SPECIFICATIONS

hydronaut

Net-zero transport — with or without a crew.

NAUTICUSROBOTICS.COM

nauticus robotics

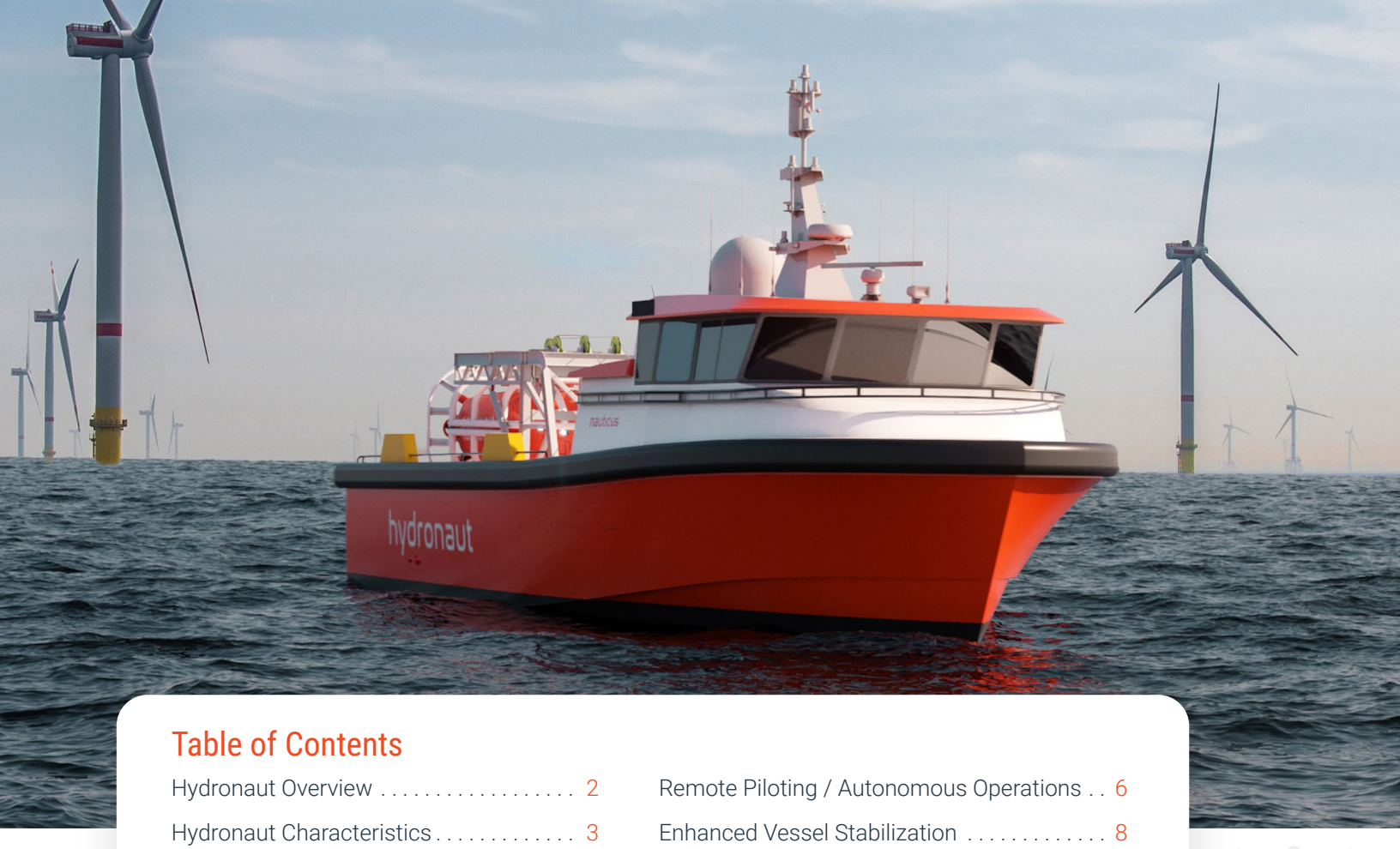


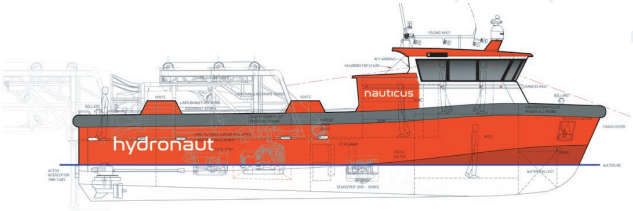
Table of Contents

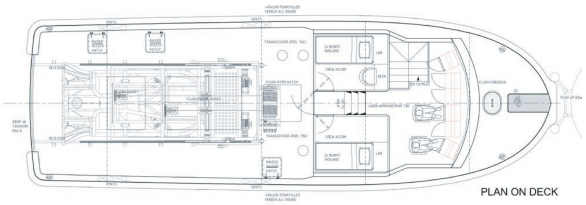
Hydronaut Overview

Hydronaut is an autonomous UAV deployment craft specifically designed to deploy Nauticus Robotics' Aquanaut platform.

Initially manned, Hydronaut has been built to class with flag and MLC compliance. The vessel is fitted with gyro-stabilization and ride control to maximize the operational envelope of the craft in manned and unmanned operations.

Comprehensive navigation and communications systems manage the transfer of offshore control, onshore control, and information for both Hydronaut and Aquanaut.





Hydronaut services include:

- Deployment of Aquanaut to undertake sub-sea activities
- Surface-based hydrographic survey activities
- Transport of goods and assets

Hydronaut Characteristics

GENERAL

Construction Material:	Marine Grade Aluminium Alloy
Hull Type:	Symmetric semi-planning monohull
Superstructure Mounting:	Integral to Hull
Classification:	BV Hull • Machinery - Light Ship - Special Service Craft – Sea Area 3
Flag:	UK Flag

PROPULSION

Main Engines:	2 * Volvo Penta IPS 9000 Tier 3
IMO:	IMO tier 3 – SCR Exhaust Aftertreatment Technology
Carbon Footprint:	Carbon Neutral Vessel operations
Installed Power:	1030 KW
Sprint Speed:	21 Kts
Service Speed	18 Kts
Vessel Station Keeping:	Dynamic Positioning System Installed

ELECTRICAL EQUIPMENT

Network:	24v DC, 400/230 50 Hz AC
Generator Sets:	1 * NANNI QLS 65T 52 KW 1 *NANNI QLS 32T 24 KW

ACCOMMODATION

Main Deck:	2 KPM Crew seats / 2 twin cabins
Below Deck:	Mess Seating, Table & Galley Shower Compartment
Air Conditioning:	Toshiba Air Cooled
Heating:	Reverse Cycle System

DECK EQUIPMENT

Anchor:	1 SHHP Pool Type
Anchor Winch:	Lewmar Electric
Side Fender:	Manuplas Foam Fender
Robot Deployment:	Kongsberg Subsea Launch & Recovery System
Robot:	Nauticus Robotics - Aquanaut

FIRE FIGHTING

Engine Space:	STAT-X
Loose Extinguishers:	In line with class requirements

DIMENSIONS

Length Overall:	18 m
Beam Overall:	6.2 m
Draft Overall:	1.2 m
Maximum Displacement:	40 T
Moulded Depth:	18 m
Crew:	4 crew + 2 passengers

TANK CAPABILITIES

Marine Gas Oil:	5,000 Ltrs (expandable)
Fresh Water:	250 Ltrs
Grey Water:	250 Ltrs
Classification:	2,600 Ltrs
Ballast Water:	2,600 Ltrs

RIDE CONTROL & COMFORT

Roll Reduction:	SMART Gyro SG80
Trim Control:	Humphree Interceptors

NAVIGATION

Main Radar:	Furuno FAR2218BB 12 kw Furuno MU190 19-inch Display
Main Electronic Chart:	Furuno FMD3100 24-inch ECDIS
AIS:	Furuno FA170
Echo Sounder:	Furuno FE800
Navtex:	Furuno NX700B
GPS:	Furuno GPS170
Speed log:	Walker 7070
Weather Station:	Airmar 2000WX/ RD33
Intercom:	Phonic 3100 Master / Slaves

ADDITIONAL EQUIPMENT

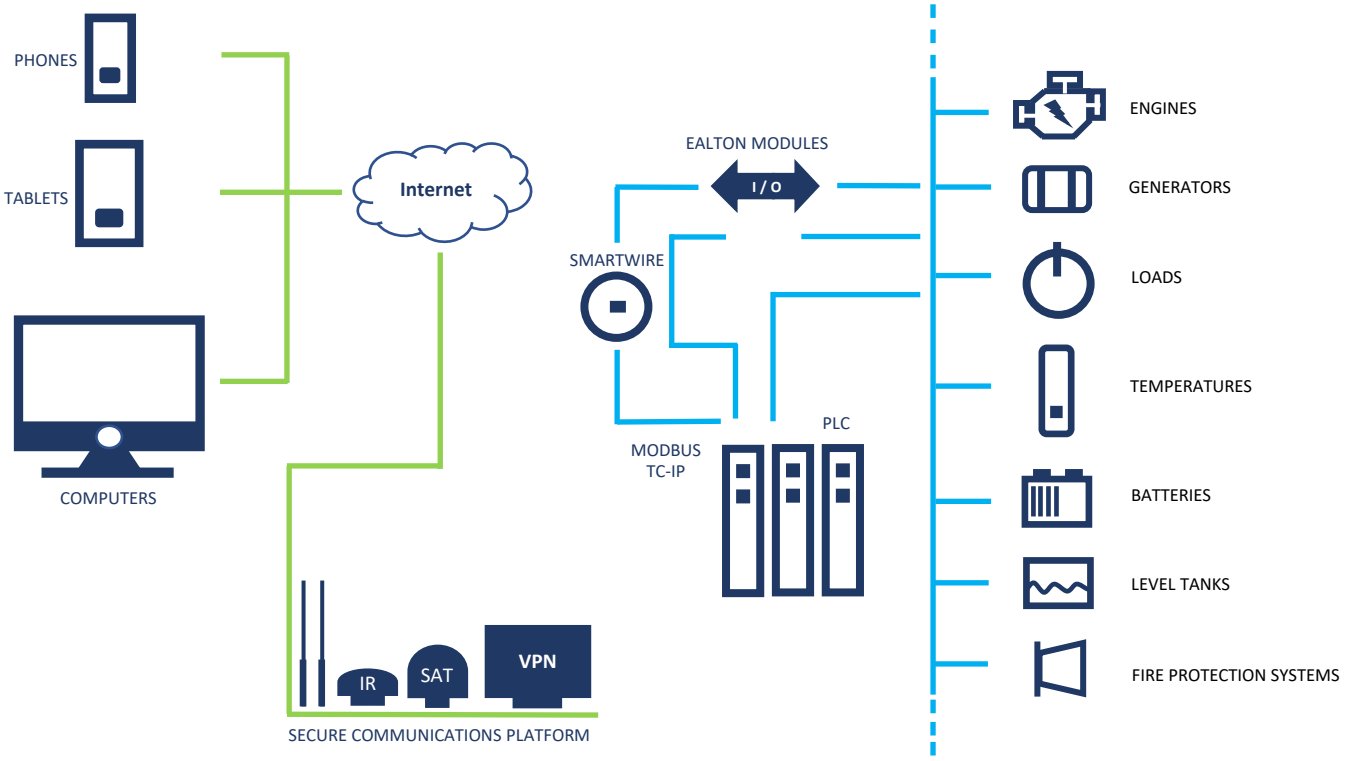
CCTV:	8 Hikvision IP Cameras Hikvision 16 Channel NVR

Ship to Shore Communications

Primary Communications:	4/5 G
Back Up Communications:	Satellite
Secondary Back Up Communications:	Iridium
Crew to Shore:	VHF/UHF
Vessel Location:	AIS

Vessel Remote Monitoring System

Hydronaut uses the Bluewave Remote Alarm System to monitor the performance of vessel critical components such as engines and generators. Remote operators continually monitor equipment status reports as well as alarm conditions. The remote monitoring system allows operators to interrogate alarm conditions and take appropriate actions as necessary.



Remote Monitoring of Generator Sets

Remote Monitoring of Fuel Tanks

Remote Fire Detection Monitoring

Remote Piloting / Autonomous Systems Hardware

Remote Piloting Hardware

Sensor Telemetry:	GSM/LoRa/WIFI Comms
Vessel Heading:	LSS AME30 Heading Sensor
Radar:	Furuno DRS4D NXT Radome
Navigation Controls:	Furuno MFD TZT9F
Marine Antenna:	Varipos V560 Antenna

Communications:	Varipos PW7720 Receiver
Weather Station:	Maximet 500 Wind Speed Ouster OS1-128 Gen2
Thermal Cameras:	4 FLIR Boson 640 60Hz Cameras
LIDAR:	Ouster OS1-128 Gen2 LIDAR
Field of View Camera:	FOV 90 Degree Camera

Remote Piloting Software

MarineAI's software stack consists of capabilities that range from low level sensor integration up to the high-level autonomy decision engine. The following section describes each of the product offerings.

GUARDIAN by Marine AI

GUARDIAN VISION
(Computer Vision)

Detects, classifies, and tracks obstacles using visible light cameras. Obstacles include vessels, buoys, navigational markers, and low-observable marine objects of unknown types, such as pot markers or flotsam. Figure 1 details the image processing pipeline which is comprised of video stream preparation, object detection, classification and filtering stages which ensure contact reliability.

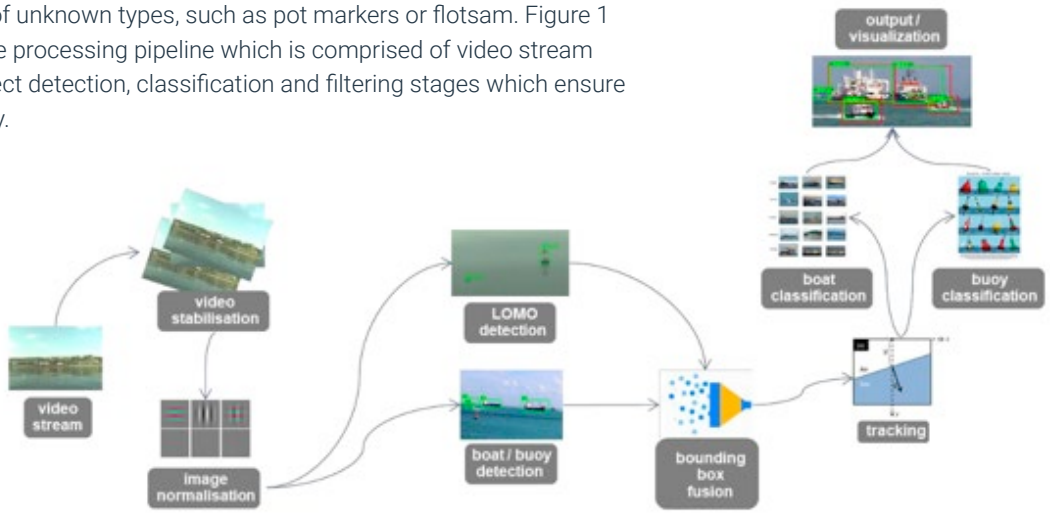


Figure 1. "Guardian Vision" profile

GUARDIAN SENSE
(Sensor Fusion)

Interfaces to supported sensors providing data retrieval, data quality analysis, and sensor failure recovery functions. Data is fused and filtered to produce a map of marine contacts and hazards which is then provided to either “Guardian Manned” or the “Guardian Autonomy” engine.

The module takes inputs from:

- GNSS
- S57/S100charts
- AIS (Terrestrial and Satellite)
- Radar
- “GuardianVision”

GUARDIAN MANNED
(Recommendation-Based Safe Navigation)

Course and speed recommendations are presented to the pilot of a crewed vessel to assist in guiding the vessel around hazards on the way to a goal position. Collision avoidance and collision regulation engines work to maintain safe navigation while advising actions which adhere to COLREGs.

Real-time insights into the system’s decision-making processes are exposed in the MARNAVSYS application. Own ship information is displayed along with relevant vessel information giving the operator an understanding of the system’s situational awareness. Maneuvers are displayed with natural language justifications for course suggestions.

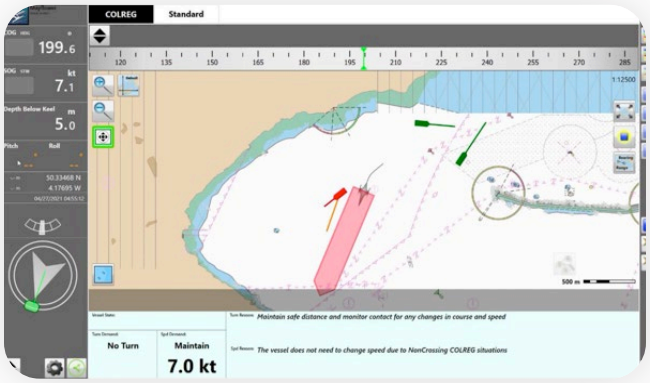


Figure 2. MARNAVSYS showing COLREG driven manoeuvre

GUARDIAN AUTONOMY (Vehicle Acts According to High-Level Decisions)

“Guardian Autonomy” closes the loop on the “Guardian” software suite. Course and speed adjustments are acted upon and the vessel is autonomously steered towards a series of goal waypoints. The “Mission Manager” capability controls the vessel’s progression through a mission, allowing for tasks to be completed along the route in response to either vessel state or environmental triggers.

- Track vehicle health state and return to home location on fault
- Operational boundary limit tracking 2D/ 3D
- Manual task switching
- Automatic task switching based on location/vessel state metrics
- One shot waypoint (Steer To)

MISSION PLANNING

Routes and mission objectives are created within the “Route Planner” application which communicates with the target vessel either over the local network or via the cloud. Mission status metrics are displayed alongside visualizations of the target routes and the vessel’s actual navigational state.

Figure 3. Route Planner

DEPLOYED HARDWARE

Two primary compute resources are used to run the above software suite. “Guardian Core” contains a low-power GPU-capable NVIDIA edge device which runs the Guardian Sense and Vision software layers.

- IP67-rated and passively cooled enclosure
- Powered by a standardized 24Vdc supply
- Ethernet, CAN bus, and serial communications

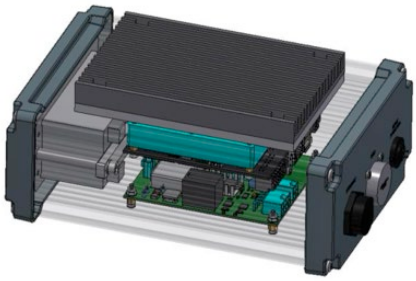


Figure 4. Guardian Core hardware

COMMUNICATION

Interaction with the vessel is achieved using both local and global communication solutions. A Peplink Max Transit SD-WAN unit installed on the vessel manages the following transport services:

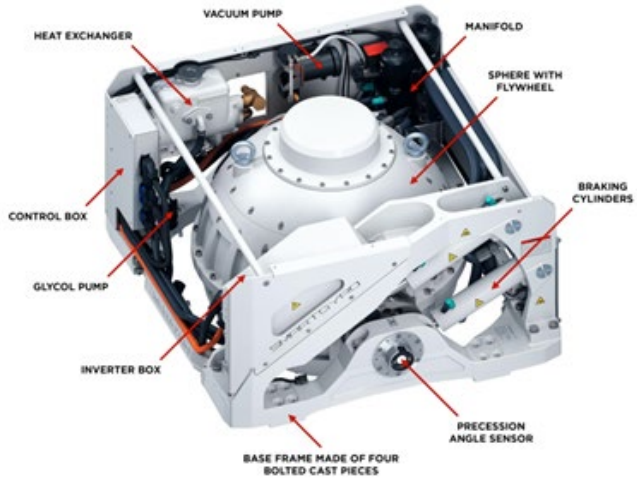
- Local MIMO WiFi
- LTE
- VesselLink 700 SATCOMs
  - Regular communication route health checks detect when a service is down, and the configured failover route started to ensure a reliable connection to the vehicle. Geo-fencing, traffic limits, and firewalls ensure that expensive services such as SATCOMs are restricted keeping operational costs managed.

Enhanced Vessel Stabilization

A Smartgyro stabilizer has been added to minimize unwanted vessel movement and greatly enhance vessel stability. The adoption of the gyro stabilizer enhances the launch and recovery parameters for Aquanaut as well as providing additional crew comfort in rough seas.

SG80 GYRO STABILIZER

Smartgyro SG80 is the gyro stabilizer of choice for boats from 60-70 ft. Ideal for both new builds and refit installations, the stabilizer can be fully serviced on-board the vessel without the need to lift out for maintenance, ensuring significant time and cost savings.



Technical Specifications

Rated Speed	5.500 RPM
Angular Momentum at Rated Speed	15,400 Nms
Anti-rolling Torque at Rated Speed	3-,100 Nm
Spool Up – Time to Rated Speed	45 minutes
Spool Up – Time to Stabilization	25 minutes
Input Voltage (DC):	24 Vdc 50/60 Hz, single phase
Spool Up AC Power	4.9 KW
Operating AC Power	2.4-4.0 KW
DC Power	220 W
Sea Water Supply	15 (min) – 30 (max) LPM 4 (min) – 8 (max) GPM
Operating Temperatures	0° - 60° C (32° - 140°F)
Envelope Dimensions	1.08 * 1.11 * 0.87 m 42.4 * 43.7 * 34.3 in
Noise Output	62-64 dBC @ 1 meter

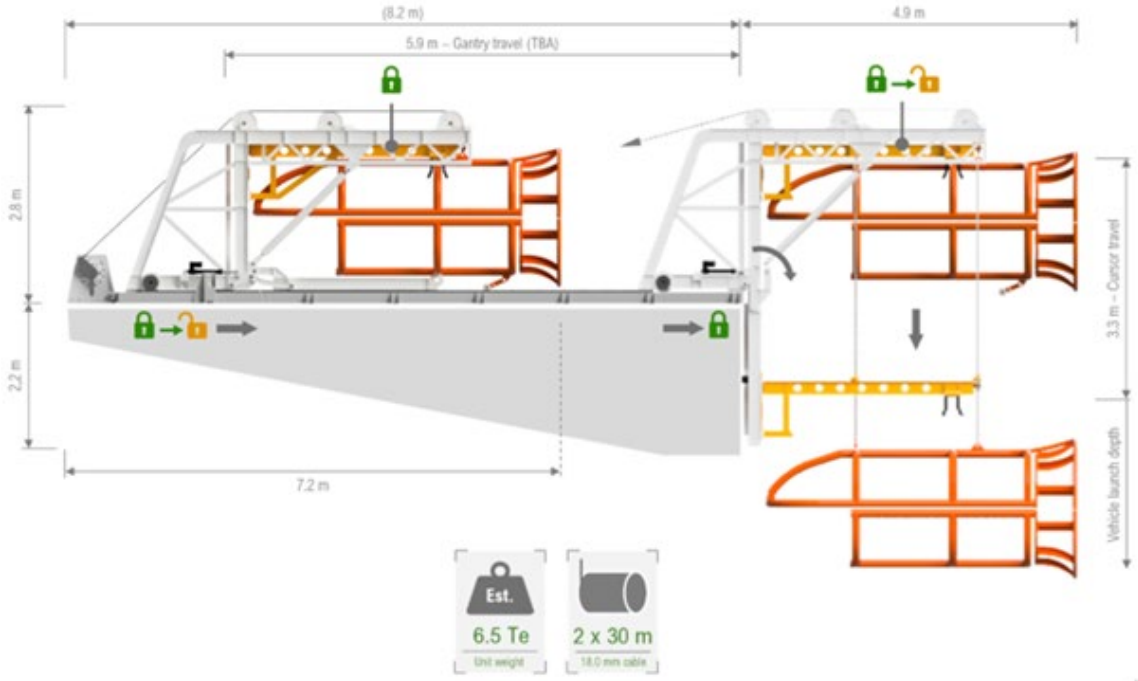
Aquanaut Launch and Recovery System

DATA	VALUE	COMMENT
Safe Working Load (Te)	4	
Dynamic Amplification Factor	1.8 / 1.3	Launch & Recovery / Deck Skidding
Cable Speed (m/s)		
Continuous	0.6	Normal Mode
Intermittent	1.6	Active Heave Comp Mode
Crane Travel Speed (m/min)	8	Horizontal Travel
Power Consumption (KW)		
Electric – System	45	400 VAC, 50 Hz
Electric – UPS	4	230 VAC, 50 Hz (Supplied from vessel)
Cooling Requirements (l/min)	4 x 20	Water with 50% Ethylene Glycol @ < 40° C (Supplied from vessel)

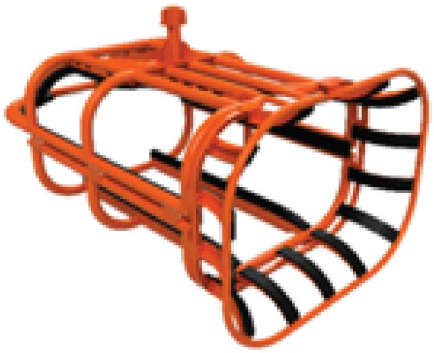
LAUNCH AND RECOVERY SYSTEM CERTIFICATION

The Launch and Recovery System is certified to DNVGL-ST-0378

- Designed to safely launch and recover an untethered vehicle over the stern of a vessel to and from a given target depth
- All-electric handling unit
- Reliable and robust construction, greatly reducing the load on the handled vehicle
- Integrated instruments for load, speed, and length readout
- Prepared for:
  - Active heave compensation
  - Remote operation*

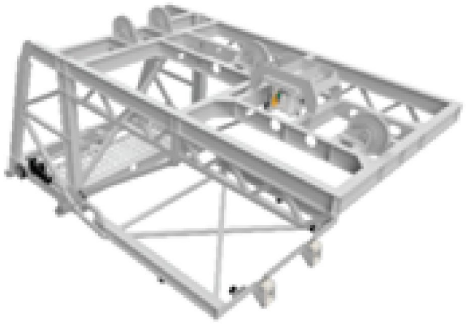


BASKET



- Semi-enclosed structure that guides and protects the vehicle to and from launch and recovery depth.
- Vehicle protection bumpers
- Integrated mechanical locking mechanism to secure vehicle inside
- Bullet for securing the basket and cursor in the crane hang-off lock
- Interface points for two lifting cables
- Made of an upper and lower part that can be split to provide service access to the vehicle

GANTRY CRANE

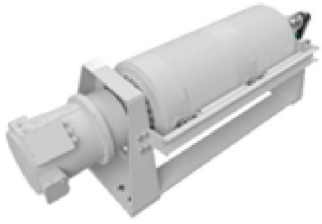


- Transports the vehicle to and from launch position over the stern
- Runs on skid beams mounted on deck, driven by an electric motor
- Routing sheaves for two lifting cables
- Hang-off fail-safe lock for cursor and basket
- Integrated vertical cursor rails
- Electrically tiltable cursor rail extensions with end stoppers

CURSOR

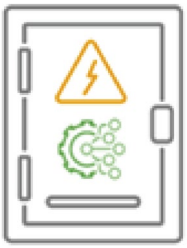
- Horizontally supports and guides the basket when mated with the cursor
- Wheels for guiding along the cursor rails
- Guide sheaves for lifting cables when basket is undocked
- Centring devices for correct alignment of the basket when entering or leaving the cursor

LIFTING WINCH



- Handles the load of the cursor, basket and vehicle during launch and recovery over the stern
- Electric motor with fail safe brake
- Machined grooves on drum for two lifting cables incl. cable clamps
- Interface brackets for deck fastening

POWER AND CONTROL CABINET



- All control system hardware, communication modules and variable frequency drives assembled in power and control cabinets to be mounted on or nearby the unit

CONTROL SYSTEM AND OPERATOR INTERFACE

OPERATOR INTERFACE

- Operators panel with touch screen GUI, pushbuttons and joysticks
- Many modes and features to facilitate safe and simple operations with minimal wear on equipment
- Same unit, multiple use:
  - Wireless or cabled unit in a carrying harness for operation around deck
  - Fixed panel for the control room

AUTOMATED FEATURES

- Active Heave Compensation - Keep the basket at rest regardless of vessel motion for easier mating with the vehicle
- Auto Depth - Automatic operation to a set depth at a set speed
- AutoLARS - Automatic Launch and Recovery of the vehicle

OPTION: CONNECTIVITY

- Operational data and sensor read-outs are logged onboard and stored in the cloud
- Live streaming and historical data -From shore, while in operation
- Powerful tools turn operational data into intelligence
- Remote operation and diagnostics from shore-based control stations
- Designed for communication disruptions and high latency

FUNCTIONAL DESCRIPTION

The vehicle is secured in the basket while on deck. The basket is stabilized by a cursor and secured to a fail-safe lock in the gantry upper structure. The gantry crane is moved by a rack and pinion drive on deck mounted skid rails.

When launching, the gantry with the cursor and basket is moved along the skidding beams on deck to the overboard position. Here, the vertical cursor rail extension is launched allowing the cursor and basket to be lowered by two lifting wires after being released from the fail-safe lock. The cursor guides the basket through the splash zone before it stops on the end of the cursor rails, allowing the lifting winch to further lower the basket.

Once below a set safety depth, the basket may be heave compensated allowing the untethered vehicle to safely exit the basket. When the vehicle is at a safe distance from the basket, active heave compensation can be disabled, and the basket recovered to deck.

Both the launch sequence, and the similar recovery sequence, can be further automated using the Auto Launch function. Using this function, the whole process is executed in one command, ideal for remote operations.

A service mode is available on deck, where a tiltable part of the deck rails enables for the basket to split and provide easy access to vehicle for service. This uses the lifting winch to tilt the gantry, cursor, and upper part of the basket where mechanical locks are used to secure the unit in tilted position. The lower basket part with the vehicle is secured to the deck. This provides ample access to the vehicle.

nauticus robotics

At Nauticus Robotics, we believe we're all responsible for protecting the world's oceans. That's why we created a highly sophisticated, ultra sustainable fleet of marine robotics — along with the intelligent software to power it.

17146 FEATHERCRAFT LANE, SUITE 450

WEBSTER, TX 77598

(281) 942-9069

NAUTICUSROBOTICS.COM