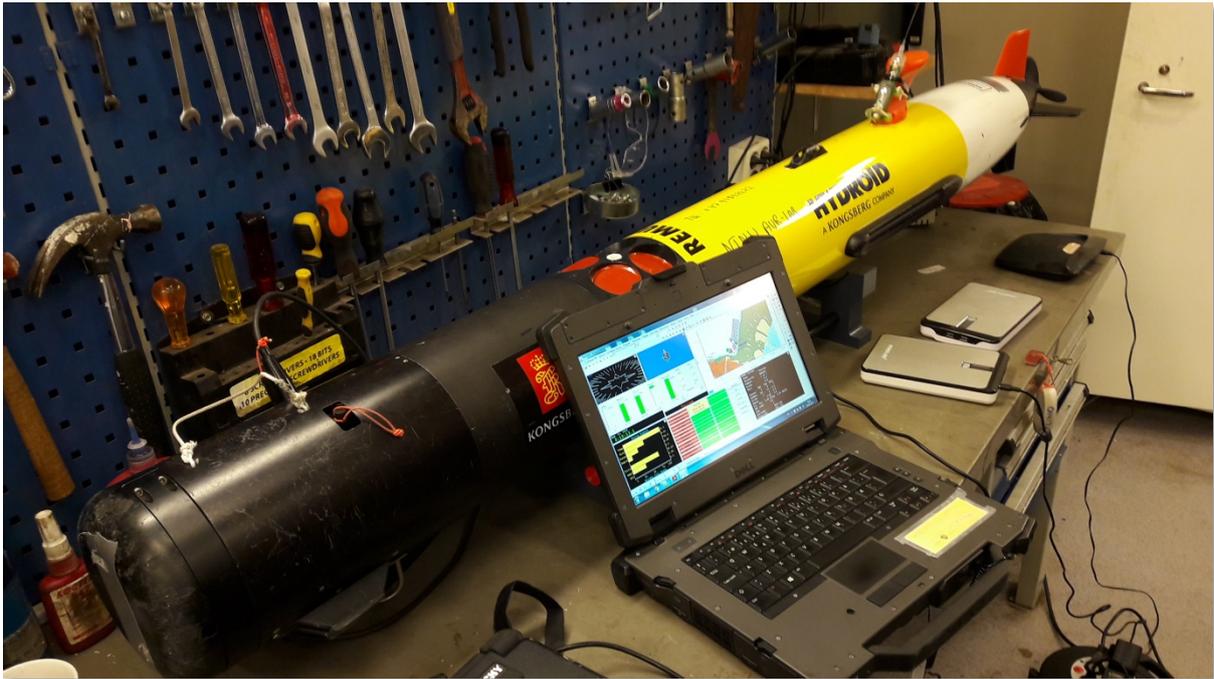


Cerulean – REMUS 100 overview



Developed as a two man-portable, yet operationally flexible AUV, the REMUS 100 system has become the industry leader since its debut in 2001. The REMUS 100 system has demonstrated capabilities, which are pertinent to marine research, hydrographic, offshore/energy, and military applications. It is ideal for coastal hydrographic survey and target localisation missions while requiring minimal infrastructure to support and operate.

The REMUS 100 AUV system was designed as a small, lightweight, low-cost, easy to use and highly accurate system for research tasks in coastal waters, reaching depths of up to 100 meters. The 100- meter rating of the vehicle has an additional safety factor of 15% to ensure safe operation at maximum depth. The vehicle also has a built-in capability to adapt automatically should the vehicle try to exceed the depth rating for any reason during a mission.

The vehicle's compact size requires minimal infrastructure for support and operation, meaning two people can deploy and operate the vehicle. The vehicle and support equipment fits in two custom designed transit cases for easy shipping and handling. Despite its small size, the REMUS 100 contains enough sophisticated sensor, navigation, and power resources to perform detailed sonar and oceanographic surveys over huge areas.

The baseline REMUS 100 AUV system provides sufficient reserve volume, payload and power to support a variety of standard or custom sensors, and it can be easily configured to meet unique mission requirements, including the addition of environmental, communications, navigation and imaging sensors.

The modular design of the REMUS 100 vehicle allows it to be set up as operational demands require. It can be equipped with a wide variety of sensor packages to suit the needs of just about any user; operators can simply change sensors via the use of v-band clamps located in the payloads section of the vehicle.

The remaining housing sections of the vehicle from the tail to the ADCP/DVL module is sealed to protect the propulsion system, main electronics chassis, batteries, and navigation from exposure to elements. A unique attribute of REMUS is its ability to visit the same study spot over and over again repeatedly. All the data REMUS collects is also timed stamped allowing the user to reference entire data sets from every sensor on the vehicle at the same time knowing it was recorded at the same precise location.

Cerulean vehicle in its transport container.



Capabilities (top level):

- **Water quality assessments**
- **Hydrographic / Geophysical Surveys (mapping seabed 3D)**
- **Ecosystem assessments**
- **Physical Oceanography**
- **Environmental Monitoring**
- **Marine/ Geology Investigation**
- **Marine Biology**
- **Fisheries research**
- **Seabed Mapping**
- **Fish Stock assessments**
- **Pipeline survey's**
- **Cabling surveys**
- **Wreckage detection (Malaysian Air)**
- **Geology Seafloor mapping**
 - **Minerals**
 - **Oil**
 - **gas**
- **Water quality**
- **Route surveys**
- **Pre-Post dredging impact surveys**
- **Debris & clearance after storms**
- **Shipwreck hunting & Salvage**

AUV/UUV 3500 - Klein 455/900 kHz Dual Frequency Side Scan Sonar with Bathymetry.

Applications:

- Hydrographic / Geophysical Surveys (mapping seabed 3D)
- Cable/Pipeline Surveys
- Environmental Assessments (Reef)
- Object Detection (Wrecks)
- Inspection
- Mine Countermeasures / Intelligence, Surveillance and Reconnaissance Surveys

The UUV 3500 was developed as a side scan sonar with the unprecedented benefit of an advanced bathymetry payload for the growing Autonomous Underwater Vehicles (UUVs). The UUV 3500 product line leverages a powerful - wholly FPGA implemented - multi-channel processing engine. The sonar engine simultaneously optimizes two different and concurrent output data streams for: photo quality side scan imagery and high accuracy, co-registered Swath Bathymetry.

The UUV 3500 operates exclusively with Klein's proprietary wideband technology providing unmatched side scan range and resolution performance in a low-power, compact and lightweight payload. The Swath Bathymetry option allows for wide swath performance which is typically 10-12 times the overall altitude of the UUV and thereby significantly greater coverage than can be achieved by a multi-beam echo sounder. Klein's newly designed, ruggedized transducers are built to last and perform in the most demanding environmental conditions.

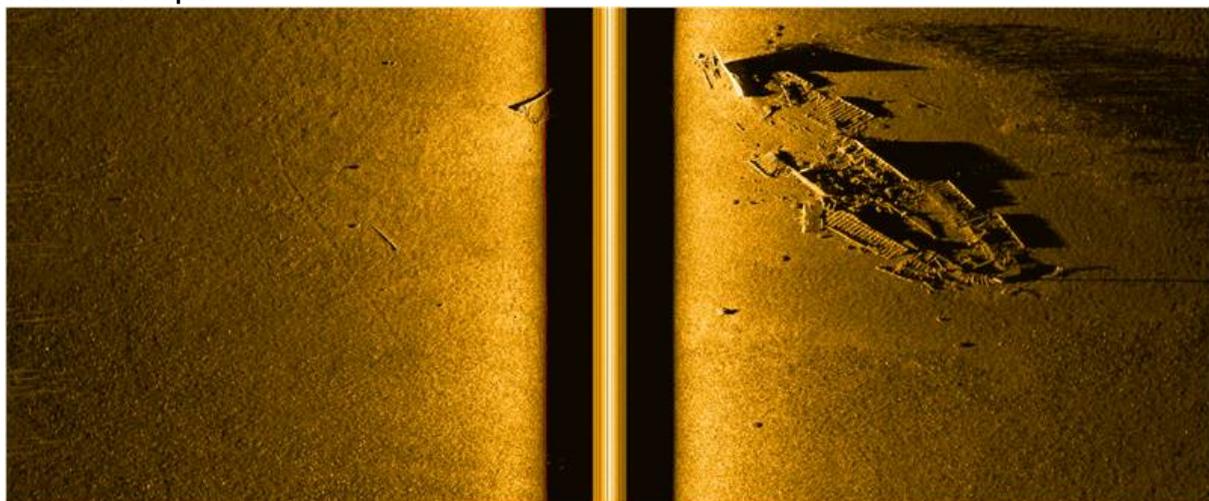
With the addition of the swath bathymetry sonar, the Klein system employs advanced interferometric signal processing to produce simultaneous estimates of the seabed topography out to the full swath extent of the sonar, typically 10-12 times the overall altitude of the AUV. The added seabed topographic measurement is post processed and co-registered with the side scan backscatter imagery to more accurately position seabed targets. Sonar beam forming is done by the Klein system electronics thus allowing for integration with on board CAD/CAC software.

To make full use of the sonar system with Bathymetry the following software will be needed

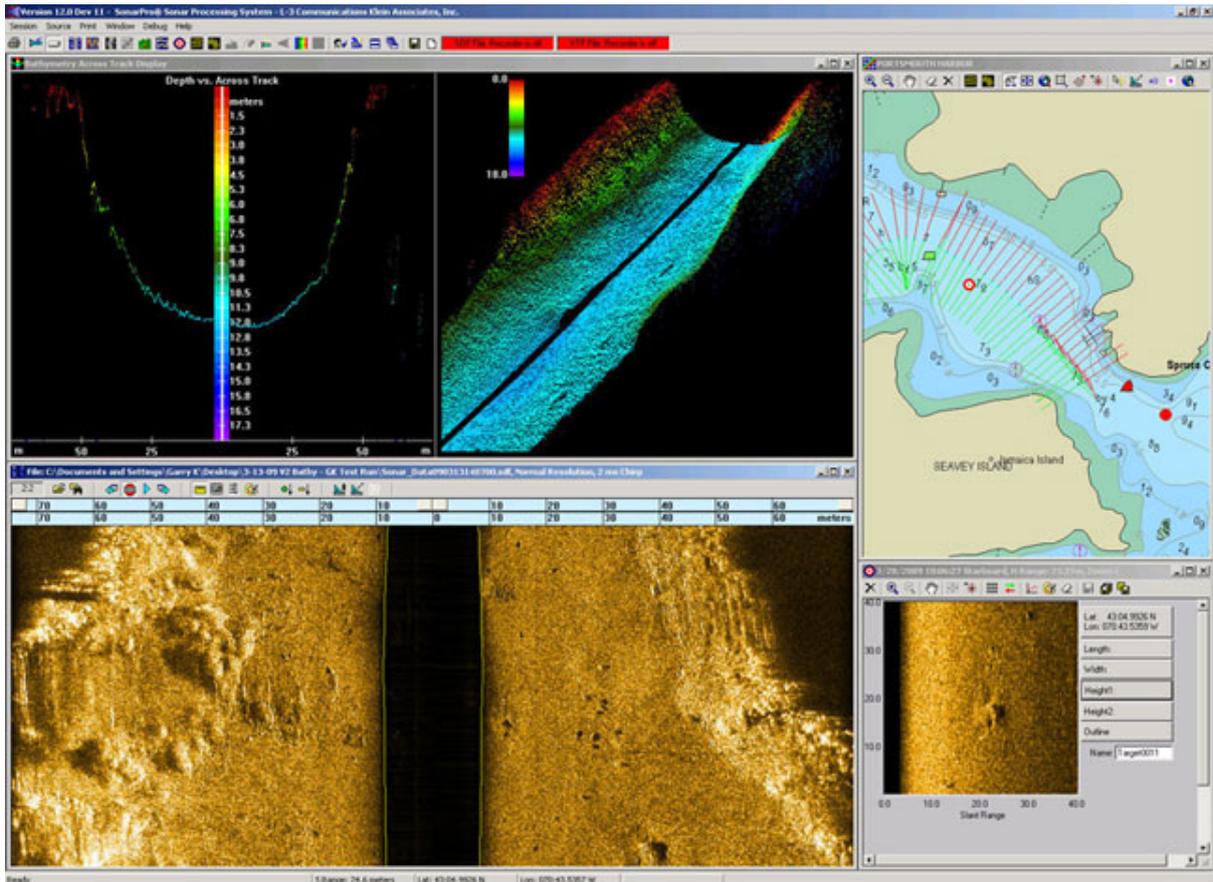
<http://kleinmariSonar.Pronesystems.com/products/sonarpro/>

Examples of Klein 3500 with bathy images:

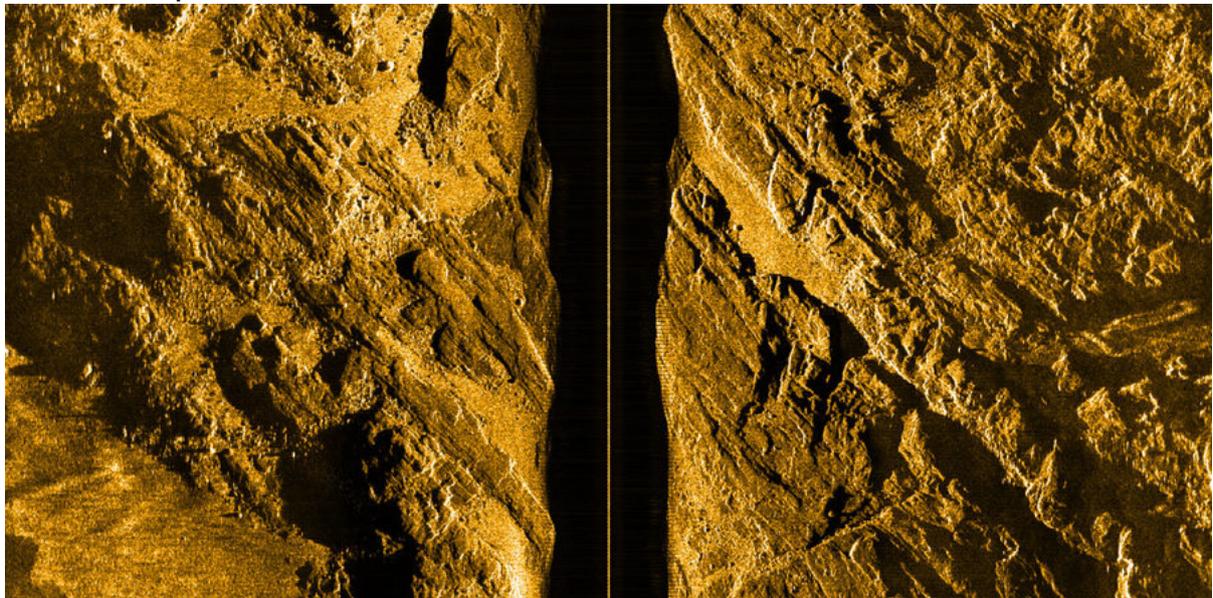
Side scan example:



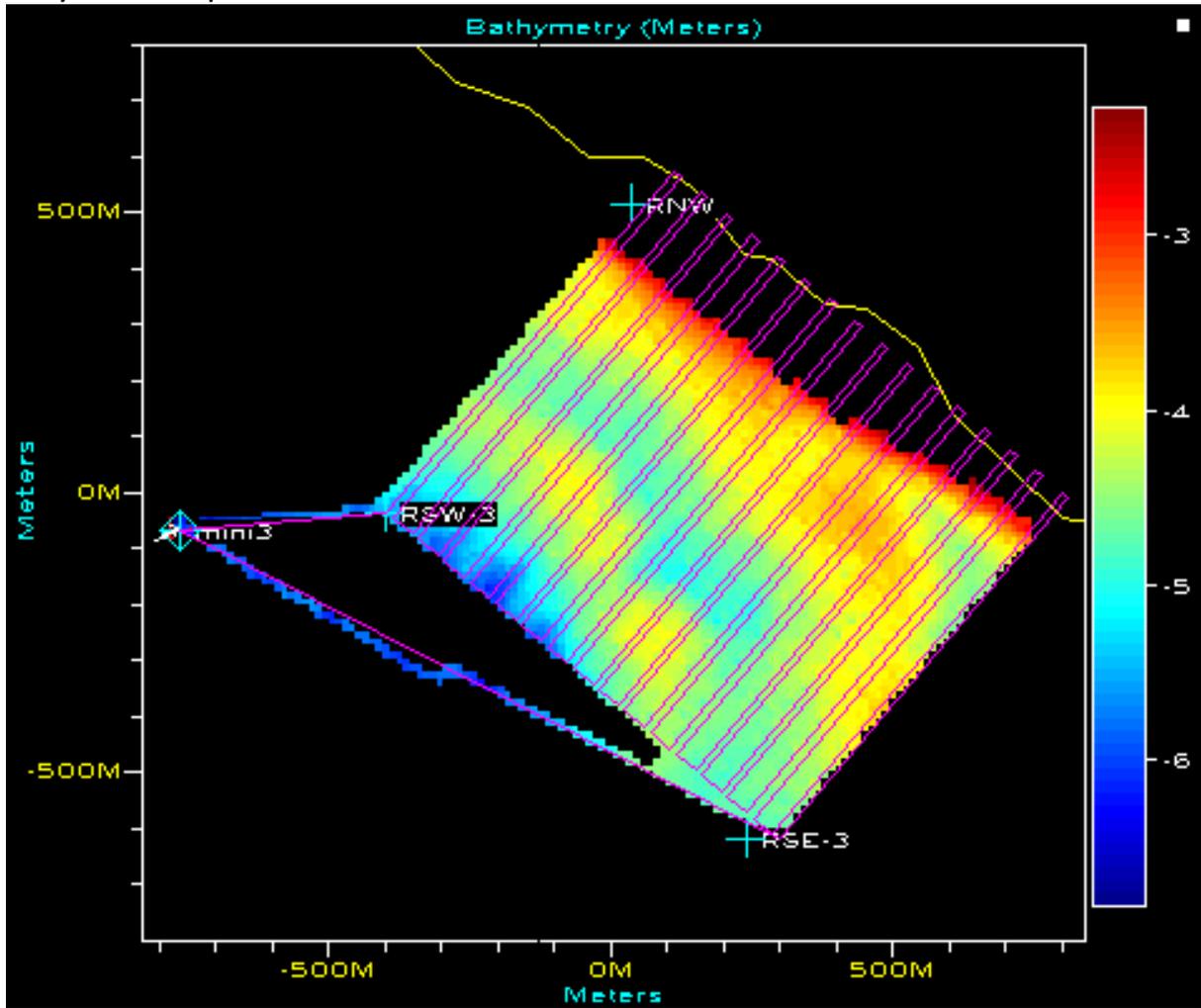
Klein Sonar Pro software



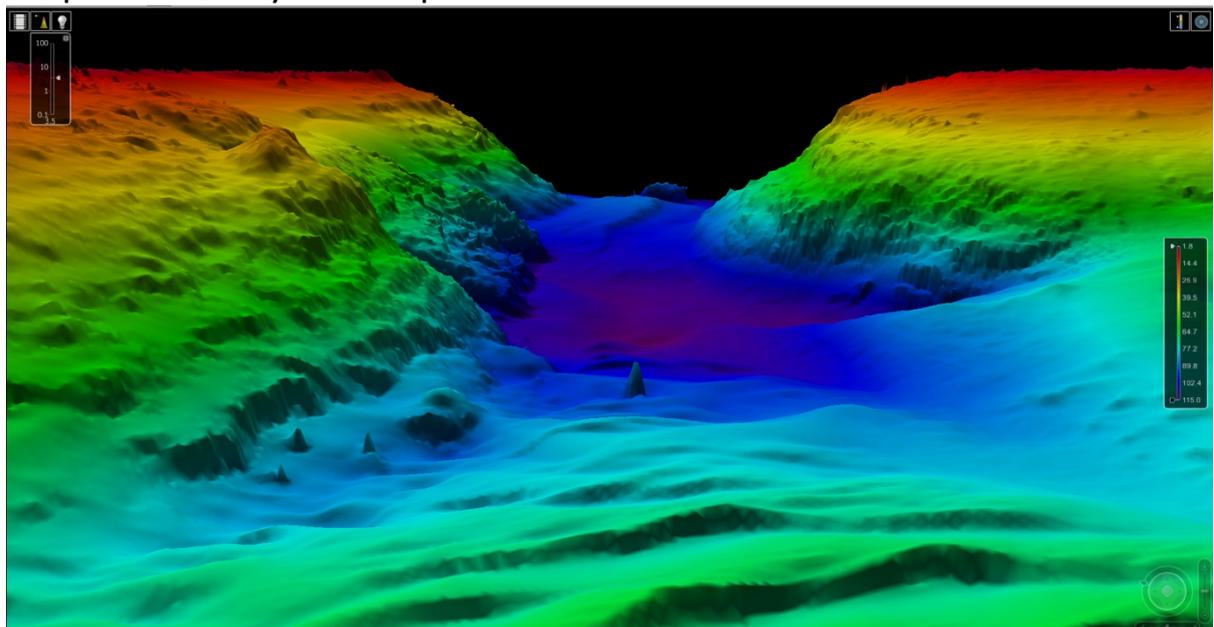
Side scan example:



Bathymetric example:



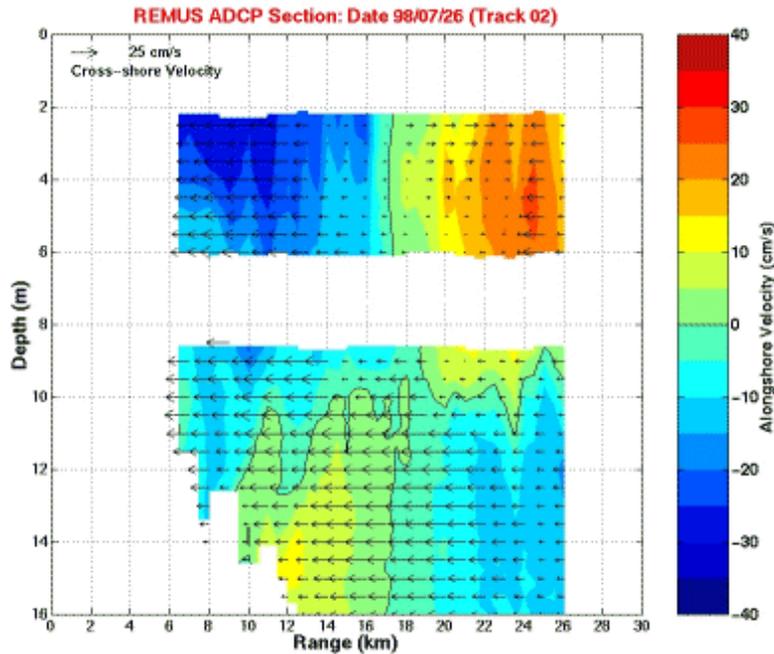
Post-processed 3D bathymetric example:



Phased Array Doppler Velocity Log (DVL) – 300 kHz – Vehicle navigation +

- Vehicle velocity
- Water current velocity (flow & current)
- Vehicle position from surface and bottom
- Depth
- Obstacle avoidance
- Terrain following
- Dead Reckoning of route travelled

Data example ADCP – Water velocity



iXblue C3 IMU w/ NavP Vehicle navigation +

- Inertial navigation for survey grade navigation
- iXblue's silent true solid state Fiber-Optic Gyroscope technology built in
- The Kongsberg Maritime NavP aided inertial navigation system built in
- Precise, reliable acoustic positioning

Wetlabs Triplet ECO Puck

The Triplet is a special-order, three-optical-sensor instrument available in a user-defined configuration. The Triplet addresses the need for multiple simultaneous scattering and fluorescence sensors for autonomous and unattended measurement platforms.

The sensor is primarily used to measure Turbidity & Fluorescence. The sensor is customised at build, capable of: one scattering, two fluorometers; two scattering, one fluorometer; three fluorometer or three scattering measurements. Options include:

- Blue scattering
- Green scattering
- Red scattering
- Chlorophyll fluorescence
- CDOM fluorescence
- Phycoerythrin fluorescence
- Phycocyanin fluorescence
- Rhodamine fluorescence
- Uranine (fluorescein) fluorescence

Aanderaa Oxygen Optode sensor.

The Oxygen optode is designed to measure absolute oxygen concentration and % saturation. The optode can be used from streams to deep sea, from fish farms to waste water and from polar ice areas to hydrothermal vents. The lifetime-based luminescence quenching principle offers the following benefits:

- Response time <8 sec (63%)
- High accuracy
- Not stirring sensitive (it consumes no oxygen)
- Lower fouling sensitivity
- Measures absolute oxygen concentrations without repeated calibrations
- Better long-term stability
- Hot water monitoring
- Less affected by pressure
- Not sensitive to H₂S
- Not freezing sensitive

YSI Conductivity and Temperature Sensor - 6560

Stable multi-probe measures conductivity and temperature levels and calculates salinity values. Thermistor readings are used to temperature-correct other parameter measurements.

Temperature

YSI utilizes a high-precision thermistor: 2252 ohms at 25°C (±1%) for temperature measurement. Resistance changes with temperature and the 6-Series sondes convert resistance into °C, °F, or K automatically. Best of all, the temperature sensor is calibration-and-maintenance-free. Specifications:

Range: -5 to 50°C

Resolution: 0.01°C

Accuracy: ±0.15°C

Conductivity

Four pure-nickel electrodes allow the YSI 6560 sensor to accurately determine the conductivity of a sample. Along with conductivity, the YSI 6-Series sonde can calculate specific conductance, salinity, resistivity and total dissolved solids. Specifications:

Range: 0 to 100 mS/cm

Resolution: 0.001 to 0.1 mS/cm (range dependent)

Accuracy: ±0.5% of reading plus 0.001 mS/cm

EK-80 Fish Sonar system

The Simrad EK80 supersedes the popular Simrad EK60, a system that has sold more than 1,100 units for research vessels worldwide and has become an international standard for fish stock assessment. Developed in close cooperation with leading marine institutes who carried out extensive testing of prototypes during the development period, the EK80 provides an advanced tool for scientists investigating marine and freshwater ecosystems.

This is the first time an EK80 has been adapted and installed on a REMUS 100 AUV

The system exploits wideband echo sounder technology where backscatter levels from a range of frequencies are processed, providing enhanced target information. The wideband frequency sweep (chirp) in combination with advanced signal processing gives exceptionally good signal to noise ratio and range resolution. This combination of high resolution and detailed frequency response assists scientists with ecosystem monitoring and stock assessments enabling them to identify species more accurately.

Post processing software is required to make the most of the EK80 data. Once the data is processed through one of the suitable packages listed below, the EK80 can deliver astonishing information about a territories fish stocks.

- Total Biomass
- Schools
- Single target detection and identification
- Seep and plume detection
- Hydrography and bottom type

Processing software:

- [Echo View](#)
- [LSS](#)
- [Sonar 5](#)

Depth Sensor - TE CONNECTIVITY PART# U5361-H00014-500PA

This sensor records pressure to calculate depth

BENEFITS

- $\pm 0.1\%$ Accuracy
- $\pm 0.5\%$ Total Error Band
- Instrument Grade and Compact
- Variety of Pressure Ports and Electrical Configurations
- Optional Stainless Steel Snubber
- CE Compliant and Weatherproof
- Gage, Sealed, Absolute, Compound
- Expedite Configurations Available (10 Days)
- 10 V/m EMI Protection
- Reverse Polarity Protection on Input
- Short Circuit Protection on Output
- -40°C to $+125^{\circ}\text{C}$ Operating Temperature

Cerulean REMUS 100 Specifications:

2.4 Notional Vehicle Technical Specifications

Hull Diameter	19 cm (7.5 in)
Length¹	170 cm (67 in)
Dry Weight¹	40 kg (88 lbs)
Maximum Operating Depth	100 m (328 ft)
Energy Storage	1.5 kWh, internal rechargeable lithium-ion batteries
Replenishment Time	6 hours
Endurance²	Up to 10 hours at 1.5 m/s (3 knots)
Propulsion	Direct drive DC brushless motor, open 3-blade propeller
Velocity Range¹	0 - 2.6 m/s (0 - 5 knots), variable over range
Maximum Range	72 km (39 NM)
DVL Acoustic Range	230 m (755 ft)
Navigation	Long Baseline (LBL), Doppler-assisted dead reckoning, Inertial Navigation System (INS), GPS
External Connections	Gigabit Ethernet, Vehicle Power/Charging
Tracking	Emergency transponder, mission abort, and in-mission tracking capabilities
Software	VIP-based laptop interface for programming, training, post-mission analysis, documentation, maintenance, and troubleshooting

¹ Dependent on sensor configuration

² Dependent on vehicle speed, sensor configuration, operating environment and mission profile

[Charitable access to advanced marine research technologies](#)