UNOLS LOAD HANDLING SYSTEM
FUNCTIONAL REQUIREMENTS
May 2005

General Description: The following information represents a set of Functional Requirements, for a general-purpose, over-the-side, scientific load handling system for use on research vessels in the UNOLS fleet. It attempts to standardize certain key features, while at the same time maintaining flexibility of design for different configurations and classes of vessel. These standardized features will add utility and operational flexibility (both short and long term) for the science party and Vessel Operator in support of a wide variety of science missions.

The system is composed of (1) a load handling apparatus, and (2) a highly instrumented and capable "smart" winch. Detailed requirements for each are vessel dependent. However, as stated above, certain elements are to be standardized as closely as possible. The apparatus has the most potential for variation and is divided into three types or arrangements. The are:

1. "Overheard Arrangement" – for use on larger vessels that have Baltic rooms or other substantial overhead structure (either on the side or aft) capable of supporting the apparatus. Generally, space and weight is not a restriction.
2. "Side Arrangement" – for use on all classes of vessel where slewing (rotation about the vertical axis) is not needed or is impractical due to limited deck space at a particular location or little variability in how the system will be used. This system also has the potential for the least complexity and weight.
3. "Aft Deck Arrangement" – For use on all classes of vessel where a large deck area needs to be covered – generally the aft deck. It is essentially an articulated crane design (which has been widely used for a variety of applications in the UNOLS fleet) with the standard design features added. This design gives the most utility, but is also the most complex with regard to operator inputs and system components.

Safe and effective deployment and recovery of science packages, without the use of tag lines or a significant number of personnel on deck, is the primary goal. Reduction of cable wear and motion-compensation are secondary goals.

These systems are intended to deploy and recover "moderately-sized" scientific packages over the side and stern. Such package include vertical profiling instruments such as CTD's, towed instrument such as "Scanfish"® and "Triaxis"®, and ROV's and AUV's. These systems are not intended to replace the stern A-frame.

I. Handling Apparatus

Geometries: [*Vessel Dependent*]

1. "Overhead Arrangement" – See Drawing C215-001
2. "Side Arrangement" – See Drawing C215-002
3. "Aft Deck Arrangement" – See Drawing C215-003

Design Standards: *ABS Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities* – 2002. Appendix 4 – "Certification of Handling Systems".

Dynamic Loading and Drag: Dynamic and drag loads shall be determined based on the design standards above.

Ultimate Design Load. Ultimate Design Load shall be considered to be the load which induces permanent deflection on any structural component of the system. This is considered to have occurred when the section reaches the **yield strength of the material used** (0.2% strain). The Ultimate Design Load shall be determined for each attachment point on the apparatus, and for each operating position ("Cast", "Recovery", and "Towing"), and provided to the Vessel Operator in both the operations manual and/or the structural drawings.

Deployment/Recovery Position: One position shall be specified by the Vessel Operator to be the DESIGN "Deployment/Recovery" position. The SWL at this position may differ from that of the maximum SWL in the "Cast/Mo-Comp Position" (see below) since minimal cable will be deployed during deployment and recovery near the surface. **Dimensional requirements for this position are vessel dependent and will be provided by the vessel Operator (See Detailed Vessel Requirements).** Because of the variety of boom positions on some of the arrangements, and the use of an extension boom, the ACTUAL deployment and recovery position will depend on environmental conditions and the specifics of the package being deployed.

Cast/Mo-Comp Position: A specific position shall be determined to be the "Cast/Mo-Comp" position for motion compensation purposes. This position should have one of the highest Safe Working Loads since the maximum amount of cable will be handled in this position. **Dimensional requirements for this position MAY be vessel dependent and will be provided by the vessel Operator as needed (See Detailed Vessel Requirements).** This position may also be dependent on the structural capabilities of the apparatus as determined by the Vendor.

Sensors shall be installed in the booms which indicate when the apparatus has been brought to the Cast/Mo-Comp position and is ready for a cast. A green "ready light" will illuminate when the apparatus is in position. While the boom is otherwise being manipulated, a yellow "caution" light will illuminate.

Towing Configuration: The lifting apparatus shall be capable of supporting towing operations by means of a forward stay connected on one end to the towing padeye on the boom tip (See Drawing #C215-006, Detail A) and to a small deck winch on the other. The deck winch may be

hydraulic, electric, or hand operated as specified by the Vessel Operator. The winch shall be fitted with both local and remote (main control console) tension monitoring so that the cable can be "pre-tensioned" to support the towing loads. The amount of pre-tensioning required shall be determined by the Vendor.

The "Tow Mode" option shall be enabled when towing operations are conducted with the forward stay attached (See "Smart Winch" Section). The design SWL for towing operations shall be per the table below and match one of the standard settings on the "Tow Mode" selector switch. The docking head shall be capable of supporting non-vertical wire angles encountered during towing options as described in the "Docking Head" Section.

Safe Working Load: Safe Working Load (SWL) is generally dependent on the class of vessel as shown in the table below. These SWL's are based on "normal anticipated operating load" which includes the wet weight of the wire, and the weight of the science package (wet or dry).

Minimum Safe Working Load Table - Apparatus (lbs)

	Vessel Class		
	"Regional"	*"Ocean"*	*"Global"*
Cast Position	6,700	11,100	12,700
Recovery Position	4,000	5,000	6,000
Towing Configuration*	5,000	6,000	7,000

*Note: "Towing Configuration" loads are the cable tensions at the maximum cable angle described in the Towing Configuration section of the Functional Requirements.

The SWL may differ at different points along the apparatus, or when the apparatus is in a different position or configuration, such as the "Towing Configuration". The Factors of Safety (FS) used shall be in accordance with the design standard listed above.

The appropriate SWL's shall be engraved on: (1) the control console in plain view of the operator, and (2) stenciled on the apparatus itself.

Weight: Weight of the apparatus shall kept to a minimum through design optimization while still meeting the design criteria above. Estimated weight budgets for the various classes of vessels and arrangements are shown in the table below. **However, actual weight budgets will depend on hull form and other vessel characteristics and will be provided by the Vessel Operator, and/or their naval architect (See Detailed Vessel Requirements).**

Approximate Weight Budget Table - Apparatus (lbs)

	Assumed Location	Vessel Class		
		"Regional"	*"Ocean"*	*"Global"*
Aft Deck Arrangement	Aft Deck	10,000	30,000	40,000
Side Arrangement	0-1 Deck	5,000	15,000	20,000
Overhead Arrangement	Top of 0-1 deck	5,000	15,000	20,000

The weight budget includes the weight of the apparatus plus all internal and external components necessary to make the apparatus fully operational per the Functional Requirements. This includes all structure, foundations, cylinders, sheaves, hydraulic power units, and local panels and controls. It does NOT include remote controls or the "Towing Configuration" deck winch.

Fairlead Sheaves (See drawing D215-005): The fairlead sheaves shall be grooved to the cable specified by the Vessel Operator. Unless otherwise specified, the minimum sheave tread diameter shall be 20" – primarily for economy of space and weight. If larger diameter cables than 0.400" are used, the tread diameter shall be 20" or **D = 400(dw)**, whichever is greater.

Where:

D = sheave tread diameter
dw = largest diameter of armor used in the cable

(Ref: Handbook of Oceanographic Winch, Wire, and Cable Technology, 3rd Edition)

The sheaves shall be made of a non-metallic material (composite, cast polyamide, or other) capable of withstanding the wire load imposed and the extreme conditions of an exposed marine environment. The material used shall be as wear resistant as possible. The finished surface of the groove shall be smooth with a surface roughness not exceeding 32 microns. The hardness of the groove when finished shall not exceed Rockwell (C-scale) 55.

A wide "V" groove shall be used for passing termination. The angle of arc over which the lower portion of the cable is supported shall not be between 135 and 150 degrees.

All portions of the cable path throughout the system shall be capable of easily passing a 4" diameter termination. All sheaves throughout the system shall have easily removable cheek plates and capture rollers to prevent the cable from jumping the sheaves when/if the cable goes slack. They shall also prevent the cable from jumping the sheave when the apparatus is in any position. Sheaves shall be attached to the apparatus by means of a bolting foundation so that they can be replaced with varying designs in the future.

Docking Head Adapter Plate and Auxiliary Padeyes: The docking head shall mate to the apparatus by means of a bolting flange welded to the tip of the outer boom (See Drawing C215-006, DETAIL A). The purpose of this bolting flange is to allow change out or complete removal of the docking head as science missions change. It also provides the location for the towing/auxiliary pad eyes.

The scantlings of the plate and number of bolts used shall meet the design standard given above. However, the number and size of bolts shall be kept to a minimum for ease of installation and removal.

Docking Head (See Drawing D215-006): The docking head shall come in three basic designs:

1. Vertical Cast Type – Used for extended profiles (CTD casts) and instrument deployments where the wire angle generally remains vertical. However, wire angles of up to 30

degrees from vertical (in all directions) may be present due to the effect of wind and current while the vessel is holding station. The vertical angle may be adjusted automatically via counter-balancing, or directly controlled by the operator using a joystick – whichever is deemed more practical and/or effective.

2. Towing Type – Used for towed instrument operations where the wire angle will routinely go from vertical (during deployment and recovery) to as much as 60 degrees from vertical – and as much as 45 degrees outboard while the vessel is turning. This type of docking head shall either use a fixed weight counter-balance, or hydraulic/pneumatic counterbalancing using cylinders to neutralize the weight of the sheave as the cable angle from vertical increases. It should NOT require input from the operator due to the variability of wire angles and the fact that the operator's station may not be occupied during extended towing operations.
3. AUV/ROV – Used for deployment and recovery of AUV's and ROV's. This type of docking head shall have the ability to slew (rotate) 360 degrees in order to position the ROV/AUV in a specific orientation on deck. The jib boom winch - fitted with a synthetic line and "Auto-Tension" capability – shall be used for deployment and recovery.

Consideration will be given to the use to a single docking head design as long as it can meet the requirements of all three operations above without becoming too large and/or complex. Consideration will also be given to a "quick release" design IN ADDITION to the standard bolting flange for change out of docking heads as long as it can meet the requirements of this section without becoming too large and/or complex

The apparatus shall be designed to use all three docking head types depending on operational needs by unbolting docking head from the adapter plate. If possible, the same docking head designs shall be able to be used on all three handling system arrangements ("aft deck", "side", and "overhead"). If not able to be identical in design, they shall be as nearly identical as possible.

The requirements below apply to all three types of docking head:

The docking heads shall hold the science package in place by means of cable tension only (See "Auto-Tension" in the **"Smart Winch" Section** below). **No physical locking mechanism shall be used**.

The docking heads shall have an integral sheave to transition the cable from boom, downward through the center of the docking head. The bottom face of the docking head shall be fitted with a standardized bolting ring appropriate for the class of the vessel. (See Detail B). This bolting ring shall be used to secure an Owner-Furnished "bumper", the design of which shall be dependent on the science package deployed. This bumper may range from a simple synthetic (Delrin or Teflon) ring, a rubber bumper, or a "saddle". The bottom face of the bolting ring shall be at least 12" from the bottom of the integral sheave when the shock absorbers are fully compressed to allow space for the cable termination.

The docking head shall be fitted with at least four shock absorbers which compress when the package is snubbed up tight using the "Auto-Tension" function. The shock absorbers shall be

approximately eight (8) to ten (10) inches long, and have a spring coefficient such that when using "Auto Tension", they compress approximately 50% (4-5") so that proper operations is clearly visible to the operator.

The docking heads shall be able to rotate ***a minimum*** of 45 degrees about the vertical access regardless of the position of the boom. This is primarily to allow relief of side stresses on the handling system in the event the package is struck by seas when snubbed into the docking head. The rotational resistance function of the docking head shall be "enabled" and "disabled" by the operator, and the amount of resistance adjustable by the operator at the remote control station. "Zero" resistance shall allow virtually free swing of the docking head in all directions. "Full" resistance shall virtually lock the docking head in its current location. The resistance function shall be enabled once the package has cleared the water, and the amount of resistance adjusted by the operator depending on sea conditions once the amount of swing is observed.

Shock Absorber: The apparatus shall be fitted with a shock absorber to reduce impact loading on the apparatus and the winch due to cable snap. Depending on the geometry of the apparatus, two systems may be used:

1. A shock absorber integral to the docking head
2. An inert gas over hydraulic shock absorber located at ONE position along the apparatus – either the inner boom, outer boom, or extension boom.

Though this shock absorber MAY aid with motion compensation, PRIMARY motion compensation shall be accomplished using winch pay-in/pay-out. All apparatus arrangements shall be fitted with a shock absorbers, as full motion compensation may no be desired by the Vessel Operator.

It may be advantageous to have the capability to "enable" and "disable" the shock absorber from an operational or maintenance standpoint. The Vendor should advise if this is the case during final design.

Auxiliary Winch Foundation: The side of the outer boom shall be fitted with a foundation for fitting of an auxiliary hoist having the same Safe Working Load as the lifting apparatus itself in the fully extended, or "Cast" position. This auxiliary hoist may be used by the operator for ROV, AUV, and/or cargo operations in lieu of the "Smart Winch" cable.

Slewing Range: For the "Aft Deck Arrangement", the slewing range for the lifting apparatus shall be at least 270 degrees, but a full range of 360 degrees is desirable.

Hydraulic Power: Hydraulic power may be either from a dedicated internal HPU, or from an external ship's service hydraulic power source depending on the vessel. **The Vessel Operator shall provide details regarding existing hydraulic system and/or requirements (See Detailed Vessel Requirements).**

Hose and Cable Supports: The inner and outer booms of the apparatus shall be fitted with hose and cable support brackets. One side shall be used (if possible) for cables and hoses installed by

the Vendor as needed for operation of the system. The other side shall be kept clear for Owner-installed scientific cables and hoses.

Stowage of the Apparatus: The "Side" and "Overhead" arrangements are self-stowing. If specific stowage requirement are required for the "Aft Deck" arrangement, they shall be specified by the Vessel Operator and the details worked out during final design.

II. - "Smart" Winch

Electric vs. Hydraulic: The winch may be either electrically or hydraulically driven as long as it meets the other system requirements described below. Ideally, the winch would be completely self-contained and not dependent on external vessel services other than input electrical power. However, hydraulic power and/or external cooling services may be needed from other vessel systems depending on the application and the winch design.

The Vessel Operator shall provide information on what external services are available and/or what internal capabilities the winch will have to have **(See Detailed Vessel Requirements).**

Direct Pull vs. Traction: The winch may be either direct pull or traction depending on the cable type, length, and desires of the Vessel Operator as long as it meets the other system requirements described below. Arrangement of the vessel and the allowable weight budget may also dictate whether or not the unit needs to be direct pull or traction.

The Vessel Operator shall specify whether or not a traction winch or direct pull winch is desirable **(See Detailed Vessel Requirements).**

Design Criteria: *ABS Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities* – 2002. Appendix 4 – "Certification of Handling Systems".

Dynamic and Drag Loading: Dynamic and drag loads shall be determined based on the design standards above.

Ultimate Design Load. Ultimate Design Load shall be considered to be the load which induces permanent deflection on any structural component of the winch. This is considered to have occurred when the section reaches the **yield strength of the material used** (0.2% strain). The Ultimate Design Load shall be determined and provided to the Vessel Operator in both the operations manual and/or the structural drawings.

Weight: Weight of the winch shall kept to a minimum through design optimization while still meeting the design criteria above. Estimated weight budgets for the various classes of vessels and winch types are shown in the table below. **However, actual weight budgets will depend on hull form and other vessel characteristics and will be provided by the Vessel Operator, and/or their naval architect (See Detailed Vessel Requirements).**

Approximate Weight Budget Table - Winch (lbs)

	Assumed Location	Vessel Class		
		"Regional"	*"Ocean"*	*"Global"*
Medium Duty "Hydrographic" Winch (CTD's & Towed Instruments)	0-1 or 0-2 deck			
	Winch	6,000	9,000	10,000
	Wire	5,100	9,800	10,600
	Total	11,100	18,800	20,600

Wire Capacity: Wire capacity is dependent on the purpose of the system, the vessel's routine operating area, and the class/size of the vessel. Generally speaking, the guidelines shown in the table in Appendix 1 shall apply.

However, space and weight budgets may also impact the maximum achievable cable length, which will have an impact on needed line pulls and SWL. This should be addressed during the RFP process, and details worked out during final design.

Safe Working Load and Line Pull: Safe Working Load (SWL) is generally dependent on the class of vessel as shown in the table below. SWL is based on "normal anticipated operating loads" which includes the wet weight of the wire and the wet weight of the science package at bare drum.

Minimum Safe Working Load and Line Pulls - Winch (lbs)

	Vessel Class		
	"Regional"	*"Ocean"*	*"Global"*
Line Pull - Full Drum	4,000	5,000	6,000
Line Pull - Bare Drum	6,700	11,100	12,700
Safe Working Load (SWL)	6,700	11,100	12,700

The Factors of Safety (FS) used shall be in accordance with the design standard listed above.

The SWL shall be clearly stenciled on the winch itself.

Science Payload: Scientific payload is generally dependent on the class of vessel. Predictions of the maximum anticipated payloads in the future are shown in Appendix 1.

Wire Speed: Winch pay-in and pay-out speed with the winch supporting a load equal to the maximum SWL shall be at least 1.5m/sec (90m/min) at mid-drum.

Wire/Cable Type: Cable types vary widely depending on operational needs and can change based on short-term operational needs, as well as evolve over the long-term. The table shown in Appendix 1 assumes that cable size will increase over the 0.322 conductor cable currently in use, and winch and apparatus SWL's and line pulls have been increased accordingly.

Cable type used at the time of production shall be specified by the Vessel Operator **(See Detailed Vessel Requirements).**

Interchangeable drums and LEBUS shell: The winch shall have an interchangeable drum and a bolted LEBUS shells so that cable/wire can be changed out as the science mission change in the short term (between cruises), or evolve in the long term (year-to-year).

Slip Ring: The drum shall be fitted with a generic foundation for the adaptation of a slip ring (Meridian Laboratory brand mercury sliprings model MXO-4/01 for .322 and .680 wires)

Termination of Cable Bitter End at the Drum: The termination of the cable shall be a lightly clamped connection in concert with "Tow Mode" such that bitter end will pull free in the event all of the cable is taken from the drum.

Levelwind: The winch shall be fitted with an electro-hydraulic levelwind system that can automatically adjust to the cable diameter without having to change any mechanical component when the drums are changed out.

Position of the Winch Relative to the Apparatus: The position of the winch relative to the apparatus is highly dependent on the arrangement of the vessel. The Vessel Operator shall provide required details of placement, and location of any obstructions, during final design. However, the winch should remain in close proximity to the apparatus – preferably immediately adjacent to prevent long cable runs. **Complicated cable paths passing across deck or between multiple decks and compartments should be avoided**. If the winch is in a separate compartment or on a separate deck – it should be a deck or compartment IMMEDIATELY ADJACENT to the apparatus.

Wire Monitoring: The wire monitoring system shall be a stand-alone system separate from other control and monitoring (Measurement Technology Northwest, www.mtnw-usa.com, or equal). The wire monitoring system shall provide wire information to both the operator (visual) and the other control systems (digital), and shall be able to feed into a wire data logging system as desired. All wire monitoring sensors shall be on one or more of the sheaves on the winch – NOT the handling apparatus.

The wire monitoring system shall have the following capabilities as a minimum:

1. Wire out (feet and meters) to a sub-meter accuracy of at least 0.1 m
2. Wire speed (m/s and ft/sec)
3. Wire Tension (pounds and Newtons)

The following alarms shall be able to be set by the operator at any time during the cast:

1. Wire length out (either ascending or descending)
2. Wire speed (either ascending or descending)
3. Cable strain

The following alarms shall operate automatically:

1. "Yellow" warning alarm will sound (both visual and audible) when cable strain exceeds 75% of the SWL of either the lifting apparatus or the winch.

2. "Red" alarm to sound (both visual and audible) when the cable strain exceeds 90% of the SWL of either the lifting apparatus or the winch.

"Auto-Tension": Auto-Tension is intended to be used ONLY during deployment and recovery to hold the package firmly against the docking head. It shall always be disabled during the cast by the operator. Once "disabled", this feature should not actually release the package until the operator actuates the winch pay-out control.

The Auto-Tension mode shall put a constant "over-tension" on the cable (above the weight of the science package itself) to hold the package firmly against the docking head. The amount of over tension shall be designed in concert with the shock absorbers on the docking head. The amount of over tension shall be adjustable by the operator and enough to compress the docking head shock absorbers from 25-75% of their full range). The cable monitoring system shall provide the auto-tension system with instantaneous cable tension developed.

"Motion Compensation": **Motion compensation is NOT required and may be specified as an option by the Vessel Operator (See Detailed Vessel Requirements).**

If desired, motion compensation shall be an "active" system using a combination of winch pay-in/pay-out and a Motion Reference Unit (MRU) located on the handling system boom (See arrangement drawings)**.** The MRU shall be capable of providing the required accuracy needed to meet the motion compensation Primary Goal below. It shall be capable of withstanding heavy vibration and full exposure to the marine environment – including high wind, temperature extremes, and all forms of precipitation – and require a minimum of maintenance and calibration.

The maximum vessel motions and accelerations to be compensated for, taken at the deck edge near where the apparatus is to be located, shall be provided by the Vessel Operator during final design. The eventual "Cast" position may be driven by these factors, in conjunction with the required overall Safe Working Load.

Primary Goal: *To remove 90% of the vertical motion of the science package in the water column that is induced by vessel motion (heave, roll, and pitch) at the location of the handling system while the winch is in the stopped position – either near the surface or at depth.*

Secondary Goal: *To help reduce cable strain and wear as much as possible. In no case shall it increase wire strain or wear.*

"Tow Mode": The winch shall be fitted with a precise, calibrated "Tow Mode" which will allow the pay out of cable under tension (either by friction brake or hydraulically) to keep cable tension below a particular desired Safe Working Load. This mode shall be used primarily when towing, and shall be capable of working at vessel speeds up to 12 knots.

The Tow Mode shall be enabled and disabled by the operator when desired. The winch shall be fully operational when the tow mode is enabled. An indicator light shall illuminate to clearly indicate when this mode is enabled. The slip load shall be adjustable by the operator in either pre-set load increments, or as percentages of SWL of the winch, to account for any variation in the SWL of any tow point or component. In no case shall the Tow Mode be able to be adjusted above the maximum SWL of the apparatus.

The Vessel Operator shall have a test and calibration procedure in place to ensure the "Tow-Mode" remains within design requirements.

Hydraulic Cable Cutter: The winch shall MAY be fitted with a hydraulic cable cutter (WebTool brand, WCO Series, www.webtool-subsea.com, or equal) activated from the operator's station as desired by the Vessel Operator depending on application **(See Detailed Vessel Requirements).** If desired, the cable cutter system shall have at least a three (3) step activation procedure to prevent unintentional cutting of the cable such as:

1. Lift protective cover
2. Turn switch to energize cutter.
3. Push button to activate cutter.

When to actually use of this system shall be determined by the vessel's internal policies and procedures.

III. Control and Panel Details:

See Drawing C215-004 for general panel layout and control details. Controls for operating all functions of the handling system (both apparatus and winch) shall be manual (i.e. switches, knobs, handles, indicator lights, etc.) – "Touch Screens" are NOT desirable. However, touch screens MAY be used for the alarm and cable monitoring panels.

A "Hold" button shall be installed on the winch pay-in/out control for long casts. It shall be located above the winch control handle, be solenoid controlled, and automatically disengage when within a pre-set depth from the surface. A "yellow" indicator light shall illuminate when then "Hold" button is engaged.

Local and Remote Control Locations: Local and remote control locations are vessel dependent and shall be specified by the Vessel Operator. However, at least one (1) basic set of local controls at the winch or base of the apparatus, and one (1) complete set of remote controls (i.e. at a winch control station) are desirable for system redundancy.

IV. Other Requirements:

Workmanship and Materials: The workmanship, components, and materials used shall be of a quality conforming to "first-class marine practice" for use on a vessel in ocean service. By "first-class marine practice" it is meant to a standard or level which leads to: 1) long service life, 2) lower maintenance cost, 3) ease of operation by shipboard personnel, 4) increased reliability in service, 5) availability of spare parts and or service from the manufacturer.

All materials and components used shall be new, free of defects, and suitable for the marine environment. All fasteners shall be 316 stainless steel. All hydraulic tubing shall be stainless steel and all hydraulic fittings which require routine maintenance (hose ends, threaded fittings, etc.) shall either be stainless steel or covered in a marine-grade wrapping system to prevent corrosion. All hydraulic cylinder rods shall be stainless steel as opposed to chrome plated. All bearings, bushing, and rotating elements shall have grease fittings and be properly grooved for the routine application of lubricant.

All controls, indicators (light, gauges, dials), outlets, and connectors located on deck, or below decks in non-conditioned spaces, shall be properly rated for full outdoor marine use.

Construction/welding: Construction and welding shall be in accordance with the standards of the American Bureau of Shipping (ABS) per the design standards given above.

Coatings: The apparatus and winch shall be coated with an epoxy-based, marine-grade coating system. The coating system shall be applied per the coating manufacturer's recommendations.

The top coat color shall be specified by the Vessel Operator during final design.

Factory Acceptance Tests and Inspections: Factory Acceptance Tests (FAT) shall be performed by the Vendor to ensure compliance with the Functional Requirements, drawings, and Specific Vessel Requirements before the system is accepted by the Vessel Operator. The FAT shall be witnessed by the ABS surveyor attending according to the design standard given above. The Vessel Operator shall reserve the right to attend the FAT, or visit the Vendor's facility for routine inspections of progress at any time during production.

Manuals: Three (3) bound copies of the Operations and Maintenance manuals shall be provided to each Vessel Operator.

Environmental Conditions: Unless otherwise specified by the Vessel Operator, the Design Service Temperature shall be between 14˚F (-10˚C) and 110˚F.

TYPICAL DEPLOYMENT AND RECOVERY SEQUENCES
(All classes of vessel)

Deployment (See Drawing C215-004 as reference for control details):

1. Load Handling System in inboard/stowed position with package on deck – no tension on cable. Hydraulics and winch "ON". Vessel on most comfortable heading for sea conditions. Docking head positioned closely above the science package.
2. Winch pay in manually by operator until package clear of the deck and docking head shock absorbers compressed ~25% (~500 pounds over tension).
3. Enable "Auto Tension". Operator allows winch control to go to "neutral" position.
4. Enable "Friction Function" and adjust friction control to eliminate swing.
5. Maneuver apparatus over side depending on arrangement
   For "Aft Deck" arrangement:
   a. "Boom Up" (inner and outer) as needed to clear rail or obstacles on deck.
   b. "Slew (Left or Right)" over side.
   c. "Boom down" as needed.
   For "Overhead Arrangement":
   a. "Boom Up" to horizontal position.
   b. "Extend" inner boom out
   c. "Boom down" to approximately 45 degrees. *Exact amount will depend on vessel characteristics and system geometry.*
   For "Side Arrangement":
   a. "Boom Out"

6. "Extend" outer boom until package is NEAR the water surface, but not in it. Amount will depend on sea state and vessel motions (judgment call by system operator).
7. Disable "Friction Function" to allow free swing of docking head.
8. Disable "Auto Tension". ("Auto Tension" will not release until operator moves control handle out of neutral position).
9. Pay out winch until package is well below the surface. Amount will depend on geometry of system and wire length needed to bring handling system to the "Cast" position without the package breaking the surface.
10. Bring handling system up and in to "Cast" Position. Green "OK" light will illuminate.
11. Pay in on winch until package at desired starting depth depending on sea state and science/technical staff request.
12. Pay out on winch – begin cast.
13. Enable "Motion Compensation" as desired. *Winch will motion compensate at each sample depth only when winch control handle goes to neutral position. Com-Comp function will begin after and appropriate delay.*
14. End of cast. Disable Mo-Comp system. Begin haul back (pay in).
15. Bring package near surface. Depth depending on sea state and science/technical staff requirements.

Recovery:

1. Package at or near surface.
2. Boom down and extend outer boom as needed to position docking head as near to surface and the package as possible – but NOT in it the sea/waves. *Proximity to surface will depend on sea state and vessel motion (judgment call by operator). In heavier sea states this height should be approximately one and a half (1.5) package heights above the surface. If package is struck by sea while near surface, docking head will pivot to relieve side loading.*
3. Pay-in winch manually by operator until package clear of the water and docking head shock absorbers compressed ~25%-50%.
4. Enable "Auto Tension". Operator allows winch control to go to "neutral" position.
5. Enable "Friction Control" and adjust to check swing of package as necessary.
6. Retract outer boom.
7. "Boom Up" as needed to clear rail or obstacles on deck (depending on arrangement of apparatus).
8. "Slew (Left or Right)" over side and onto deck (depending on arrangement of apparatus).
9. "Boom down" as needed until package is several inches off the deck (depending on arrangement of apparatus).
10. Disable "Auto-Tension". *("Auto Tension" will not release until operator moves control handle out of neutral position).*
11. Pay out on winch to set package on deck and place handling system in stowed position as needed.

When Towing (Side-mounted Arrangements):

1. Before outer boom clears side, rig forward stay on boom tip leaving ample slack on stay deck winch for free operation of apparatus.
2. Follow package deployment steps above.
3. When boom brought back to "Cast" position, remove slack from forward stay by taking in on winch until required pre-tension load is achieved.
4. Adjust setting on "Tow Mode" to match SWL of apparatus in the towing configuration. *For aft facing systems where the forward stay is not needed/used, it may be advantageous to adjust the alignment of the apparatus to closely match the anticipate wire angle to achieve the highest SWL.*

Appendix 1

	Vessel Class		
	"Regional"	***"Ocean"***	***"Global"***
Current Cable Size	0.322	0.322	0.322
Weight in Air (lbs/km)	574	574	574
Weight in Water (lbs/km)	472	472	472
Projected Cable Size	*0.375*	*0.400*	*0.425*
Projected Weight in Air (lbs/km)	*851*	*985*	*1058*
Projected Weight in Water (lbs/km)	*700*	*810*	*870*
Wire Length (m)	6,000	10,000	10,000
Total Weight of Wire in Air (lbs)	5,108	9,850	10,580
Total Weight of Wire in Water (lbs)	4,200	8,100	8,700
Projected Weight of Science Package in Air (lbs)	*4,000*	*5,000*	*6,000*
Projected Weight of Science Package in Water (lbs)	*2,500*	*3,000*	*4,000*
Line Pull of Winch at Full Drum (lbs)	4,000	5,000	6,000
Line Pull of Winch at Bare Drum (lbs)	6,700	11,100	12,700
SWL of Winch	6,700	11,100	12,700
SWL of Apparatus in "Cast" Position	6,700	11,100	12,700
Minimum SWL of Apparatus in "Recovery" Position	4,000	5,000	6,000