

# AquaMap™ ShipHull

Precision Positioning System for the ShipHull Inspection

And any other Vertical Structure



Operators Manual

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# AquaMap ShipHull Configurations

## AM-20

The AM-20 is ready for inspecting ship hulls whether you are doing diver inspection or using an underwater vehicle. All the components in this configuration are high-powered. This package offers four RBS-1H as well as the VLT-1H. Ship hull specific software is included as well as the PELICAN case and applicable manuals.

## AM-21

If you plan to integrate our hardware into your own then this is the package for you. This configuration consists of the same baseline stations, software, manuals, and PELICAN case. The significant part of this configuration is that you are given the electronics and not the actual transponder, which allows you to build it into your own submersible.

## AM-22

Some people need it all and some just want it all. If that is you then this package is ideal! It comes with four baseline stations, a VLT-1H, a diver station, Ship hull software, DiveBase Seafloor and Level 2 software, the manuals, PELICAN case, and a STM-4. The STM-4 is a surface station, which can be used as several other components if needed because they have the same electronics board. This configuration is able to do nearly any task and surely can do any of the above mentioned.

## 1. Introduction

ShipHull™ is a Long Baseline acoustic tracking system. ShipHull was originally developed as a means to track an ROV or diver as they inspect a ship's hull. Since then it has been used to inspect various other areas: docks, dams, and canals are all examples of today's uses. It can be used to inspect any vertical structure. ShipHull uses high frequency (34 kHz - 42 kHz) sound to track the diver or ROV.

### Principal Components of the ShipHull system

- All configurations include four **baseline stations** (RBS-1). The baseline stations serve as the reference points of a survey. They are deployed at the Aft Port, Aft Starboard, Forward Port, and Forward Starboard. The baseline stations are self-contained cylinders. Weighted at the bottom and floated at the top, these stations sit like antenna towers in the water.
- The **DiveBase ShipHull** software will track any underwater vehicle or diver that is equipped with a **Transponder**. Several transponders are currently available. The miniature TLT transponders are designed for tracking small ROV to depths of 300 meters (1000 feet). The larger and more sophisticated VLT-1 transponder will track ROV to depths of 1000 meters (3000 feet). It is suitable for mid-size or larger ROV. Either

transponder works well on divers; the size of the TLT-3 is usually more desirable than the VLT-1 for diver applications. Also, a DS-3 diver station is available for Diver use.



**Figure 1: A vessel being inspected by an ROV in shallow water**

The baseline stations are mounted in the corners of the vessel (AP, AS, FP, and FS). The transponder transmits a brief sonar 'ping' (or a sonar code), which travels to all baseline stations. Upon receipt of a ping, each baseline station transmits a reply. The reply pings travel back to the transponder. The transponder measures the time delay between the transmit of the interrogate ping and the receipt of the reply from each baseline station. This information is then sent through an umbilical cable to the surface.

### **Things to Keep in Mind**

ShipHull uses SONAR triangulation to determine position. It is important to understand the pitfalls of this method so that you can be aware of potential problems.

- **Line of Sight Is Important!** SONAR is a 'line of sight' technology. The sound signal must have a clear path from the transmitter to the receiver. Keep the baseline station transducers clear from obstructions that could block the signal. Make sure that terrain features such as boulders, pilings, etc don't obstruct the signal path. For best range, keep baseline station transducers at least two meters below the keel of the vessel.
- **Baseline Stations Must Be Stable!** The baseline stations serve as the reference points for navigation. If the stations move, data accuracy will be degraded accordingly. It is therefore necessary to ensure that baseline stations are not whipped about by surge, currents, or other conditions. The easiest and most reliable method is to put a heavy weight on the bottom of the baseline station (5lbs usually works) and tie off to the vessel.

## 2. ShipHull™ System Components

### ShipHull™ System Components

- Mobile Station: VLT-1, TLT-3, or DS-3
- 4 RBS-1 Baseline Stations

### Baseline Station Components

- Connector Adapter per station
- MCU-5 (Charges 5 units at once, doubles as data cable) or basic chargers
- Dummy Plug per station for utility connector
- DiveBase ShipHull software

### Not Included in the AquaMap components, but required for use

- Windows PC running on Windows XP or newer with at least 256MB of RAM
- Additional mounting hardware (weights and floats)

## 3. List of Operational Tasks

These tasks should be done sometime during the days before a ship hull survey. Desert Star Systems offers image scanning and registration services. If you prefer not to scan and process the images yourself please call to make arrangements.

### Preparation Tasks

1. Scan a ship plan
2. Register the ship plan

3. Charge the batteries

## Scan a Ship Plan

If you don't have a digital image of the ship you must scan a paper image into digital form first. Find a local architectural or engineering services shop, or perhaps a well equipped copy shop to scan large format plans. The simple, fast method is to just take a picture with a digital camera and save the file as a .bmp on the computer. You need both side view and top/bottom view of the ship.

### Required format for ship plan images

1. Black and white, to minimize file size. You can use color as well.
2. The file must be BMP format.
3. The file size of each image file should be **1 MB or less** (a smaller file size increases the speed at which your computer handles the images while tracking the mobile station).
4. The physical size of each image should be the same, as measured in pixels.

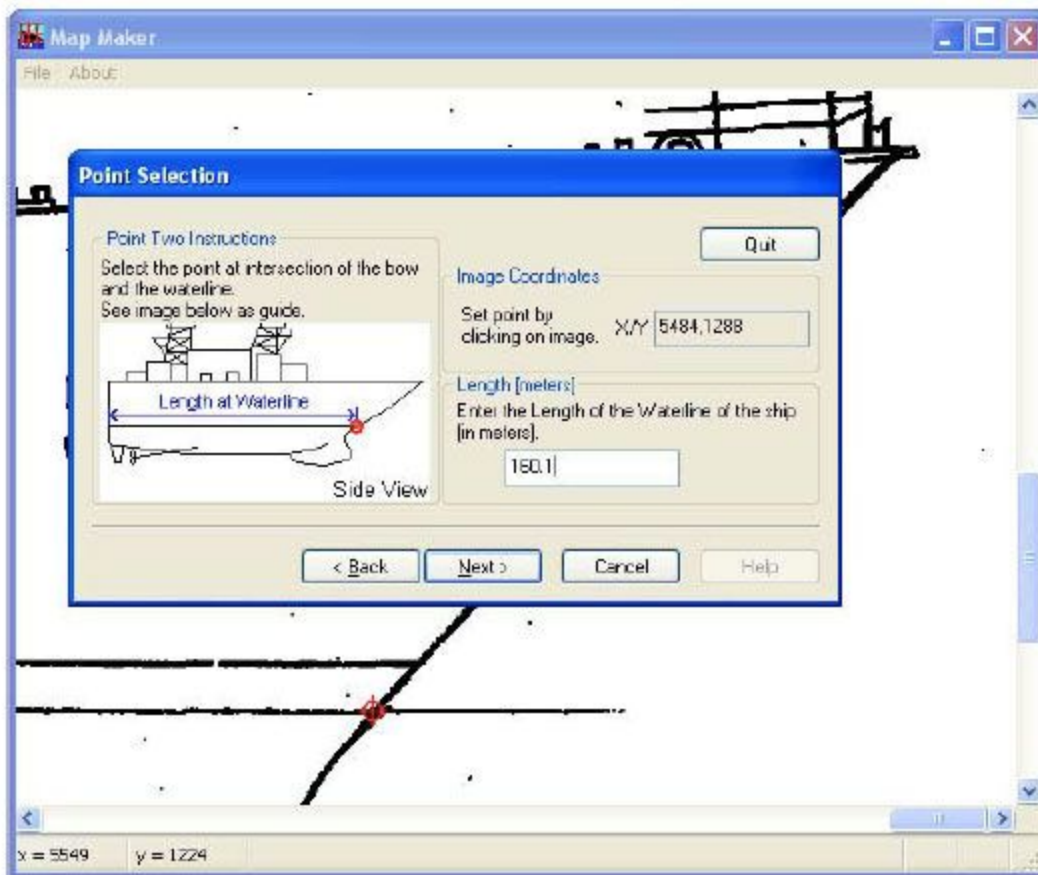


Figure 2: ShipHull Registration™ Wizard

## Register the Ship Plan

Digital images of the top and side of the ship must be “registered” into the software. When you register your ship images you are telling the ShipHull software where certain points on the ship images are; you are scaling it to size. The software that will guide you through registering your ship image is called **ShipHull Registration™**.

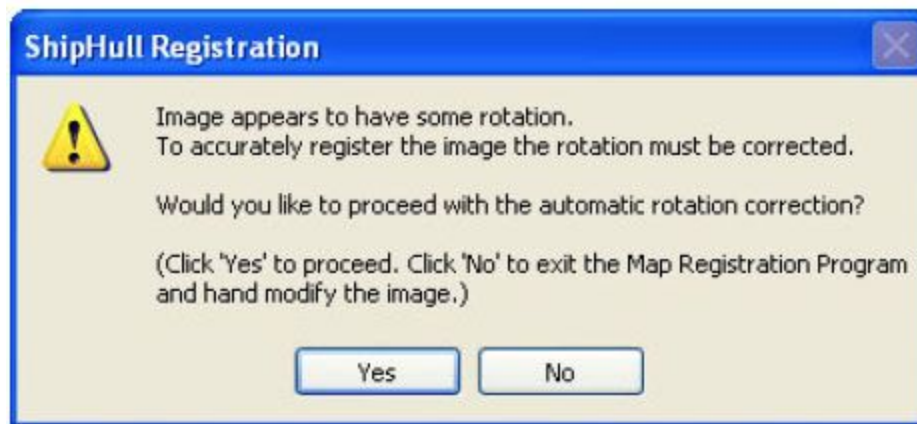


Figure 3: Correction of image rotation

**Using the ShipHull Registration™ utility** Once you have digital images of both the top and the side of the ship you are ready to use ShipHull Registration™ to register those images. Open ShipHull Registration™ and it will guide you through each step of the process. It is located in the same folder as the ShipHull application. Simply read the box in the top left corner and follow the on-screen instructions.

**You will need some ship measurement information before you get started. Those measurements are:**

1. Length of waterline
2. Draft of ship (waterline to lowest point of ship)
3. Overall length of the ship
4. Width of the stern (widest part)

The ShipHull Registration™ Wizard will walk you through defining various lines on the ship image (using the mouse pointer) and entering their measurements.

Near the end of the process the wizard will tell you that the image is rotated (i.e. the horizontal axis is not perfectly horizontal, see Figure 3) and it will ask you if you want to correct this, choose “yes”.

To complete the process follow the on-screen instructions, select “Save Registration” and give yourmap file a name. Then once saved select Finish.

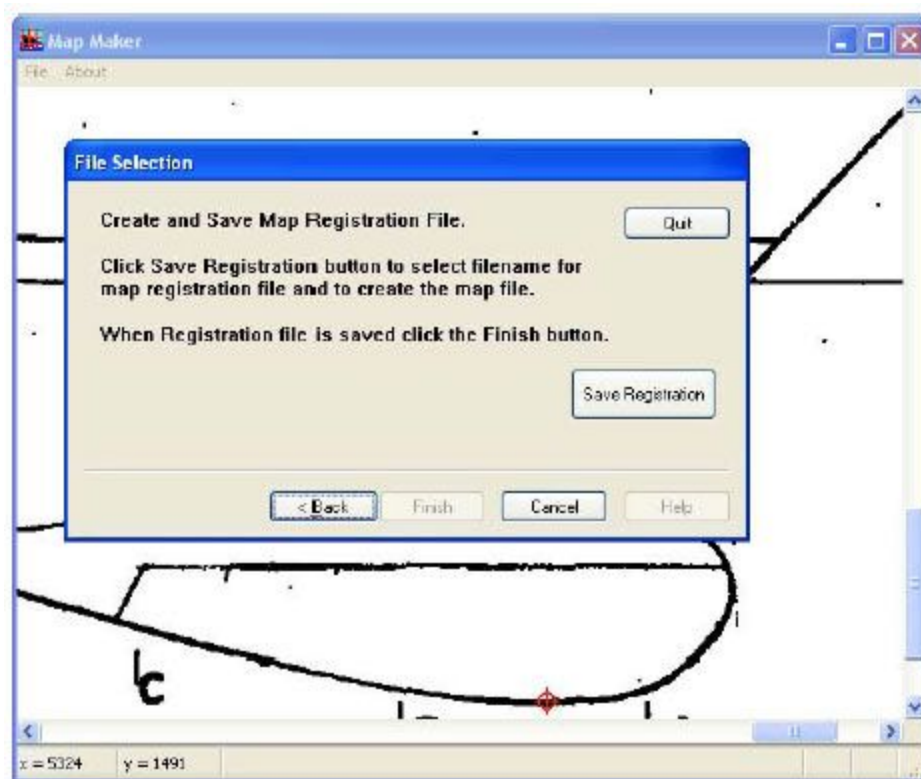


Figure 4. Saving the new map

## Charge the Batteries

The batteries should be charged within a few days of when the system will be used. This is because they have a slow self-discharge rate. For instructions and more information please see the section for **Installing the System**, below.

## 4. Installing the System

These tasks should be done when you first receive the system. The first operation should be at an inactive test vessel in a quiet location – allow a day to install and learn how to use it.

### Installation Tasks

1. Charge the batteries
2. Prepare the stations
3. Install software

4. Mount the Mobile station
5. Test the noise levels

## Charge the Batteries

The Baseline Stations and VLT-1 transponder are both equipped with rechargeable batteries.

The TLT-3 series transponder use replaceable 9v alkaline batteries. When using the DS-3, it also is equipped with rechargeable batteries.

Plug each station into the wall with the provided charging units, and turn them on (**they will not charge unless they are on**). The red LED light on the end of each station equipped with batteries should settle into a blink pattern of one second on and one second off. When it is done charging the pattern will change to one second on and three seconds off.

If the batteries were completely dead they should require about 3.5 hours to finish charging. If any other LED blink patterns occur please see the hardware manual (for the RBS-1) for the table of blink patterns that will tell you what it means.

Always try to charge the batteries a day or two before a mission. The nickel cadmium batteries in the baseline stations slowly discharge themselves over a period of 6 months, even if they're not being used. The batteries provide about 20 hours of continuous use.

## Prepare the Stations

The stations should be operational after you have charged them. These are the tasks to complete before they're ready to put in the water.

1. **Check blink patterns:** Check that each station turns on and settles into the appropriate blink pattern of a single **short** blink once per second. If any other blink pattern occurs please see the blink pattern table below and/or the hardware manual for the RBS-1 transponder to troubleshoot it.
2. **Check dummy plugs:** Check to make sure that a dummy plug is plugged into each exposed waterproof connector on the stations. The VLT-1 transponder requires a dummy plug if the external connector is not being used during in water operations.
3. **Prepare mounting lines, anchors, and any floatation devices used.**

Blink Pattern	Station Status
One short blink per second	Ready to go, standby



Triple blink once per second	Hardware error
Double-blink	It received an interrogate or reply
One sec on, 1 sec off	Charge
One sec on, 3 sec off	Charge done
Rapid blink	Low battery
No blink	Station off or battery dead

#### Install the Software

The software should install itself when you insert the CD into the computer, if it doesn't do this you can click on the **setup.exe** file in the CD directory to initiate the auto-install program.

#### Mount the Mobile Station

The station must be placed properly. Keep the transducer away from ROV thrusters or other sources of noise. Ideally the transducer should be "free and clear", i.e. the near space around it should not have anything in it that will obstruct or reflect the sound waves used by the system.

**For an ROV:** hose clamps can be used to mount a VLT-1 or TLT-3, or some other adhesive.

#### Test the Noise Levels

All ROV's emit noise and must be tested to be sure the noise is within acceptable levels for system operation.

1. Place the ROV into the water, start tracking and invoke the noise test feature. (Chapter 4)
2. Monitor noise levels as the ROV thrusters and other loads are activation.

Make sure the noise never exceed the maximum permissible amount of 120 dB. If it does, selectively switch all the ROV loads off until the noise level drops. Try moving the mounting position of the mobile station away from the noise generating device. If that also does not work, contact Desert Star of the ROV manufacturer for advice.



Figure 5: ROV with TLT-3 mounted toward the rear

DiveBase ShipHull Display

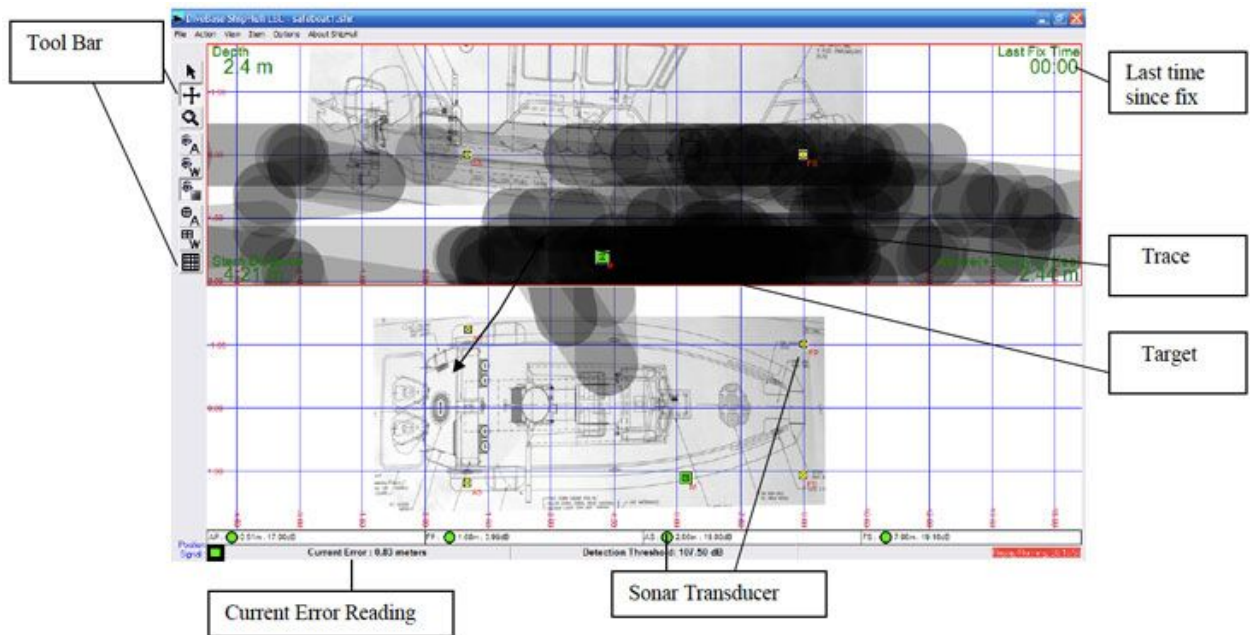


Figure 6: DiveBase ShipHull display

## 5. Deploying the System

**Overview:** This section explains how to mount the baseline stations in their correct places, tell the DiveBase software where they are.

## Deployment Tasks

1. Activate and deploy baseline stations (check LED pattern)
2. Calibrate baseline station positions in software (factory configured)
3. Check and enter visibility (based on ROV visibility)
4. Conduct a noise test (after the target is in the water)

**Good Station Mounting Is Key To Optimizing Performance** The sonar transducers of the baseline stations are the receivers of your mobile station. It is important that the stations are mounted stable. The quality of station location and mounting will directly affect the accuracy of AquaMap. We strongly urge you to read, and understand, the information in this section.

## 6. Further Setup

The positions of the surface station transducers are entered into DiveBase Shiphull using the **Action**→**Register and Calibrate** screen.

**Important Note:** The system only works in meters so any measurements in feet must first be converted to meters.

**To convert feet to meters multiply the number of feet by 0.3048. Quick Conversion: 10 feet = 3 meters**

**(approximately).** To convert meters back to feet (if you ever need to) multiply the number of meters by 3.2808.

1. Start the DiveBase ShipHull program.
2. Select **Register** and **Calibrate Baseline Stations** from the **Action** menu.
3. The window that pops up has places to enter all of the numbers, in meters. These locations can be entered manually by selecting the baseline station name “Aft Port” and clicking on your Ship where the ship is located. Do this with the remaining Stations and enter the depth as well, that’s all.

**Register and Calibrate Baseline Stations**

**Baseline Registration (Required)**

	X	Y	Depth
<input checked="" type="radio"/> Aft Port	30.00	-8.00	8.00
<input type="radio"/> Forward Port	142.00	-2.00	8.00
<input type="radio"/> Aft Starboard	80.00	8.00	8.00
<input type="radio"/> Forward Starboard	143.00	5.00	8.00

Enter Keel Depth : 8.84

Instructions :  
Hand Enter Each Baseline Station Location. (Distance Measured From Intersection Of Stern And Centerline). [Units Are In Meters].

**Baseline Calibration (Optional)**

	X	Y	Depth
Aft Port			
Forward Port			
Aft Starboard			
Forward Starboard			

Calibrate Stations Use Survey Depths

Calibration Instructions :  
Calibration Valid Only During Real-Time Tracking

Ignore Future Baseline Surveys (Replay Only)

OK Cancel

Figure 7: Register and Calibrate

## Check and Enter Visibility

To take account of the **visibility** in the water at the time of the inspection you must enter it into the software. The visibility number determines the width of the trace. For example, for a 1-meter visibility the trace will be 2 meters wide (one meter to the left, one meter to the right). The trace is used to 'paint' the seafloor, i.e. show the ground you have covered. Good visibility (or an acoustic (sonar) imaging system) will allow you to 'paint' a wider swath. Choose **Filter Settings** from the Item menu and enter the approximate visibility in the appropriate box.

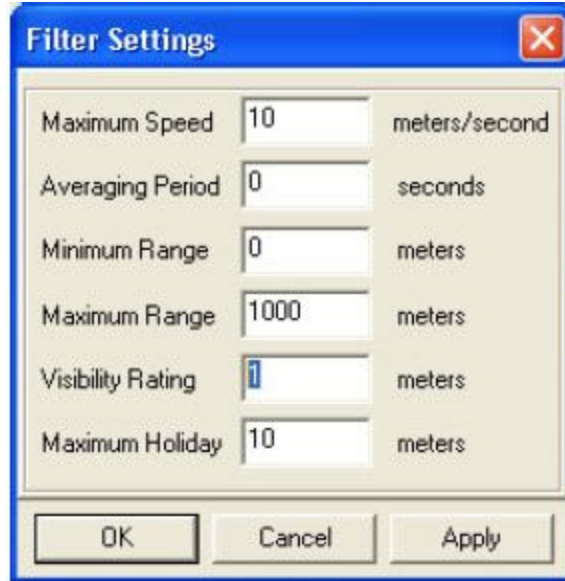


Figure 8: Entering Visibility

## Activate and Deploy the Mobile Station

1. Activate (turn on) the mobile station. Make sure you get the 'ready' blink pattern (one second on and three seconds off).
2. Select **Start Real-Time Tracking** from the **Action** menu.
3. Wait for the timer to start advancing in the upper right corner of the screen. This means that DiveBase is recording position data. If communication to the mobile station is not available, an error message will appear after about ten seconds. Check all stations power levels to make sure they battery is not exhausted on them.
4. Check that the mobile station appears as a green square on the screen in the correct place, relative to the map of the ship.
5. Navigate around to make sure that the track is corresponding to where you are moving the target (ROV, diver, etc).

## Perform a Noise Test

Common sources of noise include running engines and snapping shrimp (or other biological noise). A noise test will tell you if this background noise will interfere with system operation. If the noise level is too high, look for sources of noise that can be turned off, such as engines. You can also reduce sensitivity by raising the signal **Threshold Level**, with the slider. However, this will reduce range. In these cases, baseline station distance may have to be reduced.



Figure 9: The noise test display

1. Insure that the baseline stations are in the water and select Noise Test from the Action menu.
2. Set the Threshold Level slider to 120 dB (the recommended noise limit) and press the Start Test button
3. Test for 30 seconds to a minute. If the noise crosses the threshold every five seconds or more then you should adjust the threshold slider upwards. If there is very little noise you can move it downward to increase the range of the system.

## Perform a Baseline Calibration Survey

A baseline survey is an automatic survey done by ShipHull to verify the baseline station placement. It issues a warning if a large discrepancy between entered and actual distances is found. The baseline survey also recovers the exact depth of each baseline station, which is needed for accurate navigation. While a baseline survey can be omitted if baseline stations are placed precisely and with confidence, it should generally be conducted to guard against unpleasant surprises. ShipHull assumes that you have placed the stations in their proper locations (AP, AS, FP, and FS) that you entered in the **Register and Calibrate Screen**.

1. Guide the ROV or diver to the seafloor so that they are in a stable position.
2. Select **Register and Calibrate Baseline Stations** from the **Action** menu.
3. Wait for the software to indicate that the baseline survey was successful.
4. If you would like confirmation that the setup is accurate: send the ROV or diver to a point of reference on the ship (such as the stern or bow) and check that the display shows its position correctly.
5. For example, if the position of the mobile station does not match the ship image then the position of the Aft Port Station should be adjusted accordingly and another Baseline Survey performed.



Figure 10: Error message with helpful info

If there is a problem with the baseline survey you will receive an error message with instructions on what to try in order to fix it (Figure 10).

## 7. Operation

**Overview:** This section explains how to perform the tracking operations with AquaMap™

## Survey Tasks

1. Start tracking
2. Adjust the display
3. Record annotations
4. Retrieve the system

## Start Tracking

Select **Action/Start Real-Time Tracking** from the menu bar. The system will now communicate with the mobile station and initiate tracking operations. If there is a communication error a message box will appear.

**System Status Indicators** During real-time surveying and replay mode, the System Status Indicators (bottom of the main screen) report system status. The System Status Indicator group is made up of a Position Signal Indicator and four baseline station Range Indicators, one for each station. The baseline station Range Indicators have two possible states, red or green. Successful operation is indicated by a green circle and reported range (in meters), and an unsuccessful operation is indicated with a red circle and zero reported range. Using the Range Indicators it is possible to know if there are any problems with the baseline stations themselves.


The Position Signal Indicator has three possible states, green, orange and red. Green indicates a good calculated position fix, orange indicates a bad calculated position fix and red indicates no position fix with possible loss of communications. During replay mode only the green and orange signals are reported. **See Appendix 4: Troubleshooting** if problems occur.


## Adjust the Display

### Turning on and off graticules, annotations, waypoints

Each of these layers can be toggled on and off in the View menu or by using the control bar buttons.

### Panning and zooming

The vertical toolbar on the left side of the display has buttons for selecting panning and zooming tools. The panning tool (or Translate Tool)  can be used to click and drag the active view of the seafloor or you can use the arrow keys for panning.

The zoom tool  allows three types of zooming control. Left click to zoom in, right click to zoom out, and click-and-drag a box around any desired area to zoom with precise control. You can also use the hot-keys: O for zooming out and I for zooming in.



**Other display controls** The other buttons in the toolbar can be identified by placing the mouse pointer over them, callouts will indicate their functions. They are also pictured and labeled with their functions in the Display section as well as in **Appendix 3: Toolbar Buttons**.

## Appendix A: Hot Keys (Keyboard Shortcuts)

Menu Command	Hot Key(s)	Function (if it's not self-explanatory)
<b><u>File</u></b>		
Load Record File	Ctrl+L	Loads a record
Load Annotations	Ctrl+A	Loads an annotation file
Load Waypoints	Ctrl+W	Loads a way point file
Save Screen Image		Saves currently selected screen image
Save Annotations		Saves the current annotation file
Save Waypoints		Saves the current way point file
Clear Data / Screen	Ctrl+C	Clear all stored data from screen
Close	Ctrl+Q	Closes Application
<b><u>Action</u></b>		
Start Real-Time Tracking	T	Starts tracking of the mobile station, a new record.
Register And Calibrate Baseline Stations Dialog	C	Launches baseline registration and calibration dialog

End Real-Time Tracking	E	Ends tracking of the mobile station, closes record
Replay A Record	R	
Generate Survey Report Image	Ctrl+S	Saves full DiveBase image currently selected loaded
Noise Test	N	Launch Noise Test Dialog
<b><u>View</u></b>		
Graticule	G	Toggles graticules (grid) on and off
Annotations	A	Toggles Annotations on and off
Status Info		Toggles Status Info on and off
Waypoints	W	Toggles Waypoints on and off
Replay Control		Displays Replay Control Bar
<b><u>Item</u></b>		
Graticule Settings	Ctrl+G	Allows changing of graticule (grid) settings
Filter Settings	Ctrl+F	Allows adjustment of Visibility and other settings
Add Annotation		
Remove Annotation	Delete Key	If An Annotation is selected Delete Key with remove it.
Remove All Annotations		
Add Way Point		





Remove Way Point	Delete Key	If A Waypoint is selected Delete Key with remove it.
Remove All Way Points		






<b>Keystrokes (Listed by Functional Group)</b>	<b>Function</b>
<b><u>Deployment</u></b>	
T	Start Realtime tracking
C	Launch Baseline Register/Calibration Dialog
CTRL+F	Launch Filter Dialog (where you enter Visibility)
N	Launch Noise Test Dialog (only active during realtime tracking)
Up Arrow	Pan Up
Down Arrow	Pan Down
Right Arrow	Pan right
Left arrow	Pan left
I	Zoom In

O	Zoom <b>O</b> ut
SPACE BAR	Add annotation at mobile station location, allows free text entering
F5	Add Quick Annotation (1)
F6	Add Quick Annotation (2)
F7	Add Quick Annotation (3)
F8	Add Quick Annotation (4)
DELETE KEY	Delete Selected Annotation or WayPoint
E	End Tracking
<b><u>Reporting</u></b>	
R	Replay Record
CTRL+R	Generate full report image (saves all items displayed)
Ctrl+C	Clear Screen
CTRL+A	Load Annotations from file
CTRL+W	Load Waypoints from file
CTRL+L	Load a Record

<b><u>Others</u></b>	
CTRL+ATL+Q	Close/Quit Application
CTRL+G	Launch Graticule Settings dialog
G	View/Hide Graticule
A	View/Hide Annotations
W	View/Hide Waypoints

## Appendix B: Toolbar Buttons

Button	Name	Description
	Pointer	Allows selection of annotations and waypoints.
	Translation/Panning Tool	Allows fine control over positioning of ship plan in display. Click and drag to move image.
	Zoom Tool	Allows fine control over zooming, click and drag a box to zoom to that box. Right click = zoom in, left click = zoom out.
		Shows annotations.

		Shows Waypoints.
		Shows Graticule layer.
		Inserts Annotation.
		Inserts Waypoint.
	Graticule Setting Adjustment	Calls up Graticule Setting Dialog window for adjusting the values of the graticule.

## Appendix C: Troubleshooting

### Noise Problems

Acoustic or electric noise in the tracking environment will interfere with the signals used by the system. There are many sources of noise, including biological (snapping shrimp, etc...), ship engines, ROV motors, diver's regulators, AC power lines, low quality inverters, etc... The best way to locate controllable noise is to use the noise test feature in the tracking software to monitor noise levels as you turn on and off the possible sources of noise.

<u>ROV noise</u>	
Problem	Reason/Solution
Acoustic noise	Move transducer away from thrusters or hydraulics

<p><b>Electrical noise</b> (May be radio interference through the air/water or electrical interference through noise on power supply lines)</p>	<p>Test for power line noise by removing both the ROV transponder and the PC from AC power. Test for radio interference by shutting off all ROV systems. Use battery power, a good generator or a true sine wave inverter if power line noise is a problem. Move the ROV transponder away from the ROV to locate radio interference, then mount in a location where radio interference is minimized.</p>
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<u>System Status Indicators</u>	
Problem	Reason/Solution
<u>Baseline Range Indicator</u>	
<p>Constantly Displays Red Circle</p>	<ul style="list-style-type: none"> <li>• Possible loss of power to baseline station. Check power switch on baseline station.</li> <li>• During side surveys the hull may block the opposite side baseline stations. This will cause them to report red, but the position signal should still report good positions.</li> <li>• During bottom surveys indicator may change to red if the mobile station raises above the keel line creating another block in the line-of-site. Lower your depth so that all four baseline stations are in view of the mobile station.</li> </ul>
<u>Position Indicator</u>	
<p>Constantly Large Errors</p>	<ul style="list-style-type: none"> <li>• A persistently large error indicates that the baseline survey is incorrect.</li> <li>• If the number turns red, the system is not showing positions because the error exceeds the 'maximum error' defined in the filter settings.</li> </ul>
<p>Constantly Displays Red</p>	<ul style="list-style-type: none"> <li>• Communications problem. Cable has been disconnected on mobile station. Check cable connection to mobile station.</li> </ul>

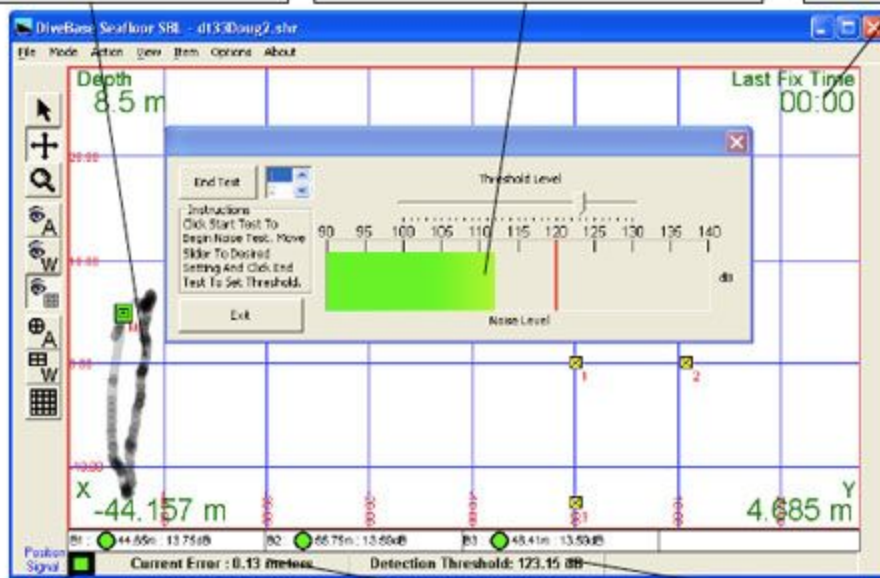
(Real-Time Only)

- Power loss. Mobile station has lost power. Check power connection (external power) or battery charge.
- Transducer is out of range or in a shadowed area.
- Transponder or Transducer has a dead battery.

**Position Trace:** The trace is painted only if the position fixes meet the quality standards defined in the position filter settings. If you see frequent gaps in the trace, then check your filter settings the other indicators on the screen to determine the cause.

**Noise Test & Detection Threshold Slider:** Use this test to evaluate vehicle and environmental noise. More noise means less system range, so make changes to reduce any noise under your control and test again. Use the slider to set the detection threshold above the prevalent noise to avoid noise-induced errors.

Check the time since last position fix to make sure your data is up to date.



Green is OK, but a red light indicates that station is out of range, shielded from view or not operating. Are the lights almost consistently green? If not, reduce baseline station spacing and/or avoid obstructions to obtain better system reliability.

For good position quality, the error should be below 1 meter or even 0.5m. A persistently large error indicates that the baseline survey is incorrect, while changing errors indicate unstable baseline station mounting or obstructions in the water. If the number turns red, the system is not showing positions because the error exceeds the 'maximum error' you defined in the filter settings (quality control).

Signal strength above detection threshold: If you see only a few dB, you are near the limit of range. Check the numbers just after baseline station deployment to verify your array is not too large for conditions. Monitor them during ops to get an early warning of an approaching out-of-range condition. CAUTION: A persistently weak signal from one baseline station or sonar transducer may indicate the baseline station transmitter or surface station sonar transducer is not working properly. Replace it.