



Review of C-Worker 6 Unmanned Surface Vehicle (USV) for Offshore Survey Support Operations

September, 2014

C-Worker 6 Presentation

Presentation Overview

- C-Worker 6 Design Brief
- C-Worker 6 Design Overview
 - Vessel design
 - General Arrangement
 - Stability
 - Propulsion
 - Tanks
 - Control system
 - Comms
 - C-Worker integration and FAT trials update
- Payloads
- LARS developments
 - System overview
 - Load testing
 - First dock tests
- Sea Fastening
- Trailer
- Future developments



C-Worker 6 Design Brief

High Level Requirements

- Rugged, work class vehicle suitable for deployment offshore for extended periods
- Modular, able to carry a variety of payloads
- Acoustically quiet
- Deployable, it must be easily transported, installed on ships of opportunity and launched and recovered
- Reliable

Performance Requirements

- Maintain survey speed in 2 knot currents requiring a top speed of around 6 knots
- High endurance, at least 30 days at sea
- It must be able to work in up to 4m seas and survive seastate 8 (full gale)
- It must have a good line of sight communications range and ultimately be able to operate over the horizon



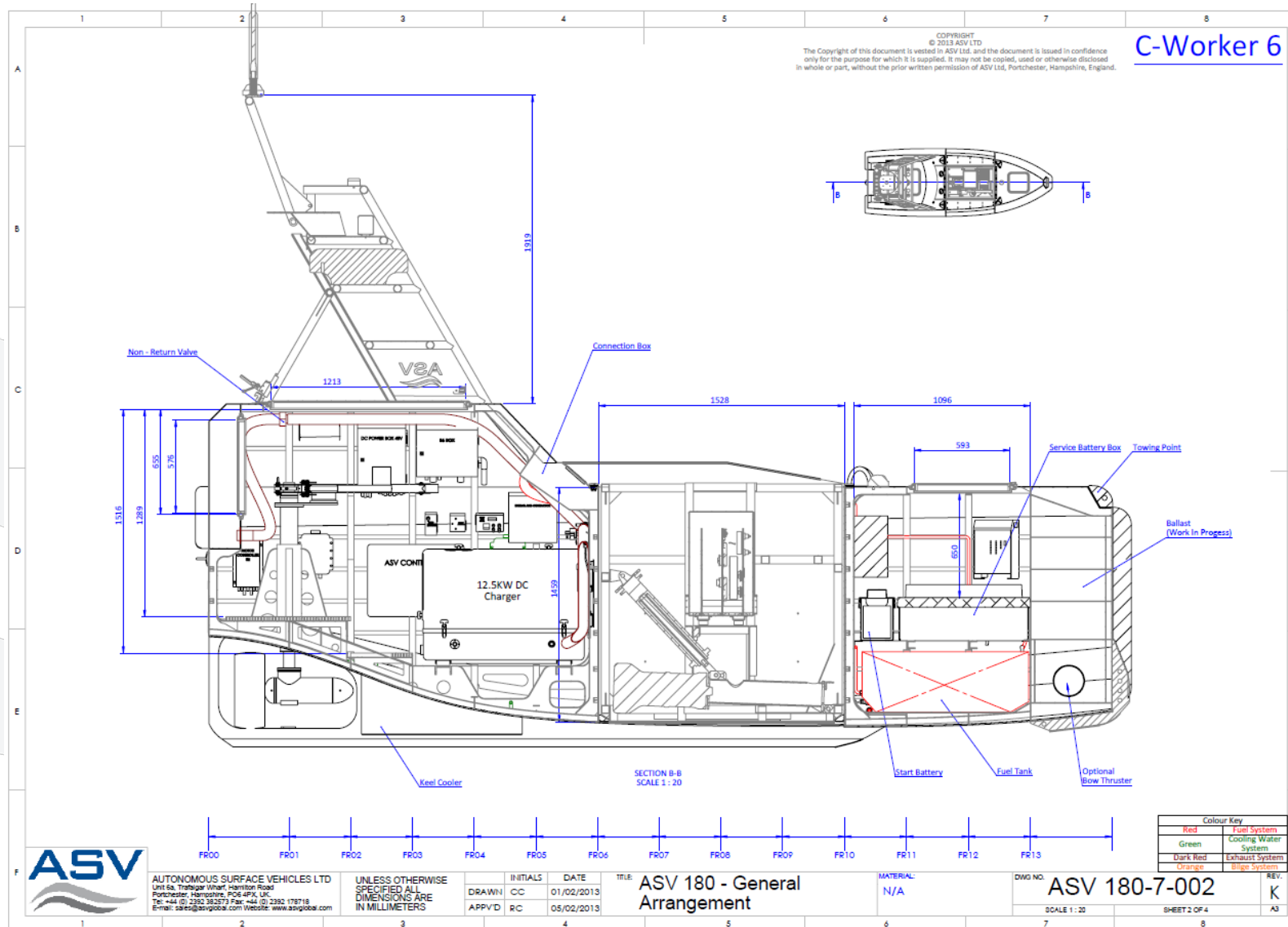
C-Worker Design Overview

Specification

Characteristic	Specification / Value
Length Overall	5.85m
Beam Overall	2.2m
Height Overall	2.2m for transport, 3.2m for launch and recovery, 4.0m operational
Draft	0.68m lightship, 0.85m full load, 2m+ with USBL
Displacement	2.8 tonnes lightship, 4.4 tonnes full load
Hull Material	Aluminium (5083) plate and Aluminium (6082) extrusions
Structural Design Standard	ISO 12215 with additional 50% margin, Lloyds SSC
Fender Material	Closed Cell foam with technical fabric coating (as used on C-Stat and C-Sweep)
Lifting beam	Modulift 5 tonnes SWL with dynamic safety factor of 6.
Paint Specification	International Interzone 505, Signal Yellow RAL 1003
Primary Propulsion	2 x 10kw DC Fischer Panda propulsion pods
Primary Power Generation	2 x 13kw (1.5kw MCR) 48V DC Gensets – Fischer Panda AGT13000 dry exhaust
Propeller details	CJR 4BLH 16 X 10
Cooling System	Twin keel coolers integrated with the skeg, one per generator
Operational speed range	0 – 6 knots
Fuel Type	Diesel
Fuel volume	1100 litres
Estimated endurance at 3 knots	55 days
Estimated endurance at 4 knots	34 days
Propulsion System Voltage	48V
Control System Voltage, Current	24V
Payload System Voltage, Power	24V or 48V, 1000W
Battery Type	8 x 115Ah 12V AGM lead acid providing 2 x 48v banks for propulsion and hotel load 2 x 44Ah Red top Optima starting batteries per generator

C-Worker 6 Design Overview – Vessel Design

General Arrangement



C-Worker 6 Design Overview – Vessel Design

Key Equipment

Lifting Beam

Fueling

Tie Down
Points (6)

Standard
Marine
Lighting

Payload Moon
Pool



C-Worker 6 Design Overview – Vessel Design

Iridium
IP Radio
AIS
(swing
mount)

VSat



HD Cameras
4-quadrant

Infrared
FLIR

Radar

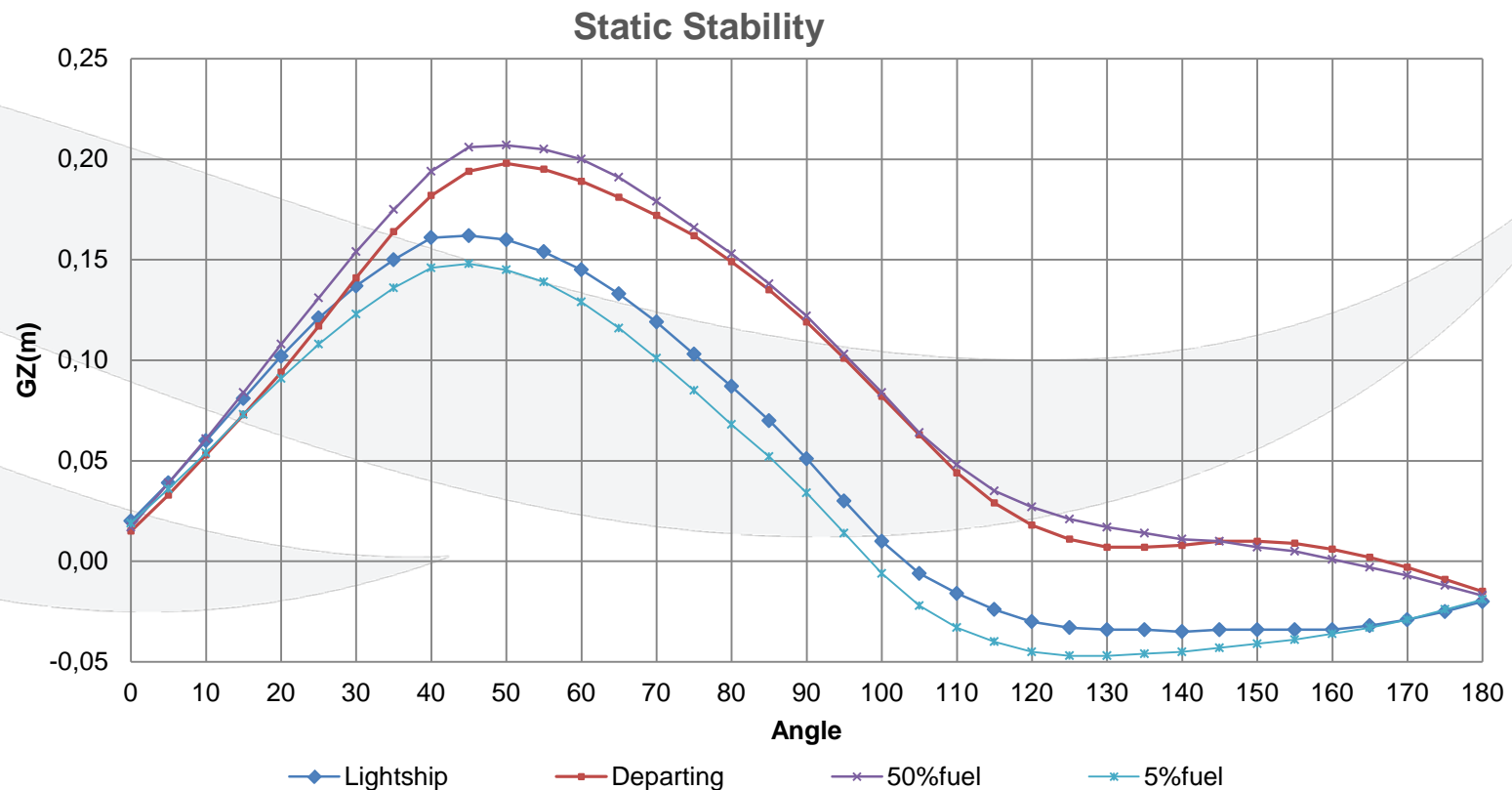
GPS Hdg.



C-Worker 6 Design Overview – Vessel Design

Intact Stability

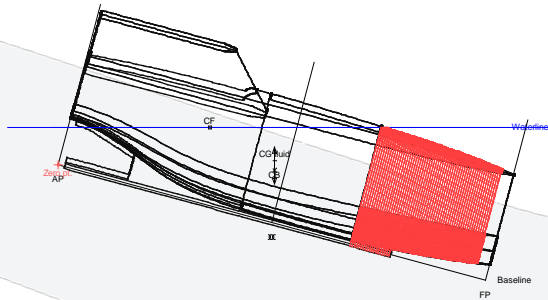
- Vessel features a self righting design
- Stability optimised to provide gentle motions
- Incline undertaken to measure real VCG position



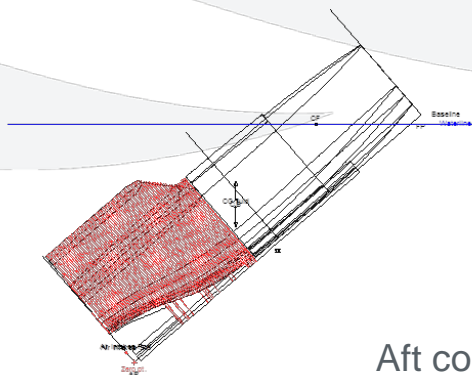
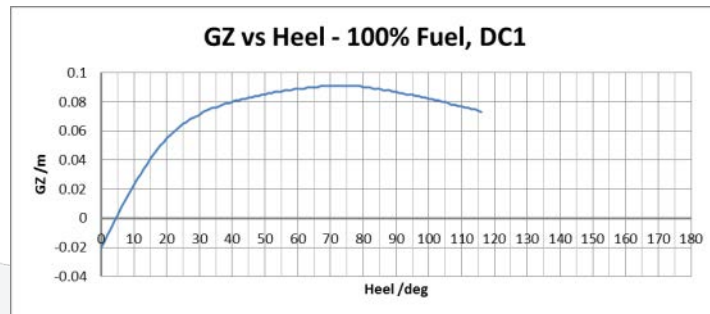
C-Worker 6 Design Overview – Vessel Design

Damaged Stability/Buoyancy

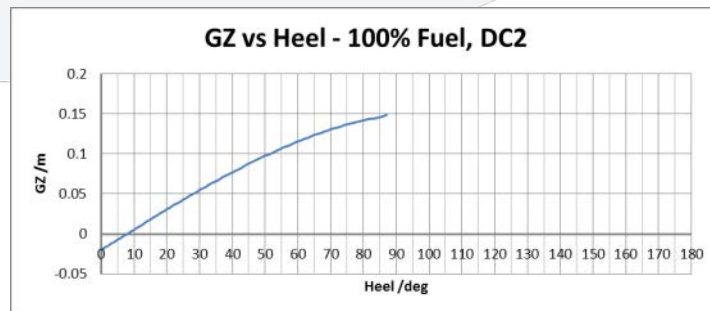
- Vessel can have any two compartments flooded and not sink at any fuel load
- Vessel remains upright with any single compartment flooded
- Two compartment flooding can result in vessel lying on side
- Vessel waterline very deep in some conditions
- Flooding to this extent will destroy all internal components



Forward compartment flooded, tanks full



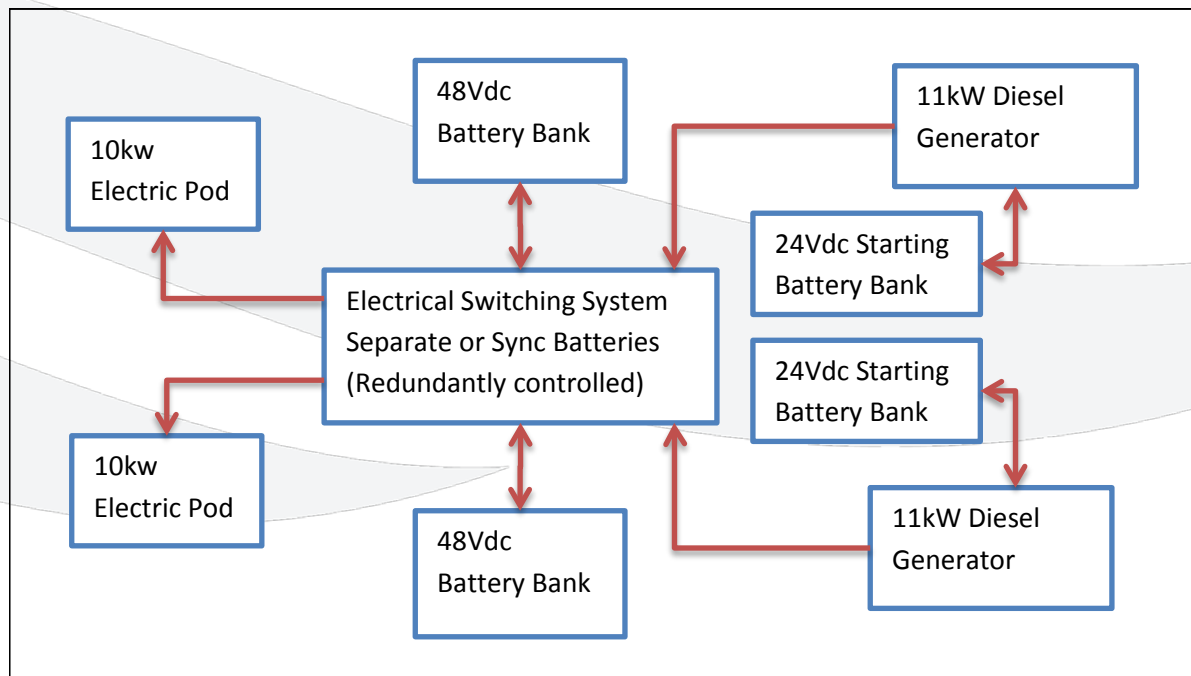
Aft compartment flooded, tanks full



C-Worker 6 Design Overview – Vessel Design

Propulsion

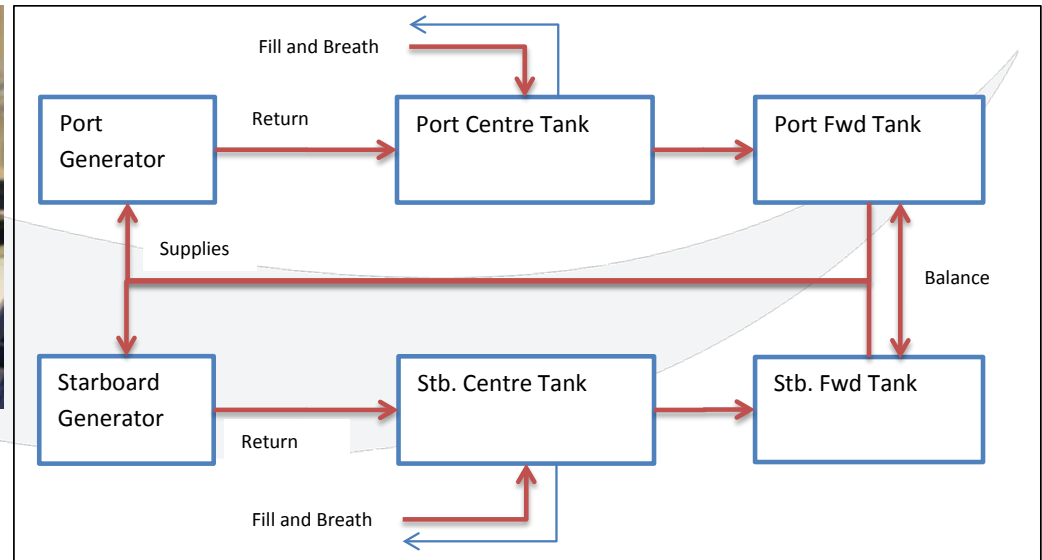
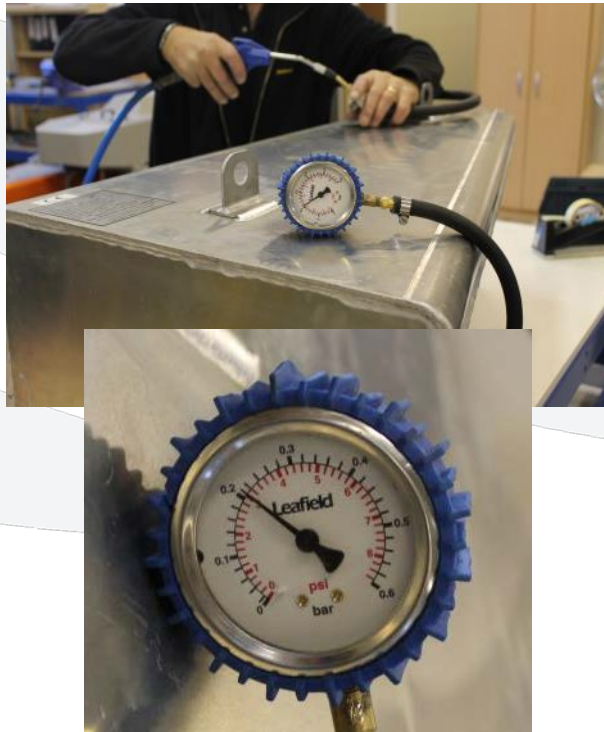
- Redundant power generation with two 11kW nominal generators
- Run one generator at a time for maximum endurance
- Run two generators for high power applications
- Redundant propulsion with two independently steered 10kW electric pods
- Prop guards to reduce chance of debris entanglement or risk to marine life



C-Worker 6 Design Overview – Vessel Design

Tanks

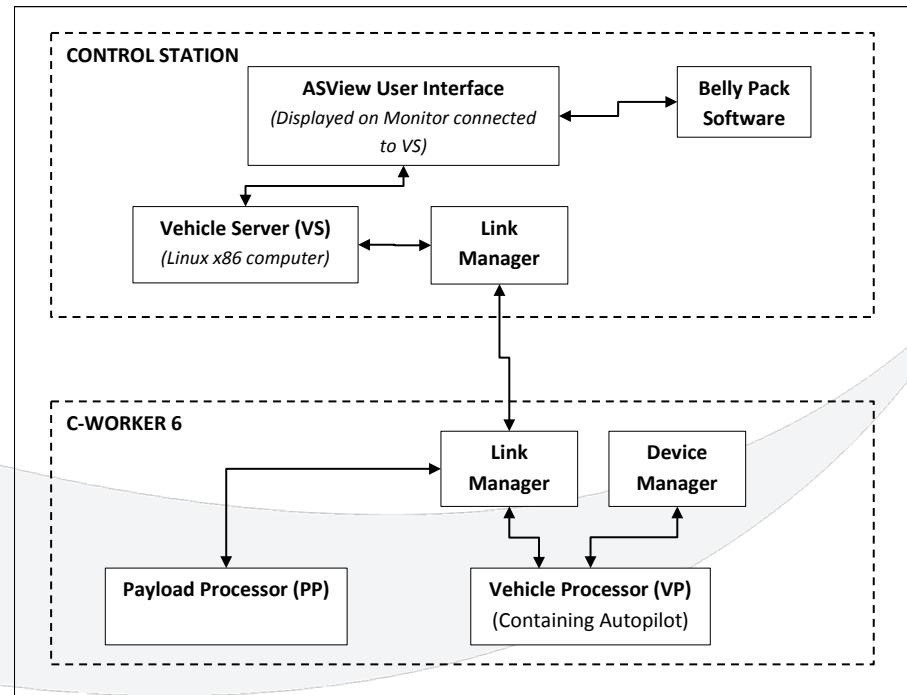
- Separate internal tanks providing double wall for environmental protection
- Fuel tanks have 1100 litre capacity
- Pressure tests undertaken on each tank and on entire system during assembly to ensure system is sealed
- System pressurised to 3psi and left for 24 hours to ensure integrity



C-Worker 6 Design Overview – Control System

Feature Overview

- User interface provides vessel control and feedback features
 - Direct manual control
 - Heading hold
 - Track hold
 - Orbit
 - Station keep
 - Line following
 - Missions formed of the above
- Provides detailed feedback of vessel systems
- Link manager can operate multiple links
- Device manager can interface with multiple devices on the USV
- Base station has a server, client architecture allowing multiple user interfaces to be connected for monitoring and control around the mother ship or control centre.
- Belly pack provides direct manual control when in close proximity to mother ship



C-Worker 6 Design Overview – Control System

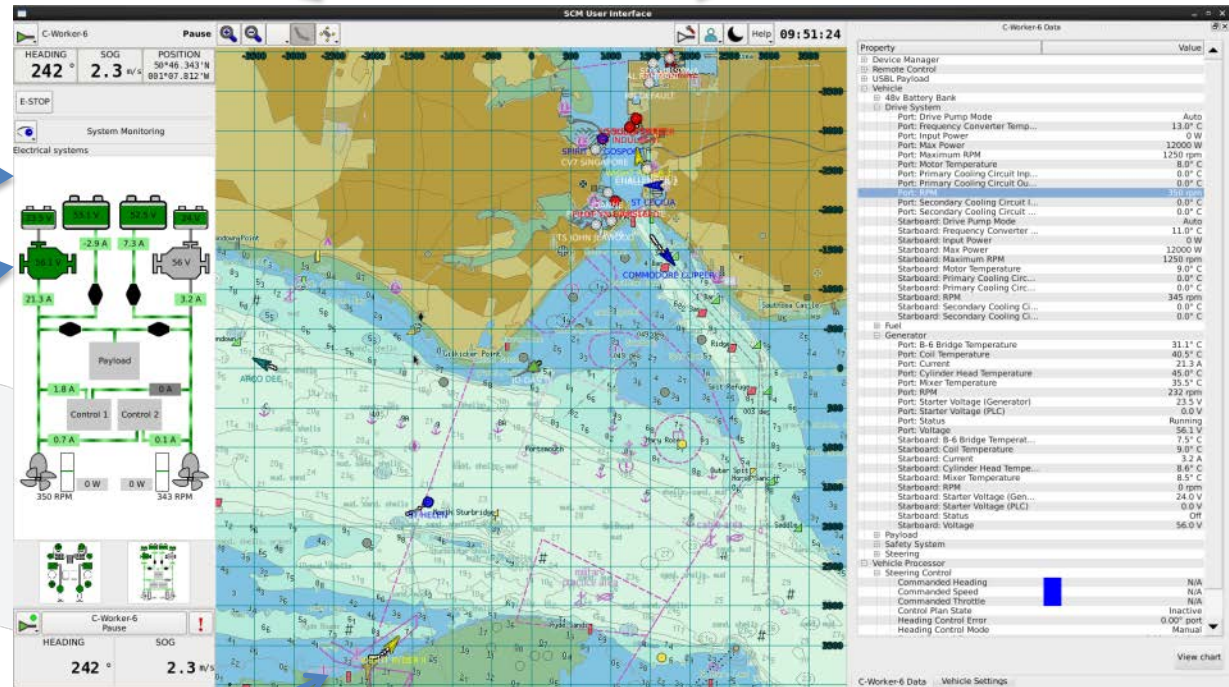
User Interface

View controls

Setup controls

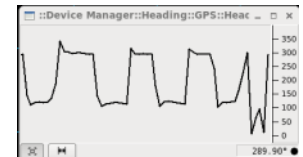
Key Data

Selectable Tabs



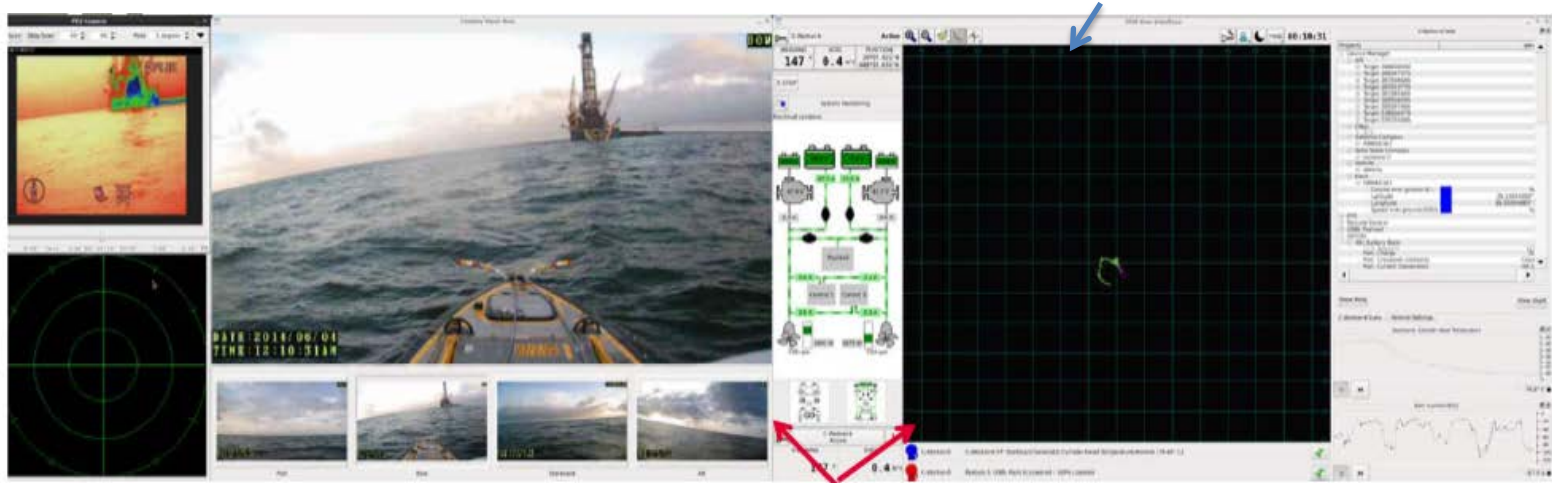
Top down displaying;
Full S57 ENC's
AIS targets from receiver on USV
Vessel track
Vessel mission plans

Data window
displays all vehicle
telemetry data. All
data can be
viewed in a trend
plot

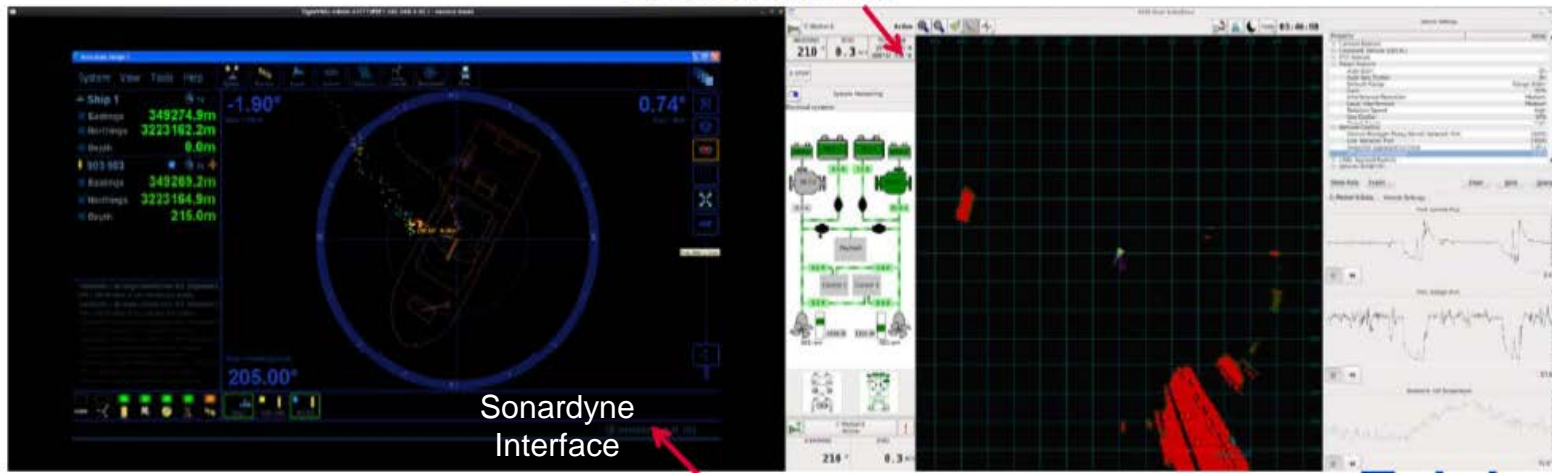


C-Worker 6 Design Overview – Control System

User Interface



ASVtd interface



Sonardyne Interface

C-Worker 6 Design Overview – Control System

Hardware

- All components in control system specified for high reliability within the environmental conditions expected on-board
- USV enclosures all have minimum IP65 environmental protection
- Solid state computers
- Belly pack provides manual control
 - Wireless upgrade in 2014
- Military or Industrial watertight connectors used on all internal connections. Sub-sea connectors on all external connections



Bellypack



Vehicle Processor Enclosure

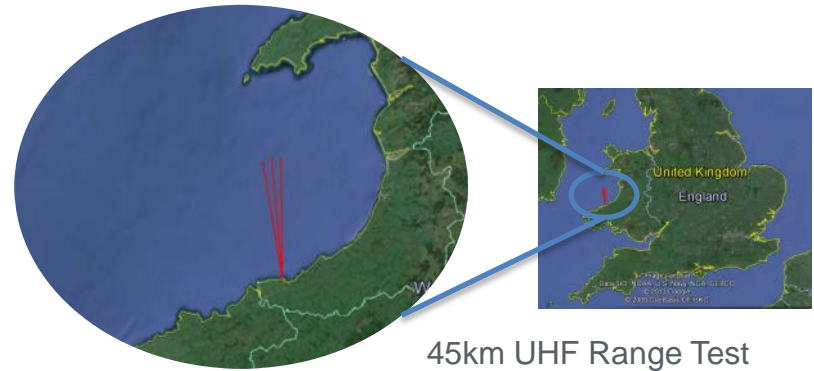


Example Shock Mounted
Vehicle Server Rack

C-Worker 6 Design Overview – Communications

Line of Sight Radio Comms

- UHF Serial Radio Modem (Tested to 45km+)
 - Low bandwidth, high reliability link for control data and basic vehicle telemetry
- L-Band Ethernet IP Data Link
 - High Bandwidth link for camera, radar and payload data (Tested to 7km, plan to test to 20km+).
- 3G/4G Cellular (where available)



Satellite Comms

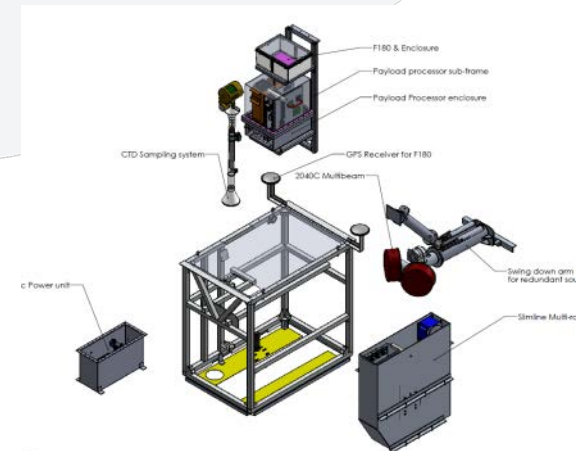
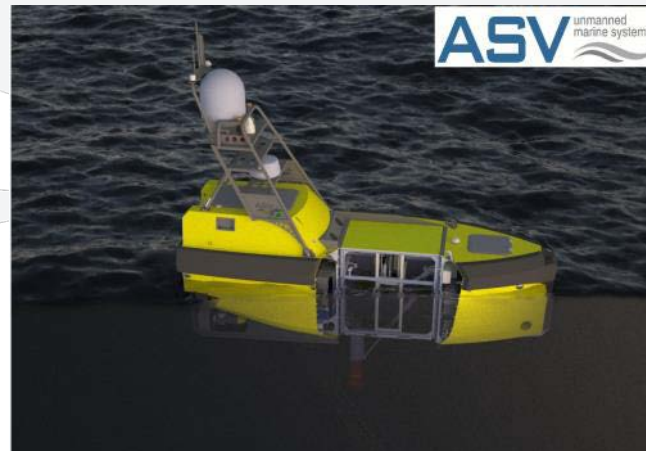
- Iridium Short Burst Data Modem
 - Worldwide coverage providing low bandwidth backup tracking and control link
- V-Sat High Bandwidth Link
 - Future upgrade planned for Q4 2014 to provide full control and feedback over the horizon.
 - Cost effective high bandwidth link
- Inmarsat High Bandwidth Link
 - Future upgrade for locations without V-Sat coverage
 - Data costs are limiting factor with this system

C-Worker 6 Payloads

Details

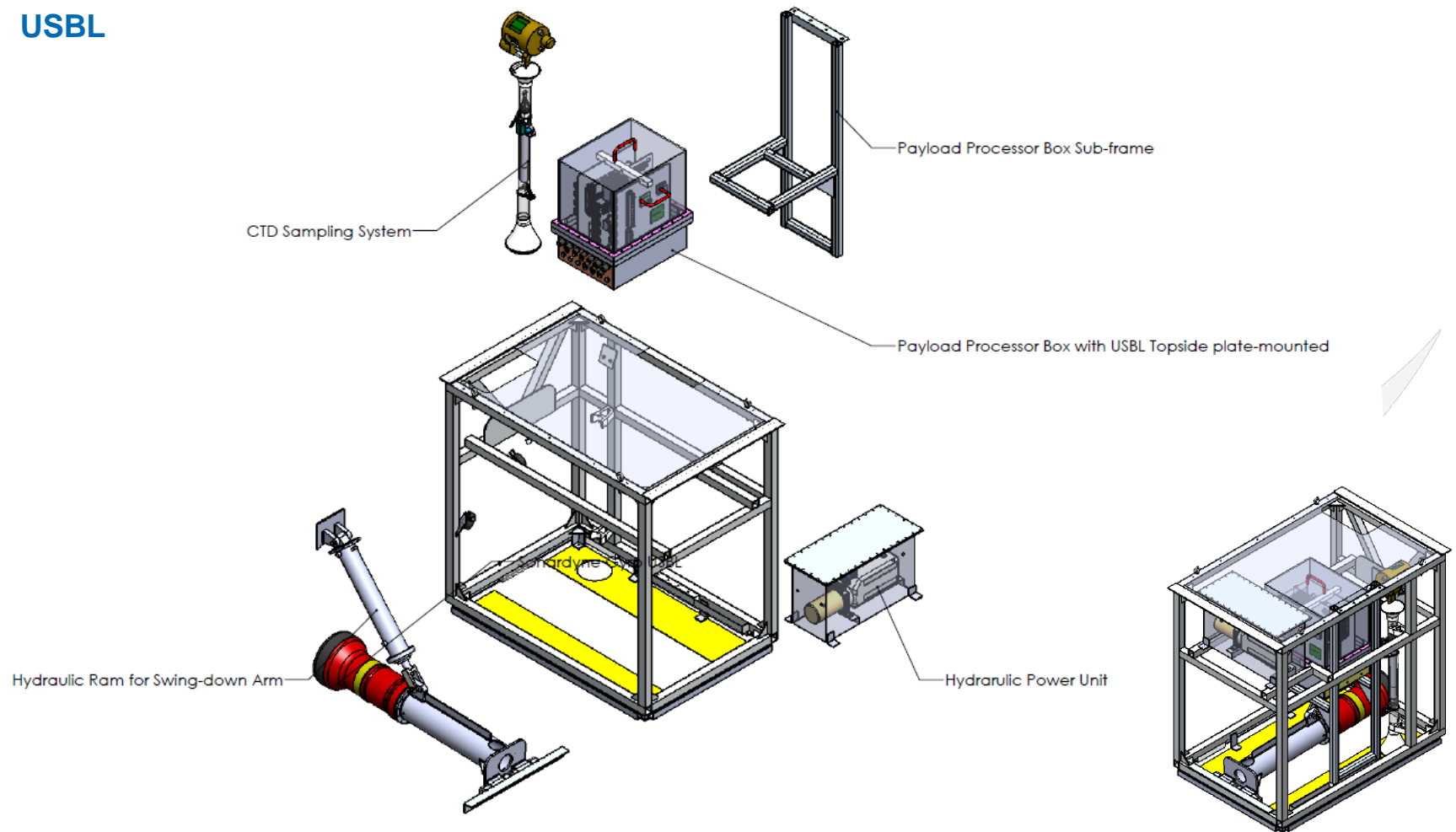
- Modular system allows rapid payload re-configuration
- Large capacity for a range of payloads and future upgrades
- Moon pool design
- Payloads can be shipped separately to vehicles if required

Characteristic	Specification / Value
Dimensions	1528mm Long by 1028mm wide by 1065mm high
Payload mass (maximum)	500kg (without restrictions on fuel capacity or self righting)
Payload – 1	USBL and CTD
Payload – 2	ADCP and CTD
Payload – 3	Multibeam Sonar System and CTD
Further payload options	PAM etc



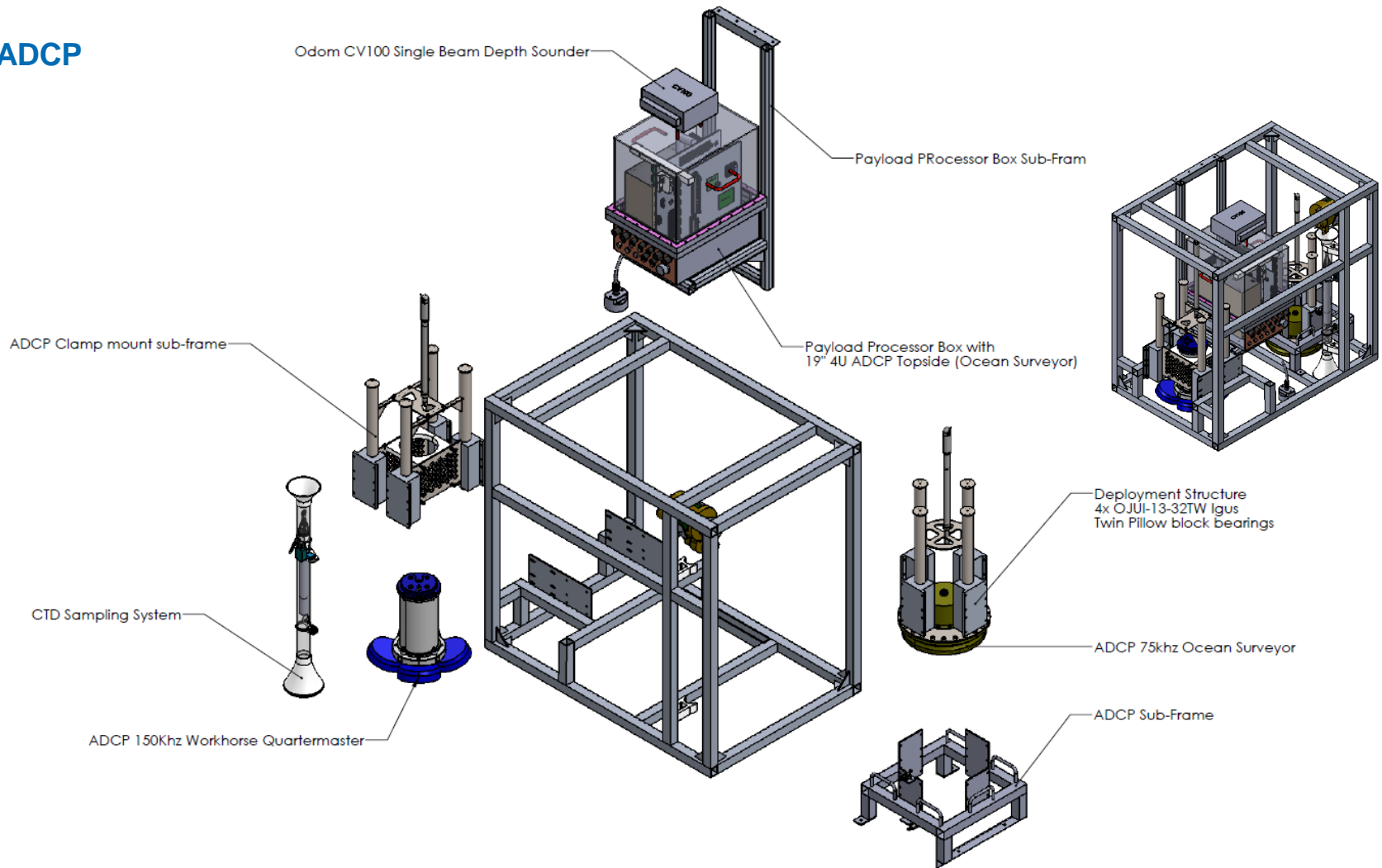
C-Worker 6 Payloads

USBL



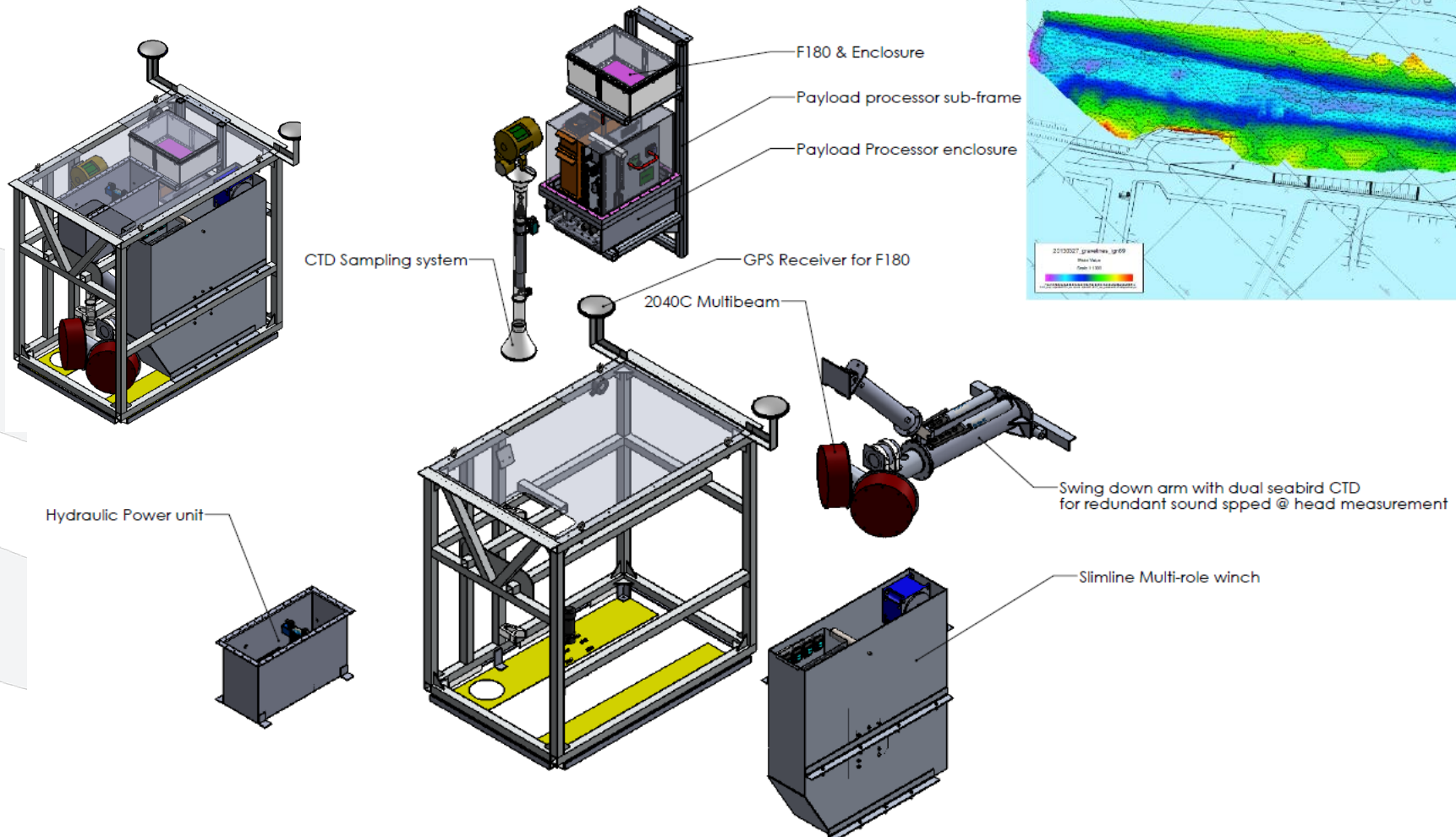
C-Worker 6 Payloads

ADCP



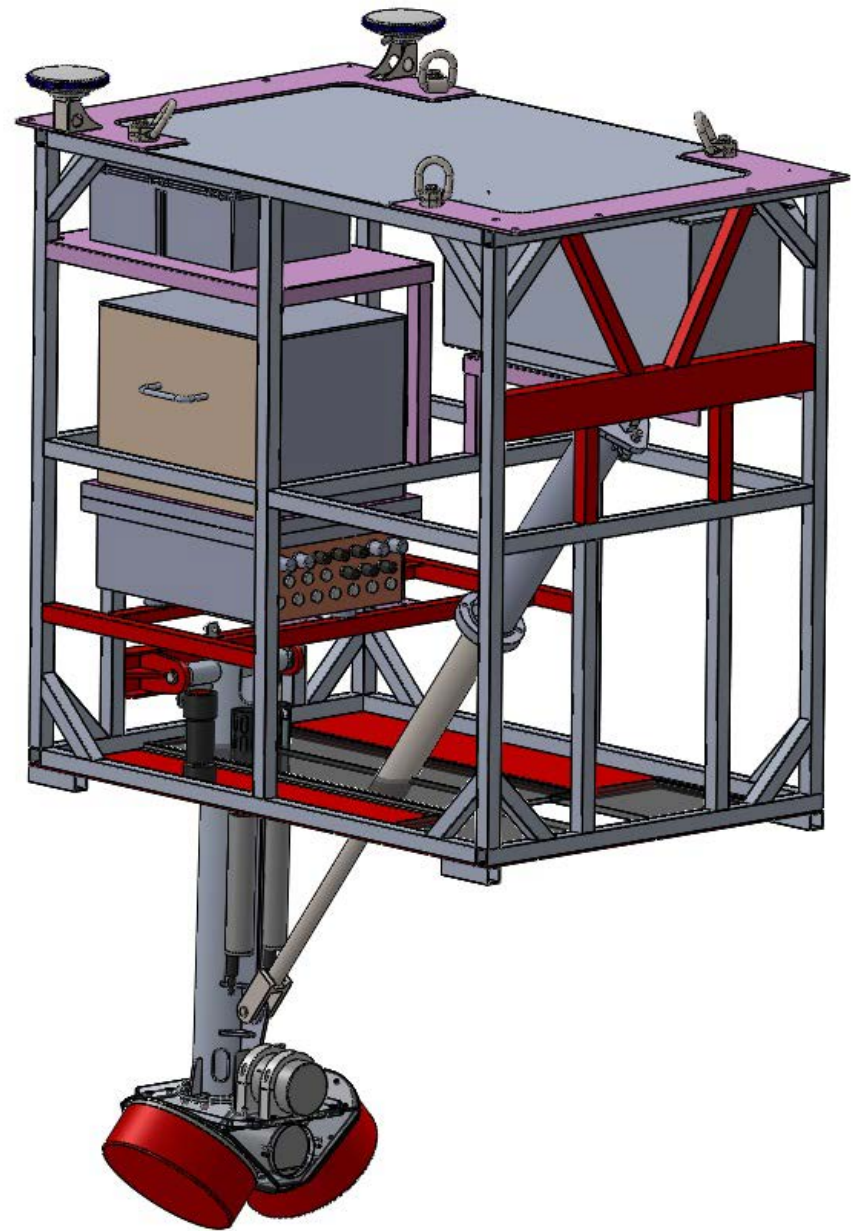
C-Worker 6 Payloads

Multibeam



C-Worker 6 Payloads

Multibeam



ROV Integration

Mine Countermeasures Vessel



C-Worker 6 LARS System - Launch

- Recovery system prepared on C-Worker
- Launch system attached to central lifting point
- Boat lifted and deposited alongside host vessel
- Off load remote release hook triggered, vessel released
- Standard operating procedure being developed



Swaged Stainless Lifting Bridle

Central lifting point
(5 Tonne SWL)



2-Step Remote Control with

Latching remote

5-Ton Capacity on both hooks for basket choker

C-Worker 6 LARS System - Recovery

- Crane lowers rod into sea
- Vessel is prepared, lowers top mast and stops generators
- Vessel is guided onto rod
- Rod elevator connects to rod
- Rod is lifted, shearing elevator from bow
- Vessel is lifted onto ships deck

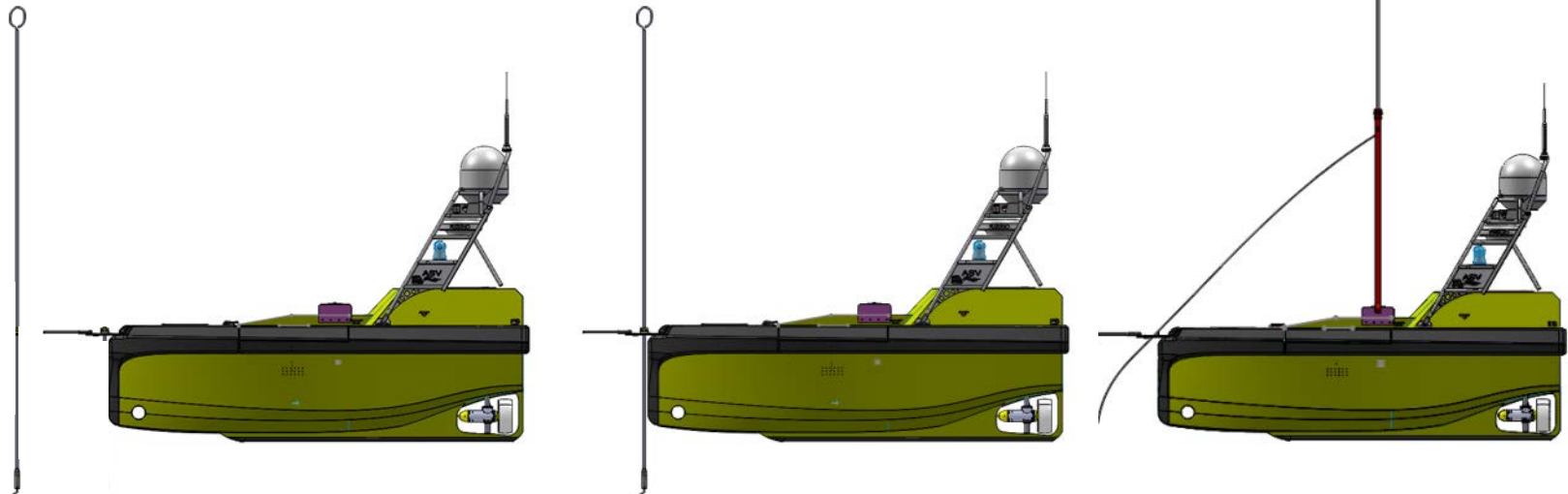


Lifting bridle (now stainless steel cable)

Rod elevator

Spring loaded 1-way latch

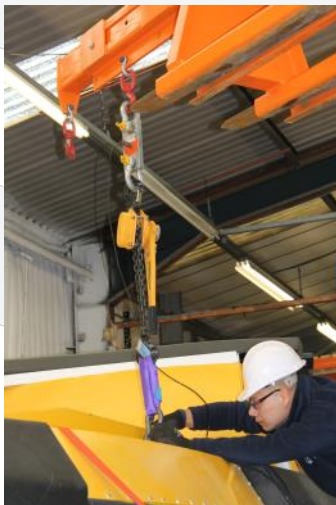
Guide whiskers



C-Worker 6 LARS System

Load testing and certification

- Load testing of all lifting components completed on first vessel
- Loads testing of USV undertaken to Lifting Operations and Lifting Equipment Regulations 2006 (LOLER) harmonised EU standard.
- Complete vessel certification pack to be provided to customers prior to any operations.



Lifting Rod

Shackles

USV

Rod Elevator

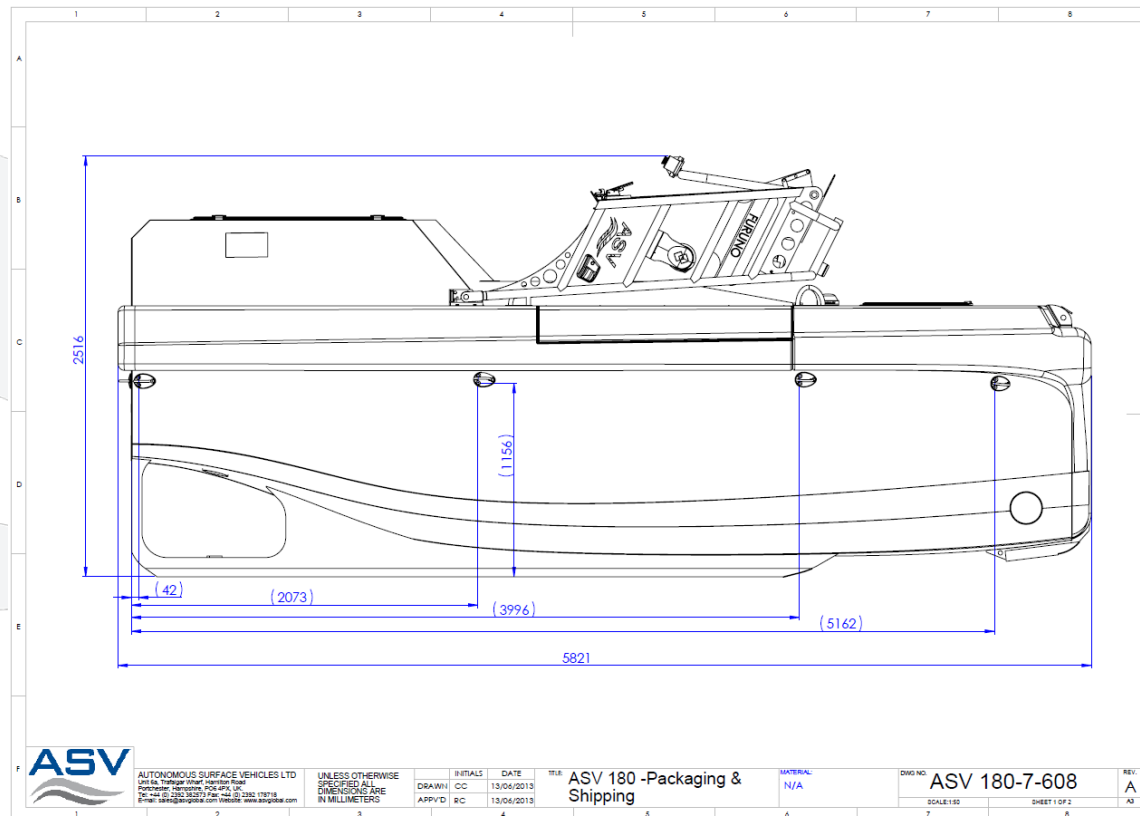
Lifting Beam

Lifting Straps

C-Worker 6 Storage and Operation – Sea Fastening

Sea Fastening

- 8 tie down points provided
- Tie down points to be tested to 2 x working load
- SWL ~400kg each
- Vessel to be stored on custom trailer or container



C-Worker 6 Storage and Operation - Trailer

Functionalities

- Transport the USV
- Store the USV on land and on deck
- Facilitate easier recovery from crane
- Provide a small crane for payload changes

Description

- Length: 8m
- Width: 2.6m
- Weight: 1545kg



Load tested to 14.5Tonnes in lifting configuration



Stabilisers on corners

Pad eyes

Small crane for servicing USV

Owner: UNIT TECHNOLOGIES					
ID: DELTA 72600					
Date: 12/20/13		Cert# IM 24016			
Tare / Empty Weight: 1500 lbs.					
Maximum Capacity: 1500 lbs.					
Maximum Weight: 1500 lbs.					
Tested To: 14500 lbs.		Lift Points			
Type of Test Performed: ULL LOAD					
NDT Performed:		Result			
VS = Visual					
Record of Inspection					
VS = Visual and NDT					
Date	Type	Inspector	Date	Type	Inspector
All test inspections performed by Certified Rigging and NDT Inspectors and conducted in accordance with all applicable standards in effect at time of service.					
DELTA RIGGING & TOOLS • www.deltarigging.com					

C-Worker 6 Storage and Operation - General

Equipment

- (lifting slings and spreader bar) provided by ASV

On shore storage

- The USV is secured on the trailer with cargo straps connected to the pad eyes

Lifting

- The USV is secured on the trailer with cargo straps connected to the pad eyes
- Strogs are placed around the USV & Trailer and lifted by the crane using a spreader bar

Storage on the vessel deck

- The USV is secured on the trailer with cargo straps connected to the pad eyes
- Sea fastening on the deck: block trailer on wood timbers
 - Secure with chain binders or turnbuckles from the heavy duty eyes on the sides of the trailer

A sunset scene over the ocean with a small boat visible on the right side.

Contact us at:

brian.anderson@asvglobal.com

+1-713-252-4680

View Videos at:

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