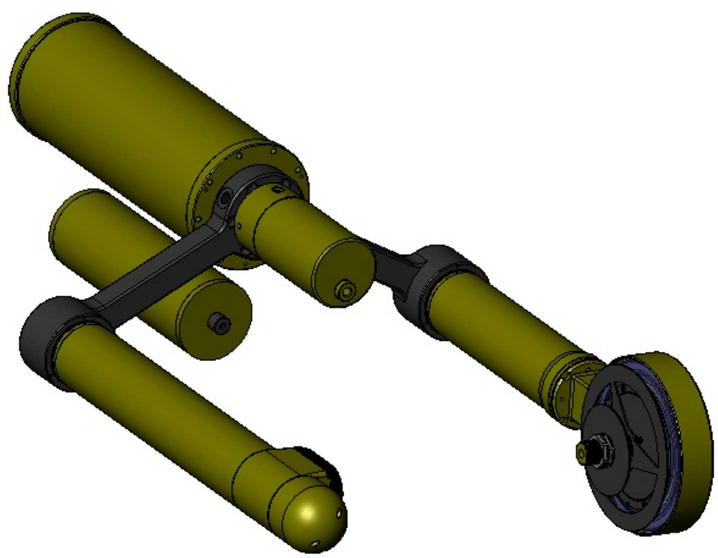
Seascan, Inc.
346 Gifford Street, Falmouth, MA 02540 U.S.A.
Phone: 508-540-3340 Fax: 508-540-2945

Operation and Maintenance of the Digital AutoVPR



Rev: April 18, 2008

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Scientific Background

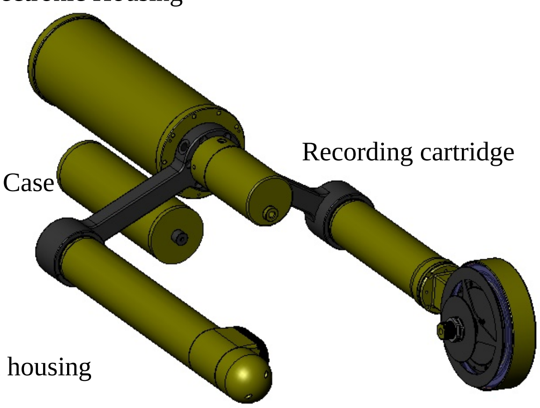
Processes controlling plankton population abundance in the sea operate over a wide range of spatial and temporal scales (Haury et al., 1978). Sampling of plankton abundance and associated environmental variables can provide insights into the causes of plankton patchiness (e.g. Gallager et al. 1996a). It has been well established that plankton patchiness is strongly correlated with physical variability (e.g., Cassie, 1960) over a broad range of scales (e.g., Haury et al., 1978; Gallager et al., 1996), and that many mechanisms are responsible for the observed patterns (Haury et al., 1978). In order to understand these processes and their underlying mechanisms, plankton distribution and its variance must be quantified on the same scales as the prevailing physical processes.

The VPR was designed to rapidly quantify distributions of planktonic taxa and particulate matter over scales of millimeters to 100's of kilometers (Davis et al., 1992, 1996; Gallager et al., 1996b). Because the VPR can be integrated with a variety of environmental sensors, it can be used for observing the dependency of planktonic distributions on hydrography (Gallager et al., 1996b). In addition, optical samples are inherently non-invasive and therefore do not alter natural orientation and morphological form of the target organisms and particles. Therefore, some aspects of plankton behavior may be inferred from the images (Gallager et al. 1998; Benfield, Davis, Gallager 2000). Very fragile forms such as jelly fish, algae, dinoflagellates and marine snow are sampled without damage allowing natural morphology of these forms to be studied (Ashjian et al submitted). Plankton and particulate data may be displayed in real time providing for an adaptive sampling strategy (Davis et al. submitted). Adaptive sampling is useful when attempting to locate specific features such as fronts, upwelling events, and Longmuir cells, or in mapping plankton patches in relation to hydrography. Real-time assimilation of plankton data into predictive physical models has been accomplished at sea and promises to change the way we use instrumentation in the sea (Ledwell et al. 2000; Lynch et al. submitted).

Instrument Description

The Autonomous Video Plankton Recorder (AutoVPR) manufactured by Seascan, Inc. is an underwater video microscope system designed for rapid quantification of plankton taxonomic composition and abundance. The AutoVPR consists of an imaging head, JPEG2000 wavelet compression processor, and a hard drive for real-time recording of plankton and particulates. The unit may be deployed simply as an additional sensor on existing platforms such as under a v-fin for continuous towing operations, or a CTD rosette for vertical profiles. The unit records image data internally and optionally can communicate to the surface over an electromechanical cable to report the CTD information.

Except for the battery which has its on separate case, the instrument body combines all sub assemblies in a single under water housing as shown in the appended drawing. It is rated for a maximum operating depth of a 1000m. Here is a brief description of each major component:



Camera: due to the specificity of the frame grabber interface and imbedded processing, choice is limited to two cameras from Uniq using the camera link interface.

One is a black and white camera, UP-1800CL with 1.45 Mega-Pixels (1390x1037), 10 bits pixel depth and a frame rate of compressed images of 20 per second.

The other camera is a 1 mega pixel color camera using a Bayer filter, Uniq model UC-1830CL. The resolution is 1024x1024 and the frame rate of compressed images is 15 per seconds.

Optics: Canon motorized zoom adapted from the J10x10R-II Lens. Uses four stepper motors for accurate and repeatable positioning of camera-lens extension, focal distance, zoom-factor and iris. The instrument has in memory; four sets of stepper motor positions each roughly doubling the field of view. These sets can be recalled to fit the type of observation required by the experiment.

Strobe: Use of a high power strobe with a maximum rate of 30 flashes per second, with energy of 1 joule per flash. The flash duration is of the order of 3.0 micro-seconds. The light is send into an optical fiber bundle and ducted to generate an 8 inch diameter ring illuminator. Appropriate exit angle and masking generates a 60 degree converging cone of light in front of the camera head to create a dark field illumination geometry.

The electronic consists of two main assemblies. One is a controller board which monitors the performance of an embedded PC running under Windows XP. The controller is assigned the following roles:

- It senses the control switch to turn power on to the accessories and the PC system. It monitors the start up of the PC and request the start of picture acquisition by the AutoVPR application when the switch is moved to capture.

It also turns off the system. The communication between the AutoVPR application and the controller use the serial comport 1 of the PC.

- It monitors the battery pack voltage under load and turns off the system before it crashes for lack of power when the battery voltage falls below a certain threshold (22V typically).
- It sets the optics to the appropriate position as memorized in the sets of working parameters. It handles the operator interface during optical calibration and echoes the CTD data to the tow cable, when using a CTD and an electro-mechanical cable.

The image capture and recording is done by the PC104+ embedded computer stack. It operates under Windows XP and boots from a solid state drive. The capture of a new image is done asynchronously. The image is compressed and passed to the computer over the PCI bus. Each image is tied to a header containing time and the oceanographic information. The resulting data is then redirected to a 40 G-bytes storage drive over a USB-2 interface. This drive is mounted in a removable cartridge and can be disconnected and transferred to a desk-top computer for data display, processing and archiving.

Specifications

Base underwater unit:

- Imaging system: camera, strobe, Jpeg2000 compression processor, single board computer, instrument housing and 24V battery in separate case
- Recording capacity of 38Gb for 3.5 hours of continuous recording with image size set at 150 Kb.
- Battery pack: 24 V NiMH battery supplies about 3 hours of continuous operation

Length:	127cm
Width:	71 cm
Height:	45 cm
Weight in air:	36 Kg
Weight in water:	25 Kg

Black and white camera, 1392 x 1024 pixels:
Optical field of view: four user selectable settings typically:
S0 = 7 x9.5 mm, S1 = 12.5x17 mm, S2 = 21x29 mm, S3 = 35x48 mm
Resolved features depend on field of view and compression.
Sampling frequency: Image acquisition is asynchronous and the frame rate will depend on the compressed image size. Image compression time and data write to disk are the limiting factor so that the rate is typically 20 Hz for 150Kb compressed image size.
Color camera 1024 x 1024 pixels:
Optical field of view: four user selectable settings typically:
S0 = 7 x7 mm, S1 = 14x14 mm, S2 = 24x24 mm, S3 = 42x42 mm
Resolved features depend on field of view and compression.

Sampling frequency: Image compression time and data write to disk are the limiting factor so that the rate is typically 15 Hz for 300Kb compressed image size.

Illumination: 1 joule per flash Xenon strobe, bulb life time 10^9 flashes.

Exposure time: 3 micro-sec allowing tow speeds up to 5 knots

Pressure housing rating: 1000m maximum

Accessory sensors:

SBE 37 or SBE 49 CTD from Seabird
ECO Puck FLNTU fluorometer and turbidity sensor from WetLabs
Oceanographic Data is merged with each video image.

Deployment modes:

The AutoVPR can be used in a variety of deployment schemes. For example:

- Vertical profiling: The AutoVPR may be mounted on a standard CTD frame and deployed in profile mode in a completely autonomous way, using its battery power and internal recording.
- Survey: The AutoVPR may be mounted under a simple 3 foot V-fin or other towed vehicle and towed at speed up to 4 knots using non-conductive cable from research vessels of all sizes including small open vessels and ships of opportunity.

Deployment Setup

There are two parts in a setup to use the VPR in the field. One is the underwater unit somewhere on deck. The other part consists of a desk top computer and the battery charger using some dry space somewhere inside. The desk top computer is used for communication, remote management, data archiving and possibly data processing. Because the AutoVPR is essentially a PC computer, it can be networked to the desk top computer over Ethernet. The supervising controller, which manages the AutoVPR, can also communicate with the desk top over a constant currant half-duplex link. It requires a special interface adapter (SAIL box) to connect to one of the desk top COM ports. As an option this SAIL box can be replaced by a Mocness modem from B.E.S.S. This allows communication over long electromechanical cables and gives access to the oceanographic data while the instrument is deployed. The cables needed to connect to the AutoVPR (Sail and Ethernet) to the desk top computer should be routed to minimize exposure to mechanical abuse and salt water. Those cables are only needed when querying the oceanographic data or checking the time of the AutoVPR embedded PC, and should be moved out of arms way when not needed.

The Sail bulk-head connector on the rear end-plate of the instrument connects to the Sail box with the supplied connector and cable. If too short, this cable can be extended with a length of shielded twisted pair (preferred) or just a two conductor cable. The Sail box connects to the desk-top using a COM port and interaction with the AutoVPR is done using HyperTerminal or some equivalent terminal software. The link between the AutoVPR and the Sail box is not polarized and connects on the front panel of the box, between the two post terminals that have not been strapped together. With the AutoVPR connected to its battery, and the Sail box powered up, connect the sail link to those terminals. The line active LED should light-up.

The Ethernet bulk-head connector connects with the supplied connector and adapter to a CAT5 network cable, itself connected to a router rather than a hub. The link is 100T and, to minimize confusion, the AutoVPR network configuration is set to accept its IP address automatically from the router. The same setting should be used by the desk-top PC. For remote management purpose, the AutoVPR uses the remote desktop connection which is part of XP. Running this software you will need to log using “Administrator” as the login name and “AutoVPR” as the password.

Supplied with the VPR is an adapter cable that will connect the VPR data cartridge to a USB-2 port on the deck computer. The cartridge will then show up as an external drive on the desk top and data can be transferred to some other storage media. The local hard drive can be use to hold the data for processing, but at a rate of 5 to 10 Gigabytes per hour of acquisition, it will probably not be large enough to be used as an archive.

Operation of the VPR, overview:

As mentioned earlier the VPR is under the supervision of the controller electronics. This controller is powered up as soon as the battery is connected and spends its time monitoring the state of the off-boot-capture switch as well as the traffic over the sail loop. When a change of state is detected on the switch the controller stops monitoring the sail loop and executes the action requested by the switch. Conversely, when the controller receives its address over the sail loop it stops monitoring the switch until it de-addresses. The default communication parameters are 300, 8, N, 1.

Unless the oceanographic data needs to be collected during deployment, the sail interface is not needed and is mostly used for setting up the optics and bench testing in the lab.

The OFF-BOOT-S0-S1-S2-S3 switch explained:

The PC part of the VPR is turned on and booted by rotating a switch on the rear bulkhead. In the boot position, the embedded computer is ready to be networked or to begin recording images using one of four predefined optical settings. Recording is started by rotating the switch to one of the S0-S1-S2-S3 positions. The system is shut down by rotating the switch back to the off position. The switch has six positions spaced 60 degrees with mechanical stops on stop and S3. When moving the switch from one position to the next, be careful not to apply excessive force, just turn gently until you feel the next detent or the stop. The notch on the switch knob should be lined up with one of the position of the indexing pattern on the back end-plate label. The switch position is sampled every second by the controller. If after a change, it does not move for three consecutive samples, the new position is decoded and acted upon. The switch will then be ignored until this action is completed. Booting or shutting down requires a significant amount of time of the order of two minutes, so stay patient.

Position OFF:

No battery power is applied to the computer, the CTD, the strobe or the camera. But battery power is always applied to the supervising controller. All cable connections should be made with the switch in this position.

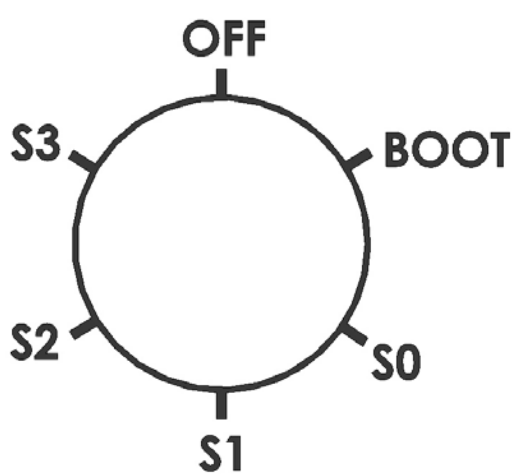
Position BOOT:

If the voltage of the battery pack is above the cut-off threshold (22V), power is sequentially applied to the CTD, the motorized optics, the strobe and the camera. Then the embedded PC is booted and the VPR application is auto started. This application will then signal the supervising controller that it is ready for capture. If for any reason, this hand shake does not happen within a certain amount of time or the VPR application reports some error, the supervising controller will shut down the PC and attempt four reboots before it quits for good. At this point the AutoVPR will not start again unless battery power has been cycled. During this booting process there are no external sign of activity that can be monitored unless one is connected to the instrument over Ethernet. If the goal is to deploy, one can elect to go directly to one of the capture position S0-S1-S2-S3.

Positions S0-S1-S2-S3:

If one moves directly from stop to one of these positions the supervising controller will execute the boot request as above and then start the capture process. Before starting the capture, the controller checks that the current optical settings, which were memorized, match with the requested capture setting (S0, S1, S2 or S3). If not the case the optical assembly is jammed back to its stop position and then moved to the appropriate location. This takes the better part of three minutes. Then the capture is started which coincides with the start-up of the strobe, giving a positive indication that every thing is in order. At the same time a Jpeg2000 data file is created on the data cartridge along with its associated index file. If any problem is encountered the supervising controller will attempt to restart the process.

Control switch positions looking from the rear of the unit



Computer maintenance in BOOT mode

This mode is used essentially for computer management over the network, data down load as an alternative to moving the data cartridge or for setting the optics before calibration.

1. Connect a properly charged battery to the unit (see charging instructions). The supervising controller will not start the VPR computer unless the battery is above 22V. It will initiate an orderly shut down of the VPR when that threshold is reached under load. A charged battery has an open circuit voltage upward of 25V.

2. Turn the control knob to Position BOOT. Wait at least 2 minutes for the computer to boot. There is no time limit to waiting in BOOT mode (other than battery life time), but it does take 2 minutes to come to full operational status. Since the computer does draw 24W of power, you could put the unit in Boot mode before deployment in capture mode but you should be aware that this will deplete your battery at a rate which is about half that of the image capture operation.

Networking

1. Connect an Ethernet router between the AutoVPR and the deck computer either by creating an isolated local network or using an existing network around the ship or lab. There is no antivirus software active on the VPR so be aware that it could be vulnerable.

2. The network setting should be consistent across computers, so make sure your deck computer is set to the same workgroup and uses the same TCP/IP properties as the AutoVPR. The label on the AutoVPR has the IP information:

Connection information includes:
Computer name: Davpr-xx where xx is the serial number (2 digits)
Workgroup: WORKGROUP
IP address: It is obtained from the router automatically
When needed, logon as **Administrator** using password **AutoVPR**

To complete a LAN, create a network connection with the same properties on your deck computer.

3. The hard drives on the AutoVPR are shared so you should see them appear under Computers near me as seen from Windows Explorer. You are now ready to download data or delete files on the AutoVPR hard drives. This is also the way to set the PC clock. Keep in mind that the C drive is the system drive and has on it the operating system and the executables of the VPR application. The D drive which is the data cartridge is also accessible and can be offloaded over the network, though the preferred way would be to disconnect it from the VPR and reconnect it directly to the deck computer using a USB port. This drive has its associated recycle bin disabled and anything deleted is gone for good, so as to free the disk space for the next data collection.

4. The preferred way to manage the computer inside the VPR is to establish a remote desktop connection using the desk top computer. To do this you should use the remote desktop application which is located in the accessories-communication folder of your computer. On the VPR itself, the remote desktop service is enabled in the computer properties. After the desktop computer connects with the VPR you will have to login using the name **Administrator** and password **AutoVPR**. At this point your deck computer display keyboard and mouse can be used to control the VPR computer. The principal use of this remote session is to check or set the VPR PC clock.

Changing the optical settings

The motorized lens system uses four stepper motors to control the respective position of the zoom, focus, iris on the lens as well as camera position behind the lens, referred to as extension. The usable positions for each channel vary from zero to a max value which represents step counts of the respective motors. The max values are preset at the factory and should not be changed. There are four memorized sets of position for the lens motors and extension that correspond to four magnifications distributed over the usable range of fields of view. All those sets reference an object plane which in sea water is located at mid distance between the camera window and the ring light. Those sets are reference as S0, S1, S2 and S3. They correspond to the typical field of views mentioned and the specifications. The depth of field is different for each set and increases with increasing field of view (decreasing magnification). Each optical setting were characterized and calibrated in the factory to define the observed volume. It is possible to switch between these sets using the control switch positions S0, S1, S2 or S3. Those settings could be modified but any change will change the observed volume and will necessitate a new calibration. The factory settings cover fields of view from 7x7 mm to 44x44 mm. A higher magnification would be difficult to obtain, but lower one could be achieved by removing the optical doubler and qualifying the new settings. All this would best be done at the factory.

Operation

Collecting data

The VPR is ready to be used when outfitted with a freshly charged battery, its data cartridge is in place and the PC time has been set and properly maintained.

The procedure to start the VPR for capture boils down to turning the control switch to the desired position S0, S1, S2 or S3. There is no need to connect any of the ancillary cables (Sail or Ethernet or SVGA). One can do an intermediate pause on the boot position but this is not necessary. The switch position is sampled by the controller every second and needs to change and give the same steady reading for three seconds before any action is taken. This allow for some hesitations and dithering from the

operator without consequences. Once the controller as acquired a steady new reading, the corresponding action will have to complete before a new switch position is taken into account. The signal that the VPR is ready to go is supplied by the strobe light when it starts flashing. The time to wait before this happens is the sum of the boot time of the PC plus the time for an eventual repositioning of the optics. This only happens when the selected setting is different from the one that was used previously.
Typically the boot time is of the order of 45 sec to a minute. If the optic has to be reset, it will take up to four minutes to get ready. If the user changes his mind and wants to go to a different setting while the VPR is already running, the VPR should be stopped first and then restarted with the appropriate setting selected.

When the strobe fails to start, the most likely reason is insufficient voltage at the battery output, due to an end of charge condition or failing battery. Replacing the battery with a freshly charged one should cure the problem. Another possibility would be the failure to create the recording files. This could be a sign that the recording cartridge is full, temperamental or missing…A way to investigate non battery related problems is to connect the Ethernet cable and monitor the start up process of the VPR application from the remote console.

Downloading data

Each startup of a capture session generates a set of two files with respective extension .dat and .idx. The Name of those files is the same and is a sequence of digit that corresponds to the VPR clock when the acquisition was started. This is the time in second reference from January 1st 1970. To be of use later it is thus important that the PC time be kept up to date.

The .dat file can be quite large especially with the color camera version (16.2 Mbytes per hours of deployment if the images are busy). It contains all the images acquired, an associated timestamp and the ancillary CTD and sensor data. The .idx file contains only pointer information to the beginning of each frame for random access of the dat file during processing.

There are two ways to get the data off the VPR to a processing computer or an archive:

1) The user can remove the data cartridge by pulling two retaining pins one on each side of it. Pull the cartridge straight out to unplug it and bring it to your processing computer. Use the USB adapter cable supplied with the instrument to connect to the computer. The data drive should show as an external drive on the processing computer. Transfer the files to the appropriate directory. This is the fastest method.
2) You can leave the data cartridge in place on the VPR; connect the VPR to the local network using the Ethernet cable. Provided that your local network was configured as described above in the networking paragraph the VPR should show up as another computer on the “My Network Places” folder. The data drive is the drive D on the VPR and is configured to be shared. You could then transfer the files over the network.

Once the transfer of files has been successfully done the files should be erased from the data cartridge to free the space. There is no Recycle bin associated with the data drive, so the files will depart for good.

Processing data

The collected data consist of two files; one contains a sequence of compressed full frame pictures and their associated header (name.dat), the other one (name.idx) contains values associated with the start of each picture in the name.dat file.

The first step of data processing is done will AutoDeck which will read each data block, separate and decode the header, decompress the image, and scan it for region of interest (roi). The detected roi's are then stored away in a special data directory structure which is compatible with the processing done by Visual Plankton. Visual Plankton is a Matlab application written by scientist (Davis, Gallager and other) in the WHOI biology department. At the core of Visual Plankton is a pattern recognition software that implements an automated classification of planktonic taxa and particulate matter. Visual Plankton can be obtained from WHOI by contacting C. Davis.

AutoDeck

The basic processing is to extract sub image that are reasonably sharp so as to be able to identify the represented object. To do this each image is de-compressed to full size and a black and white sub-image is extracted by sub-sampling one of every three pixel and scaling the pixel depth to 8 bits. This is the image that will be analysed for roi's. Looking at this analysis image data as a three dimensional object where z is the luminance of each pixel, this sub-image is slice at a level z0 called the segmentation threshold. A second image is then generated where any luminance value greater than z0 is turn to white and anything less is turned to black. This isolates intersected objects in the image as white patches which are then boxed into a rectangular area. Each area in the analysis image that maps into a box is then analyzed for structure (Focus) by looking at the light gradient and high frequency content. If the light gradient within the box is over a pre-defined threshold (Sobel) and the high frequency content exceeds a standard deviation threshold, the box is accepted as containing a roi and the corresponding sub-image augmented by the growth scale is saved as a full resolution roi. Along side with the image processing, the oceanographic data is saved in a separate file. This is done whether the image contained roi's or not.

The following page is a screen capture of AutoDeck.The graphic user interface consists of two parts:
- A display panel containing four images related to the image being processed.
- A control panel that sets the working parameters of the application.


Seascan Video Plankton Recorder v3.01 CTD: SeaBird 49 or FSI NXIC Data: 1172094070
File Options Help
Segmentation Threshold
Low 0 255 0
High 0 255 152
Focus
Sobel 0 255 9
Std Dev 0 50 10
Growth Scale (%)
100 500 344
Minimum Blob Size (Area)
10 800 10
Minimum Join Distance
1 500 1
Output Settings
Overlay ROI
Display ROI
Write ROI
FPS
0 6 60
Oceanographic Data
0 Salinity
0 Temperature
0 Depth
6 ROI
Capture Info
Path: D:\Data\Real Stuff Davpr-04\S1\
Date: Wed Feb 21 16:41:10 2007
Browse
Frames 2744 Current 15
Extraction Options
Path:
Extract All Start Frame 0
Extract Selected End Frame 2743
Stop Capture

Display Panel:

It consists of four images all derived from the original full resolution decompressed image. In the upper left corner is the analysis image. It is built from a sub-sampled (one out of three pixels, 8 bit depth) transformation of the full resolution image.

In the upper right corner is the binarized version off the analysis image with potential rois (region of interest) appearing as white blobs.

In the lower left corner each potential rois that meet the size criteria is boxed into a rectangular area which is then analyzed for light gradient and texture.

Those boxes that meet the requirements are then expended by the growth scale and qualify as rois. Corresponding areas are also shown in the analysis image. The corresponding areas in the original full resolution image are the one saved to disk when rois are being written.

Control panel:

Segmentation Threshold:

This has two slider controls, one for the Low threshold the other for the High threshold. The low threshold is by default preset at zero and is rarely used. The high threshold define the working level of segmentation with every luminance value above it converted to full white and every thing below converted to black. Its default value is set at 150. When the segmentation threshold is set to the right value, the back ground illumination is barely perceptible as a flickering of tiny dots. The binary transformation applied to the image allows the isolation of white blobs corresponding to objects in the image. These blobs are then boxed and analyzed by the focus detection algorithm.

Focus:

There are two slider controls there, one for light gradient analysis the other for texture. The Sobel control is used by the gradient analysis. This analysis performs a local computation of the light intensity change over the area of the box and is good at detecting edges. It is the primary test. The default value is 50.

The standard deviation control (Std Dev) is used by the texture analysis. This analysis is applied to those boxes that pass the Sobel test, and isolate the high frequency content of the image by transforming it though a high pass filter. It then performs a statistical evaluation and assesses variability by computing the standard deviation from the mean over the box area. If this is larger than the set threshold the box qualifies as a roi.

Growth scale:

This allows saving a larger area around the roi than what was selected around the blob during segmentation. The purpose is to preserve in the saved image some of the finer details surrounding the object like antennas, fins etc…Its default value is 100% but 200% is probably a more practical value.

Minimum blob size:

This defines a minimum size for the box passed over by the segmentation. It is expressed in pixel and allows for elimination of smaller boxes without analysis, saving on processing time. Its default value is set to 10.

Minimum Join Distance:

This feature is uses to merge a cluster of smaller boxes which are close together into a single larger box. It is used to properly isolate large translucent objects which can show up as a set of parts rather than a single entity. The distance is expressed in pixel, and any two objects closer than the specified value are merged together. Its default value is one (no merging).

Output settings:

This contains three options:

Overlay ROI: if selected, will displays ROIs in the lower right image of the display panel superimposed on each other instead of refreshing the image to the currently detected ROIs only. This allow for more time to see the result of the analysis before it is erased for the next image. This option is on by default.

Display ROI: it enables the full display panel and is on by default. Suppressing the display allows for a slightly faster processing of images.

Write ROI enables saving extracted ROIs to disk for later analysis by Visual Plankton or any other image analysis software.

FPS:

Means frame per seconds; this shows how many images are analyzed per second. Normal rates for images that are not too busy are 7 to 8 in black and white and 4 in color. This will depends on the capabilities of the computer being used.

Oceanographic Data:

Only the CTD information associated with the current image is displayed there. It shows Salinity in PSU, Temperature in Deg C and Depth (Pressure) in dBars.

Capture info:

This control allows to select the input data file. Clicking the Browse button will call a Select Capture file window with which a specific path to a directory can be selected. This will also display files of type ".idx" which are currently present in the chosen directory. These idx files have a name that consists of 10 digit which represent the date and time when the file was created in the VPR. After selecting the appropriate idx file, this time information is readily transcribed to the usual date and time representation which then displays in the Date field. Also displayed are the total number of frames contained in the file and the rank of the image currently being processed.

Extraction options:

The path field is initially blank and will display the path to the output directory once this as been chosen by either selecting Write ROI in the Output Settings Box or by selecting the set output path in the options drop down menu. There are two other options in this panel: Extract all will analyze all the frames in the file, Extract selected allows specifying a start and ending frame for the analysis.

Finally The Start Capture button toggles between starting and stopping the capture

Drop down menus:

The Config drop down menu allows to save or load a configuration file (*.vpr) which contains the settings of the analysis controls as they were chosen for a specific extraction.

The options drop down menu contains four items

Set Output Path: As mention for the Write ROI in Output Settings this allows to preset the destination directory for the output data when writing ROIs to disk.

Histogram: Normal is selected by default. The other settings for Dark Low Contrast and Bright Low contrast can be applied when the images are either dark or milky due to back scatter. This setting is rarely used and is not calibrated for observed volume assessment.

Lightfield: Is off by default. This feature is used to cancel non uniformity of the back ground illumination. This cannot be used on a static image and assumes the images to be completely independent from each other. It is useful when using low magnification and large field of views settings, where the ring light intensity varies across the image. This correction is down by generating a moving average over a set of previous images which is then subtracted from the analysis image to even cancel the back ground lighting. This feature is not calibrated for observed volume assessment.

ROI Depth: Both the color and Black and White camera have a native pixel depth of 10 bits. With the full resolution option this pixel depth in the saved ROIs is conserved by scaling the intensity to 16 bits and writing the image as either 16bit Black and White or 48bits RGB. In the case where the 8bitBW option is selected ROIs are saved as 8 bit B&W images, using a compression from 10 to 8 bits which conserve the low luminance levels

AutoDeck Data input and output:

The data input consist of a pair of files which as mention in the down loading data paragraph have .dat and .idx extension. The pair share the same name which is a long sequence of digit that corresponds to the VPR clock when the acquisition was started. AutoDeck only needs to know the name and path of the .idx file and will expect to find the .dat file of the same name in the same directory

The output path is open to the user choice but Visual Plankton will expect to find its data in a place specified as follow:

(drive):**\data**\cruise**\rois\vpr**xxx**d**xxx**h**xx
The drive can be any drive available on the computer at hand.
\data should be there, no freedom;
\cruise is the cruise name during which the data was collected, is user specified
\rois should be there, no freedom;
vprxxx The bold field needs to be there anx xxx is a cast number (3 digits no leading zeros);
\dxxx\hxx are automatically generated in the proper format with dxxx being the day of the year and hxx the hour of the day as computed from the date information contained in the input file name. If you want these day and hour value to be consistent between data collection and data processing, you need to make sure that both the VPR and the processing computer are set to the same time zone, GMT being our preferred setting. In the day folder AutoDeck will also create ctd data file with names hxxctd.dat. There is one of these files for each hour, and this files contain the oceanographic data associated with each image in a sequential order . The format is as follow:

```
// Write the CTD data
m_CtdLog.WriteData( roitime,
pInfo->DataEntry.Conductivity,
pInfo->DataEntry.Temperature,
pInfo->DataEntry.Pressure,
pInfo->DataEntry.Salinity,
pInfo->DataEntry.ChloroRef,
pInfo->DataEntry.ChloroSig,
pInfo->DataEntry.TurbRef,
pInfo->DataEntry.TurbSig,
pInfo->DataEntry.Altitude )
Output.Format( "ctd%08u:%f,%f,%f,%f,%f,%f,%f,%f,%f\r\n",
               ms, Conductivity, Temperature, Pressure, Salinity,
               ChloroRef, ChloroSig, TurbRef, TurbSig, Altitude );
```

exemple:
ctd71910228:0.000020,21.930400,-0.372000,0.010800,0.000000,0.000000,
0.000000,0.000000,0.000000
roitime is the time in ms within the day the rest is self explanatory. In the exemple that follows there is no turbidity, chlorophyll, or altimetry.

Batch processing:

AutoDeck can be called from a batch file specifying some of the working parameters. This allows to make sequential calls to AutoDeck referencing different configuration files (*.vpr), input file including the path ($(Path)$(InputFileName.idx)) and specify the output directory path and name ($(Path)$(OutputDirectory)). The syntax is as follow:

Exemple:
AutoDeck_SBE_49 *config.vpr *.\1202327904.idx *.\Test\
AutoDeck_SBE_49 *config.vpr *.\1202327905.idx *.\Test\
pause

Calibration

The observed volume of the DVPR is calibrated by moving a target plate with an evenly distributed series of refractive nodes from the camera side to the strobe side following the optical axis. A file is recorded while the target plate traverses the field at a constant rate of roughly 2 mm per second. This process is repeated for each optical setting S0, S1, S2, and S3 (high to low magnification).

The observed volume depends on a number of extraction parameters as set while using the AutoDeck software: The most important are the segmentation thresholds the standard deviation and the Sobel settings. Generally the values are set in an empirical way to grab in an optimal fashion while playing back a VPR data file acquired in the field. Having thus chosen a set of values for segmentation, standard deviation and Sobel and knowing the optical setting used during data collection, the corresponding observed volume can be assessed with the VPR_Cal software which is a modified version of AutoDeck.

To make life easier, VPR_Cal should reside in its own directory along with the required dll's and the specific configuration file CalConfig.vpr . This directory should also contain two other directories, Cal_Data and Cal_Results. Cal_Data contains the four sets of calibrations files for S0, S1, S2, S3 as well as an information file giving the details of the optical settings.

Cal_Results collect the output file for each calibration run executed. If this directory does not exist, it will be created at run time. The output files have names of the form "Analysis_xxxxxxxxxx.dat" where xxxxxxxxxx is a time stamp.

When starting, VPR_Cal will load its working parameter from the CalConfig file. Then the critical settings (segmentation, std deviation Sobel) should be adjusted in the GUI to the desired values, in a way similar to what is done in AutoDeck. Using the Option drop down menu, select the desired optical setting corresponding to the one used during the field data acquisition. This will tell VPR_Cal what calibration file to use. You can then pre-run the cal file and find the frame range of interest using the Extraction Options. When ready select write ROI and start the capture.

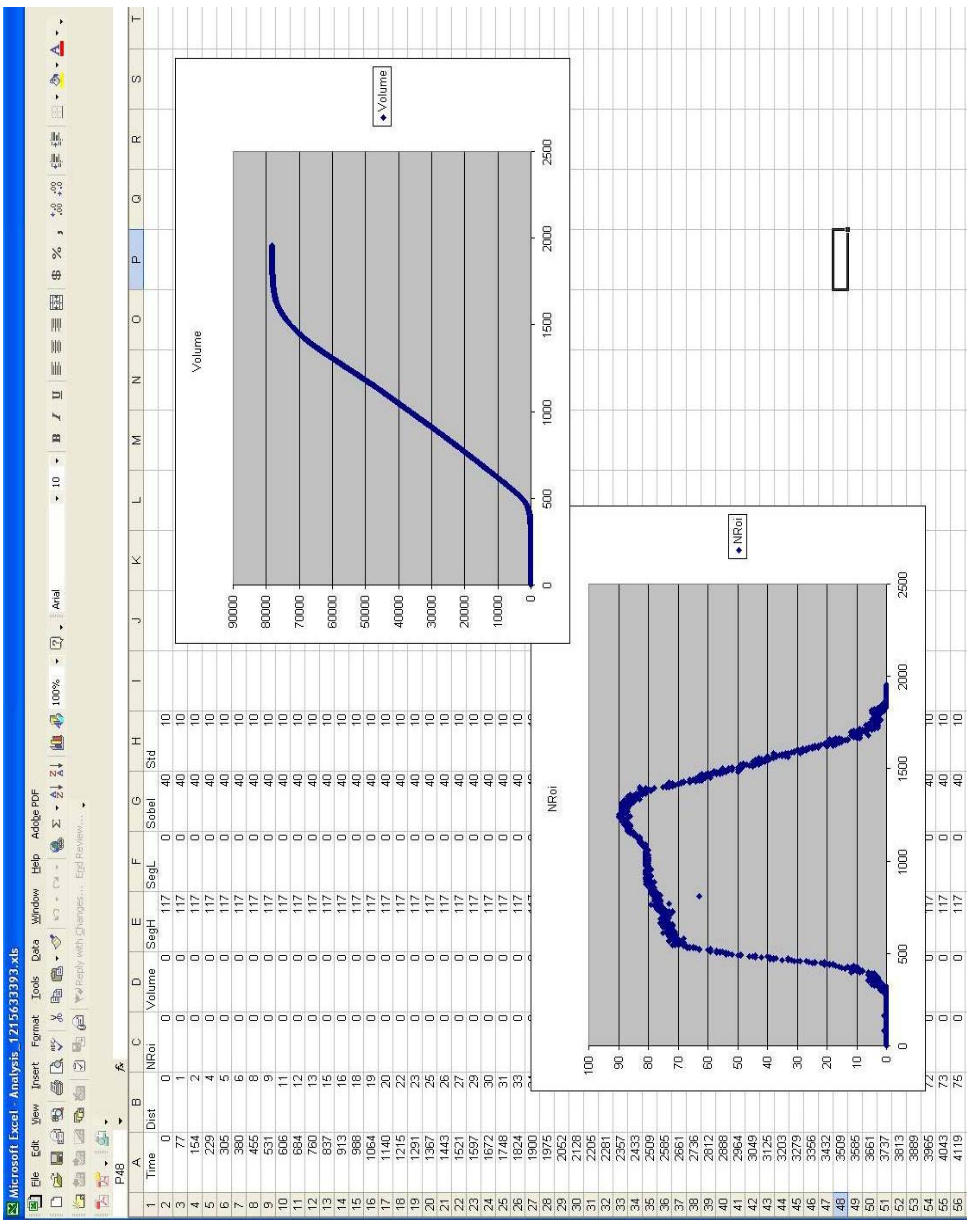
The program will display three parameters of interest:

1) The travel distance counted from the Start frame position and expressed in 1/10th of mm.
2) The number of ROI's grabbed within the image
3) The observed volume up to the current frame, expressed in mm3

The calibration files contain pictures of a special target consisting of a grid of refracting dots. The grid pitch is match to the field of view in order to limit the number of possible ROI's to a 100 or less per image. For each dot on the grid there is a corresponding target surface equal to the square of the pitch. When calibrating each picture is time-stamped and knowing the travel speed of the target, one can calculate the distance between successive frames. One can then associate a volume with each captured dot. These elementary volumes are summed over the travel of the target and give the total observed volume for the setting (segmentation, std deviation Sobel) selected. The output data (Analysis file) is a text file containing one line per frame analysed. The line contains 8 parameters separated by commas: Time ,Dist,NRoi,Volume,SegH,SegL,Sobel,Std

- Time is the elapse time in mS
- Dist is the travel distance expressed in 1/10th of mm, assuming a uniform travel speed of 1.83 mm per S
- NRoi is the number of ROI’s captured in the current frame
- Volume is the sum of all elementary volumes captured so far.
- SegH,SegL,Sobel,Std are the settings for light segmentation, Sobel value and standard deviation. If none of these settings were change during the capture run, these number should stay the same.

If needed this analysis file can be imported into Excel or some other spread sheet and NRois or the observed volume can be plotted as a function of the travel distance.



The CalConfig.vpr file is also a text file which is read and parsed by the application on start up. It could be edited but is better left alone. Each line should follow the following syntax: Name field, Data Field separated by a comma..

For exemple, it contains the following information for the DAVPR 7:

Title,DAVPR 07 Observed Volume Calibration
High Segmentation Threshold,130
Low Segmentation Threshold,0
Sobel Threshold,40
Focus StdDev,10
S0_Cal,Cal_Data\1214485992.idx
S1_Cal,Cal_Data\1214486725.idx
S2_Cal,Cal_Data\1214487460.idx
S3_Cal,Cal_Data\1214488198.idx

Maintenance

Field maintenance of the DAVPR is minimal for the user. Connectors should be checked before each deployment. Plugs should be sited in line with the bulkhead connector without sideways deflection induced by extra length of cables being secured to the frame. Extra care should be applied to the battery connectors. They should be kept properly greased and correctly seated. After each cruise at the minimum, you should disconnect all connectors and dummy plugs and inspect for corrosion. Connectors should be kept greased at all time. After each deployment you should rinse the DAVPR with fresh water, and take proper care of all the sensors according to each sensor manufacturer requirement. The battery case end cap o-rings (2-155) should be inspected and greased often, since the case is opened repeatedly. The DAVPR should not be stored outside in sub freezing temperature or full sun light.

Battery Care

Charging the battery in its case is a very bad idea. Charging the battery with anything other than the supplied charger is also a very bad idea.

The NiMH battery packs used by the VPR are nominally 24V, 9 Ah capacity. They require a special charger which was designed to control charge currant, battery voltage evolution during the charge, and internal temperature. The charging procedure is described in annex B.

The NiMH battery packs can be completely discharge and don't have memory as the NiCad technology does. They will lose their charge when not in use. If they drop down to below 2 volts then the charger will not sense the battery and will not start the charge. The solution to this is to briefly connect the battery to a power supply set to 12 volts @ 1Amp for 30 seconds to bring the battery up above 2 Volts. Then you can proceed with charging the battery with the supplied charger for the DAVPR.

Annex A, Sail commands

To communicate over the sail loop with VPR, connect the supplied interface box to the sail bulkhead connector on the instrument rear end-plate. The box convert from constant current loop (SAIL) used to communicate with the VPR supervising controller and RS232 used on the deck computer. The instrument can be in booted mode so that power is applied to the CTD and motorize lens assembly. The sail link will default to 300 bauds, 8 data, no parity. On the deck computer launch HyperTerminal, connect to the appropriate serial port and set the communication properties to use the same format as the VPR (300, 8, N, 1).
Address the VPR by sending its addressing sequence “#VPR(space)”. The instrument responds with a CR/LF and a semicolon. If the 300 baud rate is to slow for comfort it can be changed by issuing a command #00bbbbb over the loop, where bbbbb is the new desired baud rate written with 5 digits, using leading zeros (for example: #0000600 or #0009600). After issuing this command you need to change the baud rate used by HyperTerminal to match the one you just chose.

Having addressed the VPR you can used the following commands which are described using italics when the text is issued by the VPR. All commands are case sensitive and unrecognized strings of characters are answered with a ‘?<cr/lf> : ‘ sequence. No action is taken.

Help command:

```
:H<cr>
AutoVPR Sail controls
 03/29/2006
 ?B battery voltage (dV)
 ?A(cr) disp active vals
 ?M(cr) disp maxvals
 !J jams Z,F,I,E to their respective stops
 ?Sn(cr) disp set n, n=0,1,2,3
 !An(cr) copy set n to active vals and set optics
 ?D(cr) query a data frame
:
```

These are the basic commands available at all time. If you feel adventurous you can send a command X<cr> and then re-issue the H command.

```
 :X<cr>
 :H
AutoVPR Sail controls
 03/29/2006
 ?B battery voltage (dV)
 ?A(cr) disp active vals
 ?M(cr) disp maxvals
 !J jams Z,F,I,E to their respective stops
 ?Sn(cr) disp set n, n=0,1,2,3
 !An(cr) copy set n to active vals and set optics
 ?D(cr) query a data frame
 !M sdddddd sdddddd sdddddd sdddddd(cr) set max val
 !Sn(cr) copy active vals to set n
```

```
!Rc(cr) reset to zero position (c=* for all)
!Trim z,f,i,e position
!X(cr) exit through reset
n=0,1,2,3 c=Z,F,I,E s=sign extension, all data in decimal
!P (on/off) sequence power on/off
:
```

These extended set gives access to fine control of the optics as well as switching power on and off. They are intended for set up, maintenance and calibration purpose and should not be used in normal operation.

?Sn Command:

This command is used to query the values of each optical preset. The character n can take values from 0 to 3. Channels are reported in the order of Z, F, I, E for Zoom, Focus, Iris and Extension. The returned values correspond to the number of steps executed by each respective motor from their initial position to reach the set position. The values can be seen as guide numbers.

Ex:

: ?S0<cr>
+001750 +006030 +003000 +000000
: ?S1<cr>
+003925 +005650 +004000 +028500
: ?S2<cr>
+005000 +005150 +004750 +044000
: ?S3<cr>
+004000 +004300 +005000 +053000

?A Command:

Displays the currently active values at which the optic is set. These values are usually that of one of the set, but don’t have to be if the individual channels have been trimmed using the !T command.

Ex:

: ?A<cr>
+004000 +004200 +005000 +053000

?M Command:

This command reports the maximum stepper value for each of the four motorized channels, expressed in steps. Those values are factory preset and should not be changed.

Ex:

: ?M<cr>
+007900 +007600 +007000 +055500

!Sn Command:

This command is part of the extended set and transfers the currently active values of the motorized lens assembly to set n. It will ask you to confirm.

```
:!S3<cr>
 Transfer active values to set (Y/N?)N
```

!An Command:

Transfers set n to the active value and position the motorized lens assembly accordingly. This command should be used after a Jam command, to change the optical settings. The command will complete before the prompt is returned which could take up to a couple of minutes.

!M Command:

This command sets the maximum step values for each channel of the motorized lens assembly.

Set before factory calibration: do not change.

Ex:

:!M +007900 +007600 +007000 +055500 <cr>

!J Command:

This command is used when, for any reason, the current positions of the motorized lens assembly have been lost and do not match the values currently reported by the active set. This can happen if power is switched off to the system before the active set values are saved with the exit command or if a specific channel has had its clutch slip because of mechanical overload. It brings back each channel of the motorized lens assembly to its zero position. The number of steps executed is equal to the values memorized in the max set plus 100. This will lead to mechanical jamming against the respective stops of each channel, with the clutch slipping. The command will complete before the prompt is returned which could take up to a couple of minutes.

!Rc Command:

This command will reset any individual channel or all channels to its zero position by moving back each respective channel by the number of steps recorded in the current active set. This will not create any slippage of the clutch. The character ‘c’ can take the values Z, F, I, E for Zoom, Focus, Iris and Extension. The value ‘*’ resets each single channel in turn.

!T Command:

It is used to trim the position of any specified channel, starting at the current position. This command is interactive. It queries information on which channel and what increment in steps should be used. Then that channel can be moved forward of backward interactively until the command is exited. The trim command terminates when it receives a character other than ‘F’ or ‘B’.

:!T*rim (Z,F,I,E)?* F
Dlt= 50
F/B? F *N= +005250*
F/B? F *N= +005300*
F/B? B *N= +005250*
F/B? B *N= +005200*

F/B? X
:

!X Command:

This exit the lens control command set and saves the values of S0, S1 ,S2 ,S3 and the active set A (the current position of the lens assembly) it should be used for exiting to keep track of the current settings. The values for Sn and A are automatically reloaded each time the system is powered up or reset, as for instance after a battery exchange.

!P Command

This command allows to turn power on and off (up or down) to the PC stack and all the VPR subassemblies: Camera, Strobe, CTD etc. If used, you should be careful to shutdown the PC operating system first. This cannot be done from the remote console and require to physically attach a display, keyboard and mouse to the VPR embedded PC.

```
!Pwr (Up/Down)? U
```

?B Command

This allows querying the battery voltage as measured by the controller.

```
:?Bat(dV) = +000276
```

?D Command

This command is used to query an oceanographic data frame from the VPR and is useful only when the VPR is running. It will time out if data is not received within a certain delay or return a question mark if the instrument is not capturing.

```
:?D
ctd55001865865: 0.0001,24.3325,0.2350,0.0116,0000,0000,0000,0000,0000
 :
```

The first numeric data field after ctd is the time stamp. It is the same as the computer time when the frame was generated. It is followed by conductivity, temperature, pressure, salinity in floating point format. Units are the one used by the CTD. The four integer digital field that follows are place holder for the FLNTU sensor (Fluorometry and turbidity) and the last field is a spare channel.

Annex B, Charger operation:

OPERATING INSTRUCTIONS FOR MODEL XPBS-01-002 NICKEL-METAL-HYDRIDE BATTERY CHARGER

INTRODUCTION

The Model XPBS-01-002 Battery Charger is designed to recharge 20 cells, 24.0 volts, 9.5 Ah, Nickel-Metal-Hydride batteries (also works with Nickel-Cadmium batteries). There are four criteria for determining when the battery is fully charged that the unit monitors concurrently. The two primary criteria are a rise in battery temperature at a rate of 1ºC per minute (dT/dt) or a 0.5% decrease in battery voltage with respect to top level (-dV). The secondary criterion is reaching a maximum voltage during charge of 35 volts, or 1.75 volts per cell. The tertiary criterion for terminating the charge is by the timer backup, which is set to 5.5 hours.

This unit features microprocessor control, voltage sensing with 10-bit resolution and digital filtering. Power is provided with an input voltage range of 115/230 VAC, auto-sensing, with a fixed power cord. The power cord provided is standard for use in North America. The output cable is six feet long and has four wires for a customer supplied connector. The heat sink enclosure is intended to be wall mounted.

IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS - This manual contains important safety and operating instructions for the Model XPBS-01-002 Battery Charger. Before using the battery charger, read all instructions and cautionary markings on the battery charger, the battery, and the product using the battery.

CAUTION - To reduce the risk of fire or electric shock

- Do not expose unit to rain or moisture - use indoors only.
- Do not remove cover. There are no user serviceable parts inside. Refer service to qualified service personnel.
- Connect the charger directly to a grounding receptacle. An adaptor should not be used with this unit. The plug must be plugged into an outlet that is properly installed and grounded in accordance with all local codes and ordinances.
- Disconnect charger from AC power before attempting any maintenance or cleaning. Turning off controls may not reduce this risk.

WARNING

- Do not attempt to recharge non-rechargeable batteries. Charge only nickel-metal-hydride (or nickel-cadmium) rechargeable batteries. Attempting to charge other types of batteries may result in personal injury and battery damage.

DANGER - Never alter AC cord or plug provided - if it will not fit outlet, replace with the proper type of cord or have a proper outlet installed by a qualified electrician. Improper connection can result in a risk of an electric shock.

Make sure cords are located so that they will not be stepped on, tripped over, or otherwise subjected to damage or stress. Do not operate this unit with a damaged cord or plug - replace them immediately. To reduce the risk of damage to electric plug, pull by plug rather than cord when disconnecting charger.

Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way. Do not disassemble charger; incorrect reassembly may result in a risk of fire or electric shock. Refer service to qualified service personnel

Recharge batteries in well-ventilated areas to prevent the build-up of explosive gasses. Allow space around the charger and adequate air circulation to reduce internal heat build-up.

OPERATING INSTRUCTIONS

Before using this battery charger, make sure that it is compatible with your battery. Refer to the battery charger, the specifications in this manual, and your battery documentation. If batteries are hot or cold, allow them to adjust to room temperature before attempting to charge them.

CONNECTING THE CHARGER TO AC POWER

Plug the power cord into a properly grounded outlet that supplies the correct input power. This charger will automatically sense and run from an input voltage of 115 or 230 VAC, 50-60 Hz. The power indicator will light when properly connected to AC power. Also, when power is first applied, the charge and ready indicators will each flash four times in turn.

If the power indicator does not light, check to make sure that the input power is not controlled by a light switch. If there is still a problem, the charger may require service. There are no user replaceable fuses.

CONNECTING THE CHARGER TO THE BATTERY PACK

The charger output cable is provided with four wires for connecting to the battery and to a 10k thermistor. The red and black wires are for connecting to the battery, with the red wire positive and the black wire negative. The green and white wires are for connecting to the thermistor and can be connected in either order. A thermistor must be attached for the charger to operate properly.

Plug the charger output connector into the battery pack connector. The charge indicator should come on after about a second or two. The charger output remains off until a battery of at least two volts is detected.

This charger is electronically reverse protected. In a reversed condition, the charge and ready indicators will quickly flash alternating between them, and the charger output will not be turned on. When the reverse condition is removed, the indicators will reset.

CHARGING THE BATTERY

This battery charger is fully automatic. The charger starts out in the charge mode with the yellow charge indicator lit. During charge, a constant current will be delivered to the battery. When the battery is charged, one of the charge termination criteria will be detected and the fast charge will be terminated. A top charge will finish charging the battery. The charge indicator will darken and the green ready indicator will flash during the top charge. When the charger enters the maintenance mode, the green ready indicator will stop flashing and remain lit. If the battery must be used right away, it may be removed from the charger during the top charge.

If the battery does not come up to 16.0 volts within two minutes, the charger will indicate a battery fault by flashing the charge and ready indicators.

If the battery is left connected to the charger and AC power is lost, when AC power is restored, a new charge cycle will be started.

Loads should not be attached to the battery while it is being charged. Parallel loads will interfere with the charging of the battery.

If the battery temperature is outside of the start-of-charge temperature range when first attached, or if it falls outside of the normal-charge temperature range during charge, the charge cycle will be paused and the charge indicator will flash to indicate a temperature fault. This will also happen if the thermistor is not attached to the output cable or is damaged. Once the temperature enters the start-of-charge temperature range, the temperature fault indication will be cleared and the charge cycle will resume.

SPECIFICATIONS

General Conditions:
Ambient Temperature = 25 ºC (77 ºF)

• Input Voltage & Frequency:	115/230 V~, 50-60 Hz
• Battery:	24 V (20 cells) 9500 mAh Nickel-Metal-Hydride
• Charge Current:	2.30 A
• Top Charge Current:	345 mA
• NDV Inhibit Timer:	10 min.
• Top Charge Timer	2 hr.
• Minimum Battery Voltage to Detect:	2.0 V (0.1 V/cell)
• Standard Charge Start Battery Voltage:	16.0 V (0.8 V/cell)
• Start-Of-Charge Temperature:	10 to 40° C (50 to 104° F)
• Normal-Charge Temperature:	0 to 45° C (32 to 113° F)
• Operating Temperature:	0 to 45° C (32 to 113° F)
• Storage Temperature:	-40 to 80° C (-40 to 176° F)

Charge Termination Criteria:

• dT/dt Rate:	1ºC/min
• -dV/dt Detection Level:	-0.5% with respect to top level for 30 sec.
• Upper Battery Voltage Control Limit:	35 V (1.75 VPC)
• Overall Timer (backup):	5.5 hr.