2021 Product Catalog
LISST Instruments
About Sequoia Scientific, Inc.

Sequoia was founded in 1995 by Dr. Yogesh (Yogi) Agrawal and Chuck Pottsmith. Yogi received his Ph.D. from University of California, Berkeley in 1975, and was a scientist at Woods Hole Oceanographic Institution (WHOI) from 1978-1988 when he relocated to Seattle. At WHOI, Yogi had developed interests in optical and acoustic instrumentation development, marine boundary layers and sediment transport.

In Seattle, he started working at a company where he met Chuck, who studied mechanical engineering. Chuck quickly became Yogi’s right-hand man. In 1988 they got involved in an US Office of Naval Research (ONR) program studying shelf sediment transport on the California Shelf. At the time, the navy was just recognizing that acoustics and optical transmission or optical backscatter could not measure size distribution or obtain correct concentration if sediment size was unknown. ONR issued a call for proposals for instrumentation that could measure sediment size and concentration, and Yogi submitted a proposal based on laser diffraction technology. Laser diffraction was well-known and widely used in industrial process control applications. But not for in-situ equipment that was intended to be lowered into the ocean. Yogi’s proposal won and Sequoia was born with three years of funding!

Over the years almost fifty different LISST models have been developed. A few never made it past the prototype or single-customer stage, but the majority went into production at some point. Today, more than a dozen instruments derived from the original LISST-100, all manufactured and sold by Sequoia, are available from Sequoia and its distributor network covering 60+ countries. Thousands of instruments have been sold worldwide since 1995. The LISSTs are now used in scientific applications as diverse as dynamic sedimentology, bottom boundary layer, sediment transport, aquatic optics, remote sensing, plankton, harmful algae bloom, fishery, soil, terrestrial ecology, public health and drinking water studies.

The LISSTs are also used in a range of industrial and environmental environments such as aquaculture food pellet production, oil spill response, stormwater response, hydropower turbine monitoring, wastewater, mining, dredging and oil drilling operations, general environmental monitoring, and for industrial process control applications.

Almost regardless of your sediment or particle application, there is a LISST for you!

#LISST

#ParticleIntelligence
## How To Choose A LISST

<table>
<thead>
<tr>
<th>Parameter</th>
<th>200X</th>
<th>Black</th>
<th>HAB</th>
<th>Portable</th>
<th>XR</th>
<th>ABS</th>
<th>AOB5</th>
<th>Holo2</th>
<th>SL2</th>
<th>Deep</th>
<th>Glider</th>
<th>Horizon</th>
<th>Hyper-bb</th>
<th>VSF</th>
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</table>

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1. For extended deployments, the BioBlock (available for the LISST-200X, LISST-Black and LISST-HAB) must be used.
2. 50 m operational. Will survive to 300 m.
3. Concentration range for the LISST-200X, LISST-Black, LISST-HAB, and LISST-Holo2 can be increased using optical path reduction modules (PRM's).
The LISST-200X is Sequoia’s workhorse. It is a self-contained submersible laser-diffraction based particle size analyzer, designed for measuring suspended particle size and concentration in the aquatic environment - oceans, rivers, lakes, streams. A fast response temperature sensor and a high-resolution depth sensor makes it suitable for profiling or towing. With Sequoia’s optional BioBlock accessory it can be deployed for months on moorings or landers for long-term studies. For the system integrator, the LISST-200X can power and accept inputs from up to three external analog sensors. The LISST-200X is typically used for sediment, (harmful) algae, oil-spill, ocean optics, visibility, dredging, aquaculture, environmental and laboratory applications.
FEATURES

• Small angle forward scattering laser diffraction technology
• Measures particle size, concentration, beam attenuation, VSF, depth, temperature
• Self-contained with internal programmable datalogger for autonomous data collection
• Externally powered (short- and long-term deployment battery packs included)
• USB connection to PC for programming, offloading and real-time size distribution displays
• Integrated depth and fast response temperature sensors
• Power and integrate up to three external analog sensors
• Analog output of mean particle size and total volume concentration
• Wide range of accessories available

PARAMETERS MEASURED

• Particle size distribution in 36 size ranges
• Depth @ 0.01 m resolution
• Temperature @ 0.01 °C resolution; response time 2.5 s
• Optical transmission @ 0.1 % resolution
• Volume Concentration @ 0.1 µL∙L⁻¹ resolution
• VSF at 36 angles

TECHNOLOGY

• Small-angle forward laser light scattering
• 670 nm laser diode
• 32-ring custom photodiode Ring detector + 4 large angle detectors
• 25 mm optical path

MEASUREMENT RANGES

• Particle size distribution from 1 µm to 500 µm
• Depth from 0 m to 600 m
• Temperature from -5 °C to 45 °C
• Optical transmission from 0.3 to 0.99 (30 % to 99 %)
• Concentration from ~ 0.5 mg∙L⁻¹ to 700 mg∙L⁻¹ (particle-size dependent)
• VSF from 0.036 ° to 13.8 ° in water

SPECIFICATIONS subject to change without notice

PARAMETERS MEASURED

• Particle size distribution in 36 size ranges
• Depth @ 0.01 m resolution
• Temperature @ 0.01 °C resolution; response time 2.5 s
• Optical transmission @ 0.1 % resolution
• Volume Concentration @ 0.1 µL∙L⁻¹ resolution
• VSF at 36 angles

TECHNOLOGY

• Small-angle forward laser light scattering
• 670 nm laser diode
• 32-ring custom photodiode Ring detector + 4 large angle detectors
• 25 mm optical path

MECHANICAL AND ELECTRICAL

• Dimensions [Ø × L]: 10.03 cm × 63.9 cm (3.95” × 25.2”)
• Weight [air / water]: 5.4 kg / 1.7 kg (11.8 lbs / 3.8 lbs)
• Depth rating: 600 m
• External power input: 12 VDC nominal, 8 VDC to 24 VDC
• Current drain at 12 V: 100 mA Sampling, 8 mA between samples
• Sampling rate: Up to 1 Hz
• Data storage: 1 GB (~12,000,000 measurements; ~140 days)
• SubConn MCBH3M, MCBH5M and MCBH6M connectors

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e-mail info@SequoiaSci.com
www.SequoiaSci.com
The LISST-Black is a self-contained stand-alone instrument for use on profiling packages, towed and remote vehicle applications, for deployment during and after an oil spill event. The system will continuously measure particle size distribution and concentration, along with the fluorescence of refined fuels, crude oil and chlorophyll, as well as beam attenuation.
FEATURES

• Complete package based on small angle forward scattering laser diffraction technology
• LISST-200X integrated with Turner Designs Cyclops-7F fluorometers
• Measures refined fuels, crude oil, chlorophyll, particle size, concentration, beam attenuation, depth, temperature
• Self-Contained with internal programmable datalogger for autonomous data collection
• Externally powered (short- and long-term deployment battery packs included)
• USB connection to PC for programming, offloading and real-time size distribution displays
• Integrated depth and fast response temperature sensors
• Integrates on profiling package, tow vehicle or mooring/lander

Fluorometer Performance
The Turner Designs submersible instrumentation modules used in the LISST-Black includes single-channel fluorometers for detection of refined fuels, crude oil, and chlorophyll. Together with particle information from the LISST-200X, this package solution provides a comprehensive picture of potential contamination.

SPECIFICATIONS (subject to change without notice)

Parameters Measured
• Particle size distribution from 1 µm to 500 µm in 36 size ranges
• Depth @ 0.01 m resolution
• Temperature @ 0.01 °C resolution; response time 2.5 s
• Optical transmission @ 0.1 % resolution
• Volume Concentration @ 0.1 µL·L⁻¹ resolution
• Beam attenuation
  • Phycocyanin
  • Phycoerythrin
  • Chlorophyll

Operating Concentration Range
• Optical transmission from 0.3 - 0.99 (30 % - 99 %)
• Concentration from ~ 0.5 mg·L⁻¹ - 700 mg·L⁻¹ (particle-size dependent)

<table>
<thead>
<tr>
<th></th>
<th>Minimum Detection</th>
<th>Linear Range</th>
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<tbody>
<tr>
<td>Oil - Fine</td>
<td>0.4 ppm</td>
<td>0-20 ppm</td>
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<tr>
<td>Oil - Crude</td>
<td>0.2 ppm</td>
<td>0-1,500 ppm</td>
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<tr>
<td>Chlorophyll</td>
<td>0.03 µg/L</td>
<td>0-500 µg/L</td>
</tr>
</tbody>
</table>

Technology (laser diffraction)
• Small-angle forward laser light scattering
• 670 nm laser diode
• 32-ring custom photodiode Ring detector + 4 large angle detectors
• 25 mm optical path

Mechanical and Electrical
• Dimensions [W×H×L]: 10.03 cm × 13.21 cm × 63.9 cm (3.95” × 5.2” × 25.2”)
• Weight: [air / water]: 6 kg / 2.5 kg (13.2 lbs / 5.5 lbs)
• Depth rating: 600 m
• External power input: 12 VDC nominal, 8 VDC - 24 VDC
• Current drain at 12 V: 100 mA Sampling, 8 mA between samples
• Sampling rate: Up to 1 Hz
• Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)
• SubConn MCBH3M, MCBH5M and MCBH6M connectors
• Refined fuels – EX 290, EM 350
• Crude oil – EX 325 nm, EM 410-600 nm
• Chlorophyll – optical filters: EX 465, EM 496
The LISST-HAB is a self-contained, stand-alone instrument system for use on profiling packages, towed and remote vehicle applications, for deployment during a HAB event. The system will continuously measure particle size distribution and concentration, along with the fluorescence of Phycocyanin, Phycoerythrin, Chlorophyll, and Beam Attenuation.
**FEATURES**

- Complete package based on small angle forward scattering laser diffraction technology
- LISST-200X integrated with Turner Designs Cyclops-7F fluorometers
- Measures Phycocyanin, Phycoerythrin, Chlorophyll, particle size, concentration, beam attenuation, depth, temperature
- Self-Contained with internal programmable datalogger for autonomous data collection
- Externally powered (short- and long-term deployment battery packs included)
- USB connection to PC for programming, offloading and real-time size distribution displays
- Integrated depth and fast response temperature sensors
- Integrates on profiling package, tow vehicle or mooring/lander

**Fluorometer Performance**

The Turner Designs submersible instrumentation modules used in the LISST-HAB includes single-channel fluorometers for detection of Phycocyanin, Phycoerythrin and Chlorophyll. Together with particle information from the LISST-200X, this package solution provides a comprehensive picture of cyanobacteria presence.

**SPECIFICATIONS** (subject to change without notice)

**Parameters Measured**
- Particle size distribution from 1 µm – 500 µm in 36 size ranges
- Depth @ 0.01 m resolution
- Temperature @ 0.01 °C resolution; response time 2.5 s
- Optical transmission @ 0.1 % resolution
- Volume Concentration @ 0.1 µL·L⁻¹ resolution
- Beam attenuation
- Phycocyanin
- Phycoerythrin
- Chlorophyll

**Operating Concentration Range**
- Optical transmission from 0.3 - 0.99 (30-99 %)
- Concentration from ~ 0.5 - 700 mg/L⁻¹ (particle-size dependent)

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<td>Phycoerythrin</td>
<td>0.1 ppb^PE</td>
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<td>Chlorophyll</td>
<td>0.03 µg/L</td>
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<table>
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<th>Minimum Detection</th>
<th>Linear Range</th>
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<td></td>
<td>0-750 ppb^PE</td>
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<td>0-500 µg/L</td>
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</table>

**Mechanical and Electrical**
- Dimensions [W × H × L]: 10.03 cm × 13.21 cm × 63.9 cm (3.95” × 5.2” × 25.2”)
- Weight [air / water]: 6 kg / 2.5 kg (13.2 lbs / 5.5 lbs)
- Depth rating: 600 m
- External power input: 12 VDC nominal, 8 VDC to 24 VDC
- Current drain at 12 V: 100 mA Sampling, 8 mA between samples
- Sampling rate: Up to 1 Hz
- Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)
- SubConn MCBH3M, MCBH5M and MCBH6M connectors
- Phycocyanin – optical filters: EX 590, EM ≥ 645
- Phycoerythrin – optical filters: EX 531, EM ≥ 590
- Chlorophyll – optical filters: EX 465, EM 496

**Technology (laser diffraction)**
- Small-angle forward laser light scattering
- 670 nm laser diode
- 32-ring custom photodiode Ring detector + 4 large angle detectors
- 25 mm optical path

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Particle Size Distribution • Particle Volume Concentration

The LISST-Portable│XR is the world’s only portable, battery-powered laser-diffraction based particle size analyzer. Designed for use in the field and the laboratory, it analyzes the sample in a wet state to obtain particle size distribution and particle volume concentration. To ensure maximum portability and complete freedom from a laboratory environment, it features an integrated mixing chamber, touch panel display, rechargeable battery, shock mounted optics, built-in ultrasonic probe and onboard data processing and storage.
FEATURES
- Truly portable: Completely self-contained with built-in data logger, processor, rechargeable battery, ultrasonic probe and 7” touch panel color display
- No PC needed: Touch panel color display allows for easy programming, sample analysis and data display
- Rugged design: Sealed enclosure and shock mounted optics block
- Simplicity: On-screen step-by-step instructions walks the operator through a measurement
- Versatility: Multiple Mie models as well as Fraunhofer model available for inversion, selectable from the touch panel
- All data-processing performed on board and stored in ASCII format. No post-processing
- Outputs: Total volume concentration, mean size, standard deviation, optical transmission, D5, D10, D16, D25, D50 (median grain size), D60, D75, D84, D90, D95, D60/D10 (Hazen uniformity coefficient), particle surface area, silt fraction, silt volume, size distribution, battery voltage, sample notes, operator name and instrument configuration
- Compatible with water and IPA based fluids
- Laser-diffraction based

SPECIFICATIONS  subject to change without notice

Operating Concentration Range
- Size range 0.34 µm - 500 µm in 44 log-spaced size classes
- Concentration range 30 mg∙L⁻¹ - 1,900 mg∙L⁻¹. Note: Dependent on particle size (see table)

<table>
<thead>
<tr>
<th>Material</th>
<th>Concentration [mg/L] @ 95% transmission</th>
<th>Concentration [mg/L] @ 75% transmission</th>
<th>D10 [µm]</th>
<th>D50 [µm]</th>
<th>D90 [µm]</th>
<th>SMD [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO Fine</td>
<td>30</td>
<td>170</td>
<td>1.5</td>
<td>7</td>
<td>41</td>
<td>3</td>
</tr>
<tr>
<td>ISO Coarse</td>
<td>95</td>
<td>395</td>
<td>4</td>
<td>38</td>
<td>99</td>
<td>10</td>
</tr>
<tr>
<td>20-30 µm glass beads</td>
<td>195</td>
<td>1,075</td>
<td>19</td>
<td>24</td>
<td>34</td>
<td>24</td>
</tr>
<tr>
<td>Sieved sand 75-125 µm</td>
<td>345</td>
<td>1,925</td>
<td>85</td>
<td>122</td>
<td>175</td>
<td>112</td>
</tr>
</tbody>
</table>

Mechanical and Electrical
- Dimensions: [H × D × W] 17.7 cm × 29 cm × 44.3 cm (7” × 11.5” × 17.5”)
- Weight: 7.5 kg (17 lbs)
- Shipping box dimensions: [H × D × W] 78 cm × 53 cm × 28 cm (31” × 21” × 11”)
- Gross weight: 22 kg (49 lbs)
- Data storage: 1 GB flash card (~100,000 size distributions and associated sample information)
- Rechargeable Lithium-ion batteries provide six hours of sample processing. Batteries classified as non-hazardous for air shipment
- 25 W, 40 kHz ultrasonic probe with controller electronics, managed from the touch panel display

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LISST-Tau is a high-precision transmissometer for underwater vehicles, profiling packages, CTDs, and other systems. With high-quality optics and a carefully selected LED source, it transmits a collimated beam through the water, and precisely measures the light transmitted through its 15 cm path. Light modulation with synchronous detection rejects ambient light, while oversampling and averaging yield better than 16-bit resolution. LISST-Tau’s digital controller applies calibration coefficients, corrects for temperature effects, and transmits data from both digital and analog outputs. Included software provides real-time display of data, and functions for checking and updating pure-water calibrations. LISST-Tau advances the state of the art for in-situ transmissometers.
FEATURES

- Measures optical transmission and beam attenuation
- Externally powered
- RS-232 and analog real-time outputs
- Ambient light rejection
- Onboard temperature compensation

SPECIFICATIONS (subject to change without notice)

Parameters Measured
- Optical transmission
- Beam attenuation

Operating Ranges and Stability
- Operational temperature range: -3 °C to 35 °C
- Storage temperature range: -20 °C to 50 °C
- Beam attenuation range: ~0 m^{-1} to 30 m^{-1}
- Linearity (concentration): >99 %
- Short-term stability (1 min standard deviation)
  - Transmission: ~0.002 %FS
  - Beam attenuation: ~0.0003 m^{-1}
- Long-term stability (6 hr test)
  - Transmission: ~0.003 %FS/hr
  - Beam attenuation: ~0.00016 m^{-1}.hr^{-1}

Technology
- Optical path length: 15 cm
- Source wavelength: ~532 nm LED
- Source spectral bandwidth: <10 nm FWHM
- Acceptance angle (half angle, in water): 1.0 °
- Optical transmission @ 16-bit resolution

Mechanical and Electrical
- Dimensions [Ø x L]: 5.1 cm x 40.6 cm (2.00“ x 16“)
- Weight [air / seawater]: 1.140 kg / 0.585 kg (2.5 lbs / 1.3 lbs)
- Depth rating: 2,000 m
- Sampling rate: Up to 1 Hz (default)
- External power input: 7 VDC to 25 VDC
- Current drain @ 12V: 42 mA average during sampling
- Connector: SubConn MCBH6M

LISST-Tau data from 20+ profiles collected over a 4.5 day glider deployment. Dashed lines indicate timing of the five individual profiles. Note chl maximum, small-scale structure and stability over time and pressure.
The LISST-ABS is a low-cost acoustic backscatter sensor designed specifically for measuring suspended sediment concentration. It is designed for fixed-point measurements and operates at 8 MHz. At this frequency, acoustic has a nearly flat response to particles in the size range 30 µm to ~400 µm. As a result, the LISST-ABS maintains calibration within ± 30 %. This compares with optical turbidity sensors that maintains calibration within ± 400 % over the same size range.
**Features**

- Calibrated for life from factory
- Outputs concentration in analog, SDI-12 and RS232 formats on the underwater connector
- Integrates with any datalogger that can provide power and accept analog, SDI-12 or RS232 signals
- Installs on fixed structures, profiling packages and underwater vehicles or tow bodies (minimum 15 cm from solid boundaries)

**Specifications**

**Parameters Measured**
- Suspended Sediment Concentration (point measurement)

**Concentration Range**
- (1 to 30,000) mg·L⁻¹ for 7 µm silt
- < 20,000 mg·L⁻¹ for 200 µm sand

**Mechanical and Electrical**
- Dimensions: [Ø × L] 5.08 cm × 33.65 cm (2" × 13.25")
- Weight (air): 0.5 kg (1 lbs)
- Weight (water): 0.22 kg (0.5 lbs) buoyant in water
- Power supply voltage: 11 VDC - 18 VDC
- Current draw: 100 mA
- Depth rating: 100 m
- 10 mm Ø ceramic transducer
- Sample rate 1 Hz (average of 1000 measurements)
- Sample volume: [Ø × L] 10 mm × 15 mm approximately, 55 mm from the transducer
- Impulse MCBH-8-MP SS endcap connector
- ABS plastic housing

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*Above:* LISST-ABS mounted to a streamlined depressor wing that allows it to be towed at speeds in excess of 5 knots.

*Right:* The relative responsivity of optical turbidity meters contrasted with the LISST-ABS acoustic backscatter sensor.
The LISST-AOBS is a simple, low-cost Super-Turbidity sensor to measure suspended sediment concentration (SSC). Super-Turbidity is a new technology (Patent Pending) developed by Sequoia Scientific, Inc. It involves pairing a LISST-ABS with a turbidity sensor using a weight factor, which results in a single, combined output from the two sensors. Once paired, the LISST-AOBS retains near-constant calibration for SSC over a wide grain-size range. The LISST-AOBS Super-Turbidity sensor is supplied by Sequoia as an integrated and paired turbidity and acoustic sensor with a variety of cabling and data logger options.
FEATURES

• Paired acoustic and optical technologies
• Near-constant calibration within a factor of two for grain-sizes from 1 µm – 500 µm
• Complete, integrated package pairing a LISST-ABS and a Turner Designs Turbidity Plus™
• Includes Y-cable providing power and integrated SDI-12 communication to and from both sensors
• Tolerant to biofouling (LISST-ABS); integrated wiper (Turbidity Plus™)

SPECIFICATIONS (subject to change without notice)

Parameters Measured

• Suspended Sediment Concentration (SSC; mg/l)
• NTU

Technology

• Combined 850 nm optical turbidity sensor and 8 MHz acoustic backscatter sensor
• Optics per ISO 7027 turbidity technique
• Mechanical wiper for turbidity sensor
• SDI-12 output
• Sample volume (acoustic; Ø × L): 10 mm × 15 mm @ 55 mm from transducer

Operating Concentration Range

• 1 mg·L⁻¹ to 30,000 mg·L⁻¹ (LISST-ABS) or
• 0 NTU to 3,000 NTU (Turbidity Plus™)

Mechanical and Electrical

• Dimensions [H × W × L]: 5.72 cm × 10.16 cm × 33.65 cm (2.25” × 4” × 13.25”)
• Weight, air: 0.7 kg (1.54 lbs)
• Transducer Ø: 8 mm ceramic
• Power supply: 9 VDC to 15 VDC (12 VDC nominal)
• Current drain: 200 mA
• Depth rating: 100 m
The LISST-Holo2 is a submersible digital holographic camera. It is designed for capturing holograms of suspended particles (algae, plankton, sediment, oil droplets, flocs etc.). The internal rechargeable battery and memory allow for collection of up to 100,000 holograms. To facilitate data processing, the included software ranks the holograms by image content richness, then automatically extracts particle information and images from the holograms. The resulting data output is a composite image where all particles are in focus, as well as the particle size distribution and volume concentration.
**FEATURES**

- In-situ digital in-line holographic technology
- Self-contained with internal datalogger and rechargeable battery
- Ethernet connection to PC for programmable data collection—no software needed for programming or offloading data
- Power via internal rechargeable battery pack or external power source
- Programmable data collection including burst and fixed Rate modes and programmable start and stop conditions
- Automated firmware updates possible when instrument is connected to the Internet
- Automated ranking of collected images based on richness of data, permitting a user to view the most interesting holograms first
- Data processing yields in-focus particle images and particle volume distribution
- Optical Path Reduction Modules available for higher concentration ranges
- Towable up to 4 knots (2.05 m·s⁻¹).

**SPECIFICATIONS** subject to change without notice

### Parameters Measured

- Particle images for observation and classification
- Particle distribution
- Particle volume concentration
- Temperature
- Depth

### Measuring Ranges

- 25-2500 µm equivalent spherical diameter, features down to 4 µm
- ~0-50 mg·L⁻¹ (grain-size dependent)

### Technology

- Solid state diode laser @ 658 nm
- 4.4 µm pixel size digital camera; 1600 ~ 1200 pixels

### Mechanical and Electrical

- Dimensions [Ø × L]: 13.3 cm × 75 cm (5.25" × 29.5")
- Weight [air / water]: 9.5 kg / 3.6 kg (21 lbs / 8 lbs)
- Depth rating: 600 m
- Memory: 237 GB internal solid-state drive
- Sampling rate: 25 Hz
- Sample volume: 1.86 cm³
- Power: Internal rechargeable NiMH battery or external power, 12 VDC - 24 VDC
- Current consumption @ 12 VDC [sleeping / idling / collecting images]: 4 mA / 0.6 A / 0.85 A. Max current spike 1.7A for up to 40 s upon power up
- Connectors: SubConn 1 x MCBH5M, 1 x MCBH6M, 1 x DBH8M.

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The LISST-SL2 is designed exclusively for river sediment monitoring. The sensor is deployed from a bridge or boat with a small winch. A topside box with rechargeable batteries provides power to the sensor. The LISST-SL2 then returns real-time data of all parameters. Data are transmitted from the topside box to a PC or tablet via Bluetooth for immediate processing and display.
FEATURES

- Small angle forward scattering laser diffraction technology
- Measures particle size distribution, sediment concentration, current velocity, depth, temperature
- Iso-kinetic sampling using feedback-controlled pump operation
- 2-wire communication protocol consistent with USGS B-reel use
- Topside box with rechargeable batteries for LISST-SL2 power and Bluetooth for real-time data transfer to PC/tablet
- Data processed and displayed in real-time on PC/tablet
- Software delivers point-integrated and depth-integrated sediment data
- Change units from ft and ft·s\(^{-1}\) to m and m·s\(^{-1}\)

SPECIFICATIONS

Parameters Measured
- Particle size and concentration in 36 size ranges.
- Depth @ 0.02 m resolution.
- Velocity @ 0.03 m·s\(^{-1}\) resolution.
- Water temperature @ 0.1 °C resolution.

Measuring Ranges
- Sediment concentration from ~10 mg·L\(^{-1}\) to 44,000 mg·L\(^{-1}\) for 120 µm particles. NOTE: The actual concentration limits are highly grain-size dependent
- Particle size from 1 µm to 500 µm
- Depth from 0.15 m to 30 m
- Velocity from 0 m·s\(^{-1}\) to 3.5 m·s\(^{-1}\)
- Iso-kinetic control from 0.5 m·s\(^{-1}\) to 3.5 m·s\(^{-1}\)
- Water temperature from 0 °C to 25 °C

Mechanical and Electrical
- Dimensions: LISST-SL2 [Ø × L]: 17 cm × 87 cm (6.7” × 34.2”)
- Weight: LISST-SL2 [air/submerged]: 19.5 kg/8.2 kg (43 lbs/18 lbs)
- Dimensions: topside box [H × L × W]: 41.7 cm × 33.4 cm × 22.1 cm (16.4” × 13.2” × 8.7”)
- Weight: topside box: 8.6 kg (19 lbs)
- Rechargeable battery life: 6 hours continuous sampling
The LISST-Deep instrument obtains *in-situ* measurements of particle size distribution, volume concentration, optical transmission, and the optical volume scattering function (VSF). Using a 670 nm diode laser and a custom silicon detector, small-angle scattering from suspended particles is sensed at 32 log-spaced angle ranges. This measurement is post-processed to obtain size, concentration, transmission, and VSF. The electronics and optical configuration in the LISST-Deep are very similar to the LISST-100X. However, because of the extreme difficulty associated with keeping alignment under high pressure, the LISST-Deep hardware design is radically different from the LISST-100X. This allows the LISST-Deep to be deployed down to 3000 m and obtain reliable measurements in waters with optical transmission up to 98.5%.
FEATURES

- Small angle forward scattering laser diffraction technology
- Self-contained with internal datalogger
- Externally powered
- RS232 connection to PC for programming, offloading and real-time size distribution displays
- Programmable, autonomous data collection
- Integrated depth and temperature sensor
- 32 size classes
- Optional external battery pack, rated to 3000 m depth
- Optional 80% path reduction module for higher concentrations
- Sea-Bird cable for powering from Sea-Bird CTD

SPECIFICATIONS

Parameters Measured

- Particle size in 32 size ranges
- Depth @ 0.8 m (80 cm) resolution
- Optical transmission
- Volume concentration
- Volume scattering function (VSF)
- Temperature @ 0.01 °C resolution

Measurement Ranges

- Particle size from 1.25 µm to 250 µm OR 2.5 µm to 500 µm
- Depth from 0 m to 3,000 m
- Optical transmission from 0.3 to 0.985 (30 % to 98.5 %)
- Concentration from 1 mg·L⁻¹ to 800 mg·L⁻¹. NOTE: Strongly grain-size dependent; see table
- Temperature from -5 °C to 45 °C

<table>
<thead>
<tr>
<th>Material</th>
<th>98% optical transmission Concentration [mg/L]</th>
<th>30% optical transmission Concentration [mg/L]</th>
<th>D10 [µm]</th>
<th>D50 [µm]</th>
<th>D90 [µm]</th>
<th>SMD* [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO Fine (ISO 12103-1,A2)</td>
<td>1</td>
<td>70</td>
<td>1.5</td>
<td>7</td>
<td>41</td>
<td>3</td>
</tr>
<tr>
<td>ISO Coarse (ISO 12103-1,A4)</td>
<td>5</td>
<td>150</td>
<td>4</td>
<td>38</td>
<td>99</td>
<td>10</td>
</tr>
<tr>
<td>20-30 µm glass beads</td>
<td>8</td>
<td>445</td>
<td>19</td>
<td>24</td>
<td>34</td>
<td>24</td>
</tr>
<tr>
<td>75-125 µm sieved sand</td>
<td>13</td>
<td>810</td>
<td>85</td>
<td>122</td>
<td>175</td>
<td>112</td>
</tr>
</tbody>
</table>

Technology

- Small-angle forward laser light scattering
- 670 nm laser diode
- 32-ring custom photodiode ring detector
- 50 mm optical path
- 10 mm optical path with optional 80 % path reduction module.

Mechanical and Electrical

- Dimensions [Ø × L]: 12.57 cm × 80.3 cm (4.95” × 31.5”)
- Weight [air / water]: 17 kg / 8 kg (38 lbs / 18 lbs)
- Depth rating: 3,000 m
- External power input: 9 VDC nominal, 6 VDC to 24VDC
- Power drain [measuring / quiescent]: 145 mA / 8 mA
- Sampling rate: Up to 1 Hz
- Memory: 1 GB (~12,500,000 size distributions)
The LISST-Glider is a version of the LISST-200X designed for glider integration. The LISST-Glider is available in a version for Teledyne Webb Research’s SLOCUM G2 and G3 gliders and another for Kongsberg’s Seaglider C2. The LISST-Glider must be purchased from either Teledyne Webb Research or Kongsberg Underwater Technology.
**FEATURES**

- Small angle forward scattering laser diffraction technology
- Measures particle size, concentration, beam attenuation, volume scattering function (VSF)
- Self-contained with internal programmable datalogger for autonomous data collection
- Output of mean particle size and volume concentration to internal glider control system

**SPECIFICATIONS** (subject to change without notice)

**Parameters Measured**
- Particle size distribution in 36 size ranges
- Optical transmission @ 0.1 % resolution
- Volume concentration @ 0.1 µL·L⁻¹ resolution
- VSF at 36 angles

**Measurement Ranges**
- Particle size distribution from 1 µm to 500 µm
- Optical transmission from 0.3 to 0.99 (30 % to 99 %)
- Concentration from ~ 0.5 mg·L⁻¹ to 700 mg·L⁻¹ (particle-size dependent)
- VSF from 0.036 ° to 13.8 ° in water

**Technology**
- Small-angle forward laser light scattering
- 670 nm laser diode
- 32-ring custom photodiode Ring detector + 4 large angle detectors
- 25 mm optical path

**Mechanical and Electrical**
- Dimensions: Depending on glider
- Weight: Depending on glider
- Depth rating: 600 m
- External power input: 12 VDC nominal, 8 VDC - 24 VDC
- Current drain @ 12 V: 100 mA sampling, 8 mA between samples
- Sampling rate: Up to 1 Hz
- Data storage: 1 GB (~12,000,000 measurements; ~140 days @ 1 Hz)
The LISST-Horizon is a self-contained instrument for bench-top deployment in a research vessel laboratory. Plumbed to continuous underway uncontaminated seawater, it continuously measures PSD and particle concentration, as well as inherent optical properties (IOPs).
Parameters Measured

• Volume scattering function (VSF) at 60 angles
• Particle size distribution in 60 size classes inverted from scattering measurements
• Beam transmission
• Derived IOPs including total scattering, backscattering, and absorption by difference \((a = c – b)\)
• Sample temperature and fluidics parameters such as pressures and flow rate

Mechanical and Electrical

• Dimensions \([L \times W \times H]\): 674 mm \times 375 mm \times 293 mm
• Weight: 19 kg
• Laser: 520 nm solid state diode laser
• External power input: 110/220 VAC converted to 24 VDC using provided power brick
• Plumbing connections using 3/8” OD (½” OD for drain) tubing and push-to-connect fittings
• External tanks for holding clean water background

Front view: sample cover open & touch panel

Top view: open chamber with mixers
Sequoia presents the world’s first commercially available hyperspectral backscatter instrument, Hyper-bb. The Hyper-bb is a submersible single-angle backscattering instrument with configurable spectral channels. The primary measurement delivered by the Hyper-bb is spectral backscattering over the wavelength range 430 nm to 700 nm. Hyper-bb also has high-performance depth and temperature sensors. Data is saved onboard the instrument in non-volatile microSD memory, which can be later downloaded via the Hyper-bb software.
FEATURES

• Spectral backscattering over the wavelength range 430 nm to 700 nm
• High-performance depth and temperature sensors
• Internal data storage
• Powered from external battery pack (optional accessory), CTD, or 2-50 m power/communication USB cable

SPECIFICATIONS (subject to change without notice)

Optical
• Centroid angle ~ 135°
• Sample volume ~ 2 mL
• Beam diameter ~ 12 mm
• Spectral coverage ~ 430 nm to 700 nm
• Spectral bandwidth ~ 9 nm (blue) to ~ 17 nm (red)
• Scan speed ~ 15 s for 430 nm to 700 nm with a 10 nm channel spacing, i.e. channels @ 430, 440, 450,…, 690, 700 nm (220 measurements per channel)

Mechanical and Electrical
• Dimensions [Ø × L]: 13.4 cm × 51.9 cm (5.25” × 20.42”) including handle
• Weight [air / water]: 6.0 kg / 1.2 kg (13.3 lbs / 2.6 lbs)
• Depth rating: 600 m
• External power input: 12 VDC nominal, 8 VDC - 26 VDC
• Communication: RS-232, 9600 baud, 115k baud for data download
• Storage: Internal datalogger with 1 GB microSD memory

TECHNOLOGY

• Calibration tank with stepper motor
• External battery pack with 16 standard alkaline D-cells
• Cables (up 50 m length) for real-time data
On the market since 2012, Sequoia's LISST-VSF is a submersible instrument for measuring the volume scattering function (VSF) in situ with some polarization discrimination capability. The instrument covers the angular range from 0.1 ° to 150 ° in water by combining a standard LISST ring detector with a rotating ‘eyeball’ optic. Polarization of the incident laser beam is alternated between horizontal and vertical, the received scattered light is split into its two linear polarization components and sensed by separate photomultiplier tubes permitting calculation of the particulate VSF and degree of linear polarization (DoLP). The LISST-VSF is programmable and externally-powered.
**FEATURES**

- In-situ measurements of $P_{11}$ (VSF) and $P_{12}$ (DoLP) elements of the scattering Mueller matrix from 15-150° in water
- VSF ($P_{11}$) at small angles, 0.1° to 15° in 32 logarithmic angle steps
- Integration of 0.1-150° VSF provides a good estimate of total particle scattering coefficient $b_p$
- Beam attenuation cp. measured with LISST-100X optics
- Roving Eyeball optics permit 1° resolution in angles between 15-150°
- Approximately 2 seconds per measurement set (2 polarizations of incident laser beam)
- Daylight rejection by laser modulation
- Extension of dynamic range in VSF measurements using control of laser power and photomultiplier gain
- Data from small and large angles in a single data stream, including depth and temperature
- External, submersible battery pack included.

**SPECIFICATIONS**

Subject to change without notice

**Parameters Measured**

- Small-angle VSF in 32 log-spaced angles, from 0.1° to 15°
- VSF and $P_{12}$ (DoLP) from 15° to 150° in 1° steps
- $b_p$ estimate from VSF integration over 0.1° to 150°
- Temperature @ 0.01 °C resolution
- Depth @ 0.08 m resolution
- Beam attenuation

**Measurement Ranges**

- Temperature from –5 °C to 50 °C
- Operational depth 0 m to 50 m
- Beam attenuation > 0.1 m⁻¹

**Technology**

- Solid state diode laser @ 658 nm
- 4.4 µm pixel size digital camera; 1600 × 1200 pixels

**Mechanical and Electrical**

- Dimensions [Ø × L]: 12.7 cm × 95.7 cm (5.0” × 37.7”)
- Weight [air]: 13.1 kg (28.9 lbs)
- Depth rating: 300 m (NOTE: 50 m operational depth)
- External power supply: 12 VDC to 15 VDC
- Power drain [sampling]: 1.5 A
- Sampling rate: Approximately 2 s for a full measurement of VSF and $P_{12}$
- Storage: 128 GB, equivalent to 24,000 measurements
- Rechargeable NiMH battery pack (included) @ 14.4 V nominal, 15 Ah

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Left: Measured $P_{11}$ (VSF) of 0.33µm beads compared to Mie theory

Right: $P_{12}$ (normalized by $P_{11}$) of 0.33µm beads compared to Mie theory

Left: In situ $P_{12}$ (normalized by $P_{11}$) of water in Elliot Bay, WA, USA

Right: Detail of the LISST-VSF optics path, showing the receive optics
ACCESSORIES

LISST-100X

External Power Supply
Alkaline Battery Pack
Two-Piece Clamps for Mounting
Large Volume Test Chamber
Background Chamber
Full Path Flow Through Chamber
Full Path Mixing Chamber
BioBlock
Shipping Case
Optical Path Reduction Modules (50, 80, 90% reduction)
ACCESSORIES

LISST-ABS, -AOBS, -PORTABLE | XR & -DEEP

- LISST-AOBS Y Cable
- LISST-AOBS Connecting Bracket
- LISST-ABS/-AOBS Submersible Float Kit
- LISST-ABS/-AOBS Submersible Data Logger
- LISST-ABS/-AOBS Data Logger Kit
- LISST-Portable | XR Replacement Ship Case
- LISST-Portable | XR Replacement Charger & Cables
- LISST-Portable | XR Replacement Lids
- LISST-Portable | XR Replacement Ultrasonic Probe Tip
- LISST-Deep External Battery Housing
ACCESSORIES

LISST-200X

Large & Small External Battery Housings

BioBlock

BioBlock Clamps

Mounting Frame

Small Battery Housing Clamps

Replacement Rechargeable Batteries

Short Battery Cable

Background Test Chamber

Integrated Comm & Power Cables

Scoop (for diverting flow of water through optical path)

Full Path Flow Through Chamber

Optical Path Reduction Module

Towed Underwater Depressor