TABLE B.3 - ATLANTIS Starboard Squirt Boom and Aft CTD Winch
Note: Some of the figures below are estimates for Appendix B illustration only.

REQUIRED DATA	**Operator/Designer Response**	
Deployment Type	*Station Keeping-Deep Water*	*McElroy manual only indicates a vertical load on the boom. Nothing on board ATLANTIS indicates that towing is allowed, however "tow-yo" have been conducted off this boom. It is reported that towing calculations were done on this boom design for REVELLE. MCD should be developed jointly between WHOI and SIO. Deployment type might be able to be changed to "Station Keeping & Towing - Deep Water". RIght now this is in conflict with the system description below of how the system is actually used. One should be changed until more information is known.*
Provide a brief narrative of scientific purpose and the equipment to be deployed. A drawing or drawings of the proposed "system" or "component" architecture is to be appended showing, for example, tension member angles and potential loadings (Principal, Secondary & Worst Case) relative to the various system elements. Provide information on the vessel or vessels (size(s), type(s), UNOLS or not, etc.) intended for the system deployment, its/their area(s) of operation and the likely weather conditions to be encountered.	This system is used to deploy and recover a variety of science packages over the starboard side including CTD rosettes, small corers and "tow-yo" instruments. The system is made up of a McElroy model 15000 squirt boom and a Markey DESH-5 CTD winch; both of which are permenently installed on the 0-2 deck, starboard. Typcial deployments range from surface casts to 10,000m which are often greater than 75% of the water depth. The winch is normally fitted with 0.322 conducting cable, but it is possible to change drums/wires.	
Provide Primary Deployment Information:		
Package Description	Various	
Maximum Package Weight	Various	
Base Package Mass	Various	
Added Mass to Include Captured and Entrained Added Mass (E.G., Water/Mud)	Various	
Maximum Hydrodynamic Resistance	Various	
Dynamic Factors	1.17 g vertical (Assuming Global AGOR side deployment, See Glosten document XXXXX)	*It is possible to use dynamic factors less than the Appendix A requirement of 1.75 if the characteristics of the vessel are known. 1.75 is the requirement (based on ABS) if you don't know anything else.*
Tension Member Type and Breaking Load. Either Nominal Breaking Load (NBL) or Assigned Breaking Load (ABL) per Appendix A	Rochester 0.322	
Maximum Tension Member Weight (In Water)	Depends on deployment & package (See Appendix A calculation for CLIVAR as example)	
Maximum Tension Member Mass	See Appendix A calculations	
Tension Member Factor of Safety per Appendix A	2.0 (Levelwind design requires up-grade. Reduced cable life expected due to small diameter vertical rollers)	
Tension Member Maximum Permissible Tension (MPT) or SWL	5000 lbs	
Maximum Anticipated Depth/Length of Deployment	10,000m	
Maximum Allowable Depths of Water	Full Ocean	
Deployment/Water Depth Ratio	*Near 100 % depending on station depth*	
Principal Loading	*entrained water, resistance, cable weight in water)*	
Secondary Loading	*Dynamic effect on total mass. See Appendix A calculation for the given deployment.*	
Worst Case Loading	*10,000 lbs (Package fouls in submerged wreck)*	*This results in the DLT for an Inspected Vessel like ATLANTIS.*
Load Limiting Device or Conditions (Section B.4)	None	*Use of a LLD on an Inspected Vessel would have to be approved by USCG.*
Maximum Anticipated Operating Tension (MAOT):	10,000 lbs	*Per Appendix B Section B.4 (No LLD and vessel large enough to impart this level on loading)*
Design Line Tension (DLT):	Unknown	*This needs to be confirmed through MCD development*
Ultimate Design Load (UDL):	Unknown	
Maximum Permissible Tension (MPT):	5000 lbs	*This is what you would set the alarm on the cable monitoring system.*
MAOT < or = DLT?	**Unknown**	*Without a LLD, MAOT must be less than DLT*
Other Emergency Means of Package or Tension Member Detachment	None	
Other Means for Package Control	None	
Description of Fail Safes in the Event of Power Loss or Mechanical/Electrical Failure of System Components	None	

GEOTRACES LHS - KNORR
Note: Some of the figures below are estimates and are provided for Appendix B illustration purposes only.

COMPONENT	UDL (LBS)	DLT (LBS)	MPT (LBS)	Comments
1. Handling Apparatus				
McElroy Model 15000 Squirt Boom	Unknown	Unknown	**Unknown** (but probably > 5000 lbs)	Ship's operating manual describes the boom being designed for 15,000 static load which implies this load hung from the padeye. This needs to be converted to MPT with the current winch arrangement defining the cable geometries. There was no further information in the McElroy manual. It is reported that these calculations have been run for REVELLE, including tow loading. WHOI may be able to get the required information from SIO to develop a common MCD for both ships depending on winch arrangement. There may be additional information in the WHOI files ashore, but none was available on the ship during the NSF inspection and therefore not available to the crew.
2. Winch				
Markey DESH-5	Unknown	Unknown	At least 12,000 lbs	MCD needs development through interface with Markey. This make/model may already be included in the GP with Duke. Since line pull at bare drum is 12, 000 lbs there is no concern that it can withstand the breaking strength of the 0.322 currently in use. It may be able to be used with much larger cables if desired and still meet 46 CFR, which might save replacement costs. MCD should also give bolt loads at the foundation which could eventually be used to check ship's structure. Given the time in service, there is little concern about fixed winches such as this. Analysis of foundations and deck structure would be a very low priority.
3. Tension Member				
Rochester 0.322	10,000 lbs	10,000 lbs	**5000 lbs**	Cable monitoring system, sheave diameters and training all allow FS= 2.0 per Appendix A. However, the Markey levelwind has 4" diameter levelwind rollers which would limit the FS to 5.0. NSF realizes that full ocean work (particularly the up-coming CLIVAR work) necessitates the use of a FS of 2.0. If the other aspects of Appendix A are followed, the only detriment of the undersized rollers is the negative impact on cable life. There should be no concerns about personnel safety. A technical solution to the Markey levelwind design is under discussion and will be implemented on the Global ships as soon as practicable.
4. Blocks/Sheaves				
WHOI Provided Harken Block	Unknown	20,000 lbs	10,000 R = 20,000	MCD needs development, but easily available from vendor spec sheets and verified through testing. See WHOI block load testing photos as well as the standard block MCD format. MCD should include padeye reaction at MPT which is normally 2x MPT
5. Hardware				
WHOI Provided 1/2" Shackle at Block	Unknown	> 20,000	R = 20,000	From Crosby spec sheet
6. Deck Bolting Pattern				
System Maximum Permissible Tension (MPT)			**5000 lbs**	
System Design Line Tension (DLT)		**Unknown**		

R/V ATLANTIS
(AGOR 25)

CTD Harken Block tested to 12,500 LBS for 5 minutes.
May 20th 2010

Bosun

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Chief Mate

CG–050905

CHIEF MATE

Hydro wire Block tested to 5625 LBS for 5 minutes.
May 20th 2010

R/V ATLANTIS
(AGOR 25)

Bosun

Chief Mate

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

CG-050905

CHIEF MATE

GENERAL DESCRIPTION AND SPECIFICATION

1. OUTLINE

The MARKEY Type DESH-5 Research Winch is a special winch designed to suit the operating requirements encountered during deep-sea scientific exploration.

The Research Winch is provided with the following features:

- One removable drum with Lebus grooved shell for 0.322" cable.
- One spare drum with Lebus grooved shell for 1/4" wire.
- Totally enclosed reduction gears
- Manual and air operated drum brake
- Manual drum clutch
- Two gear ranges for HIGH-PULL and HIGH-SPEED winch operation
- Level-wind adjustment clutch - handwheel type
- Level-wind with 1 meter circumference sheaves
- Load pin and speed/scope sensor integral with level-wind

For general winch arrangement, refer to MARKEY Research Winch Outline, Type DESH-5, Dwg. C-32774, (See Section 4).

2. IDENTIFICATION

The winch data plate is located on the gear case cover. The winch serial number is also welded to the base sill at the end of the gearcase.

3. WEIGHTS

Winch Net Weight (less wire rope) .... 14,950 Lbs.

Approx. Weight (in air) 10,000 meters .322 EM Cable .. 4,850 Lbs.

Starter Panel Net Weight .... 750 Lbs.

Isolation Transformer Net Weight .... 670 Lbs.

4. BASE AND GEAR HOUSING

The winch base, the side frames, and the integrally formed oil-tight gear housing are fabricated from steel plates and shapes to form a rigid main structure. All shafts are line-bored for accuracy and are fitted with anti-friction type roller bearings, with the exception of the drum shaft bearing in the outboard frame, which is fitted with a bronze sleeve-type bushing. This bushing is split into two halves, to simplify drum removal.

5. REDUCTION GEARING

Four sets of steel, cut-tooth spur & helical gear reductions are provided to give a total ratio of 37.2:1 in the HIGH-PULL gear range and a 24.9:1 ratio in the HIGH-SPEED gear range. The result is a 1.5:1 speed change ratio between the two ranges.

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Good description for MCD.

6. GEAR AND PINION DESCRIPTION

	TEETH	DP	TOOTH FORM	FACE
Main Gear	92	3	20 deg. FD	5-3/4"
Main Pinion	27	3	20 deg. FD	6-1/4"
Ratio:	3.41:1			
HIGH-PULL Interm. Gear	107	5	20 deg. FD	4-1/4"
HIGH-PULL Interm. Pinion	32	5	20 deg. FD	4"
Ratio:	3.34:1			
HIGH-SPEED Interm. Gear	96	5	20 deg. FD	3-1/2"
HIGH-SPEED Interm. Pinion	43	5	20 deg. FD	4-3/4"
Ratio:	2.23:1			
Motor Gear	85	7	30 deg. Helical	2-7/8"
Motor Pinion	26	7	30 deg. Helical	3-1/8"
Ratio:	3.27:1			

7. CABLE DRUM

The drum is of fabricated steel design and is fitted with a Lebus grooved drum shell designed for 0.322" diameter electromechanical cable. A spare drum is also provided, and is fitted with a Lebus grooved drum shell designed for 1/4" diameter wire rope. The drum is provided with a suitable dead-end designed for leading the cable through the drum flange into the center of the hollow drum shaft, thus permitting multi-conductor cable to be used on the drum and connected to the slip-ring assembly. The slip ring assembly is mounted on the outboard end of the drum shaft. The cable drum is designed to provide reasonably quick removal and replacement of the drum with spare drums.

7A. DRUM SPECIFICATIONS

Drum Dimensions:
18" Barrel Dia. (Under Lebus Shell)
38" Barrel Length
44" Flange Diameter

Rated Drum Capacity: 10,000 meters of 0.322" diameter electromechanical cable

8. WINCH PERFORMANCE SUMMARY @ 100% Base Rating

HIGH-PULL GEAR RANGE

Barrel Lyr.: 12,000 Lb. Line Pull at 155 ft/min (47 m/min)
Mid-Scope: 6,904 Lb. Line Pull at 269 ft/min (82 m/min)
Full Drum: 5,297 Lb. Line Pull at 351 ft/min (107 m/min)

HIGH-SPEED GEAR RANGE

Barrel Lyr.: 8,054 Lb. Line Pull at 231 ft/min (70 m/min)
Mid-Scope: 4,634 Lb. Line Pull at 401 ft/min (122 m/min)
Full Drum: 3,555 Lb. Line Pull at 523 ft/min (160 m/min)

(Also refer to Drum Performance Charts, pages 2-3 & 2-4)

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Line pull on winches could generally be considered to be the MPT. What is not known is the DLT, but it would be higher depending on the Factors of Safety used by Markey. Discussion would be required with Markey to determine as part of MCD development.

CHAPTER 6
DECK MACHINERY

4.0 HYDROBOOMS

Safety Factor of 6

The hydrobooms (Figure 6-4-1), are located on the 02 level. One of the hydrobooms (CTD) is on the starboard side frame 80 and the other (ROV) is located on the port side frame 100. They are manufactured by McELORY and are Model 15000. The hydrobooms are used for launching and recovering oceanographic equipment and running wire or cable from the hydrographic winches. The CTD hydroboom is designed for a static safe working load of 15,000 lbs perpendicular to the ship's deck. The ROV hydroboom is designed for 46,000 lbs breaking strength of the wire rope. The total length of each hydroboom extended is 43′. Each hydroboom has one extension boom that is 18′ long. Both hydrobooms are controlled from the Winch Control House and the ROV hydroboom can be operated from the Main Deck at Frame 99 port side. The ROV hydrobbom can be pinned in the extended position.

Both hydrobooms use a common hydraulic system that consists of a power pack which contains a constant volume pump, motor, reservoir, heater, and solenoid valve. The pump is driven by a 40 hp motor.

4.1 HYDRAULIC SYSTEM

The hydraulic power pack (Figure 6-4-2) is located on the 02 level and consists of a 40 hp motor driving a Hartman model PVX696 hydraulic pump. The motor receives its power from power panel P410 through a motor controller located in the Wet Lab. The motor, manufactured by Marathon, is rated at 1,800 rpm. The pump is an axial piston with a swashplate. The reservoir has a capacity of 100 gal of hydraulic oil. The same type of hydraulic oil used in the Z-drive steering system is used in the hydroboom power pack. Every three months, the drain plug on the reservoir should be opened slightly to check for water. If water is present, the unit should be drained and flushed, and clean oil should be added. The hydraulic oil is filtered by a 10-micron filter on the return line to the reservoir.

Hydraulic oil flows from the pump to a solenoid valve, which directs the oil to the reservoir unless the EXTEND button is pushed. If the EXTEND button is pushed, the solenoid valve shifts and aligns the corresponding ports, allowing the oil to flow through the directional valve to the back side of the extendable boom, creating hydraulic oil pressure to force the extension boom out. If the RETRACT button is pushed, the directional

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These pages are from the vessel's operating manual that was provided by the shipyard at delivery. There was no such description in the McElroy manual. This is good general information for inclusion in the MCD.

Number: 2 Author: NSFUSER Subject: Sticky Note Date: 2/4/2012 11:54:10 AM

The starboard boom is described as only having a 15,000 lbs static load rating which would imply this load hung directly on the padeye. This would mean an MPT of something less (10,000 lbs ?) when the cable is reeved over the sheave depending on cable geometry. This needs to be investigated during MCD development which was reportedly done on REVELLE. DLT also needs to be confirmed.

Number: 3 Author: NSFUSER Subject: Sticky Note Date: 2/4/2012 12:09:22 PM

The port boom is accurately described as reeved over the sheave, but it is not known from this document is whether this is DLT or MPT, but it reads like DLT. It was later determined by the Glosten as part of the evaluation above.

WHOI HYDROBOOM

Structural Analysis – Phase 2

PREPARED FOR:				BY:
Woods Hole Oceanographic Institution Woods Hole, Massachusetts				Courtney C. Ewing PROJECT NAVAL ARCHITECT
THE GLOSTEN ASSOCIATES 1201 Western Avenue, Suite 200, Seattle, Washington 98101-2921 TEL 206.624.7850 FAX 206.682.9117 www.glosten.com				CHECKED: Garth Wilcox, PE PROJECT MANAGER
				APPROVED: Timothy S. Leach, PE PRINCIPAL-IN-CHARGE
DOC:	REV: A	FILE: 10002.02		DATE: 4 June 2010

GARTH WILCOX
STATE OF WASHINGTON
SIGNED ORIGINAL ON FILE AT GLOSTEN
35560
REGISTERED PROFESSIONAL ENGINEER

References

1. 46 CFR 189.35 – Weight Handling Gear.
2. Modified 25000 Hydro-Boom Drawing No. J98003-001, George Thompson & Associates, Inc., 9 March 1998.
3. Assembly Views Atlantis Portside Sheave, Drawing, 24 September 2003.
4. Structural Module Assembly No. 19 Dwg. No. 6932819, Halter Marine, Inc., 4 March 1994
5. Rochester Wire & Cable Product Data Sheet 0.680" Electro-Optic Wire.
6. Glosten Report – WHOI Hydroboom Structural Analysis, 16 February 2010.

Summary

The *R/V Atlantis* (AGOR 25) is equipped with a port side hydroboom, currently rated for 25 kips SWL. During Phase 1, a set of maximum wire breaking strength values was calculated for key parts of the port side hydroboom. Phase 2 involved a shipcheck to determine and confirm details of the hydroboom construction, a reevaluation of the maximum load values based on the information from the shipcheck, a further reevaluation for a new load case consisting of towing a load from the hydroboom, and development of recommendations for strengthening the hydroboom to support the use of 0.680" wire. The 0.680" wire has a breaking strength of 46 kips (Reference 5).

This report establishes the current capabilities of the hydroboom system regarding USCG requirement 46 CFR 189.35 and includes a structural evaluation of the hydroboom, its major components, and foundations. The analysis establishes the maximum wire capacity of the system by analyzing each system component and increasing the wire breaking strength until the stress of the component reaches the allowable stress.

The hydroboom is constructed of A514 high strength steel, which has a yield strength of 100 ksi and an ultimate strength of 120 ksi. The ship structure is mild steel, with a yield strength of 34 ksi and an ultimate strength of 58 ksi. The analysis considers the following structural components:

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This appears to be MPT (25,000 lbs)

- Extended boom
- Fixed boom
- Sheave pins
- Sheave support assembly
- Inner sheave foundation
- Boom tip bolts
- Boom base bolts
- Below deck structure

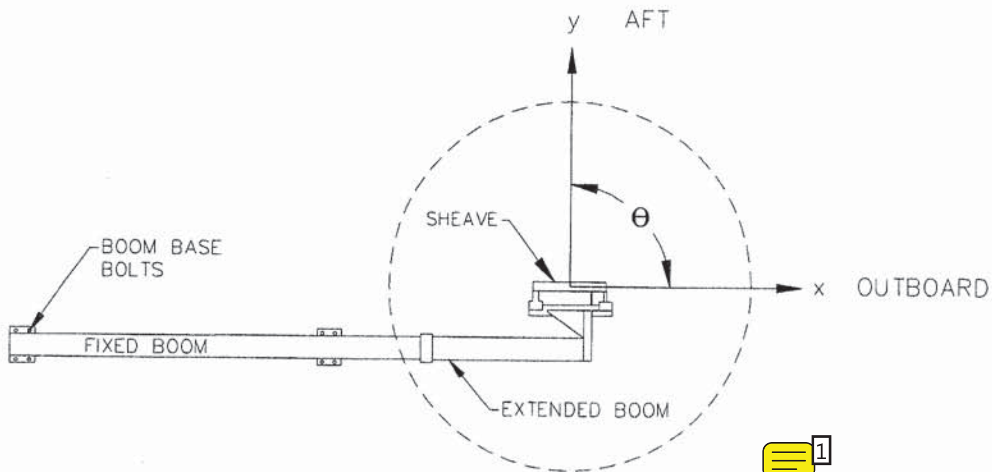

Figure 1: Hydroboom, Plan View

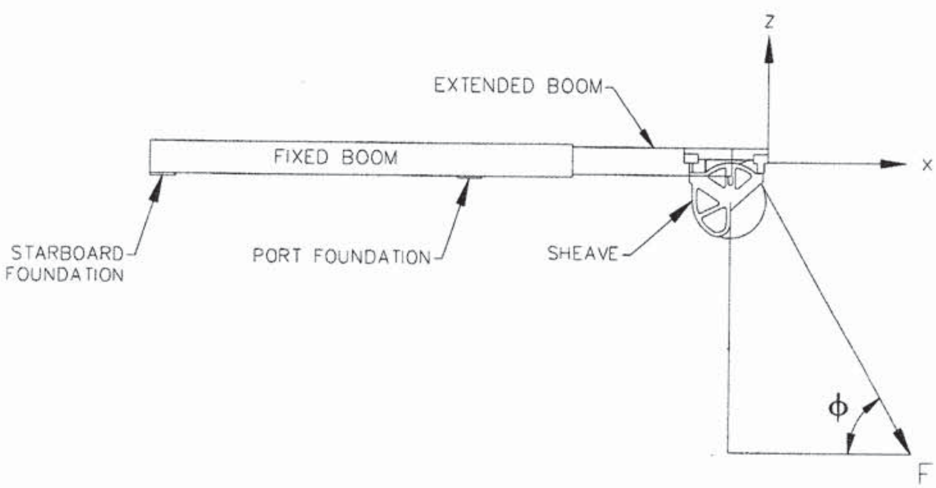

Figure 2: Hydroboom, Elevation

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Excellent diagrams for inclusion in the MCD.

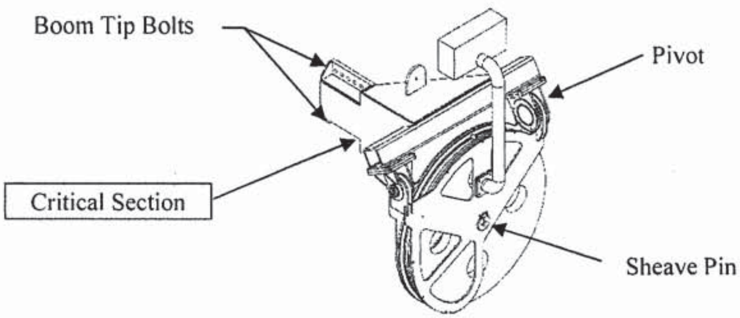

Figure 3: Hydroboom, Sheave Assembly

The hydroboom system was analyzed regarding USCG requirement 46 CFR 189.35, which requires a factor of safety of 1.5 times the breaking strength of the wire. Below is a summary of the maximum allowable wire breaking strength in kips of each system component in its current configuration, as reevaluated under Phase 2.

Component	Maximum Allowable Wire Breaking Strength (kips)		Notes
	Normal Condition	Towing Condition	
Extended Boom	46.0	43.0	Normal Condition meets CFR criteria for 0.680 wire. *von Mises stress 0.3 ksi > allowable; principal stress < allowable.
Fixed Boom	33.7	32.0	Requires structural modifications.
Outer Sheave Pin (at Boom Tip)	89.0	88.0	Meets CFR criteria for 0.680 wire.
Inner Sheave Pin (to Winch Room)	46.3	46.3	Meets CFR criteria for 0.680 wire.
Outer Sheave Support Structure	40.3	38.4	Requires structural modifications.
Inner Sheave Foundation	> 46.0	> 46.0	Meets CFR criteria for 0.680 wire.
Boom Tip Bolts	28.0	20.4	Requires structural modifications.
Base Bolts	49.9	49.9	Meets CFR criteria for 0.680 wire.
Port (outboard) Foundation	24.3	24.4	This is the limiting component for the hydroboom; requires structural modifications.
Stbd (inboard) Foundation	68.0	69.0	Meets CFR criteria for 0.680 wire.

* von Mises stress is used as a failure criteria check, but does not represent a true stress as seen by the boom. Typically, a higher allowable stress is used with von Mises stress criteria.

Analysis Methodology

As in Phase 1, the hydroboom was analyzed assuming pick loads over a range of angles from directly outboard ($\theta = 0$ degrees) to directly inboard ($\theta = 180$ degrees) in a 30-degree cone of operability ($\phi = 60$ degrees). For the towing condition, the cone angle was increased to 50 degrees ($\phi = 40$ degrees), and only angles leading aft were analyzed ($\theta = 45$ to 135 degrees), as illustrated in Figures 1 and 2.

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NSF ended up paying for these up-grades - even though the manual appeared to show the breaking strength of 0.680 (46,000 lbs) was considered.

Number: 2 Author: NSFUSER Subject: Sticky Note Date: 2/4/2012 12:05:15 PM

Cable leads out of the boom are important and well evaluated here. Incoming angles are not as significant a factor for bending since the cable runs along the boom. Incoming cable angles from the hydro winch on starboard boom will be important given the winch/boom arrangement.

Appendix A contains the structural calculations. A spreadsheet was developed to check all of the normal loadings from 0 to 180 degrees. A second spreadsheet was developed to check the towing conditions. The spreadsheets show the maximum allowable breaking strength for each of the hydroboom components and the foundations.

Each component is evaluated using an allowable stress criterion to determine the maximum wire breaking strength it can support, such that the allowable stress is not exceeded. The allowable stresses given below are based on USCG criteria for weight handling gear.

46 CFR 189.35-9(c)(1) states that "The safety factor for all metal structural parts shall be a minimum of 1.5; i.e., the yield strength of the material shall be at least 1.5 times the calculated stresses resulting from application of a load equal to the nominal breaking strength of the strongest section or wire rope used" (Reference 1).

This corresponds to an allowable bending stress of:

- 100 ksi / 1.5 or 66.7 ksi for A514 high strength steel
- 34 ksi / 1.5 or 22.7 ksi for mild steel

The allowable shear stress is:

- 66.7 ksi / 1.5 or 44.4 ksi for A514 high strength steel
- 22.7 ksi / 1.5 or 15.1 ksi for mild steel

Coordinate System

X – Positive outboard

Y – Positive aft

Z – Positive up

Forces on the Boom

The Phase 1 spreadsheet made some simplifications about the application of the load to the sheave. The load was applied to the center of the sheave, which was fixed in space. It was realized that the towing conditions would make these simplifications less valid, and the spreadsheet was rewritten to allow the sheave to swing and align itself to the load resulting from the tension created by the pick load and winch (see Figure 4). Once the spreadsheet was modified for the towing loads, it was also used to evaluate all of the loadings. The moments on the boom increased in Phase 2 because the moment arms increased from allowing the sheave to swing. Therefore, some of the allowable loads on the boom components have been reduced.

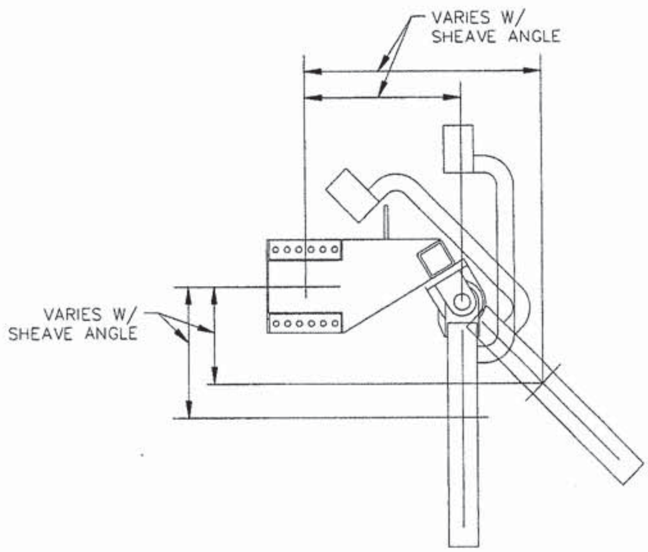

Figure 4: Hydroboom End, Looking Outboard

Extended and Fixed Boom

The vertical and horizontal reactions, as well as the shear, bending, compressive, and torsional forces, were calculated for both the extended and fixed booms. Each boom was analyzed separately as a simply supported beam. The extended boom is supported by the fixed boom overlap, and the fixed beam is supported by the deck foundation. The fixed boom has a capacity of 33.7 kips, which was limited due to the von Mises stress. The extended boom has a slightly higher maximum capacity of 46.0 kips. The von Mises stress and the AISC unity check reveal that the extended boom is extremely close to the allowable buckling load. An FEA model of the extended boom was built, which confirmed that the buckling loads are within acceptable levels.

Outer Sheave Support Structure

The resultant boom tip forces and moments were applied to the outer sheave support structure. The available drawing is not clear on the material used in this structure; however, it is assumed to match the material in the hydroboom, which is 100 ksi A514 high strength steel.
The material needs to be confirmed. The sheave pivot shear and pivot beam bending were checked by hand calculations and found to be well below limiting values. The highest bending stress is 14.4 ksi, and the highest pin shear is 6.5 ksi.

The support assembly itself has stresses exceeding the CFR limits. This occurs at the transition from the bolting flanges to the tapered beam section marked “critical section” in Figure 3. This calculation has stretched the capabilities of this analysis, and it would be best to ask the original designers of this structure to perform an FEA to confirm the values obtained with the spreadsheet. However, it appears that an FEA would not yield results which would pass the CFR criteria.

Boom Tip Bolts

The resultant boom tip forces and moments were applied to the bolt pattern at the boom tip. The stresses in the bolts are considerably higher than those calculated in the Phase 1 report due to two factors: additional loads determined by the improved calculation method, and correction of a mistake in the original calculations. This is particularly extreme in the upper forward corner bolt. The tip bolts are the limiting component of the hydroboom.

Boom Components

The section properties of the sheave pins were calculated based on measurements taken from the vessel. The resultant load was applied to the pin to determine the shear stresses.

Tensile and shear stresses were calculated for the fixed boom base bolts.

All boom component stresses are within the allowable stress range.

Deck Structure

The computed foundation reaction loads were applied to the deck structure in way of the fixed boom base pads. The ship's structure was taken from Reference 4 drawings and from detailed measurements obtained during the shipcheck. The 8" x 1/2" flatbars underneath the portside foundation pads exceed the allowable bending stresses. Additional underdeck structure is required in this location. The starboard foundation stresses and buckling limits are well within the allowable limits.

Inner Sheave Foundation

The foundation shear stresses were checked for the resulting pin loads and found to be well within the allowable stress range.

Modifications

Boom Tip Bolts

The existing boom tip bolt pattern has a row of bolts at the top and bottom. This provides little resistance to forces applied in the horizontal plane due to having the sheave cantilevered off the aft side of the boom. To better counter these forces, a vertical row of bolts may be added on the forward side of the boom tip. This will entail welding two mating flanges to the existing boom tip and sheave support structure. To accomplish this, the existing padeye will also have to be modified. During normal loading operations, the addition of six 1.25" diameter Grade 8 bolts in the proposed vertical orientation (see Figure 5) will allow the maximum wire breaking strength to be increased to 46 kips.

However, the stresses due to the towing condition are even higher. Solutions to counter the towing loads include designing an entirely new, larger, bolted connection for the boom end; or alternately, welding the sheave support structure to the end of the boom, which would obviate the need for the extra bolts.

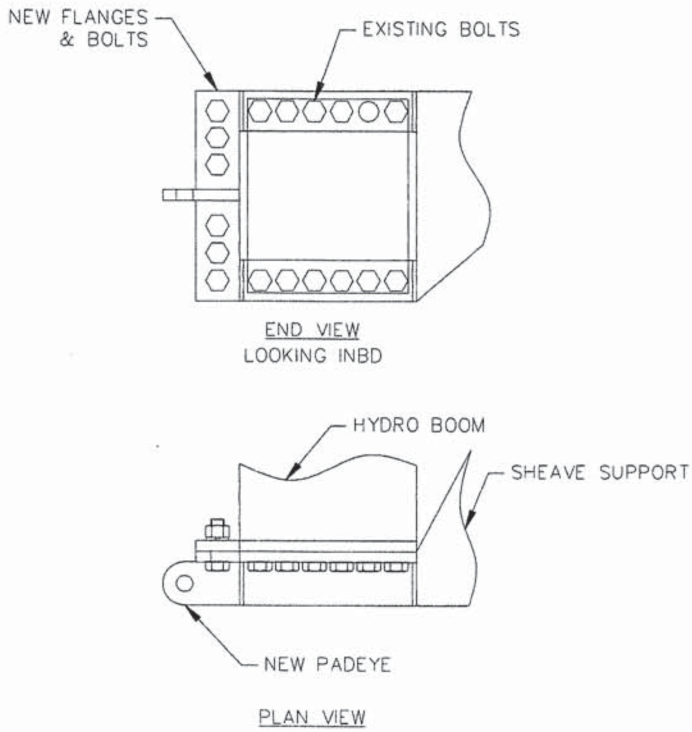

Figure 5: Boom Tim Bolting Modifications

Fore Guy

A padeye on the boom tip already exists, although it may need modifications, as described above. A fore guy taken from this padeye in a horizontal plane to the deckhouse or the crane base will decrease the moment in the horizontal plane, M_z. This will drop the stresses in the fixed and extended booms, and move them into the acceptable range for both normal conditions and towing conditions.

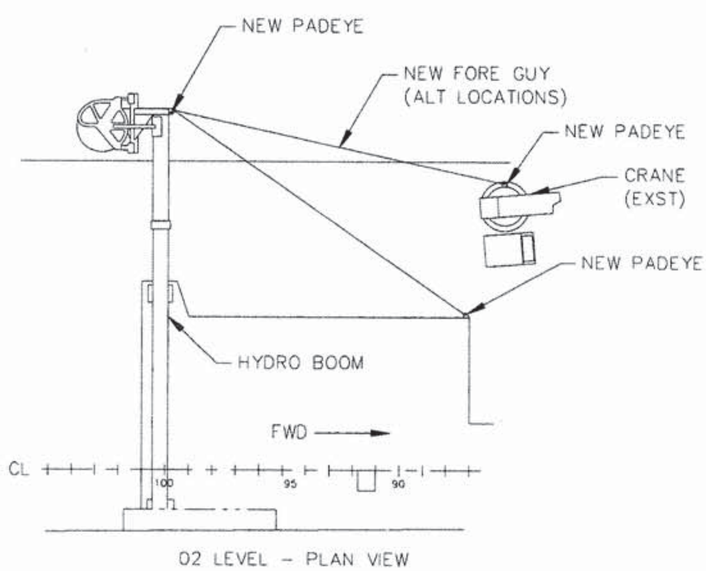

Figure 6: Hydroboom Towing Configuration

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Port boom is not rated for towing unless stays are installed. It is unknown under what cable loads this will be required on the starboard boom until the MCD is developed. The ATLANTIS has not yet taken the steps to install the required padeyes and stays, but they have the necessary information.

Fixed Boom

Because it is only desired to use the fore guy in towing situations, other solutions are examined for the fixed boom in normal operation. Flatbar doublers may be welded along both faces at the top forward and bottom aft corners of the fixed boom. Four 7" x 3/4" flatbars will bring the maximum wire breaking strength up to 46 kips (see Figure 7).

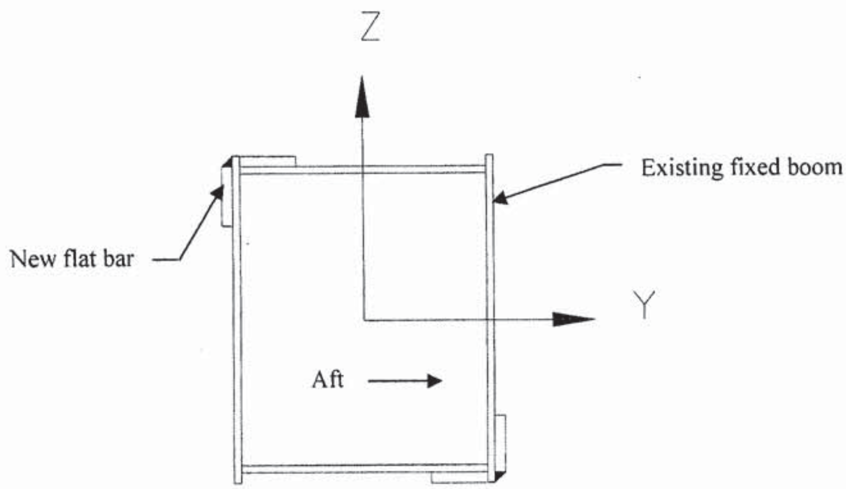

Figure 7: Fixed Boom Modifications

Portside Foundation

The existing transverse structure supporting the portside foundation includes two 8" x 1/2" flat bars, and a 5" x 3" x 1/4" angle. The stress in each of these members exceeds the allowable bending stress; therefore, a new longitudinal flat bar chock should be installed to break up the span of the transverse members. This will help distribute the load to the large transverse girders (see Figure 8).

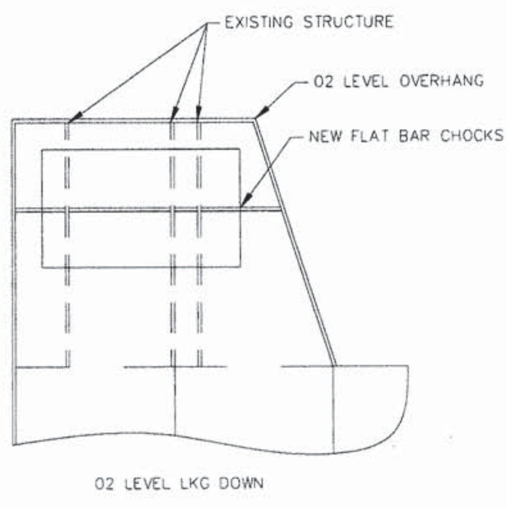

Figure 8: Port Foundation Modifications

Outer Sheave Support Assembly

It is possible to envision a modification to the critical section of the support structure that eliminates the discontinuity at the bolting flanges; however, when combined with the need to add extra boom tip bolts and a padeye, it would be best to redesign and replace this section of the assembly entirely.

Cost Estimate

Estimates indicate that the above modifications will cost approximately $54,000. This assumes that the vessel would already be in a shipyard and, therefore, does not include costs such as berthing.

Conclusions and Recommendations

For the existing hydroboom, the maximum wire breaking strength for both normal and towing load conditions is 24.3 kips. To operate with 0.680" wire at a breaking strength of 46 kips, the following changes must be made:

1. A fore guy needs to be rigged for all towing conditions.
2. The fixed boom must be reinforced with flatbar doublers, unless the fore guy is used at all times.
3. The outer sheave support assembly must be redesigned to take higher moments, and it must be attached with additional bolts.
4. Additional structure must be added beneath the portside foundation pad.