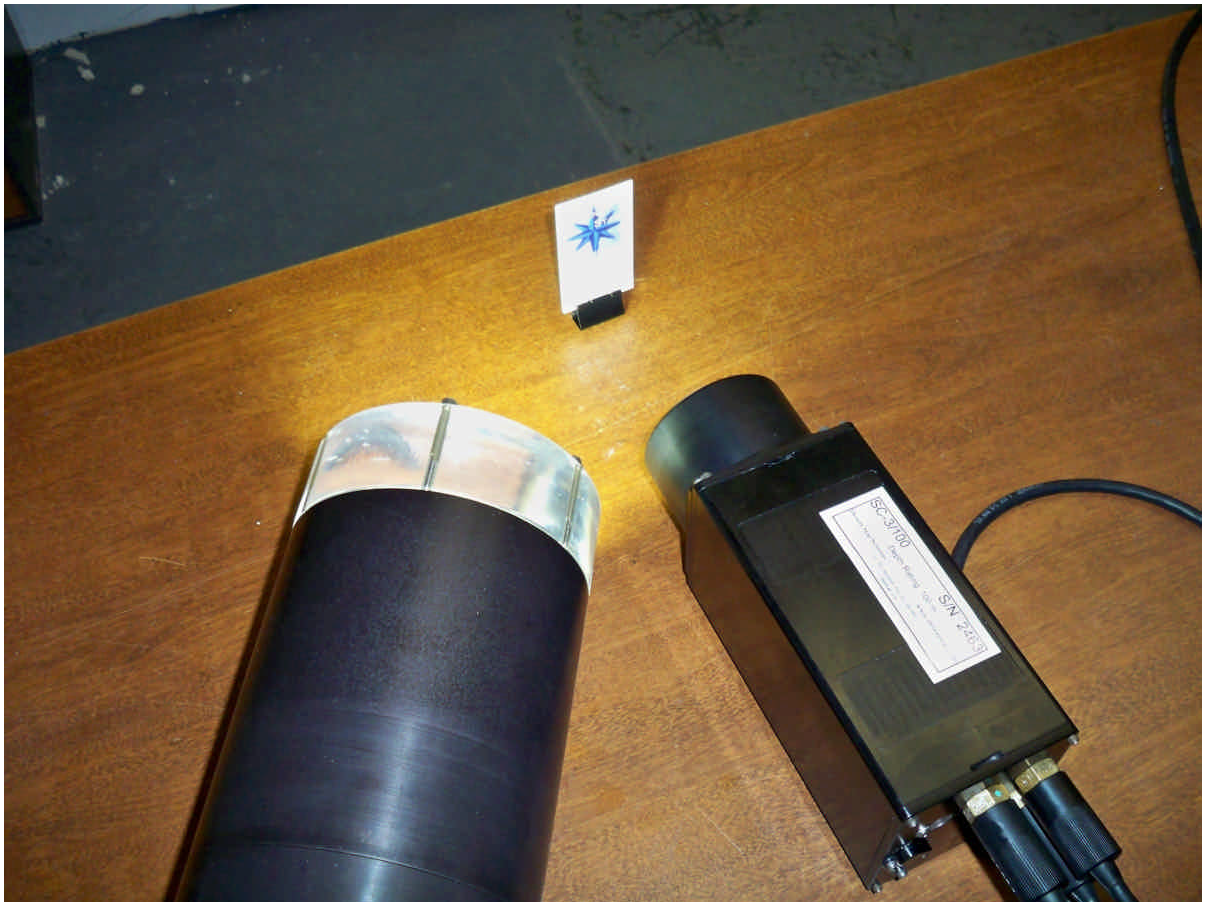
Camera remote operation from the surface via RS-485 interface:
For this application, the camera should be ordered without an internal battery, so that it can be initialized by cycling external power. The PC is connected via the Sealevel USB/RS-485 adapter to the umbilical, and images can be retrieved via the umbilical while the camera remains underwater. The RemoteCAM software is run on the PC. Disconnect surface camera power for 30 seconds or more, then re-connect to get the submerged camera to link to RemoteCAM.

Camera autonomous station without surface link:
The camera is now powered by the SBP-2 battery pack (blue cylinder) and the surface umbilical is not used.

Image retrieval via Firewire:
Connect the camera to a Firewire port on your PC via the short adapter cable. The adapter cable includes a Firewire regular to mini connector adapter. Use as suitable for your PC. If the PC doesn't have a Firewire port, adapter cards are available. Use the Image_Retrieval software.

Charging the external battery:

The SBP-2 battery can be used to power SharkEye for autonomous operations without a surface umbilical. To charge the battery, connect it to the supplied AC adapter via the adapter cables as shown. Leave it on charge for 24hours. It's OK to charge it longer (such as over a weekend) without causing any damage. But, we would advise against just leaving it for really long duration (several days) on charge.



Taking Macro Images:

This picture shows our configuration for taking some macro test shots. The goal was to obtain an image covering about 15cm x 15cm, and then evaluate its resolution. A business card was used as the target. The camera is equipped with a Computar 8 mm / F1.4 lens. The lens can be replaced (see picture and explanation below). This lens required a distance of about 14cm between the front edge of the lens hood and the target in order to obtain a 15cm x 15cm field. Underwater, the distance would be more, about 21cm. That is due to the magnifying effect of water when using a flat lens port. Note how the strobe is a little distance from the camera, pointed at an angle. It should always be done that way in order to minimize backscatter caused by particulates in the water.

Test Picture / Resolution Evaluation:

Here is the test picture; full view and detail view. With the lens wide open at F/1.4, the exposure time was about 1/3000 sec. That is unnecessarily short, and so it is better to close the adjustable iris somewhat to obtain a greater depth of field (distance range of sharp focus) and improve image quality (lenses tend to perform better with the iris somewhat closed). The Computar does not indicate the specific f-stop setting, but it was probably around F/5.6 and the exposure time was now 1/250 sec.

Lens exchange, and selecting the color or the night vision sensor:

This detail shows the SharkEye SC-3 lens hood removed. The Computar 8mm F/1.4 lens is visible. There are two rings on the lens for the control of iris and focus. As the camera has an internal focus motor, the focus ring on the lens does not need to be adjusted (it can be anywhere). You can control focus remotely. The lens can be unthreaded, and replaced with a different lens offering for example a greater focal length (smaller field of view but better detail at a fixed distance) or a shorter focal length (greater field of view, less detail). The lens mounting plate can also be removed and then rotated by removing the four screws around the lens. This is done to select the TC-253 night vision sensor. That sensor can be useful for longer distance imaging or when there is a concern that light might disturb the marine life. The night vision sensor still needs some light however. It is monochrome, has less resolution and in general the image is a bit noisy – as is typical for night vision devices.

Camera system in shipping case. Some items, such as the SBP-2 battery pack and a custom umbilical here, may be shipped in a separate box if they don't fit into the shipping case.