MBARI's Tiburon II
Final Design Specification (DRAFT)

Revision 0.0

Monterey Bay Aquarium Research Institute
7700 Sandholdt Rd.
Moss Landing, CA 95039
Contact: Dale Graves
grda@mbari.org
1 (831) 775-1913

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1 Introduction

1.1 General Description

The ROV *Tiburon*, designed and developed by MBARI, is an outstanding science and engineering platform that has completed over 1100 dives since 1997, supporting a wide variety of science and engineering activities. *Tiburon* is now poised for replacement to update obsolete systems, improve reliability, reduce maintenance requirements, and upgrade science capabilities.

During the past 10 to 20 years, the technical and operational requirement to support deep-submergence science activities at MBARI and in the broader sense the ocean science community have become increasingly more complex as new sensors, instruments, and ocean observing systems are developed. *Tiburon* was originally designed to serve primarily as a highly technical ocean observing and exploration tool, with high-quality imaging capabilities in a maneuverable vehicle, incorporating a broad suite of sensors and samplers that could be configured quickly for various science and engineering missions. Since *Tiburon's* development, the priorities for ROV capabilities have evolved from that of a sophisticated exploratory tool well equipped with sensors, to highly capable submersible platform that is easily configurable to support a broad spectrum of activities. Priorities for future MBARI ROV operations include *Ocean Exploration* (Gulf of California, Juan de Fuca Ridge, Hawaii, and eastern Pacific sites), *Ocean Observatory Support* (benthic node connection, subsea fiber-optic cable installation, instrument & sensor installation & recovery, ROV support for AUV docking stations), *Ocean Experimentation & Sampling* (instrument deployment, sample collection in mid-water and benthic habitats), and *Ocean Education & Outreac*h (high quality imagery for collaboration with MBA, BBC, NOVA, etc.). The need for sophisticated imaging & sensing remains, but new requirements for heavy payload capabilities, seamless sensor & instrument integration and data management, and complex manipulations, sample collection, instrument servicing, and seafloor cable-laying have become high priorities for ROV operations, and will likely dominate MBARI's future ROV requirements. The obsolescence of some of Tiburon's systems, coupled with the growing technical demands of MBARI's expeditionary ROV science and the forthcoming requirements to support MOOS and MARS ocean observing systems, has created a juncture for review of *Tiburon's* operational capabilities.

1.2 Purpose of Document

This document has two goals, first is to provide a means for MBARI and SMDH to collaborate on a final design specification for the Tiburon II ROV system. MBARI has taken the first step by providing the below outline and specification for the new vehicle. This is MBARI's wish list. SMDH, after review, should provide comments or questions regarding any item that is not clear or could be problematic or not cost effective to implement. Once both SMDH and MBARI have agreed on a final detailed specification, this document will be revised to reflect those changes and will be the basis for the RFQ and sales contract. Some sections of this document's text are in ***bold blue italic***, this indicates a request from MBARI for more information or comment from SMDH.

2 Equipment Specification

2.1 Mechanical

2.1.1 System of Units

All fasteners and fittings shall be of the Imperial System

2.1.2 Factor of Safety Method of Design

Please comment on applicable engineering reference for design. i.e. your in-house ISO 9001 documentation.

2.1.2.1 Dynamic Loading

The vehicle shall be designed to accommodate a launch and recovery in sea state five (5). Design for accelerations shall meet or exceed the *ABS RULES FOR BUILDING AND CLASSING Underwater Vehicles* section 9.3 or other equivalent standard.

2.1.3 Materials

2.1.3.1 Bolts, Screws, other Fasteners

Materials for fasteners shall comply with the American National Standard & Unified Standard or equivalent. All fasteners shall be of the appropriate grade for the intended service.

2.1.4 Operating Depth

All systems and sub-systems shall be rated to an operational depth of 4000 MSW.

2.1.5 Dimensions & Weights

The vehicle outfitted with the MBARI specified core equipment including a tool sled (<1,100 pounds in air) and the vehicle trimmed to be approximately 50-75 pounds positive in salt water will not exceed 11,100 pounds in air. Vehicle dimensions will not exceed 3.5 meters long x 2 m wide x 2 m high. Small changes are acceptable and final weights and dimensions shall be agreed upon during the preliminary design.

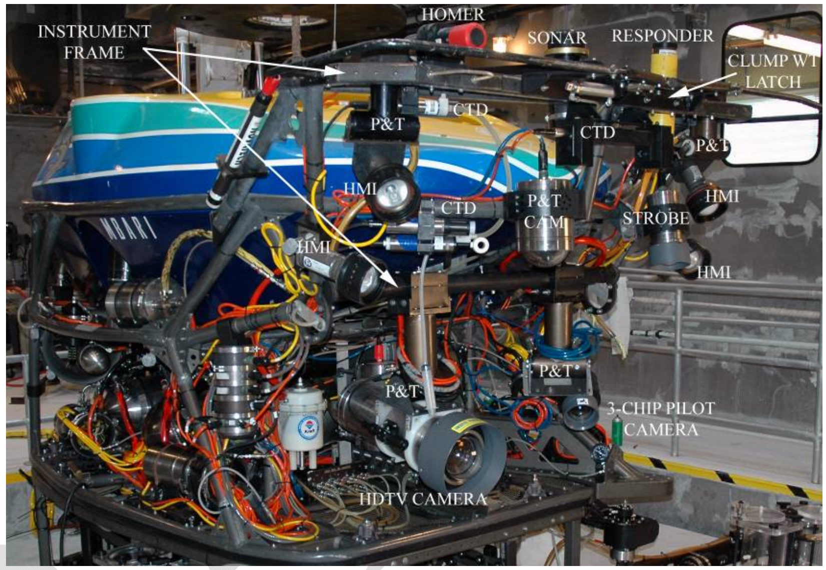
2.1.6 Frame

The vehicle frame shall be manufactured from 6000 series aluminum, non-anodized and anode protected. All frame welding shall be post weld stress relieved, solution heat treated, and aged to original condition as per best shop practice. All structural welds shall be Gas Tungsten Arc Welded (GTAW). Weld appearance and workmanship shall comply with the American Welding Society structural welding code ANSI/AWS D1.1 SECTION

3.0 or equivalent specification for workmanship. The frame will have a through frame lift capacity of 1 ton.

2.1.6.1 Instrument Sub Frame

We would like to propose the idea that MBARI be responsible for the design and layout of the instrument frame and brackets for the core science gear as listed below. MBARI would work in conjunction with SMDH to design a sub-frame that would bolt on to the vehicles main frame. SMDH will provide sufficient mounts on the core frame to support the instrument frame and provide a interface drawing for approval by MBARI. This sub-frame would include the mounts for the majority of MBARI's core instrumentation such as pan & tilts, cameras, sonar, lights, CTD, etc. The Instrument frame would be designed and fabricated by MBARI and integrated to the vehicle upon delivery to MBARI in 2008.

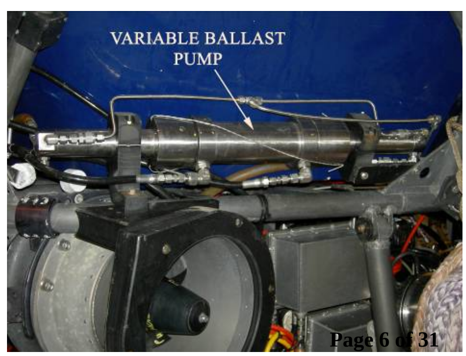


2.1.7 Buoyancy

2.1.7.1 Syntactic Foam Module

The syntactic foam pack is to be rated for 4000 meter operation with less than 3% water absorption over 20 years. Design of the buoyancy module should allow for the placement of a science payload over 200 pounds on the front of the ROV with less than 10 degrees induced pitch. The pack shall provide recesses for the VB spheres and umbilical during launch & recovery. In addition, the majority of MBARI provided instrumentation will be located forward on the Instrument sub frame. The foam pack should have a protective coating such as a sprayed polyurethane finish and color to be determined. ***Please provide foam manufacturers specifications including foam density.***

2.1.7.2 Variable Buoyancy System:



MBARI designed and developed a Variable Buoyancy (VB) control system for assisting in the operational control of Tiburon. The VB system is used primarily to keep the vehicle neutrally buoyant with a secondary function of assisting in the dynamically changing payload to assist in the deployment and recovery of science equipment during a dive without compromising ROV operations. The VB system is not intended to be used for vertical positioning. The VB system uses seawater as the medium for adjusting buoyancy. This is accomplished by opening a valve to flood the buoyancy spheres and lose buoyancy. Gaining buoyancy is accomplished by pumping the entrained seawater out of the spheres. The MBARI provided VB system will be incorporated into the design of the vehicle. Voids in the syntactic foam module will be provided by SMDH to accommodate the VB spheres (4) so as not to clutter the open frame of the vehicle. General specifications are listed below in Table 1:

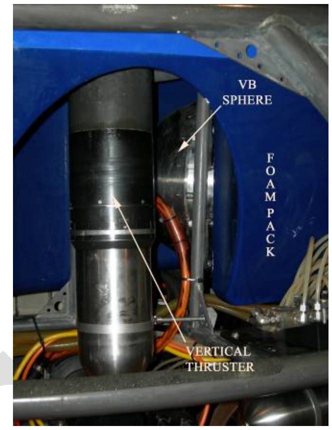


Table 1

VB SYSTEM WEIGHTS (kg)					
Device	*Qty.*	*In air wt*	*Air total*	*In H20 wt.*	*H20 total*
Pump	1	13.18	13.18	9.17	9.17
Sphere (dry)	4	17.39	69.56	-3.68	-14.72
Directional control valve	1	1.36	1.36	1.36	1.36
Flood valve	1	1.5	1.5	1.5	1.5
Plumbing	1	6.82	6.82	5.97	5.97
Total:			***92.42***		***3.28***

The Flood Valve is a specially designed solenoid valve that operates on 24 VDC @ 1A. The VB system can be removed from Tiburon in the first quarter of 2007 and shipped to SMDH's facility for integration. ***Please reply with a timeframe.***

2.1.7.3 Payload

The vehicle outfitted with the core instrumentation as listed below and a MBARI tool sled (1100 pounds in-air/520 pounds in-water) shall support an additional 600 pound science payload and maintain the ability to be neutral in salt water. 150 of the 600 pounds can be variable ballast.

2.1.8 Hydraulics

Hydraulics will be used for propulsion of the vehicle, compensation and the operation of hydraulic tools such as manipulators, vibercoring, dredge pump, cable laying tool sled, collection tools, etc. Refer to Appendix A - Hydraulic block diagram. ***Please provide feedback***

2.1.8.1 Vehicle Power

It is understood that the system proposed is 50 shp. However, MBARI would like to explore any chance of increasing the system closer to 75 shp if possible. ***We would like more input from SMDH on the feasibility of moving up to 75 shp before we specify a vehicle power requirement.***

2.1.8.2 Hydraulic System & Components

The hydraulic system will provide a flow up to 90 lpm at a nominal pressure of 210 bar. The system will include the following:

- Curvetech Hydraulic Power Unit (HPU) – 50 to 75 shp, 3000vac, 4 pole motor with a 70cc/rev on demand pump. Temperature sensors for monitoring motor winding temperature.
- Curvevetech Thruster Control Unit (iTCU) for operation of the thrusters and a spare valve to provide a high flow tooling port. Integral pump load valve, PRV, pressure, temperature, and moisture monitoring.
- Curvetech Intelligent 12 function (15 lpm) valve pack (iHCU) for operation of MBARI core and mission specific equipment. The valve pack will be outfitted with proportional valves which permit the remote control of flow for each valve. Equipped with moisture sensor.
- (4) Curvetech Hydraulic Pressure Compensators – 2.75L rolling diaphragm construction with analog linear level sensors for real time feedback.
- Curvetech Compensator Reservoirs – 15 L with integral 6.3 L compensator with level alarm and oil temperature sensor.
- (7) Curvetech HTE 380 Thruster
- Variable ballast pump supply (up to ~30 lpm) valve for operation of the variable ballast system. ***Not sure how this can be provided without using our one spare tooling port.***
- Tool sled supply (up to ~30 lpm) with quick disconnects (type to be determined).
- Schilling T2 supply.
- High and Low pressure filters

2.1.8.3 Thruster Placement & Capabilities

2.1.8.3.1 Thruster Placement

3 vertical thrusters will be positioned one port and one starboard about 25% back from the front of the vehicle and the third thruster mounted aft central. The MBARI tool sleds when mounted on the vehicle, will not provide an unobstructed path for the vertical down thrust, therefore, the verticals must be angled out sufficiently to provide a clear path for thrust. The horizontal thrusters will be in a conventional vectored configuration, but when performing scientific observations a special thrust control algorithm (Observation Mode) will be selected to minimize the disturbance of the viewing area from thruster wash. When in the Observation Mode, only the rear thrusters will perform fore/aft propulsion and only one set of fore aft thrusters will be used to move the ROV laterally. Details of the algorithm shall be agreed upon by SMDH and MBARI.

2.1.8.3.2 Thrust Capabilities

Power sharing algorithms will be developed to provide a mode of operation that gives priority to vertical or horizontal thrust depending upon the operation at hand. The horizontal thrusters will provide up to 600kg of thrust in both fore/aft and lateral directions. The vertical thrusters will provide up to 500 kg of vertical thrust.

2.2 Electrical / Optical

Refer to Appendix A – Electrical / Optical block diagram. ***This represents MBARI's understanding of how the vehicle hardware will be laid out. Please respond with comments and or corrections.***

2.2.1 Electrical Assemblies

All pressure vessels shall be hydrostatically tested to 1.25 times the operating pressure. An applicable test procedure shall include cycles, hold times, and temperatures as applicable. An appropriate pressure test procedure shall be mutually agreed on between MBARI and SMDH. All 1 atm. pressure housings shall be constructed of Titanium. All pressure compensated housing materials shall provide adequate corrosion prevention for the intended service. ***Please provide feedback***

In addition to SMDH's ground fault detection for the three and single phase AC systems, MBARI will require a ground fault detection scheme to detect and isolate faults on individual DC buses. The system must be able to detect current leakage to sea-water down to approximately 10 micro amps. GFM alarms will be able to be displayed on the GUI and thresholds will be field configurable.

MBARI has designed and implemented a ground fault monitoring board to work with the WAGO 750-477 differential analog input module. The circuit is used to scan the high and low outputs of Vicor DC/DC converters that supply the various regulated DC voltages on the vehicle and detects leakage to sea-water. The individual opto-isolated relays are switched on one at a time by a WAGO 750-530 digital output via the ch. Select (J1 and J2). The sense lines at J2 and J3 are connected to the high and low outputs of the Vicor and J4-1 is connected to frame (sea-water).

MBARI can provide this circuit if SMDH desires.

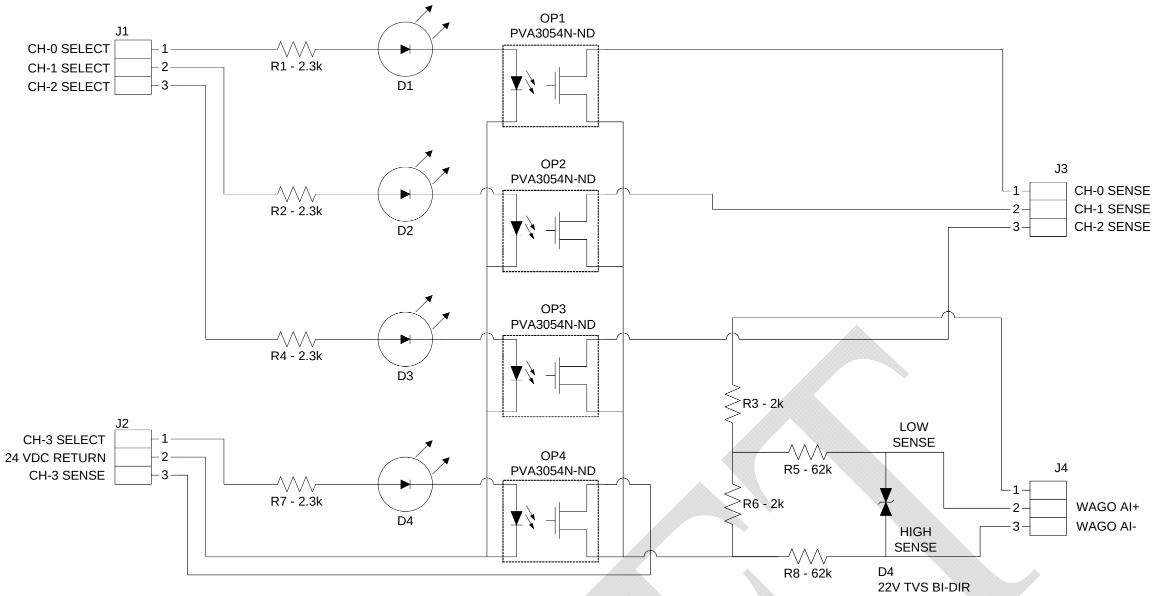


Figure 1: MBARI's GFM board for use with WAGO 750-477 and 750-530.

2.2.2 Sub-Sea Control Pod

The Sub-Sea Control Pod will be a one atmosphere pressure vessel containing the MBARI provided FOCAL multiplexer, various DC supplies and110vac protection and switching. The Sub-Sea Control Pod will provide independent power switching, GFM and isolation for all connected instruments. In addition, mechanical isolation relays will be provided for all serial data lines to assist with fault detection. The Sub-Sea Control Pod will have environmental sensors for temperature, humidity and water intrusion feedback. 10 to 15% of the total internal volume of the control pod will be uncommitted space for future additions. ***MBARI would like to get more detail from SMDH on the design and proposed function of the Sub-Sea Control Pod, so that we can get a better understanding of the vehicle's electrical design and layout***

2.2.2.1 Connectors & Cables

Seacon MINI-CON series connectors will be used for all camera, data and fiber optic ports coming from the Sub-Sea Control Pod. MBARI will provide the cables for all of the MBARI associated equipment and the 4 pass fiber optic connector . SMDH will be responsible for all other connectors on the Sub-Sea Control Pod and any cables that provide connection to other SMDH equipment. Connector material shall be stainless steel type 316 equivalent or better. The pin outs for the camera and data ports are as follows:

Table 2

Composite Camera Port Pin Assignment W/Serial Comms. (MINK-10-FCR)	
Pin	*Function*
1	RS-485(A) or RS-232 (tx from ROV)
2	RS-485(B) or RS-232 (rx from ROV)
3	Power common
5	24 vdc (+)
6	12 vdc (+)
8	Video
10	RS-232 common

Scorpio Strobe Port Pin Assignment (MINK-10-FCR)	
Pin	*Function*
2	Strobe Trigger
3	Strobe Stop
5	5 vdc (+)
10	Common

3 chip (RGB) Pilot Camera Pin Assignment (MINK-19-FCR)	
Pin	*Function*
1	12 vdc (+)
2	12 vdc return
3	Frame ground
4	Blue shield
5	12 vdc (+)
7	RS-232 (tx)
8	Blue video
9	Green shield
10	12 vdc return
11	RS-232 (rx)
12	RS-232 common
13	Green video
15	Red shield
18	Red video

Scorpio Digital Still Camera Pin Assignment (MINK-19-FCR)	
Pin	*Function*
1	12 to 30 vdc (+)
2	Power return
3	Frame ground
4	USB Shield (Picture Download)
5	Strobe Trigger
6	RS-485 shield (GUI)
7	RS-485 DATA+ (GUI)
8	USB DATA+ (Picture download)
9	USB Return (Picture download)
10	Strobe ground
11	RS-485 DATA - (GUI)
12	RS-485 Common (GUI)
13	USB DATA - (Picture download)
14	Video Shield
17	Composite Video
18	Strobe Stop

Composite Camera Port Pin Assignment W/out Serial Comms. (MINK-10-FCR)	
Pin	*Function*
3	Power common
5	24 vdc (+)
6	12 vdc (+)
8	Video

100 mbps Ethernet Pin Assignment (MINK-10L-FCR)	
Pin	*Function*
1	110 vac (1000w)
2	TX +
3	TX -
4	RX +
5	RX -
10	110 vac

2.2.2.2 FOCAL 903 Video/Data Multiplexer

MBARI will provide a FOCAL 903 for the core vehicle with the specifications listed below in Table 3. This system can be provided to SMDH at any time.

Table 3

FOCAL 903 Remote Configuration					
Item		*RS-232*	*RS-485*	*VIDEO*	*100BT*
VIB-TX, REMOTE VIDEO CARD				4	
VIB-TX-8, REMOTE VIDEO CARD (8X4)				8	
FMB (1310/1550)					
EIB-10/100-1470 (1470/1490)					1
8 CH 485, 907-485			8		
DIB-485			5		
DIB-232-16		16			
CBP-241-HR-24V (CHASSIS)					
Totals:		***16***	***13***	***12***	***1***

2.2.3 Main Junction Box

The Main Junction box will be an oiled filled, pressure compensated enclosure which permits switching, control, isolation and ground fault monitoring of the core vehicle and MBARI provided instrumentation. In lieu of connectors for each device controlled from the main j-box, MBARI requests that cable compression gland fittings be used to reduce the number of possible connector failure points. MBARI has designed a fitting that has been in use on both of our vehicles for several years with success and can provide these to SMDH. 10-15% of the internal volume shall be uncommitted for future expansion.

2.2.3.1 Ground Fault Monitoring

If the required DC power for the instrumentation originates from the Main Junction Box, then ground fault monitoring (GFM) will be performed on both the high and low sides of the main DC power buses (24vdc and 12vdc) and the 110vac input.

2.2.4 Auxiliary Interface Junction Box

The Auxiliary (Science) Interface Junction box will be an oil filled, pressure compensated enclosure that provides a flexible interface for mission specific instrumentation. This junction box must provide a wide range of power buses and data protocols to meet the present and future needs of the science and engineering research and development activities. The control of the Auxiliary J-box will be handled through the core vehicle control software and MBARI must be able to easily configure the GUI to accommodate future analog and digital I/O requirements. The junction box will have a water intrusion detection circuit. Refer to Appendix A – Auxiliary (Science) Junction Box block diagram for more details.

2.2.4.1 Auxiliary Power Requirements

The total auxiliary power requirement for the vehicle is 3000 watts. The J-box will have inputs providing 110vac limited at 1000 watts and 240vdc limited at 2000 watts. These main inputs will have some sort of remote or thermal reset current limit device to provide overload protection. The 240vdc will provide power to Vicor DC/DC converters that provide regulated 48vdc @ 150watts, 24vdc @250w and 12vdc @ 150w. Additional space in the J-box will be provided to add another Vicor module if required in the future. The individual bus voltages will have switched (high and low isolated) outputs and power ratings as listed below in Table 4.

Table 4

Bus Voltage Outputs and Power Ratings		
Bus	*Number of Outputs*	*Switch Rating (watts)*
110vac	2	1000
240vdc	2	1000
48vdc	1	600
24vdc	8	12
12vdc	4	6

2.2.4.2 Auxiliary Data Requirements

MBARI will provide a Prizm Mini Mux II fiber optic video and data multiplexer to meet the Auxiliary J-box data requirements. A minimum of (2) RS-232 channels will have relays to allow for remote mechanical isolation of the data and ground lines from the multiplexer port. The MiniMux II is pressure tolerant to 4000 meters and has data I/O as listed below in Table 5. This unit can be supplied to SMDH at any time.

Table 5

PRIZM MINI MUX II Configuration						
Item			*RS-232*	*RS-485*	*VIDEO*	*10BT*
Mother board			2	1	2	
Ethernet daughter board			4			1
		Total:	***6***	***1***	***2***	***1***

2.2.4.3 Connectors & Ports

The J-box will have a minimum of (12) ports for instrumentation, (1) RS-485 data port for control of the J-Box I/O, (1) fiber port for the MINI MUX and (1 to 2) ports for the incoming power buses. MBARI will provide in-house designed and fabricated gland fittings for the power and data ports.

2.2.4.4 Ground Fault Monitoring

Ground fault monitoring (GFM) will be performed on both the high and low sides of the Auxiliary J-box's four main DC power buses (240vdc, 48vdc, 24vdc and 12vdc) and the 110vac input. Two spare GFM channels are required for future expansion.

2.2.5 Lighting Junction Box

The lighting junction box will be an oiled filled, pressure compensated enclosure that supports the operation of (6) DeepSea Power & Light, 400 watt SeaArc 2 HMI/MSR lamps and (4) 250 watt incandescent lights provided by MBARI. Three dual ballasts which are housed in 1 atm housing will be provided for the operation of the SeaArc HMI lights. The junction box will provide on/off control of all the light circuits and dimming capability for the incandescent lights. In addition, the Lighting Junction box will provide ground fault monitoring for each light circuit and the capability to isolate the fault. The junction box will have a water intrusion detection circuit.

MBARI will provide compression gland fittings for the Junction box and all the cables required for the operation of the lights.

2.2.6 Umbilical Termination Junction Box

The Umbilical Termination Junction box will be an oiled filled, pressure compensated enclosure. It will be designed to be as compact as possible and positioned on the vehicle to provide easy access for fast connect/disconnect of the umbilical. The umbilical will enter the j-box through a compression gland fitting (TBD). Burton HV connectors will be used to distribute the HPU and ROV instrument power. A Seacon MINP-4FO-FCRL-RL-TI, 4 pass single mode fiber connector and MINP-4FO-CCPL-TI cable will be provided by MBARI for connection of the fibers to the sub-sea control pod. In addition, MBARI will also provide a Seacon MINF-1FOSM-BCRL-TI connector and associated cable for direct connection of the HDTV camera. The junction box will have a water intrusion detection circuit.

2.2.7 ROV Instrument Power Transformer

2.2.8 Core Instruments (MBARI Provided)

Tiburon II core instrumentation and associated cables as listed below in sections 2.1.4.1 thru 2.1.4.3 will be provided by MBARI. Since the equipment is being transferred from the original Tiburon to Tiburon II and Tiburon will remain operational until June of 2008, it won't be possible to provide all of this equipment for test and integration at SMDH's facility. ***SMDH should provide MBARI with a list of specific equipment that they feel is essential for test and integration of the vehicle and we will try to accommodate with available spares or removal from operations.***

2.2.8.1 Navigation

Table 6

NAVIGATION SYSTEMS													
Device	*232*	*485*	*422*	*TTL*	*10BT*	*100BT*	*Video*	*240v*	*48v*	*24v*	*12v*	*5v*	*Watts*
usbl				1						1			30
gyro	1									1			12
sonar	1									1			24
homer	1									1			12
dvl	1								1				5
depth sensor	1									1			0.5
altimeter	1									1			6
Total:	***6***	***0***	***0***	***1***	***0***	***0***	***0***	***0***	***1***	***6***	***0***	***0***	***89.5***

Table 7

NAVIGATION WEIGHTS (kg)					
Device	*Qty.*	*In air wt*	*Air total*	*In H20 wt.*	*H20 total*
DVL	1	18	18	12.1	12.1
Octans	1	18	18	9	9
Altimeter	1	5	5	2.7	2.7
Depth sensor	1	1.33	1.33	1.33	1.33
Homer	1	2.1	2.1	1.3	1.3
Responder	1	4.5	4.5	2.5	2.5
VHF radio beacon	1	1.6	1.6	0.95	0.95
Xenon strobe	1	1.7	1.7	1	1
Sonar	1	6.4	6.4	3.3	3.3
Total:			***58.63***		***34.18***

2.2.8.2 Cameras & Viewing

Table 8

CAMERA & VIEWING													
Device	*232*	*485*	*422*	*TTL*	*10BT*	*100BT*	*Video*	*240v*	*48v*	*24v*	*12v*	*5v*	*Watts*
HDTV										1			53
pilots camera	1						3				1		6
digital still		1					1				1		6
digital strobe												1	100
down camera	1						1				1		6
umbilical camera							1			1			5
aux cameras							4			4			20
pan & tilts		1								4			75
Total:	***2***	***2***	***0***	***0***	***0***	***0***	***10***	***0***	***0***	***10***	***3***	***1***	***271***

Table 9

CAMERA AND VIEWING WEIGHTS (kg)					
Device	*Qty.*	*In air wt*	*Air total*	*In H20 wt.*	*H20 total*
HDTV	1	36.7	36.7	16.8	16.8
Pilot camera	1	5.67	5.67	2.95	2.95
Still camera	1	5.67	5.67	2.95	2.95
Strobe	1	5.67	5.67	2.95	2.95
Internal P&T camera	1	11.8	11.8	6.4	6.4
Aux camera	4	0.4	1.6	0.28	1.12
PT-10	2	4.4	8.8	4.2	8.4
PT-25	2	9.8	19.6	5.7	11.4
HMI Ballast	3	15.56	46.68	9.29	27.87
HMI Light	6	3.67	22.02	1.8	10.8
Incandescent Light	4	1.25	5	0.57	2.28
Total:			***169.21***		***93.92***

2.2.8.3 Science Tools

2.2.8.3.1 Tool Sleds

In addition to the core vehicle, MBARI has individual tool sled packages designed for specific science missions that are always coupled to the vehicle. MBARI will design and build the tool sleds to bolt on to the bottom of the core vehicle. MBARI will provide the tool sled hardware (guide cones) required for the attachment of the sleds. The weight of each Tool sled will not exceed 1100 lbs. in air and 450 lbs. in water. The 600 lbs payload requirement is in addition to the weight of the tool sled. The Kraft manipulator is part of the tool sled and therefore the weight is included in the tool sled total weight. Interconnect requirements are as follows:

- RS-232 data channel for operation of the tool sled controller.
- RS-422 data channel for operation of the Kraft manipulator.
- 48 vdc @ 5 amps (unregulated) for tool sled controller power
- 240 vdc @ 4 amps (unregulated) for tool sled tools.
- Two video channels for tool sled cameras.
- Hydraulics requirement, >= 8 gpm @ 3000 psi. (quick disconnects TBD)

Table 10

TOOL SYSTEMS													
Device	*232*	*485*	*422*	*TTL*	*10BT*	*100BT*	*Video*	*240v*	*48v*	*24v*	*12v*	*5v*	*Watts*
ctd	1									1			5
toolsled interface	1						2	1	1				1200
vb valve										1			50
acoustic modem	1									1			30
kraft			1							1			
schilling	1								1				72
Total:	***4***	***0***	***1***	***0***	***0***	***0***	***2***	***1***	***2***	***4***	***0***	***0***	***1357***

Table 11

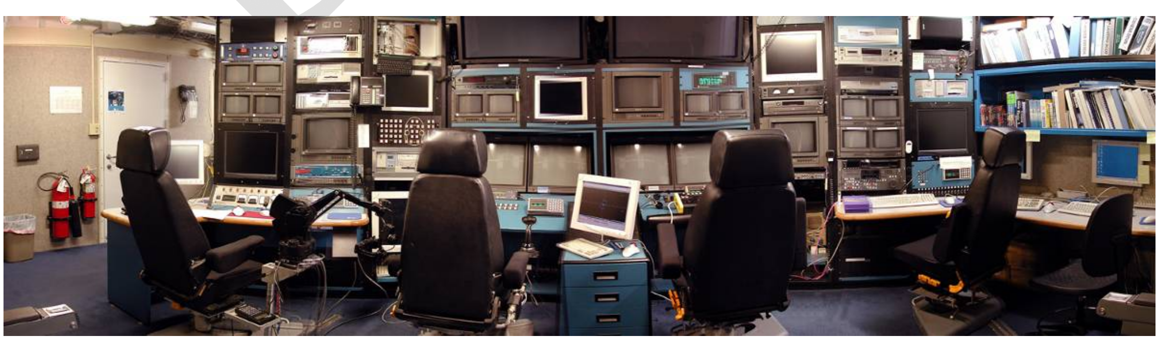
TOOL WEIGHTS (kg)					
Device	*Qty.*	*In air wt*	*Air total*	*In H20 wt.*	*H20 total*
Schilling	1	90.9	90.9		0
Kraft	1	72.7	72.7	44.54	44.54
CTD	1	13.7	13.7	8.6	8.6
Tool sled attachments	4	0.9	3.6	0.8	3.2
Clump weight latch	1	6.81	6.81	5.75	5.75
Acoustic modem	1	2.75	2.75	2.1	2.1
Emergency cutter	1	2.27	2.27	1.81	1.81
Tool Sled	1	613.81	613.81	190.68	190.68
Total:			***806.54***		***256.68***

2.3 Surface Control Equipment and Power Distribution

Refer to Appendix A – Surface Block Diagram for MBARI's interpretation of the configuration of the top side hardware. ***Please provide feedback.***

2.3.1 Control Room

The panoramic view of Tiburon's control room is shown below. Starting at the far left is the Co-pilots station. The co-pilot is responsible for manipulator, sonar and other instrument operations, umbilical haul in / pay out and alarm & data monitoring. The pilots station is next and the then the chief scientist and co-scientist. MBARI will utilize as much of the control room equipment as possible.



2.3.2 Control System

The Control system must provide interfaces that are designed to be flexible and configurable to allow easy integration of third party systems into the control system.

2.3.2.1 Software

2.3.2.1.1 Graphical User Interface (GUI)

The system must provide at a minimum, 3 work stations with Graphical User Interfaces (GUI) for control and monitoring of vehicle systems. The individual GUI screen layouts must be able to be expanded or modified by MBARI when required. The GUI's must support touch screens. An example of MBARI required graphical, in addition to numeric displays are as follows:

- Graphic display of vehicle thrusters and level of thrust commands
- Pitch & Roll (some type of artificial horizon)
- Pan & Tilt feedback (x,y graph type display)
- Turns counter history with set point (compass rose showing set point and vehicle heading history).

Numeric displays are required for the following MBARI items:

- HDTV camera lens feedback (focus, zoom and Iris)
- Umbilical out (Delta)

A list of standard GUI items will be finalized during the preliminary design review.

2.3.2.1.2 Joy Stick Integration

Tiburon's existing joysticks will be incorporated into the new vehicle system. MBARI can provide Tiburon's spare joysticks to SMDH for integration and testing when required.

Some operational tasks require the ROV to track very delicate animals in the mid-water column. MBARI has utilized the capability to reduce the thruster output by scaling the joystick command output to allow for finer control of the vehicle during these maneuvers. MBARI will require this capability to be incorporated into the vehicle.

During sample collection activities, the pilot is sometimes required to precisely position the vehicle to place a specimen in a sampler and then quickly close the door to that sampler to capture the animal. The pilot can't afford to let go of the joystick to activate the hydraulic valve through the GUI, so we currently provide the capability to map a particular valve in advance to a button on the joystick. This allows the pilot to never have to take his eyes off the screen nor hands off the joystick. A summary of the integration of control system items with the joy sticks are as follows:

- Button on main joystick for enable/disable of MBARI observation mode. When the observation mode is enabled by the joy stick, the joy stick command is scaled to the percentage that is selected on the GUI. When the observation mode is disabled, the joy stick command is set back to 100%

- (2) Buttons on vertical joystick for enable/disable of vertical and main joy stick lock. The vertical or main joy stick command value is locked, when the joystick lock button is activated. After the joystick value is set and the input from the joystick is returned to zero, if a new joystick value of 50% or greater is detected, the joystick lock is disabled. The joystick lock is also disabled when the button is pressed again after lock condition is set.
- Switch on main joystick for operation of mapped valve from GUI.
- Trigger on main joystick for enable/disable of AutoROV Heading function.

The specifications for the joy sticks are as follows:

- *Vertical axis:* (Measurement Systems, Inc. P/N = 523U).
- *Horizontal axis:* (Measurement Systems, Inc. P/N = 547 – 3 axis)

2.3.2.1.3 Focal Video Switcher

The MBARI provided Focal 903 multiplexer has one 8x4 video card (8 switched to 4) which can take 8 input channels of video and via the FOCAL console, select 4 channels for output. The control of the video switcher is performed through the FOCAL console mux by providing +5vdc to 4 channels to select Video input A or B. The control of the FOCAL video switcher shall be incorporated in to the control system and the switcher operated through the GUI.

2.3.2.1.4 Advance Navigation Controls (MBARI R&D)

Tiburon currently supports an interface that allows an external controller to receive real-time ROV telemetry. The interface also executes ROV thrust commands sent by the external controller. The ROV telemetry data and thrust commands are sent and received by the Tiburon control system over a serial port. The Tiburon control system sums the received thrust commands with the pilot joystick commands to allow the pilot to assist or disturb the external controller. The Tiburon control system also monitors a digital input, the closure of which disables the external controller interface. An emergency cutoff button is attached to this digital input to allow the pilot to immediately disable external control.

Tiburon II shall support a similar advanced controls interface to allow for the control of the ROV by an external controller. The data in table 12 shall be sent to the advanced controls interface from the Main Control Computer via a serial connection. The data is required to have a latency of no more than ??? ms. The data string shall be sufficiently flexible as to allow for the addition of future data items with minimal configuration changes. The format of the data string as well as the serial port configuration shall be agreed upon by MBARI and SMDH.

The Main Control Computer shall also receive thrust commands as shown in table 13 from the advanced controls interface and sum those commands with the pilot commands in real-time. The format of the command string shall be agreed upon by MBARI and SMD.

Table 12

SMD control system data to be sent to Advanced Controls Interface		
data	*type*	*units*
Heading	float	degrees
Pitch	float	degrees
Roll	float	degrees
Depth	float	meters
Altitude	float	meters
AutoHead state	boolean	N/A
Emergency Cutoff state	boolean	N/A
Observation Mode state	boolean	N/A
Bypass Mode state	boolean	N/A
Heading Thrust	float	TBD
Lateral Thrust	float	TBD
Axial Thrust	float	TBD
Vertical Thrust	float	TBD

Table 13

Advanced Controls Interface commands sent to SMD control system		
data	*type*	*units*
Heading Thrust	float	TBD
Lateral Thrust	float	TBD
Axial Thrust	float	TBD
Vertical Thurst	float	TBD

2.3.2.1.5 Navigation Processor

The MBARI Navigation Processor or NavProc is a computer that interfaces various ship and ROV navigations systems together. NavProc can send and receive data over serial ports or via a proprietary publish/subscribe data distribution system know as Datamanager. Once data has been published to Datamanager any other Datamanager node on the network can subscribe to that piece of data.

The data in Table 14 shall be sent to the NavProc computer from the Main Control Computer via a serial connection. The data is required to have a latency of no more than (TBD) ms. The data string shall be sufficiently flexible as to allow for the addition of future data items with minimal configuration changes. The format of the data string as well as the serial port configuration shall be agreed upon by MBARI and SMD.

The Main Control Computer shall also receive MBARI system variables as shown in table 15 to be displayed on the GUI. The format of the data string shall be agreed upon by MBARI and SMD.

Table 14

SMD control system data to be sent to NavProc		
data	*type*	*units*
Vehicle in water	boolean	N/A
Heading	float	degrees
Pitch	float	degrees
Roll	float	degrees
Altitude	float	meters
Depth	float	meters

Table 15

NavProc System Data sent to SMD control system		
data	*type*	*units*
Umbilical payout	float	meters
Umbilical delta	float	meters
HDTV humidity	float	percentage
HDTV leak detect	boolean	N/A
HDTV zoom position	float	TBD
HDTV focus position	float	TBD
HDTV iris position	float	TBD

2.3.2.1.6 Video Overlay

Tiburon II will use the Options VIGRA video overlay to display vehicle information on the pilots video display. The VIGRA overlay system can receive this data via a serial or TCP connection.

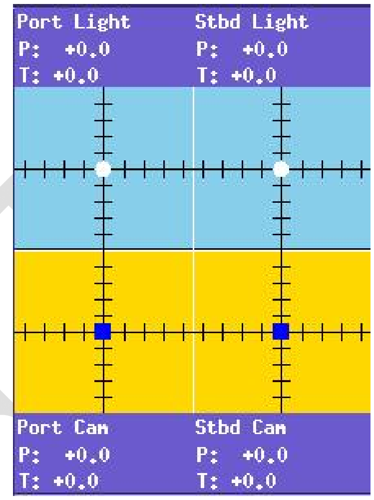
The data in table 16 shall be sent to the VIGRA overlay unit from the Main Control Computer via a serial or TCP connection. The data is required to have a latency of no more than (TBD)ms. The data string shall be sufficiently flexible as to allow for the addition of future data items with minimal configuration changes. The format of the data string as well as the serial port configuration shall be agreed upon by MBARI and SMD.

Table 16

SMD control system data to be sent to VIGRA overlay Unit		
data	*type*	*units*
Heading	float	degrees
Hydraulic Pressure	float	PSI
Depth	float	meters
AutoHead state	boolean	N/A
Altitude	float	meters
Divenumber	integer	N/A
Date	string	date string

2.3.2.1.7 *Integrated Viewing System*

Tiburon currently uses an integrated viewing system or IView to control the camera and light pan and tilts. This system allows the control of the cameras to be shared between the pilots and scientists. The IView system also supports special viewing modes that have proven useful in different observation scenarios.



Though the pan and tilts will be controlled via the IView controller it is necessary to have the pan and tilt positions displayed both graphically and numerically on the pilot GUI for diagnostic purposes. In order to display the pan and tilt positions on the pilot GUI the Main Control Computer shall receive pan and tilt data as shown in table 17 via a serial string. The format of the serial string shall be agreed upon by MBARI and SMD. The data shall be displayed on the pilot GUI both graphically and numerically in a similar fashion as shown in figure to the right. The layout of the pan and tilt portion of the GUI shall be agreed upon by MBARI and SMD.

Table 17

IView pan and tilt data sent to SMD control system		
data	*type*	*units*
Port light pan	float	degrees
Port light tilt	float	degrees
Starboard light pan	float	degrees
Starboard light tilt	float	degrees
Port camera pan	float	degrees
Port camera tilt	float	degrees
Starboard camera pan	float	degrees
Starboard camera tilt	float	degrees

2.3.2.2 Control System Hardware

2.3.2.2.1 *SMDH Hardware*

All SMDH control system hardware such as PC's, monitors, etc. must run on 110VAC/60Hz.

2.3.2.2.2 *Video Equipment*

MBARI will provide all the associated equipment such as monitors, recording decks, video overlay, control room video switcher, video distribution and conversion equipment.

2.3.2.2.3 MBARI Core Instrumentation

MBARI will provide all the associated equipment required to support MBARI core instrumentation such as PC's, cabling and deck boxes.

2.3.3 ROV Auto Functions

The vehicle will have the following suite of automatic control routines:
SMDH – Please provide what the accuracies are for the following functions

- Auto Depth. ROV automatically remains at a constant water depth (+/- 1 meter?). This function will incorporate a nudge feature to modify the current set point.
- Auto Altitude. ROV automatically remains at constant distance from the seabed (+/- .2 meters?). Feedback will be provided from an altimeter or DVL. This function will incorporate a nudge feature to modify the current set point.
- Auto Heading. ROV automatically maintains a constant heading (+/- 2 deg.?). Feedback will be provided by the vehicle's FOG. This function will incorporate a nudge feature to modify the current set point.
- Auto Hold. ROV maintains current position in X and Y (+/- x cm). Feedback will be provided by the DVL when bottom lock is available and by the Sonardyne fusion system when bottom lock is not available. This function will incorporate a nudge feature to modify the current set point.
- Auto Step. ROV moves a user input distance in X and/or Y direction (+/- x cm). Feedback will be provided by the DVL. This function will incorporate a nudge feature to modify the current set point.
- Auto Home. ROV automatically returns to a preset "home" position (+/- x cm). Feedback will be provided by the DVL.
- Auto Track. ROV automatically follows pipe / cable using TSS or equivalent tracking device. SMDH will provide description of input protocol for Auto Track.
- Auto Route. ROV automatically follows a pre-programmed route of waypoints.
- Thruster Plane Priority. Vertical or horizontal thrusters are selected to take priority.
- Control Reversal. Joystick commands are reversed for moon pool launch & recovery operations.
- Lost Thruster Compensation. If a thruster fails, it can be isolated and the control system will modify control algorithms to compensate.
- Pitch, Roll, Horizontal and Vertical Trims.

2.3.4 Power Distribution

2.3.4.1 Western Flyer Power

The Western Flyer is a diesel electric propelled vessel with SCR controllers and therefore ships power is considered noisy. The figures below are screen captures from a scope which show the effects of the SCR drives on the main power during different modes of thrusting while in DP.

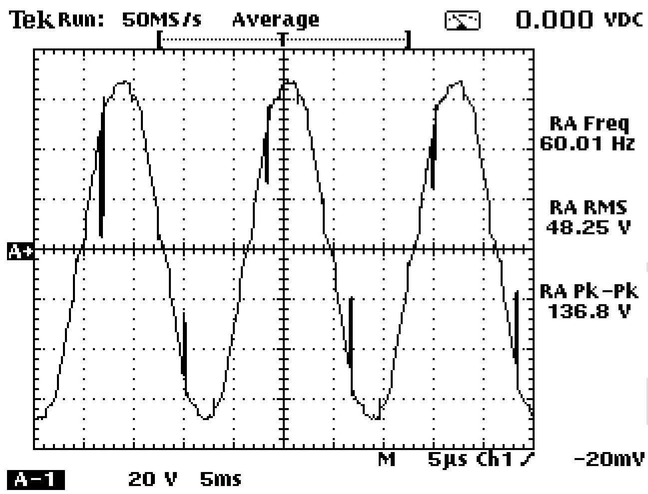


Figure 2: Snap shot (10x probe) of the Western Flyer power with minimal thrust.

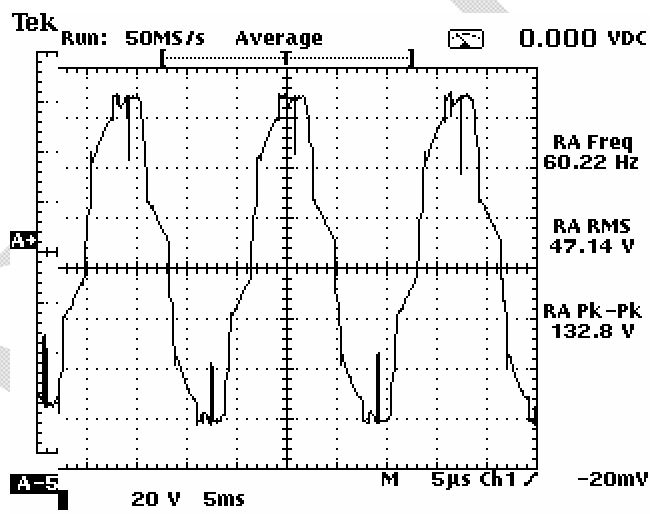


Figure 3: Snap shot (10x probe) of Flyer power with moderate thrust.

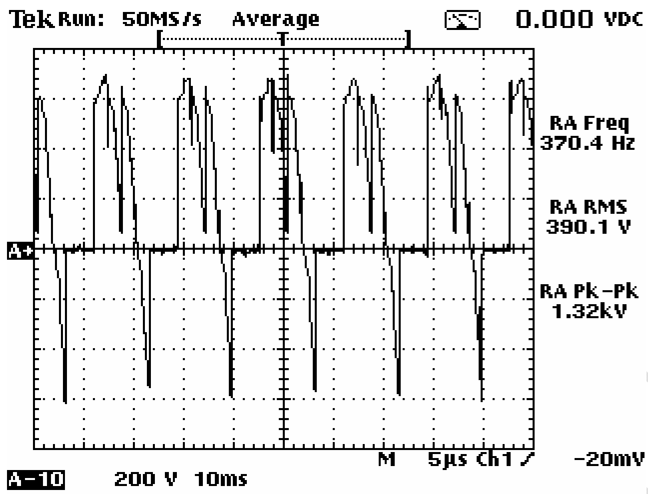


Figure 4: Snap shot of Flyer power with heavy thrust.

The Western Flyer power specifications are 480 vac 3 phase (delta) – 60 Hz / 400 amps. MBARI would prefer to utilize the current Tiburon power conditioning equipment on the Western Flyer for the single phase (60Hz) instrument power, since there are 3 of these units on the Flyer (one for ROV service, one for ship service and one spare) and are built into the machinery spaces. The specifications for the units can be found at http://www.pacificpower.com/products/ms-series.aspx.

2.3.4.2 High Voltage Systems & GFD and Interruption

Both high voltage single phase and HPU 3 phase power shall be continually monitored the insulation of the umbilical conductors. If insulation falls below a preset level an alarm will sound and if it falls below a lower preset level the high voltage power to the ROV is shut off. The PDU and high voltage transformers systems shall be manufactured to IMCA (AODC) guidelines. ***Please provide feedback on dimensions and what is considered a suitable location for PDU and transformers. (Is an air condition space required?) Is there any other type of remote display of PDU information such as temperature of transformers, single and 3 phase currents, etc.?***

2.4 Deployment System

2.4.1 Umbilical Handling System (UHS)

The UHS is designed to deploy, tend, recover and store 5000 meters of 0.68 inch diameter armored umbilical. The ROV & UHS consists of a traction winch, storage drum, motion-compensated crane and ROV launch & recovery crane. The system was designed and built by Dynacon Inc.

2.4.1.1 Slip ring

The current UHS slip ring for Tiburon will be replaced with a PRIZM Model CK7206 which provides 7 single mode fiber passes with < 4db attenuation for any pass and 20 power rings (5 sets of 4 rings) rated at 5000 volts @ 20 amps maximum.

2.4.2 Launch & Recovery System (LARS)

The R/V Western Flyer is a dynamically positioned SWATH vessel with a dedicated moon pool for launch & recovery of the ROV. The launch process starts with the ROV picked up using an articulated crane outfitted with a motion-damped docking head. The umbilical and its mechanical termination pivots aft at the latch and is laid down flat in a recess in the foam pack to allow the docking head to make positive contact with the foam pack. The vehicle is attached to the crane through a spectra braid lift line. The moon pool doors are opened, the crane is tipped down and the winch is operated to lower the vehicle in water. The vehicle is outfitted with a motorized latch for release of the spectra braid line once the ROV is in the water. The umbilical is deployed through the Dynacon motion-compensated crane. Before deployment, floats and a second spectra lift line are attached to the first 30 meters of umbilical from the ROV for recovery.

The recovery process starts by deploying a clump weight / guide wire in the moon pool area to a depth of approximately 50 meters. The vehicle is equipped with a guide wire latch on the bow that allows it to couple on to the wire. The vehicle locates the guide wire on sonar at a depth of about 40 meters, flies in on the wire and attaches to it. The ROV then ascends to a depth of 25 meters where the previously attached second spectra line is attached to the recovery crane. The vehicle continues its ascent up the guide wire until it reaches the surface and is then winched in to the docking head of the crane, lifted through the moon pool, and placed on deck.

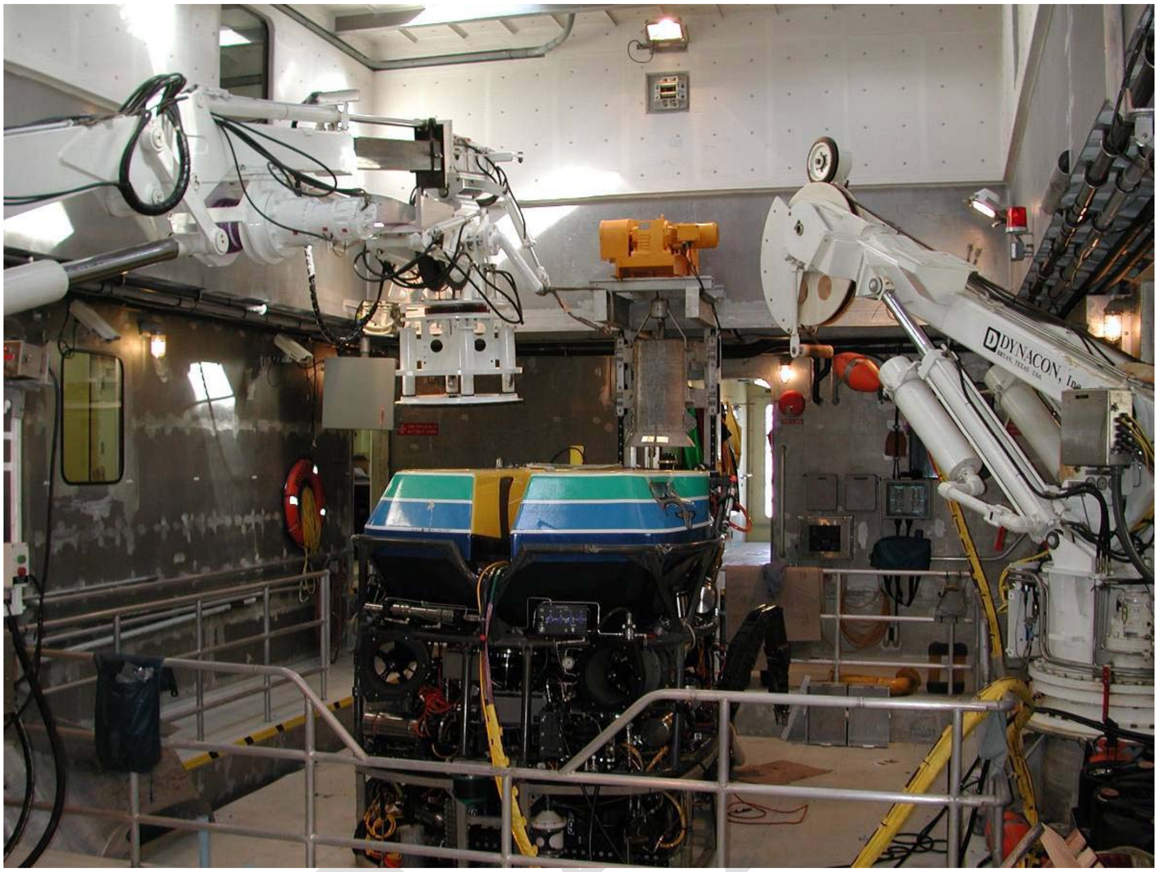


Figure 5: Western Flyer LARS / Moon Pool Area.

2.4.2.1 Remote Belly Pack

A belly pack for control of the vehicle during launch and recovery of the vehicle as it transits through the moon pool interface is required. The current belly pack has joysticks for thruster control, display for depth and and buttons to enable/disable auto heading & depth functions.

Figure 6: Remote Belly Pack in Moon Pool Area.

2.4.2.2 Vehicle Latch

After reviewing the existing Tiburon launch & recovery latch. It has been determined that it is not capable of supporting the increased weight of the new vehicle. Therefore, a design is required to accommodate the release of the synthetic lift line from the vehicle during the deployment operation. One of the 12 hydraulic valves can be used to release a pin if desired.

2.4.3 Umbilical Cable

2.4.3.1 Cable Specifications

The provided umbilical must be compatible with MBARI's UHS on board the RV Western Flyer and suitable for deep water (4000 meters) ROV operations. The umbilical shall support its own weight and the dynamic loads produced by the ship (estimated at 1.52 G's). The umbilical is not required to support the load of the ROV in air. The ROV will be deployed and recovered by a separate line. The umbilical shall provide a minimum 5 years of service in a dynamic ocean environment. It shall be SMDH responsibility to insure that ROV and all sub systems work as expected through the provided umbilical at full operational depth (4000 meters). The general specifications for the umbilical are as follows:

- Length - The delivered umbilical shall not be less than 5000 meters.
- Finished Diameter – The umbilical diameter shall be 17.3 +/- .18mm
- Fibers – There shall be 5 single mode fibers. Attenuation in each fiber under the working load and pressure will not exceed .4 db per kilometer at 1310 and .3 db per kilometer at 1550 nm. wavelengths.
- Induced Rotation – Free end rotation shall not exceed .5 deg/m at loads up to 60kN
- Weight – 1110 kg/km in air, 870kg/km in water.
- Minimum Bend Radius – 210mm (static), 230mm (dynamic)
- Minimum Breaking Load – 180kN
- Working Load – 60kN

2.4.3.2 Testing

The purpose of the testing is to demonstrate the suitability of the umbilical for the normal service conditions encountered by the ROV. The umbilical shall be tested to show that it meets the specification to which it was manufactured. This test procedure is to be agreed between SMDH and MBARI with the following used as a guide line:

- Production Testing – Performed by the umbilical manufacture during production.
    - Dimensional – Size of components, insulation thickness, lay lengths, copper polyester tape overlap, sheath thickness and diameter.
    - Electrical – High voltage and insulation resistance test at 5kVdc, conductor resistance, capacitance, screen resistance, Impedance and attenuation on the quad.
    - Optical – OTDR traces on all fibers both prior to lay-up and on completed umbilical (measured at 1300 and 1550 nano meters.
    - Strength – A sample will be tested to destruction in a tensile test machine. The minimum value to be attained is 180kN.
- Functional
    - Load & Elongation – Elongation against load, overall diameter against load, optical attenuation, electrical continuity

  - Rotation – Rotation of umbilical under working load.
  - Bend Cycling Under Load – Assess the effects on the electrical and optical properties resulting from bend cycling under load.
- Hydrostatic Pressure – (6000 psi)
  - Electrical – conductor resistance and core insulation resistance.
  - Optical – OTDR traces on all fibers measured at 1300 and 1550 nano meters.
- Material Tests – Ensure that all materials are compatible with the type of oil (Shell Tellus or equivalent) to be used with the umbilical termination j-box
- Thermal Behavior – Thermal behavior of the cable will work with MBARI's UHS drum with nominal amount of current load.

2.4.3.3 Terminations

A suitable means for a mechanical termination and strain relief of the umbilical to the vehicle shall be provided. The strain relief and termination must be able to pivot aft to a horizontal position and recessed to allow for the mating of the LARS docking head.

3 Documentation

A complete documentation set for the operation and maintenance of the ROV system will be provided, comprising of the following:

- Equipment specifications and description
- Equipment operating procedures
- Maintenance procedures
- Relevant assembly drawings
- Electrical and hydraulic circuit diagrams
- Parts lists
- Software description and user interface instructions
- Proprietary equipment manuals
- Equipment interface documents

Three paper copies of the above documentation will be provided along with three electronic copies stored in Adobe Acrobat format on CD. Electrical and hydraulic circuit diagrams will be provided as a separate document in electronic DXF or DWG format to allow MBARI to update the documents as hardware is changed or upgraded.

4 Spares

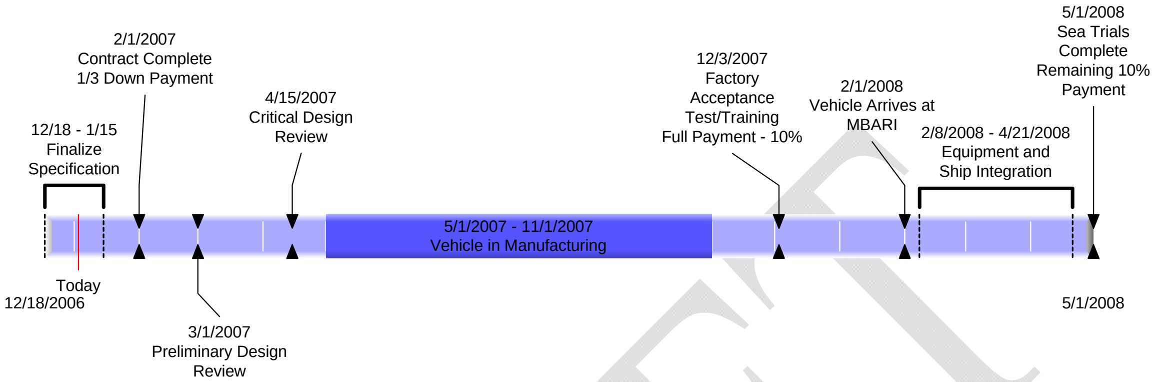
Please provide a recommended spares list

5 Design Review and Acceptance Testing

As part of the design process, MBARI will participate in a minimum of a preliminary and critical design review at the offices of SMDH. MBARI will witness the FAT and will sign off against each of the agreed tests during the FAT. FAT test will be agreed upon by SMDH and MBARI during the PDR.

6 Milestones & Payment Schedule

Please provide corrected dates for milestones and manufacturing interval. Are there additional milestones that SMDH would like to add?



7 MBARI Project Team Contact Information

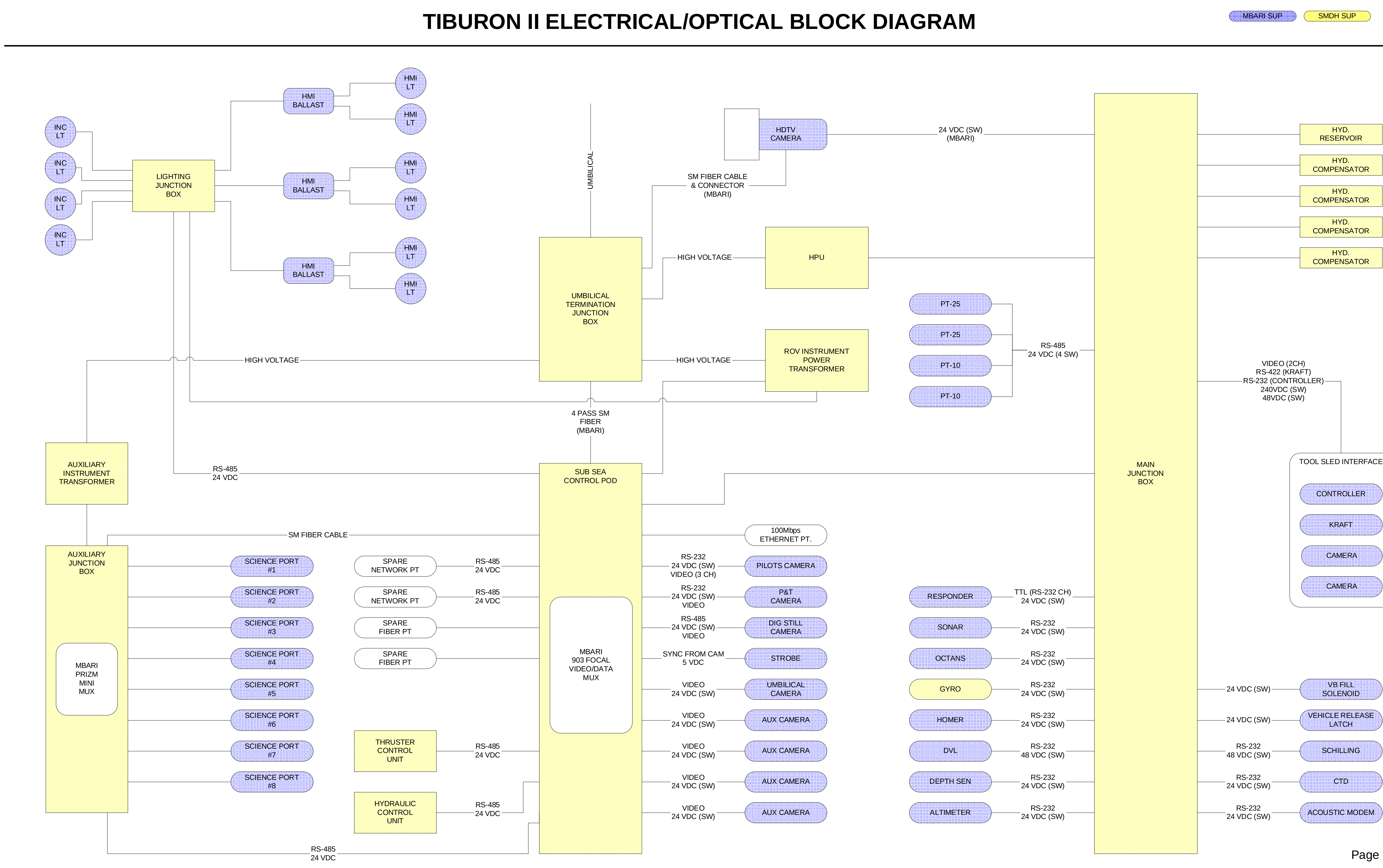
Program Manager:	Dale Graves,	Ext.	1913	grda@mbari.org
Program/Software Engineer:	Mike Risi		1834	mrisi@mbari.org
Program Scientist:	Jim Barry		1726	barry@mbari.org
Mechanical Engineer:	Brett Hobson		1941	hobson@mbari.org
Mechanical Engineer:	Mark Brown		1939	mob@mbari.org

Appendix A

Block Diagrams

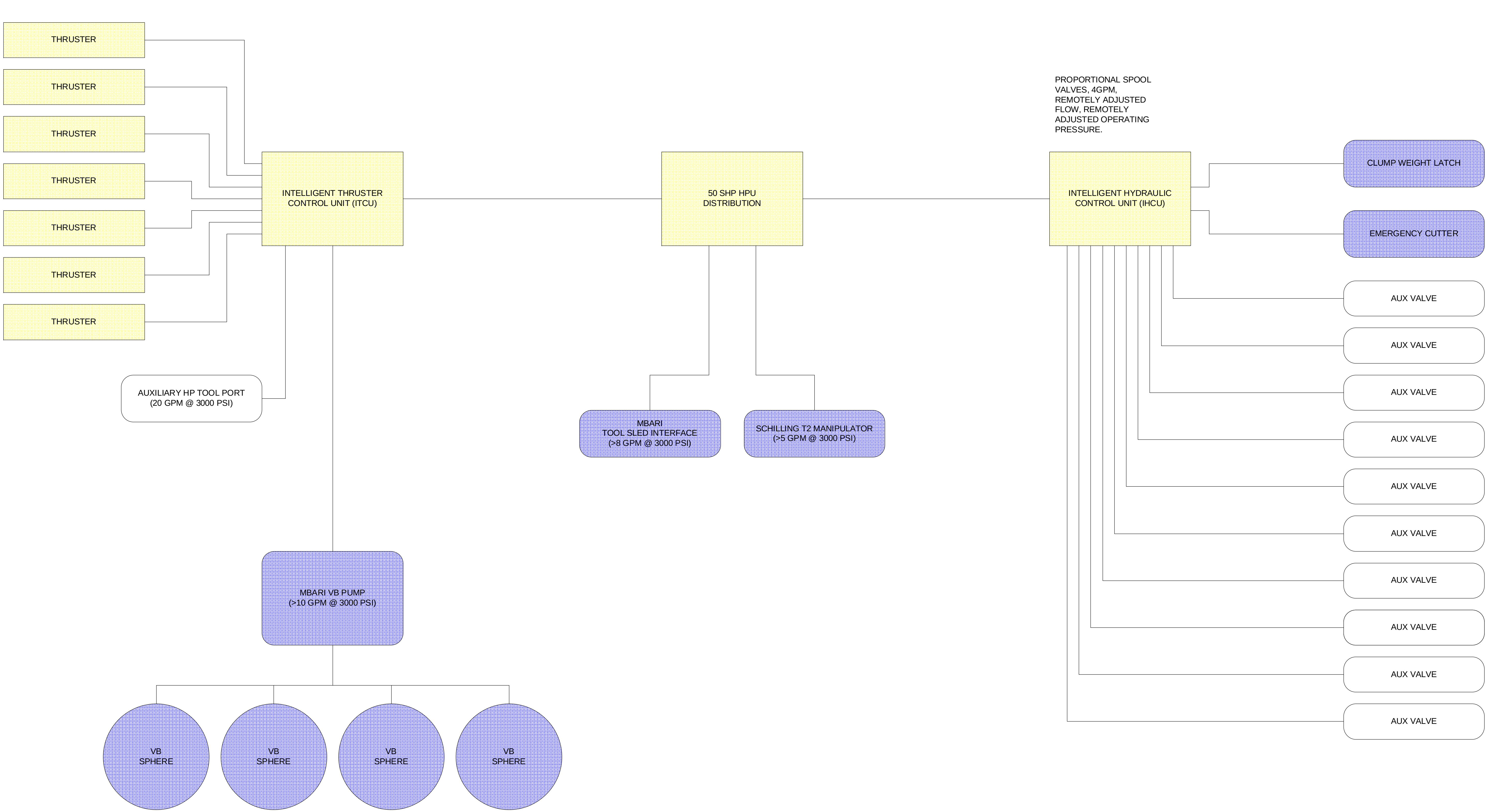
Electrical / Optical Block Diagram
Surface Block Diagram
Hydraulic Block Diagram
Auxiliary (Science) Interface J-Box Block Diagram

TIBURON II ELECTRICAL/OPTICAL BLOCK DIAGRAM



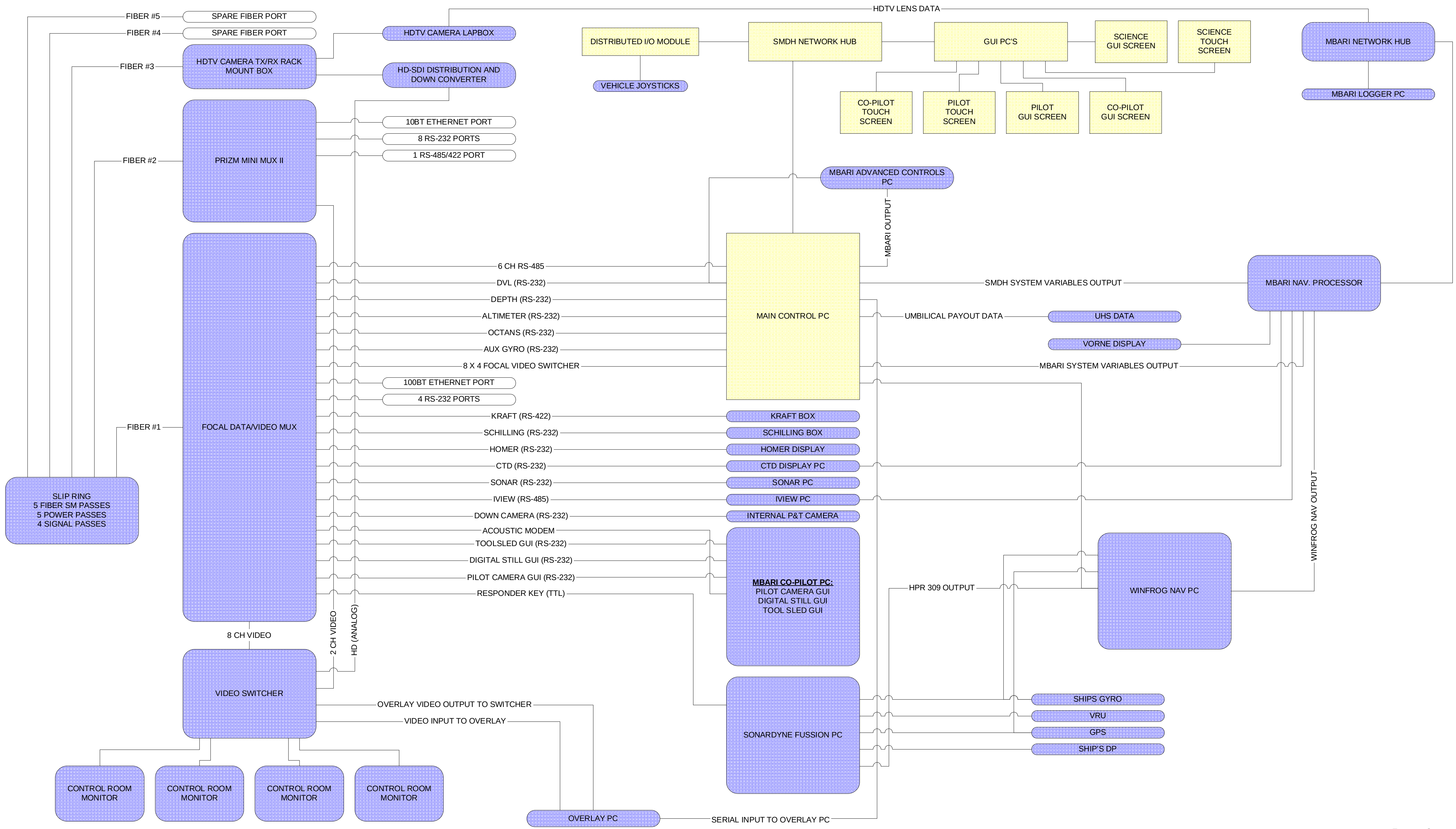
TIBURON II HYDRAULIC BLOCK DIAGRAM

Friday, December 15, 2006



SURFACE BLOCK DIAGRAM

Friday, December 15, 2006



AUXILIARY (SCIENCE) INTERFACE J-BOX

Friday, December 15, 2006