

MBARI'S 4000-METER SCIENCE ROV

TIBURON II

ROUGH ORDER OF MAGNITUDE (ROM) PROPOSAL

Customer:

**Monterey Bay Aquarium
Research Institute**

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1 INTRODUCTION

1.1 VEHICLE GENERAL DESCRIPTION

This proposal addresses MBARI's requirement for the next generation science ROV, Tiburon II, intended to take over from the institute's successful original Tiburon system. The vehicle described in this proposal is based on Schilling Robotics' successful QUEST™ ROV system, a proven work-class electric vehicle that has operated in depths up to 4,000 meters since 2001.

The QUEST™ ROV system offers work-class capability, and un-paralleled control system flexibility in the commercial industry. The vehicle's control system is comprised of Schilling Robotics' new Digital Telemetry System™ (DTS™), which is based on a gigabit Ethernet backbone. The system is modular and extremely flexible, offering multiple expansion, redundancy, and future upgrade paths, making it a perfect fit for both work-class and scientific operational environments.

1.2 PURPOSE OF PROPOSAL

This proposal describes the existing QUEST™ ROV system with several proposed modifications to meet the MBARI specification.

2 REQUIREMENTS

2.1 HIGH LEVEL REQUIREMENTS

The proposed Tiburon II vehicle will be in compliance with MBARI's following requirements.

1. Tiburon II will be functionally adaptable to the RV Western Flyer
2. The vehicle science payload will meet or exceed the 600 lbs minimum requirement
3. System depth rating will be 4000 meters at a minimum
4. Vehicle hydraulics will support new science tools requiring up to 10 gpm @ 3000 psi
5. Tiburon II will provide an estimated 400 lbs per thruster
6. The overall available ROV power will exceed 40 kW
7. Existing equipment currently owned by MBARI will be utilized where possible

2.2 POWER

2.2.1 Umbilical

The umbilical currently in use on MBARI's Tiburon vehicle shall be utilized with the new system, unless otherwise agreed with purchaser.

2.2.2 Source Power

The Tiburon II system shall be provided with a power converter, capable of supporting noisy input power. Power converter models / manufacturers will be decided following a design review with MBARI.

2.2.3 Auxiliary Instrument Power

The Tiburon II vehicle will be provided with the following auxiliary power buses at a minimum. Additional power buses may be available, depending on the final system configuration to be decided following a team design review. It is understood at this time that switchable power as described in the original MBARI specification will be supplied by the purchaser at this time, and as such this equipment is not included in this scope.

- Unregulated or regulated 240 VDC @ 25 A minimum
- Unregulated or regulated 48 VDC @ 15 A minimum

2.2.4 Ground Fault Interruption

The system will be provided with Megacon ground fault interruption protection (standard fit).

2.3 PAYLOAD ISSUES

The Tiburon II system will be provided with a minimum of 600 lbs reserve ("science") payload. This payload will be provided inclusive of 150 lbs of variable buoyancy, but exclusive of tool sleds (estimated at 200 lbs in-water weight) and core instrumentation.

2.3.1 Syntactic Foam

The Tiburon II system shall be provided with syntactic foam pack-type buoyancy. 3% water absorption over the life of the foam pack is a typical design guideline. The syntactic foam pack shall be coated with polyurethane to provide a flexible protective exterior.

The buoyancy shall be configured to support science payloads up to 200 pounds with less than a 10 degree induced pitch (in instances where the auto-leveling feature is not in use).

2.3.2 Fixed Ballast

No provision for fixed ballast shall be included in the ROV, unless otherwise agreed with purchaser during preliminary design reviews.

2.3.3 Variable Ballast

The Tiburon II system shall support the installation and integration of the MBARI-designed and supplied variable ballast (VB) system. The vehicle proposed shall be configured with hydraulic supply and control tie-ins for the VB system, which is to be provided and integrated by the purchaser.

2.4 VEHICLE PROPULSION

The Tiburon II vehicle shall incorporate seven (7) 9 kW brushless DC thrusters. Each thruster is capable of providing approximately 205 kg of thrust, significantly exceeding current Tiburon performance capabilities.

The vehicle shall meet the following performance specifications at a minimum:

- Forward speed (minimum): 1.5 knots (tether drag not incl.)
- Lateral speed (minimum): 1.0 knot (tether drag not incl.)
- Vertical speed (minimum): 40 meters / minute

2.4.1 Thruster Placement

Four (4) thrusters shall be installed at 45 angles at each corner of the vehicle frame (a "quad" arrangement). Three (3) thrusters shall be installed in the vertical plane, with two (2) thrusters being located at the forward end of the vehicle and the remaining thruster being located at the aft end of the system. Final thruster placement and operational control modes shall be determined following a review of science tasks with the goal of minimizing or removing any thruster wash in areas of interest.

2.5 SOFTWARE, CONTROL, TELEMETRY & VIDEO

2.5.1 General

The DTS™ control system and associated software provides significant interface options to the user. User-configurable outputs of system data, and configurable inputs for display of MBARI data require some development time by Schilling Robotics (included in NRE estimate listed in this proposal).

2.5.2 Pilot's Graphical User Interface

The standard Schilling Robotics GUI offers a high degree of customization of settings by operators / users. Field reconfiguration of the system is not currently available without the user investing in a wide range of development tools. It is recommended that all major software modifications be performed by Schilling Robotics, in conjunction with the MBARI team when required.

Significant data is available for display on the GUI. The Tiburon II display will include the following at a minimum:

- Vehicle heading
- Vehicle depth
- DVL data including altitude
- Pan & tilt positions
- Thruster feedback (RPM)
- Power switch states
- ROV pitch
- ROV roll
- System hydraulic pressure
- Ground fault information
- Compensation fluid levels (each circuit)
- Cable turns counter
- Auto modes
- Depth delta (new data to be provided)
- Power system states (some development required)

2.5.3 Control System

The following auto-modes shall be available for the Tiburon II system:

- Auto-depth
- Auto-heading
- Auto-altitude
- Thruster trim (all axes)
- Pitch trim
- Roll trim
- StationKeep™ (position-holding)
- Displacement (controlled movement of ROV while in StationKeep™ mode)

The Schilling Robotics controls team shall work closely with MBARI staff and provide access to software for advanced work. Scope of access and work shall be defined during system design reviews.

2.5.4 Video Overlay

Schilling Robotics supplies the Options VIGRA as a standard video overlay system. The unit is field configurable and any data can be displayed on the video overlay. Up to three (3) video channels can be provided, each with its own overlay configuration. The unit will support RGB inputs and outputs. Additional features include length measurement, still shot capturing, and video pointer with freehand sketching.

2.5.5 Video Requirements

The DTS™ support digital and analog video, in both PAL and NTSC formats. To support HDTV and 3CCD (RGB) video requirements, a survey junction box inclusive of a 4-channel Prizm MiniMux II unit shall be provided. The resulting system configuration shall provide the user with significant video capability.

The core Tiburon II system proposed shall support the following video types / channels:

- NTSC, PAL & RGB
- Channels: 8 (12+ optional with addition of DTS™ VIM modules as required)
- HDTV (up to 4 channels / using SDI interface)

2.5.6 Auxiliary Data Requirements

The DTS™ features a significant capacity for auxiliary data channels and is easily configurable for upgrades and future expansion. Serial data ports can be provided by configuration the DTS™ nodes with serial interface modules (SIMs) where required. Network interface modules (NIMs) can be used to provide interfaces for Ethernet devices.

Two (2) spare fibers (in addition to the main fiber used for telemetry) shall be provided at the ROV.

2.5.7 Auxiliary Hydraulic Valves

A standard 12-station general function valve pack, manufactured by Sub-Atlantic, is proposed at this time for the Tiburon II system. The valve pack can be configured with either solenoid or proportional valves, or a combination of the two types as required. The valves included in this valve pack provide a maximum flow rate of approximately 2.2 gpm, which does not meet the MBARI specification. Higher flow valves are available to meet the specification as stated, and a budget has been included in this proposal to supply the valves as requested.

A single high-flow (10 gpm @ 3000 psi) valve shall be provided to support variable hydraulic flow tooling.

2.6 DIMENSIONS, WEIGHTS & FRAME

2.6.1 Vehicle Dimensions

The maximum vehicle size shall not exceed the following dimensions:

- Length: 3.5 m
- Width: 2.0 m
- Height: 2.0 m

2.6.2 Weights

The vehicle shall not weigh in excess of 10,000 pounds. This weight does not include tooling sleds.

2.6.3 Frame

The Tiburon II frame shall be based on the QUEST 07 ROV frame. The forward portion of the frame may be modified to suit purchaser requirements for installation of additional sensors and other equipment. Through frame lift provided by the frame shall be 2,000 pounds minimum.

3 CORE INSTRUMENTATION

Most vehicle subsystems and all instrumentation currently in use on the MBARI Tiburon system shall be used on the Tiburon II system unless otherwise agreed. The Tiburon II system shall be compatible with all items listed in the MBARI request for tender specification.

4 LAUNCH & RECOVERY SYSTEM

The Tiburon II shall be compatible with the existing RV Western Flyer launch & recovery system. Schilling Robotics shall supply a latch / release assembly for the new ROV system, based on MBARI's current design. The new unit will be upgraded to support the increased system weight and through-frame lift capabilities.

5 DESIGN REVIEW & ACCEPTANCE TESTING

5.1 DESIGN REVIEWS

Preliminary (PDR) and critical (CDR) design reviews shall be held with MBARI to ensure system specifications are in accordance with requirements prior to proceeding with final engineering and production.

5.2 ACCEPTANCE TESTING

Schilling Robotics will perform a Factory Acceptance Test (FAT) to demonstrate all system performance characteristics possible in the factory test tank at the completion of the system integration. MBARI will be required to sign off on the FAT prior to the system departing the factory.

Schilling Robotics shall support sea trials testing on board the RV Western Flyer. Support rates have been included in this proposal for estimation purposes only. Additional support is available in the form of integration and installation assistance if required.

6 SPARES, TOOLS & TEST EQUIPMENT

A budget for system spares has been included in this proposal. The estimate provided includes budget for the procurement of spare parts, tools, and test equipment necessary to repair and maintain the Tiburon II system. Schilling Robotics will stock a significant percentage of system spares in Davis, California, but may not be able to guarantee all items will be in stock and available at all times.

7 DOCUMENTATION

Thorough documentation shall be provided with the Tiburon II system in both electronic and hard-copy format. Operators will have continuous access to system documentation using the Schilling Robotics website. Technical documentation and software updates will be provided on a regular basis as available / required.

7.1 MANUALS

Three (3) CD and paper copies of the following system manuals will be provided with the system.

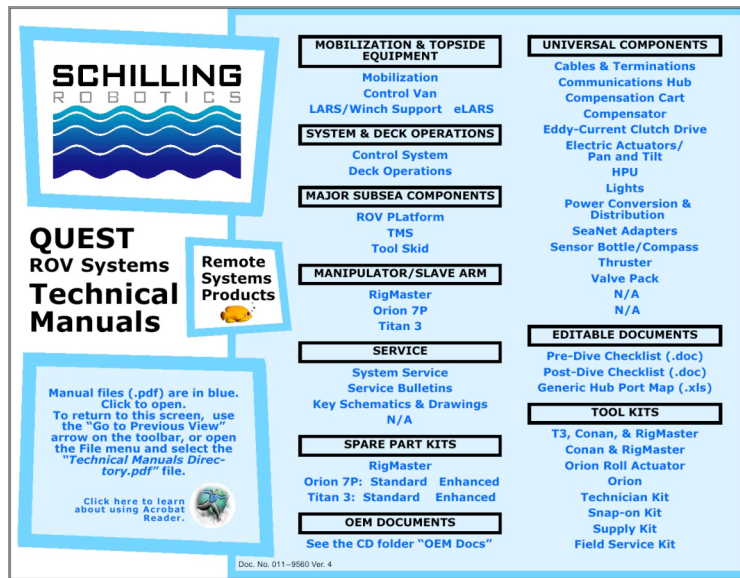
- Operation & maintenance / technical manual
- OEM operation & maintenance / technical manuals
- As-built documentation & fabrication / certification manual

The operation, maintenance and technical manuals will describe the normal operation of the vehicle and sub-systems, in addition to emergency contingency procedures. Troubleshooting and repair procedures and flow charts will also be provided as part of the system documentation.

The manuals will contain the following at a minimum.

- General arrangement drawings of the vehicle

- General arrangement drawings of all sub-assemblies
- Electrical schematics
- Hydraulic schematics
- Detailed parts lists cross-referenced to GA drawings
- Data sheets and technical manuals for OEM equipment
- Detailed colour photographs of all components and overall construction



8 PLANNED MAINTENANCE & POST-DELIVERY SUPPORT

Schilling Robotics recognizes the importance of providing detailed instructions regarding recommended and critical maintenance tasks to be performed on the Tiburon II system to maintain operational reliability. Detailed maintenance routines will be provided with the system, including pre and post-dive checks, and regular preventative maintenance schedules.

Schilling Robotics is recognized in the offshore industry worldwide for our commitment to customer service. Our service department and worldwide representatives can be contacted 24 hours a day to service the needs of our customers.

Skilled field engineers are available for installation, training, or operational support if required.

Technical support will be available from all Schilling Robotics locations (Davis, California, Houston, Texas, and Aberdeen, Scotland).

9 TRAINING, SIMULATION & MISSION-PLANNING

Schilling Robotics offers a range of training courses and certifications for system operators. Additionally, 3D simulation systems are available for training purposes, or for purchase by clients for use in their facilities or offshore.

10 SYSTEM ROM PRICING

10.1 EQUIPMENT ROM ESTIMATE

Final pricing shall follow a detailed specification review with purchaser.

TIBURON II VEHICLE & CONTROL SYSTEM (4,000M)

Vehicle Construction

Flotation module rated for 4,000m with 275kg reserve buoyancy	Included
Aluminum support frame, 1000kg through-frame lift (minimum)	Included
Front protection frame, aluminum	Included
Quick-disconnect receptacles for tooling skid interface	Included

System Propulsion & Tooling Equipment

Seven (7) 9kW 380mm thrusters (Sub-Atlantic, brushless DC), ~205kg thrust each	Included
Hydraulic compensation circuits & plumbing	Included
One (1) 22kW / 30hp hydraulic power unit, installed	Included
One (1) 22kW / 30hp hydraulic power unit, installed	Included

Telemetry, Lighting & Power Equipment

One (1) 240VDC / 48VDC (7kW) instrument power assembly (Schilling), installed	Included
One (1) 12-station valve pack / 6 solenoid, 6 prop. valves inst. (Sub-Atlantic)	Included
One (1) 12-port lighting control unit (Schilling), installed	Included
Three (3) 16-port DTS™ nodes (Schilling), configured w/8 video & 40 serial ports total	Included
Two (2) 48VDC:26VDC conversion modules (Schilling), installed	Included

Topside Power, Control & Associated Equipment

Control console w/HD-compatible display system	CFE
Two (2) DTS™ rack nodes	Included
RSE™ PCs, incl. server (1 ea.), client (2 ea.), and real time computer (1 ea.)	Included
Two (2) operator / MMI touchscreens, rackmount	Included
Interface system - RSE™ to MBARI joysticks	Included
Annotation system (Options, VIGRA)	Included
120kVA HF power inverter unit (INET), installed w/boost transformer	Included
Power distribution & conditioning equipment, & main 30m main power cables	CFE
19" auxiliary equipment racks	CFE
Deck cable, control room to winch	CFE

Total Vehicle & Control System Price:	\$1,673,000
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10.2 UMBILICAL ESTIMATE

The following pricing covers the main system umbilical. Actual pricing for the umbilical was not available at the time of submittal of this proposal. A budgetary estimation has been provided at this time.

UMBILICAL EQUIPMENT

Umbilical, 5000-m, 0.680" diameter Rochester	\$329,670
Umbilical termination kit (includes 2 ea. QDs)	\$9,400
Total Umbilical Equipment Price:	\$339,070

10.3 NON-RECURRING ENGINEERING ESTIMATE

Final spares and tools budget subject to review with purchaser.

SPARES, TOOLS & TEST EQUIPMENT

Spares kit (budgetary allocation)	\$325,000
Tools & test equipment package	\$25,000
Consumables package	\$10,000
Compensation unit, portable	\$5,333
Total Spares & Tools Price:	\$365,333

10.4 NON-RECURRING ENGINEERING (NRE) ESTIMATE

Expected design tasks have been estimated from a level-of-effort standpoint. It is recommended that MBARI and Schilling Robotics perform a system specification review prior to executing project to more thoroughly define expected scope relating to purchaser / manufacturer supplied equipment and software.

NON-RECURRING ENGINEERING (NRE)

Custom GUI modifications	Included
MBARI control console / joystick interface	Included
Advanced control external interface support ("Stanford Box")	Included
Umbilical design verification & test support	Included
Liftpoint design review / modification for RV Western Flyer launch & recovery	Included
Frame modifications to suit MBARI tooling sleds	Included
MBARI pan & tilt control / interface w/iView	Included
Power monitoring interface with GUI	Included
Total Package Price:	\$600,000