

LISST-100X

Particle Size Analyzer

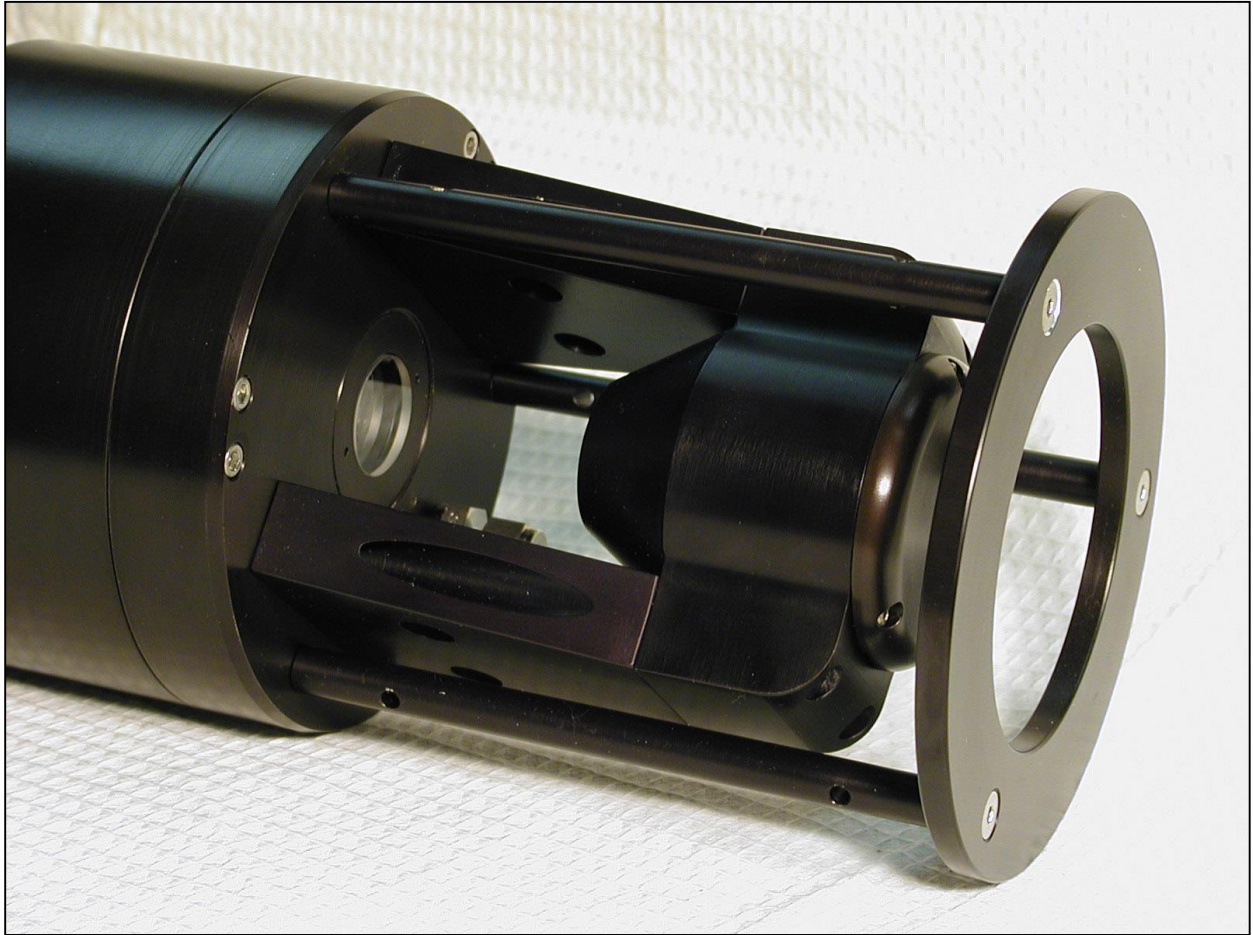
User's Manual

Version 5.1

(October 2015)



2700 Richards Road, Suite 107
Bellevue, WA 98005-4200
Tel: (425) 641-0944 Fax: (425) 643-0595



SEQUOIA

© This document is copyrighted by SEQUOIA SCIENTIFIC, INC

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- 100X instrument and the principles of its operation.

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

Technical assistance

For technical assistance please contact your local Distributor or Sequoia. Please be sure to include the instrument serial number with any correspondence.

IMPORTANT: Please read APPENDIX G: TECHNICAL ASSISTANCE *BEFORE* you call or email.

Sequoia Scientific, Inc. contact information:

Telephone: +1(425) 641-0944

Email: info@sequoiasci.com

PLEASE NOTE: The LISST-100 particle size analyzer (discontinued in 2004) will not communicate with the software version 5.1 described in this manual. If you have a LISST-100 you can use version 5.1 to PROCESS your data, but you must use version 4.65 (Windows XP compatible only) in order to program and offload data from your LISST-100. The LISST-100 is no longer supported by Sequoia Scientific, Inc.



Waste Electrical and Electronic Equipment

Smaltimento di apparecchiature elettriche ed elettroniche da rottamare

Table of Contents

SECTION 1: INTRODUCTION TO THE LISST-100X	11
INTRODUCTION	11
GENERAL DESCRIPTION	14
SECTION 2: OPERATION	17
GETTING STARTED	18
STEP BY STEP PROCEDURES	40
Step by Step Procedure: Record and Store Background Scatterfile	42
Step by Step Procedure: Offloading Data Files	44
Step by Step Procedure: Deleting Files From Memory	46
Step by Step Procedure: Processing a single raw data file	47
Step by Step Procedure: Batch Processing Multiple raw data files	54
Step by Step Procedure: Batch Processing Multiple raw data files from the command line	59
Step by Step Procedure: View processed data file	61
Step by Step Procedure: Data Quality Control	65
Step by Step Procedure: Simple Real-time data processing	67
Step by Step Procedure: Advanced Real-time data processing	71
Step by Step Procedure: Configuring data collection	77
INSTRUMENT COMMUNICATION	83
LISST-100X COMMAND SUMMARY	87
LISST-100X COMMAND DETAILS	88
PERFORMANCE OPTIMIZATION	97
INSTRUMENT MOUNTING, DEPLOYMENT ORIENTATION, STORAGE AND MAINTENANCE	101
Step by Step Procedure: Changing the Battery	105
TECHNICAL SPECIFICATIONS	111
APPENDIX A: SIZE RANGES, OBSERVATION ANGLES, DATA STORAGE FORMAT	112
APPENDIX B: CONNECTOR PINOUTS FOR LISST-100X	119
APPENDIX C: LISST-SOP SOFTWARE BUTTON DESCRIPTION	122
APPENDIX D: SOFTWARE UPGRADE INSTALLATION PROCEDURE	124
APPENDIX E: ZSCAT CHAMBER INSTALLATION PROCEDURE	126
APPENDIX F: BIOBLOCK USE	128
BIOBLOCK INSTALLATION INSTRUCTIONS FOR THE LISST-100X	129
CONFIGURING AND OPERATING THE BIOBLOCK ON THE LISST-100X	132
BIOBLOCK BATTERY REPLACEMENT	134
APPENDIX G: TECHNICAL ASSISTANCE & TROUBLESHOOTING	135
APPENDIX H: LISST ACCESSORIES	138
WARRANTY	141
INDEX	143

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 only 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 to the observed scattering, the method of laser diffraction is mostly *independent* of particle composition.

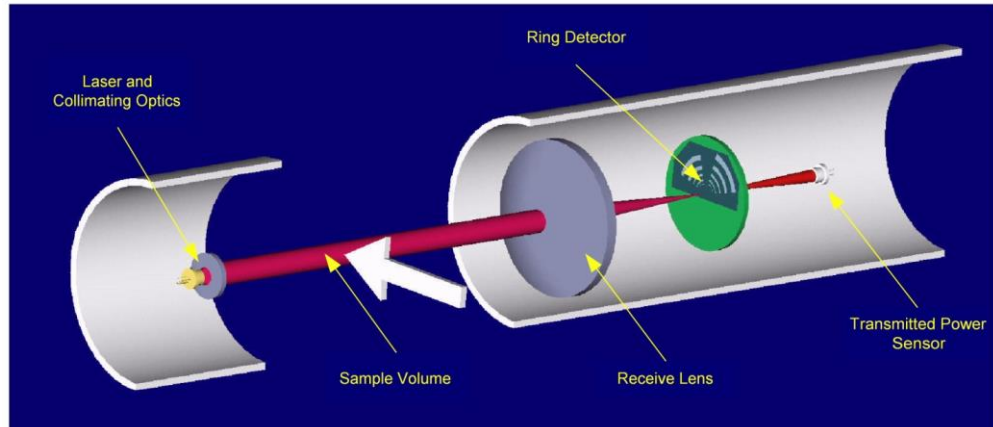
In the aquatic sciences, particle refractive index is poorly known because particles are often a mixture of mineral grains and living and dead particles of biological origin. Thus, except for shape effects, laser diffraction offers an excellent method for size-distribution estimation.

By calibrating for concentration with ISO standard natural particles, shape effects are empirically included for in the determination of the volume concentration of the suspended particles. The user can convert to mass concentration by multiplying with an appropriate density. If the density of the particles is not known it is not possible to convert the volume concentration to mass concentration.

The LISST-100X records the scattering intensity over a range of small angles using a specially constructed multi-ring detector shown in the graphic below. 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/library/technical-papers/>

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



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., 1991¹. A more up to date description of the technology and its application is provided by Agrawal & Pottsmith, 2000².

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.

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 distribution³ 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.

The volume distribution is obtained by inverting the above equation. Included with the LISST-100X instrument, we have provided software that obtains the inverted volume distribution \underline{N}_V

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.

³The volume distribution is related to the number distribution via $N_V = a^3 n(a)$. It represents the volume concentration 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) or 2.5-500 (Type-C). See Appendix A 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, data storage and scheduling computer, and a battery system.

The instrument is capable of autonomous operation. Windows software (XP and W7 32- and 64-bit compatible) 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 transmission, depth, and temperature. An auxiliary Analog port is available for recording data from an external device such as an OBS 3+, a Sea-Bird MicroCat CTD or a Turner Designs Cyclops-7 fluorometer⁴.

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 Windows software. For MATLAB users, inversion scripts are available for download from Sequoia's website: www.SequoiaSci.com.

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) or 0.00085-0.17 radians (Type C). This angular range corresponds, respectively, to size ranges from 1.25 to 250 μm (Type B) or 2.5 to 500 μm (Type C).

See Appendix A: Size Ranges, Observation Angles, Data Storage Format on page 112 for more information.

General layout

The LISST-100X consists of the following parts: a solid-state diode laser operating at 670 nm wavelength and fiber-optically connected to a laser beam collimating system, a beam manipulation and orienting system, a scattered-light receiving lens, the custom designed 32-ring detector, preamplifier electronics, a ring-selecting multiplexer circuitry, and a data logger. All these components are inside the black-anodized pressure housing and the user has no access to any of these.

⁴ The LISST-100X must be configured for one of these options at the factory prior to shipping.

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 sensor⁵. 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 such as salt and sediment 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 data file.

Note that because the temperature sensor is embedded in the endcap, it has a significant lag as the entire connector endcap must respond to the changing temperature. The temperature sensor will work well if the rate of change is slow, e.g. a front moving past the instrument, but it will show a significant lag if the rate of change is large, such as typically happens during profiling applications.

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 end cap; see Appendix B: Connector Pinouts for LISST-100X for the connector pin outs. The instrument can be configured to use 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 battery pack is NON-rechargeable and outputs +9 V. It has a room-temperature capacity of 42 A-hr. When the instrument is in stand-by mode the current drain is 8.5 mA. In Low Power Sleep mode the current drain drops to 120 μ A. 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 that can estimate the battery consumption is included with the software on the Ship Disk you received with your instrument. The spreadsheet can also be downloaded from Sequoia's website: www.SequoiaSci.com, click Library, then Downloads, then LISST-100X.

⁵ A gauge pressure sensor is calibrated to measure the pressure relative to a given atmospheric pressure, as opposed to an absolute pressure sensor, which measures pressure relative to a vacuum. The pressure sensor on the LISST-100X will read 0 at atmospheric pressure.

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 +12 VDC and should not exceed +15VDC. **NOTE:** LISST-100X units shipped after 1 March 2012 will accept up to +24 VDC external power. 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 using the LISST-100X, put the instrument into Low Power Sleep mode to reduce battery drain to about 10 μ A. This is done from the provided software. Make sure the endcap switch is in the “1” position when in low power sleep.

Auxiliary Equipment

The instrument is shipped pre-aligned and tested. A small 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 is supplied so that a user need only provide a PC running Windows.

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.

Accessories

For extended laboratory applications various chambers are available, see Appendix H: LISST Accessories on page 138.

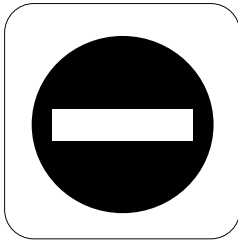
Section 2: Operation

Section Organization

Section 2 is divided into 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

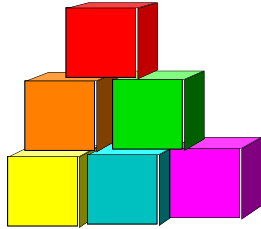
- LISST-100X is a sensitive optical instrument - please handle it gently as you would handle a very expensive camera.
- Critical alignments may be disturbed if the instrument is subjected to shock or rough handling.
- Evidence of shock/rough handling will void the warranty.
- Whenever in transit, store the instrument in the provided padded shipping case.
- If placing the instrument vertically on the standoffs, be sure to do so gently as the Compact Flash Memory Card inside may otherwise come loose.



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.

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

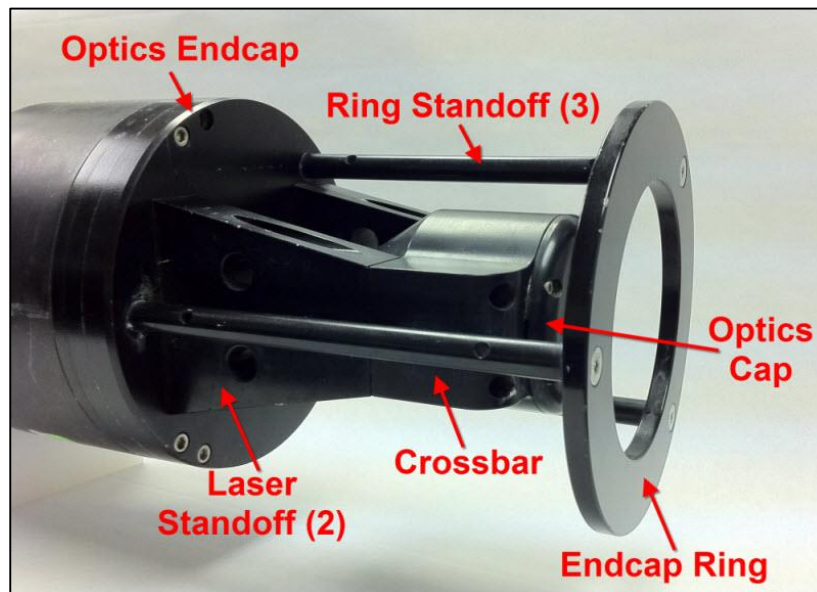
Let's assume that you are opening the LISST-100X shipping cases for the first time. Inside you will find the following: User's Manual, USB memory card (credit card size) with the software), LISST-100X instrument, Plastic Instrument stands, Small Volume Horizontal Test Chamber, Communications cable, test particles, insulated stainless steel clamps, External Power cable, and Allen wrench set.

Step 1: Remove Instrument from shipping case.



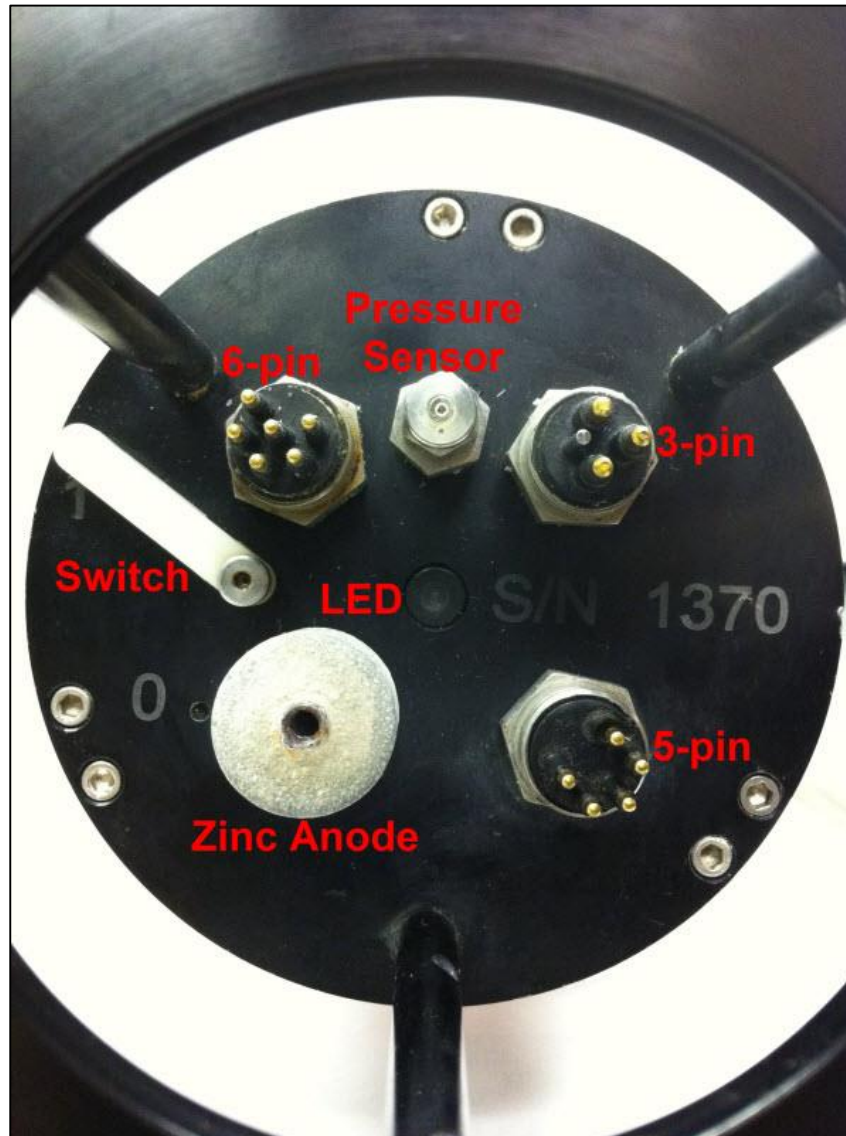
Start by removing the white plastic instrument stands and set them on a flat working surface. Remove the LISST-100X from the case and set it on the stands. The LISST-100X has two distinct ends that we will refer to as the Optics endcap and the Connector endcap. The connector endcap has three underwater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

Optics endcap



The user should never try to loosen or disassemble any of the components attached to the optics endcap. Doing so will immediately void any warranty.

Connector endcap



On the connector endcap, the 3 connectors are as follows:

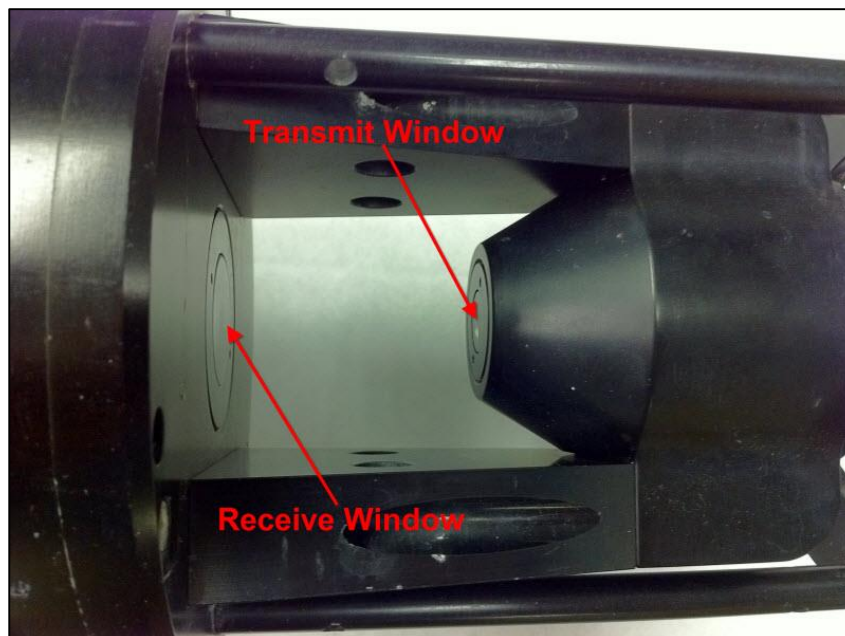
3-pin connector: Used for BioBlock connection (see Appendix B: Connector Pinouts for **LISST-100X** and Appendix F: BioBlock Use)

5-pin connector: Used for serial communication and external power. See Appendix B: Connector Pinouts for **LISST-100X**.

6-pin connector: Used for analog in and digital in/out signals. See Appendix B: Connector Pinouts for LISST-100X

Step 2: Check for clean windows

At this time, 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. The transmit window is located in the crossbar suspended above the optics 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 lukewarm water and a mild soap solution (e.g. mild hand soap, liquid dish soap) and then rinsing off all soap residue with clean, particle free water such as deionized water, MilliQ water or distilled water. The windows can also be wiped clean with a soft cloth (e.g. a lens cloth) and alcohol. It is not recommended to use stronger solvents, such as acetone or toluene. Also, 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 2 meter 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. It is located below the engraved serial number. After removing the cap install the cable making sure that proper alignment of the cable is maintained, so that the connectors are not bent.

Step 4: Install the Horizontal test chamber



Remove the Small Volume Horizontal test chamber from the shipping case if it is not already installed on to the instrument. Attach the flexible 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 chamber see Appendix E: Zscat Chamber Installation Procedure on page 126.

We can now fill the chamber with clean, particle-free water. Sequoia

uses 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 software SOP 5.1

At this point the instrument is ready to go. Install the software that is required for operation of the instrument. A software disk or USB card is included with each instrument. In addition to the communication and processing program the disk also contains calibration files specific for your instrument. Insert the disk into the CD- or DVD drive on your PC to install the software, or plug in the USB-drive to a USB port.


Please note the following with respect to the software version 5.1:

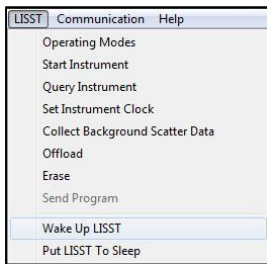
- On a 64-bit Windows PC, the software will be installed in the following folder: C:\Program Files (x86)\Sequoia\LISST100, while on 32-bit Windows machines, the install folder will be C:\Program Files\Sequoia\LISST100
- The installer also creates a folder called C:\Program Data\Sequoia\LISST100. There are 2 very important files in this folder: InstrumentData.txt and LISST.ini. These 2 files contain various calibration parameters about your instrument and the software will not work if you move these files to another location.
- Version 5.1 **WILL NOT** work with the older LISST-100 instruments (except for processing raw data files). It is NOT possible to use version 5.1 to program and offload data from a LISST-100 instrument, only a LISST-100X will work with version 5.1.
- If you already have a LISST-100X and have the software version 5.0 installed on your PC, an update installer is available at Sequoia's website. The update installer will preserve your current InstrumentData.txt and LISST.ini files.
- More detailed information can be found in Appendix D: Software Installation & Upgrade *Procedure* on page 124.
- See also our YouTube video: <http://www.youtube.com/watch?v=VoLouNQeH4s>

Step 6: Start LISST-SOP program

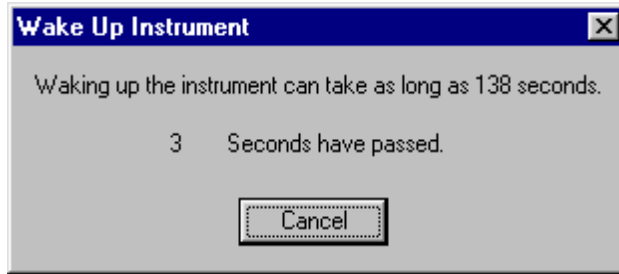
Start the LISST-SOP software by selecting it from the Start menu. The name LISST-SOP refers to the Standard Operating Procedure functionality of the program. Appendix C: LISST-SOP Software Button Description on page 122 describes the functions of each button.

Step 7: Wake up instrument from Sleep mode

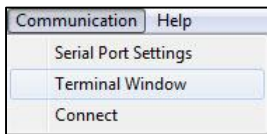
The instrument is shipped in a low power Sleep mode to conserve battery power. To wake up the instrument select *Wake Up LISST* from the *LISST* menu or press the  button. A dialog box will appear




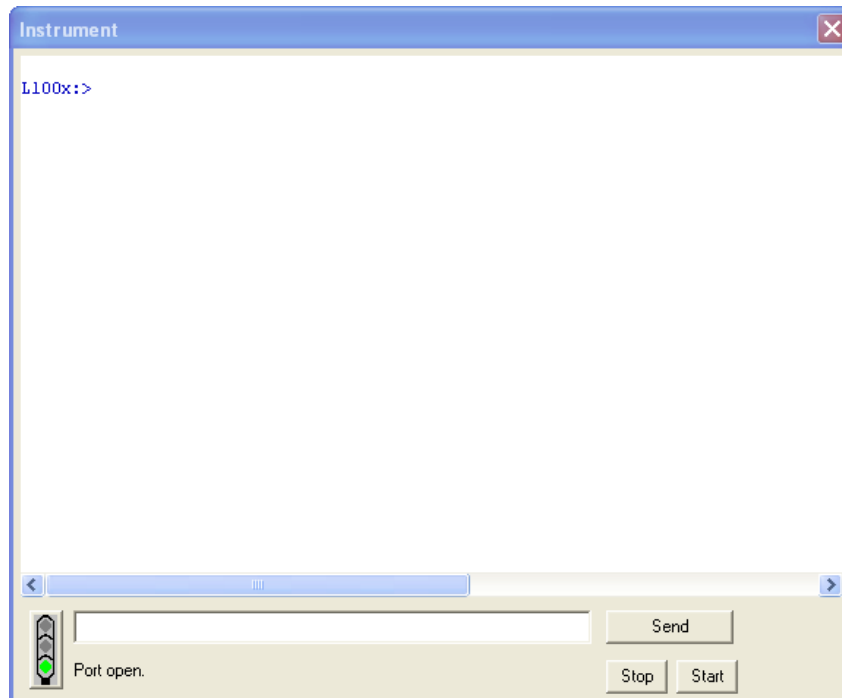
counting down the maximum time required for the instrument to wake up. The instrument sleeps for 30 seconds, wakes up for 1 second to look for a wake up command and then goes back to sleep. Therefore the wait could be as long as 32 seconds for the LISST-100X. Upon wake up the instrument status will be 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.



Step 8: Open Terminal window



The LISST-SOP has a terminal window that allows the user to communicate directly with the instrument using a set of 2-letter commands; see LISST-100X Command Summary on page 87 for details. To open the Terminal window select *Terminal Window* from the *Communication* window or select the  button from the tool bar. A window similar to the one shown below will appear.



If you do not see the L100x:> prompt, click the Send button.

A set of two-letter commands can be typed into the box in the lower

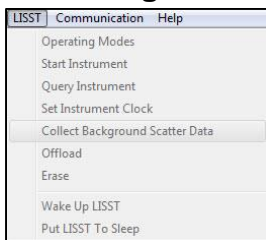
section of the window. When the Enter key or the Send button is pressed the command will be sent to the instrument. The Start button sends a GO command to the instrument to start the instrument sampling using the current settings. The STOP button sends a CTRL-C to stop the sampling and to turn off the main power. A list of the commands that can be sent to the LISST-100X can be found in the section LISST-100X Command Summary on page 87.


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.

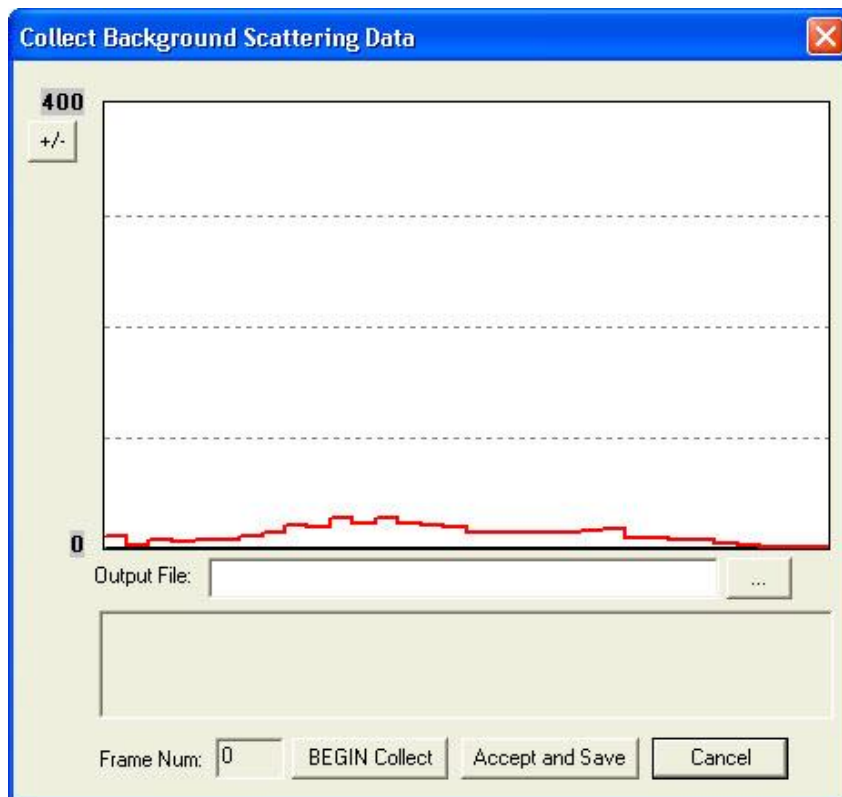
Step 9: Datalogger

The LISST-100X data logger uses a removable Compact Flash Memory Card. The LISST-100X comes standard with 1GB RAM, enough for 12,500,000 size distributions. The Compact Flash Card can be removed (see Appendix G: Technical Assistance & Troubleshooting on page 135). By using a PCMCIA adapter or USB card reader the data files can be directly transferred to the PC. However, the standard procedure is to offload the files using the 2-m communication cable and the LISST-SOP software.

Step 10: Acquiring Background Scattering

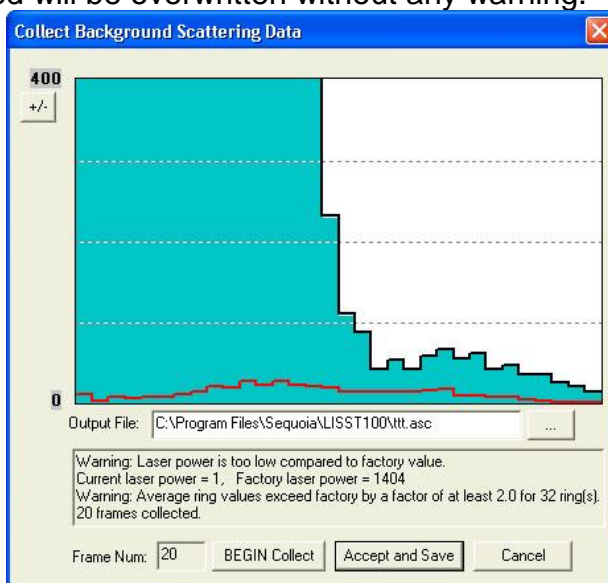


The background scattering measurement is critical to good instrument performance. It is especially critical for clean water applications where the optical transmission is greater than 90% over the 5 cm path. The background scattering will also check the overall health of the instrument. It will verify that all of the systems are functioning and that the optics is 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  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 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.


NOTE: If you have already saved a background file, then decide to do another one and you click *Accept and Save*, the background file you just saved will be overwritten without any warning.

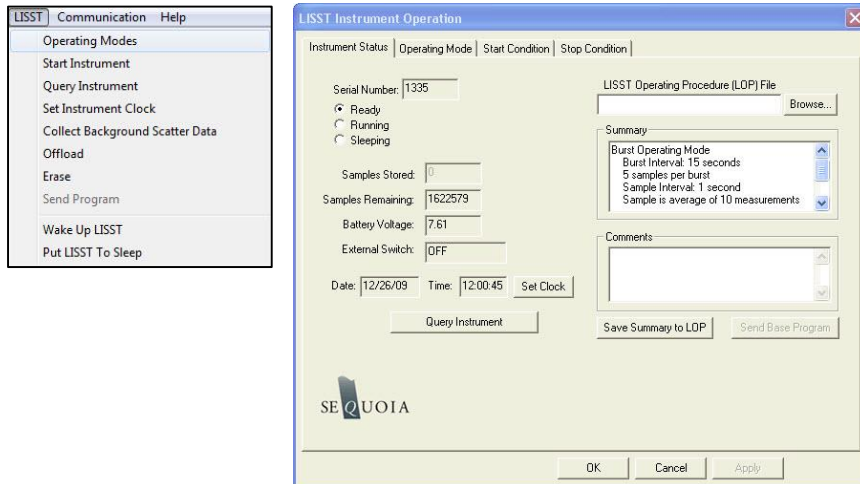


If there is a problem with the instrument or if the water or windows are not clean, error messages will be displayed. Dirty water or windows will generally cause higher values across the middle rings.

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

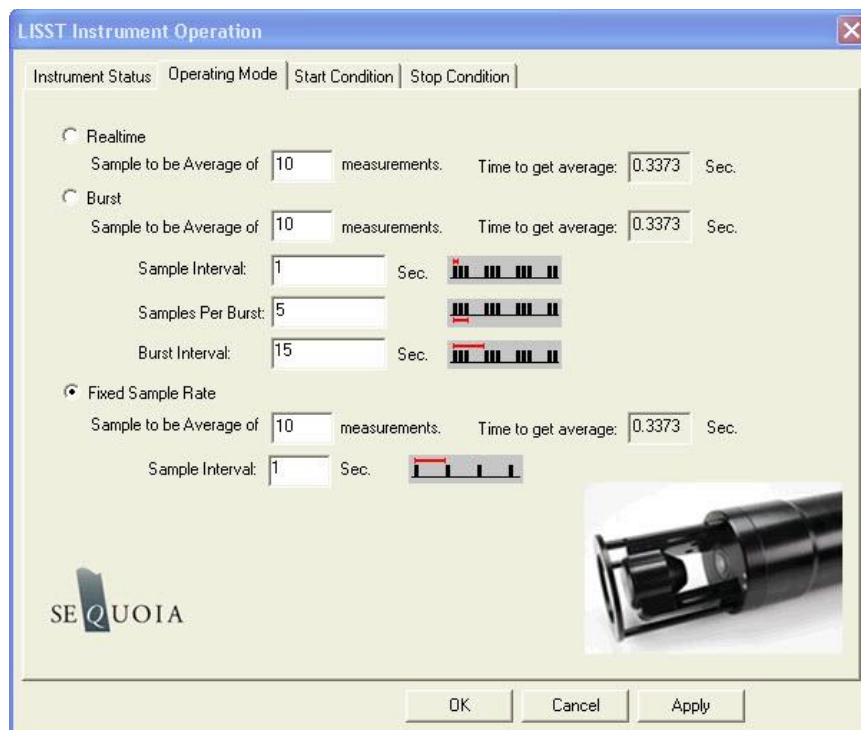
The Operating Modes window is used to set all of the deployment parameters. To open the window, choose *Operating Modes* from the *LISST* menu or press the  button on the tool bar. A window similar to the one shown will appear. The window has four tabs: Instrument Status, Operating Mode, Start Condition, and Stop Condition.



The Instrument Status page gives information about the instrument. It also allows previously saved instrument configuration files (LOP's) 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. The Comments windows allows for entering data about the current configuration, for example metadata relating to the current settings.

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 Fixed Sample Rate. You can also select the samples per average and sample rates on this screen.



Real time Mode

The Real-Time 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 on board the instrument when this mode is used.**

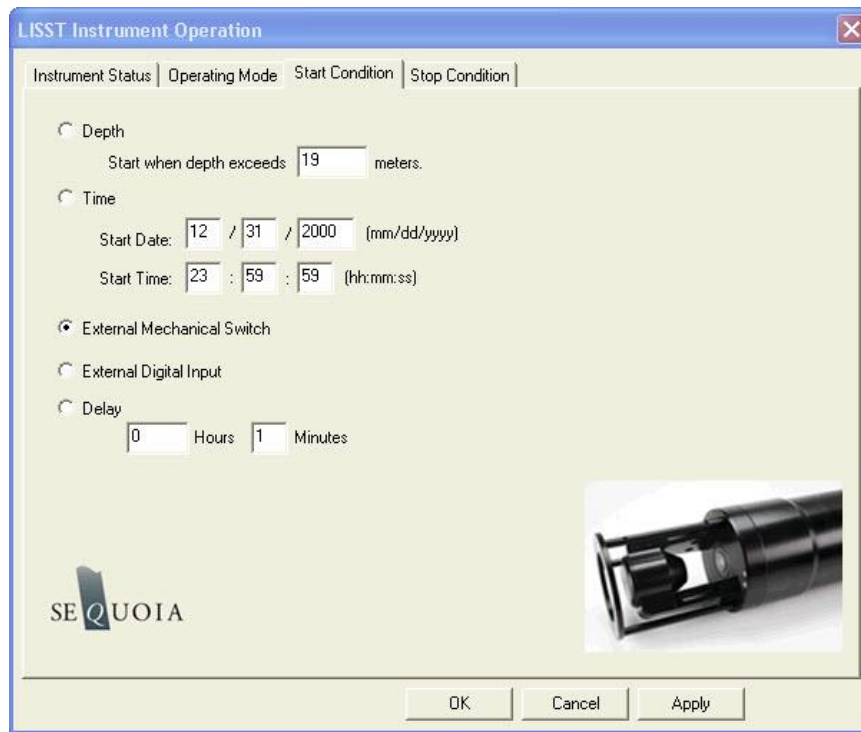
Burst and Fixed Rate Modes

The Burst and Fixed Sample Rate modes are used to save data to a raw data file on board the instrument. 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 Sample to be Average of 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.

The LISST-100X measures internally at ~20 Hz, but the data cannot be stored to the data logger at this rate. The individual measurements are averaged into a sample, and it is this sample average that is stored at a maximum sample rate of 1 Hz. For the example shown above, the instrument is set to sample in the Fixed Sample Rate mode at a 1 Hz rate with 10 measurements per average. This average is obtained in 0.34 seconds.

Step 13: Setting Start Conditions

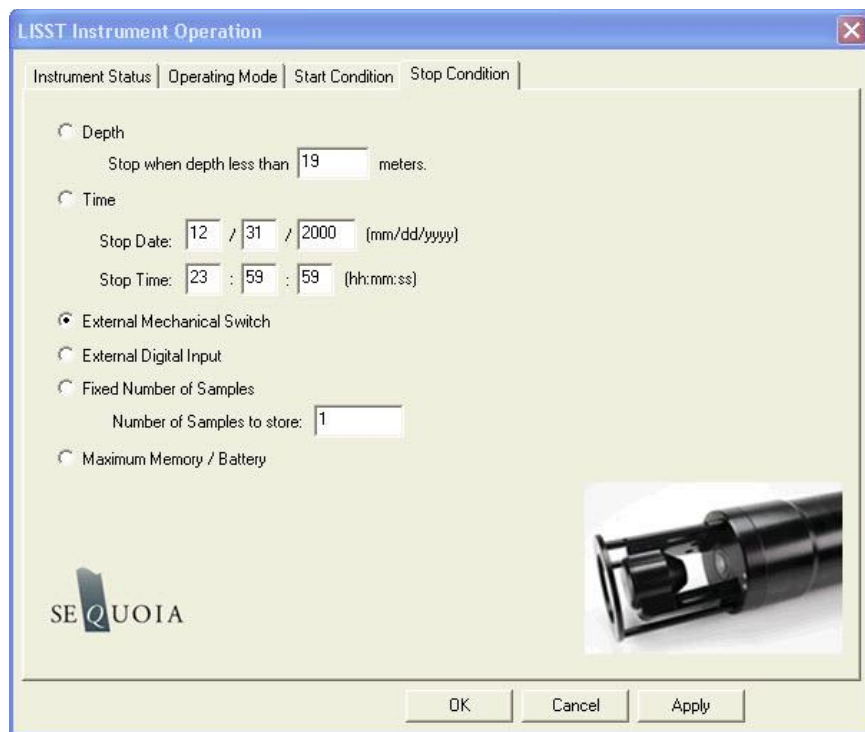
After selecting the Operating mode the start and stop conditions can be selected. Choose the *Start Condition* tab at the top of the window.



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 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/Low Battery (<less than 6.5 V).



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

After selecting the Stop Conditions return, click the APPLY button to complete the configuration. This will transfer the settings to the instrument. Then return to the Instrument Status page by clicking on the Instrument Status Tab.

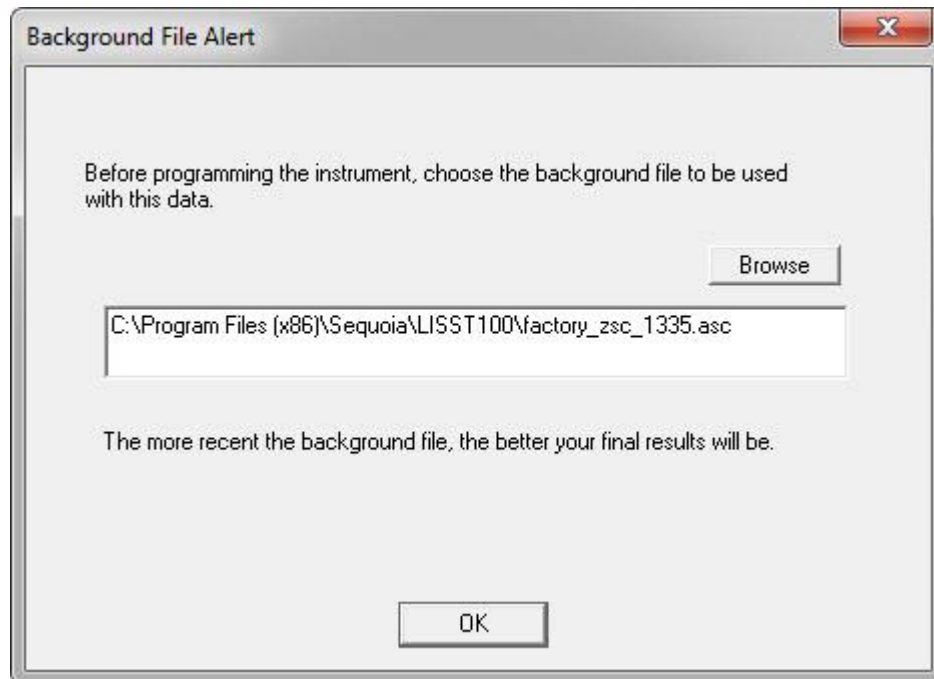
Step 15: Saving the settings for future use

The Instrument Status Page will now display the summary of the settings that have been selected. These settings 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 files 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.

Step 16: Background file selection

After pressing the *OK* button to complete the configuration, the window below will appear, prompting you to select the zscat file to be used for processing the data when you have obtained them.



Select the background file you intend to use for processing your data. Note that the software DOES NOT store this information anywhere. It is a reminder that you must have obtained a good background file before beginning the data collection.

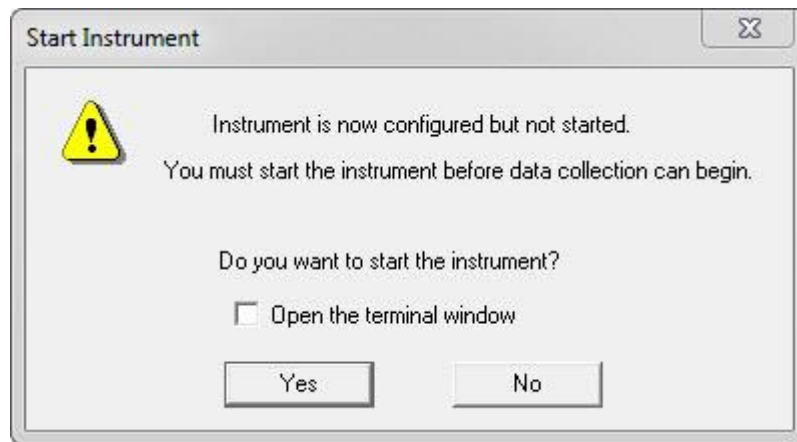
**Step 17:
Background file
warning**

If the background file you selected is more than 6 hours old, a File Warning dialogue box will appear, alerting you that final data quality could be compromised. Select from the 3 options (Select a different background file, collect a new background or accept the risk and continue).



**Step 18: Start
Instrument**

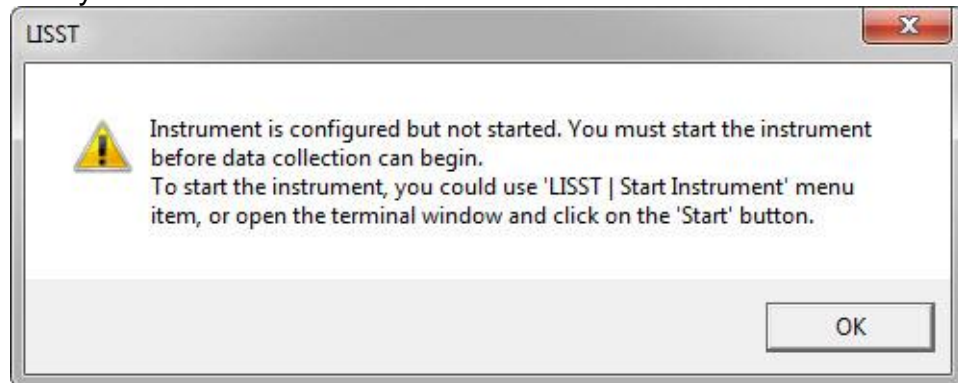
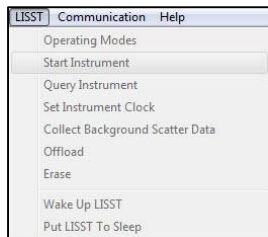
The instrument is now configured for deployment, **however, it is not yet running.**



You MUST start the instrument in order to start the program on the datalogger that controls the sampling. If you do not do that, the LISST will never start sampling or react to the start and stop conditions.

Note that starting the instrument is not necessarily the same as starting sampling (unless you have a delay start of 0 minutes set as your start condition). For example, if you have selected switch start, then starting the instrument will start the program on the datalogger, which will then start to look for the switch being flicked to the “1” position. Only then will actual sampling begin.

If you select the No button, the warning below appears, informing you how you can start the instrument.



When the instrument has been started, depending upon the Start Conditions, text will be displayed approximately every 30 seconds in the terminal window. 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 19: 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.

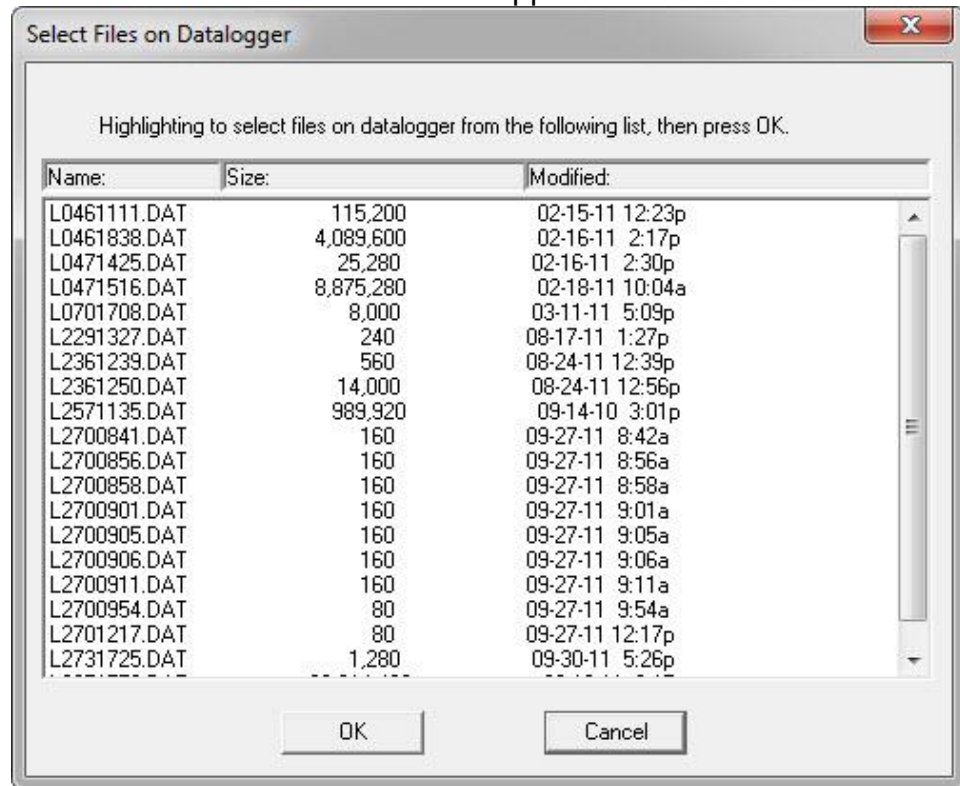
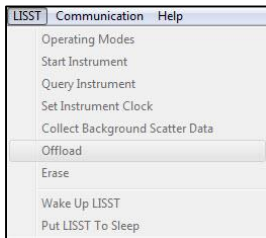
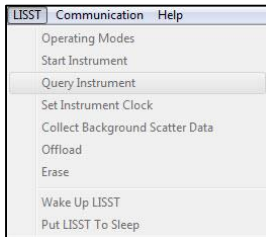
To stop a running program use the Stop button on the Terminal window or the  button on the tool bar.



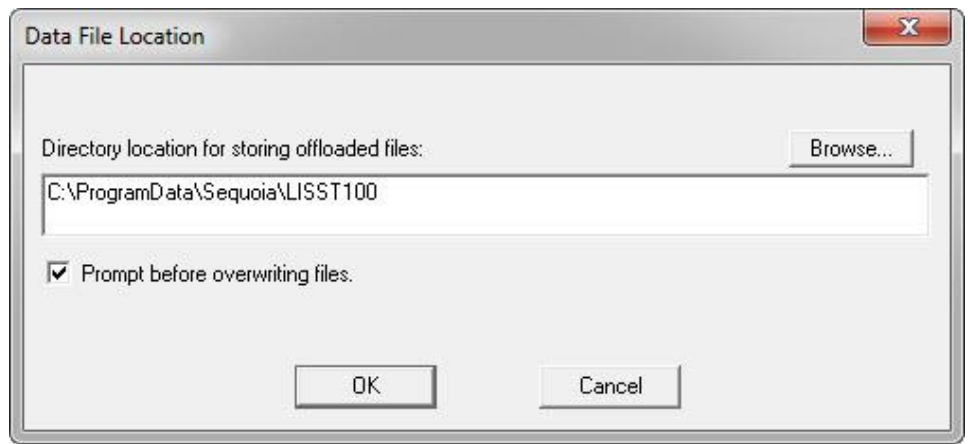
It is good practice to always send a Stop command to the instrument before attempting any other communication with the instrument.

**Step 20:
Downloading
data**

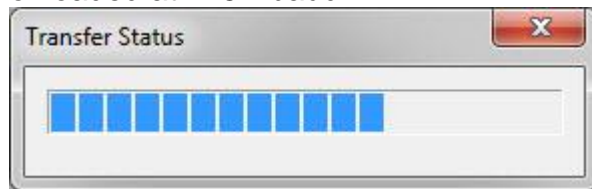
The instrument has now stored data in the on-board Compact Flash card. Pressing the Instrument Query Button , will display the instrument status including the number of samples saved. To offload the data select *Offload* from the *LISST* menu or choose the  button from the toolbar. A list of files will appear:



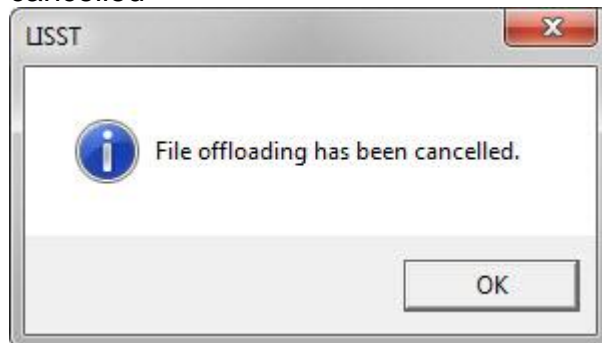
Choose the files to offload by clicking on them while holding down the CTRL key. The Shift key can also be used to select a range of files. Select OK and then choose a location to save the files to.




The files will be saved with names in the following format: *Ldddhhmm.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.

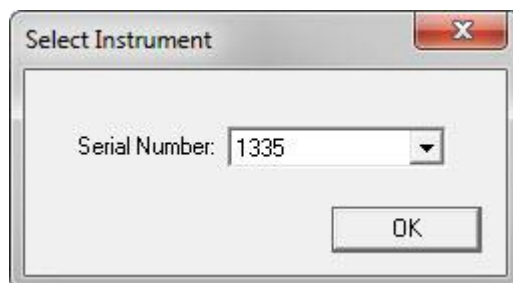
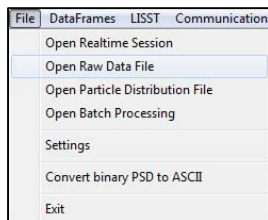


If you click the cancel button in the upper right corner of the transfer window the current file transfer (and any remaining file transfers) will be cancelled

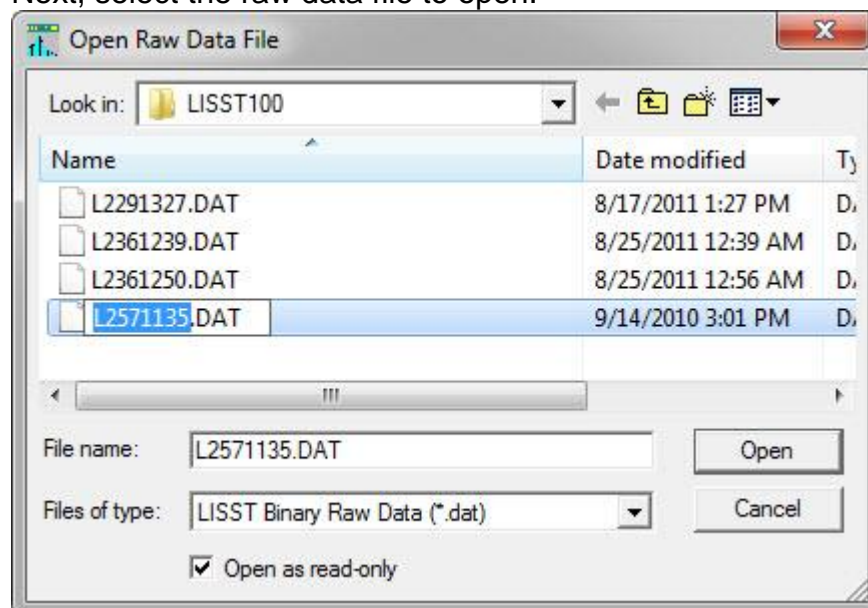


Step 21: Processing Raw Data

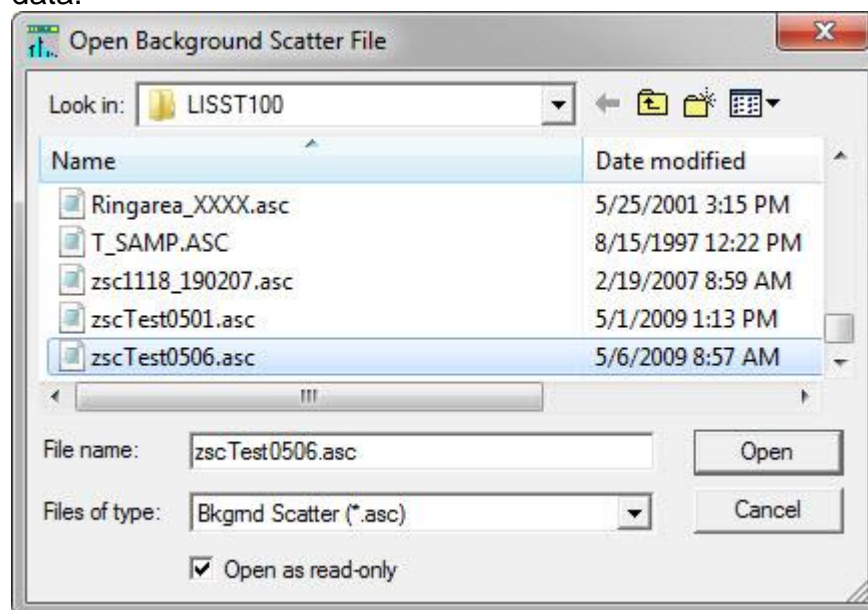
We now have the data transferred from the instrument to the PC. To process the data file choose '*File | Open Raw Data File*' or press the  button on the toolbar. Select the instrument serial number in the drop down menu. Only instruments that are listed in the InstrumentData.txt and LISST.ini files are listed.



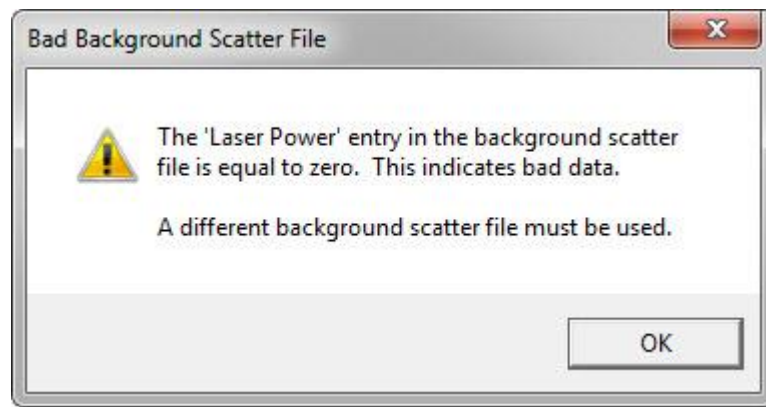
Next, select the raw data file to open.



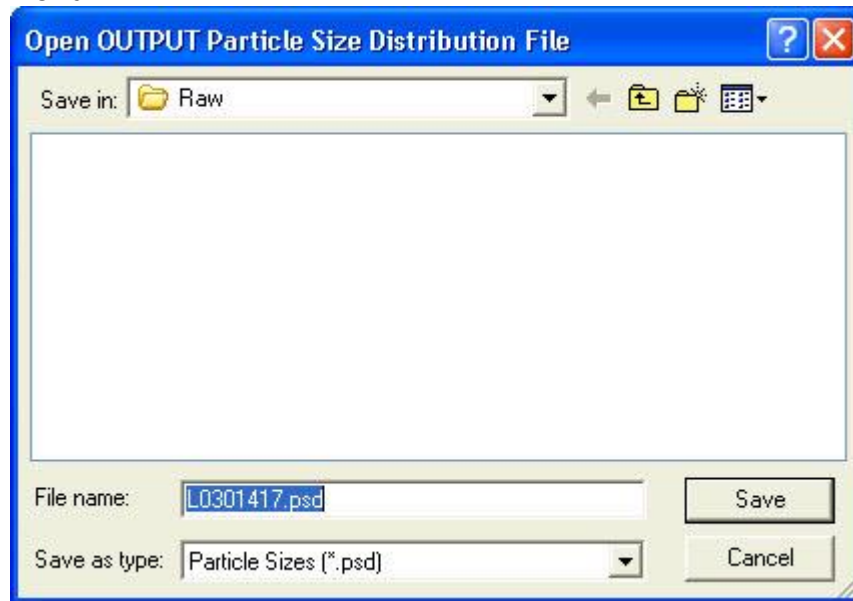
Next, select the background scatter file to use when processing the data.



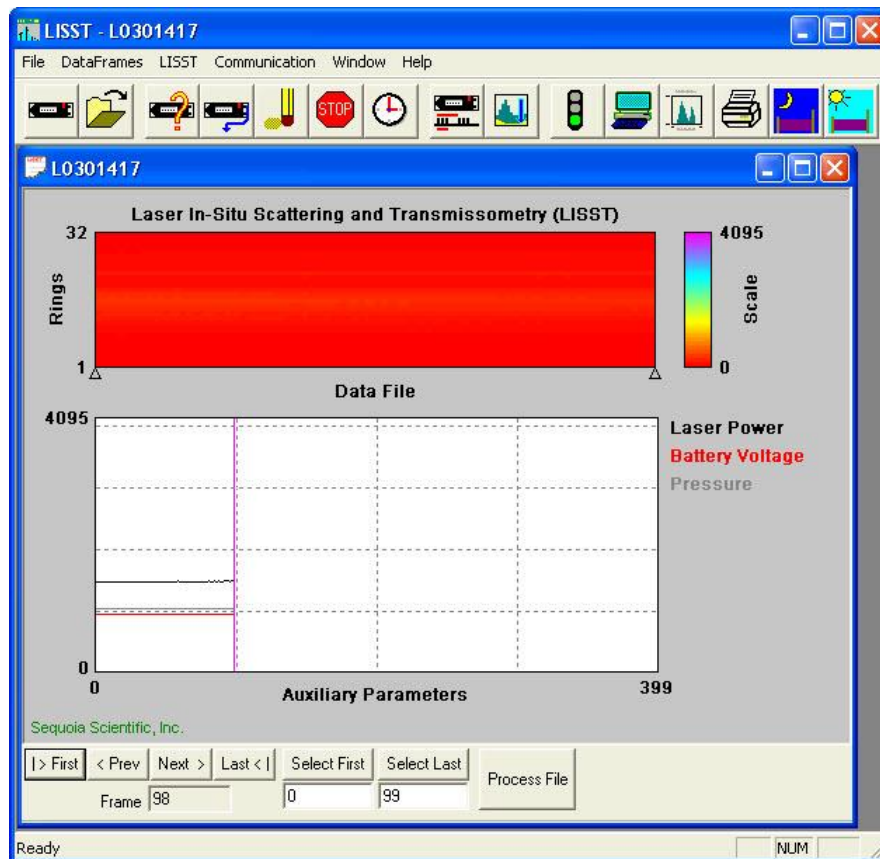
The LISST-SOP will do a check of the laser power value in the selected background scatter file. If the laser power is 0 (zero), a warning is displayed and the user must select another background scatter file.



Finally, specify the output file name for the processed data. Note that a .PSD file is always created. Any other file types (.ASC or .LOG) being created depends on the selections in the Settings selection in the File menu.

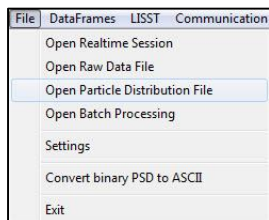



The software will automatically determine the Instrument Type (B or C) using the Serial Number and the InstrumentData.Txt file. Also the detector calibration file (RingArea file) is being selected automatically based on the serial number. A display similar to the one shown below will appear.

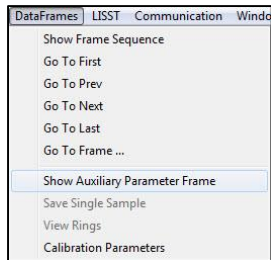
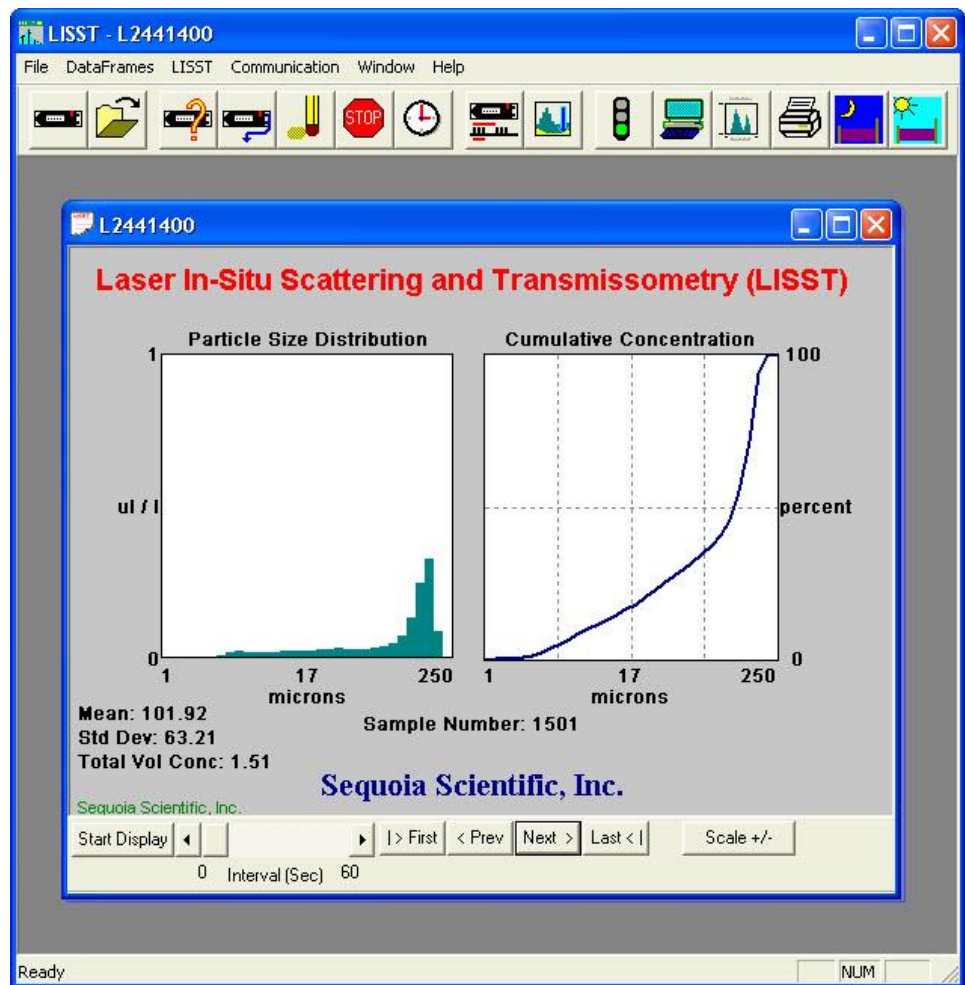


The range of samples to process can be selected by entering values in the *Select First* and *Select Last* boxes. The default selection is to process the complete file. Press the *Process File* button to convert the raw file into processed size distributions. For more details on the available options when this window is open please see the detailed Instruction for Processing Raw Datafiles. For our example press the *Process File* button in order to process the entire file. When the processing is complete the button label will change to read *Finished*.

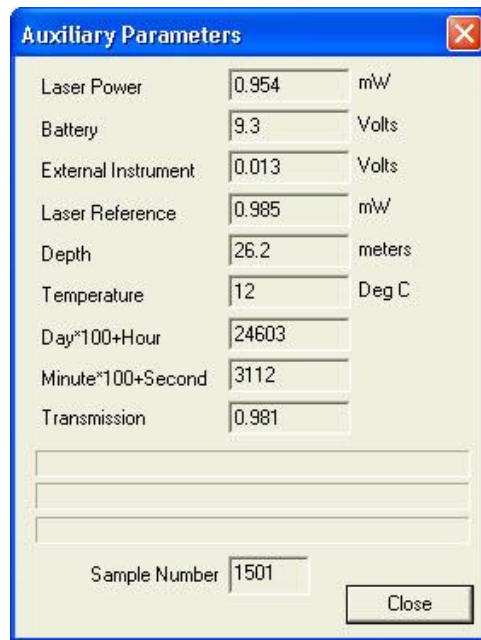
Step 20: Viewing Processed Results



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 *Start Display* 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 *Stop Display* 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.

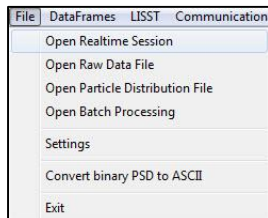



Step 21: Opening RealTime Session

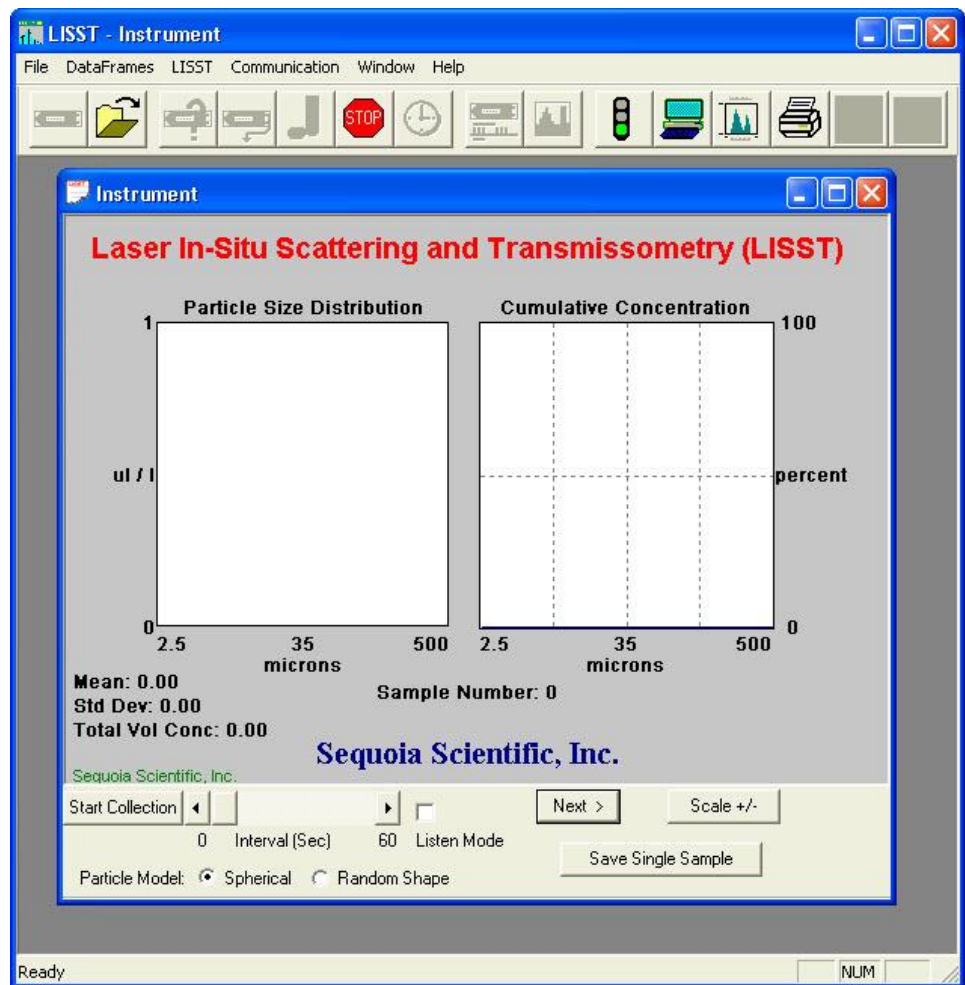
The LISST-SOP software also supports the ability to acquire data, process it, and display it in Real-time. The Real-time display of the processed data is very similar to the display of processed data. The instrument can be configured for a Real-Time session before data is collected but it is no longer 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: For extended Real-Time sessions it is recommended to use external power. 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 Start Collection button to start and stop continuous 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.

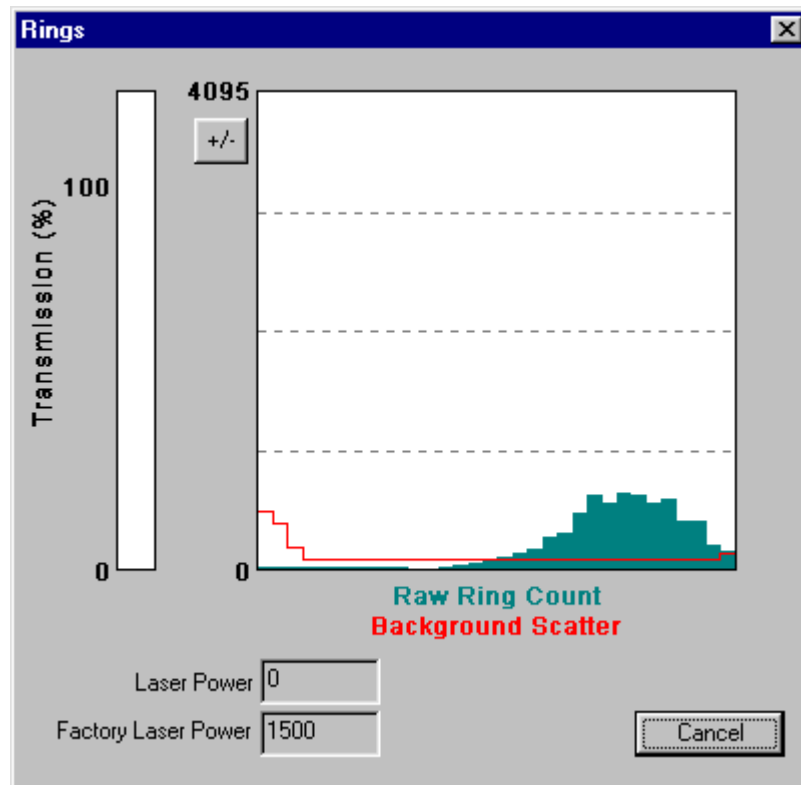
The Next button is used if the continuous data collection mode is not being used. Pressing the next button will command the LISST to make a measurement and transmit the data to the SOP for display.

The Spherical / Random Shape radio buttons can be selected in order to display the results as being processed under the assumption that the particles are spheres or randomly shaped (natural grains) particles.

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

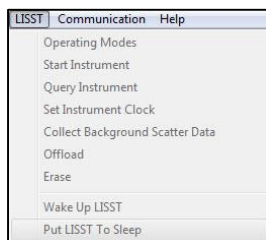
DataFrames menu. A typical display is shown below.



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 80 μ a. 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 or using the buttons on the toolbar. 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 Scatter file (zscat file)	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. Page 42.
Downloading raw data files	Each data collection sequence is stored to a separate datafile on the compact flash memory. Files can be offloaded to the PC using the Download data function of the LISST-SOP software. Page 44.
Deleting Raw data files	After downloading the data files can be deleted from memory. This step-by-step procedure covers deleting files. Page 46.
Processing a single raw data file	Data that has been downloaded from the datalogger on the LISST-100X is in a raw binary file (.DAT extension). It must be processed into particle size by the LISST-SOP program. If you only have one raw data file to process (e.g. from a long-term mooring deployment), follow these processing steps that includes optional displays and procedures. Page 47.
Batch Processing Multiple raw data files	Data that has been downloaded from the datalogger is in a raw binary file (.DAT extension). It must be processed into particle size by the LISST-SOP program. If you have multiple raw data files to process (e.g. from a series of profiling deployments), follow these processing steps that allows you to process all files in one operation. Page 54.
Batch Processing Multiple raw data files from the command line	Data that has been downloaded from the datalogger is in a raw binary file (.DAT extension). It must be processed into particle size by the LISST-SOP program. However, if you have multiple raw data files to process (e.g. from a series of profiling deployments), it is possible to bypass the SOP and process the files in one operation using a command issued from the command line. Follow these processing steps to prepare your system for the command line processing. Page 59.
View Particle size data	After processing of the data into a Particle Size Distribution file (.PSD extension) the data can be viewed to the screen. This step-by-step procedure covers the viewing of data and optional displays. Page 61.
Data Quality Control	Basic data quality control is explained. Page 65.
Simple Real-time data processing	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. Page 67.


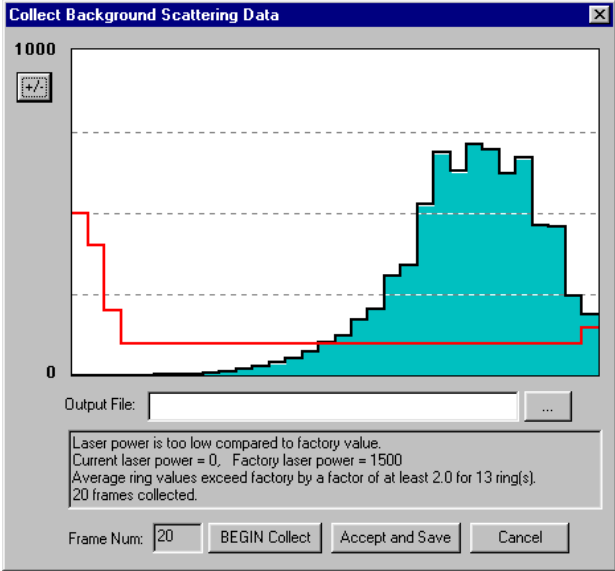
**Advanced
Real-time data
processing**

The advanced real-time data processing allows for using all data collection modes and start/stop options (e.g. burst mode, delayed start, pressure start) with the real-time processing and display. Page 71.

**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 lists the available options and the unique features of each. Page 77.

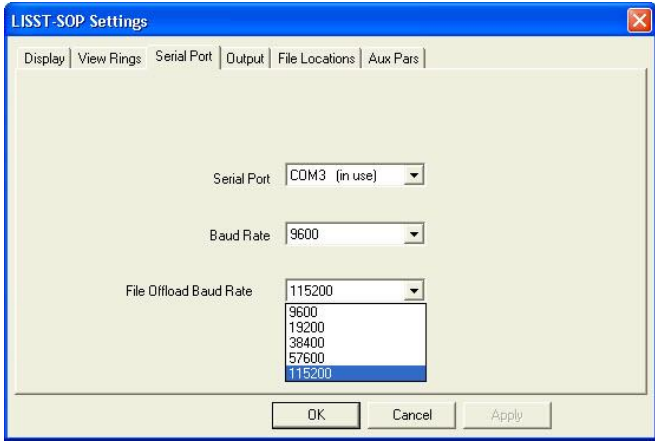
STEP BY STEP PROCEDURE: RECORD AND STORE BACKGROUND SCATTERFILE

Step	Action	Result
1	<ul style="list-style-type: none"> Clean instrument and install Horizontal test chamber. Fill with clean filtered water 	Optics submerged in water
2	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Open the <i>Collect Background Scatter Data</i> from the <i>LISST</i> 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.  <p>When the <i>BEGIN Collect</i> 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 <i>Accept and Save</i> button.</p>	Background collected and saved.



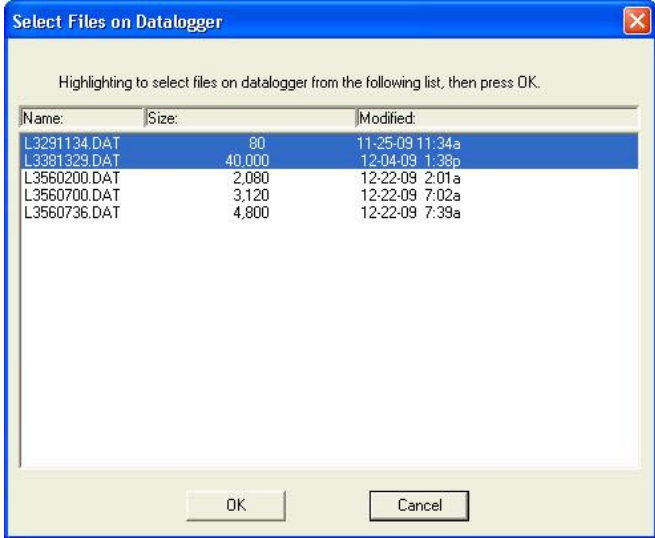
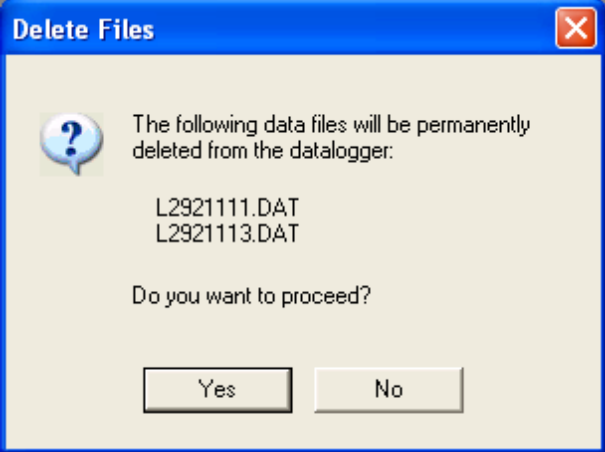
4	<ul style="list-style-type: none"> • If there is a problem with the instrument or if the water or windows are not clean, error messages will be displayed. Dirty water or windows will generally cause higher values across the middle rings. Large bubbles or particles in the water can cause higher values 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. 	
5	<ul style="list-style-type: none"> • The SOP will apply simple quality control checks to the background data. If the background does not pass any of the QC checks, you will be notified of the most likely cause of failure (e.g. dirty windows, bubbles, ect.). Follow the instructions in the message to improve the background. You should not rely solely on the SOP quality control checks when deciding to accept a background. The SOP will check for the most likely background problems however its algorithm is not exhaustive. Do your best to insure the instrument and background water are as clean as possible. 	Background QC messages will help you collect the best background possible

STEP BY STEP PROCEDURE: OFFLOADING DATA FILES

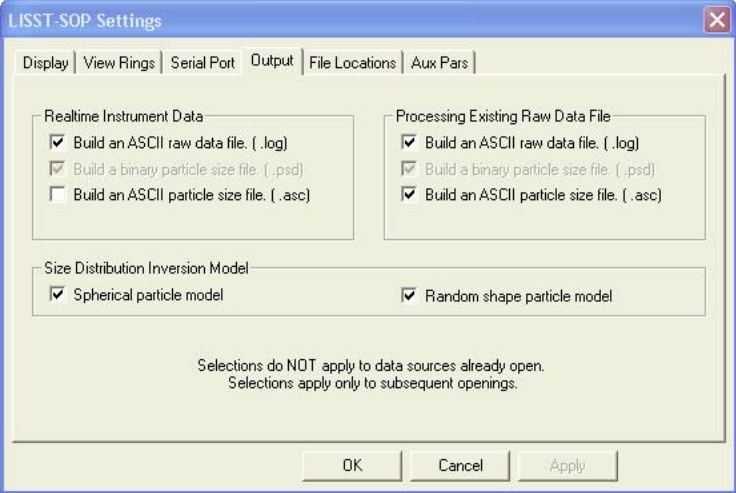
Step	Action	Result
1	<ul style="list-style-type: none"> Start LISST-SOP program 	Program started.
2	<ul style="list-style-type: none"> Select Offload from the LISST menu or press on the Offload button. 	Gets current directory of files from memory and displays the list.
3	<ul style="list-style-type: none"> 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. <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> </div> <ul style="list-style-type: none"> 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. Press OK to begin the offloading. <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> </div> <ul style="list-style-type: none"> The file names will remain the same as on the compact flash card. The file creation date and time will not be preserved. 	Files selected and path set

4	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> The standard offload baud rate is 115K. If you are using a long offload cable (e.g. 20, 30 or 50 m cable, see Appendix H: LISST Accessories on page 138) this value may be too high and cause errors during offloading. If an offload error occurs, you can change the offload baud rate as follows: 	
6	<ul style="list-style-type: none"> Go to Settings in the File Menu and click the Serial Port tab. In the File Offload Baud Rate drop down menu, choose a lower baud rate and try again.  <ul style="list-style-type: none"> NOTE: The change in download baud rate is only supported by LISST-100X firmware versions higher than 1.900. If you do not see the dropdown box, your firmware version does not support change in baud rate. Contact Sequoia (info@SequoiaSci.com) in order to get a later firmware version that will support changes in offload baud rates. 	
Notes :		

STEP BY STEP PROCEDURE: DELETING FILES FROM MEMORY

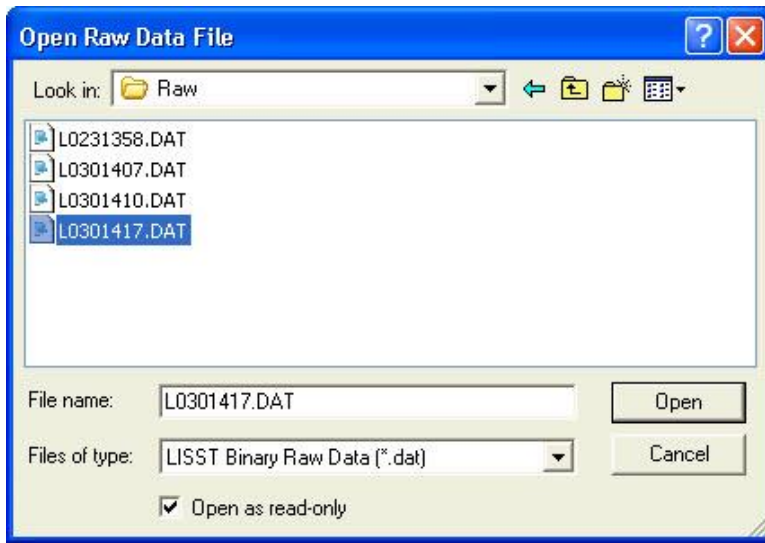
1	<ul style="list-style-type: none"> Start the LISST-SOP program and click the  button to connect to the LISST-100X. 	
2	<ul style="list-style-type: none"> Click  button or select the <i>Erase</i> option from the <i>LISST</i> menu. A list of files on the datalogger will appear. 	
3	 <p>Select the files to be deleted, then click the OK button. Use the CTRL key to select multiple files or the SHIFT key to select a range of files.</p>	
4	 <ul style="list-style-type: none"> Confirm the files to be deleted by clicking the Yes button. <p>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</p>	

STEP BY STEP PROCEDURE: PROCESSING A SINGLE RAW DATA FILE

Step	Action	Result
1	<ul style="list-style-type: none"> Start the LISST-SOP program 	Program started.
2	<ul style="list-style-type: none"> 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. This selection must be made BEFORE starting the processing command.  <ul style="list-style-type: none"> NOTE: A binary PSD file is always created when processing raw data. This is used to display the processed data to the screen using the software. The ASC file is a space delimited ASCII file containing the fully processed and calibrated data. This is useful for loading into spreadsheets such as Excel etc. The LOG file is a space delimited ASCII file containing the raw data from the LISST-100X data logger. This is useful for looking at the raw data in a spreadsheet such as Excel etc. 	Select file types to be created.
3	<ul style="list-style-type: none"> You must also select the inversion model to be used with the real time data processing: Spherical, randomly shaped or both. The Spherical particle model performs the mathematical inversion under the assumption that the particles that scattered light are all spheres. Sequoia employs the full Mie solution when using this approach. The Mie solution is a generalized solution to the scattering of light from spheres and is being used as the standard inversion method by all laser manufacturers. 	Select inversion method(s) to be used – spherical, randomly shaped or both.

	<ul style="list-style-type: none"> • However, sediment particles in the aquatic environment are never perfect spheres. Consequently Sequoia provides an option to invert the scattering pattern under the assumption that the particles are randomly (or irregularly) shaped particles. The exact details of how this inversion takes place is described in a scientific paper by Agrawal et al.⁶, which can be downloaded from the library section on Sequoia’s website (www.SequoiaSci.com). The direct URL is http://www.sequoiasci.com/library/technical-papers/. The paper is also included on your ship disk. A brief version of the method is described in this News article on Sequoia’s website: http://www.sequoiasci.com/article/random-shaped-particles-lissts/ • So what method should you use? If you are going to compare with the output from another laser particle sizer, for example a laboratory particle sizer, you should choose the Spherical particle model. The reason for this is that no other laser manufacturer provides a randomly shaped particle model for inversion, so there will be nothing to compare to. Generally, it is recommended that you keep both boxes checked (this is also the default option), so that you won’t have to reprocess your data because you need to see what the data look like when processed as randomly shaped particles. • Please note that when you choose to process your raw data files using the Random shaped particle option, the size range of the processed data changes according to Appendix A: Size Ranges, Observation Angles, Data Storage Format on page 112, although the raw scattering data that are being processed are exactly the same. For details, please consult the paper by Agrawal et al.(2008) 	
4	<ul style="list-style-type: none"> • Select Open Raw Data File from the File menu 	Begins process of

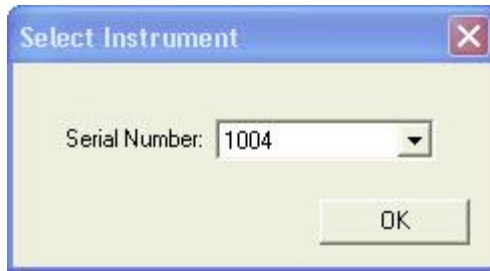
⁶ Agrawal YC, Whitmire A, Mikkelsen OA, Pottsmith HC (2008): Light scattering by random shaped particles and consequences on measuring suspended sediments by laser diffraction. Journal of Geophysical Research, Vol. 113, C04023, doi:10.1029/2007JC004403.



specifying raw data file and all information needed for data processing.

5

- Choose the serial number of the instrument that collected the data to be processed.

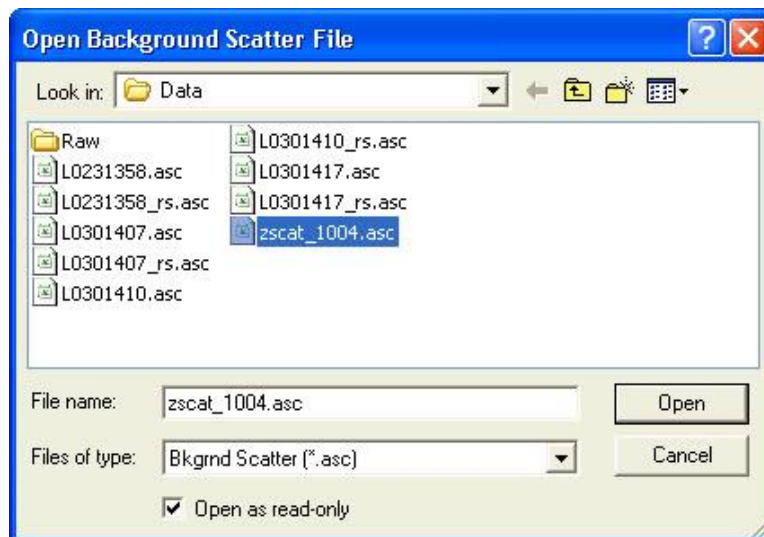


Instrument serial number selected.

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.

6

- Select the background scatter data file from the file selection window.

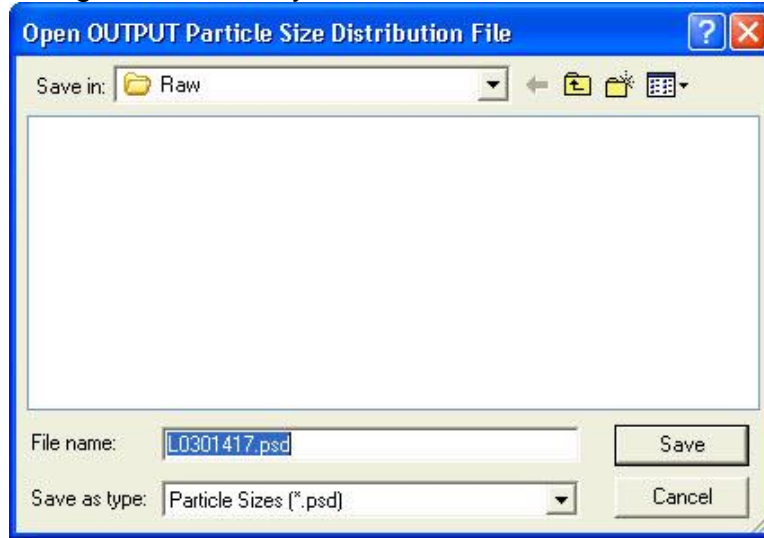


Background scatterfile selected.

Double click the file or type the file name and press Open.

7

- Select the output data file name. The default file name shown is the same as the raw data name but with a .PSD extension (Particle Size Distribution). You can change this name if you wish.



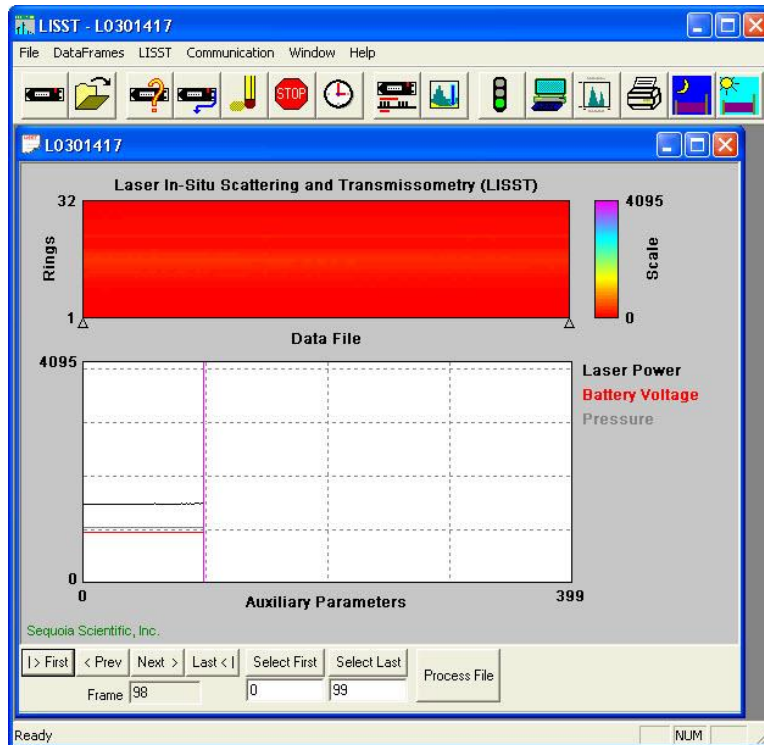
If other output types are selected they will automatically have the same base name but with different extensions.

- **Note:** file types other than the default PSD file must have been selected before starting the Open Raw Data file command. See step 2.

Output data file name selected.

8

- 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.

Main data processing selection window displayed to the screen.

- 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.

9

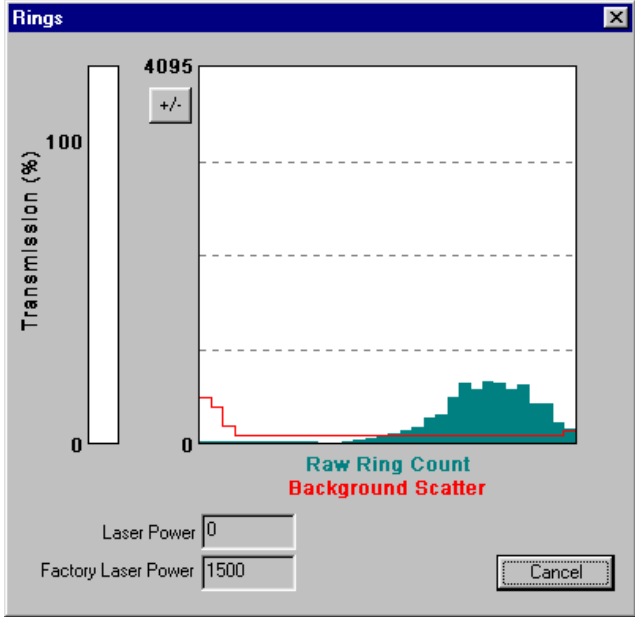
- Additional information is stored in the processed datafile. The Auxiliary parameter window displays these values for the current sample pointed to by the vertical cursor. They will update as the cursor is moved. Selecting the Show Auxiliary Parameter Frame from the DataFrames menu opens the window. An example of this window is shown below.

The screenshot shows a window titled "Auxiliary Parameters" with a close button (X) in the top right corner. The window contains a list of parameters, each with a text input field and a unit label:

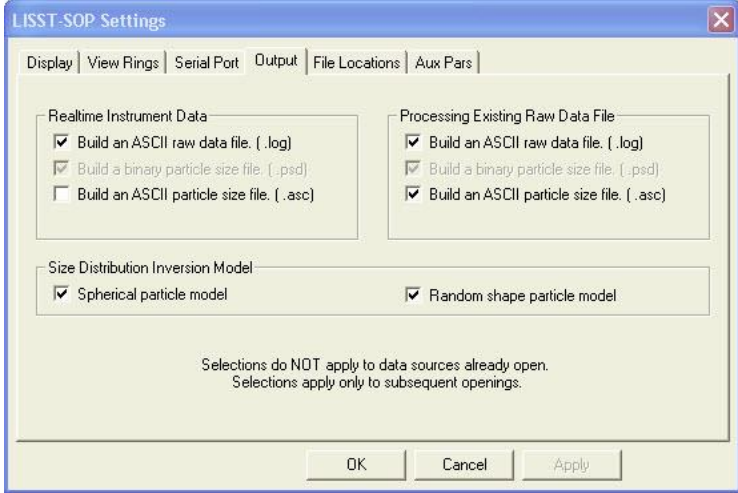
Laser Power	0.954	mW
Battery	9.3	Volts
External Instrument	0.013	Volts
Laser Reference	0.985	mW
Depth	26.2	meters
Temperature	12	Deg C
Day*100+Hour	24603	
Minute*100+Second	3112	
Transmission	0.981	

Below the list are three empty text input fields. At the bottom, there is a "Sample Number" field containing the value "1501" and a "Close" button.

Auxiliary parameter window displayed.

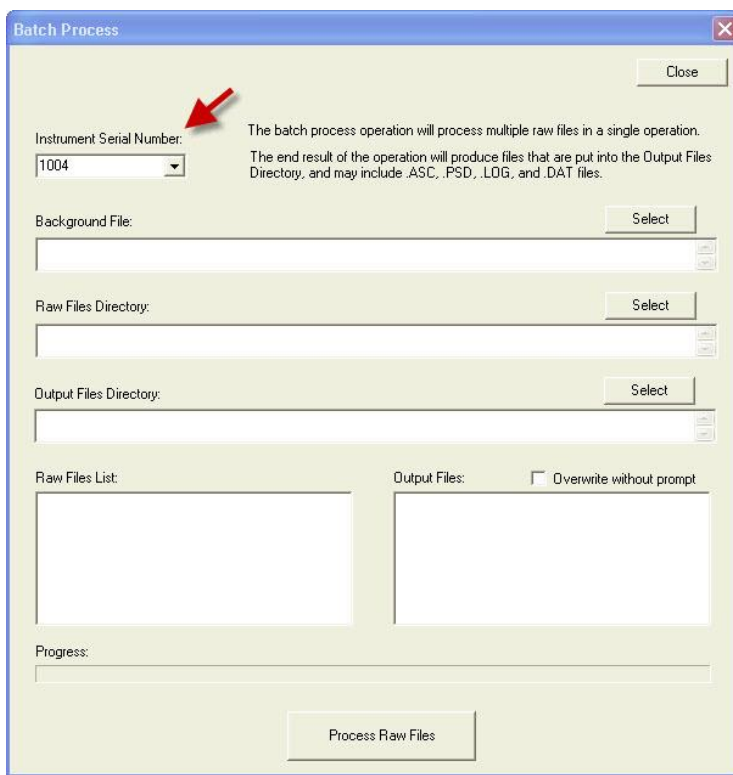
<p>10</p>	<ul style="list-style-type: none"> The raw scattering values can be graphically displayed by selecting the <i>View Rings</i> command from the <i>DataFrames</i> menu. An example of this display is shown below. As with the Auxiliary Parameters, the vertical cursor indicates the sample currently displayed. 	<p>Value of rings for current frame displayed.</p>
<p>11</p>	<p>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 <i>Select First</i> button will set the current cursor position as the starting point for processing. Similarly selecting <i>Select Last</i> will set the end point for processing. Use the <i>Next</i> and <i>Previous</i> buttons scroll through the complete datafile. The <i>Select First</i> and <i>Select Last</i> points do not need to be on the same displayed plot.</p>	<p>Range to process selected.</p>
<p>12</p>	<p>After selecting the range to process press the <i>Process File</i> button. The display will show the processing progress and the <i>Process File</i> button text will change to <i>Finished</i> when the processing is complete. The window can now be closed.</p>	<p>Processing Completed</p>
<p>Notes :</p>		

STEP BY STEP PROCEDURE: BATCH PROCESSING MULTIPLE RAW DATA FILES

Step	Action	Result
1	<ul style="list-style-type: none"> Start the LISST-SOP program 	Program started.
2	<ul style="list-style-type: none"> 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. This selection must be made BEFORE starting the processing command.  <ul style="list-style-type: none"> 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 space delimited ASCII file containing all the processed data. The LOG file is a space delimited ASCII file containing the raw data from the LISST-100X data logger. 	Select file types to be created.
3	<ul style="list-style-type: none"> You must also select the inversion model to be used with the real time data processing: Spherical, randomly shaped or both. The Spherical particle model performs the mathematical inversion under the assumption that the particles that scattered light are all spheres. Sequoia employs the full Mie solution when using this approach. The Mie solution is a generalized solution to the scattering of light from spheres and is being used as the standard inversion method by all laser manufacturers. 	Select inversion method(s) to be used – spherical, randomly shaped or both..

	<ul style="list-style-type: none"> • However, sediment particles in the aquatic environment are never perfect spheres. Consequently Sequoia provides an option to invert the scattering pattern under the assumption that the particles are randomly (or irregularly) shaped particles. The exact details of how this inversion takes place is described in a scientific paper by Agrawal et al.⁷, which can be downloaded from the library section on Sequoia's website (www.SequoiaSci.com). The direct URL is http://www.sequoiasci.com/library/technical-papers/. The paper is also included on your ship disk. A brief version of the method is described in this News article on Sequoia's website: http://www.sequoiasci.com/article/random-shaped-particles-lissts/. • So what method should you use? If you are going to compare with the output from another laser particle sizer, for example a laboratory particle sizer, you should choose the Spherical particle model. The reason for this is that no other laser manufacturer provides a randomly shaped particle model for inversion, so there will be nothing to compare to. Generally, it is recommended that you keep both boxes checked (this is also the default option), so that you won't have to reprocess your data because you need to see what the data look like when processed as randomly shaped particles. • Please note that when you choose to process your raw data files using the Random shaped particle option, the size range of the processed data changes according to Appendix A on page 112, although the raw scattering data that are being processed are exactly the same. For details, please consult the paper by Agrawal et al.⁵ 	
4	<ul style="list-style-type: none"> • Select Open Batch Processing from the File menu 	Begins process of specifying raw data files and all information needed for batch data processing.
5	<ul style="list-style-type: none"> • Choose the serial number of the instrument that collected the data to be processed. 	Instrument serial number selected.

⁷ Agrawal YC, Whitmire A, Mikkelsen OA, Pottsmith HC (2008): Light scattering by random shaped particles and consequences on measuring suspended sediments by laser diffraction. Journal of Geophysical Research, Vol. 113, C04023, doi:10.1029/2007JC004403.

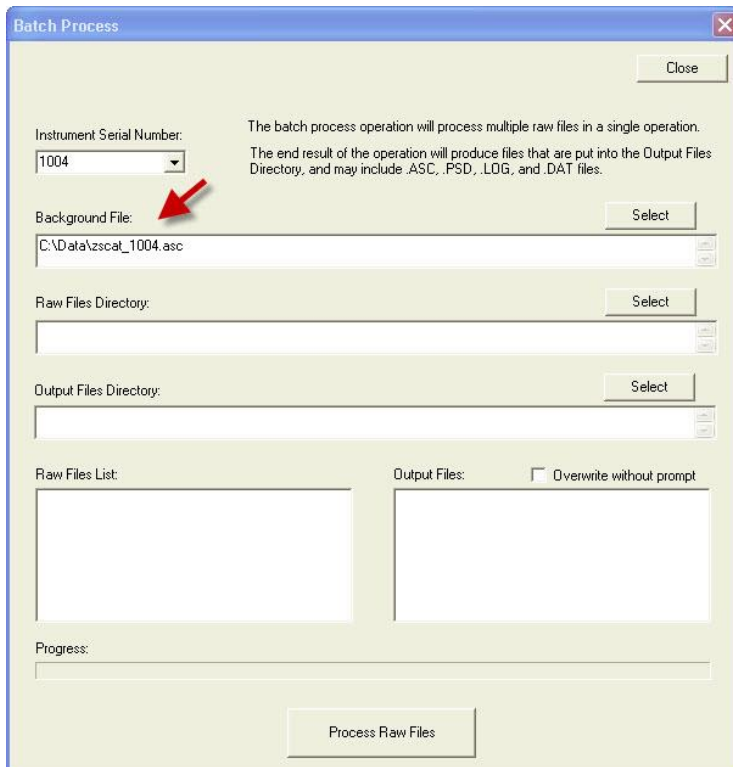


- Only the serial numbers of the instruments loaded into the InstrumentData.Txt file and have the calibration values loaded into the LISST.INI file in the Windows directory can be used.

6

- Select the background scatter file (zscat file) to be used for processing your data. Click the select button and navigate to the folder where your zscat file is located and select it.

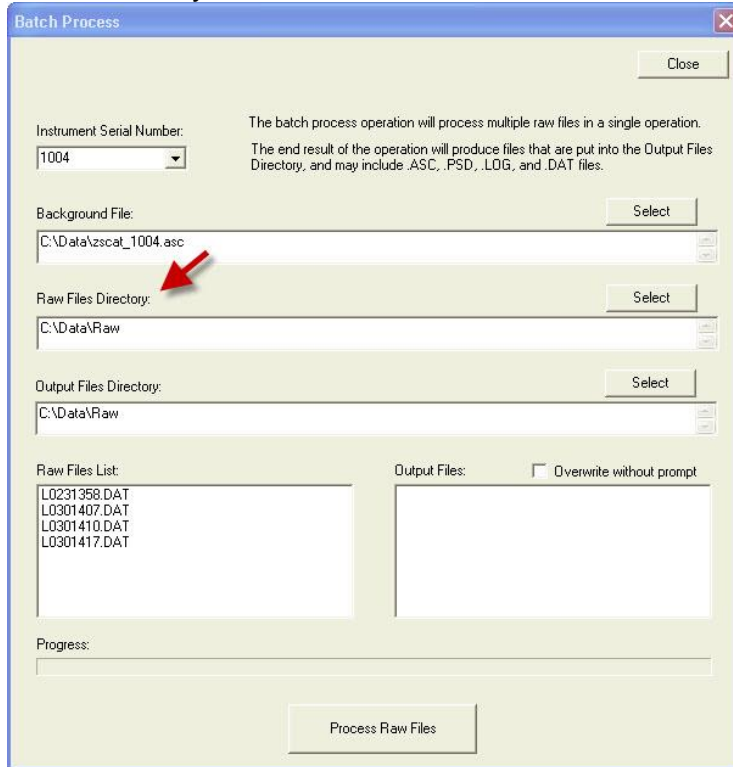
Background scatterfile selected.



7

- Select the directory where your raw data files (.DAT or .LOG extension) are located. Click the select button and navigate to the desired folder and select it. Please note that ALL raw data files in the folder will be processed. If you wish to only process a selection of files in a folder, these files must be copied to an empty directory, which must then be selected as the Raw Files Directory.

Raw Files Directory selected.



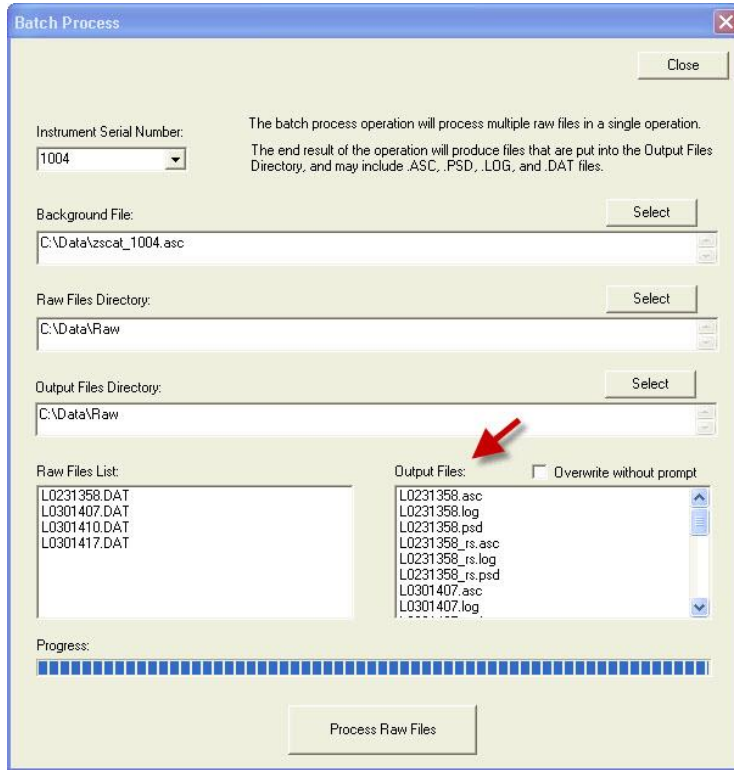
- By default, the Output Files Directory will be the same as the Raw Files Directory. However, if you wish to change this to another directory, then click the select button in order to choose another directory.
- The Raw Files List box now shows all the raw data files (.DAT or .LOG extension) that are in your Raw Files Directory, while the Output Files Box shows .ASC, .PSD, and .LOG files that may already exist in the Output Files Directory.
- You cannot change the output file names. The file name of the processed files will be the same as that of the raw data files, but with a different extension (e.g. .ASC, .PSD or .LOG). If you have selected Randomly shaped Particle Inversion Model, the processed files will have an _rs suffix
- **Note:** file types other than the default PSD file must have been selected before starting the Open Raw Data file command. See step 2.

8

- You can now click the Process Raw Files button and all raw data files will be processed. The processed

Batch processing..

files will show up in the Output Files window. Note that in this case there are 6 processed files for each raw data file: An .ASC, .PSD and .LOG file for both spherical and random shape inversions. Note that the files processed using the randomly shaped inversion method have an _rs suffix.



9

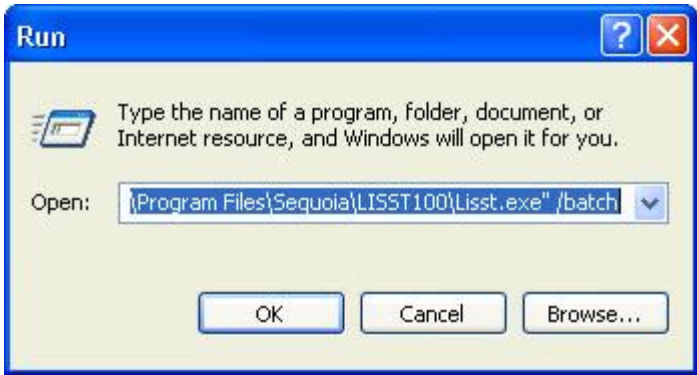
- Click the close button in the top right when you are done.

Close the batch processing window.

Notes

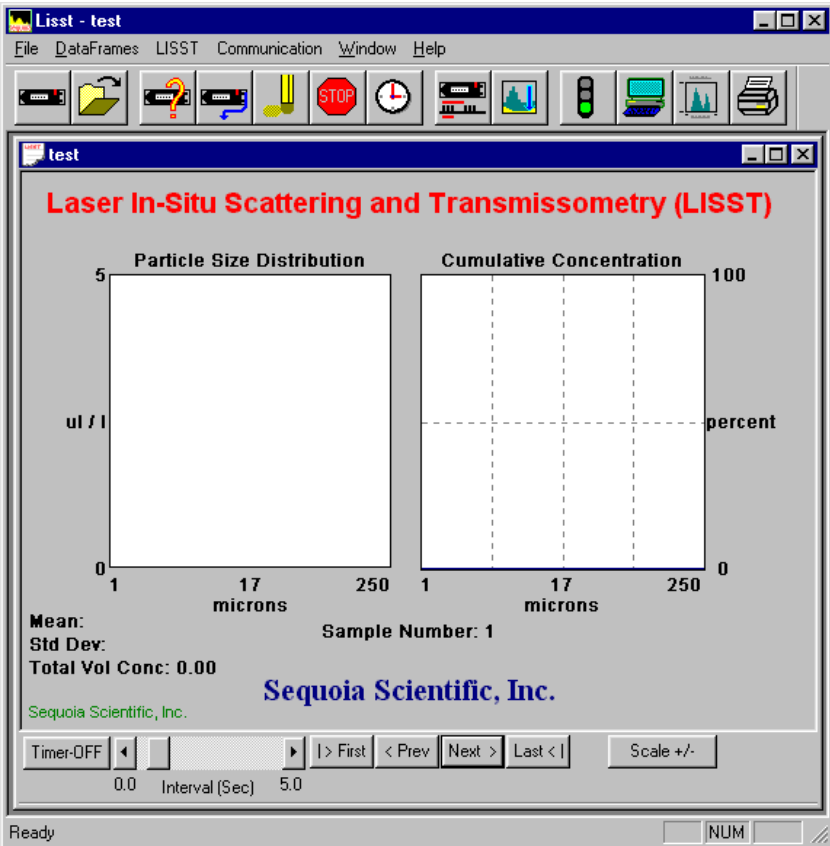
:

STEP BY STEP PROCEDURE: BATCH PROCESSING MULTIPLE RAW DATA FILES FROM THE COMMAND LINE

Step	Action	Result
1	<ul style="list-style-type: none"> Once you have processed one set of batch files, it is possible to call the batch processing routing from the command line for future use. 	Batch processing from the command line.
2	<ul style="list-style-type: none"> The command line batch command DOES NOT accept directories or filename inputs. In order for it to work, you MUST FIRST batch process a set of files using the batch processing procedure described on page 54, in order to set up correct paths for the zscat files and raw and processed directories to be used. The paths and file names are stored in the LISST.INI file, which resides in the C:\Program Data\Sequoia\LISST100 directory. You can examine the LISST.INI file before and after batch processing to gain familiarity with the changes that happens to the INI file. 	Precautions using batch processing from the command line.
3	<ul style="list-style-type: none"> Issue the following command at the command line prompt: lisst.exe /batch and all files in the directories selected in the Batch Processing Files menu will be processed for the instrument serial number and zscat file selected. The LISST SOP program will not open up and you will not be given any status bar. <div style="text-align: center;">  </div> <ul style="list-style-type: none"> If you are not issuing the batch command from the directory where the lisst.exe program resides, you must specify the full directory, e.g. C:\Program Files\Sequoia\LISST100\lisst.exe /batch or "C:\Program Files\Sequoia\LISST100\lisst.exe" /batch 	Issuing the batch processing command.

Notes :	
-------------------	--

STEP BY STEP PROCEDURE: VIEW PROCESSED DATA FILE

Step	Action	Result
1	<ul style="list-style-type: none"> Start LISST-SOP program 	Program started.
2	<ul style="list-style-type: none"> Select <i>Open Particle Distribution File</i> from the <i>File</i> menu. 	Open Particle Distribution File selected.
3	<ul style="list-style-type: none"> 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.
4	<ul style="list-style-type: none"> After selecting the processed file a window similar to the one shown below will appear.  <p>The screenshot shows the LISST software window titled 'Lisst - test'. It features a menu bar with 'File', 'DataFrames', 'LISST', 'Communication', 'Window', and 'Help'. Below the menu is a toolbar with various icons. The main display area is titled 'test' and contains two side-by-side graphs. The left graph is labeled 'Particle Size Distribution' and the right is 'Cumulative Concentration'. Both graphs have a y-axis from 0 to 5 (labeled 'ul / l') and an x-axis from 1 to 250 (labeled 'microns'). The cumulative concentration graph also has a secondary y-axis from 0 to 100 (labeled 'percent'). Below the graphs, the text reads: 'Mean:', 'Std Dev:', 'Total Vol Conc: 0.00', and 'Sample Number: 1'. At the bottom, there is a control panel with buttons for 'Timer-OFF', navigation arrows, ' > First', '< Prev', 'Next >', 'Last < ', and 'Scale +/-'. A slider bar for 'Interval (Sec)' is set to 5.0. The status bar at the bottom left shows 'Ready' and 'NUM'.</p>	
5	<ul style="list-style-type: none"> 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 <i>Timer</i> 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 <i>Timer</i> button. 	

6

- 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.

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

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.

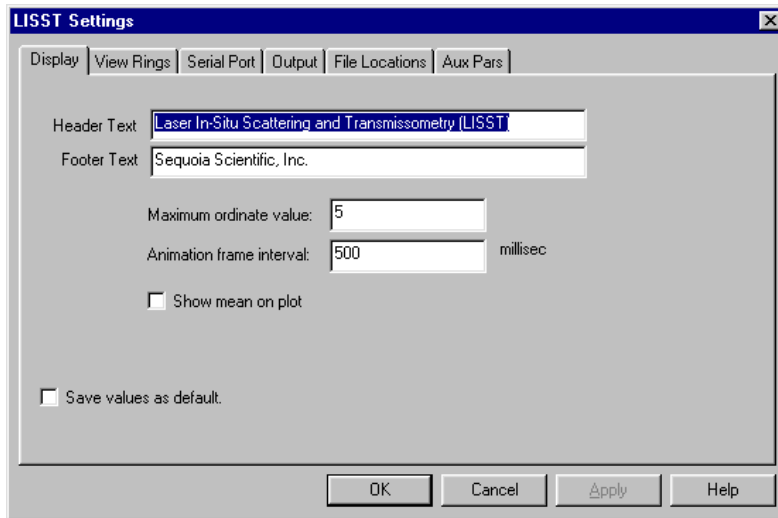
Maximum Scale Setting

Maximum Scale Value: 5

Cancel OK

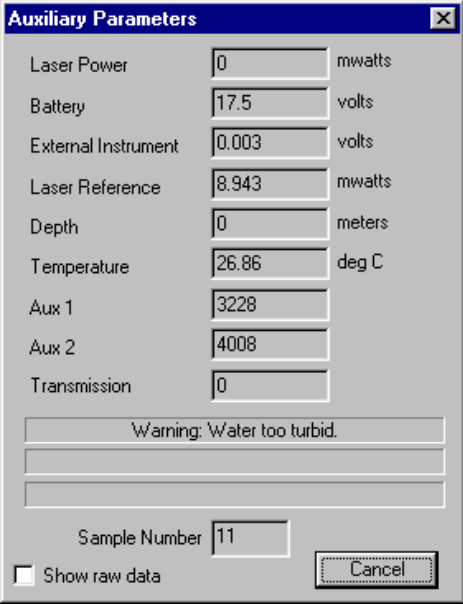
- Other options are also available for customizing the display such as changing the header and footer text or adding lines to show the mean and standard deviation. These features are located on the *Display* tab of the *Settings* window as shown below.

Display setting modified.



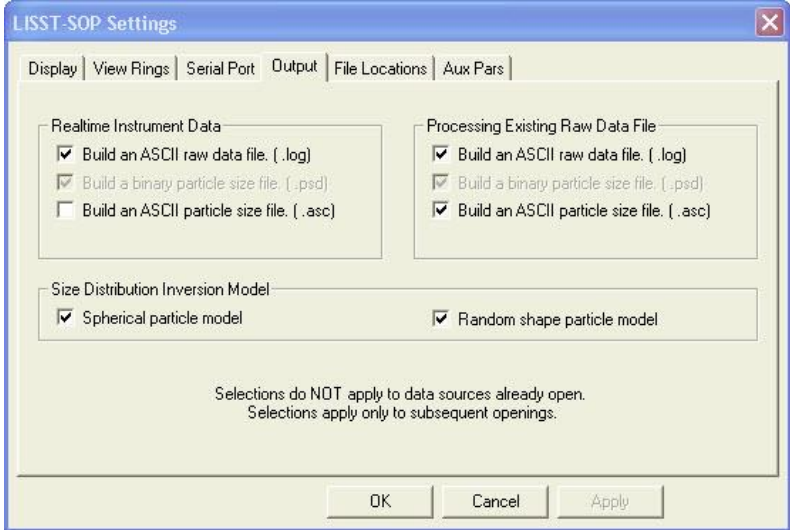

8	<ul style="list-style-type: none"> • The current display can be sent to the printer by choosing <i>Print</i> from the <i>File</i> menu. • <i>Print Preview</i> and <i>Print Setup</i> are also available. 	Display printed.
9	<ul style="list-style-type: none"> • When finished viewing the processed data close the window. 	Viewing of data complete.
Notes :		

STEP BY STEP PROCEDURE: DATA QUALITY CONTROL

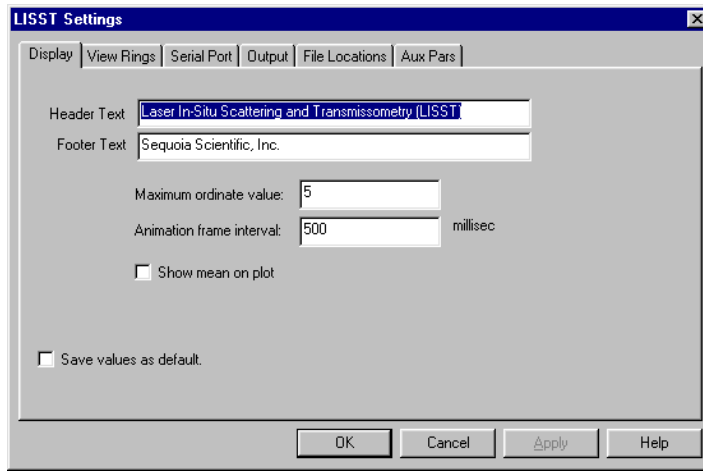
1	<ul style="list-style-type: none"> Follow steps 1-6 in the previous section: View Processed Data File and look at the Auxiliary Parameter Frame 	Data file loaded and Auxiliary Parameter frame shown.
2		
3	<ul style="list-style-type: none"> The first thing to look for is to make sure that the Laser Reference box is displaying numbers different than 0. In the example above Laser Reference is at 8.943 mW, but this number can vary from instrument to instrument, and will also vary as the instrument becomes older and, to some extent, with temperature. Values around 0.5-2 mW are the most common values. Laser Reference should never be 0 (or very close to 0, e.g. 0.02 mW). If this is the case the laser is most likely dead. In this case only your pressure data and temperature data will be any good. The laser must be replaced. Contact Sequoia or your local distributor for instructions on what to do. Tip: If you selected 'Create .ASC file' when processing your data, you can load the .ASC file into Excel or another spreadsheet and easily check all the Laser Reference values - the Laser Reference value is in column number 36 (column AJ in Excel). 	Check your Laser Reference values – they *MUST* be >> than 0.

4	<ul style="list-style-type: none"> The next thing to look for is to check the Transmission values. The transmission must be a number between 0 and 1. It is physically impossible for the transmission to be negative or larger than 1 (one). Tip: The transmission value is in column 41 of the .ASC file (column AO in Excel). If transmission shows up as being larger than 1 (one), then your measurement is most likely taken in very clear water and/or you have a bad zscat measurement obtained with dirty water and/or dirty windows. If your zscat measurement was obtained using dirty water, it may be possible to redo the zscat using clean water and re-process the data, then check to see if the transmission values drop below 1 (one). 	It is physically impossible for the Transmission value to be less than 0 (zero) or larger than 1 (one).
5	<ul style="list-style-type: none"> If your transmission values generally are in the 0.98-0.995 range, your measurements are taken in very clear water. This means that the signal-to-noise ratio will be low, and the data may have a lot of noise in them, but can most likely still be used. 	Transmission values very close to 1 yields noisy data.
6	<ul style="list-style-type: none"> If your transmission values are < 0.10 (or 10%), the water is too turbid. Disregard these data. 	Data with transmission values < 10% should be disregarded.
7	<ul style="list-style-type: none"> If your transmission values are > 0.995 (or 99.5%), the water is too clear. Disregard these data. 	Data with transmission values > 99.5% should be disregarded.
8	<p>Summarizing</p> <ul style="list-style-type: none"> Disregard data if laser reference is 0 or very close to 0 (laser is dead, contact Sequoia). Disregard data if transmission is > 0.995 (> 99.5%). Disregard data if transmission is < 0.10 (< 10%). Be wary of data collected at transmission values between 0.98 and 0.995 – low signal-to-noise ratio. Be wary of data collected at transmission values between 0.30 and 0.10 – generally decreasing data quality as the transmission decreases below 0.30 (30%). 	Quick guide for data QC

STEP BY STEP PROCEDURE: SIMPLE REAL-TIME DATA PROCESSING

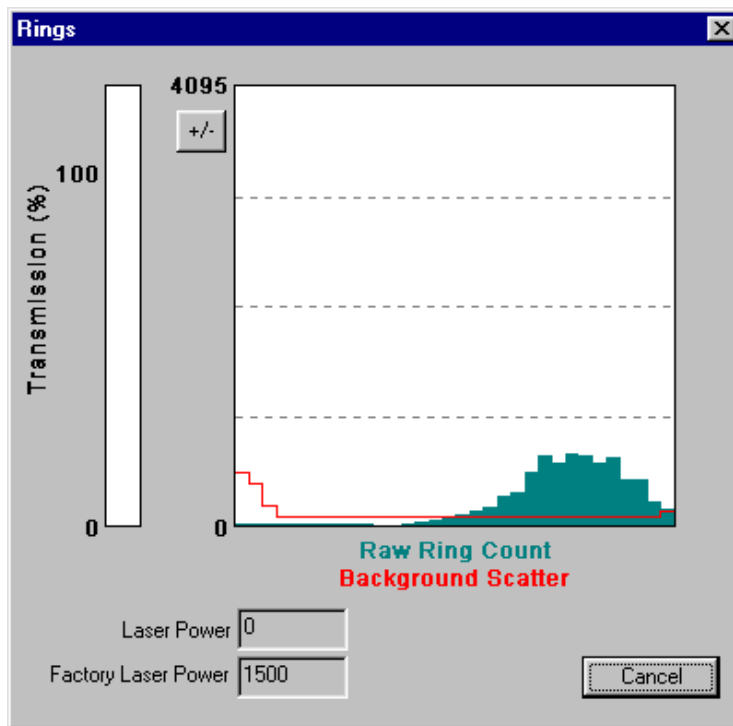
Step	Action	Result
1	<ul style="list-style-type: none"> Connect the instrument to the PC and start the LISST-SOP program. 	Program started.
2	<ul style="list-style-type: none"> Open the Operating Modes Window and choose the Real-Time Operating Mode. 	Instrument configured for Real-Time data collection.
3	<ul style="list-style-type: none"> Before starting a Real-Time session the output file options must be set. This must be done before selecting <i>Open Real-Time Session</i>. Select Output from the Options menu. The window below will appear. <div style="text-align: center;">  </div> <ul style="list-style-type: none"> 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. It is strongly recommended that you always build a LOG file, otherwise troubleshooting the data will be very difficult if any problems or questions about the data quality should appear. You must also select the inversion model to be used with the real time data processing: Spherical, randomly shaped or both. For details on these selections, see page 47. 	Output file type selected.
4	<ul style="list-style-type: none"> Select Open Real-Time Session from the File menu or press on the  button. 	Open Instrument selected.

5	<ul style="list-style-type: none"> Choose the correct Background Scatter File and Select an Output file. 	Background and Output file selected.
6	<ul style="list-style-type: none"> 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.
7	<ul style="list-style-type: none"> 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.
8	<ul style="list-style-type: none"> 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 <i>Show Auxiliary Parameter Frame</i> from the <i>DataFrames</i> menu. 	Auxiliary Parameter window opened.
9	<ul style="list-style-type: none"> The scale of the Volume Distribution plot can be changed by using the <i>Scale +/-</i> 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. <div data-bbox="337 1115 711 1339" data-label="Image"> </div> <ul style="list-style-type: none"> 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 <i>Display</i> tab of the <i>Settings</i> window as shown below. 	Display setting modified.



10

- 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.




Value of rings for current frame displayed.

11

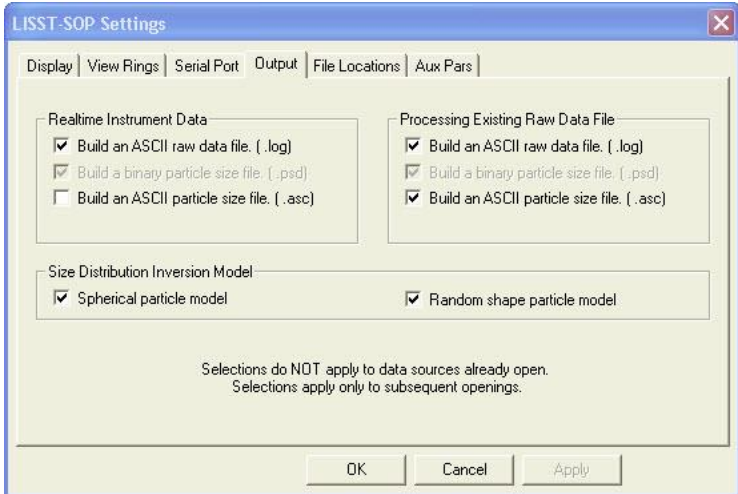
- A single sample may be saved to a separate file by pressing the *Save Single Sample* button


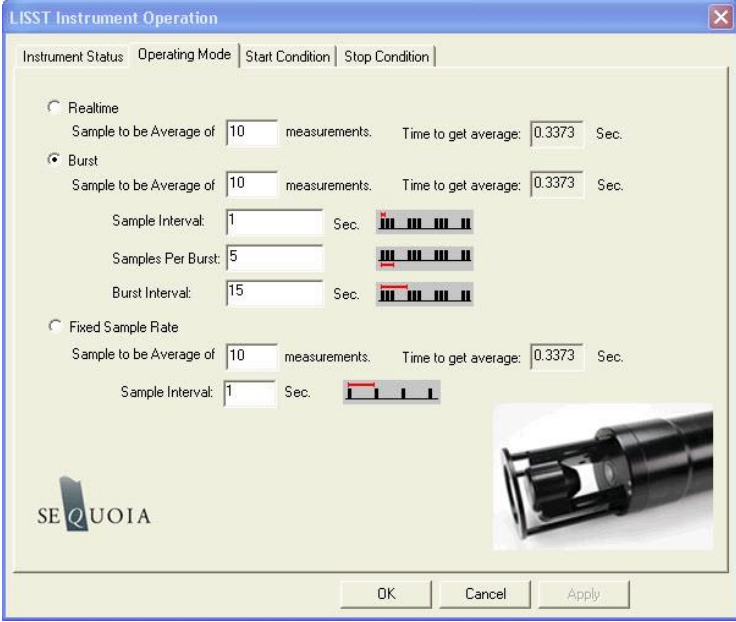
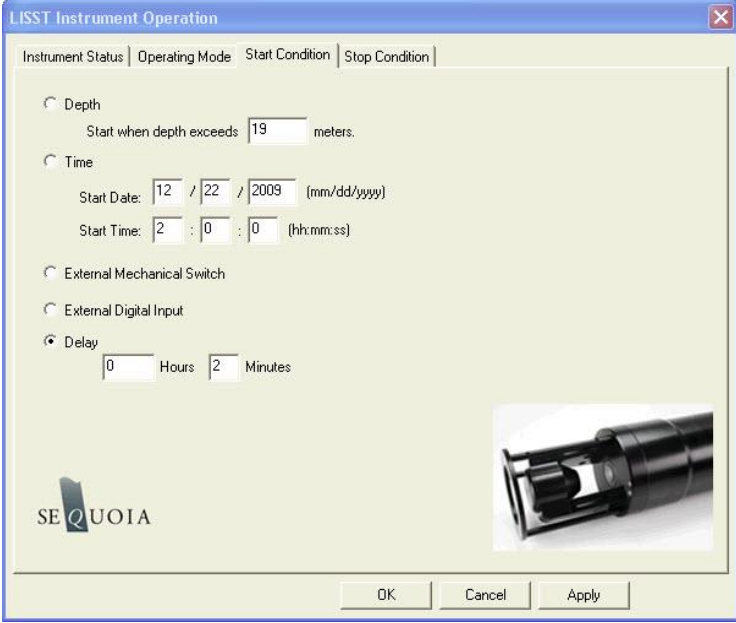
Averaged data acquired and stored to an ASCII file.

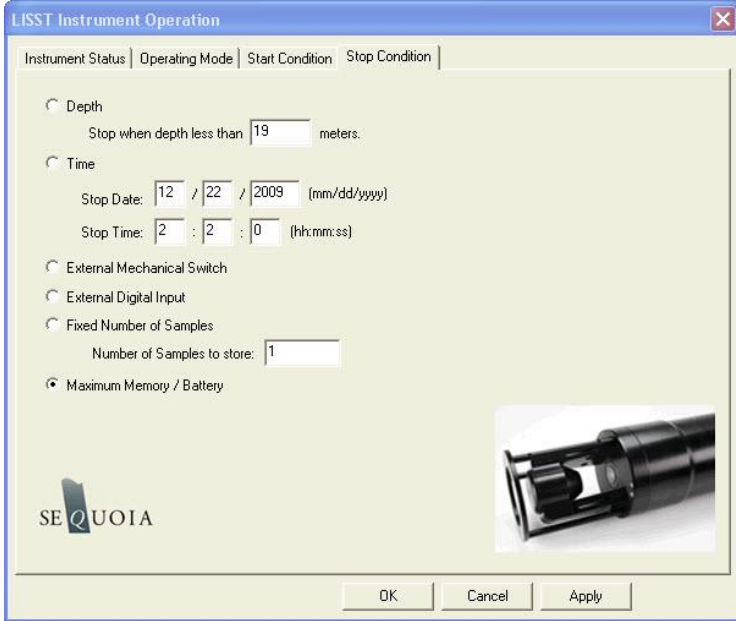
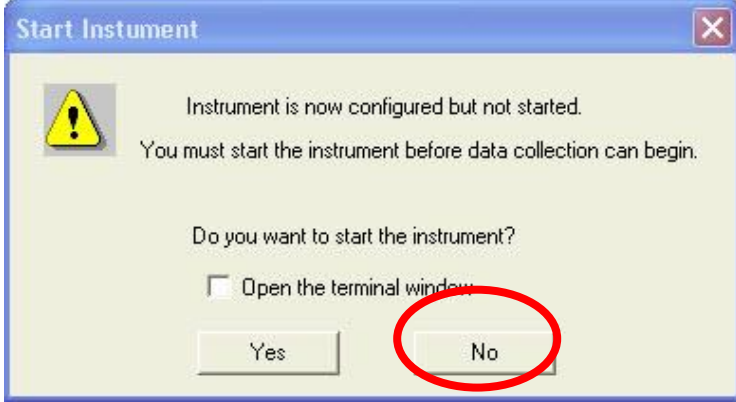
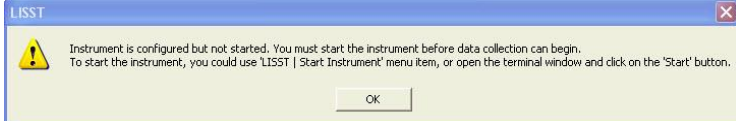
12	<ul style="list-style-type: none">• When finished, close the main window to stop communication with the LISST-100X. <p>CAUTION: The laser and Main power are on continuously while in the Real-Time Session. The program will stop and the power will be turned off when the window is closed. However, if 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 the  button on the toolbar.</p> <p>To start data collection again, press the <i>Next</i> button. The instrument will power up and store a sample. This will take more time than a normal sample. Once powered up the instrument will perform as usual.</p>	Finished and shutdown.
----	--	------------------------

STEP BY STEP PROCEDURE: ADVANCED REAL-TIME DATA PROCESSING

All operating modes can be used in Realtime mode. However, if you wish to use burst mode or fixed sample rate in Realtime Mode, or use any other start method for the realtime mode than the start button in the realtime mode window, you must follow the steps below.

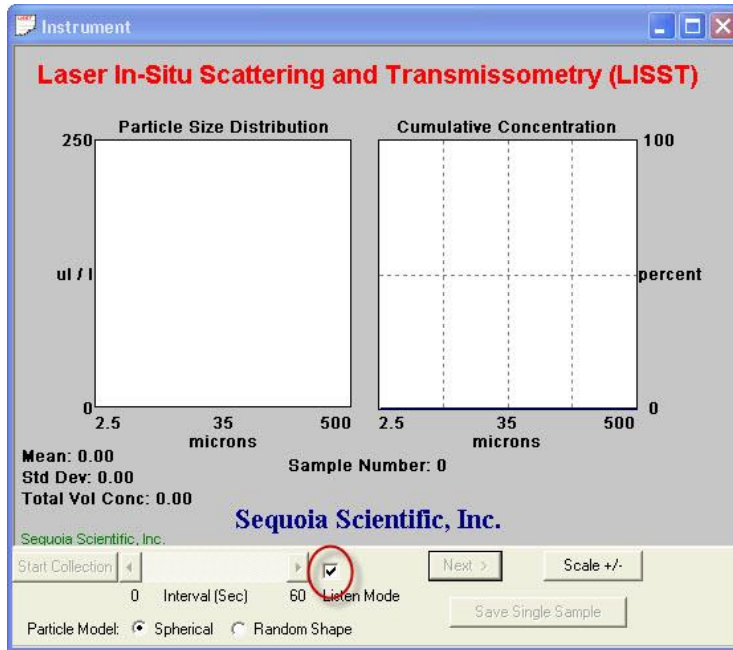
Step	Action	Result
1	<ul style="list-style-type: none"> Connect the instrument to the PC and start the LISST-SOP program. 	Program started.
2	<ul style="list-style-type: none"> Before starting a Real-Time session the output file options must be set. This must be done before selecting <i>Open Real-Time Session</i>. Select Output from the Options menu. The window below will appear.  <ul style="list-style-type: none"> 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 space delimited ASCII file containing all the processed data. The LOG file is a space delimited file containing the raw data from the datalogger. It is strongly recommended that you always build a LOG file, otherwise troubleshooting the data will be impossible if any problems or questions about the data quality should appear. You must also select the inversion model to be used with the real time data processing: Spherical, randomly shaped or both. For details on these selections see page 47. 	Select output settings.

3	<ul style="list-style-type: none"> Select Open Real-Time Session from the File menu or press on the  button. 	Open Instrument selected.
4	<ul style="list-style-type: none"> Choose the correct Background Scatter File and Select an Output file. 	Background and Output file selected.
5	<ul style="list-style-type: none"> Open up the operating mode windows and select the desired operating mode. In this case burst mode is being selected: 	Instrument configured with the desired operating mode for the advanced real time sampling.
6	<ul style="list-style-type: none"> Now click the Start Condition tab in order to set the Start Condition. In this case, a 2 minute delay is being selected. 	Start condition selected.

7	<ul style="list-style-type: none"> Click the stop condition tab and select the stop condition mode. In this case the Maximum Memory/Low Battery stop mode is being selected.  <p>NOTE: the real time mode can always be stopped by selecting the Stop button in the SOP window.</p>	Stop condition selected.
8	<ul style="list-style-type: none"> Now click Apply, and then OK. You will be asked if you wish to start the instrument. It is <i>very</i> important that you do NOT start the instrument – click the No Button. 	Apply settings, but do NOT start instrument
9	<ul style="list-style-type: none"> You will then see the following warning, click OK. 	Ignore warning (click OK to proceed).

10

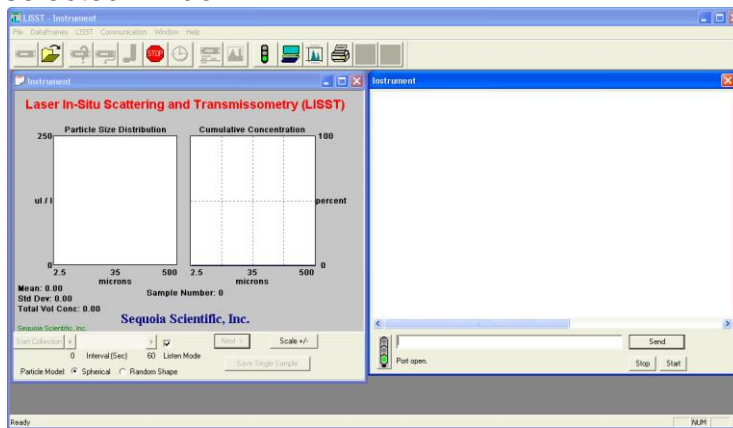
- Now, open up the realtime window (File/Realtime), select the background scatter file you want to use for processing the realtime data, and select an output file name. Then click OK, and the realtime window will open up. Check the Listen Mode check box.



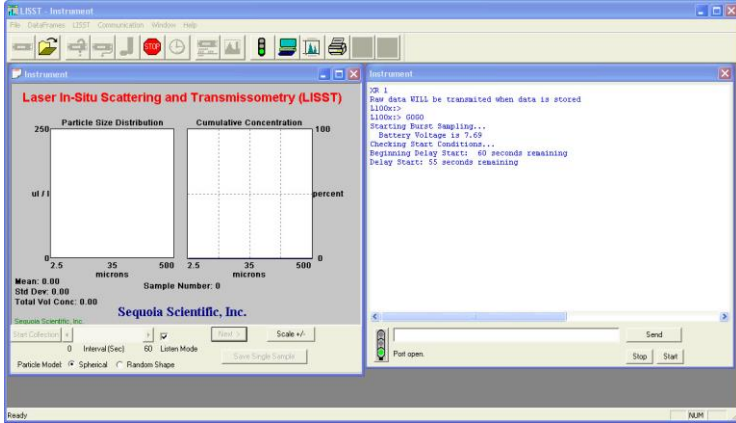
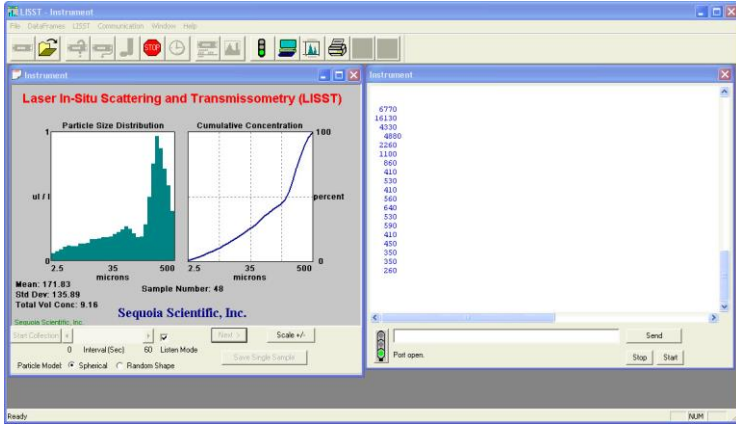

Prepare real time window for listen mode.

11


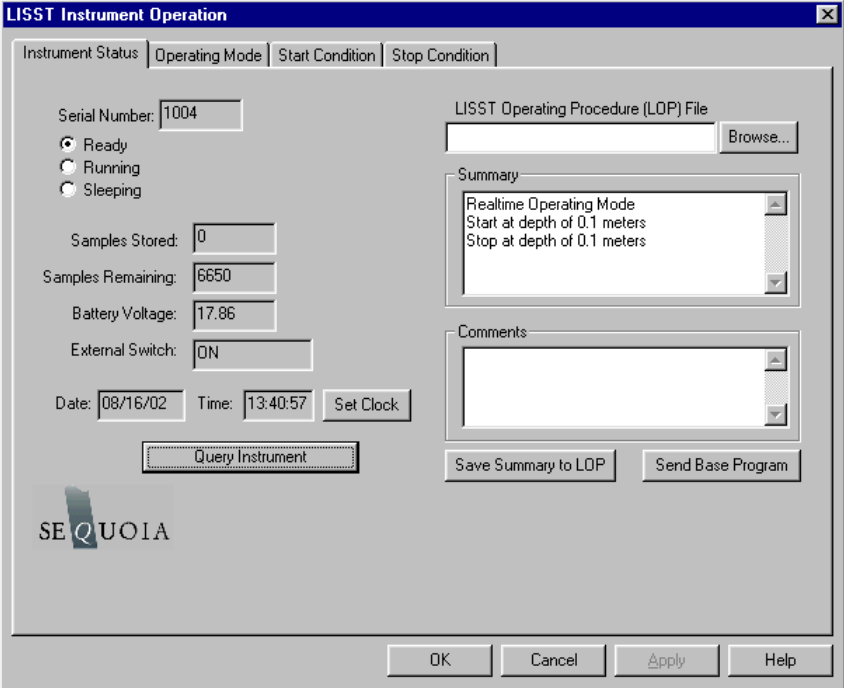
- Next, open the terminal window, and place it next to the Realtime window. Make sure the terminal window is the selected window.



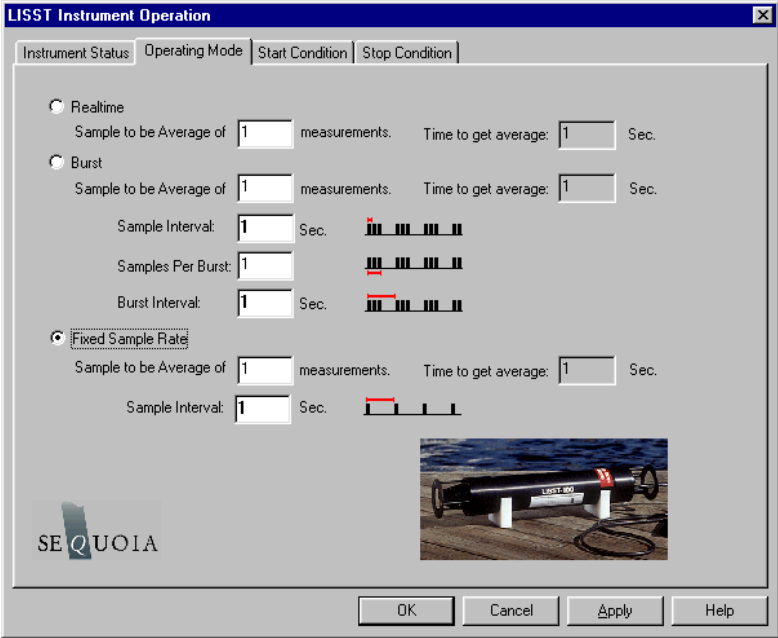
Open up and select terminal window.

<p>12</p>	<ul style="list-style-type: none"> When you are ready to start the realtime sampling, click the Start button in the Terminal window. You will see that the instrument starts and will wait for the start condition to occur. 	<p>Instrument started and waiting for start condition to occur.</p>
<p>13</p>	<ul style="list-style-type: none"> Once the start condition has been met, the instrument will transmit raw data to the SOP, which is continually listening for data. As soon as the SOP receives a set of raw data it will process them and display the results to the screen.  <ul style="list-style-type: none"> A .PSD file is being saved as default, but it is very strongly recommended that the user also always selects a .LOG file output option in File/Settings Output tab before starting the real time processing. Please note that you can select between Spherical and Random shape inversion models in real time mode, but you can only select the mode(s) that were chosen in the Output tab of the File/Settings menu before the real time menu was opened up. 	<p>SOP displays real time data using the selected operating mode.</p>
<p>14</p>	<ul style="list-style-type: none"> The terminal window should be closed when the instrument has been started. Keeping it open may delay the updating of the real time display. In order to stop the real time sampling, click the  button. 	<p>Stopping advanced real time mode.</p>

STEP BY STEP PROCEDURE: CONFIGURING DATA COLLECTION

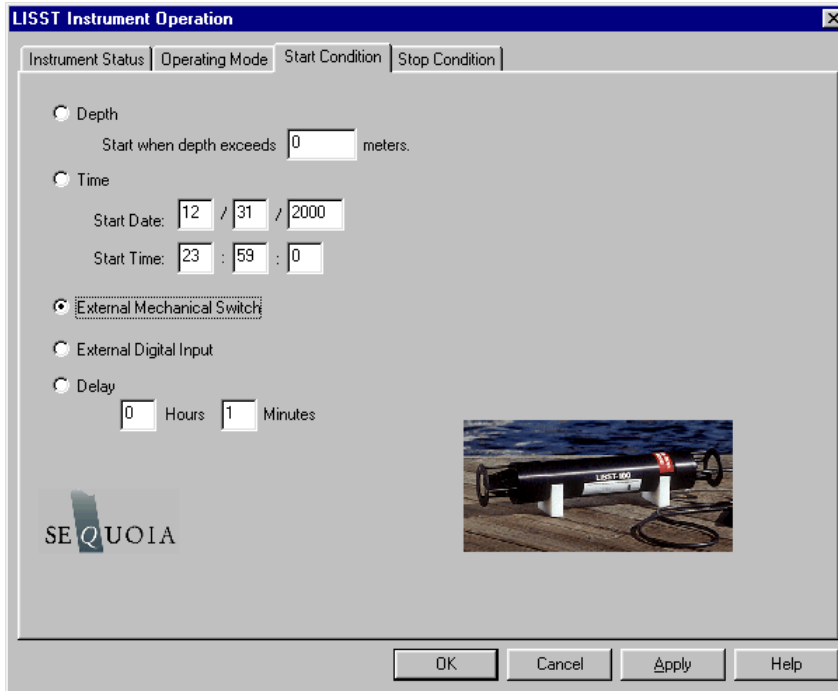
Step	Action	Result
1	<ul style="list-style-type: none"> Connect the instrument to the PC and start the LISST-SOP program. 	LISST-SOP open and communicating with LISST-100X.
2	<ul style="list-style-type: none"> Open the Operating Modes window by choosing <i>Operating Modes</i> from the <i>LISST</i> menu or by pressing the  button on the toolbar.  <p>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.</p> <p>To set the LISST-100X data logger clock to the computer clock press the <i>Set Clock</i> button. Press the <i>Query Instrument</i> button to refresh the display.</p>	<p>Instrument Status Displayed.</p> <p>Clock set</p>

3	<ul style="list-style-type: none"> 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 <i>Apply</i> or <i>OK</i> buttons. <p>LISST Operating Procedure files can be saved by clicking the <i>Save Summary to LOP</i> 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.</p>	
---	---	--

4	<ul style="list-style-type: none"> By selecting the <i>Operating Mode</i> 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.  <ul style="list-style-type: none"> 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 Fixed sample rate 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
---	---	--------------------

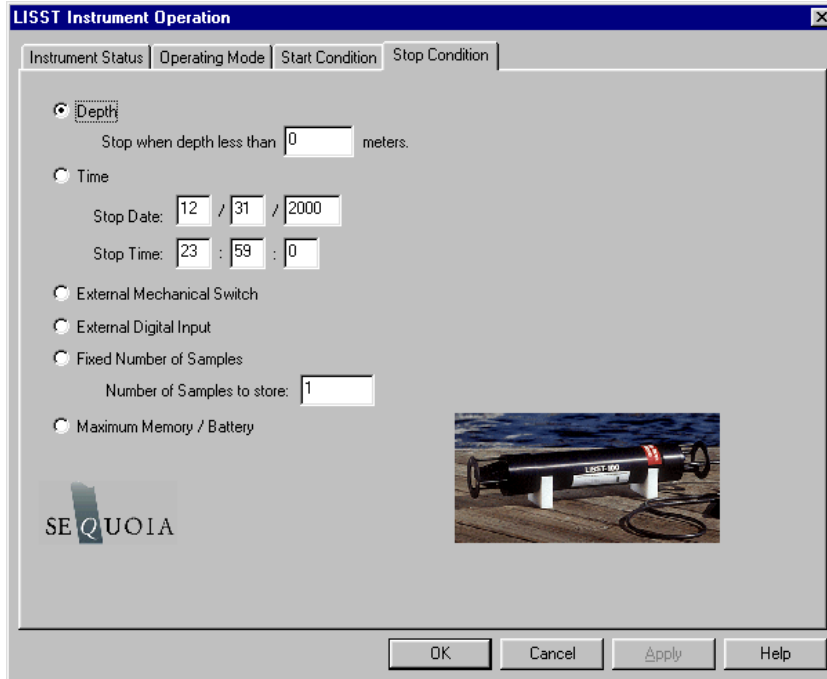
5

- 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.



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.



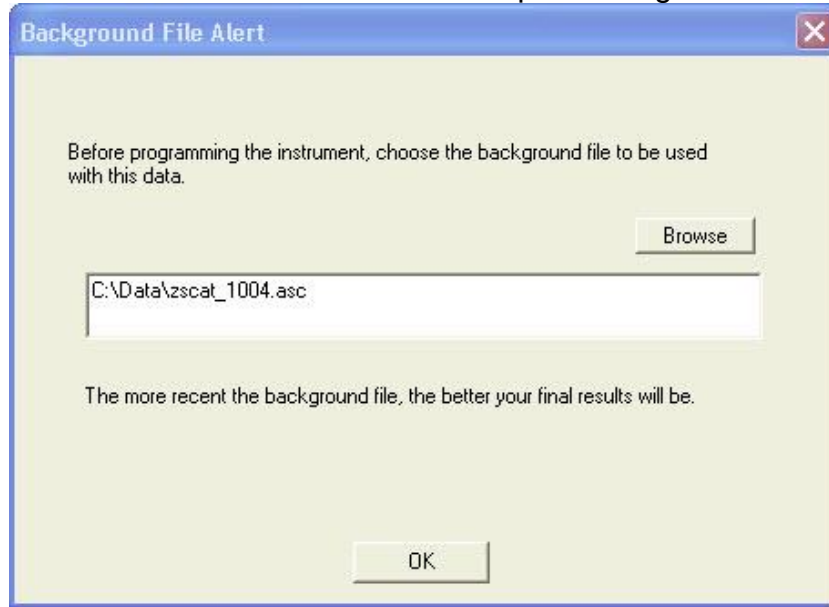
- If the Stop Condition is Depth, External Mechanical Switch, or External Digital Input and the Start Condition is also one of these three options the Base Program on the instrument will return to waiting for the Start condition. For example, if the start and stop conditions were set to External Mechanical 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.

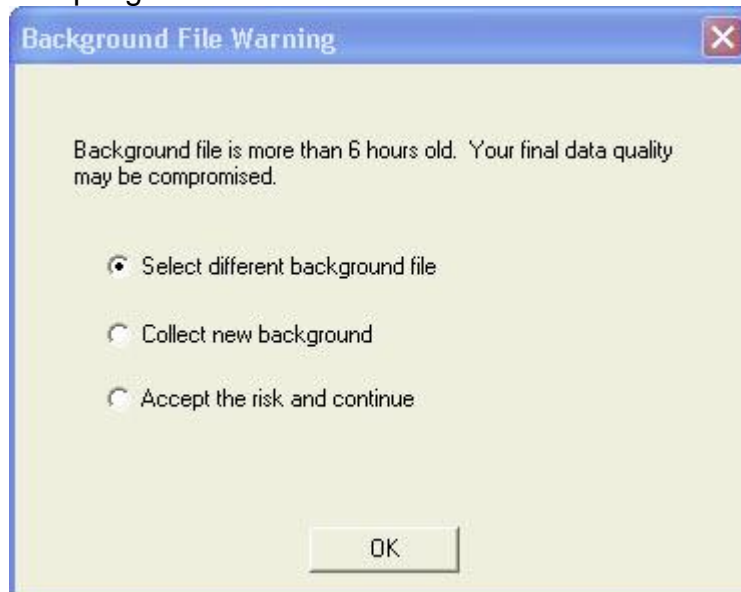
8

- If the *OK* button is pressed, when the configuration is complete the user will be prompted to select the zscat file that the user later intends to use for processing the data.



9

- If the selected zscat file is more than 6 hours old, a warning is issued, and the user is being given a choice between selecting a different file, collecting a new background, or accepting the risk and continue:



- For best results, the zscat file should ALWAYS be taken as close as possible to the deployment.
- **NOTE:** The SOP makes no record of which background file was selected. The warning is put in place to make the user aware of the importance of obtaining good and recent zscat measurements.

10	<ul style="list-style-type: none"> Clicking the OK button will then open the <i>Terminal</i> 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 <i>Start</i> button on the <i>Terminal</i> window. The <i>Start</i> button is equivalent to typing GO and pressing Enter from any terminal program. 	
11	<ul style="list-style-type: none"> 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 5-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. The transfer rate can be changed as described in the Step by Step Procedure: Offloading Data Files on page 44.

Using the Terminal Window

Opening the Terminal Window, or alternate terminal software such as MotoCross (installs in the LISST100 folder during installation of the SOP), 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 LISST-100X Command Summary on page 87 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 permissible input voltage on the digital input line 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	The Maximum Memory or Low Battery Stop condition will continue to sample until the memory capacity has been reached or when the

Battery:

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

DB	Display Current Battery Voltage
DD	Display current Disk Directory
DS	Display current status information
DT	Display Current Time and Date
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
SB x	Set Samples per Burst
SC <i>mm/dd/yy hh:mm:ss</i>	Set Clock with time and date, where <i>mm</i> =month, <i>dd</i> =day, <i>yy</i> =year, <i>hh</i> =hour(24 format), <i>mm</i> =minute, <i>ss</i> =seconds, Example: ST 01/05/2005 21:05:03
AS	Autostart Setting
BB	BioBlock Connection
SD	Store Current Settings as Default
SM	Store Mode Setting
ZD	Reset Depth Sensor Offset

Acquisition/Action Commands

DL filename	Delete File
GO	Start Data collection using current parameters
GX	Grab sample and transmit it
XR	Display Raw data to screen when average saved
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: New Operating Mode: Fixed Rate Mode

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 output: New Measurements per Average: 10
Cautions:	None

ST	Set Start Condition
Syntax:	ST x or st x, where x is the start condition code described below
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 output: New Start Condition Setting: Delay Start

TD	Set Start Condition Data
Syntax:	TD x or td x, where x is the start condition data described below
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 as follows: <ul style="list-style-type: none"> • 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 3 (if Start Condition = 1 (Depth Start)) output: New Start Condition data = 3 Start Condition: Depth Start at 3 meters input: TD 12/31/05 23:59:59 (if Start Condition = 2 (Time/Date Start)) output: New Start Condition data = 12/31/05 23:59:59 Start Condition: Time Start at 12/31/05 23:59:59 Input: TD 2 (if Start Condition = 5 (Delay Start)) Output: New Start Condition data = 2 Start Condition: Delay Start with 2 minute delay

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

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 output: New Stop Condition Setting: Fixed Number Stop

PD	Set Stop Condition Data
Syntax:	PD x or pd x, where x is the stop condition data as described below
Description:	The PD command sets the stop condition data to be used when the collection data. The stop condition data is used with the Stop Condition settings as follows. <ul style="list-style-type: none"> • 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 PD 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 PD setting is ignored for Mechanical Switch Stop (option 3), Digital Input Stop (option 4) or Maximum memory or Low Battery Stop (option 6).
Example:	input: PD 3 (if Stop Condition =1 (Depth Stop)) output: New Stop Condition data = 3 Stop Condition: Depth Stop at 3 meters input: PD12/31/05 23:59:59 (if Stop Condition = 2 (Time/Date Stop)) output: New Stop Condition data = 12/31/05 23:59:59 Stop Condition: Time Stop at 12/31/05 23:59:59 input: PD 2 (if Stop Condition = 5 (Fixed Number of Samples Stop)) output: New Stop Condition data = 2 Stop Condition: Fixed number Stop at 2 samples

SI	Set Sample Interval
Syntax:	SI x or si x, where x is the number of seconds between samples, from 1 to 10,000.
Description:	In Fixed Rate Mode (OM = 3) or Burst Rate Mode (OM = 2), the sample interval is the number of seconds between two consecutive samples, each composed as an average of a number of measurements (specified by the MA command).
Example:	input: SI 5 output: New Seconds between Samples: 5

BI	Set Burst Interval
Syntax:	BI x or bi x, where x is the number of seconds between the start of 2 consecutive bursts, from 1 to 10,000 seconds.
Description:	In Burst Mode (OM = 2), the burst interval is the number of seconds between two consecutive bursts, each burst composed of a number of samples per burst (specified by the SB command).
Example:	input: BI 900 output: New Seconds between Bursts: 900

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

SC	Set Clock with time and date
Syntax:	SC mm/dd/yy hh:mm:ss or sc mm/dd/yy hh:mm:ss Where mm=month, dd=day, yy=year, hh=hour (24 hour 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 output: Command Data in SC is: 01/05/01 21:05:03 Current Date/Time: Friday, January 05, 2001 21:05:03

AS	Autostart Setting
Syntax:	AS x or as x, where x is 1 (yes) or 0 (no)
Description:	With Autostart enabled, the firmware will immediately start the sampling program that is stored in the EEPROM of the Persistor datalogger upon power up of the instrument. Use the SD command to store the current settings as default values to be used in conjunction with the AS command.
Example:	input: AS 1 output: AutoStart will occur upon power up!
Cautions:	1) If Autostart is enabled, the user cannot talk to the instrument when powering it up – it will immediately start sampling according to the SD defaults. In order to stop sampling and establish normal communication, the user must issue a stop command, by either pressing the STOP button or issuing a CTRL-C command in the terminal window when the instrument is powered up. 2) Make sure the current program settings are as desired and saved as default settings (see SD).

BB	BioBlock Connection
Syntax:	BB x or bb x, where x can be 0, 1, 10 or 11
Description:	Configure the BioBlock Connection Setting and send test commands. Input options are: 0 = BioBlock is not connected. 1 = BioBlock is connected. 10 = BioBlock is connected and issues a command to close the BioBlock. 11 = BioBlock is connected and issues a command to open the BioBlock.
Example:	Input: BB 1 Output: BioBlock is now connected!
Cautions:	None

SD	Store Current Settings as Default
Syntax:	SD or sd
Description:	Issue the SD command to verify the current settings. Then confirm (1 = yes, 0 = no) that these settings should be burned into the EEPROM to be used with the AutoStart setting.
Example	input: SD output: LISST-100X Current Status and Settings Serial number = 1335 Firmware Version 1.997 Feb 16 2011 14:18:45 Operating Mode: Fixed Rate Mode Start Condition: Delay Start with 3 minute delay Stop Condition: Fixed Number Stop at 2 samples Measurements per Average: 10 Sample Interval: 5 Battery Voltage is 7.28 Current Date/Time: Wednesday, August 17, 2011 12:24:14 Current Day of the Year: 229 Do you wish to set current settings to be defaults? (1=yes,0=no): [0] ? 1 Current Settings being saved to EEPROM... Current Settings saved as defaults!!!
Cautions:	If you change any of the settings after issuing the SD command you must reissue the SD command to save the updated settings.
SM	Store Mode Setting
Syntax:	SM x or sm x, where x is 1 or 0
Description:	The Store Mode setting disables (x = 1) or enables (x = 0) data storage on the internal drive. No Ldddhmm.DAT file will be created if store mode is disabled.

	It is intended to be used for long-term real-time deployments, where it may not be desirable to have the data stored on the datalogger to avoid it filling up.
Example:	input: SM 1 output: Data will NOT be stored after each sample!!! input: SM 0 output: Data will be stored after each sample!!!
Cautions:	Be very careful that the correct store mode is selected before a deployment where it is the intent to store the data internally on the instrument datalogger! Issue a DS command to verify the status of the store mode setting. A warning will be displayed as part of the DS status if the store mode is disabled: WARNING: Data storage disabled. Data will not be saved!!!
ZD	Reset Depth Sensor Offset
Syntax:	ZD or zd
Description:	The ZD (or zd) command resets the depth sensor offset so that the sensor reads a depth of 0m at zero depth (in air). You must issue the ZD command, then select 1 (yes) or 0 (no) to reset depth sensor
Example:	input: ZD output: Depth Sensor Offset Reset Procedure Started. Instrument must be at zero depth and similar temperature to field conditions. Do you wish to reset Depth Sensor offset? (1=yes,0=no): [0] ? 1 Previous offset was -14.03. New offset is -13.87. Previous Depth was -0.15 meters. New Depth using corrected offset is 0.00 meters.
Cautions:	None

Acquisition/Action commands

DL	Delete file from Compact Flash Module
Syntax:	DL <i>filename</i> or dl <i>filename</i> where <i>filename</i> 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 data 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. CAUTION: The GX command does not check for the presence of a BioBlock. If the BioBlock is closed and you issue a GX command no meaningful data will be returned as the data will be read the BioBlock in close position.

XR	Display Raw data to screen when average saved
Syntax:	XR x or xr x, where x =1 (yes) or x = 0 (no)
Description:	If display of raw data is enabled, the RAW data will be printed to the serial port between curly brackets in 40 rows: { 32 ring values + 8 Aux parameters }
Example:	input: XR 1 output: Raw data WILL be transmitted when data is stored
Cautions:	None

YS	YMODEM Offload
Syntax:	YS <i>filename</i> or ys <i>filename</i> where <i>filename</i> 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.

Performance Optimization

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

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 is not correct the instrument will not function correctly. The background file can easily provide the user with information about the status of the alignment.

Background Scatterfile and its Importance

Clean optics end before acquiring a background 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.

Use particle free water for the background scatterfile 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 0.2 μ m 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 are needed to fill the chamber.

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 low concentration 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.

Background scatterfiles should always be obtained before each data collection.

In order to check the status of an instrument you will need to open the most current background scatter file, as well as the factory background scatter file (factory_zsc_SNSN.asc), where SNSN is the instrument serial number. The files are space separated and will easily open up in Excel or other spreadsheets. Once you have opened the files you will see that they consist of 40 rows and 1 column of data.

The first indicator of an alignment problem is a severe drop in the currently transmitted laser power (row 33) when compared to the factory laser power. The laser power and laser reference values (row 36) will change over time but they should track together. If the value of the laser power:laser reference ratio for your current background measurement is less than 85% of the laser power:laser reference ratio from the factory background file, misalignment may be occurring.

The second indicator of misalignment is high value on the inner rings. The inner rings are shown on the left side of the background display. The most important rings for misalignment indication are rings 1-4 in the background scatter file. 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, and is also the reason for the decrease in transmitted laser power.

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 it can be concluded that the instrument is misaligned.

The transmit optics on the LISST-100X do allow for the possibility of the user adjusting the alignment. 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, Deployment Orientation, Storage and Maintenance

This section contains information on mounting, storing and maintaining 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 is to keep the window surface vertical by mounting the instrument horizontally. This is most critical when the water motion is slow. When working in rivers or in a towed or profiling 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. The clamps supplied with the instrument can also be used.

Spare clamps for mounting the instrument are available from Sequoia. See Appendix H: LISST Accessories on page 138.

Precautions for vertical mounting

If mounting the instrument vertical the optics endcap should always face downwards. If the connector endcap faces downwards, and the instrument is subjected to a bump or shock during deployment, the Compact Flash Memory Card inside can come loose, making it impossible to offload data.

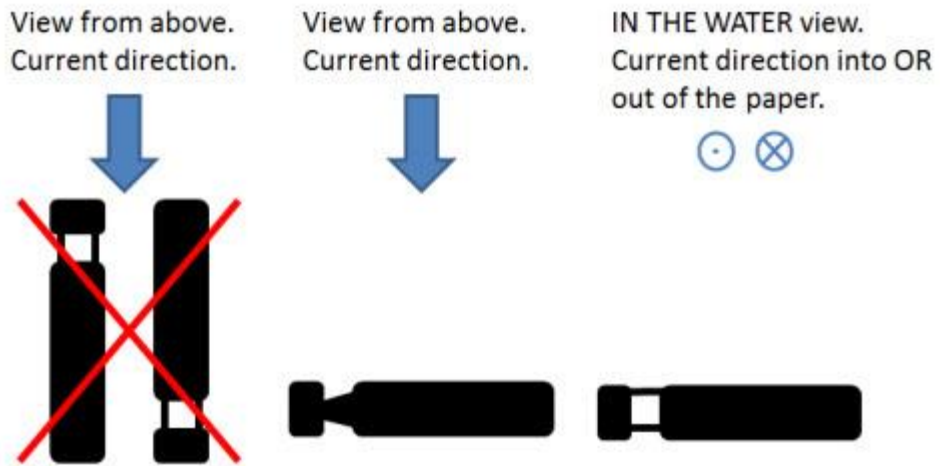
Use the supplied U-shaped mounting blocks or the stainless steel clamps with rubberized inserts for vertical mounting.

Precautions for mounting with a BioBlock

IF A BIOBLOCK IS INSTALLED, THE INSTRUMENT MUST BE MOUNTED IN A HORIZONTAL POSITION.

Precautions for in-water orientation relative to the current flow

If possible, the instrument should always be deployed so that it is perpendicular to the current and the water is flowing as unobstructed as possible through the optics end of the instrument. The diagram below shows the optimum orientation with respect to the current flow.



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. Failure to properly isolate the instrument from all other metal will void the warranty.


A set of stainless steel clamps with rubberized interiors ships as part of the instrument package. Use these or the plastic clamps for mounting, and make sure that no metal is in direct contact with the pressure housing or other components of the instrument. If you lose the spare clamps, replacement clamps are available for purchase from Sequoia. See Appendix H: LISST Accessories on page 138.

Storage notes



Again it must be emphasized that the LISST-100X is a sensitive instrument. When not in use, the instrument should be stored in its shipping case. For longer storage (year or so), the communication cable should be disconnected and the battery pack should be 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.

Low Power Sleep Mode

To put the instrument into low power sleep mode choose *Put LISST to Sleep* from the *LISST* menu or click the  button.

NOTE: 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.

Cleaning the optical windows

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. Do not use 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

O-rings that seal the mating parts of the instrument must be maintained and inspected regularly. Whenever the connector 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.

Calibrations and adjustments

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. Such samples ship as part of the instrument package. Standard particles can be obtained from manufacturers of standard particles, such as Whitehouse Scientific (<http://www.whitehousescientific.com/>) or PTI – Powder Technology Inc. (<http://www.powdertechologyinc.com/>).



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.

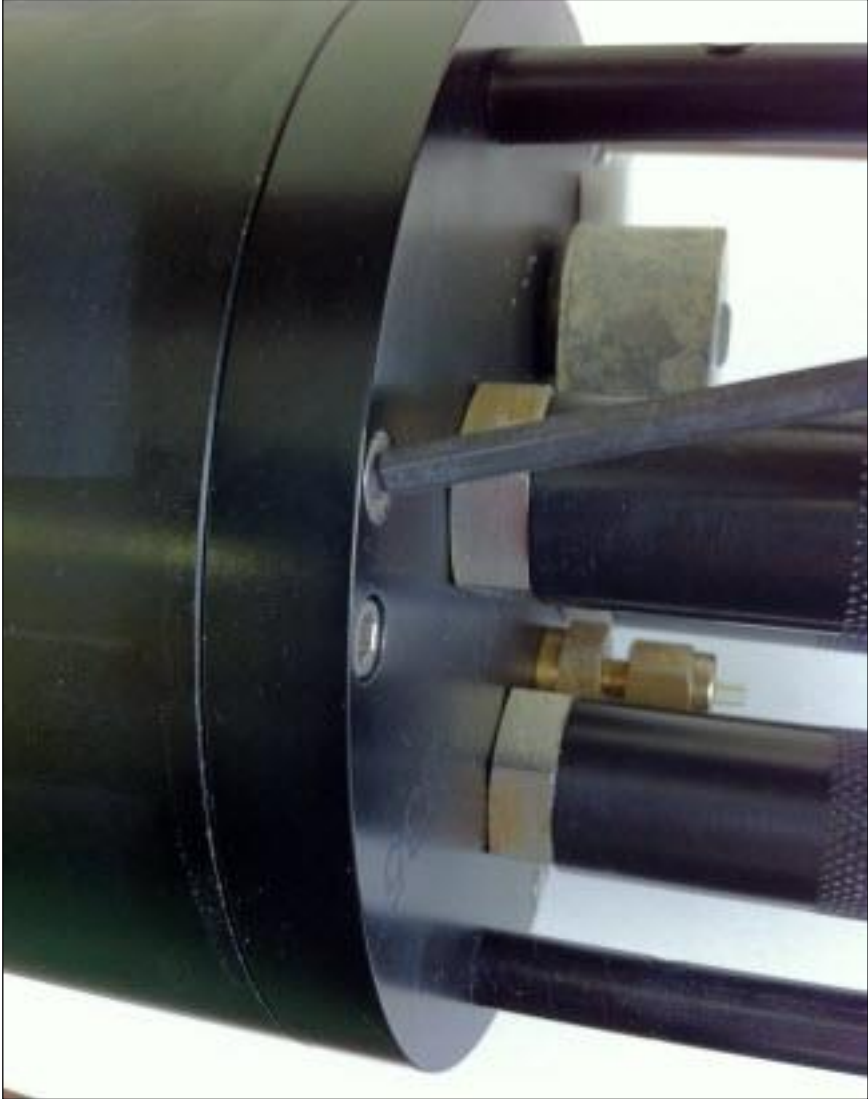
Maintenance Notes


Battery Power and Access

The main battery is mounted to the connector end cap. SEQUOIA supplies the custom 9V battery packs for use with the LISST-100X instrument. The use of batteries other than these may void your warranty.

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

STEP BY STEP PROCEDURE: CHANGING THE BATTERY

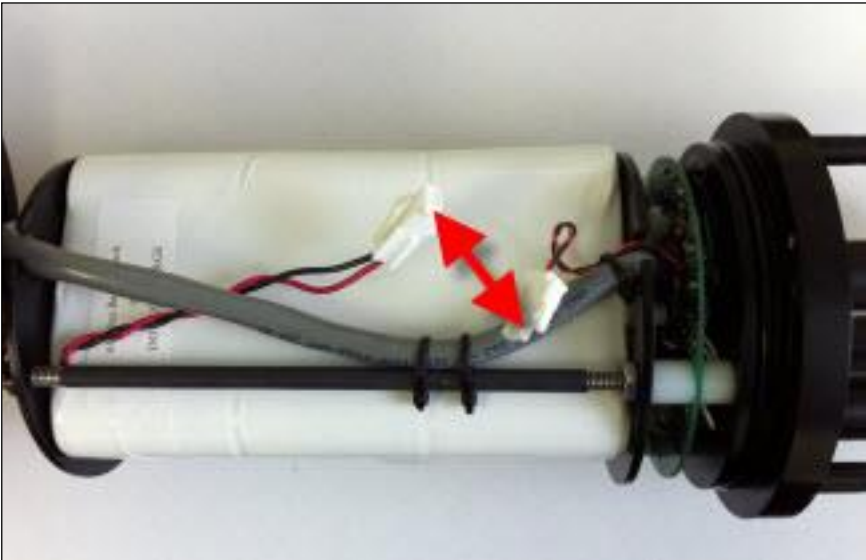
Step	Action	Result
1	<ul style="list-style-type: none"> Place the instrument in a horizontal position. <i>U-blocks have been provided for this purpose</i> 	
2	<ul style="list-style-type: none"> Disconnect all external cables from the end cap. 	
3	<ul style="list-style-type: none"> Install caps on connectors to protect pins. CAPS MUST BE INSTALLED ON THE CONNECTORS BEFORE SUBMERGING THE INSTRUMENT INTO WATER. 	Caps installed on the connectors.
4	<ul style="list-style-type: none"> Remove the six recessed bolts from end cap; there will be three long bolts and three shorter bolts <i>Use the provided Allen wrench, size 9/64. The threads of the bolts have been coated with an anti-seize compound. Spare bolts are included with the instrument.</i> 	The recessed bolts removed from the end cap.

5	<ul style="list-style-type: none"> Next, insert the three long bolts into the threaded holes next to the hold-down screws 	The three long bolts are inserted
6	<ul style="list-style-type: none"> Remove the endcap by gently threading the long bolts in evenly. They will bottom out against the edge of the pressure housing and slowly force out the connector endcap. When the O-ring becomes visible, grasp the ring attached to the endcap with standoffs and pull gently away from the case. Slight rotation will sometimes be helpful .  <ul style="list-style-type: none"> 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 pressure housing. Tipping of the endcap can cause binding. DO NOT PRY THE END CAP OFF WITH SCREWDRIVERS. 	End cap and battery removed from the case.
7	<ul style="list-style-type: none"> To expose the battery and battery cable connectors, remove the Velcro wrap. 	Battery is visible

8

- 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.

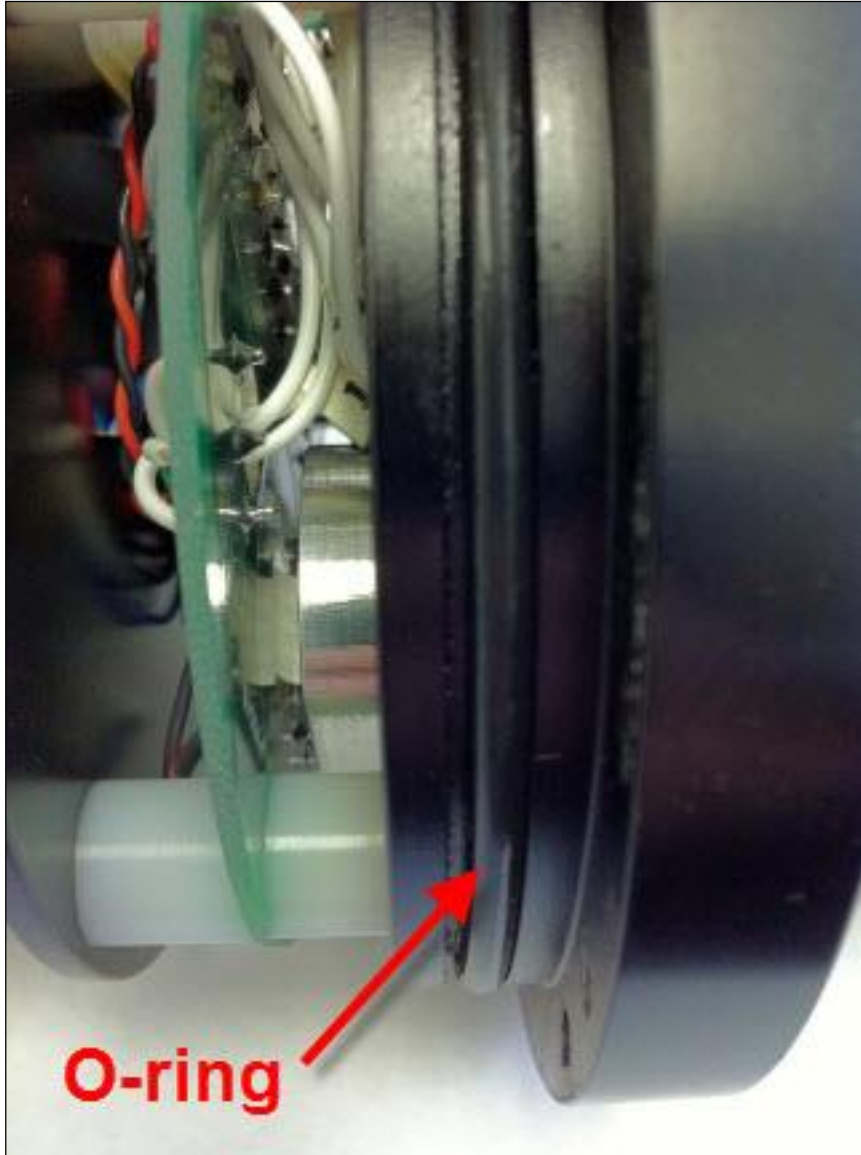



9	<ul style="list-style-type: none"> Disconnect the power cord from the battery and remove it from its place between the rods.  <ul style="list-style-type: none"> <i>Before removing the battery, make note of its orientation so that the replacement battery can be positioned similarly.</i> 	Battery removed
10	<ul style="list-style-type: none"> Insert the new battery in exactly the same orientation as the old battery. 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 replaced
11	<ul style="list-style-type: none"> 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 on the terminal window if the instrument is connected to the software. 	Power on. Instrument NOT in sleep mode.
12	<ul style="list-style-type: none"> 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 arranged properly it will be difficult to insert the battery into the pressure case. 	Battery wrapped up.

13

- Before installing the end cap into the case, thoroughly clean and lightly grease the O-ring. Inspect the O-ring for any cuts or defects.

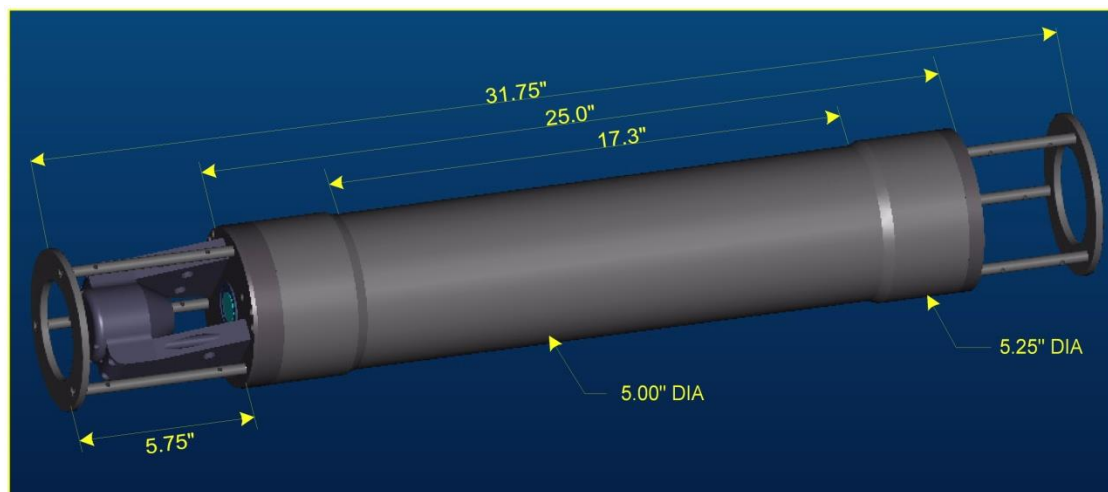
O-ring greased and inspected for any defects.



<p>14</p>	<ul style="list-style-type: none"> • Clean and lightly grease the inside diameter of the pressure housing where the O-ring seals. 	
<p>15</p>	<ul style="list-style-type: none"> • Install the end cap into the case by first lining up the holes in the end cap with the threaded holes in the case. <i>A slight twisting motion will help the O-ring obtain a good seal. This will also allow the bolt holes to be lined up.</i> 	<p>The end cap installed into the case and the case is now sealed.</p>
<p>16</p>	<ul style="list-style-type: none"> • Applying uniform force, push the end cap into the case. After the end cap is inserted, slightly rotate the end cap. 	<p>End cap is back in place.</p>
<p>17</p>	<ul style="list-style-type: none"> • Install the bolts, tightening evenly, until they are snug but not tight. • Warning: Do not over tighten. The stainless steel screws can damage the threads of the aluminum case if over tightened. 	<p>End cap is secured in place with the bolts.</p>

Technical Specifications

- Parameters measured/derived
 - Particle Size distribution*
 - Total Volume Concentration*
 - Optical Transmission*
 - Depth*
 - Temperature*
 - Volume Scattering Function*
- 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 μm , Type C: 2.5 - 500 μm
- Resolution: 32 size classes, log-spaced
- Data storage memory: 1GB (~12 million measurements) standard.
- Maximum sample speed: 1 size distributions per second (standard)
- Temperature-sensor range: -10 to 45°C resolution: 0.01° C
- Depth Sensor range: 0 to 300 m of H₂O, resolution: 0.08 m of H₂O
- External power input: 12V nominal (9-15V max, 0.5 A min; **9-24V max, 0.5 A min for units shipped after 1 March 2012**). **NOTE: THIS DOES NOT APPLY FOR UNITS WITH EXTERNAL BATTERY PACKS: THESE CAN ONLY ACCEPT A MAXIMUM OF 9V AT ALL TIMES.**
- Dimensions: 13.33 cm (5.25") \varnothing x 80.7 cm (31.75") L
- Weight in air: 12 kg (25 lb)
- Weight in water: 4 kg (8.5 lb)
- Depth rating: 300 m
- Connector Endcap screws: Socket head cap screws #8-32 3/4" long
- Endcap O-ring: Parker Part # 2-244



Appendix A: Size Ranges, Observation Angles, Data Storage Format

Size Ranges for SPHERICAL particle inversion method

There are 32 size ranges logarithmically placed from 1.25 - 250 microns in diameter (type B), or 2.5 – 500 μm (type C). In both cases, the upper size in each bin is 1.180 times the lower.

The table below shows the lower and upper limit of each size bin in microns, together with the median size (also in microns) for each size bin for type B and C instruments.

Size bin #	Type B			Type C		
	Lower	Upper	Median	Lower	Upper	Median
1	1.25	1.48	1.36	2.50	2.95	2.72
2	1.48	1.74	1.60	2.95	3.48	3.20
3	1.74	2.05	1.89	3.48	4.11	3.78
4	2.05	2.42	2.23	4.11	4.85	4.46
5	2.42	2.86	2.63	4.85	5.72	5.27
6	2.86	3.38	3.11	5.72	6.75	6.21
7	3.38	3.98	3.67	6.75	7.97	7.33
8	3.98	4.70	4.33	7.97	9.40	8.65
9	4.70	5.55	5.11	9.40	11.1	10.2
10	5.55	6.55	6.03	11.1	13.1	12.1
11	6.55	7.72	7.11	13.1	15.4	14.2
12	7.72	9.12	8.39	15.4	18.2	16.8
13	9.12	10.8	9.90	18.2	21.5	19.8
14	10.8	12.7	11.7	21.5	25.4	23.4
15	12.7	15.0	13.8	25.4	30.0	27.6
16	15.0	17.7	16.3	30.0	35.4	32.5
17	17.7	20.9	19.2	35.4	41.7	38.4
18	20.9	24.6	22.7	41.7	49.2	45.3
19	24.6	29.1	26.7	49.2	58.1	53.5
20	29.1	34.3	31.6	58.1	68.6	63.1
21	34.3	40.5	37.2	68.6	80.9	74.5
22	40.5	47.7	43.9	80.9	95.5	87.9
23	47.7	56.3	51.9	95.5	113	104
24	56.3	66.5	61.2	113	133	122
25	66.5	78.4	72.2	133	157	144
26	78.4	92.6	85.2	157	185	170
27	92.6	109	101	185	218	201
28	109	129	119	218	258	237
29	129	152	140	258	304	280
30	152	180	165	304	359	331
31	180	212	195	359	424	390
32	212	250	230	424	500	460

Size Ranges for

There are 32 size ranges logarithmically placed from 1.25 - 250

**RANDOMLY
shaped particle
inversion
method**

microns in diameter (type B), or 2.5 – 500 µm (type C). In both cases, the upper size in each bin is 1.180 times the lower.

The table below shows the lower and upper limit of each size bin in microns, together with the median size (also in microns) for each size bin for type B and C instruments.

Size bin #	Type B			Type C		
	Lower	Upper	Median	Lower	Upper	Median
1	1.00	1.18	1.09	1.90	2.25	2.07
2	1.18	1.39	1.28	2.25	2.65	2.44
3	1.39	1.64	1.51	2.65	3.13	2.88
4	1.64	1.94	1.79	3.13	3.69	3.40
5	1.94	2.29	2.11	3.69	4.35	4.01
6	2.29	2.70	2.49	4.35	5.14	4.73
7	2.70	3.19	2.93	5.14	6.06	5.58
8	3.19	3.76	3.46	6.06	7.15	6.59
9	3.76	4.44	4.09	7.15	8.44	7.77
10	4.44	5.24	4.82	8.44	9.96	9.17
11	5.24	6.18	5.69	9.96	11.8	10.8
12	6.18	7.29	6.71	11.8	13.9	12.8
13	7.29	8.61	7.92	13.9	16.4	15.1
14	8.61	10.2	9.35	16.4	19.3	17.8
15	10.2	12.0	11.0	19.3	22.8	21.0
16	12.0	14.1	13.0	22.8	26.9	24.8
17	14.1	16.7	15.4	26.9	31.8	29.2
18	16.7	19.7	18.1	31.8	37.5	34.5
19	19.7	23.2	21.4	37.5	44.2	40.7
20	23.2	27.4	25.2	44.2	52.2	48.0
21	27.4	32.4	29.8	52.2	61.6	56.7
22	32.4	38.2	35.2	61.6	72.7	66.9
23	38.2	45.1	41.5	72.7	85.7	78.9
24	45.1	53.2	49.0	85.7	101	93.1
25	53.2	62.8	57.8	101	119	110
26	62.8	74.1	68.2	119	141	130
27	74.1	87.4	80.5	141	166	153
28	87.4	103	94.9	166	196	181
29	103	122	112	196	232	213
30	122	144	132	232	273	252
31	144	169	156	273	322	297
32	169	200	184	322	381	350

The following lines of code in MATLAB will compute the lower, upper and median size in microns of each bin for both instrument types. See also this article on Sequoia's article page: <http://www.sequoiasci.com/article/processing-lisst-100-and-lisst-100x-data-in-matlab/>

```
rho=200^(1/32);
x = 1.25; %lower limit for first size range for type B, spherical particles
x = 2.50; %lower limit for first size range for type C, spherical particles
x = 1.00; %lower limit for first size range for type B, randomly shaped
particles
x = 1.90; %lower limit for first size range for type C, randomly shaped
particles
bins(:,1) = x*rho.^([0:31]); %lower limit
bins(:,2) = x*rho.^([1:32]); % upper limit
bins(:,3) = sqrt(bins(:,1).*bins(:,2)); %mid-point
```

The following lines of code in MATLAB will compute the lower, upper and median angles (in degrees) for the VSF measurement in air and water:

```
B_all = logspace(0,log10(200),33)*0.1; %create 33 logspaced angles over a
1:200 dynamic range starting at 0.1degrees (type B LISST).
B_all = B_all';
ANGLES_O2(:,1) = B_all(1:32);%The lower limits are the first 32 (of 33)
ANGLES_O2(:,2) = B_all(2:33);%The upper limits are the last 32 (of 33)
ANGLES_O2(:,3) = sqrt(ANGLES_O2(:,1).*ANGLES_O2(:,2));%Midpoints.

C_all = logspace(0,log10(200),33)*0.05; %create 33 logspaced angles over a
1:200 dynamic range starting at 0.05degrees (type C LISST).
C_all = C_all';
ANGLES_O2(:,4) = C_all(1:32);%The lower limits are the first 32 (of 33)
ANGLES_O2(:,5) = C_all(2:33);%The upper limits are the last 32 (of 33)
ANGLES_O2(:,6) = sqrt(ANGLES_O2(:,4).*ANGLES_O2(:,5));%Midpoints.

ANGLES_H2O = ANGLES_O2./1.33;%Create angles in water using the refractive
index of water
```

Angles in air

Angles (in Degrees) for the VSF measurement *in air* are shown in the table below.

See also Sequoia's article page:

<http://www.sequoiasci.com/article/angles-for-lisst-100x-vsfc-measurement-in-air/>

Ring #	Type B			Type C		
	Lower	Upper	Median	Lower	Upper	Median
1	0.100	0.118	0.109	0.050	0.059	0.054
2	0.118	0.139	0.128	0.059	0.070	0.064
3	0.139	0.164	0.151	0.070	0.082	0.076
4	0.164	0.194	0.179	0.082	0.097	0.089
5	0.194	0.229	0.211	0.097	0.114	0.105
6	0.229	0.270	0.249	0.114	0.135	0.124
7	0.270	0.319	0.293	0.135	0.159	0.147
8	0.319	0.376	0.346	0.159	0.188	0.173
9	0.376	0.444	0.409	0.188	0.222	0.204
10	0.444	0.524	0.482	0.222	0.262	0.241
11	0.524	0.618	0.569	0.262	0.309	0.284
12	0.618	0.729	0.671	0.309	0.365	0.336
13	0.729	0.861	0.792	0.365	0.430	0.396
14	0.861	1.02	0.935	0.430	0.508	0.467
15	1.02	1.20	1.10	0.508	0.599	0.552
16	1.20	1.41	1.30	0.599	0.707	0.651
17	1.41	1.67	1.54	0.707	0.834	0.768
18	1.67	1.97	1.81	0.834	0.985	0.906
19	1.97	2.32	2.14	0.985	1.16	1.07
20	2.32	2.74	2.52	1.16	1.37	1.26
21	2.74	3.24	2.98	1.37	1.62	1.49
22	3.24	3.82	3.52	1.62	1.91	1.76
23	3.82	4.51	4.15	1.91	2.25	2.07
24	4.51	5.32	4.90	2.25	2.66	2.45
25	5.32	6.28	5.78	2.66	3.14	2.89
26	6.28	7.41	6.82	3.14	3.70	3.41
27	7.41	8.74	8.05	3.70	4.37	4.02
28	8.74	10.31	9.49	4.37	5.16	4.75
29	10.31	12.17	11.20	5.16	6.09	5.60
30	12.17	14.36	13.22	6.09	7.18	6.61
31	14.36	16.95	15.60	7.18	8.47	7.80
32	16.95	20.00	18.41	8.47	10.00	9.21

Angles in water Angles (in Degrees) for the VSF measurement *in water* are shown in the table below.

See also Sequoia's article page:

<http://www.sequoiasci.com/article/angles-for-lisst-100x-vsfc-measurement-in-water/>

Ring #	Type B			Type C		
	Lower	Upper	Median	Lower	Upper	Median
1	0.075	0.089	0.082	0.038	0.044	0.041
2	0.089	0.105	0.096	0.044	0.052	0.048
3	0.105	0.124	0.114	0.052	0.062	0.057
4	0.124	0.146	0.134	0.062	0.073	0.067
5	0.146	0.172	0.158	0.073	0.086	0.079
6	0.172	0.203	0.187	0.086	0.102	0.093
7	0.203	0.240	0.221	0.102	0.120	0.110
8	0.240	0.283	0.260	0.120	0.141	0.130
9	0.283	0.334	0.307	0.141	0.167	0.154
10	0.334	0.394	0.362	0.167	0.197	0.181
11	0.394	0.465	0.428	0.197	0.232	0.214
12	0.465	0.548	0.505	0.232	0.274	0.252
13	0.548	0.647	0.596	0.274	0.324	0.298
14	0.647	0.764	0.703	0.324	0.382	0.351
15	0.764	0.901	0.829	0.382	0.451	0.415
16	0.901	1.063	0.979	0.451	0.532	0.489
17	1.063	1.255	1.155	0.532	0.627	0.578
18	1.255	1.481	1.363	0.627	0.740	0.682
19	1.481	1.747	1.609	0.740	0.874	0.804
20	1.747	2.062	1.898	0.874	1.031	0.949
21	2.062	2.433	2.240	1.031	1.217	1.120
22	2.433	2.871	2.643	1.217	1.436	1.322
23	2.871	3.389	3.119	1.436	1.694	1.560
24	3.389	3.999	3.681	1.694	1.999	1.841
25	3.999	4.719	4.344	1.999	2.359	2.172
26	4.719	5.568	5.126	2.359	2.784	2.563
27	5.568	6.571	6.049	2.784	3.286	3.025
28	6.571	7.754	7.138	3.286	3.877	3.569
29	7.754	9.151	8.424	3.877	4.575	4.212
30	9.151	10.80	9.941	4.575	5.399	4.970
31	10.80	12.74	11.73	5.399	6.371	5.865
32	12.74	15.04	13.84	6.371	7.519	6.921

Raw Data Storage Format

The values in the binary raw data file (.DAT extension) are stored in the order shown in the table below.

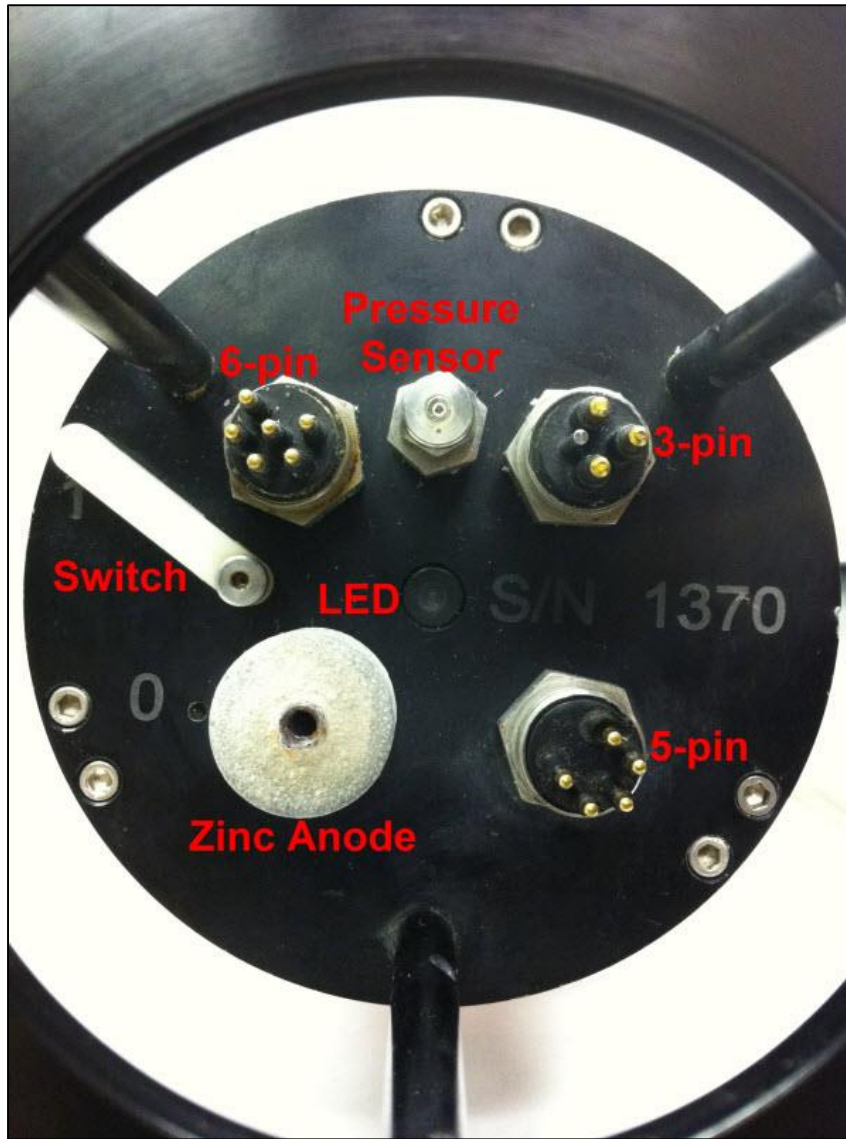
Elements	Parameter
1:32	Light intensity on detectors 1 through 32
33	Laser transmission Sensor
34	Battery voltage in raw counts
35	External Auxiliary input 1 (0 to 5V = 0 to 4096)
36	Laser Reference sensor
37	Pressure in cm
38	Temperature in units of 100ths of degrees C
39	(Day*100 + Hour) at which data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

Processed Data Storage Format

The values in the processed data file (.ASC extension) are stored in the order shown in the table below. Each sample is stored in one row.

Elements	Parameter
1:32	Volume concentration (in $\mu\text{l/l}$) for size class 1 through 32. NOTE: The volume concentration is computed under the assumption that the volume conversion constant was measured over a 5 cm path length. If you are using a path reduction module (PRM), the concentrations in columns 1 through 32 will not be correct. However, you can correct it simply by multiplying the volume concentration by a factor of 2, 5 or 10 for data obtained with 50, 80, and 90% PRM's respectively.
33	Laser transmission Sensor [mW]
34	Battery voltage in calibrated units [V]
35	External Auxiliary input 1 in calibrated units [mW]
36	Laser Reference sensor in calibrated units [mW]
37	Pressure in calibrated units [m]
38	Temperature in calibrated units [C]
39	(Day*100 + Hour) at which data taken
40	(Minutes*100 + Seconds) at which data taken
41	Computed optical transmission over path
42	Beam-attenuation (c) [m^{-1}]. NOTE: The beam attenuation is computed under the assumption that the path length is 50 mm (0.05 m). If you are using a path reduction module (PRM), the beam attenuation will NOT be correct. However, the optical transmission is still correct, so you can compute the beam attenuation using the following expressions: $c = -\ln(\text{optical transmission}) * (1/0.025 \text{ m})$ if you are using a 50% PRM (25 mm path length). $c = -\ln(\text{optical transmission}) * (1/0.01 \text{ m})$ if you are using an 80% PRM (10 mm path length) and $c = -\ln(\text{optical transmission}) * (1/0.005 \text{ m})$ if you are using a 90% PRM (5 mm path length). An alternative option is to multiply the beam attenuation in column 42 with 2, 5 and 10 for data obtained with 50, 80, and 90% PRM's respectively.

Appendix B: Connector Pinouts for LISST-100X



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

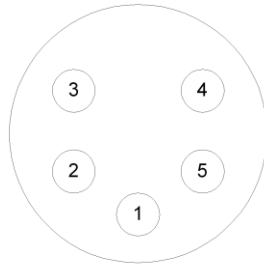
Communications and Power Connector (5 pin connector)

Connector Manufacturer: Impulse Enterprise, Inc. San Diego, CA, USA

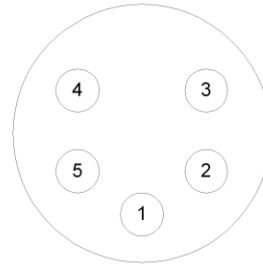
Connector Part Number (Bulkhead): MCBH (WB)-5-MP Stainless Steel

Mating Cable Part Number: MCIL-5-FS

Connector Pin #	Use
1	Power/Serial Ground
2	External Power In (+9V nom. 6-15V) ⁸
3	Power/Serial Ground
4	Serial Out (to DB-9 Pin 2)
5	Serial In (to DB-9 Pin 3)



Bulkhead Endview



Cable Endview

⁸ For instruments shipped after 1 March 2012, 9-24V Max, 0.5 A min

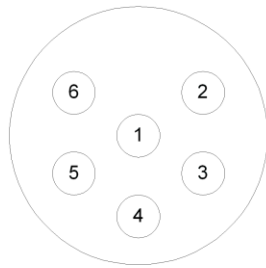
Auxiliary Input Connector (6 pin connector)

Connector Manufacturer: Impulse Enterprise, Inc. San Diego, CA, USA

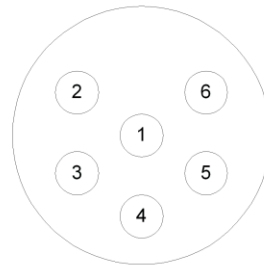
Connector Part Number (Bulkhead): MCBH (WB)-6-MP Stainless Steel

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

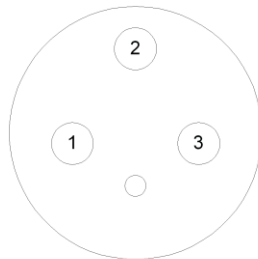
BioBlock Connector (3 pin connector)

Connector Manufacturer: Impulse Enterprise, Inc. San Diego, CA, USA

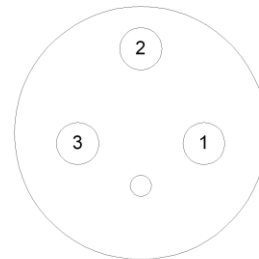
Connector Part Number (Bulkhead): MCBH (WB)-3-MP Stainless Steel

Mating Cable Part Number: MCIL-3-FS

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




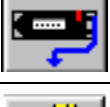
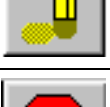


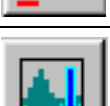
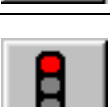




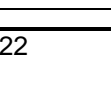




Bulkhead Endview



Cable Endview

Appendix C: 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 the instrument for its current configuration and displays the information to the screen.
	Offload	Offloads stored data to a file for later processing.
	Erase	Erases user selected files from the data logger.
	Stop	Sends a CTRL-C to the instrument to stop a running program.
	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.

	Put LISST to sleep	Attempts to wake up instrument from low-power sleep mode. This may take up to 40 seconds.
	Wake up LISST	Puts instrument into low-power sleep mode.

Appendix D: Software Installation & Upgrade Procedure

The following procedure describes the installation of the LISST-SOP Version 5.1 software. The LISST-SOPv5.1 is available from the Sequoia Scientific's web site (<http://www.sequoiasci.com/product/lisst-100x/>) and is included on a USB card with new instruments. If you are installing SOPv5.1 from your USB card, the necessary files are already included with the installer. You can simply double click the SetupSOPv5_1_6.exe installer and follow the onscreen instruction to complete the installation. If you are acquiring the software from Sequoia's website, please follow the instructions below.

NOTE THAT VERSION 5.1 DOES NOT SUPPORT COMMUNICATION WITH THE LISST-100; ONLY WITH THE LISST-100X. YOU MUST USE VERSION 4.65 (Windows XP compatible only) TO COMMUNICATE WITH AND PROGRAM A LISST-100.

UPDATING EXISTING INSTALLATION

Download Install file If SOPv5.0 (the previous version) is already installed on your machine, the software can be updated while preserving your existing instrument files.

The LISST-SOPv5.1 update installer is available from the Sequoia Scientific's web site (<http://www.sequoiasci.com/product/lisst-100x/>). Choose the .zip file labeled "LISST-100X SOP Ver 5.1 - UPDATE INSTALLER". Save this file to your computer.

Unzip and Run SetupSOPv5_1_6_Update.exe Unzip the file to a temporary folder on your hard drive. Run the SetupSOPv5_1_6_Update.exe installer. Follow the onscreen instructions to complete the installation.

NEW INSTALLATION FROM WEBSITE

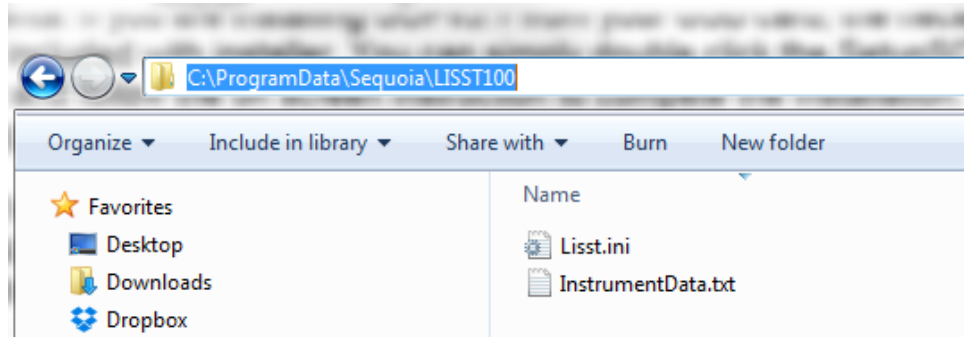
Download Install file The LISST-SOPv5.1 installer is available from the Sequoia Scientific's web site (<http://www.sequoiasci.com/product/lisst-100x/>). Choose the .zip file labeled "LISST-100X SOP Ver 5.1 - FULL INSTALLER". Save this file to your computer.

Unzip and add files Unzip the file to a temporary folder on your hard drive, and then add the following files to the temporary folder:

- Factory_zsc_SNSN.asc, where SNSN is the instrument serial number.
- InstrumentData.txt
- Lisst.ini
- ringarea_SNSN.asc, where SNSN is the instrument serial number.

Note that it is absolutely necessary to have these files. The program will not run without them. These files will be located on the original disk or USB card that was shipped with your instrument. You can also retrieve them from an existing LISST-SOP installation

on another computer. They will be located under C:\Program Files (x86)\Sequoia\LISST100 and C:\ProgramData\Sequoia\LISST100. The latter directory may be hidden on your computer. To access the directory simply copy and paste the path into windows explorer.



Run SetupSOPv5_1_6.exe

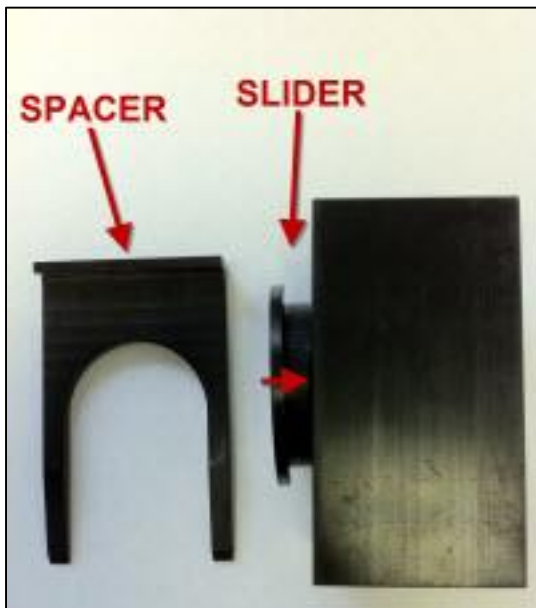
When you have added the 4 files above to the same folder as the installer, run the SetupSOPv5_1_6.exe installer. Follow the onscreen instructions to complete the installation.

Appendix E: Zscat Chamber Installation Procedure



Step 1) Before installing the Small Volume Zscat Chamber first clean the windows of the LISST-100X.

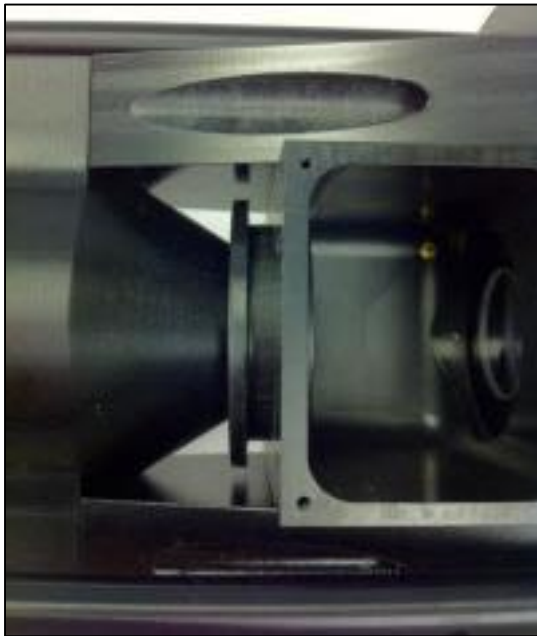
NOTE: On older versions of the LISST-100X it may also be necessary to remove the endcap ring and standoffs on the optics endcap. Remove the three screws on the endcap ring and then unscrew the standoffs.



Step 2) Remove the Spacer and push the Slider toward the center of the chamber.



Step 3) Carefully insert the Chamber into the optical path of the LISST-100X. Be careful not to let the O-rings come into contact with the optical windows of the LISST-100X.



Step 4) By reaching in from the top of the chamber push the Slider out until the chamber is up against the optics endcap. The Slider should mate to the cone shape of the transmit optics.

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 without binding.



Step 5) Once the slider is positioned such that the O-ring is engaging 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.

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; only IN the chamber.

Appendix F: BioBlock Use

The BioBlock Anti-Biofouling Shutter system is a bolt-on optional accessory that is available for the LISST-25X and LISST-100X. Copper disks are placed very near the optical windows. The copper discourages any biology from growing on the optical windows. The BioBlock is self-contained with its own battery pack. It uses a 5V logic signal from the dedicated BioBlock connector on the LISST-100X connector endcap.

This appendix is separated into three parts. The first section covers the installation of the BioBlock onto the LISST-100X in 6 steps.

The second section discusses configuring the firmware in the instrument to recognize the BioBlock and use it during data collection.

The third section discusses general maintenance such as cleaning and battery replacement.

BioBlock Installation Instructions for the LISST-100X



Step 1) The BioBlock for the LISST-100X is shipped fully assembled and ready to mount onto the LISST-100X. Please note that the main body of the BioBlock can be used on the LISST-25X and LISST-100 in addition to the LISST-100X. Therefore it is important to specify which type of instrument the BioBlock will be used with at the time the order is placed. The photo on the left shows the assembled BioBlock next to the LISST-100X.

The BioBlock is shown in the Closed (windows covered) position. This position is best for correctly positioning the unit during installation. The BioBlock should be removed from the LISST-100X in the Closed position to facilitate re-installing it at a later date. The BioBlock may be commanded to go to the Closed position prior to installation by connecting it to the LISST-100X and using the LISST-100X software. **Do not manually rotate the crank arm that drives the shutter.**

The BioBlock has two main parts. The main cylindrical body contains the motor, batteries, and electronics. Mounted to the end of the main body is the translating shutter assembly with copper plates. The shutter assembly is attached to the rotating crank arm with a plastic arm.



Step 2) The image to the left shows how the BioBlock is inserted between the triangular Crossbar Standoffs of the LISST-100X.



Step 3) However, before installing the BioBlock we must first remove one of the screws on the endcap.

Rotate the LISST-100X to match the photo. The two endcap screws should be above the Crossbar Standoff on the left. One is threaded into the endcap and the other is longer and threaded into the instrument housing.

Remove the shorter screw such that the threaded screw hole is empty. This is the most clockwise screw of the pair. This threaded hole will be used to hold the BioBlock in place.



Step 4) Slowly slide the BioBlock shutter assembly straight down between the Crossbar Standoffs and the windows (the LISST-100X sample volume), taking care not to drag the copper plates across the windows.

The assembly is designed to fit snugly between the Crossbar Standoffs. If the fit is too tight the plastic sides of the assembly may be lightly sanded until the parts fit together easily.

Holding the BioBlock body firmly against the LISST-100X, and ensuring that the shutter assembly is centered in the LISST-100X sample volume, install and tighten the mounting screw. This screw is provided with the unit and is not the screw that was removed in Step 3.



Step 5) Use large tie-wraps to secure the BioBlock body to the LISST-100X, as shown in the photo on the right. The tie-wraps should be placed over the bolts extending from the mounting brackets. Trim excess ends of tie-wraps.



Step 6) Connect the BioBlock cable to the LISST-100X and configure the instrument using the instructions on the following pages.

Then verify normal operation by cycling the system using the LISST.EXE software. The BioBlock shutter should position itself smoothly during cycling, with no binding.

If necessary, loosen the mounting screw slightly and adjust the position of the BioBlock slightly to improve operation, and then re-tighten the screw.



The figure on the left shows the fully assembled BioBlock on the LISST-100X.

Configuring and Operating the BioBlock on the LISST-100X

The LISST-100X comes pre-configured for use with the BioBlock. There is a dedicated 3-pin BioBlock connector on the endcap and the firmware is designed to utilize the BioBlock shutter during sampling. The only thing remaining is to inform the firmware that the BioBlock has been installed. To do this a simple two letter command has been added to tell the instrument the BioBlock is attached. The command is BB (short for BioBlock). The summary of the command is below.

BB	BioBlock Configuration and Test Command
Syntax:	BB or bb
Description:	Configure the BioBlock Connection Setting and send test commands.
Example:	input: BB 1 output: BioBlock is now connected! Input options: 0 = BioBlock is not connected. 1 = BioBlock is connected. 10 = BioBlock is connected and issues a command to close the BioBlock. 11 = BioBlock is connected and issues a command to open the BioBlock.

As shown in the table above the BB command has multiple input options. In addition to telling the firmware that the BioBlock is connected, the command can also be used for testing the operation of the BioBlock. For example, issuing a BB 10 command will enable the connection and send the command to close the BioBlock. A BB 11 command will also enable the connection and send an open command.

During normal sampling the LISST-100X firmware will command to open the BioBlock before each sample is collected (provided that the LISST-100X is configured for use with the BioBlock!).

After the sample is recorded the time until the next sample is computed by the LISST-100X firmware. If the time remaining is less than 30 seconds the BioBlock will remain open. If the time is greater than 30 seconds the BioBlock will close and then reopen two seconds before the next sample.

When using the Real Time mode of the LISST-SOP software, the BioBlock will not be commanded to open at the beginning of sampling. Therefore it must be manually opened using the BB 11 command.

To issue the BB command, open the Terminal window on the standard LISST-SOP Windows software. At the L100X:>> prompt type BB followed by the input option. Pressing Enter will set the BioBlock connection and issue any open or close commands. If a Display Status (DS) command is now issued the listing of the instrument status will now include a message that the BioBlock is now connected.

The BioBlock in its standard configuration is powered independently from the LISST-100X and uses two standard alkaline D batteries for power. The electronics inside the BioBlock includes a battery monitor. If the voltage of the battery is too low a signal will be sent to the LISST-100X. If LISST-100X sees that the BioBlock battery is low it will command the

BioBlock to remain open. By monitoring the battery, the BioBlock can be left in the open position before the battery voltage is too low so that the LISST-100X can still obtain measurements even if the BioBlock batteries have died.

The BioBlock

BioBlock Battery replacement

The BioBlock uses two standard Alkaline D cells to power its operation. The following procedure can be used to replace the batteries. It is recommended that the batteries be replaced before each extended deployment and that the procedure is carried out indoor on a workbench.

The following tools are needed:

Screwdriver.

2 Alkaline replacement D cells.

O-ring grease (if O-ring needs greasing).

Spare O-ring is O-ring needs to be replaced (spare O-rings ship with each BioBlock).

Step 1) Disconnect the cable attaching the BioBlock to the LISST-100X at the BioBlock. The BioBlock can remain connected to the LISST-100X if desired.

Step 2) Remove the three screws holding the connector endcap to the main body of the BioBlock. These screws are 4-40UNC socket head cap screws that are 5/8 inches long.

Step 3) Carefully remove the endcap from the main body by gently pulling on the endcap with a slight twisting motion. Be careful not to pull the assembly out too far. Wires connect this endcap to the internal circuitry and therefore the travel is limited.

Step 4) The two batteries are held in place by a battery mount attached to the connector endcap. Remove the batteries and replace with fresh alkaline batteries. **Wrap each battery with electrical tape to keep it in place during installation.** Please note that the battery mount is flexible and when inserted in to the housing the squeeze on the batteries will increase to insure a good connection. Make sure that the tape does not impede the batteries from sliding and making good contact.

Step 5) Check the O-ring on the connector endcap. The surface should be clean and free of cuts. If needed, add a very light coating of O-ring grease to make assembly easier. The O-ring is a Parker O-ring #2-133.

Step 6) Carefully slide the battery assembly into the housing. It should be possible to rotate the assembly after installation to line up the screw holes.

Step 7) Install the three screws holding the endcap in place. Tighten the screws to just slightly tighter than finger tight. **The sealing of the endcap is *NOT* dependent on the tightness of the screws.** Since the metal screws are threaded into plastic it is easy to over tighten the screws and strip the threads in the housing. **Do not over tighten the screws.**

Step 8) Reattach the cable to the LISST-100X and test the operation using the BB 11 and BB 10 commands. The commands can be issues through the Terminal window of the LISST-SOP software.

Appendix G: Technical Assistance & Troubleshooting

Q: I think that I have a problem with my data and/or my data processing and would like you to have a look at them - can you do that? What data do I need to send to you?

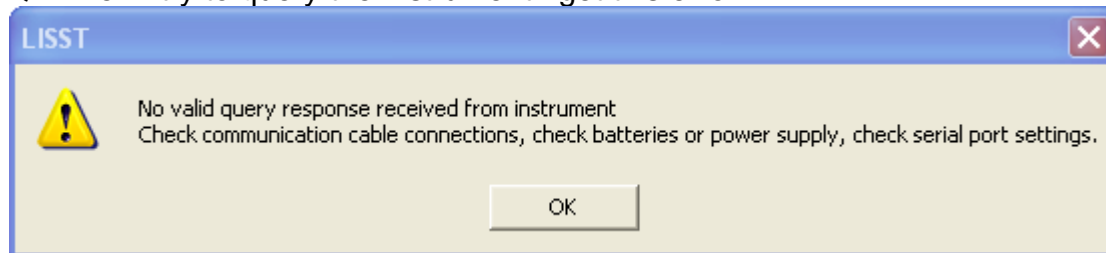
A: We'll be happy to look at your data and help you figure out what is going on. We ALWAYS need the following from you:


- 1) The raw data (the file(s) with either a .DAT or a .LOG extension).
- 2) The zscat file you used for processing your data.
- 3) The serial number of the instrument you are using.

If you are returning data from more than one instrument, please send them in separate emails, with data from only one instrument in each email, and the subject line clearly indicating instrument type and serial number. Email the data to your local Sequoia distributor, together with a detailed explanation of what you were doing and how the data were collected. If you purchased the instrument directly from Sequoia, email the data to info@SequoiaSci.com.

PLEASE NOTE: We cannot use the .psd or .asc files produced by the LISST-SOP for troubleshooting – do not include these in your email. We can only help you if you supply the information listed in 1-3 above.

Q: When I try to query the instrument I get this error:



A: In addition to checking the cable, power and serial port settings, make sure that the instrument is not running or sleeping. Open up the terminal window and confirm that no program is running. If a program is running, stop it by clicking the  button, close the terminal window and try to query the instrument again.

Q: I cannot connect to my LISST-100X. The communication cable is connected to my computer as well as my LISST-100X and the LISST-SOP is running, but I am unable to talk to the instrument.

A: Check the following:

- 1) First, make sure that the instrument is not already programmed and waiting for a start event to appear (see the Q&A immediately above this one).
- 2) Do not use a netbook for connecting to a LISST-100X. It will generally not work. If you are using a netbook, switch to a desktop, a laptop, or a notebook computer (in that preferred order) running the LISST-SOP.

Note for DELL users: It is known that some DELL computers have an error in their BIOS

that makes it difficult to connect to the serial port, either directly if it exists or via a USB-serial adapter if no serial port exists. If you are using a DELL computer, check on DELL's website (www.dell.com) if a BIOS upgrade is available for your particular model. If an upgrade is available, download and install it and try connecting again before proceeding further. It is not known if this problem also exists for computers from other manufacturers.

3) If possible, connect directly to an actual serial port (i.e. do not use a USB-Serial adapter unless absolutely necessary) and check if this makes a difference.

4) Close the LISST-SOP and open up the MOTOCROSS program. This program is located in the LISST100 directory on your computer (motocross.exe). Be sure that the selected communication port is correct and that its settings are correct.

5) Check the connectivity of the communication cable. You will need 2 paperclips and a voltmeter. You also need to consult the connector diagram for the 5-pin connector, both the male bulkhead connector and the cable end (see Appendix B: Connector Pinouts for LISST-100X on page 119). Make sure that the cable is connected to the serial port of the PC and proceed as follows:

- Check the voltage between pins 1 and 2 on the communication cable. You may need the paperclips to extend the measuring pins of the voltmeter to make a proper contact inside the cable. The voltage should read 12 V. If it does not, the cable may be defect.
- Short the female pins 4 and 5 on the communication cable using one or both paperclips. Type some characters into MOTOCROSS. They should appear on the screen. If they do not, the cable may be defect.
- Measure the voltage between pins 3 and 4 of the male bulkhead 5-pin connector on the LISST-100X. The voltage will be 0 most of the time, and should spike to between -5 to -9V every 2 minutes for about 2 seconds. It can be challenging to maintain contact for 2 minutes, so take care to ensure constant contact, and then watch the voltmeter continuously.

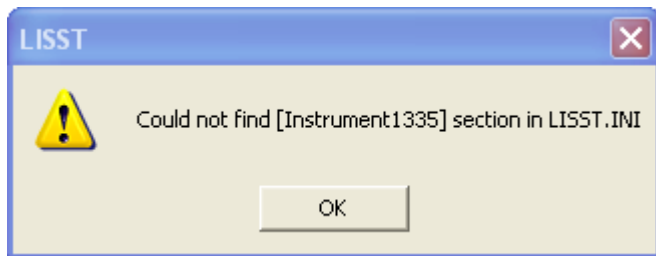
6) Remove the end cap, and disconnect the main battery. Measure the battery voltage on the main battery. It should be above 6V and close to 9V for a new battery. If it is below 6V replace the battery and try again.

7) Locate test point TP2 (minus) and P12 (plus) on the connector endcap board. Measure the voltage between the 2 test points. This voltage should be the same as for the battery.

8) Locate the right hand side of D2 and measure the voltage between the right side of D2 and TP2. Voltage must be present.

9) If there is still no connection, contact your local distributor or Sequoia directly at info@sequoiasci.com. Be sure to include your full contact info as well as instrument serial number. It is also useful for us to know when was the last time you talked to the instrument and what the instrument has been doing since last time you talked to it (e.g. in storage, deployed in the field, shipped to another location etc.). Also let us know the results of each of the tests above.

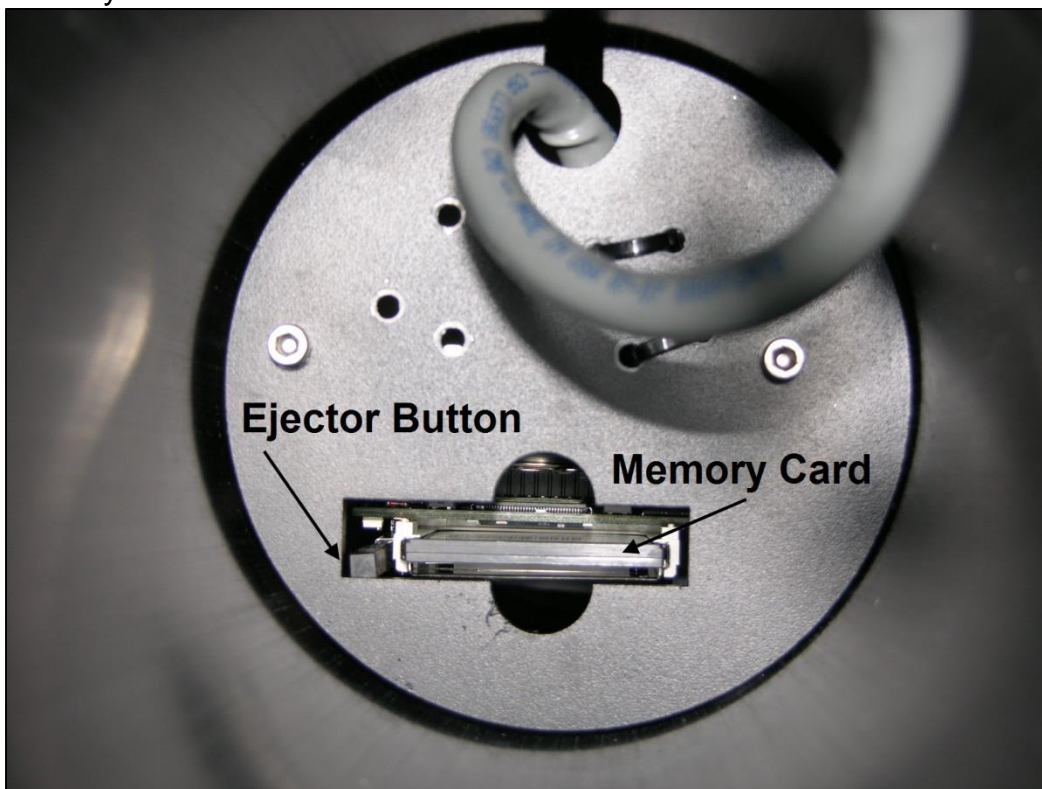
Q: When I try to program the instrument I get this error (note: [Instrument1335] will change depending on the serial number of your instrument):



A: Go to your C:\ProgramData\Sequoia\LISST100 folder and search for the LISST.INI file. Open it up in Notepad or a similar text editor. Make sure that the section containing your instrument calibration constants are located in the file. If not, copy them from the LISST.INI file that was included on the ship disk for your instrument. Then re-save the edited LISST.INI file in C:\ProgramData\Sequoia\LISST100.

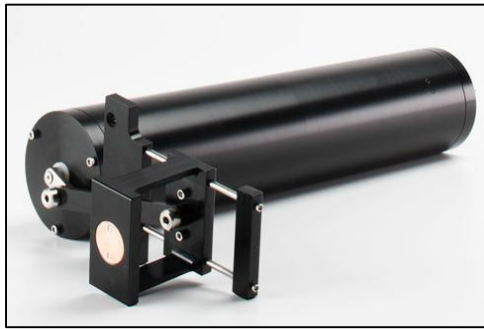
Q: When I try to offload the data I get an error and the offload stops. I can talk to the instrument and program it, but it will not offload.

A: It is possible that the Compact Flash Memory Card inside the instrument has come loose. Open up the connector endcap and pull out the battery (it is not necessary to remove the battery). Look inside the instrument, and you will see a faceplate with a cut-out for the memory card:



Push on the memory card to make sure that it is fully seated in the memory card holder, then try offloading data again. Take care not to push on the card ejector button when you are pushing the memory card back in place.

Appendix H: LISST Accessories



BioBlock

A mechanical anti-fouling accessory for the LISST--100X (and LISST-25X). Sliding copper shutters in front of the windows limit fouling to a minimum. BioBlock is controlled by the LISST-100X or LISST-25X to open before a measurement takes place and close again after the measurement.



Custom Power and Communication Cable

Integrated Power and Communications cables are available for the LISST-100X/-STX in lengths of 20, 30 and 50 meters. The yellow jacketed cable has a breaking strength of 1000 pounds. The standard underwater connectors for communications and power are molded to the cable.



Full Path Mixing Chamber

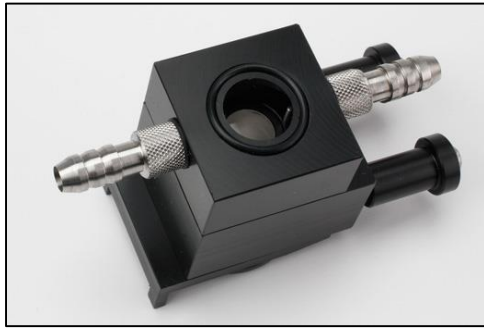
Allows the submersible LISST-100/-100X to also be used as a laboratory particle size analyzer. Installs on to the optics of a standard path (5 cm) LISST-100/-100X. The chamber has a volume of approximately 115 ml with built-in drain and magnetically coupled mixer. Power supply with adjustable speed controller provided.



Full Path Flow-Through Chamber

Allows a sample to be pumped through the chamber. Installs on to the optics of a standard path (5 cm) LISST-100/-100X.

When combined with your own pump and stirred sample container the Full Path Flow Through Chamber allows the submersible LISST-100/-100X to be used as a laboratory particle size analyzer.



Small Volume Flow-Through Chamber

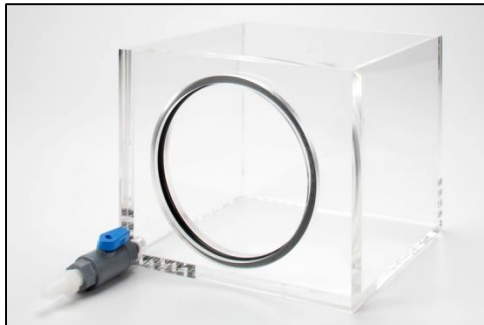
Reduces the optical path length to 1 cm for higher maximum concentrations. Optimized for pumped flow through applications and seals on optics of standard 5 cm path instruments only.

When combined with your own pump and stirred sample container the Small Volume Flow Through Chamber allows the submersible LISST-100/-100X to be used as a laboratory particle size analyzer.



Path Reduction Modules

The Optical Path Reduction Modules (PRM) are used with the LISST-100/-100X and LISST-ST/-STX to reduce the optical path in the field, thereby increasing the maximum sediment concentration that can be measured, without the need for permanent optical path reductions. PRMs are available to reduce the optical path by 50, 80, and 90%.



Large Volume Test Chamber

Horizontal acrylic chamber with O-ring and drain valve. Ideal for doing background measurements (zscats) with a PRM in place.



Clamps

2-piece or 1-piece clamps for easy mounting of the LISST-100/-100X to a frame or simply to a wire for stand-alone profiling. **One set of clamps ships as standard with the LISST-100X.** Sold as set of 2 complete clamps only.



LISST-100X Replacement Batteries

Battery packs for the LISST-100X / LISST-STX with 18 alkaline batteries assembled into a custom battery pack to provide the +9 and -9V required. The battery pack is **not** rechargeable. **One battery pack ships as standard with the LISST-100X.**

NOTE: The LISST-100X/-STX battery pack CANNOT be used with the LISST-100/-ST instruments.



Replacement Zscat Chamber

Used for doing background scatter measurement (zscat) before deployment.

One chamber ships as standard with the LISST-100X.

Warranty

STATEMENT OF LIMITED, EXTENDED WARRANTY

This Statement of Limited Warranty applies to all Sequoia Scientific, Inc. ("SEQUOIA") products ("Products"). Any additional or different terms, including any terms in any purchase order, will be of no effect unless agreed to in writing by an authorized representative of SEQUOIA as reflected in a written SEQUOIA quotation.

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.

2. Correction of Non-Compliance

If, during the twelve months after delivery (the "Warranty Period"), 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 the Warranty Period and ships the Product to SEQUOIA within one month after the end of the Warranty Period. As to any Product repaired or replaced by SEQUOIA, the Warranty Period will end upon the later of the end of the original Warranty Period or 90 days after SEQUOIA's delivery of the repaired or replacement Product to Customer. Any Product, component, part or other item replaced by SEQUOIA becomes the property of SEQUOIA. SEQUOIA may use refurbished components in the repair of Products supplied hereunder.

SEQUOIA's warranties shall be void and not apply if the Product has been subjected to misuse or alteration or repaired by a party not approved by SEQUOIA or the serial number on a product (if applicable) has been altered or defaced. SEQUOIA shall not be liable for normal wear and tear (such as replacement of consumables), nor for defects or failure caused by maintenance, misuse, negligence or failure resulting from non-compliance with SEQUOIA's specifications, operating or maintenance manuals.

3. Infringement Indemnification

If any Product does not comply with the warranty set forth in 1(c) above, SEQUOIA will defend and indemnify Customer against any third-party claim asserted in any proceeding against Customer based on this noncompliance; provided that Customer gives SEQUOIA prompt written notice of the claim, SEQUOIA has exclusive control over the defense and settlement of the claim, Customer provides such assistance as SEQUOIA may request in connection with the defense and settlement of the claim (in which event SEQUOIA will reimburse the reasonable out-of-pocket costs incurred by Customer to provide such assistance), Customer does not settle the claim without the prior written consent of SEQUOIA and, upon SEQUOIA's request, Customer returns the Non-Complying Product to SEQUOIA for modification, replacement or a refund of the purchase price paid by Customer to SEQUOIA for the Non-Complying Product, less a reasonable allowance for Customer's use prior to return.

4. Exclusive Warranties

THE WARRANTIES SET FORTH IN PARAGRAPH 1 ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. SEQUOIA DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED (INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND ANY IMPLIED WARRANTY ARISING FROM COURSE OF PERFORMANCE, COURSE OF DEALING, OR USAGE OF TRADE) OTHER THAN THOSE SPECIFICALLY SET FORTH IN PARAGRAPH 1.

5. Exclusive Remedies

CUSTOMER'S RIGHTS AND REMEDIES SET FORTH IN PARAGRAPHS 2 AND 3 ABOVE ARE EXCLUSIVE AND IN LIEU OF ANY AND ALL OTHER RIGHTS AND REMEDIES FOR ANY BREACH OF OR OTHER FAILURE TO COMPLY WITH ANY WARRANTY WITH REGARD TO ANY PRODUCT.

6. No Consequential Damages

SEQUOIA will not be liable for any indirect, incidental, special or consequential damages, any cover, or any loss of revenue, profit, data or use.

7. Limitations of Liability

SEQUOIA's liability (whether in contract, tort, or otherwise; and notwithstanding any fault, negligence, strict liability or product liability) with regard to any Product (including, but not limited to, any breach of or default by SEQUOIA) will in no event exceed the purchase price paid by Customer to SEQUOIA for such Product. Further, SEQUOIA will not be liable for, or be in breach of or default on account of, any delay or failure to perform as a result of any cause, condition or circumstance beyond SEQUOIA's reasonable control.

8. Indemnification by Customer

Customer acknowledges that the Products are designed and manufactured for use in non-critical, monitoring situations. If Customer chooses to purchase a Product or Products for use in applications that could result in damages in excess of the price of the Product if the Product does not operate properly or otherwise fails, Customer acknowledges and agrees that it is Customer's responsibility to provide for redundancy and/or other safety or back-up measures sufficient to assure that failure of a Product(s) will not cause such damages. Customer agrees that it will defend and hold SEQUOIA harmless from any and all claims and costs (including but not limited to attorney's fees and other costs of defense against such claims) in excess of the price of the Products arising directly or indirectly from such Customer's use of the Products. Such indemnification is a critical part of the consideration being provided by Customer (over and above the price paid for the Product(s)) for the right to use the Products for such purposes and Customer shall not use a Product or Products for such purposes if it is unwilling or unable to provide such indemnification.

9. Statute of Limitations

Customer will not commence any action based on breach of warranty with respect to any Product more than 18 months after SEQUOIA's delivery of such Product.

10. Software

The Products may include or be delivered with certain computer programs, databases or other software that is proprietary to SEQUOIA. SEQUOIA hereby grants Customer a nonexclusive license to use such software solely for the purpose of operating Products. Customer will not: use any such software for any other purpose; modify, adapt, translate, or create derivative works based on any such software; or disassemble, decompile or reverse engineer any such software. No title to or ownership of any software or intellectual property rights are transferred to Customer.

11. U.S. Government Restricted Rights Notice

All software, data, technical information, and written materials provided by SEQUOIA are provided with restricted rights. Use, duplication, or disclosure by the government is subject to restrictions as set forth in subparagraph (c)(1)(ii) of the Rights in Technical Data and Computer Software clause at 48 C.F.R. § 252.227-7013 or in subparagraph (c)(2) of the Commercial Computer Software-Restricted Rights clause at 48 C.F.R. § 52.227-19, as applicable. Portions of these items may be unpublished. SEQUOIA reserves all rights under applicable copyright laws.

12. Controlling Document

In the event of any conflict or inconsistency between any provision of this Statement of Limited Warranty and any other provision of the Order, the provision of this Statement of Limited Warranty will control.

13. Controlling Law

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 for the purpose of applying another jurisdiction's law. The U.N. Convention on Contracts for the International Sale of Goods will not apply.

Index

A

Accessories	138
Analog Inputs	15
Auxiliary Parameter Window	51, 62

B

Background	
acquiring.....	23, 40, 42
importance	23
Battery	
drain.....	16
external	111
life15	
replacement	105
BioBlock	138
battery replacement.....	134
Configuring	132
installation	19, 128

C

Clamps	139
Connector	
3-pin.....	19, 121
5-pin.....	19, 120
6-pin.....	19, 121
BioBlock	121
diagrams	119
Connector endcap	19
Corrosion	102

D

Data	
offloading.....	44
view processed	61
Data Processing	
batch processing.....	54
batch processing from the command line.....	59
real-time, advanced.....	71
real-time, simple.....	67
single file	47
Data Storage Format	
processed data.....	118
raw data	117
Digital Inputs	15

E

Error Messages	
could not find [Instrumentxxxx]	136
no valid query response.....	135
External I/O Ports	
analog.....	15
digital	15, 84, 85
External Power Supply	16, 111

F

File type	
.asc.....	35, 47, 118
.dat.....	117
.log.....	47
.psd.....	35, 47
Firmware	45, 83
configuring for BioBlock.....	132
Flow-Through Chamber	
full path	138
small volume	139

I

InstrumentData.txt file	
location.....	21
Inversion Model	
randomly shaped particles	48, 55
spherical particles.....	47, 54

L

Laser Power	
low	25, 43
Laser Transmission	117, 118
LISST.ini file	
location.....	21

M

Maintenance	104
Memory	23
Metadata	25
Misalignment	43
Mixing Chamber	138
Mounting	101
precautions for vertical	101
with a BioBlock	101

O

Offload baud rate	45
Offload Baud Rate	45
Operating Mode	25, 71, 77
burst	78
Fixed sample rate.....	78
real time	78
Optics endcap	18

P

Path Reduction Module	See PRM
Precautions	17
Pressure Sensor	15
PRM	118

R

Real time26

S

Scattering Angles
 computing114
 in air115
 in water116

Serial Port Settings83

Size Ranges111, 112
 computing114
 randomly shaped particles112
 spherical particles112

Sleep Mode
 put to sleep39
 wake up21

Software
 installation21, 124

Specifications111

Standard Particles103

Start Conditions79
 depth start84
 external digital input84
 external mechanical switch84
 time delay84
 time start84

Stop Conditions80

 depth stop85
 external digital input85
 external mechanical switch85
 fixed number of samples85
 low battery85
 maximum memory85
 time stop85

Storage102

T

Temperature Sensor15

Terminal Window83

Test Chamber
 large volume139
 standard zscat140

Troubleshooting
 cannot connect135
 cannot offload137

Two Letter Commands83

V

View Rings52

Z

Zscat Chamber140
 installation126