UNOLS Load Handling System
Functional Requirements
Rev: July 2008

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 are less of 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.

The primary goals of these new systems are:

1. Safe and effective deployment and recovery of science packages without the use of tag lines or personnel on deck,
2. Reduction of peak tensions and potential damage to cables,
3. Enhanced utility to science and ship operators.

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: *UNOLS Research Vessel Safety Standards, Appendix B, UNOLS Load Handling System Design Standards, 2008.*

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 SWL 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" shall illuminate when the apparatus is in position. While the boom is otherwise being manipulated, a yellow "caution" light shall illuminate.

Towing Position: The lifting apparatus shall be capable of supporting towing operations with side loading on the cable at 45 degrees from vertical. **It is intended that the "Auto-Render/Recover" option shall be enabled when conducting towing operations.** The design SWL for towing operations shall be at least as given in the table below, with the "Auto-Render/Recover" set at or below this point. 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, **but shall be specified by the Vessel Operator per the Detailed Vessel Requirements.** 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) as described in the Design Standards.

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 be 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.

Fairlead Sheaves (See drawing D215-005): The fairlead sheaves shall be grooved according to the *UNOLS Research Vessel Safety Standards, Appendix A, UNOLS Wire and Cable Safe Working Load Standards, 2008.* **The Vessel Operator shall specify which maximum Factor of Safety (Section 2.0, 3.0. or 4.0) should be used for design purposes.**

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.

All portions of the cable path throughout the system shall be capable of easily passing a 4" diameter termination. Wide "V" grooves in the sheaves are preferred for this reason.

All sheaves throughout the system shall have easily removable cheek plates and/or capture rollers to prevent the cable from jumping the sheaves when the cable goes slack. They shall also prevent the cable from jumping the sheave when the apparatus is at various positions. Sheaves shall be attached to the apparatus by means of a bolting foundation so that they can be easily replaced with a different design, or for maintenance, throughout the vessel's life.

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.

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 standard docking head shall be designed to accomplish the following operations:

1. Vertical Casts – 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.

2. Towing Operations – Used for towed instrument operations where the wire angle will routinely go from vertical (during deployment and recovery) to as much as 45 degrees from vertical fore-and-aft, and as much as 45 degrees outboard while the vessel is turning.

3. AUV/ROV Operations – Used for deployment and recovery of AUV's and ROV's. It is assumed that there would be a secondary submersible docking head with an umbilical winch and slewing mechanism below the primary docking head; the primary docking head being affixed to the apparatus and handling the main winch cable.

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

be used. The docking head shall be fitted with at least four shock absorbers which compress when the package is snubbed up tight using the "Auto-Position" function. The shock absorbers shall be approximately eight (8) to ten (10) inches long, and have a spring coefficient such that when using "Auto Position", they compress approximately 50% (4-5") so that proper operation is clearly visible to the operator.

The docking heads shall have an integral sheave or sheaves 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 capable of being fully immersed in a seaway without damage, loss of function, or releasing the package. The docking heads shall be able to rotate *a minimum* of sixty (60) 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.

The docking head shall be fitted with hydraulic/pneumatic counterbalancing cylinders to neutralize the weight of the sheave as the cable angle moves from the vertical. 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.

Shock Absorber: The apparatus shall be fitted with a shock absorber to reduce (not eliminate) potential cable damage due to snap loading unless the Vendor can demonstrate that cable snap can be similarly reduced by using the motion-compensation system (winch pay-in/pay-out) at all depths, including at the surface. 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 as described below. All apparatus arrangements shall be fitted with a shock absorbers, as full motion compensation may not be specified by the Vessel Operator.

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 (if fitted) may be used by the operator for science and/or cargo operations in lieu of the primary 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 per the 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: Unless specified by the Vessel Operator, the winch may be either electrically or hydraulically driven as long as it is capable of meeting all of the other system requirements herein. 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 vessel design.

The Vessel Operator shall provide information on what external services are available and/or required per the **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 is capable of meeting all of the other system requirements herein. 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 per the Detailed Vessel Requirements.

Design Criteria: *UNOLS Research Vessel Safety Standards, Appendix B, UNOLS Load Handling System Design Standards, 2008.*

Weight: The weight of the winch shall be 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 per the 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. **Space and weight budgets may also impact the maximum achievable cable length, which will have an impact on needed line pulls and SWL and should be addressed in the Detailed Vessel Requirements**.

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 per the Design Standards **at bare drum**. The SWL shall be clearly stenciled on the winch itself.

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 in design of internal structural components shall be in accordance with the Design Standard listed above.

Science Payload: Scientific payload is generally dependent on the class of vessel. Predictions of future 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 per the Detailed Vessel Requirements.

Interchangeable drums and LEBUS shell: The winch shall have an interchangeable drums and bolted (removable) 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 "Auto-Render/Recover" 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 it in order to prevent long cable runs. **Complicated cable paths passing across deck or between multiple decks and compartments should be avoided**. If the winch must be in a separate compartment or on a separate deck, it should be a deck or compartment immediately adjacent to where the handling apparatus is installed.

Wire Monitoring and Display System: The wire monitoring and display system shall provide visual information to the winch operator, digital data to the control systems, and shall be able to feed into a wire data logging system. All primary wire monitoring sensors shall be on one or more of the sheaves on the winch. Secondary or redundant sensors may be located on the handling apparatus as long as they can be properly integrated and calibrated with the system.

The wire monitoring system shall be in compliance with the *UNOLS Research Vessel Safety Standards, Appendix A, UNOLS Wire and Cable Safe Working Load Standards, 2008.* **The Vessel Operator shall specify which maximum Factor of Safety (Section 2.0, 3.0. or 4.0) should be used for design.**

The wire monitoring system shall also have the capability of displaying the following information 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 tension

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-Position": The "Auto-Position" feature is intended to be used ONLY during deployment and recovery to eliminate pendulum effect and the need for personnel to stabilize the package once clear of the deck or the water. It shall be enabled and disabled at the discretion of the

system operator. Once "disabled", this feature should not release the package until the operator actuates the winch pay-out control.

The "Auto-Position" mode shall hold the package firming against the docking head during full articulation of the apparatus from the deck to the water surface. The amount of tension placed on the cable to hold the package shall be designed in concert with the shock absorbers on the docking head.

Because of the operational importance of the "Auto-Position", a completely redundant set of the sensors for this feature shall be installed.

"Motion Compensation": 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. The MRU, and its associated cabling, shall be capable of withstanding heavy vibration and full exposure to the marine environment – including high wind, temperature extremes, salt spray, and all forms of precipitation – and require a minimum of maintenance and calibration.

The motion-compensation feature shall be able to be enabled and disabled by the system operator as desired.

Primary Goal: *Remove at least 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 or paying in or out and from the surface to full depth.*

Secondary Goal: *To reduce peak/dynamic cable tensions per Appendix A.*

Other specific requirement for motion-compensation feature are:

1. Fully operational during both deployment and recovery (paying in and out),
2. Work from the surface to full depth.

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 or included in the Detailed Vessel Requirements. The eventual "Cast" position may be driven by these factors, in conjunction with the required overall Safe Working Load.

"Auto-Render/Recover": The winch shall be fitted with a precise, calibrated "Auto-Render/Recover" feature which will allow the winch to maintain a constant, maximum cable tension as set by the system operator by automatically paying in or out.

This feature shall be used to:

1. To keep the cable tension below a maximum permissible operational limit according to the RVSS, Appendix A,

2. To keep the cable tension from exceeding a certain limit as dictated by a particular cruise or science requirement,
3. To prevent the cable tension from exceeding the SWL of the handling apparatus or winch.

For towing, this feature shall be capable of working at vessel speeds up to 6.0 knots. Vessel speed up to 12.0 knots is desirable.

"Auto-Render/Recover" shall be enabled and disabled by the operator when desired.

The winch shall be fully operational when this feature is enabled. An indicator light shall illuminate to clearly indicate when this mode is enabled. The winch render/recover load shall be adjustable by the operator at the main control station **in maximum increments of 500 lbs, and from a minimum of 10% of maximum SWL up to the full SWL of the winch/apparatus**. Adjustment in 100 lbs increments are desirable. In no case shall the "Auto-Render" mode be able to be adjusted above the maximum SWL of the winch/apparatus.

Because of the operational importance of the "Auto-Render/Recover", the Vendor shall demonstrate that a load cell having a proven record of high reliability ("3PS", Houston, Texas, or equal) is to be used, or a completely redundant load cell shall be installed.

Test and calibration procedures for the "Auto-Render/Recover" feature shall be in compliance with the RVSS, Appendix B.

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 may only 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 316 stainless steel and all hydraulic fittings (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, bushings, and rotating elements shall have grease fittings and be properly grooved for the routine application of lubricant. Environmentally safe grease shall be used.

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 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 Detailed Vessel Requirements before the system is accepted by the Vessel Operator. The FAT shall be witnessed by either a classification society surveyor or USCG according to the Design Standards 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 in the Detailed Vessel Requirements, the design service temperatures shall be between 14˚F (-10˚C) and 110˚F, or in accordance with the RVSS Appendix B; whichever is more stringent.

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 ~50%.
3. Enable "Auto Position". Operator allows winch control to go to "neutral" position.
4. Adjust docking head friction to reduce package swing if needed.
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 either in or near the water surface depending on sea state and vessel motions (judgment by system operator).
7. Adjust docking head friction to allow free swing of docking head as needed. In heavy sea states the docking head should be allowed to swing once package is in the water.
8. Disable "Auto Position". ("Auto Position" will not release until operator moves winch control handle out of the neutral position).
9. Pay out winch until package is below the surface. Amount will depend on the 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. Set "Auto-Render/Recover" to match particular operational demands.
12. Set depth or wire speed alarms as desired.
13. Pay in on winch until package at desired starting depth depending on sea state and science/technical staff request.
14. Pay out on winch – begin cast.
15. Enable "Motion Compensation" as desired.
16. End of cast. Begin haul back (pay in).
17. Bring package near surface. Depth depending on sea state and science/technical staff requirements.
18. Disable "Motion Compensation" as desired or when ready to recover.

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. *Proximity to surface will depend on sea state and vessel motion (judgment of 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 ~50%.
4. Enable "Auto Position". Operator allows winch control to go to "neutral" position.
5. Adjust docking head friction 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 Position". *("Auto Position" 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:

1. Follow package deployment steps above.
2. When boom brought back to "Cast" position, adjust setting on "Auto-Render/Recover" to match SWL of apparatus in the towing configuration or wire 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