



# SOLE SOURCE JUSTIFICATION

## YSI HYCAT PRO AUTONOMOUS SURFACE VEHICLE

### SYSTEM OVERVIEW

**The HYCAT Pro is a unique, state-of-the-art vehicle with autonomous capabilities** that is designed for use in a wide variety of applications requiring water quality, bathymetric, side-scan, and/or flow data. The YSI HYCAT Pro is designed to improve the quantity and quality of environmental field data while significantly reducing technician labor and boat time. The HYCAT Pro can be fitted with a number of different sensor packages to allow a complete survey of multiple parameters simultaneously. Those sensor packages include the Edgetech 2205 for multibeam and side scan sonar imaging, a number of SBG INS options for improved positioning accuracy, Sontek M9 HydroSurveyor/RiverSurveyor for current profiling and discharge measurements, Velodyne Puck LiDAR for terrestrial mapping, AML Micro SV for sound velocity measurements, or an EXO2(s) Water Quality Sonde with up to 7 water quality sensors from the EXO product line.

## FEATURES AND SPECIFICATIONS

1. The vehicle shall be capable of working in fresh, brackish, or seawater. Beaufort Wind Scale Identifier 4.
2. The vehicle shall not exceed 5.9' in length, has a draft (antenna down) of 0.5', 2.83' beam, and a standard weight of 115.5 lbs.
3. The vehicle shall have a top speed of greater than 6 knots.
4. The battery compartment shall be watertight and isolated from all other vehicle compartments.
5. The vehicle shall be a man portable catamaran constructed of foam filled fiber reinforced plastic.
6. The vehicle shall be supplied with two external IP68 rated user USB 3.0 ports.
7. The vehicle shall have Red/Green Port/Starboard coloring for user situational awareness.
8. The vehicle shall be capable of operating using a singular 1500 WHrs 24VDC nom UN38.3 rate rechargeable Lithium-Ion batteries that is field swappable. Mission duration is 7hours at an average cruising speed of 2 knots.
9. The vehicle shall have a battery that can be charged either installed or removed from the vehicle
10. The vehicle shall have, as a standard, a 6th Gen Intel Core i5-6440EQ 4-Core 2.7 GHz processor with MS Windows 10, up to 512GB solid state drive for data storage.
11. The vehicle shall be supplied with user-friendly mission planning software that accepts most standard geo-referenced chart types.
12. The vehicle shall be supplied with vehicle control software to provide a user interface to the vehicle that allows for mission loading, data transfer, diagnostic checks and manual vehicle control.
13. The vehicle shall be supplied with autonomous and remote-control modes.
14. The vehicle shall be compatible with HYPACK Survey.
15. The vehicle shall have the ability to remotely power cycle all onboard systems via shore side interface.
16. The base vehicle shall include: vehicle assembly, camera (forward looking real-time), thrusters (protected and pocketed with SST guard), data acquisition computer (DAC), 5.8 GHz wireless communications, USB remote control, and base station with receiving antenna/modem with computer.
17. The base vehicle shall have the ability to accommodate a Sontek M9 ADCP, YSI EXO2s multiparameter water quality sonde, modified EdgeTech 2205 multibeam and dual frequency side scan, Velodyne Puck LiDAR, and an SBG INS.



## FEATURES AND SPECIFICATIONS

18. The vehicle shall record all data onboard.
19. The vehicle shall continue to operate and collect data even after the communication link has been broken.
20. The vehicle shall have a forward facing camera that can be viewed by the user in real-time.
21. The vehicle shall have an autonomous mode that allows the vehicle to operate without user interaction once HYPACK mode is activated.
22. The vehicle shall be able to collect discharge measurements.
23. The vehicle shall be able to collect multibeam bathymetry data with 8:1 coverage to depth ratio
24. The vehicle shall have the option of having a fully integrated dual antenna GNSS INS system with positional accuracy up to 1 cm (depending on GNSS)
25. The vehicle shall be able to collect LiDAR data for terrestrial mapping
26. The vehicle shall be able to have an integrated RTK radio or cellular gateway for real time corrections
27. The vehicle shall be able to collect low and high frequency side scan sonar data
28. The vehicle shall be fitted with a safety lanyard that can be pulled to deactivate power to thrusters.
29. The vehicle shall use one switch to turn on/off entire vehicle and will have an indicator light that will notify the user when the vehicle is ready to operate.
30. The instrument shall be capable of utilizing a dissolved oxygen sensor that employs the Luminescent “Lifetime” Dissolved Oxygen measurement technique. This sensor shall be capable of measuring dissolved oxygen in the range of 0-20 mg/l with an accuracy of +/- 0.1 mg/l; and in the range of 0 - 200% saturation with an accuracy of +/- 1% air saturation with a response time of less than one minute under all or zero flow conditions without the use of a stirring device. In addition the sensor must be able to measure dissolved oxygen in the range of 20 - 50 mg/l with an accuracy spec at this range of +/- 5% of the reading; and in the range of 200 - 500% saturation with an accuracy spec of +/- 5% of the reading.
31. The vehicle shall be capable of measuring temperature using a thermistor in the range of -5 to 50 degrees C with an accuracy of +/- 0.01 degrees C and a resolution of 0.001 degrees C. The instrument shall also provide, as an option, the capability of having a characterized temperature output with an accuracy of +/- 0.05 degrees C. The output shall be capable of being displayed in Celsius, Fahrenheit, or Kelvin.



## FEATURES AND SPECIFICATIONS

32. The vehicle shall be capable of measuring conductivity using a four-nickel electrode cell in the range of 0 -100 mS/cm with an accuracy of +/- 0.5% + 0.001 uS/cm and a resolution of 0.0001 to 0.01 mS/cm. The output shall be capable of being displayed in mS/cm or uS/cm. The conductivity sensor shall be capable of measuring over the entire range (0-100 mS/cm) without changing the cell constant. Capable of measuring Total Dissolved Solids if Conductivity and Temperature used.
33. The vehicle shall be capable of measuring pH in the range of 0-14 with an accuracy of +/- 0.2 and a resolution of 0.01 using a combination electrode with a gel filled reference electrode. This same sensor is also used for measuring most low-ionic strength waters.
34. The vehicle shall be capable of measuring ORP in the range of -999 to +999 mV with an accuracy of +/- 20 mV and a resolution of 0.1 mV using a combination electrode with a gel filled reference electrode.
35. The instrument shall be capable of outputting a salinity calculation based on the conductivity and temperature measurements in the range of 0-70 PPT with an accuracy of 1.0% or +/- 0.1 PPT (whichever is greater) and a resolution of 0.01 PPT. The algorithms used for the calculation should be those found in the Standard Methods for Examination of Water and Wastewater.
36. The vehicle shall have the capability of being supplied with a nephelometric type turbidity probe capable of measuring turbidity in the 0 – 4000 FNU range with an accuracy of +/- 2% of reading or 0.3 FNU's (whichever is greater) in YSI AMCO-AEPA Polymer standards for range of 0-999 FNU and +/- 5% of reading for 1000-4000 FNU. Resolution of 0.01 FNU's for 0-999 FNU and 0.1 FNU's for 1000-4000 FNU. Measurements should have reasonable agreement to the HACH 2100AN benchtop meter.
37. The vehicle shall have the capability of being supplied with a chlorophyll probe capable of measuring chlorophyll fluorescence in the 0 - 400 ug/L range with a resolution of +/- 0.01ug/L. Part of Total Algae sensor.
38. The vehicle shall have the capability of being supplied with a blue-green algae probes capable of measuring blue-green algae fluorescence in the 0 – 100 ug/L range for PC and 0-280 ug/L range for PE. Versions available for either freshwater or marine environments. Part of Total Algae sensor.
39. The vehicle shall have the capability of being supplied with an fDOM probe capable of measuring fDOM in the 0-300 ppb QSE range with a detection limit of 0.07 ppb QSE and a resolution of 0.01 ppb QSE.

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## FEATURES AND SPECIFICATIONS

40. Water quality sensor assembly can be calibrated via wireless Bluetooth communications.
41. The vehicle shall be supplied with either an AML Micro SV or EXO2(s) for providing speed of sound updates to Edgetech in real-time
42. The vehicle shall be supplied with autonomous fail safes including but not limited to: 2 times integrated battery backups with automatic shutdown scripts, minimum operating fail safe, lost communication fail safe, low battery warning fault and annunciation to user, real-time battery capacity feedback, and internal time stamped logging of all low level and high level parameters

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# HYCAT PRO SYSTEM SPECIFICS: SYSTEM

## Dimensions

- Length: 1.83m
- Beam: 0.91m
- Draft: 0.17m
- Weight: 52.3 kg

## Endurance

- 7.0 hrs @ 2 kts
- 5.5 hrs @ 3 kts
- 2.1 hrs @ 4 kts

## Operational Sea State

- Beaufort Wind Scale identifier 4

## Environmental Operating Conditions

- Air Temperature: -20 to + 45 Deg.C
- Water Temperature: +4 to +32 Deg.C

## Propulsion System

- 2 x 1KW BLDC Pocket Thrusters

## Battery

- 1 x 1500 Whr 24VDC nom UN38.3 rated Li-ion Battery. Field swappable.

## On-Board Electronics

- 6th Gen Intel Core i5 data acquisition computer. Robust data acquisition not effected by communications drop out.

## Communications

- Real time data monitoring and sensor interfacing

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# HYCAT PRO SYSTEM SPECIFICS: SENSORS

## **Edgetech 2205**

- 540kHz bathymetry (8:1 coverage to depth ratio)
- 1600kHz high resolution sidescan
- 540kHz motion compensated sidescan
- Backscatter

## **INS Options:**

SBG Ekinox D dual antenna GNSS INS (Fully integrated)

- Up to 0.02° Roll & Pitch (RTK)
- Up to 0.05° GNSS-based Heading
- 1 cm Position (Depends on GNSS)
- 5 cm Real-time Heave
- 2.5 cm Delayed Heave

SBG Apogee D dual antenna GNSS INS (fully integrated)

- Up to 0.008° Roll & Pitch (RTK)
- Up to 0.04° GNSS-based Heading
- 1 cm Position (Depends on GNSS)
- 5 cm Real-time Heave
- 2.5 cm Delayed Heave

## **SonTek M9 HydroSurveyor/RiverSurveyor**

- Depth Measurement
  - Range (Vertical Beam): 0.2m to 80m
  - Range (Slanted Beams): 0.2m to 40m
  - Accuracy: 0.02m (sound speed corrected)
  - Resolution: 0.001m
- Velocity Measurement
  - Profiling Range (Distance): 0.06m to 40m
  - Profiling Range (Velocity):  $\pm 10$  m/s
  - Accuracy: Up to  $\pm 1.0\%$ ,  $\pm 0.2$  cm/s
  - Resolution: 0.001 m/s
- Acoustic Bottom Tracking
  - Range:  $\pm 10$  m/s
  - Altitude: 0.2 – 40m
- Discharge Range
  - Range with Bottom-Track: 0.3m to 40m
  - Range with RTK GPS or DGPS: 0.3m to 80m

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## HYCAT PRO SYSTEM SPECIFICS

### Velodyne Puck LiDAR

- 16 Channels
- Measurement Range: 100 m
- Range Accuracy: Up to  $\pm 3$  cm (Typical)<sup>1</sup>
- Field of View (Vertical):  $+15.0^\circ$  to  $-15.0^\circ$  ( $30^\circ$ )
- Angular Resolution (Vertical):  $2.0^\circ$
- Field of View (Horizontal):  $360^\circ$
- Angular Resolution (Horizontal/Azimuth):  $0.1^\circ - 0.4^\circ$
- Rotation Rate: 5 Hz – 20 Hz

### EXO2(s) Sensors

- Conductivity
  - Range: 0 to 200 mS/cm
  - Resolution: 0.0001 to 0.01 mS/cm
  - Accuracy:  $\pm 0.5\%$  of reading or 0.001 mS/cm, w.i.g. (0-100 mS/cm)  $\pm 1\%$  of reading (100-200 mS/cm)
- Temperature
  - Range:  $-5$  to  $50^\circ\text{C}$
  - Resolution:  $0.001^\circ\text{C}$
  - Accuracy:  $\pm 0.01^\circ\text{C}$  ( $-5$  to  $35^\circ\text{C}$ )  $\pm 0.05^\circ\text{C}$  ( $35$  to  $50^\circ\text{C}$ )
- Dissolved Oxygen
  - Range:  $-0$  to  $500\%$  Air Sat; 0 to 50 mg/L Concentration
  - Resolution: 0.1% Air Sat; 0.01 mg/L Concentration
  - Accuracy:  $\pm 1\%$  of reading or 1% sat., w.i.g., (0 to 200%)  $\pm 5\%$  of reading (200 to 500%) Air Sat;  $\pm 5\%$  of reading (20 to 50 mg/L) Concentration
- fDOM
  - Range: 0 to 300 ppb QSE
  - Resolution: 0.01 ppb QSE
  - Accuracy: Linearity:  $r^2 \geq 0.999$  for 0 to 300 ppb QSE, MDL of 0.016 ppb QSE
- pH
  - Range: 0-14 pH units
  - Resolution: 0.01 pH unit
  - Accuracy:  $\pm 0.1$  within  $\pm 10^\circ\text{C}$  of cal temp  $\pm 0.2$  for all other temps
- ORP
  - Range: -999 to 999 mV
  - Resolution: 0.1 mV
  - Accuracy:  $\pm 20$  mV



# HYCAT PRO SYSTEM SPECIFICS

## EXO2(s) Sensors, continued

- Rhodamine
  - Range: 0 to 100 RFU or 0 to 1,000 µg/L
  - Resolution: 0.01 RFU or 0.01 µg/L
  - Accuracy: ±5% or 0.1 µg/L w.i.g, Linearity:  $r^2 > 0.999$
- TAL-Chlorophyll
  - Range: 0 to 100 RFU or 0 to 400 µg/L chl
  - Resolution: 0.01 RFU or 0.01 µg/L of pigment
  - Accuracy: Linearity:  $r^2 \geq 0.999$  for Rhodamine WT across full range
- TAL-Phycocyanin
  - Range: 0 to 100 RFU or 0 to 100 µg/L PC
  - Resolution: 0.01 RFU or 0.01 µg/L of pigment
  - Accuracy: Linearity:  $r^2 \geq 0.999$  for Rhodamine WT across full range
- TAL-Phycoerythrin
  - Range: 0 to 100 RFU or 0 to 280 µg/L PE
  - Resolution: 0.01 RFU or 0.01 µg/L of pigment
  - Accuracy: Linearity:  $r^2 \geq 0.999$  for Rhodamine WT across full range
- Dissolved Oxygen
  - Range: -0 to 500% Air Sat; 0 to 50 mg/L Concentration
  - Resolution: 0.1% Air Sat; 0.01 mg/L Concentration
  - Accuracy: ±1% of reading or 1% sat., w.i.g., (0 to 200%) ±5% of reading (200 to 500%) Air Sat; ±5% of reading (20 to 50 mg/L) Concentration
- Turbidity
  - Range: 0 to 4000 FNU
  - Resolution: 0.01 FNU to 0.1 FNU
  - Accuracy: 0.3 FNU or ±3% of reading, (0 to 999 FNU) ±5% of reading (1000 to 4000 FNU)

## AML Micro SV

- Path Length: 33mm
- Accuracy: +/- 0.05 m/s
- Range: 1400 to 1600 m/s
- Precision: 0.03 m/s
- Resolution: 0.015 m/s

