LISST-100X

Particle Size Analyzer

User's Manual

Version 4.60
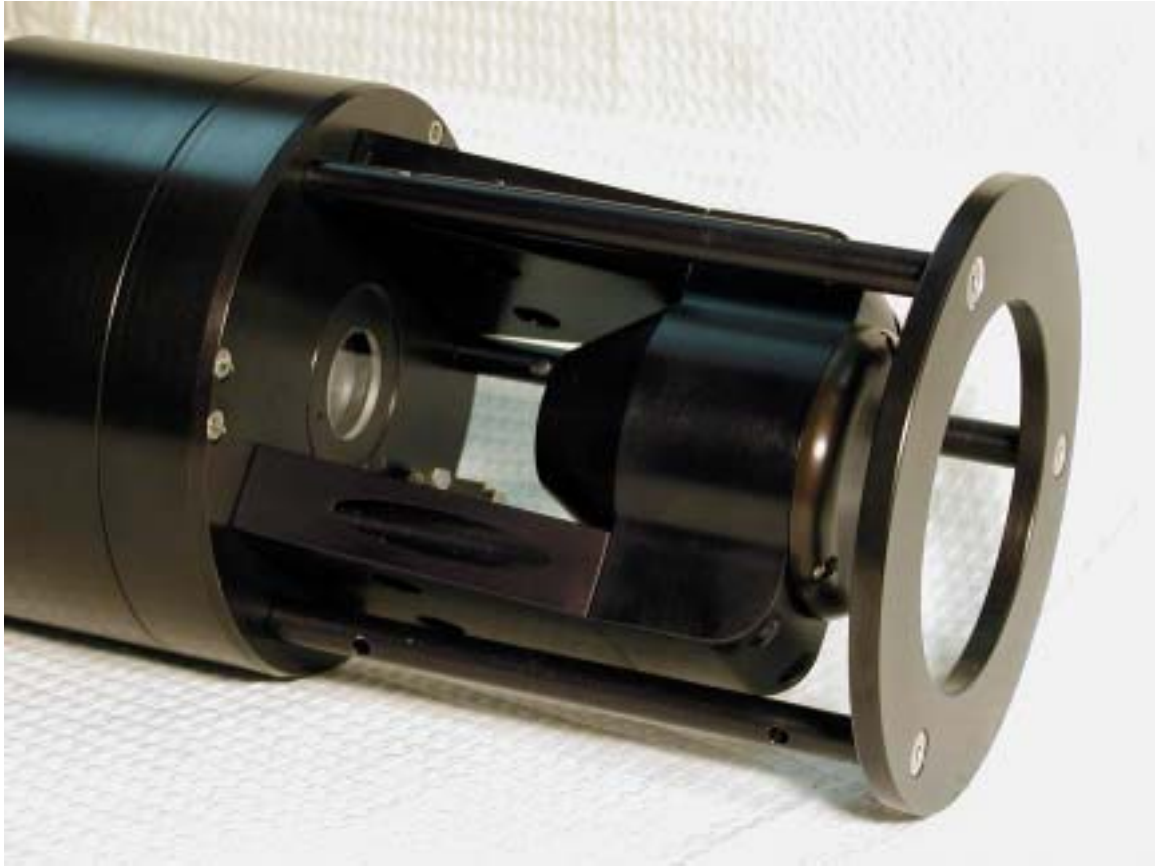
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Welcome to the LISST-100X Particle Size Analyzer

Using this manual
This manual is divided into two sections.

Section One contains an introduction to the LISST- 100 instrument and the principles of its operation.

Section Two provides a detailed set of instructions for using and caring for the instrument.

Instrument specifications
For a listing of instrument-specific constants, as used in the software for data processing, refer to Appendix A.

Technical assistance
For technical assistance please contact your local Distributor or a Sequoia Technical Service Representative listed below. Please be sure to include the instrument serial number with any correspondence.

Factory Technical Service Representatives

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Section 1: Introduction to the LISST-100X

Introduction

Principle of Operation

The product name LISST is derived from the term that describes its operation: **L**aser **I**n-**S**itu **S**cattering and **T**ransmissometry. LISST is a Trademark of Sequoia Scientific, Inc.

The LISST-100X instrument uses the technique of laser diffraction to obtain *particle size-distribution* (PSD), also called *volume distribution* in this manual. This section describes the principle of operation of your instrument.
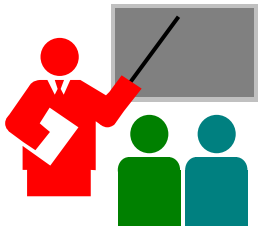
The laser diffraction method for sizing particles was invented in the 1970's and rapidly became the most widely used optical method for determining size distribution for the simple reason that for laser diffraction, the composition or refractive index of the particles is not important. This method determines size distribution of an ensemble of particles, as opposed to counting type devices that size one particle at a time. The reason that laser diffraction is unaffected by composition of particles is that the scattering of laser light is observed at multiple, *small* forward angles. At these small angles, light scattering is determined almost entirely by light *diffracted* by the particle. The light *transmitted* through the particle makes only a weak contribution to the measured scattering. Since the light transmitted through the particle would *experience* the composition of the particle, i.e. its refractive index, and since it makes only a weak contribution

A collimated laser beam enters water, light is scattered by particles and sensed by a multi-ring detector behind a receiving lens. A photodiode placed behind a centered hole measures optical transmission

to the observed scattering, the method of laser diffraction is mostly *independent* of particle composition. In the aquatic sciences, particle refractive index is poorly known. Thus, except for shape effects, laser diffraction offers an excellent method for size-distribution estimation. Shape effects are a matter of continuing research and no definite generalized guidelines are available to account for them *by any method*. Consequently, laser diffraction methods deliver the equivalent-spheres size distribution. By calibrating for concentration with ISO standard natural particles, shape effects are empirically included.

The LISST-100X records the scattering intensity over a range of small angles using a specially constructed multi-ring detector shown in the graphic above. This measurement is also known to optical scientists as the *volume scattering function* and can be used as such for studies of underwater image propagation and beam spread. A growing number of publications of measurements using the LISST-100X instrument is available on our website: http:www.sequoiasci.com.

The conversion of the multi-angle scattering to size distribution involves a mathematical *inversion*. In this step, a size-distribution is found that would produce multi-angle scattering that fits the observation. There exists a vast literature on the subject of this inversion. For the stout-hearted user interested in learning all about it, we recommend the most germane study of the subject:

> "Optimal scaling of the inverse Fraunhofer diffraction particle sizing problem: The linear system produced by quadrature," by E. D. Hirleman, *Particle Characterization*, 4, 128-133, 1987.

The main conclusions are that the information content of the data is most stably retrieved by use of ring-type detectors, with each ring measuring the scattering over a sub-range of angles, and that the resolution is limited to relatively few size classes depending on the noise in the data. For example, for the dynamic range in scattering angles of 200:1 that is built into the LISST systems, typically only 12-14 truly *independent* size classes can be resolved.

Simpler descriptions of principles and practice are offered in a separate study by Agrawal et al., 1991[1]. A more up to date description of the technology and its application is provided by Agrawal & Pottsmith, 2000[2].

We explain the *inversion* process as follows: Let $\underline{E}$ be the 32-element data vector that contains the angular scattering energy sensed by the 32 silicon rings. It is related to the volume distribution[3] via

$$\underline{E} = \underline{K}\, \underline{N}_V$$

where $\underline{K}$ is the scattering property kernel matrix and $\underline{N}_V$ is the volume distribution.

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[1] Agrawal, Y.C., I.N. McCave, and J.B. Riley, 1991: "Laser diffraction size analysis," in *Principles, methods and applications of particle size analysis*, J.P.M. Syvitski, editor, Cambridge University Press, pp. 119-128.

[2] Agrawal, Y. C. and H. C. Pottsmith, 2000: Instruments for Particle Size and Settling Velocity Observations in Sediment Transport, Marine Geology, 168, pp 89-114.

The volume distribution is obtained by inverting the above equation. To test whether the estimated solution is a good one, one may compute the prediction of a scattered energy estimate $\underline{E}_e$ as

$$\underline{E}_e \;=\; \underline{\underline{K}}\,\underline{N}_e$$

If the measurements $\underline{E}$ are consistent with $\underline{E}_e$, the estimates of $\underline{N}_e$ can be considered good. Included with the LISST-100X instrument, we have provided software that obtains the inverted volume distribution $\underline{N}_V$. We have also provided the matrix $\underline{\underline{K}}$ for your instrument (in ASCII and MATLAB® formats) in order for you to test your results.

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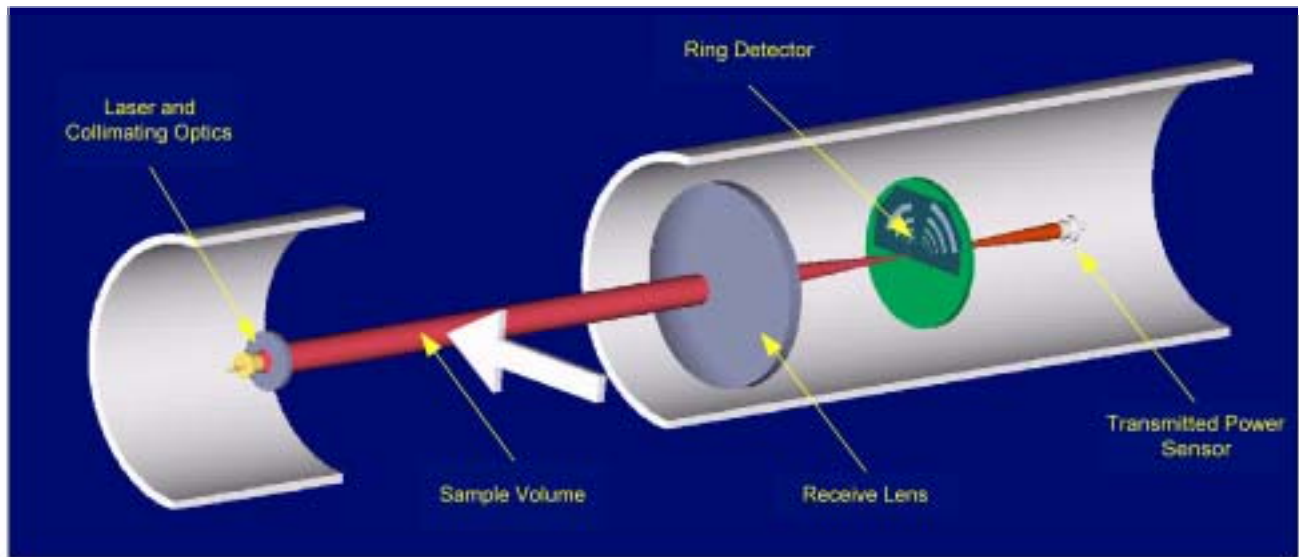
[3]The volume distribution is related to the number distribution via $N_V = a^3\, n(a)$. It represents the volume concentration of particles of particles in the size range a to $a + da$. The results from the LISST instruments provide the volume concentration of particles in each of 32 size classes. The size classes are log-spaced from the range 1.25-250 microns (Type-B instruments), 2.5-500 (Type-C), or 7.5-1500 microns (Type-D, LISST-FLOC). See Appendix B for further details.

General Description

The LISST-100X instrument is a laser diffraction device. It consists of optics for producing a collimated laser beam, a specially constructed detector array, electronics for signal pre-amplification and processing, a data storage and scheduling computer, and a battery system.

The instrument is capable of autonomous operation. For such operation, software is provided to program the instrument for a specific sampling schedule. The primary measurements delivered by the LISST-100X are the small-angle scattering properties of particles in water, the laser optical transmissivity, depth, and temperature. An auxiliary Analog port is available for recording data from an external input.

After recovery of the instrument, small-angle scattering data are off-loaded from the instrument and subsequently *inverted* mathematically on a PC to produce the particle size distribution. The inversion function is included in the software.

The principal measurement—angular scattering distribution— is obtained over 32 ring-detectors whose radii increase logarithmically from 102 to 20,000 microns. The detector is placed in the focal plane of the receiving lens. The rings cover an angular range from 0.0017 to 0.34 radians (Type-B), 0.00085-0.17 (Type-C), or 0.00028-0.053 radians (Type-D, or LISST-FLOC) . This angular range corresponds, respectively, to size rangesL 1.2 to 250 microns (Type-B), 2.5-500 (Type-C) and 7.5-1500 microns (Type-D, or LISST-FLOC).

General layout This self-contained instrument consists of the following parts: a solid-state laser operating at 670nm wavelength and fiber-optically connected to a laser beam collimating system, a beam manipulation and orienting system, a scattered-light receiving lens, the specially designed 32-ring detector, preamplifier electronics, a ring-selecting multiplexer circuitry, and a data logger.

Depth and Temperature In addition to measuring the particle size and concentration, the LISST-100X also has built-in Depth and Temperature sensors. The Depth sensor is a 500 psi strain gauge sensor. The stainless steel fitting on the Connector endcap is used for testing this sensor. It is not required for normal operation. However,when not used for testing, this fitting helps keep contamination out of the pressure sensor. The temperature is measured using a high precision thermistor imbedded into the Connector end cap. Both values are stored automatically in the standard-format LISST-100X datafile.

External I/O Ports   The LISST-100X is also equipped with an external ANALOG IN port for recording the output of one other analog instrument. Additionally, 2 DIGITAL I/O ports are provided for communicating with up to two instruments. The I/O ports can be used for synchronization of the LISST-100X with two other instruments; e.g., the LISST-100X may provide a timing pulse to a CTD, or it may provide a 'start sample' pulse to another LISST-100X. The same ports can be used to receive similar commands. Contact Sequoia Scientific for more information on interfacing the LISST-100X with other instruments. These ports are available on the 6-pin underwater connector on the Connector Endcap. Appendix C shows the connector pinouts.   The instrument can be configured to use on the the Digital I/O ports as a trigger to start and stop sampling.

Battery Life   The primary power source for the LISST-100X is a custom alkaline D-cell battery-pack. The pack outputs +9 volts. It has a room-temperature capacity of 42 A-hr. When the instrument is in stand-by mode, (i.e., displaying the L100X> prompt) the current drain is XX mA. If used as advised, the battery provided in the instrument has a capacity to power the instrument for up to a year. For profiling applications, where the instrument is sampling continuously, the battery pack has about 60 hours of "On" time. Powering down the instrument between samples can greatly extend the deployment times.   An EXCEL spreadsheet is included with the software that can estimate the battery consumption

 For laboratory or tethered usage, a connector is provided on the endcap to draw power from an external source. The voltages required from the external power supply are +9. Cables up to 50 meters can be provided to supply external power and communication with the instrument.   This can allow Real-Time observation of the Size Distributions.

> **When not in use, use the Low Power Sleep mode of the instrument to reduce battery drain to about 10μA. This can be done from the provided software.**

Auxiliary Equipment

The instrument is shipped pre-aligned and tested. A chamber is provided for obtaining measurements of background scattered light from optical surfaces. This background is subtracted from actual particle scattering measurements to obtain the true particulate scattering. Additionally, small tools used to open endcaps, spare batteries, and communication cable are supplied so that a user need only provide a PC.

Software is provided to communicate with the instrument, schedule an experiment, offload the data, and invert the measurements to obtain particle size distribution and volume concentration. For laboratory use or for monitoring the progress of an experiment, the software can be used for real-time processing.

For laboratory testing an optional Small Volume Full Path Mixing Chamber is available. This chamber mounts to the optics of the LISST-100X and seals around the windows of the instrument. The sample can then be added to the chamber and the built-in mixer will keep the sample mixed with the measurements are being made. The picture below shows the chamber being installed onto the LISST-100X.

Section 2: Operation

Section Organization

Section 2 is divided in to two main sections. The first section is the Getting Started section. This section will walk the user through using the instrument from opening the shipping case through processing downloaded data. Reading the Getting Started section will give most users enough information to starting using the instrument. Following the Getting Started section are detailed instructions for performing various procedures
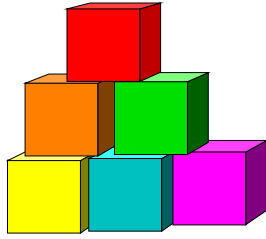
General Precautions

LISST-100X is a sensitive optical instrument. Please handle it gently. Critical alignments may be disturbed if the instrument is subjected to shock or rough handling. Evidence of shock/rough handling will void the warranty. Whenever in transit, store the instrument in the provided padded shipping case.
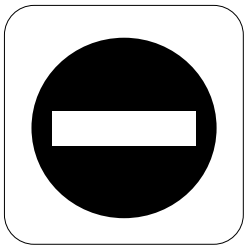
	WARNING **The LISST-100X uses a laser diode emitting a maximum of 1 mW of visible (red) light at a wavelength of 670nm. the laser beam under normal circumstances is not a threat. However, if objects are placed in the path of the laser beam, the light could be reflected into the eye causing permanent damage.**

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Getting Started

This section is designed to give the user a quick introduction to the operating procedures for the LISST-100X. It gives step by step instructions to unpack, load software, and acquire data in the lab. Following the introduction are details on each step of the process.

Contents of shipping case

Let's assume that you are opening the LISST-100X shipping cases for the first time. Inside you will find the following: User's Manual with software disk, LISST-100X instrument, Plastic Instrument stands, Small Volume Horizontal Test Chamber, Communications cable, External Power cable, and Allen wrench set.

Step 1: Remove Instrument from shipping case.

Start by removing the white plastic instrument stands and set them on a flat working surface. Remove the LISST-100X from the case and set it on the stands. The LISST-100X has two distinct ends that we will refer to as the Optics endcap and the Connector endcap. The connector endcap has three underwater connectors that are used for communication. external power, and connecting to optional accessories or instruments. The battery pack is attached to the inside of this endcap. The optics endcap contains the optical windows that the laser beam passes through to make a measurement. The internal optics and electronics are mounted to the inside of this endcap.

Step 2: Check for clean windows

At this time let's check the optical windows to make sure that they are clean. There are two windows. The Receive window is mounted in the center of the optics endcap. Transmit window is located in the Crossbar suspended above the endcap. The best way to check the windows is by using a flashlight. By shining light from one side and viewing from the other the surface of the windows can be easily checked for cleanliness. If there is dirt or fingerprints on the windows clean them first by rinsing them with water and then by wiping them with a soft cloth and alcohol. Stronger solvents, such as acetone, can be used if necessary but is not recommended as a general practice. Liquid dish soap can also be used. In general, do not use any abrasive cleaners or wipes. Treat the windows as you would an expensive camera lens.

Step 3: Attach the Communications Cable

Remove the Communications cable from the shipping crate. It is the cable with the 9-pin DB-9 connector on one end and the 5-pin underwater connector on the other. Remove the underwater cap from the Communications connector. The connectors will all look similar. The Communication connector is the only 5-pin connector. If the unit is rotated so that the metal zinc anode is located at the top (or North), the Communications connector will be on the left (or West). After removing the cap install the cable making sure that the proper alignment is maintained.
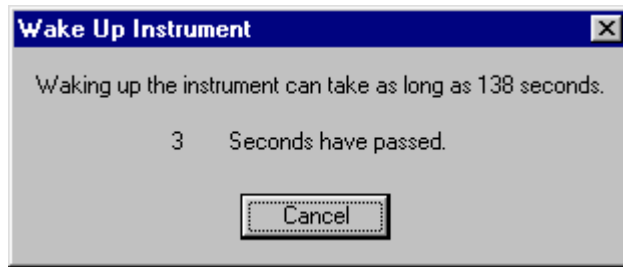
Step 4: Install the Horizontal test

Remove the Small Volume Horizontal test chamber from the shipping case if not already installed on to the instrument. Attach the flexible

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chamber	tubing and tubing stop clamp. This chamber is designed to slip between the optical windows of the instrument such that the optic can be submerged for testing or calibration. For more information on installing the see Appendix F. We can now fill the chamber with clean filtered water. We use steam-distilled bottled water filtered through a 0.2 micron filter. Tap water may contain too many particles and may also contain dissolved gas that can release and form small bubbles on the optical surfaces.
Step 5: Install the provided software	At this point instrument is ready to go. Let's install the software that is required for operation of the instrument. A software disk is included with each instrument. In addition to the communication and processing program the disk also contains calibration files specific for your instrument. Follow the installation instructions in the README.TXT file on the disk to install the software.
Step 6: Start LISST_SOP program	Start the LISST-SOP software by selecting it from the Start menu. The name LISST-SOP refers to the Standard Operating Procedure functionality of the program. Users with experience on previous versions of the LISST-100 software may find the Appendix E, What's New in Version 4.XX a good introduction to the software. Appendix D has a table describing the functions of each button. It is highly recommend that existing users who are upgrading to Version 4.60 from earlier versions (Versions 3.xx) of the LISST software read Appendix F before continuing. There are a number of steps that must be performed before the software will function correctly with older instruments.
Step 7: Wake up instrument from Sleep mode	The instrument is shipped in a low power Sleep mode to conserve battery power. To wake up the instrument select *Wake Up LISST* from the *LISST* menu. A dialog box will appear counting down the maximum time required for the instrument to wake up. The instrument sleeps for 30 seconds, wakes up for 1 second to look for a wake up command and then goes back to sleep. Therefore the wait could be as long as 32 seconds for the LISST-100X. Upon wake up the instrument status will be displayed. If the cable connections are not correct or if the battery is not installed a warning message will appear after the time expires. The serial port settings can be checked by selecting *Serial Port Settings* from the *Communication* menu. The default settings are COM1, 9600 baud, 8 data bits, No parity, 1 stop bit, and no protocol.

Wake Up Instrument

Waking up the instrument can take as long as 138 seconds.

3   Seconds have passed.

Cancel

Step 8: Open Terminal window

The LISST-SOP has a terminal window that allows the user to communicate directly with the instrument. To open the Terminal window select Terminal Window from the Communications window or

select the   button form the tool bar. A window similar to the one shown below will appear.

Instrument

OK
>

OK
>

OK
>

Send

Port open.   Stop   Start
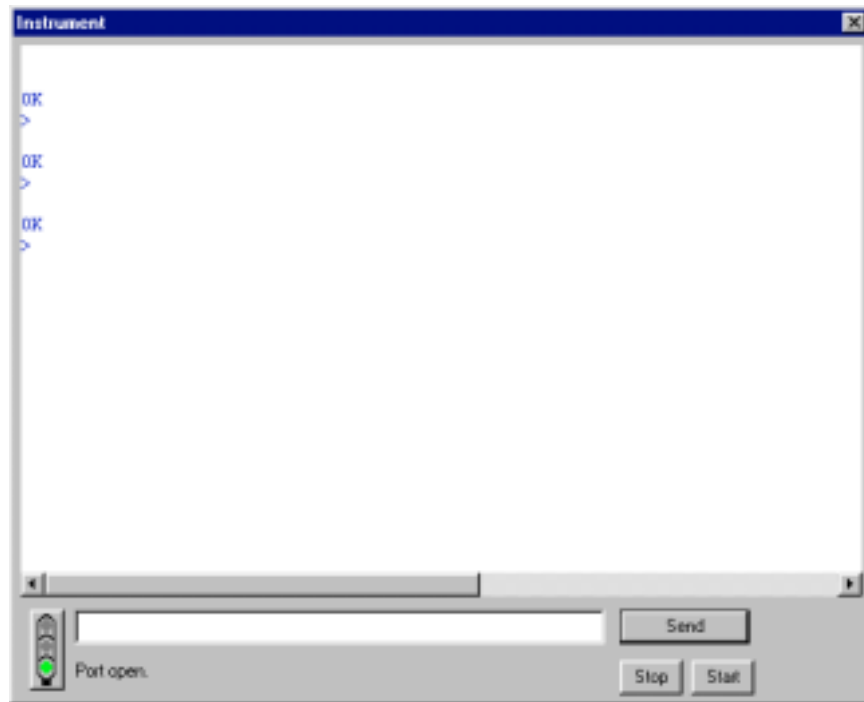
Commands can be typed into the box in the lower section of the window. When the Enter key or the Send button is pressed the command will be sent to the instrument. The Start button sends a GO command to the instrument to start the instrument sampling using the current settings.   The STOP button sends a CTRL-C to stop the sampling and to turn off the main power.

Pressing enter should bring up an L100X> prompt.

If the instrument is still in the Low Power Sleep Mode it will print ZZZ to the screen every 30 seconds. To wake the instrument from the Terminal window, press the Stop button immediately after the ZZZ is displayed. The instrument will only respond to the Stop button for 1 second after the ZZZ is displayed. After the 1 second the instrument is in a low power mode and will not respond to commands for another 30 seconds.

Step 9: Intro to the new Datalogger

The datalogger inside the LISST-100XX has recently be upgraded. It is different from earlier versions of the LISST-100. New instruments using the new datalogger have been given the name LISST-100X. Units using the previous version datalogger will be called LISST-100. The new datalogger of the LISST-100X uses removable Compact Flash cards. Compact Flash Cards are available with up to 1Gb of memory. The LISST-100X comes standard with 16Mb. The Compact Flash Cards can be removed. By using a PCMCIA adapter or USB card reader the data files can be directly transferred to the PC. The standard procedure is to offload the files using the LISST-SOP software at 115K baud.

The LISST-100X now has standard two-letter commands that can be used for interfacing the instrument with other dataloggers and sensors. The commands are similar to the commands used with the LISST-25X instrument. A complete description of the commands is shown in the LISST-100X Command Summary section.

Step 10: Acquiring Background Scattering

A new feature of the LISST-SOP is the ability to acquire background scattering in real-time. The background scattering measurement is critical to good instrument performance. It is especially critical for clean water applications where the optical transmission is greater than 80% over the 5cm path. The background scattering will also check the overall health of the instrument. It will verify that all of the systems are functioning and that the optics are still in alignment. The current background will be acquired and displayed relative to the factory background scattering for the instrument. The image below shows an example of this display. It is opened by either selecting *Collect Background Scatter Data* from the *LISST* menu or by pressing the [icon] button on the toolbar. After selecting the factory background scatter file to use for comparison the window will display.
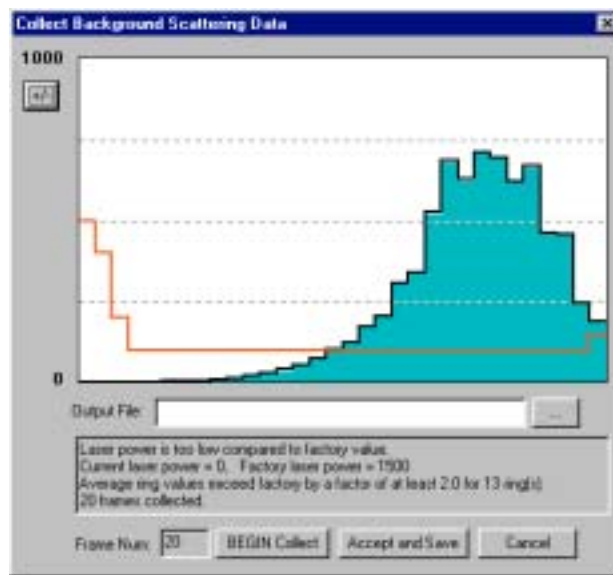

When the *BEGIN Collect* button is pressed 20 samples will be displayed to the screen as they are acquired. After all 20 are collected

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the average will be displayed. If the values are acceptable the values can be saved to a file. Enter the filename in the box and press the *Accept and Save* button.

If there is a problem with the instrument or if the water or windows are not clean, error messages will be displayed. Dirty water or windows will generally cause higher values across the middle rings. Large bubbles or particles in the water can cause higher values on the inner rings or left hand side of the display. High values on the inner rings combined with a lower Laser power value can also be an indication of optical misalignment.

Step 11: Configuring Instrument for Deployment

The heart and soul of the new LISST-SOP software is the Operating Modes window. This window is used to set all of the deployment parameters. To open the window, choose *Operating Modes* from the LISST menu or press the ▦ button on the tool bar. A window similar to the one shown below will appear.
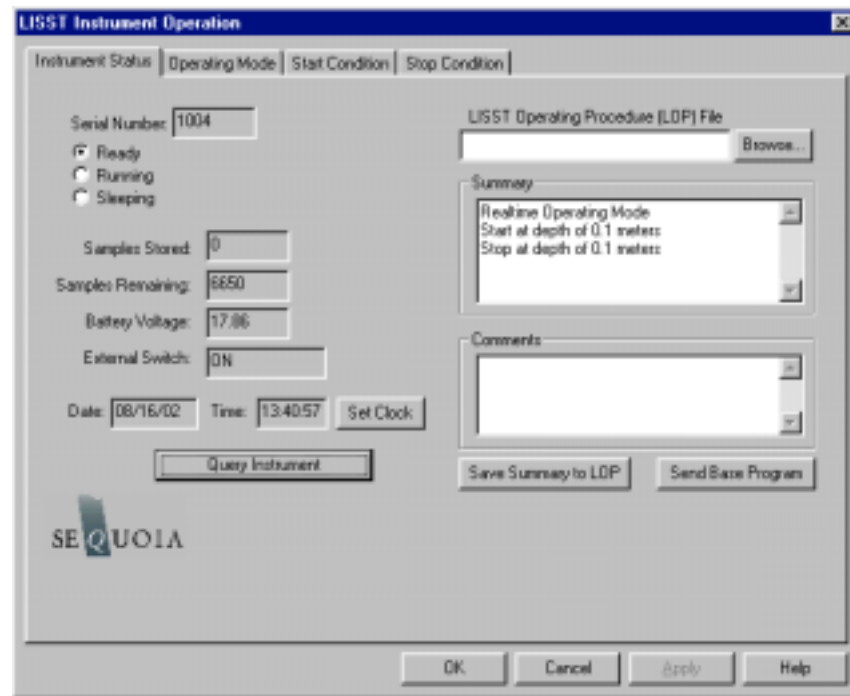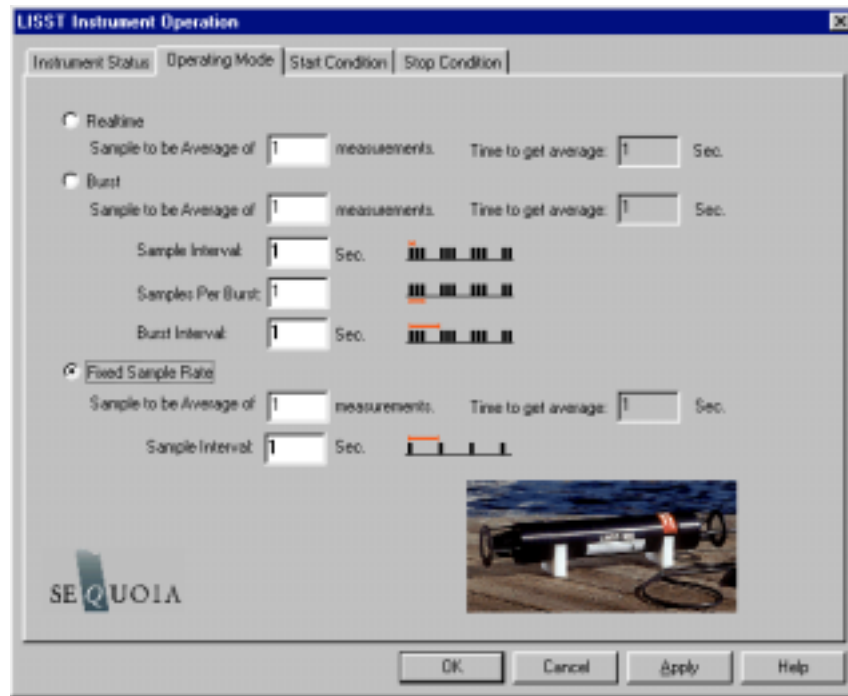

The window has four tabs, Instrument Status, Operating Mode, Start Condition, and Stop Condition. The Instrument Status page gives information about the current instrument. It also allows previously saved instrument configuration files to be loaded on to the instrument. The ability to save the current settings to a file is also available. The Summary window shows the current deployment configuration.

Step 12: Setting Operating Mode

By selecting the *Operating Mode* Tab at the top of the main window the screen below appears. This screen is used to set the type of sampling; RealTime, Burst, or Continuous. You can also select the

samples per average and sample rates on this screen.

The RealTime mode is used for real-time size distribution displays. This mode sends the raw data to the LISST-SOP software for conversion to Size Distribution and displaying on the screen. No data is saved in the datafile.

The Burst and Continuous modes are used to save data in the on-board datafile.   The icons next to the various values give a better understanding of their meaning. The software automatically checks the values entered to make sure that there is no conflict. For example, when a Measurements per Average value is entered, the minimum sample interval is computed. If this value is less than the minimum permitted the value will be changed to the minimum and the text will turn red. A similar test is done on the Burst Interval setting.

For this example let's set the instrument to sample in the Continuous mode at a 1 Hz rate with 10 measurements per average.

Step 13: Setting Start Conditions

After selecting the Operating mode the start and stop conditions can be selected. Choose the *Start Condition* tab at the top of the window.

The Start Condition window, shown below, is used to select the mode in which sampling will be started.
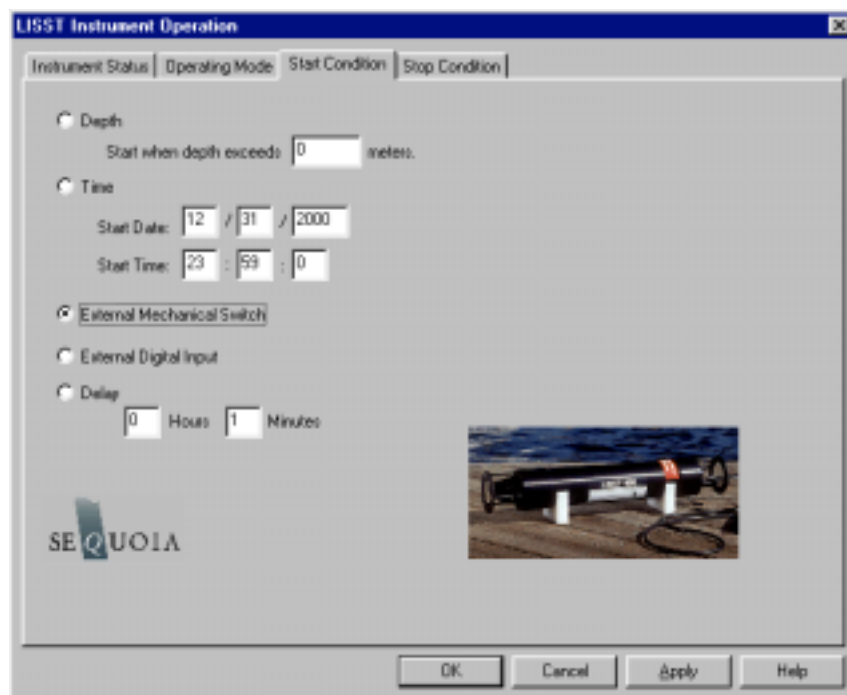
There are five options: Depth, Time, External Mechanical Switch, External Digital Input, and Time Delay. Select the mode by clicking on the button next to the its label. Select the correct parameters as required. For this example let's select the External Mechanical Switch Start Condition.

Step 14: Setting Stop Conditions

Similarly the Stop conditions can also be selected. Click on the *Stop Condition* Tab to open the Stop Condition window. The available stop conditions are: Depth, Time. External Mechanical Switch, External Digital Input, Fixed number of samples, and Maximum Memory or Low Battery.

For this example, choose the External Mechanical Switch as the Stop condition.

After selecting the Stop Conditions return to the Instrument Status page by clicking on the Instrument Status Tab.

Step 15: Saving the settings for future use

Once the settings have been sent to the instrument the Instrument Status Page will display the summary of the settings that have been selected. These setting can be saved for later use by selecting the Save Summary to LOP. A file name will be prompted for. The file will be given an LOP extension which will identify it as a LISST Operating Procedure File. Comments can be entered before saving in the box below the summary. Previously saved LOP file can be opened using the Browse button.

Press the *Apply* button to configure the instrument. This will cause the settings to be transmitted to the instrument. The configuration will take about 30 seconds. Once the configuration is completed we can return to the Instrument Status page to see the summary of the settings and save them for future use if desired. Press the *OK* button to complete the configuration. A prompt will ask if we would like to open the Terminal window to start the instrument. Choose *OK*

Step 16: Starting the program

The instrument is now configured for deployment, however, it is not yet running. In order for the instrument to respond to the correct Start Condition the program must be started.

The configuration of the instrument can be checked by selecting *Query Instrument* from the *LISST* menu or by choosing the button from the tool bar. A window will appear showing the current status and configuration. New samples will be added to any currently saved in the datafile. Choose *Erase* from the *LISST* menu or press the button to erase the datafile. For users of the previous versions of the software this is equivalent to setting D=0. The data is not actually erased but the memory pointer is reset to the beginning so that any old data will be overwritten.

To start the program, press the Start button in the lower right section of the Terminal window. The program will start and display text to the screen as it is running. Depending upon the Start Conditions, text will be displayed approximately every 30 seconds. At this point the user will know that the instrument is running and is ready to be deployed. For our example it will be displaying a message that reads "Waiting for Mechanical Switch ON signal"

Step 17: Collecting Data

When the start conditions are met the instrument will start sampling. The green LED on the connector endcap will illuminate each time a sample is

acquired.

For our example we can move the white plastic lever on the endcap to the "1" position. Sampling will start. If the Terminal window is still open text will be displayed as the instrument acquires data. Data collection will continue until the Stop Conditions are met. In our case, until the switch lever is returned to the "0" position.

If the Start and Stop Conditions are set to Depth, External Mechanical Switch, or External Digital Input the program will return to checking for the Start Condition. This will only be true if the Start and Stop conditions match. For example, Depth Start and Depth Stop. For all other Start Conditions the program will terminate and return to the L100X> prompt.

To stop a running program use the Stop button on the Terminal window or the ![stop] button on the tool bar.

Step 18: Downloading data

The instrument has now stored data in the on-board Compact Flash card. Pressing the Instrument Query Button, ![icon], will display the instrument status including the number of samples saved. To offload the data select *Offload* from the *LISST* menu or choose the ![icon] button from the toolbar. A list of files will appear. Choose the files to offload by clicking on them while hold down the CTRL key. The Shift key can also be used to select a range of files. Select OK and choose a location to save the files to. The files will be saved with names in the following format: L*dddhhmm*.dat, where *ddd* is the day of the year, *hh* is the hour, and *mm* is the minute that the file was first written to. As the data is downloading a Transfer Status window will appear. The data is offloaded at 115K baud.
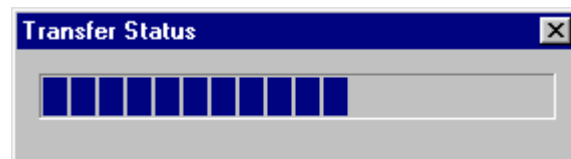
Step 19: Processing Raw Data

We now have the data transferred from the datafile of the instrument to a file on the PC. To process the data file choose *Open Raw Datafile* or press the ![icon] button on the toolbar. Select the instrument serial number, raw data file to open, and background scatter file to use when processing the data. The software will automatically determine the Instrument Type (A, B or C) using the Serial Number and the InstrumentData.Txt file. Unlike earlier versions of the software, the RingArea file (instrument detector calibration file) is automatically selected based on the serial number. A display similar to the one shown below will appear
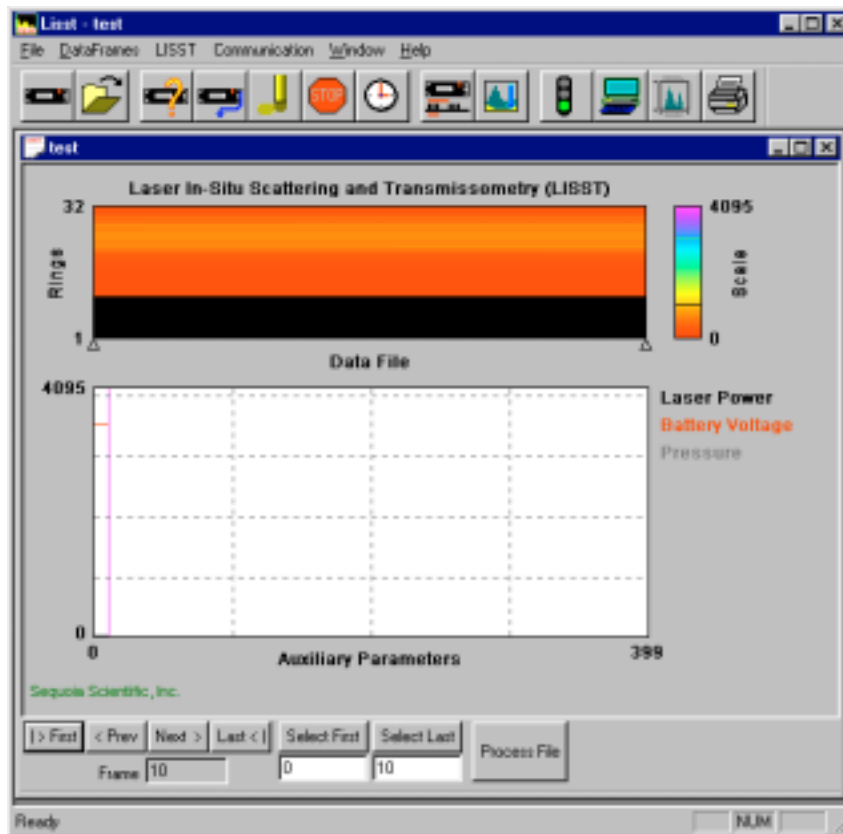
The range of samples to process can be selected by entering values in the *Select First* and *Select Last* boxes. The default selection is to process the complete file. Press the *Process File* button to convert the raw file into processed size distributions. For more details on the available options when this window is open please see the detailed Instruction for Processing Raw Datafiles. For our example press the *Process File* button. When the processing is complete the button label will change to read *Finished*.

Step 20: Viewing Processed Results

Processed data files are stored as ASCII files and as binary files with a PSD extension. The PSD files can be opened and viewed on the screen. To open a processed Particle Size Distribution file choose Open Particle Distribution File or press the ⬚ button on the toolbar. A display similar to the one below should open. The left hand figure will display a bar chart showing the Volume concentration in each of the 32 log spaced size classes. The right hand plot will be the Cumulative Concentration. To view the samples as a movie press the *Timer Off* button. The slider bar next to the button adjusts the refresh rate. The *First*, *Prev*, *Next*, and *Last* buttons allow you to step through the measurements one frame at a time. When the last frame is reached the movie display will stop. Use the *First* button to return to the first sample and press the *Timer Off* button to restart the display.
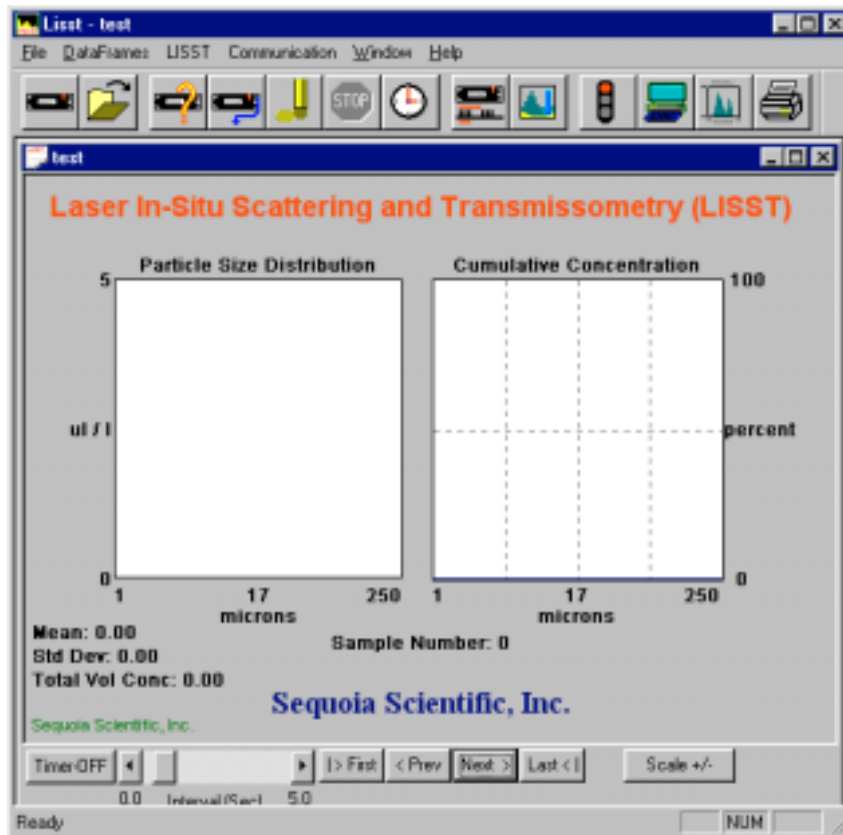
To view the value of the auxiliary parameters, such as time and depth, select the *View Auxiliary Parameter Frame* from the *DataFrames* menu. A display similar to the one below will appear showing the calibrated values.

Step 21: Opening RealTime Session

The LISST-SOP software also supports the ability to acquire data, process it, and display it in Real-time. The Real-time display of the processed data is very similar to the display of processed data. The instrument can be configured for a Real-Time session before data is collected but it is no longer required. The current setting for Measurements per Average is used when acquiring the sample to display. The recommend value for the Measurements per Average is 10. Higher values can be used but the updating of the display will be reduced. The Start and Stop conditions will not be used and therefore their settings are not relevant.

NOTE: It is recommended that if extended Real-Time sessions are going to be done that external power and not battery power be used. The batteries will be used up fairly quickly during a Real Time session.

When exiting the Real-Time session the power should automatically shut off. Pressing the Stop button on the toolbar or the Terminal window will turn off the power. Pressing these buttons when the instrument is already off will have no ill effects.

To open the Real-Time session, choose *Open Real-Time Session* from the *File* menu or press the ⬛ button. Choose a background file to use when processing the data. Choose an output PSD file. A display very similar to the View Processed datafile will be displayed.
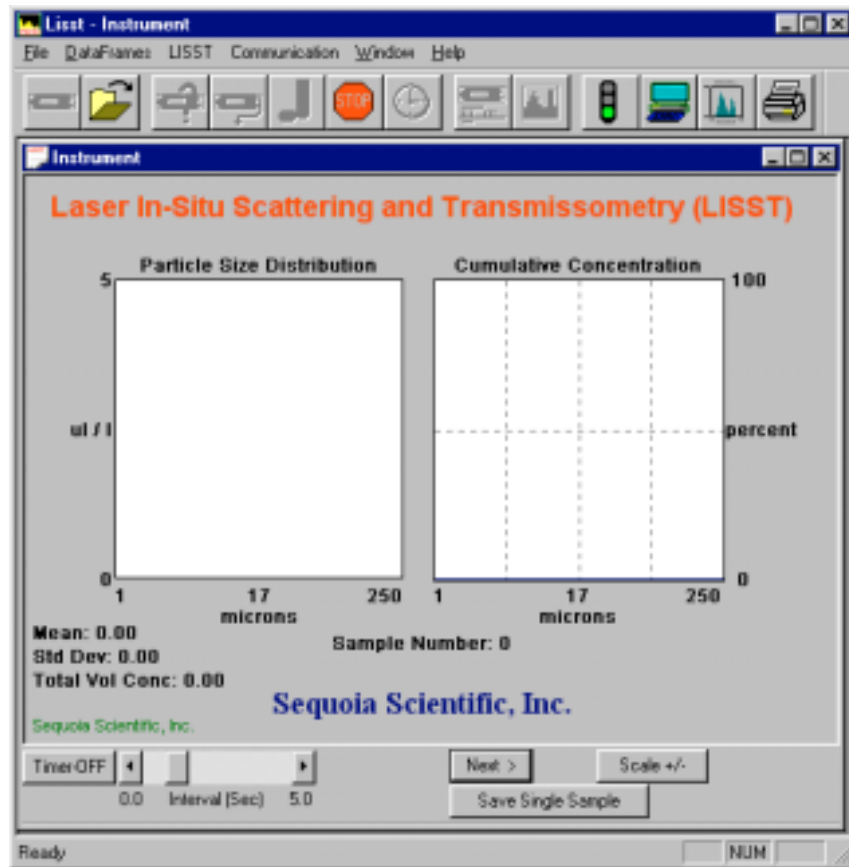
Use the Timer button to start and stop data collection. The slider bar controls the data acquisition time.

The Scale +/- Button adjusts the Particle Size Distribution scale. The

Save Single Sample button records a single sample to an ASCII file.

Note: The main power and laser will be on until this window is closed or until the Stop button is pressed. Significant loss of battery life can occur if the instrument is left powered up for an extended period of time.

The Auxiliary Parameters window can be opened during the Real-Time session so that the values of various parameters such as depth and transmission can be monitored. The raw scattering values on the detector rings can also be viewed by selecting *View Rings* from the *DataFrames* menu. A typical display is shown below.
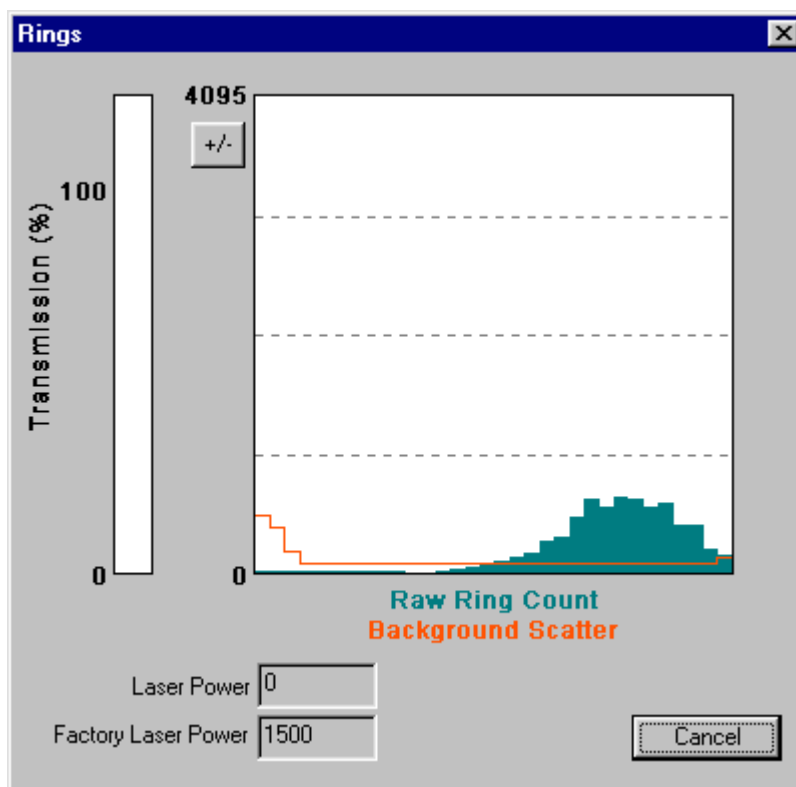
The view rings display is also available when processing a Raw Data file. However, it is not available when viewing a processed Size Distribution file.

Step 22: Put instrument back to sleep

After finishing with the instrument it should be put back into its low power sleep mode. In this mode, with the communication cable disconnected, the drain on the battery is only about 0.08 ma. The sleep mode can be used for extended periods. However, it is recommended that for long term storage that the Main battery be disconnected.

To put the instrument in to low power sleep mode choose *Put LISST to Sleep* from the *LISST* menu. There are also two new buttons on the toolbar for putting the instrument to sleep and waking it up. To get the lowest power consumption the Communications cable must be disconnected from the instrument.
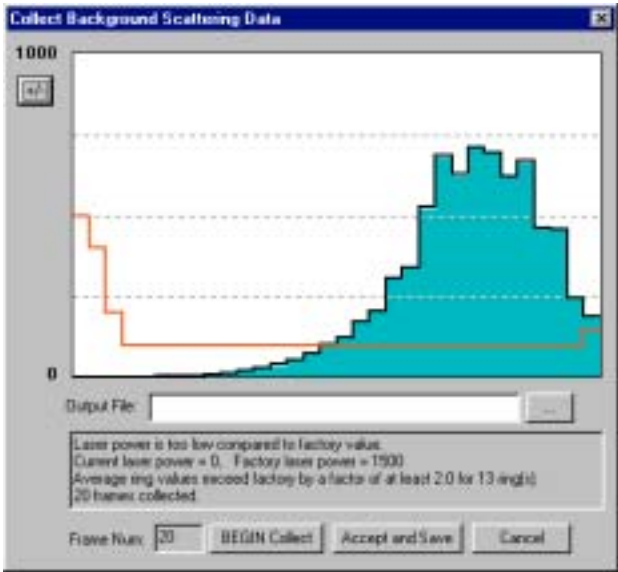
The above steps are meant to give a brief introduction to most of the procedures that are required to operate the LISST-100X. Most of these steps are covered in detailed Step-by-Step instructions in the following sections.

Step by Step procedures

The following topics are covered with Step by Step instructions.
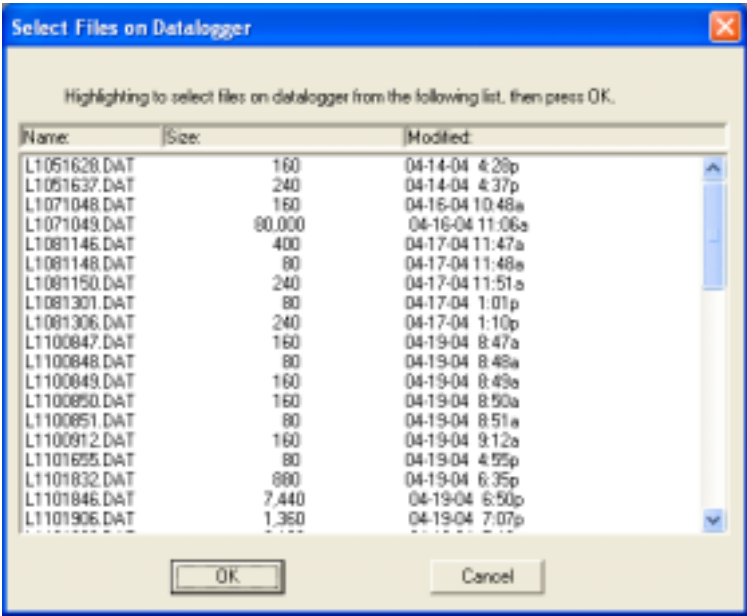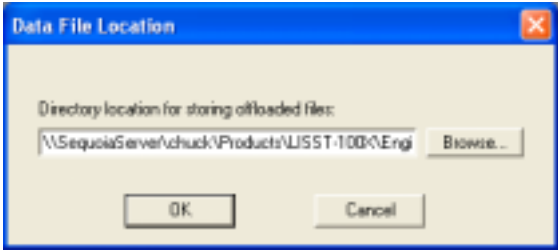
Recording and storing a Background Scatterfile	Recording a background scatter file is the first step in acquiring data. This step-by-step describes the proper procedure to record and download a background scatter file and save it for later processing. Information on interpreting the Background Scatter file is also provided.
Downloading raw data files and Deleting Raw files	Each data collection sequence is stored to a separate datafile on the compact flash memory. Files can be offoaded to the PC using the Download data function of the LISST-SOP software. After downloading the data files can be deleted from memory. This step-by-step procedure covers offloading and deleting files.
Process raw data	Data that has been downloaded from the datalogger is in a raw binary file. It must be processed into particle size by the LISST-SOP program. the processing steps including optional displays and procedures.
View Particle size data	After processing of the data into a Particle Size Distribution (PSD) file the data can be viewed to the screen. This step-by-step procedure covers the viewing of data and optional displays.
Process data in Real-time	Real-time processing of data requires configuring the datalogger to output the raw information to the LISST-SOP program. This step-by-step procedure covers the acquisition and storage of processed data.
Configuring Data Collection	The LISST-SOP software allows the user to program the instrument with a number of start and stop conditions. This step-by-step procedure list the available options and the unique features of each.

Step	Action	Result
1	• Clean instrument and install Horizontal test chamber. • Fill with clean filtered water	Optics submerged in water
2	• Connect communications cable and run LISST-SOP software. • If the data acquisition program is still running, stop its execution with a <CTRL-C>.	Communications program started. L100X> prompt showing
3	• Open the *Collect Background Scatter Data* from the *LISST* menu or by pressing the button on the toolbar. After selecting the factory background scatter file to use for comparison the window will be displayed. When the *BEGIN Collect* button is pressed 20 samples will be displayed to the screen as they are acquired. After all 20 are collected the average will be displayed. If the values are acceptable the values can be saved to a file. Enter the filename in the box and press the *Accept and Save* button.	Background collected and saved.
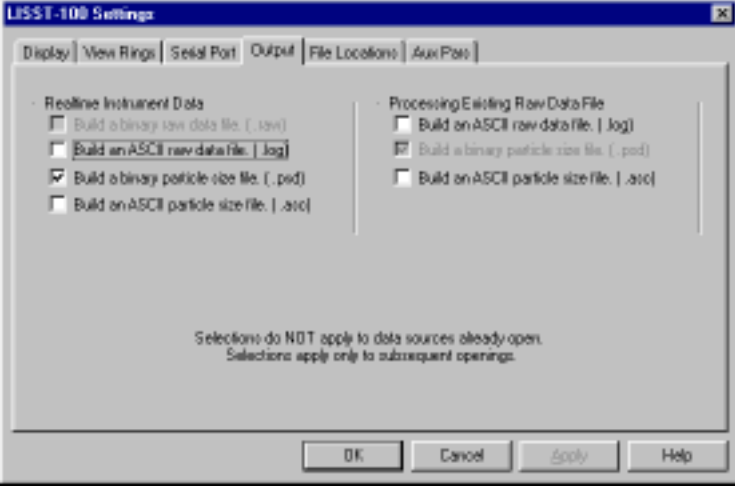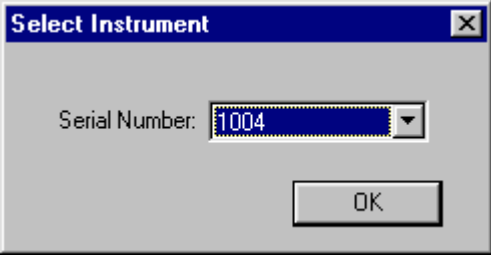
4	• If there is a problem with the instrument or if the water or windows are not clean, error messages will be displayed. Dirty water or windows will generally cause higher values across the middle rings. Large bubbles or particles in the water can cause higher values on the inner rings or left hand side of the display. High values on the inner rings combined with a lower Laser power value can also be an indication of optical misalignment.	
Notes:		
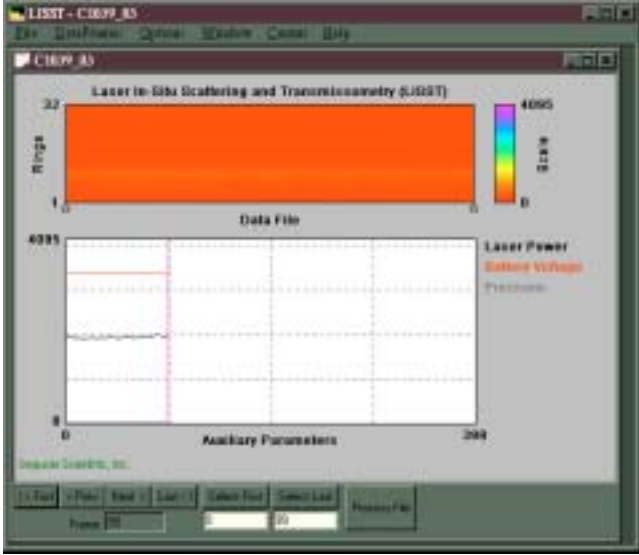
STEP BY STEP PROCEDURE: OFFLOADING/DELETING DATA FILES

Step	Action	Result
1	• Start LISST-SOP program	Program started.
2	• Select Offload from the LISST menu or press on the Offload button.	Gets current directory of files from memory and displays the list.
3	• Choose the files to be offloaded by clicking on the file name on the list. Multiple files can be selected by hold down the CTRL key while clicking on files. Use the SHIFT key to select a range of files. • Press the OK button to accept the current selection. A dialog box with a path for storing the downloaded data will appear. Edit the path or press on the Browse button to select a new path. The files names will remain the same as on the compact flash. The file creation date and time will not be preserved. Press OK to begin the offloading. 	Files selected and path set.

4	• A Status bar will be displayed for each file offloaded. Text in the lower left corner will display the current file being offloaded.	Offloading files from memory to the PC
5	**Deleting Files from memory** • After a file has been offloaded from memory is can be deleted from the compact flash memory. • Open the Terminal window by choosing Terminal Window from the Communication menu or by pressing on the Terminal Window button.	
	• At the Terminal Window enter the command DD in the command box and press the send button. The DD command (Display Directory) will list all the files in memory to the screen. • To delete a file enter the command DL *filename.ext* where *filename.ext* is the file to offload. Wildcards such as *.* or L*.dat can also be used. WARNING: Once a file has been deleted there is no way to recover the data. Make sure that the file has been properly offloaded before deleting any files.	

STEP BY STEP PROCEDURE: PROCESSING RAW DATA

Step	Action	Result
1	• Start LISST-SOP program • Select Settings from the File menu and click on the Output Tab. The window below will appear prompting for the desired output to use for the future data processing. Note: this selection must be made BEFORE starting the processing command. 	Program started. Note: A binary PSD file is always created when processing raw data. This is used to display the processed data to the screen. The ASC type is a spaced delimited file containing all the processed data. The LOG file is a space delimited file containing the raw data from the datalogger.
2	• Select Open Raw Data File from the File menu	Begins process of specifying raw data file and all information needed for data processing.
3	• Choose the serial number of the instrument that collected the data to be processed. Only the serial numbers of the instruments loaded into the InstrumentData.Txt file and have the calibration values loaded into the LISST.INI file in the Windows directory can be used.	Instrument serial number selected.
4	• Select the background scatter data file from the file selection window. Double click the file or type the file name and press Open.	Background scatterfile selected.

5	• Select the output data file name. The default file name shown is the same as the raw data name but with a different extension. You can change this name if you wish. Provide the file name and press Save. If other output types are selected they will have the same base name with different extensions. Note: file types other than the default PSD file must have been selected before starting the Open Raw Data file command. See step 1.	Output data file name selected.
6	• A display similar to the one shown below will appear. • The top portion of the display is a graphical representation of the raw data from the 32 rings. The value of the 32 rings is represented as a vertical line with time moving from left to right. • The lower portion of the display shows the time history of some of the Auxiliary parameters. This can be useful for determining when the instrument came out of the water, when a particular profile was started, or for determining what range of the datafile to process. To change which Auxiliary parameters are displayed, choose *Auxiliary Parameter Display* from the *Options* menu. • Note that only 400 samples of the Auxiliary Parameters are displayed at a time. Use the Next and Previous buttons to move through the complete datafile. The triangles on the lower edge of the upper display will indicate where in the complete datafile the currently displayed section is located. • The vertical cursor on the lower plot can be moved by clicking the mouse at the desired location.	Main data processing selection window displayed to the screen.

7	• Additional information is stored in the processed datafile. The Auxiliary parameter window displays these values for the current sample pointed to by the vertical cursor. They will update as the cursor is moved. Selecting the Show Auxiliary Parameter Frame from the DataFrames menu opens the window. An example of this window is shown below.	Auxiliary parameter window displayed.
	Auxiliary Parameters	
	Laser Power 0 mwatts	
	Battery 17.5 volts	
	External Instrument 0.003 volts	
	Laser Reference 8.943 mwatts	
	Depth 0 meters	
	Temperature 26.86 deg C	
	Aux 1 3228	
	Aux 2 4008	
	Transmission 0	
	Warning: Water too turbid.	
	Sample Number 11 ☐ Show raw data [Cancel]	
8	• The raw scattering values can be graphically displayed by selecting the View Rings command from the DataFrames menu. An example of this display is shown below. As with the Auxiliary Parameters, the vertical cursor indicates the sample currently displayed.	Value of rings for current frame displayed.
	Rings	
	4095	
	+/-	
	Transmission (%) 100	
	0 0	
	Raw Ring Count **Background Scatter**	
	Laser Power 0	
	Factory Laser Power 1500 [Cancel]	
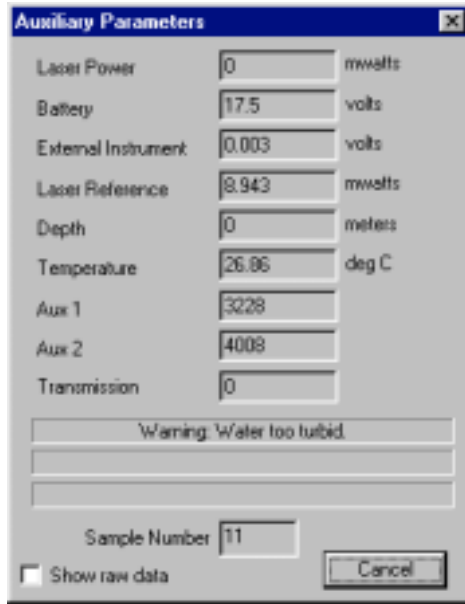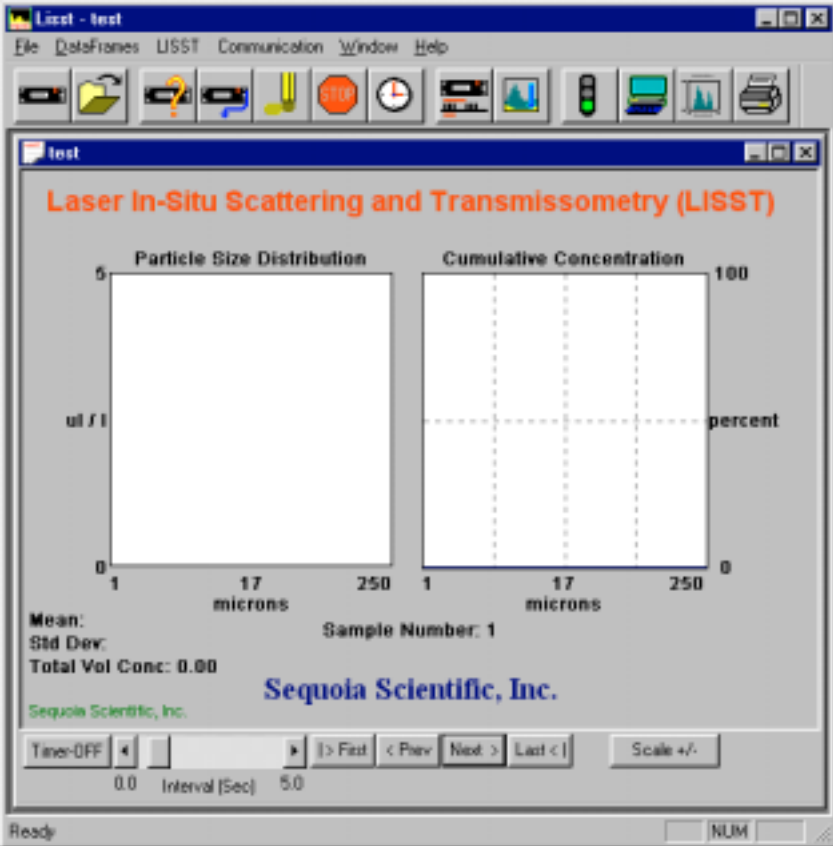
9	To select the range of raw data to process position the cursor at the desired starting sample. The display at the lower portion of the screen will show the current sample or frame. Pressing the *Select First* button will set the current cursor position as the starting point for processing. Similarly selecting *Select Last* will set the end point for processing. Use the *Next* and *Previous* buttons scroll through the complete datafile. The *Select First* and *Select Last* points do not need to be on the same displayed plot.	Range to process selected.
10	After selecting the range to process press the *Process File* button. The display will show the processing progress and the *Process File* button text will change to *Finished* when the processing is complete. The window can now be closed.	Processing Completed
Notes:		

STEP BY STEP PROCEDURE: VIEW PROCESSED DATAFILE

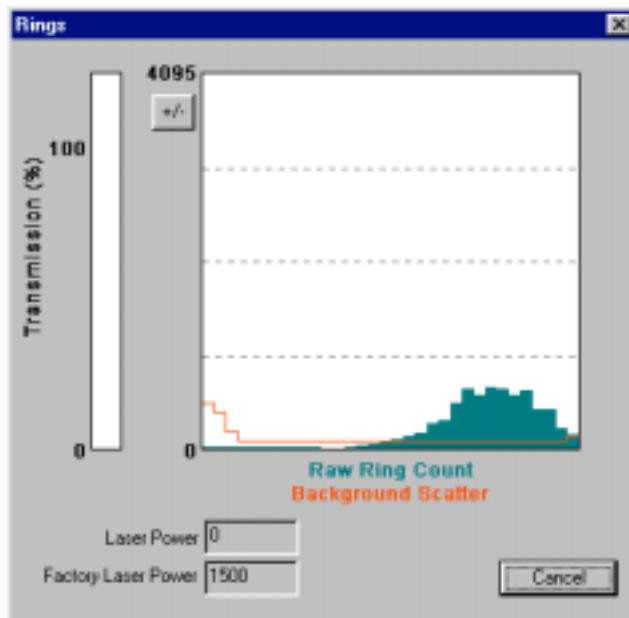| Step	Action	Result
1	• Start LISST-SOP program • Select *Open Particle Distribution File* from the *File* menu.	Program started. Open Particle Distribution File selected.
2	• Select the processed data file from the file selection window. Double click the file or type the file name and press Open.	Processed datafile selected.
3	• After selecting the processed file a window similar to the one shown below will appear. • The left hand display is the volume distribution in units of micro-liters/liter in each size class. The right hand display is the Cumulative Concentration.	
4	• Only a single sample is displayed at a time. By using the buttons on the bottom of the display it is possible to manually or automatically step through the datafile. The *Timer* button will step through the datafile by updating the display at a fixed rate. The rate is set by the slider bar next to the *Timer* button.	

5	• Additional information is stored in the processed datafile. The Auxiliary parameter window displays these values for the current sample. They will update as the Volume distribution is changed. The window is opened by selecting *Show Auxiliary Parameters Frame* from the *DataFrames* menu. An example of this window is shown below. 	
6	• The scale of the Volume Distribution plot can be changed by using the *Scale +/-* button. After selecting the button a display similar to the one shown below will prompt you for the maximum concentration for the Y-axis of the plot. • Other options are also available for customizing the display such as changing the header and footer text or adding lines to show the mean and standard deviation. These features are located on the *Display* tab of the *Settings* window as shown below.	Display setting modified.
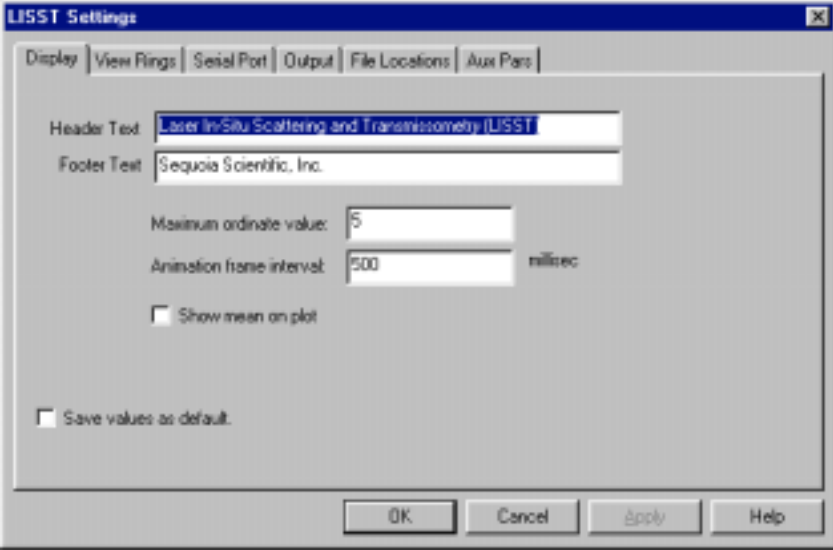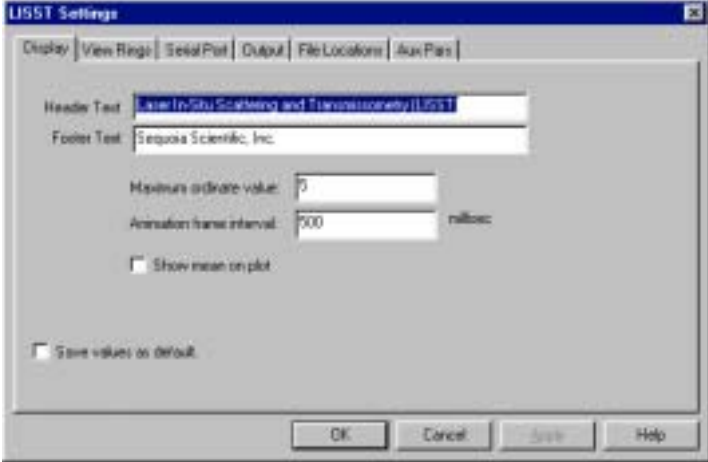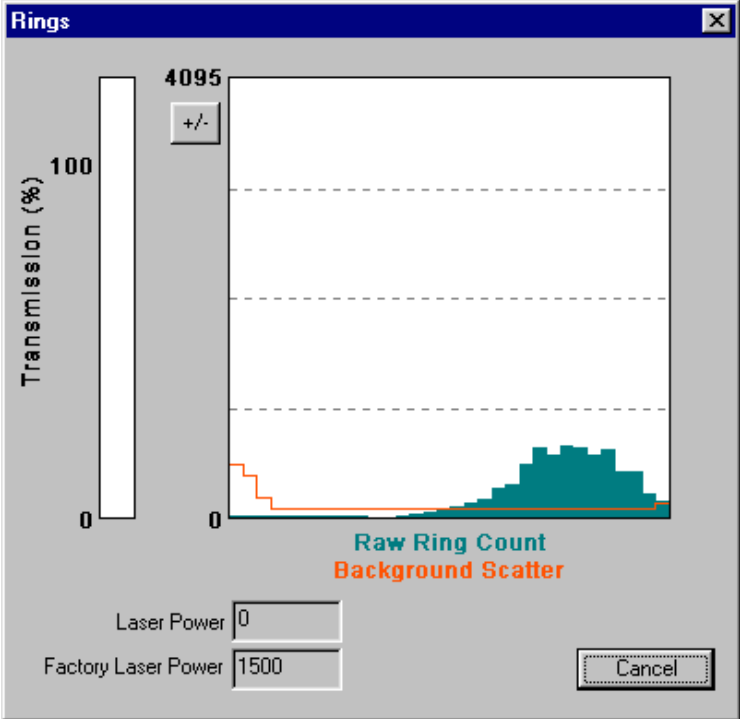
7	• The current display can be sent to the printer by choosing *Print* from the *File* menu. • *Print Preview* and *Print Setup* are also available.	Display printed.
8	• When finished viewing the processed data close the window .	Viewing of data complete.
Notes:		

STEP BY STEP PROCEDURE: REAL-TIME DATA PROCESSING
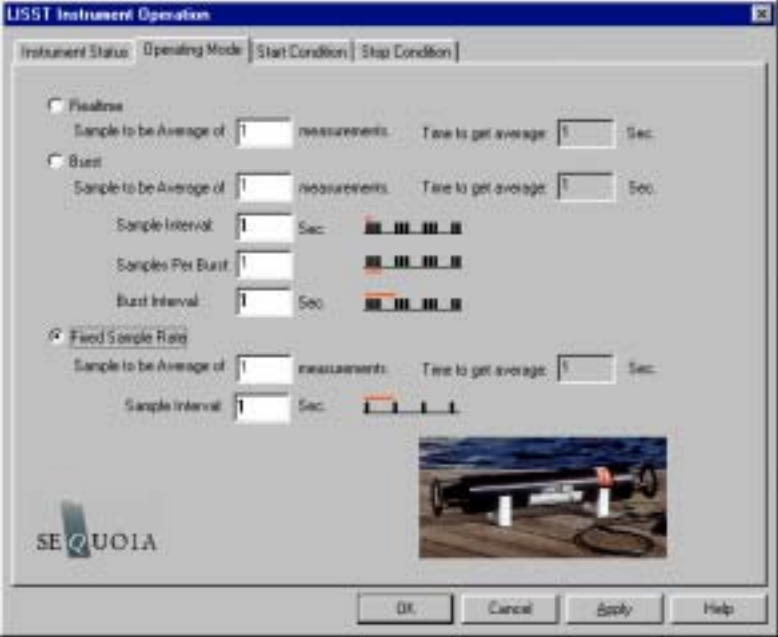
Step	Action	Result
1	• Connect the instrument to the PC and start the LISST-SOP program. • Open the Operating Modes Window and choose the Real-Time Operating Mode.	Instrument configured for Real-Time data collection.
2	• Before starting a Real-Time session the output file options must be set. This must be done before selecting *Open Real-Time Session*. Select Output from the Options menu. The window below will appear. 	Output file type selected. Note: A binary PSD file must be selected before any other file type will be stored. This is used to display the processed data to the screen. The ASC type is a spaced delimited file containing all the processed data. The LOG file is a space delimited file containing the raw data from the datalogger
3	• Select Open Real-Time Session from the File menu or press on the [icon] button. • Choose the correct Background Scatter File and Select an Output file.	Open Instrument selected. Background and Output file selected.
4	• A display will appear on the screen. It is similar to the main window of the View Processed Data function. • By selecting the Next button the window will be updated with the current size distribution. Note that if the water is clean the display may not show any volume distribution. The Sample Number value displayed underneath the plots will increment each time a sample is saved.	Sample saved.

5	• The Timer button function is similar to its use in viewing processed data. The timer will automatically acquire data at a fixed rate. Note that this rate is limited to about 1 Hz due to the processing of the raw data into Volume distributions. The slide button next to the Timer button controls the sample speed. If it is set too fast it will automatically reset to the maximum allowed rate.	Timer button pressed and samples updating automatically.
6	• The Auxiliary parameter window can be opened to display the current values of the auxiliary parameters such as pressure and temperature. Open the window by selecting the *Show Auxiliary Parameter Frame* from the *DataFrames* menu.	Auxiliary Parameter window opened.
7	• The scale of the Volume Distribution plot can be changed by using the *Scale +/-* button. After selecting the button a display similar to the one shown below will prompt you for the maximum concentration for the Y-axis of the plot. • Other options are also available for customizing the display such as changing the header and footer text or adding lines to show the mean and standard deviation. These features are located on the *Display* tab of the *Settings* window as shown below. 	Display setting modified.

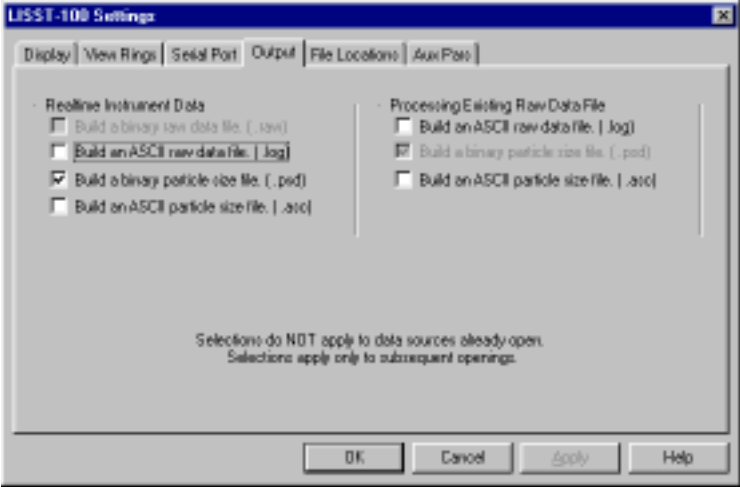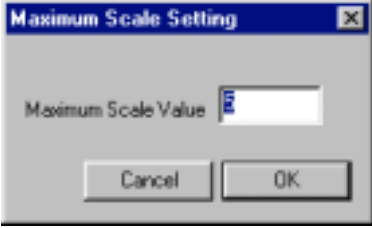| 8	• The raw scattering values can be graphically display by selecting the View Rings command from the File menu. An example of this display is shown below. ![Rings dialog box] **Rings** ☒ 4095 +/- 100 Transmission (%) 0 0 **Raw Ring Count** **Background Scatter** Laser Power `0` Factory Laser Power `1500` `Cancel`	Value of rings for current frame displayed.
9	• A single sample may be saved to a separate file by pressing the *Save Single Sample* button	Averaged data acquired and stored to an ASCII file.
10	• When finished, close the main window to stop communication with the LISST-100X. CAUTION: The laser and Main power are on continuously while in the Real-Time Session. The program will stop and the power will be turned off when the window is closed. However, if the window is left open the power will remain on, potentially draining substantial life from the battery. To turn off the power without exiting the Real-Time session, press on 🛑 button on the toolbar. To start data collection again press the *Next* button. The instrument will power up and store a sample. This will take more time that a normal sample. Once powered up the instrument will perform as usual.	Finished and shutdown.

STEP BY STEP PROCEDURE: CONFIGURING DATA COLLECTION

Step	Action	Result
1	• Connect the instrument to the PC and start the LISST-SOP program.	LISST-SOP open and communicating with LISST-100X.
2	• Open the Operating Modes window by choosing *Operating Modes* from the *LISST* menu or by pressing the ▣ button on the toolbar. When first opening the Operating Modes window the LISST-SOP program will send a Ctrl-C to the LISST-100X. If a program is running it will be stopped. This is required so that the LISST-SOP program can get the status information from the LISST-100X. To set the LISST-100X data logger clock to the computer clock press the *Set Clock* button. Press the *Query Instrument* button to refresh the display.	Instrument Status Displayed. Clock set

3	• To load a pre-saved LISST Operating Procedure file (LOP) enter the file name in the file box or click on the Browse button to navigate to the correct file. • After the file is selected the appropriate settings will be made. To apply these settings to the instrument press the *Apply* or *OK* buttons. LISST Operating Procedure files can be saved by clicking the *Save Summary to LOP* button. The setting must have first been sent to the instrument using the Apply button. The Summary section will only update after the settings have been applied to the instrument.	
4	• By selecting the *Operating Mode* Tab at the top of the main window the screen below appears. This screen is used to set the type of sampling; RealTime, Burst, or Continuous. You can also select the samples per average and sample rates on this screen. • The RealTime mode is used for real-time size distribution displays. This mode sends the raw data to the LISST-SOP software for conversion to Size Distribution and displaying on the screen. No data is saved in the datafile. • The Burst and Continuous modes are used to save data in the on-board datafile. The icons next to the various values give a better understanding of their meaning. The software automatically checks the values entered to make sure that there is no conflict. For example, when a Samples per Average value is entered, the minimum sample interval is computed. If this value is less than the minimum permitted the value will be changed to the minimum and the text will turn red. A similar test is done on the Burst Interval setting.	Operating Mode set

| 5 | • Select Start Conditions tab to configure when the instrument will begin sampling.

• There are five options: Depth, Time, External Mechanical Switch, External Digital Input, and Time Delay. Select the mode by clicking on the button next to the its label. Select the correct parameters as required.
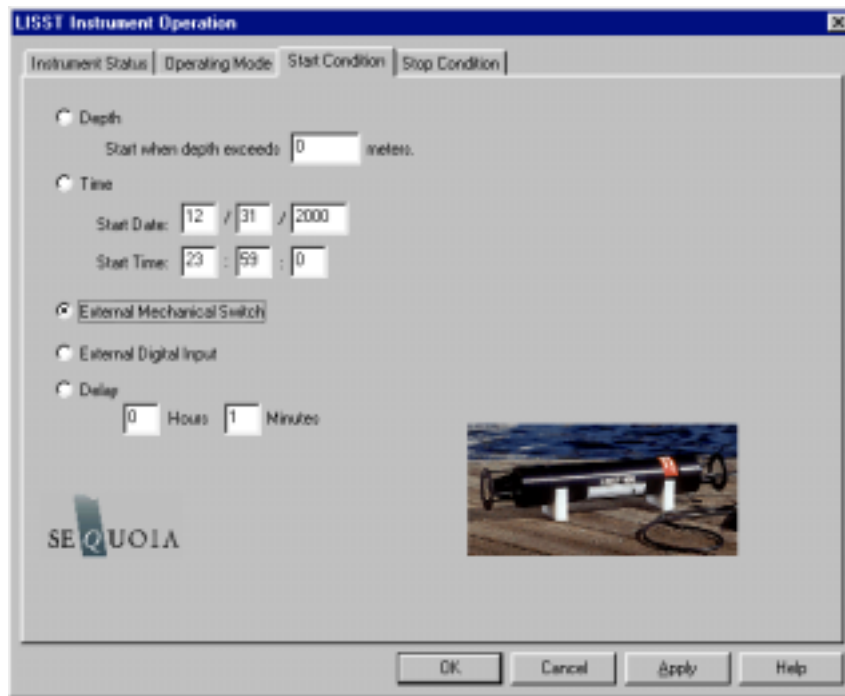
![LISST Instrument Operation dialog — Start Condition tab showing Depth, Time, External Mechanical Switch (selected), External Digital Input, and Delay options with SEQUOIA logo.] | . |

| 6 | • Choose the Stop Conditions Tab to select the conditions when sampling should stop.

 • The available stop conditions are: Depth, Time. External Mechanical Switch, External Digital Input, Fixed number of samples, and Maximum Memory or Low Battery.
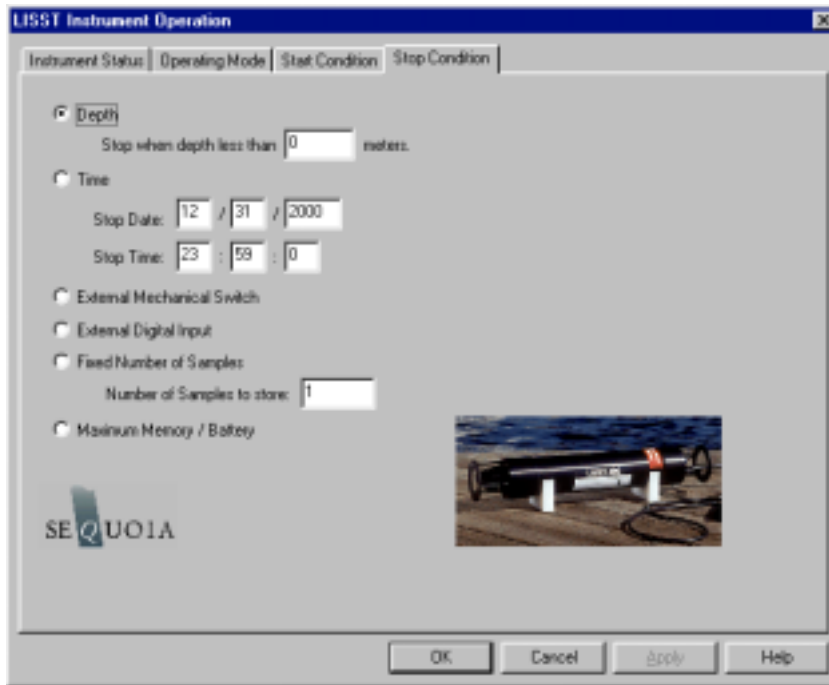
 • If the Stop Condition is either Depth, External Mechanical Switch, or External Digital Input and the Start Condition is also one of these three option the Base Program on the instrument will return to waiting for the Start condition. For example, if the start and stop conditions were set to External Mechanical Switch then multiple sampling sessions can be obtained by flipping the switch on and off. This is useful when doing profiles. It eliminates the need to communicate with the instrument between profiles. | . |

7	• Select *Apply* or *OK* buttons to configure the instrument with the current settings. If the *Apply* button is pressed the program will return to the current window. Returning to the *Instrument Status* window will display a summary of the current settings.	.
	• If the *OK* button is pressed, when the configuration is complete the user will be prompted to open the *Terminal* window to start the program. The program on the instrument is configured but not running. To start the program and have it start looking for the Start conditions press the *Run* button on the *Terminal* window. The *Run* button is equivalent to typing RUN and pressing Enter from any terminal program.	
	• The Base Program will display text to the screen as it is running to confirm that it is running and to indicate where it is in the sampling cycle. Once the program is confirmed to be running and waiting for the correct start conditions, the LISST-SOP program can be closed and the communications cable can be disconnected. Be sure to replace the connector cap before deployment.	

Instrument Communication

Serial Port Settings

Communication with the LISST-100X is via an RS-232C link. A cable that connects the instrument to a PC has been provided. This cable connects the 4-pin underwater connector on the instrument to a DB-9 serial port connector. If required, DB-9 to DB-25 pin adapters are available.

The RS232 link communicates at 9600 baud, 8 data bits, No parity, and 1 stop bit. Data file transfer is done using a YMODEM transfer at 115K baud.

Using the Terminal Window

Opening the Terminal Window, or alternate terminal software, with the proper COM port and communications settings will allow the user to communicate with the instrument. The LISST-100X should respond by either displaying text from a running program or echoing an L100X> prompt. If the instrument is in the Deep Sleep Mode it will only wake up every 30 seconds, Print ZZZ to the screen and then return to sleep.

The instrument firmware is retained in on-board flash memory and will start executing when power is applied. After a power up, pressing the ENTER key will cause an echo of the L100X> prompt. The Stop button will also send the commands to turn off the main power to the laser and electronics. Pressing the Stop button when the instrument is not running will not hurt the instrument. It is recommended to press the Stop button multiple times after stopping a running program to make sure that the main power is properly shut off. Pressing the Start button will begin the collection of data using the current configuration.

Two Letter commands

Under most situations the LISST-SOP will be used to configure and operate the LISST-100X. However, there are times when the LISST-100X must interface to another datalogger or custom program. For this purpose a set of two letter commands is available to operate the instrument. See the following section for detailed descriptions of each command.

Start Condition   The LISST-SOP software or two letter commands can configure the LISST-100X with one of five Start conditions: Depth, Time, External Mechanical Switch, External Digital Input, and Time Delay. The details of each condition are described below.

Depth Start: The built-in depth sensor of the LISST-100X is used to check the current depth to determine if the desired start depth has been exceeded. The instrument is powered up and 5 measurements of the depth are averaged over a two-second period. If the depth exceeds the threshold the program will proceed to the data collection routine. If the depth does not exceed the threshold the instrument will power down and wait 28 seconds before checking the depth again. The program will continue checking until the depth is exceeded or until the program is stopped.

Time Start: The program will check the current time every second and compare it to the Start Time. If the Start Time is equal to or earlier than the current time the program will go directly to the data collection routine. It will continue checking the time until the Start Time is reached or until the program is stopped.

External Mechanical Switch Start: The LISST-100X has a white plastic lever on the endcap. This lever has a magnet imbedded in it. This magnet can activate a switch inside the pressure case. The base program looks at the status of this switch once a second. If the switch is in the on or "1" positions the program will go directly to the data collection routine. It will continue checking the switch status until the switch is moved to the "0" position or until the program is stopped. When in the "0" position the lever is up against the zinc anode.

External Digital Input Start: The LISST-100X is equipped with auxiliary inputs on the 6-pin underwater connector. Pin 2 of the 6-pin connector is the DIG 1 input. The program will check the status of the digital input once a second. If the voltage at the DIG 1 input is greater than 2 volts (relative to Digital Ground, Pin1) the program will go directly to the data collection routine. It will continue checking the status of the digital input until voltage exceeds 2 volts or until the program is stopped. *WARNING: The maximum input voltage on the digital inputs is 3.3 volts.*

Time Delay Start: The time delay start condition will cause the program to wait the specified number of seconds before continuing on to the data collection routine.

Data Collection Routine   The LISST-SOP software can configure the Base program with one of six Stop conditions: Depth, Time. External Mechanical Switch, External Digital Input, Fixed number of samples, and Maximum Memory or Low Battery. The details of each condition are described below.

Stop Condition   The LISST-SOP software can configure the Base program with one of six Stop conditions: Depth, Time. External Mechanical Switch, External Digital Input, Fixed number of samples, and Maximum Memory or Low Battery. When storing data in the Fixed Sample Rate mode the Stop conditions are checked after each averaged sample has been saved. When storing data in the Burst mode the Stop conditions are only checked after a full Burst has been completed. The Start and Stop conditions have no effect on the Real-time sampling mode. The details of each condition are described below.

Depth Stop: The built-in depth sensor of the LISST-100X is used to check the current depth to determine if it is less than the desired Stop depth. The averaged depth from the last sample acquired is used as the current depth. If the depth is less than the threshold the sampling will stop. If the depth is not less than the threshold the program will continue sampling as per the configuration. If the Start Condition is a Depth Start the program will wait 30 seconds and then return to looking for the Depth Start Conditions. The delay is to keep the instrument from starting and stopping too quickly as the instrument is moving up and down. If the Start Condition is Depth Start the Base program will return to checking for the Start Conditions. For all other Start Conditions the when the current depth is less than the threshold the program will stop and return to the L100X> prompt.

Time Stop: The program will check the current time after each sample or burst and compare it to the Start Time. If the Start Time is equal to or later than the current time the program will stop and return to the L100X> prompt.

External Mechanical Switch Stop: After each sample or burst the status of the Switch lever is checked. If the switch lever is in the off or "0" position sampling will stop. If the Start Condition is a Switch Start the program will return to checking the start condition. For all other Start conditions the program will stop and return to the L100X> prompt.

External Digital Input Stop: The status of the Dig 1 input is checked after each sample or burst. If the voltage at the input is less than 0.7 volts the sampling will stop. If the Start Condition is a Digital Input Start the program will return to checking the start condition. For all other Start conditions the program will stop and return to the L100X> prompt.

Fixed Number of Samples: The program will acquire a fixed number of samples before stopping. For the Fixed Sample Rate mode the number of samples saved is checked after each sample is saved. In the Burst mode the number of samples is checked only after each burst. Therefore it may be possible to save more samples than specified. When the number of sample to be saved

has been reached the program will stop and return to the L100X> prompt.

Maximum Memory or Low Battery: The Maximum Memory or Low Battery Stop condition will continue to sample until the memory capacity has been reached or when the battery voltage has dropped to less than 6 volts. The program will continue to sample until one of these conditions is met. It will then return to the L100X> prompt.

LISST-100X Command Summary

Display Commands

DD	Display current Disk Directory
DS	Display current status information
DB	Display Current Battery Voltage
HE	Display general help messages and command list

Setup Commands

OM x	Set Operating mode.
ST x	Set Start Condition.
TD x	Set Start Condition Data
SP x	Set Stop Condition
PD x	Set Stop Condition Data
SI x	Set Sample interval
MA x	Set samples per average equal to x
BI x	Set Burst Interval
SC *mm/dd/yy hh:mm:ss*	Set Clock with time and date, where *mm*=month, *dd*=day, *yy*=year, *hh*=hour(24 format), *mm*=minute, *ss*=seconds, Example: ST 01/05/2005 21:05:03
SB x	Set Samples per Burst

Acquisition/Action Commands

DL filename	Grab sample and transmit it
GO	Start Data collection using current parameters
GX	Grab sample and transmit it
YS	YMODEM offload of file at 115K Baud
ZS	Acquire 20 samples and transmit them. Used by SOP Acquire Background.
ZZ	Go into deep sleep mode (minimum power consumption)

LISST-100X Command Details

Display Commands

DB	Display Battery Voltage
Syntax:	DB or db
Description:	The current battery voltage is displayed to the screen.
Example:	input: DB output: Current Battery voltage: 8.90 volts

DD	Display Disk Directory
Syntax:	DD or dd
Description:	Display current disk directory in DOS type format. Includes total bytes used and bytes available.

Example:	input: DD
	results: L100x:>dd
	        LISST-100X Disk Directory
	
	        Volume in drive C is NONAME
	        Volume Serial Number is 778B-155F
	
	      Directory of C:\
	      L040305_.BIN 4,136 03-05-04 6:30p
	      L183705.BIN 1,672 03-05-04 6:37p
	
	        2 file(s) 5,808 bytes
	        0 dir(s) 15,933,440 bytes free
	     L100x:>

DS	Display current status information
Syntax:	DS or ds
Description:	The instrument settings and status are displayed to the screen.

Example:	input: DS
	output:
	      LISST-100X Current Status and Settings
	Serial number = 1004
	   Operating Mode: Burst Mode
	   Start Condition: Time Start at 03/10/04 09:22:00
	   Stop Condition: Fixed Number Stop at 1 samples
	   Measurements per Average: 10
	   Sample Interval: 1
	   Burst Interval: 1
	   Samples per Burst: 0
	   Battery Voltage is 8.90
	   Current Date/Time: Wednesday, March 10, 2004 10:18:49
	
	input: DS 1

	output:
	LISST-100X Current Status and Settings
	SN = 1004
	OM = 2
	ST = 2
	TD = 03/10/04 09:22:00
	SP = 5
	PD = 1
	MA = 10
	SI = 1
	BI = 1
	SB = 0
	BB = 0
	CT = 0
	IC = 0
	Current Time = 03/10/04 10:18:49
	Battery = 890
	Switch = 0
	Memory= 15005640

HE	Display general help messages and command list
Syntax:	HE or he
Description:	Displays the list of command to the screen.
Example:	input: HE output: LISST-100X Commands (followed by 30 lines of text)

Setup Commands

OM	Set Operating Mode
Syntax:	OM x or om x
Description:	Sets the Operating Mode to one of the following types: 1 = Real Time Mode 2 = Burst Mode 3 = Fixed Rate Mode OM command only without a parameter will initiate a prompt for the Operating mode.
Example:	input: OM 3 output:

MA	Set measurements per average
Syntax:	MA x or ma x Where x = number of samples per average
Description:	Each recorded or displayed measurement is based on an average of measurements. The number of measurements per average is set using the SA command. If no value follows command, prompts will be displayed for the value.
Example:	input: MA 10
Cautions:	None

ST	Set Start Condition
Syntax:	ST x or st x, where x is the start condition code:

Description:	The ST command sets the start condition to be used when the GO command is issued. The start condition options are:
	    1 = Depth Start
	    2 = Time/Date Start
	    3 = Mechanical Switch Start
	    4 = Digital Input Start
	    5 = Delay Start
	If no value follows command, prompts will be displayed for the value.

Example:	input: ST 5

TD	Set Start Condition Data
Syntax:	TD x or td x, where x is the start condition data :
Description:	The TD command sets the start condition data to be used when the GO command is issued. The start condition data is used with the Start Condition setting. For example, if the Start Condition is Depth Start (option 1) the input will be start depth in meters. If the start condition is set to Time/Date Start (option 2) the input for TD will be the start date and time. If the Start Condition is Delay Start (option 5) the input will be time delay in seconds. The TD setting is ignored for Mechanical Switch Start (option 3) or Digital Input Start(option 4). If no value follows command, prompts will be displayed for the value.
Example:	input: TD 12/31/05 23:59:59 or TD 3600

SP	Set Stop Condition
Syntax:	SP x or sp x, where x is the stop condition code:

Description:	The SP command sets the stop condition to be used when collecting data. The stop condition options are:
	    1 = Depth Stop
	    2 = Time/Date Stop
	    3 = Mechanical Switch Stop
	    4 = Digital Input Stop
	    5 = Fixed Number of Samples Stop
	    6 = Maximum memory or Low Battery Stop
	If no value follows command, prompts will be displayed for the value.

Example:	input: SP 5

PD	Set Start Condition Data
Syntax:	PD x or pd x, where x is the start condition data :

Description:	The PD command sets the start condition data to be used when the collection data. The stop condition data is used with the Stop Condition setting. For example, if the Stop Condition is Depth Stop (option 1) the input will be stop depth in meters. If the stop condition is set to Time/Date Stop (option 2) the input for TD will be the stop date and time. If the Stop Condition is Fixed Number Stop (option 5) the input will be the number of samples to collect before stopping. The TD setting is ignored for Mechanical Switch Stop (option 3) or Digital Input Stop(option 4).
Example:	input: PD 12/31/05 23:59:59 or PD 3600

SB	**Set Samples per Burst**
Syntax:	SB x or sb x where x is the number of samples per burst. Each sample it taken at the sample interval set by the SI command. If no value follows command, prompts will be displayed for the value.
Example:	input: SB 10

SC	**Set Clock with time and date**
Syntax:	SC mm/dd/yy hh:mm:ss or st mm/dd/yy hh:mm:ss Where mm=month, dd=day, yy=year, hh=hour(24 format),mm=minute, ss=seconds If no values follow the "**SC**" or "**sc**" command, prompts for entering the time and date will be displayed.
Example:	input: SC 01/05/2001 21:05:03

Acquisition/Action commands

DL	**Delete file from Compact Flash Module**
Syntax:	DL *filename* or dl *filename* where *filename* is the name of the file to be deleted.
Description:	DL command is used to delete file from the Compact flash module. Wildcards such as *.* can be used.
Example:	Input: DL L159*.dat Output: Are you sure (Y/N)…
Cautions:	WARNING: Make sure that the file being delete has already been offloaded before deleting the file. Once the file is delete it can not be recovered.

GO	**Start Data Collection using current Settings**
Syntax:	GO or go
Description:	Starts Fixed Rate or Burst Mode Data collection using current settings.
Example:	Input: GO

	Output: Waiting for start conditions…
Cautions:	To stop acquisition before it is complete press the Stop button or **CTRL-C**.

GX	**Grab sample and transmit it**
Syntax:	GX or gx
Description:	Acquires single averaged sample and displays the result to the screen.

Example:	Input: GX
	Output: {
	       …. 32 ring values + 8 Aux parameters
	        }

Notes:	The GX command does not store the sample to a datafile.

YS	**YMODEM Offload**
Syntax:	YS *filename* or ys *filename* where *filename* is the name of the file to be offloaded.
Description:	Offloads file from Compact Flash Module to PC using YMODEM offload at 115 Kbaud
Example:	Input: YS L1391205.dat Output: Starting…
Notes:	The YS will initiate the YMODEM offload on the instrument. A YMODEM file transfer must be started on the PC to accept the data. HyperTerminal can accept YMODEM file transfers at 115K baud.

ZS	**Grab 20 samples and transmit it**
Syntax:	ZS or zs
Description:	Acquires 20 averaged sample and displays the result to the screen. The ZS command is used by the LISST-SOP program when acquiring a background.

Example:	Input: ZS
	Output: {
	       …. 32 ring values + 8 Aux parameters
	        }
	     repeat 20 times

Notes:	The ZS command does not store the sample to a datafile.

ZZ	**Go into deep sleep mode (minimum power consumption)**
Syntax:	ZZ or zz
Description:	Sends LISST-25X in to low power sleep mode. Instrument will wake up every 10 seconds and wait for a response. If there is no response with in 2 seconds, the instrument will return to sleep mode.
Example:	Input: ZZ Output: Deep Sleep… Enter zz to wake up

	Deep Sleep… Enter zz to wake up
	Deep Sleep… Enter zz to wake up
Cautions:	The background scattering data and other settings are not affected by the ZZ command.

This section contains information on optimizing the performance of the LISST-100X.

Background Scatterfile and its Importance

As was discussed in earlier sections, the LISST-100X uses a custom detector to measure light scattered at small angles from particles in water. In order to measure only the scattered light contributed by the particles, a measurement of the background scattering must be obtained. This background scattering can come from a number of areas. Scratches on the windows, imperfections on the optics, and other sources all contribute to the scattered light. By subtracting this background scattering from the measured data, a true measurement of the light scattered from the particles can be obtained. The measurement of background scattering has come to be called a "ZSCAT". The name comes from the fact that the measurement is obtained using water with zero "scatterers" or particles.

It is very important that clean and bubble free water is used. The water can be fresh or salt water. For most applications, it has been found that steam-distilled water is sufficient. Steam-distilled water is typically available in one-gallon containers. We have found that this distilled water tends to be a bit cleaner than typical bottled or packaged water. We buy steam-distilled drinking water and filter it through a 0.2μm filter.

Watch for outgassing

Another consideration when acquiring a background is "outgassing" causing small bubbles to form on the instrument and windows. Bubbles on the windows will greatly modify the scattering pattern, rendering the background useless. Be sure to remove any bubbles from the windows before acquiring a background scatterfile. Use a squirt bottle or pipette to blow the bubbles off the window.

A small volume horizontal chamber has been provided for submerging the optics while acquiring a background. It is inserted between the windows of the optics, The instrument should be placed horizontally on the supplied white plastic supports. Roughly 120 milli-liters of water is needed to fill the chamber.

Clean optics end before acquiring a background

Because the area surrounding the windows is submerged, it is important to thoroughly clean and rinse this part of the instrument before acquiring a background.

Toothbrush, liquid soap and water works well for cleaning the optical end of the instrument; do not use abrasive powders, they will scratch optics and destroy instrument performance.

Avoid Direct sunlight

Direct sunlight should also be avoided when obtaining a background. The unit is relatively insensitive to sunlight; however, bright light can increase the noise in the measurement and give a false background scattering measurement. It is recommended that the end of the instrument be shrouded with a dark cloth during the acquisition of the background. In general, the background should be taken in conditions that match the deployment conditions as closely as possible.

The low concentration limit of LISST-100X is very sensitive to the quality of the background scatterfile. For this reason, when working in near-surface or mid-depth water, it is very important that a good background file be obtained with very clean water. As particle concentrations increase, the relative signal-to-background noise ratio also increases, thus reducing the importance of the background. *However, Background Scatterfiles should always be done before an experiment.*

Plastic bags, Tupperware or clean containers of any kind can be used to acquire a background. The instrument's optics end can be submerged in them vertically, as long as the optics are completely submerged and there is no blockage of the windows by bubbles or other objects.

Backgrounds Scatterfiles should always be done before each data collection.

Optical Alignment   The background scatterfile is the best source of information on the current health of the LISST-100X. It provides information on the current functionality of all of the major systems including laser, ring detector, data collection electronics, and optical alignment. The LISST-100X is a sensitive optical device. The laser must be aligned such that the focused spot is centered on the hole in the center of the ring detector. If this alignment in not correct the instrument will not function correctly. The background file can easily provide the user with information about the status of the alignment.

The first indicator of an alignment problem is a severe drop in the transmitted laser power. The laser power and laser reference values will change over time but they should track together. If the laser power drops to less than 50% of the factory value, without a corresponding drop in the laser reference value, misalignment may be occurring.

The second indictor of misalignment is high value on the inner rings. The inner rings are shown on the left side of the background display. As the focused laser starts to move away from the center of the ring detector it will scatter more light onto the inner rings. This will cause the inner ring values to be much higher than the factory values.

It must be noted that low laser power or high inner rings may not always indicate misalignment. Low laser power can also occur because the windows or water is dirty or if there are bubbles on the window. Large particles or bubbles can cause the inner rings to be higher than factory values. All of the other possibilities must be eliminated before the conclusion of misalignment can be reached.

The newest generation of transmit optics do allow for the possibility of the user adjusting the alignment in the field. A written procedure can be provided for this procedure. However, it is highly recommended that the need for re-alignment be discussed with a trained Sequoia Scientific technical service representative before attempting this procedure.

Instrument Mounting

This section contains information on mounting of the LISST-100X.

Mount the instrument Horizontal

The LISST-100X measures scattered light to obtain particle size distributions. Therefore it is important to keep particles from sticking to the window surface. The first line of defense it to keep the window surface vertical by mount the instrument horizontally. This is most critical when the water motion is slow. When working rivers or towed application the orientation is not as critical.

The center section of the main pressure case has a slightly smaller diameter than the ends. The smaller diameter section is the suggest mounting area. The U-shaped mounting block provided with the instrument fit this diameter and can be used for mounting the instrument.

Isolate from all other metal

To reduce the corrosion of the aluminum parts a zinc anode is attached to the Connector endcap. This anode must be exposed to the water for it to be effective.

When mounting the instrument be sure to electrically isolate the instrument from all other metal. Any contact with other metal can greatly increase the rate of corrosion. Isolate the instrument with rubber or plastic to keep the LISST-100X from being the sacrificial anode for the mounting hardware.

Again it must be emphasized that the LISST-100X is a sensitive instrument. When not in use, the instrument should be stored in a well padded case. For longer storage (year or so), the communication cable should be disconnected and the battery pack should be disconnected or removed. If you do not wish to remove the battery or disconnect it, battery life can be prolonged with the use of the Low Power Sleep Mode. In this mode the instrument will use no more than 10% of a typical battery life over a 6 month duration.

To put the instrument in to low power sleep mode choose *Put LISST to Sleep* from the *LISST* menu. To get the lowest power consumption the Communications cable must be disconnected from the instrument and the Switch Lever on the endcap must be in the "1" position.

As has been noted earlier, the condition of the windows is critical to the performance of the LISST-100X. Care must be taken when cleaning the windows. The windows and the instrument should be rinsed thoroughly with fresh water after each deployment. The windows should be cleaned with a soft cloth or lens tissue. Liquid detergent/soap and water may be used. For removing grease spots, finger prints, etc, alcohol may be used. We recommend against the use of stronger solvents such as Acetone or Toluene.

Abrasive powders must never be used near the optics windows, they will scratch the windows and degrade instrument performance.

O-rings that seal the mating parts of the instrument must be maintained and inspected regularly. Whenever the end cap is removed, check the o-ring for any cuts or marks, and clean and lightly grease the o-ring before installing the end cap. Spare end cap o-rings have been provided. O-rings are inexpensive items that provide an invaluable service; replace them if in any doubt about their condition. When replacing the O-ring, be sure to clean the O-ring groove thoroughly with cotton-swabs etc. making sure that no fibers or particles of dirt are left after the cleaning.

The LISST-100X should not require any adjustment or calibrations. The pressure and temperature sensors can be re-calibrated if desired. The performance of the instrument can be checked with the use of a sample of particles of a known size distribution.

Comparison of the LISST-100X's performance with that of other particle-size measuring devices that are not based on laser diffraction may result in inconsistencies because the instruments may measure different properties of the particles to interpret particle size.

Maintenance Notes

Battery Power and Access

The main battery is mounted to the connector end cap. SEQUOIA supplies the custom battery packs for use with the LISST-100X instrument. The use of batteries other than these may void your warranty. When using laboratory power supplies, the user must exercise extreme caution in using correct polarities on the external 3-pin connector. Reverse polarities or misconnection may damage the electronics, the repair of which would not be covered under the warranty. Although the data backup battery will preserve the data for over two years, we recommend that the data backup battery be replaced before each long field deployment. If you do remove the back-up battery, the instrument loses track of how much memory (RAM) it has. To restore this information, after replacing the back-up battery, load and RUN the program Base program.

The step-by-step procedure for accessing and replacing the battery pack is described below.

Step	Action	Result
1	• Place the LISST-100X in a horizontal position. *U-blocks have been provided for this purpose.* • Disconnect all cables from the end cap. • Install caps on connectors to protect pins. | **Caps MUST be installed on connectors before submerging into water.**	Caps installed on the connectors.
2	• Remove the three recessed bolts from end cap. *Use the Allen wrench provided. The threads of the bolts have been coated with an anti-seize compound. Spare bolts are included with the LISST-100X.*	The recessed bolts removed from the end cap.
3	• Next, remove the end cap by grasping the ring attached to the end cap with standoffs and pull away from the case. Slight rotation will sometimes be helpful. *The end cap has an o-ring seal on the inside diameter of the case. The compression of the o-ring seal contributes to the effort required to remove the end cap.* *The end cap should remain parallel to the end of the case. Tipping of the end cap can cause binding.* **Do Not Pry the End Cap Off.** *If the removing the endcap requires extensive effort threaded holes next to the holddown screws have been provided to force the endcap away from the case. Remove the screws from the case and insert them into the threaded holes. Thread the screws in evenly until the endcap is free. When the o-ring on the end cap clears the case, the end cap and battery combination should slide easily from the case.* *WARNING: The endcap and battery cable assembly will still be connected to the main electronics. The assembly can only be removed a few inches from the end of the pressure case.* To expose the battery and battery cable connectors, remove the Velcro wrap.	End cap and battery removed from the case.

Continued on the next page...

4	• To remove the battery, release the Velcro wrap and loosen the nuts on the threaded rods. Remove the plate. Do not remove the threaded rods. *Before removing the battery, make note of its orientation so that the replacement battery can be positioned similarly.* • With the new battery in place, tighten the nuts on the threaded rods to finger tightness. Re-apply wrap allowing for access to the power connectors. **Make sure that the battery does not overhang the edge of the end cap diameter. If the battery is offset, the end cap may not seat properly, making installation difficult.**	Battery removed and replaced.
5	• Re-Connect the white female 2-pin connector to the white male 2-pin connector. Connecting these connectors will apply power to the electronics module. Once power is applied the instrument begin running and the L100X> prompt will be displayed. It may be necessary to put the instrument into low power sleep mode after the battery is reconnected. • Re-wrap the battery with the Velcro wrap. Adjust the position of the connectors to minimize the diameter of the assembly. If the connectors are not arrange properly it will be difficult to insert the battery into the pressure case.	Power on.
6	• Before installing the end cap into the case, clean and lightly grease the o-ring. • Remove the o-ring and inspect for any cuts or defects. *Use clean fingers to apply o-ring grease. Paper or cloth can leave fibers on the o-ring which can cause the o-ring to leak. The inside diameter of the case should be similarly cleaned and lightly greased.*	O-ring greased and inspected for any defects.
7	• Install the end cap into the case by first lining up the holes in the end cap with the threaded holes in the case. • Applying uniform force, push the end cap into the case. After the end cap is inserted, slightly rotate the end cap. *A slight twisting motion will help the o-ring obtain a good seal. This will also allow the bolt holes to be lined up.* • Install the bolts, tightening evenly, until they are snug but not tight. **Do not over tighten. The stainless steel screws can damage the threads of the aluminum case if over tightened. The endcap has a radial o-ring seal and is not dependent on the tightness of the screws for sealing.**	The end cap installed into the case and the case is now sealed.

Technical Specifications

- Parameters measured/derived
    - *Particle Size distribution*
    - *Total Volume Concentration*
    - *Optical Transmission*
    - *Depth*
    - *Temperature*
- An external analog input (0-2.5V)
- Two external digital I/O ports (5V logic)
- Optical path length: 5 cm standard, 2.5 cm optional
- Optical transmission: 12 bit resolution
- Particle size range: Type B: 1.25 - 250 micron diameter, Type C: 2.5 –500 micron
- Resolution: 32 size classes, log-spaced
- Data storage memory: 16MB (195,000+ samples) standard, expandable to 1 GB
- Maximum sample speed: 1 size distributions per second (standard)
- Temperature-sensor range: -10 to 45°C resolution: 0.01^{o} C
- Depth Sensor range: 0 to 300 m of H$_2$O, resolution: 8 cm of H$_2$O
- External power input: 12V nominal (6 to 15V)
- Dimensions: 13.33 cm (5.25") dia x 81 cm (32")
- Weight in air: 12 Kg (25 lb)
- Weight in water: 4 Kg (8.5 lb)
- Depth rating: 300 m (standard)
- Connector Endcap screws: Socket head cap screws #8-32   3/4" long
- Endcap O-ring: Parker Part # 2-244

LISST-100X Particle Size Analyzer
 Instrument Specific Documentation

Instrument Data

Serial Number	
Manufacture Date	
Instrument Type	
Memory Capacity	
Owner	

Auxiliary Parameters

The table below lists the auxiliary parameter labels and calibration constants. These values are saved in the LISST.INI file. They can be viewed or edited using the "Edit Calibration Constants" from the DataFrames menu.

Auxiliary Parameter	Display Label	Multiplier	Offset	Units
Parameter 1	Laser Power			
Parameter 2	Battery			volts
Parameter 3	External Instrument			
Parameter 4	Laser Reference			
Parameter 5	Pressure			meters depth
Parameter 6	Temperature		0	deg. C
Parameter 7	Day*100 + Hour	1	0	
Parameter 8	Minutes*100 + seconds	1	0	
Volume Conversion Constant				

Additional Accessories

Notes

Reference Data:

Ring Values 1   Laser Power (counts)   =
  1 – 5   2   Reference Laser Power =
 (counts)   3
          4
          5   **Verified by: _____**

Size Ranges, Angles of Observation and Data Storage Format

Size Ranges   There are 32 size ranges logarithmically placed from 1.25 - 250 microns in diameter, or 2.5 – 500 microns (the upper size in each bin is 1.180 times the lower).

The table below shows the <u>median</u> size of each size class. For clarity the table is shown with multiple rows. In the output data file the data for each size class is oriented in one row from small to large.

Type B Instruments – 1.25 to 250 micron size range

1.36	1.60	1.89	2.23	2.63	3.11	3.67	4.33
5.11	6.03	7.11	8.39	9.90	11.7	13.8	16.3
19.2	22.7	26.7	31.6	37.2	44.0	51.9	61.2
72.2	85.2	101	119	140	165	195	230

Type C Instruments – 2.50 to 500 micron size range

2.73	3.22	3.80	4.48	5.29	6.24	7.36	8.69
10.2	12.1	14.3	16.8	19.9	23.5	27.7	32.7
38.5	45.5	53.7	63.3	74.7	88.2	104	128
157	186	219	259	293	332	391	462

Angles   The median angles (in Degrees) for the VSF measurement are shown in the table below.

Type B Instruments – 1.25 to 250 micron size range

0.106	0.125	0.148	0.174	0.206	0.243	0.287	0.338
0.40	0.47	0.56	0.66	0.77	0.91	1.08	1.27
1.50	1.77	2.09	2.46	2.91	3.43	4.05	4.78
5.64	6.65	7.85	9.26	10.93	12.90	15.22	17.96

Type C Instruments – 2.50 to 500 micron size range

0.053	0.063	0.074	0.087	0.103	0.121	0.143	0.169
0.20	0.24	0.28	0.33	0.39	0.46	0.54	0.64
0.75	0.89	1.04	1.23	1.45	1.72	2.02	2.39
2.82	3.33	3.93	4.63	5.47	6.45	7.61	8.98

Raw Data Storage Format   The values in the raw data file are stored in the order shown in the table below.

Elements	Parameter
1:32	Light intensity on detectors 1 through 32
33	Laser transmission Sensor
34	Battery voltage in raw counts
35	External Auxiliary input 1 (0 to 5V = 0 to 4096)
36	Laser Reference sensor
37	Pressure in raw counts
38	Temperature in units of 100ths of degrees C
39	(Day*100 + Hour) at which data taken
40	(Minutes*100 + Seconds) at which data taken

Processed Data Storage Format   The values in the processed data file are stored in the order shown in the table below. Each sample is stored in one row.

Elements	Parameter
1:32	Volume concentration (in ul/l) for size class 1 through 32
33	Laser transmission Sensor
34	Battery voltage in calibrated units
35	External Auxiliary input 1 in calibrated units
36	Laser Reference sensor in calibrated units
37	Pressure in calibrated units
38	Temperature in calibrated units of degrees C
39	(Day*100 + Hour) at which data taken
40	(Minutes*100 + Seconds) at which data taken
41	Computed % Optical transmission over path
42	Computed Beam-C in units of 1/m

The LISST-100X has 3 separate underwater connectors. A 5-pin, a 6-pin, and a 3-pin connector. The photograph above shows the placement of each connector. The text below describes detailed wiring for each connector.

Communications and Power Connector (5 pin connector)

Connector Manufacturer: Impulse Enterprise, Inc. San Diego, CA, USA
Connector Part Number (Bulkhead): MCBH-5-MP Stainless Steel
Mating Cable Part Number: MCIL-5-FS

Connector Pin #	Use
1	Power/Serial Ground
2	External Power In (+9V nom. 6-12V)
3	Power/Serial Ground
4	Serial Out (to DB-9 Pin 2)
5	Serial In (to DB-9 Pin 2)

Bulkhead Endview

Cable Endview

Auxiliary Input Connector (6 pin connector)

Connector Manufacturer: Impulse Enterprise, Inc. San Diego, CA, USA
Connector Part Number (Bulkhead): MCBH-6-MP Stainless Steel
Mating Cable Part Number: MCIL-6-FS

Connector Pin #	Use
1	Digital Ground
2	Digital In #1
3	Digital In #2
4	No Connection
5	Analog In (0 to 2.50V max)
6	Analog Ground

Bulkhead Endview

Cable Endview

BioBlock Connector (3 pin connector)

Connector Manufacturer: Impulse Enterprise, Inc. San Diego, CA, USA
Connector Part Number (Bulkhead): MCBH-3-MP Stainless Steel
Mating Cable Part Number: MCIL-3-FS

Connector Pin #	Use
1	Signal Ground
2	Signal (Open/Closed)
3	Battery Sense
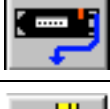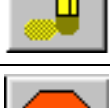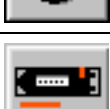
Bulkhead Endview

Cable Endview

Appendix D: LISST-SOP Software Button Description

Button	Label	Description
	Open Real-Time Session	Runs the instrument for Real-Time operation. Note: instrument must be already configured for real-time sampling and be running (i.e. not hibernating). [To wake from hibernation, choose Wake Up LISST from LISST menu.]
	Open	Open raw or processed file. Depending on extension of file requested to open, the appropriate procedure is started.
	Query Instrument	Queries instrument for it's current configuration and displays the information to the screen.
	Offload	Offloads stored data to a file for later processing.
	Erase	Erases the datafile by resetting the datafile pointer, (variable D in former versions), to zero.
	Stop	Sends a CTRL-C to the instrument to stop a running program. Also sends PCLR 10 to turn off main power.
	Set Instrument Clock	Sets the internal instrument clock to match the currently connected computer clock
	Operating Modes	Opens the Instrument Sampling Configuration window where operating mode and sampling schemes can be configured.
	Collect Background	Opens the real-time background collection windows where background-scattering files can be collected in real-time.
	Connect/Disconnect	When the instrument communication has not been initialized the Connect/Disconnect button will be a red light. Pressing the button will toggle the communications status. When the Connect/Disconnect button is showing a green light the instrument communication has been initialized. Pressing the button will disconnect the instrument.
	Open Terminal	Pressing the Open Terminal button will bring up the terminal window for communication with the instrument including Start and Stop buttons.
	Program Settings	The Program Settings button bring up the general settings windows for setting display parameters and other software settings, such as File Output, Com Port settings, and Plot .
	Print	When viewing processed data the Print button will be activated. Pressing the button will send the current display to the printer.

Appendix E: Software Upgrade Installation Procedure

The following procedure describes the installation of the LISST-SOP Version 4.60 software for users who have previously received an instrument with Version 3.xx software. Instruments shipped after August 19, 2002 were shipped with a version of the SOP software and do not require the following procedures.

Step 1) **Download Install file:** The LISST-SOP Version 4.60 is available from the Sequoia Scientific web site. The file downloads are restricted to existing customers only. Existing customers can register for download by filling out the form on the website. When propmted for a instrument serial number enter a valid 4 digit serial number. The files can then be downloaded. Future visits to the download page can be accessed by entering the email and password selected at the time of registration. Choose the file labeled "LISST-SOP Version 4.60 software for the LISST-100X". Save this file to disk.

The *LISST-SOP_Install.EXE* file is a self-extracting Zip file that contains the files required to install the LISST-SOP software. This will include *SETUP460.EXE*, *LISST1004.TTB*, *InstrumentData.txt,* and some instrument specific files for the example instruments #1004 and #1005. Run the program and press OK to extract the files into a temporary folder of your choice. Before running the *SETUP460.EXE* program there are a few tasks that must be performed.

 Step 2) Configure Instrument Specific Files: The downloaded install file contains some generic instrument specific files. These files will need to be replaced with files from the folder containing the previous version of the LISST software. Copy the *RingArea_1xxx.ASC* file and the *Factory_ZSC_1xxx.ASC* files from the previous version's folder or the floppy disk sent with the instrument to the LISST-SOP install folder. The *xxx* should be replaced with the serial number of the instrument. For example, for unit 1001 the files should have the following names, *RingArea_1001.ASC* file and *Factory_ZSC_1001.ASC*. Some older versions of the software did not use this naming convention. If there are no files with serial numbers in the name copy the *RingArea_B.ASC* (or *RingArea_C.ASC* for type C instruments) to the new folder and rename it using the serial number naming convention as shown above. Similarly, copy and rename the *Factory_ZSC.ASC* file. If multiple instruments are to be used with the LISST-SOP copy a RingArea and Factory_ZSC file for each instrument to the new folder. The example files for instruments 1004 and 1005 can be deleted if desired.

Step 3) Edit *InstrumentData.txt*: The *InstrumentData.Txt* file contains a listing of a few basic properties of each instrument to be used with the LISST-SOP software. Open the file using any text editor such as Notepad. The file contains five comma-delimited columns of numbers. The first column is the four-digit serial number of the instrument. The serial number cannot contain any letters, only numbers. The second column is the instrument type (A, B, or C). Type A is the early 5-500 micron unit. Type B is the 1.25-250 micron unit. Type C is the 2.5-500 micron unit. The third column is the memory size. The options are either 529000 (standard) or 2102000 (2Mb upgrade) for the orginal LISST-100. For the LISST-100X instrument enter 2102000. The fourth column is the Calibration Constant. This value is instrument specific and can be found in the LISST.INI file in the C:/Windows directory from the previous installation. It can also be found by selecting "Edit Calibration Constants" in the previous versions. The fifth column is an indicator for the LISST-100X type instruments. Place an X in this column for the LISST-100X instruments and leave it blank for the LISST-100 instruments. Save the changes to the *InstrumentData.Txt* file.

Step 4) Edit *LISST.INI:* The LISST-SOP software is designed to support the use of multiple instruments. The *LISST.INI* file contains the calibration values for the auxiliary parameters for each instrument to be used. Before installing the LISST-SOP rename the LISST.INI file in the Windows folder to *LISSTV3.INI* and copy it to the temporary install directory. Open the *LISSTV3.INI* file with Notepad. Also open the *LISST.INI* file in the temporary install directory. In the new LISST.INI file there will be two instrument specific sections labeled *[LISST1004]* and *[LISST1005]* these sections will need to be replaced with the correct calibration values for each instrument. Each instrument will have its own section with a heading that is *[LISSTxxxx]* where xxxx is replace with the serial number of the instrument. The previous version *LISSTV3.INI* will have a section labeled *[Instrument1]*. This section can be copied from the old *LISST.INI* file for each instrument and placed into the new *LISST.INI* file. Save the changes to the new *LISST.INI* file. During the setup of the software this file will be copied to the Windows folder. The existing *LISST.INI* file will be renamed *LISST.old*.

Step 5) Run *Setup460.EXE* **and configure software:** Run the *Setup460.exe* program from the floppy drive. From the *Start* menu select *Run* and enter *A:/Setup460.exe*. A Welcome screen will appear. Choose *Next* to continue to the Destination Directory screen. The default directory is *C:\program files\Sequoia\LISST100*. Use the *Browse* button to choose a different directory. Once a directory is chosen press Next. Press *Next* again to start the install process. When it is completed press *OK* to finish and exit the setup program. From the Start menu navigate to Programs then Sequoia Scientific then LISST. If a desktop icon is desired, right click on LISST and choose "Send To" and then "Desktop as icon". This will create an icon on the desktop for later use. Note: the "Start In" directory must be the same as the LISST.EXE program. Start the program by double clicking on the icon or choosing LISST from the Start menu. From the *File* menu choose *Settings*. Select the *File Locations* tab. The directory shown should be the same as the installation directory. If it is not, use the Browse button to navigate to the correct directory. The default directory is *C:\program files\Sequoia\LISST100*.

Step 4) Configure and Install Base program (for Orginal LISST-100 instruments only): The LISST-100X no longer uses a Base Program. The following description is for older style LISST-100 instrument that do require a Base Program.
The Base program is a combination of all of the previous TTB programs. The LISST-SOP program is used to choose the desired settings that are then used to command the Base program. Before loading this program on to each LISST instrument we must first configure it with the correct serial number and memory size. Open the LISST1004.TTB program with any text editor such as Notepad. Change the serial number to match the instrument serial number at Line 1815. If the instrument is configured with a 2Mb memory upgrade you will also need to change Lines 10010 and 13620. At these lines there are two lines of code. One line has REM in front of it. To switch lines move the REM from one to the other. Save the file as *LISSTxxxx.TTB* where *xxxx* is the serial number of the instrument. This step should be repeated for each instrument. Note: Some instruments may have custom features such as the options Conductivity and Temperature sensor. These instruments will require a custom Base program that has been modified to work with the instrument. Contact Sequoia Scientific for more details.
After changing the serial number, this program can then be loaded into the instrument. Before installing the program into the instrument using the new LISST software, connect the communications cable and establish a connection using the new Terminal window of the LISST software. To open the terminal window choose *Terminal Window* from the *Communications* menu. Make sure that no programs are running, the OK> prompt is displayed, and any resident program is cleared by issuing a NEW command.

To install the new base program from the LISST-SOP program select the *Send Program* option from the *LISST* menu. A file selection dialog box should be displayed. Choose the program that is to be

loaded on to the instrument and select OK. A transfer status display will appear as the program is loaded. To confirm the loading issue a LIST command from the Terminal Window.

The software and instrument are now ready to use.

Appendix F: Horzontal Chamber Installation Procedure

Step 1) Before installing the Small Volume Horizontal Chamber first clean the windows of the LISST-100. It will also be necessary to remove the endcap ring and standoffs on the optics endcap. Remove the three screws on the ring and then unscrew the standoffs. Remove the Spacer and push the Slider into toward the center of the chamber. The Mixing bar can be left in the chamber or removed.

Step 2) Carefully insert the Chamber into the optical path of the LISST-100. Be careful not to touch the o-rings to either glass windows. The Slider should mate to the cone shape of the transmit optics. By reaching in from the top of the chamber push the Slider out until the chamber is up against the optics endcap. The o-ring in the slider should just be starting to engage with the wall of the chamber. It may be necessary to press on the top, bottom and sides of the Slider to get it to slide out with out binding.

Step 3) Once the slider is positioned such that the o-ring is engaging in the wall of the chamber the Spacer can be inserted between the outside wall of the chamber and the lip of the Slider. The tapered side of the spacer should go against the Slider lip. This will cause compression of the o-rings and seal the chamber.
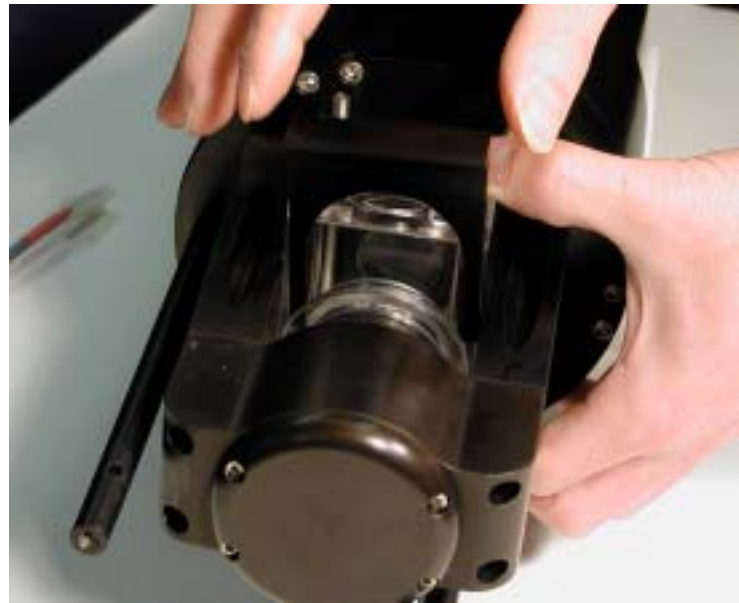
Step 4) The chamber can now be filled with clean water. It is highly recommended to do a background scatterfile after assembly to make sure that the windows are still clean. It is NOT necessary to have water around the chamber as with previous designs.

Warranty

This Statement of Limited, Extended Warranty applies to the products ("Products") being purchased by _____ _____("Customer") from Sequoia Scientific, Inc. ("SEQUOIA") pursuant to PO _____(the "Order"). The Products include, but are not necessarily limited to, the following:

LISST-100X Particle Size Analyzer   **Serial Number #** _____

SEQUOIA and Customer agree as follows:

1.   Limited Warranty

SEQUOIA warrants that upon delivery by SEQUOIA (a) the Products will be free from defects in materials and workmanship, (b) the Products will perform substantially in accordance with SEQUOIA's applicable specifications, and (c) any Products (or components or parts thereof) that are manufactured by SEQUOIA do not infringe any U.S. patent or copyright.

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If any Product does not comply with the warranties set forth in 1(a) and 1(b) above, SEQUOIA will, at its option, either (a) repair the Product, (b) replace the Product, or (c) refund the purchase price paid by Customer to SEQUOIA for the Product; provided that Customer gives SEQUOIA written notice of the noncompliance within one (1) year after SEQUOIA's delivery of the Product (as the same may be extended for repaired or replacement Products as provided for herein, the "Warranty Period"). If Customer does not give SEQUOIA such written notice within the Warranty Period, then such warranties will be satisfied in full. Customer will cooperate with SEQUOIA's efforts to repair or replace any noncomplying Product. Without limiting the generality of the foregoing, Customer will comply with SEQUOIA's request for return of any such Product to SEQUOIA (in which event SEQUOIA will pay for round-trip shipment within the United States) or for access to accomplish the repair or replacement on Customer's premises. As to any Product repaired or replaced by SEQUOIA, the Warranty Period will end upon the later of one (1) year after SEQUOIA's delivery of the original Product or 90 days after SEQUOIA's delivery of the repaired or replacement Product. Any Product, component, part or other item replaced by SEQUOIA becomes the property of SEQUOIA.

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This Statement of Limited Warranty will be governed by the laws of the State of Washington without reference to its rules relating to choice of law, except to the extent preempted by the laws of the United States. The U.N. Convention on Contracts for the International Sale of Goods will not apply.

    CUSTOMER: **SEQUOIA:**

                                                     <u>Sequoia Scientific, Inc.</u>

By:_____

 Title:_____

By:_____

 Title:_____