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MBES – Patch and Performance Testing

HYPACK 2022 – Training Event

Objectives of this session

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- Patch Test Location
- Planning and Running Survey Lines
- Cross Sections and Why

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- How to Interpret Results
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Understanding the Patch Test

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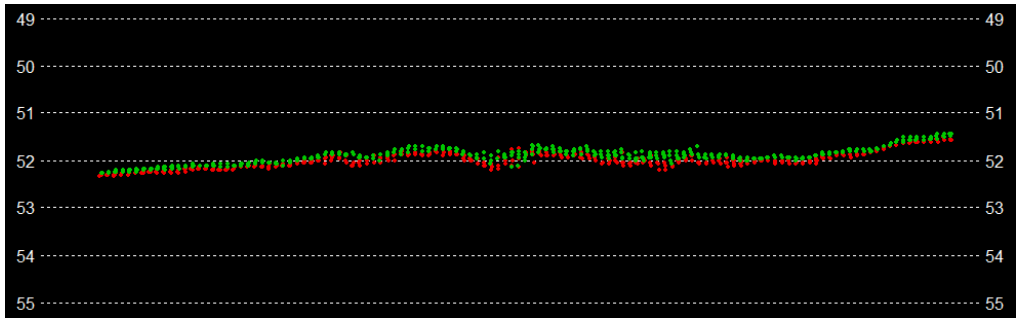
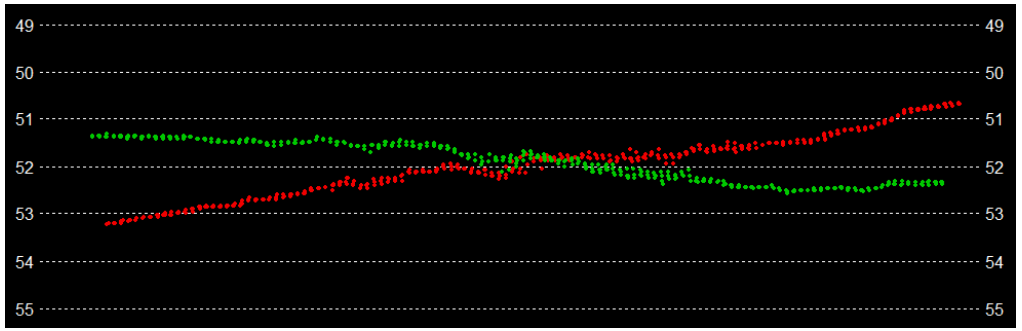
Why Patch Test?

Multibeam and Lidar systems are very directional.
Small angular alignment errors lead to large data errors.



Cross section from two survey lines that overlap well:

- Correct Roll offset = Angularly aligned = No Roll bias.



Cross section from two survey lines with poor overlap:

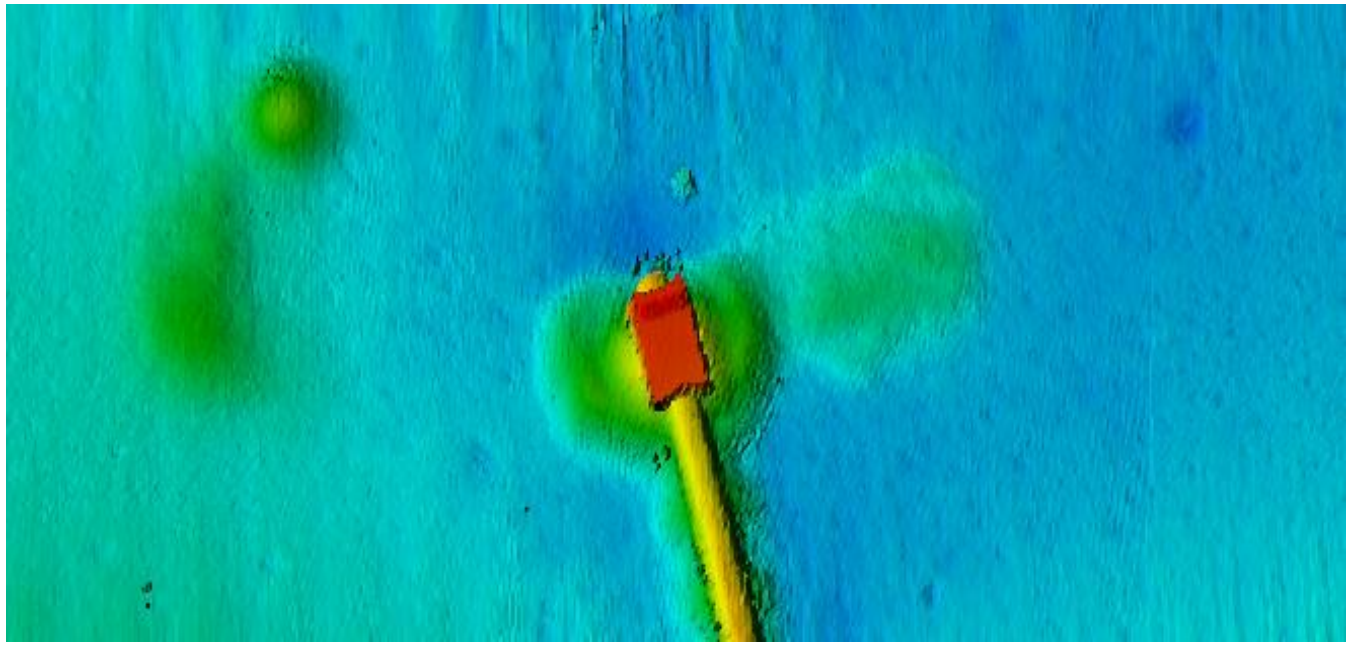
- Incorrect Roll offset = Angularly misaligned = Significant Roll bias.

Patch Testing finds correct Roll, Pitch and Yaw offsets (misalignment angles).
Also corrects for Position system Latency.

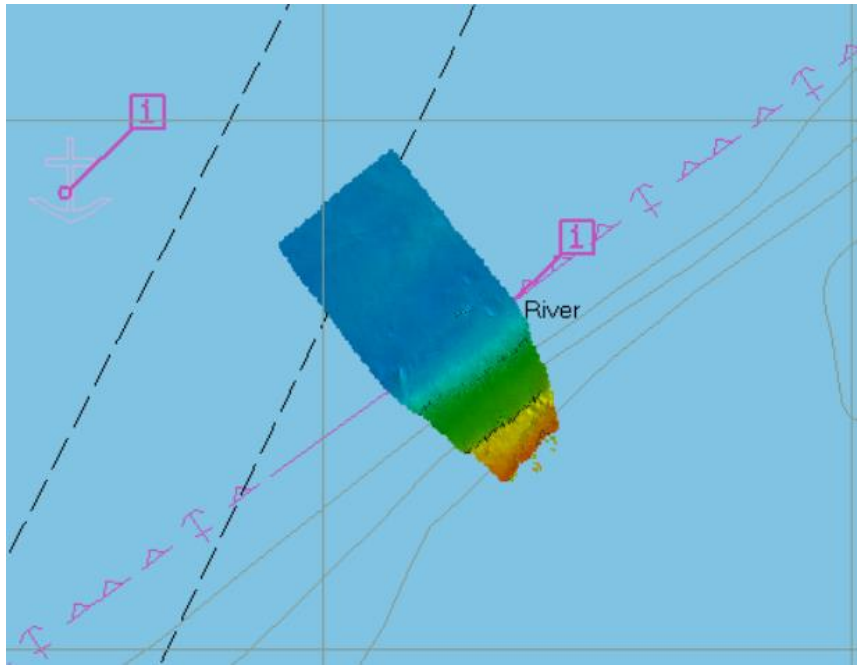
Patch Test Location

Finding a proper location can be difficult

- **Roll Test** - A reasonably flat and level bottom is needed. (As seen in previous slide)
- **Pitch, Yaw, and Latency Test** - An area of bottom with variable terrain changes



This has everything. Perfect.

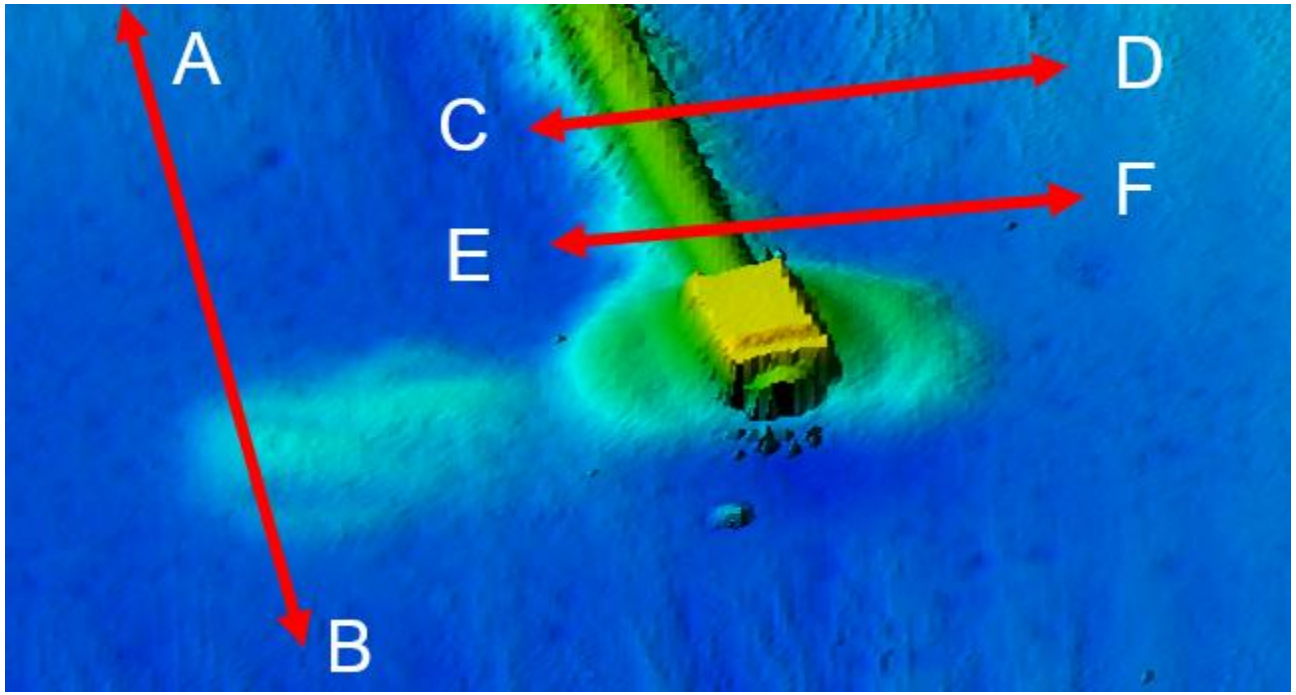


Channel with side slope works well.

Be aware the traveling perpendicular to the current, will cause problems with obtaining proper overlap.

Planning and Running Survey Lines

Basic survey line layout for single head MBES. This line geometry doubles any alignment errors.



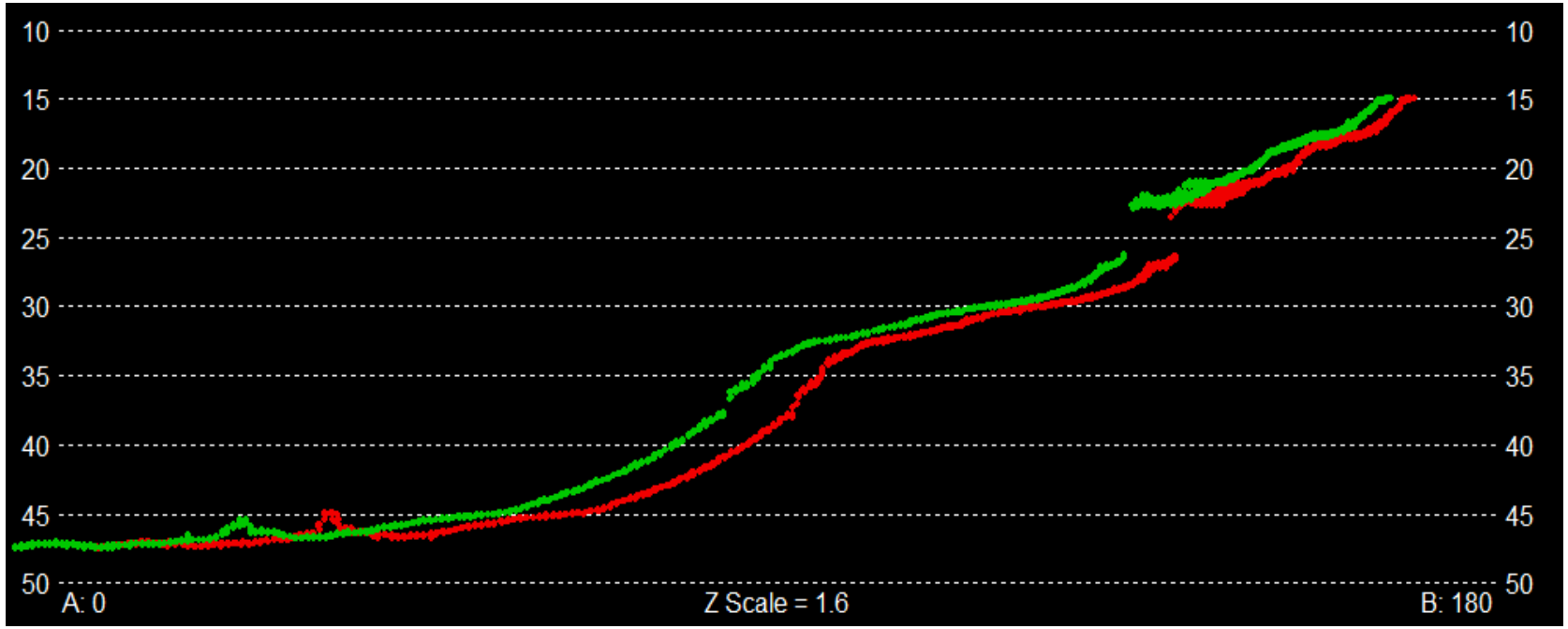
- Roll Test: A-B both directions, survey speed.
- Pitch Test: C-D both directions, survey speed.
- Yaw Test: C-D and E-F, same direction, survey speed. Offset = ½ average depth.
- Latency Test: C-D, same direction, high then low speed.

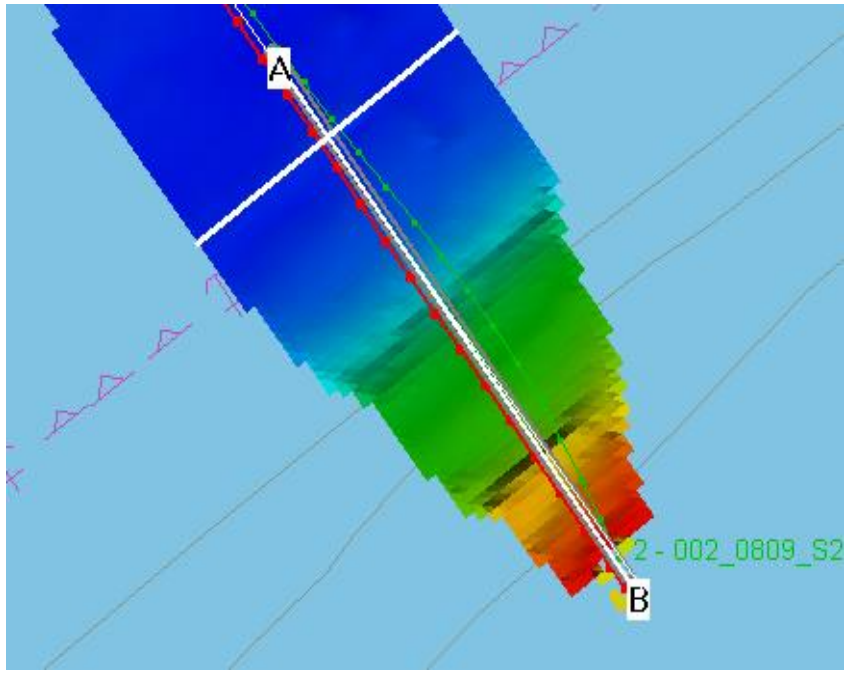
This is the basic line layout. With experience you will find short cuts. For example, line C-D could be extended for roll testing also.

Cross Sections and Why

Line geometry and survey are intended to *double* alignment errors when cut in cross section.

- Roll cross sections are taken across track.
- Pitch, Yaw and Latency cross sections are taken along track.
- MBMAX64 processing picks the proper cross section when lines are loaded in pairs.





A-B Cross Section views.

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MBMAX64 Patch Test

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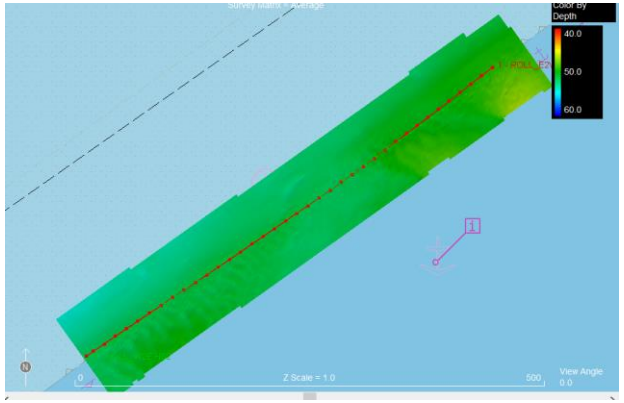
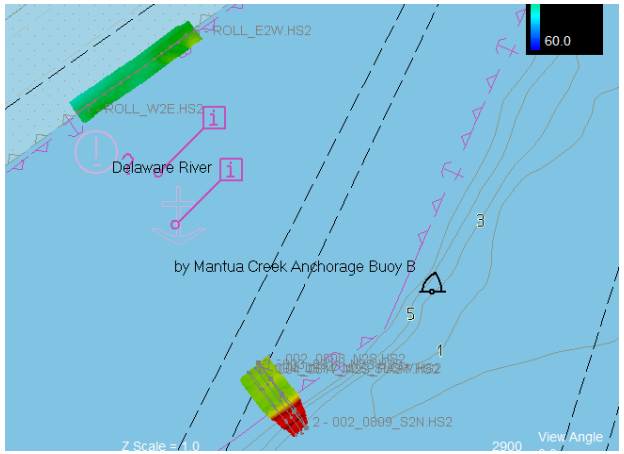
How to Load Files

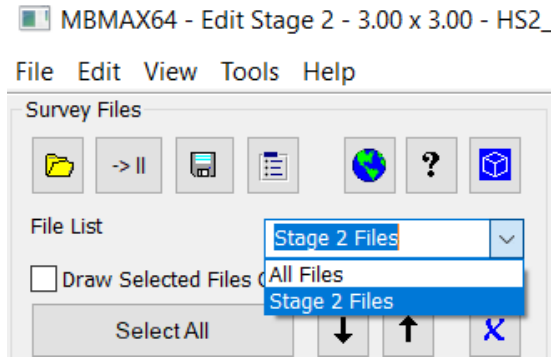
Files may be loaded in pairs or the entire survey may be loaded at once.



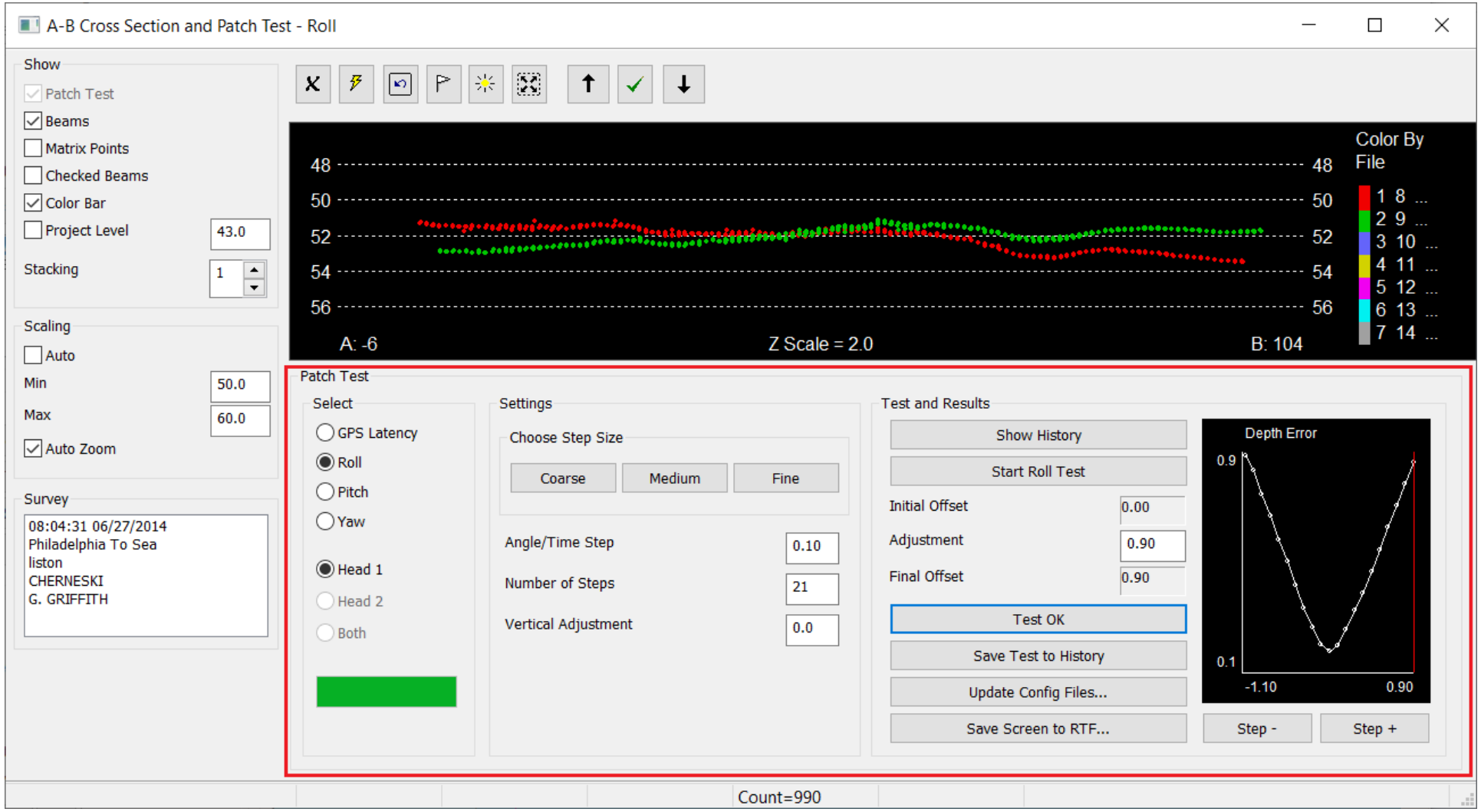
Loading just the Roll Test. Loading files in pairs is good when you are new at this. The testing process may be easier to keep track of.



Loading the entire test. An efficient way of working. Requires somewhat advanced MBMAX64 skills to switch between Stages 1 and 2.



Introduction to the Patch Test Window



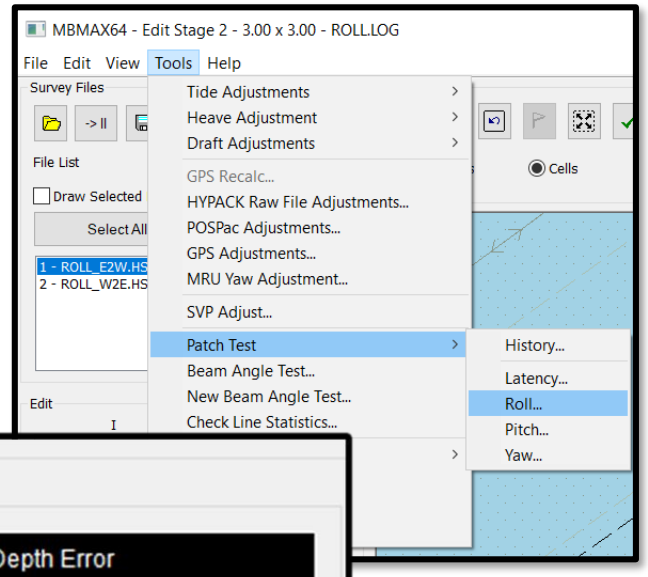
Doubles as an edit window (A-B Cross Section at top)

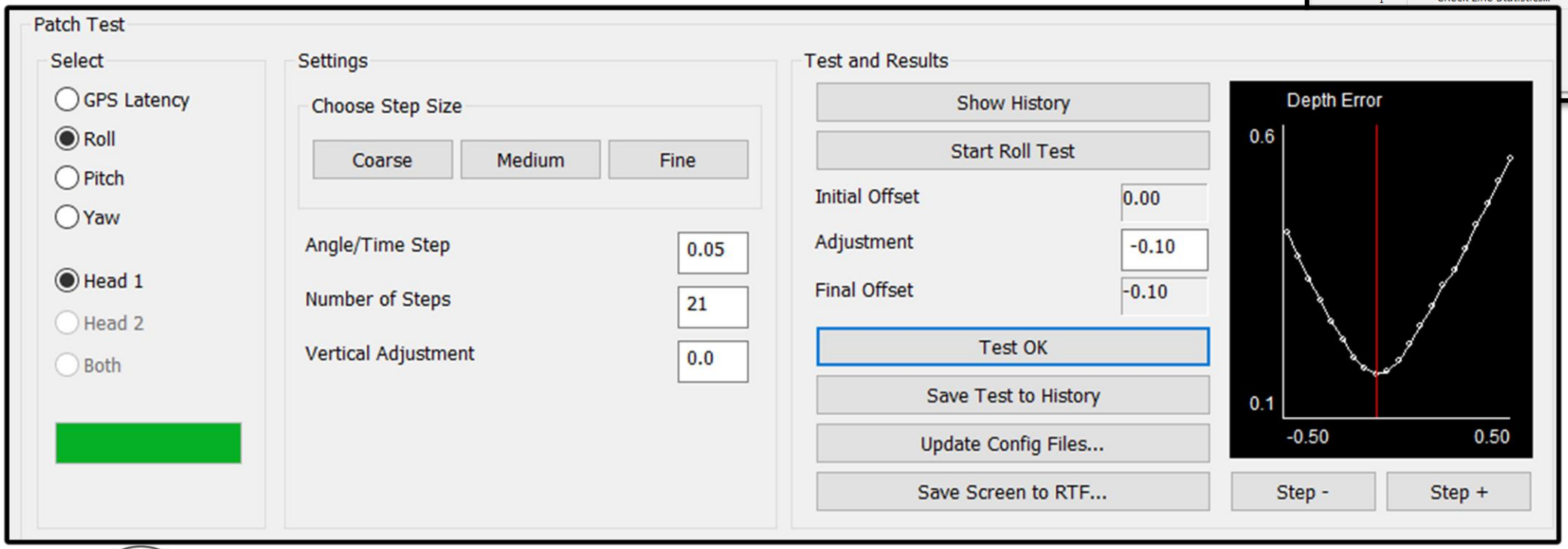
Patch testing controls and results at the bottom.

Enough already, run the program!

How to Run a Test

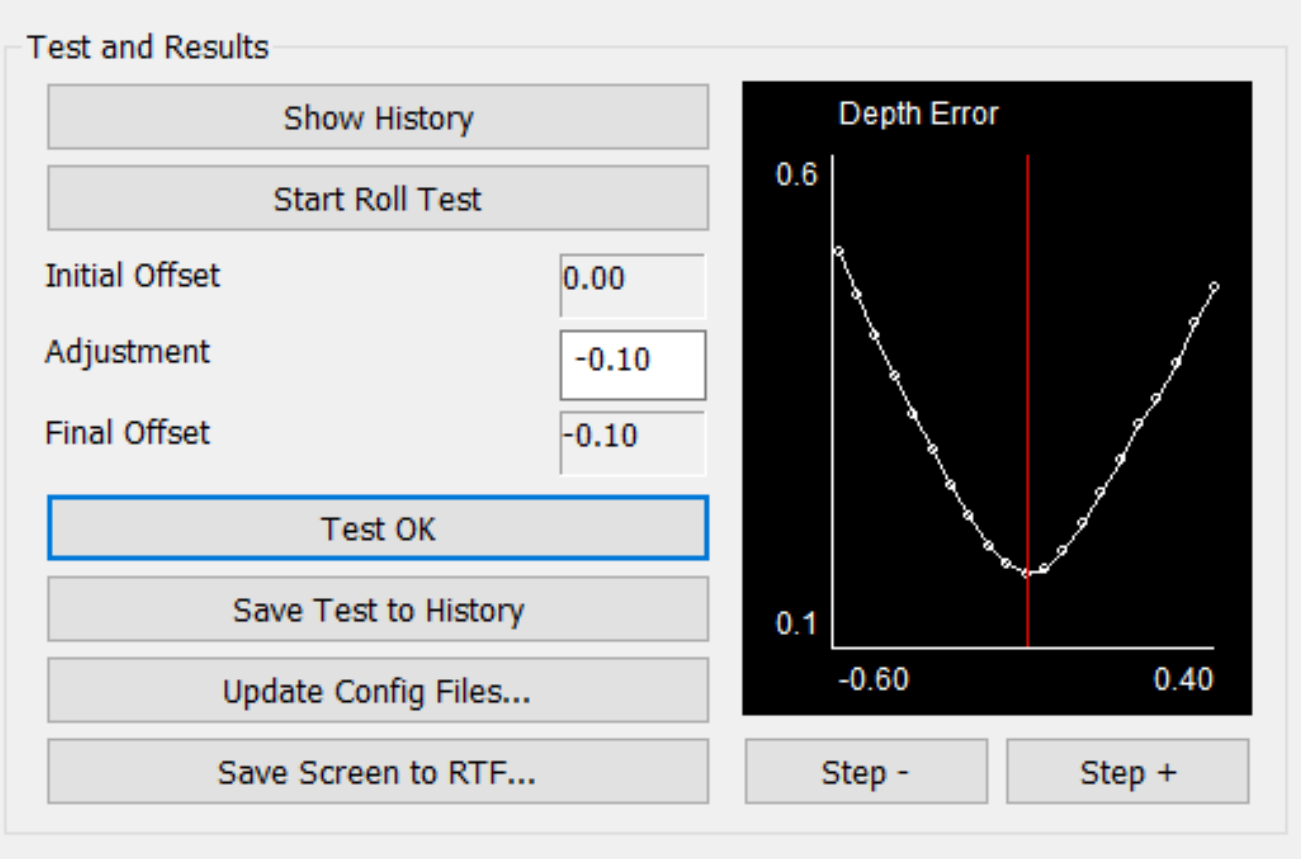
- Run MBMAX64 and load a pair of files. Roll test is good for starters. Advance to stage 2 editing.
- Use Tools menu, Patch Test, Roll to bring up the test.
- Select Roll Test, Head 1, Coarse Steps then Start Roll Test.
- Click Medium Steps to start again. Click Fine Steps to start one more time. If things went right click Test OK and you should see something like below.





How to Interpret Results

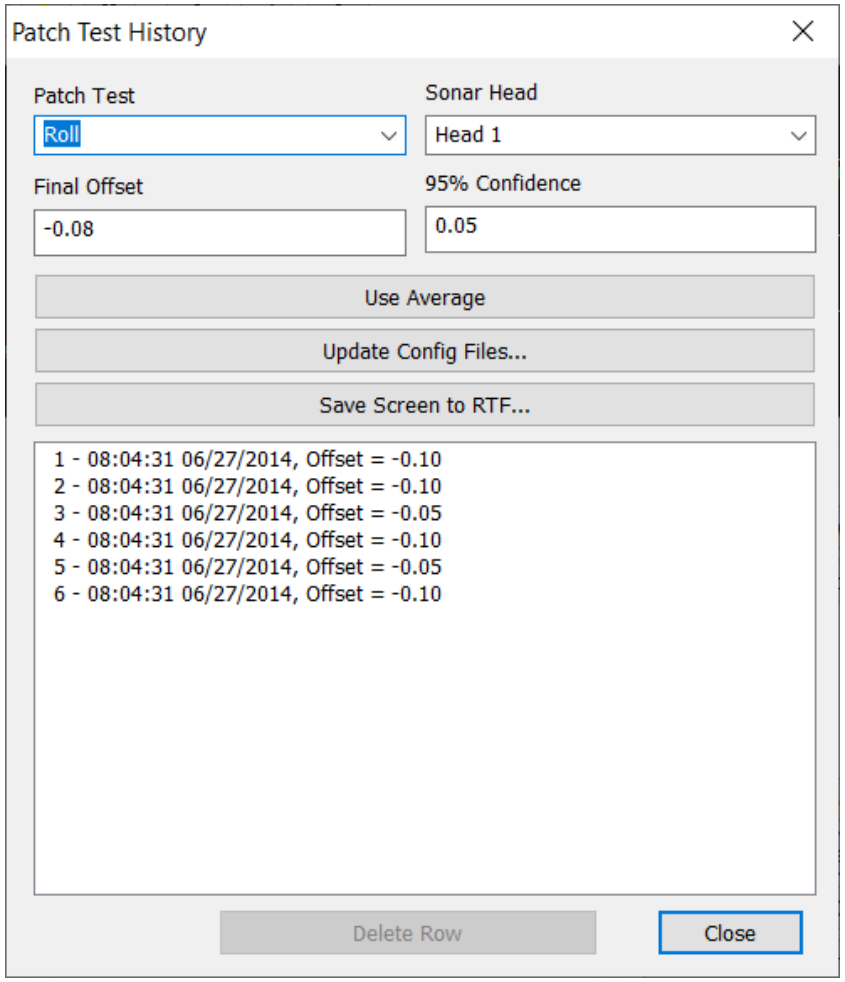
Results from a good Roll test. The pronounced V-Shaped curve shows best fit overlap between cross section.



- **Initial Offset**: From HYSWEEP Hardware setup.
- **Adjustment**: Patch test change to Initial Offset.
- **Final Offset**: Test result for updating offsets.
- **Test OK**: Click this to accept results.
- **Save Test to History**: Use this to keep a history of testing. It's a good idea because there will be slight variations between tests.
- **Step + / Step -**: Visually inspect and manually override statistical selection at different offset steps. Sometimes there's a better answer!

Using Patch Test History

History tracking finds the statistical best result.



- History is tracked for each test – Latency, Roll, Pitch and Yaw.
- Each head is tracked for dual head systems.
- **Final Offset** = Average of all test.
- **95 % Confidence** shows any ‘bias’ and how well tests agree.

- **Use Average** updates current testing. (What you are doing now).
- **Update Config Files** puts the average result in HYSWEEP.INI
- **Save Screen to RTF** generates a report file.

Be suspicious of patch test modules that give results to 5 digits after the decimal!

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Run Examples

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Order is Important

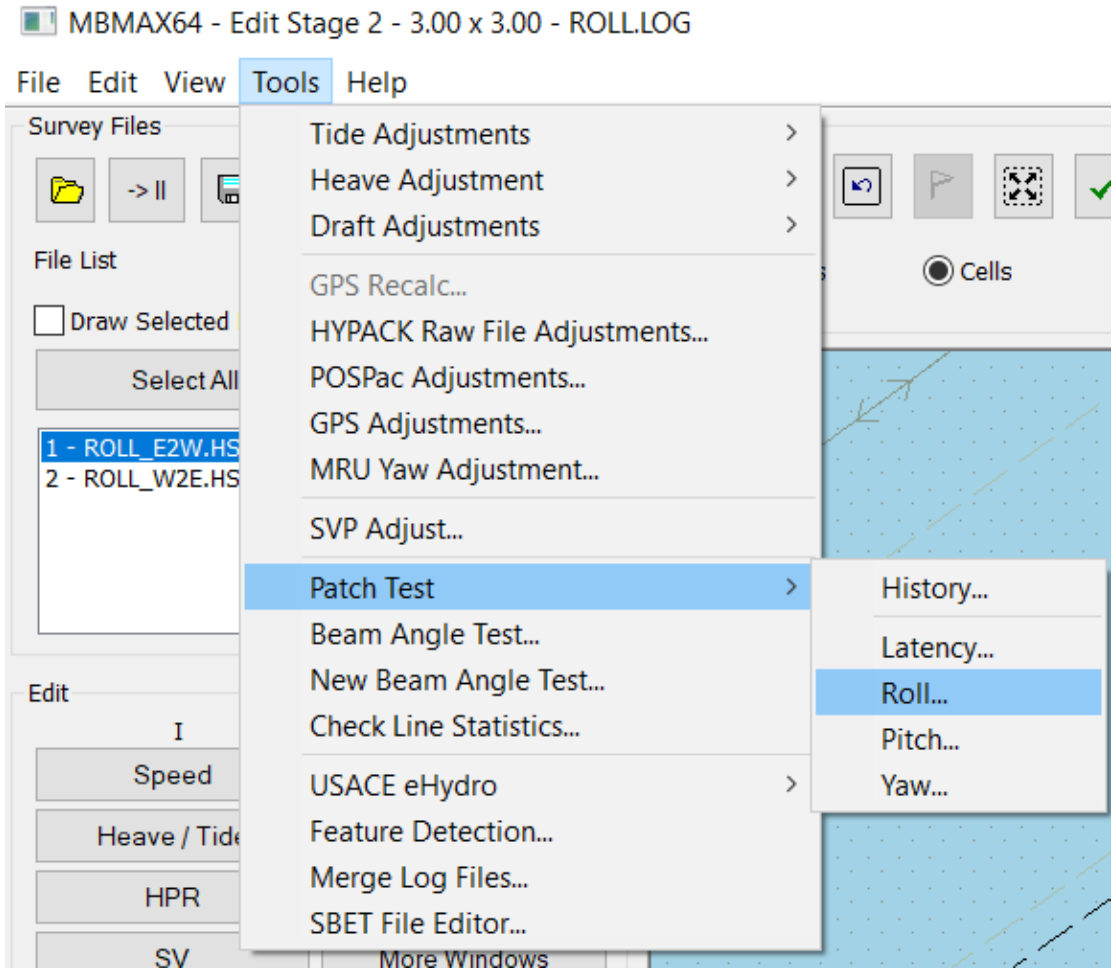
Remember LRPY – Latency then Roll then Pitch then Yaw.

- Find the Latency offset first (Should be 0.00, but should be tested for verification).
- Latency will be applied to the Roll Test files.
- Latency and Roll values will be applied to the Pitch Test files
- Latency, Roll, and Pitch values will be applied to the Yaw Test files

Do it again (using same order) to check results. The second run should give finer results.

If a test comes up with a value that is totally different something went wrong.
Possible that the ‘wrong’ files were selected for the Test.
Rerun the tests until there is agreement and consistency.

Auto Cross Sections

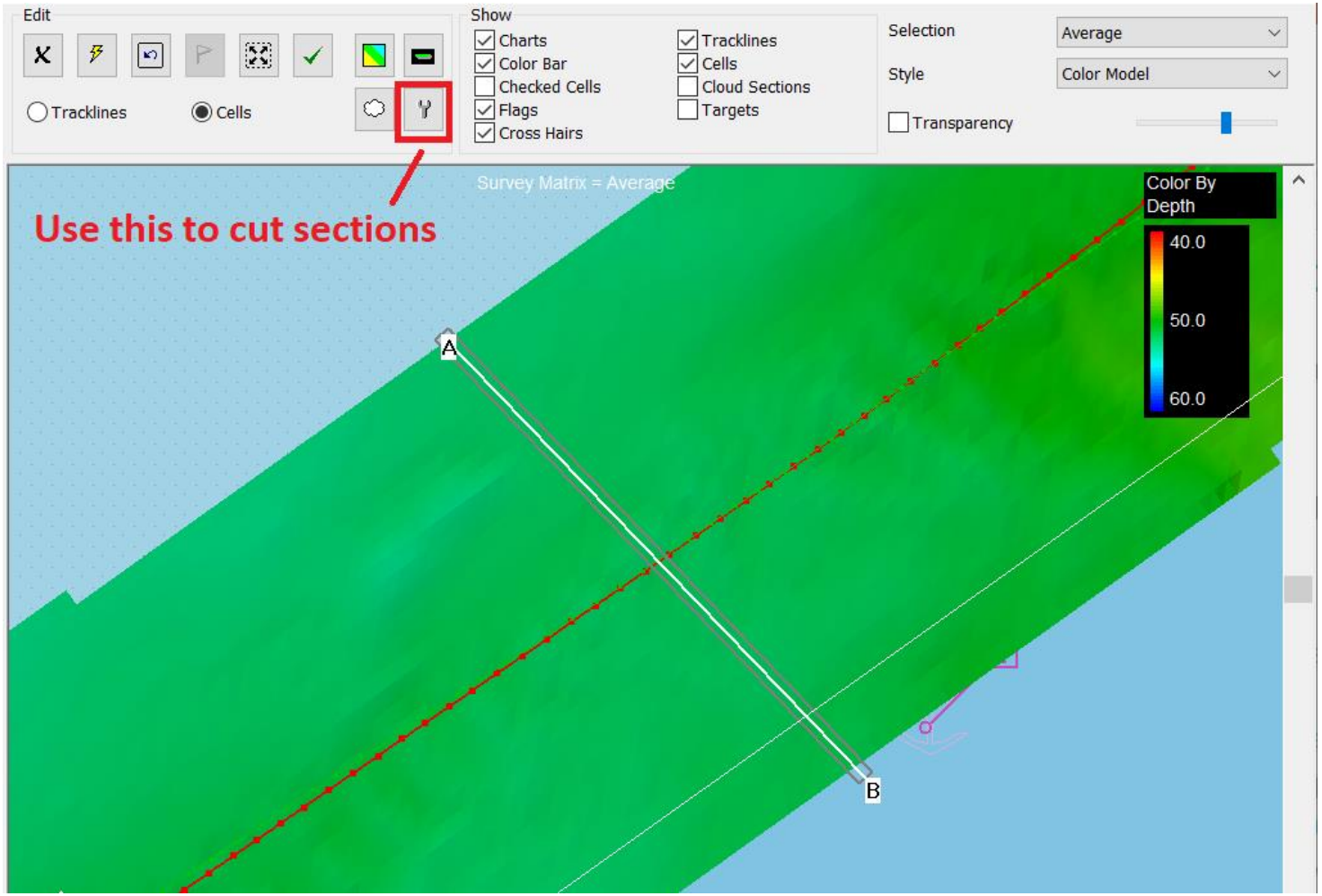


MBMAX64 can find a correct cross section when files are loaded in pairs. For example,

- Load a pair of Roll lines then advance to Stage 2.
- Click **Tools** > **Patch Test** > **Roll** to start testing.
- Repeat for Pitch and Yaw.
- Perform test for Latency, as needed.

Testing is the same for Auto or Manual cross sections.

Manual Cross Sections

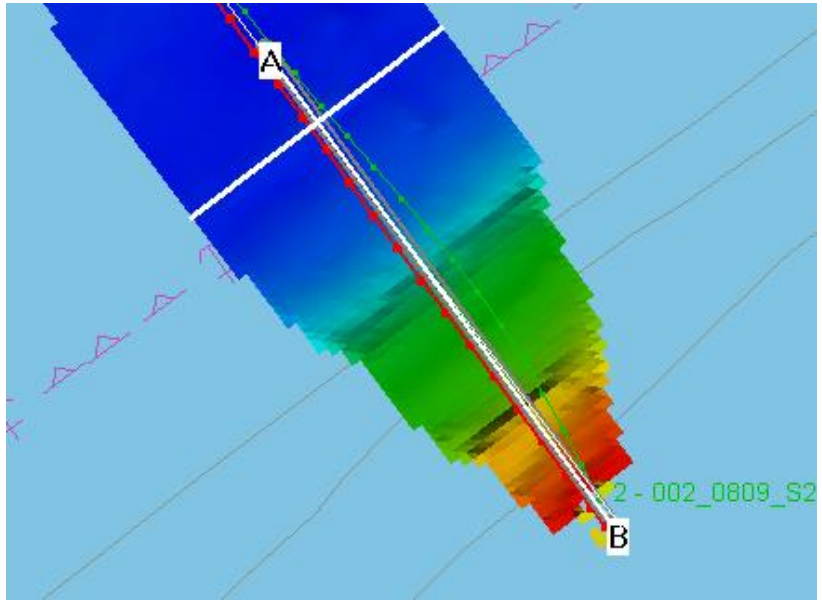


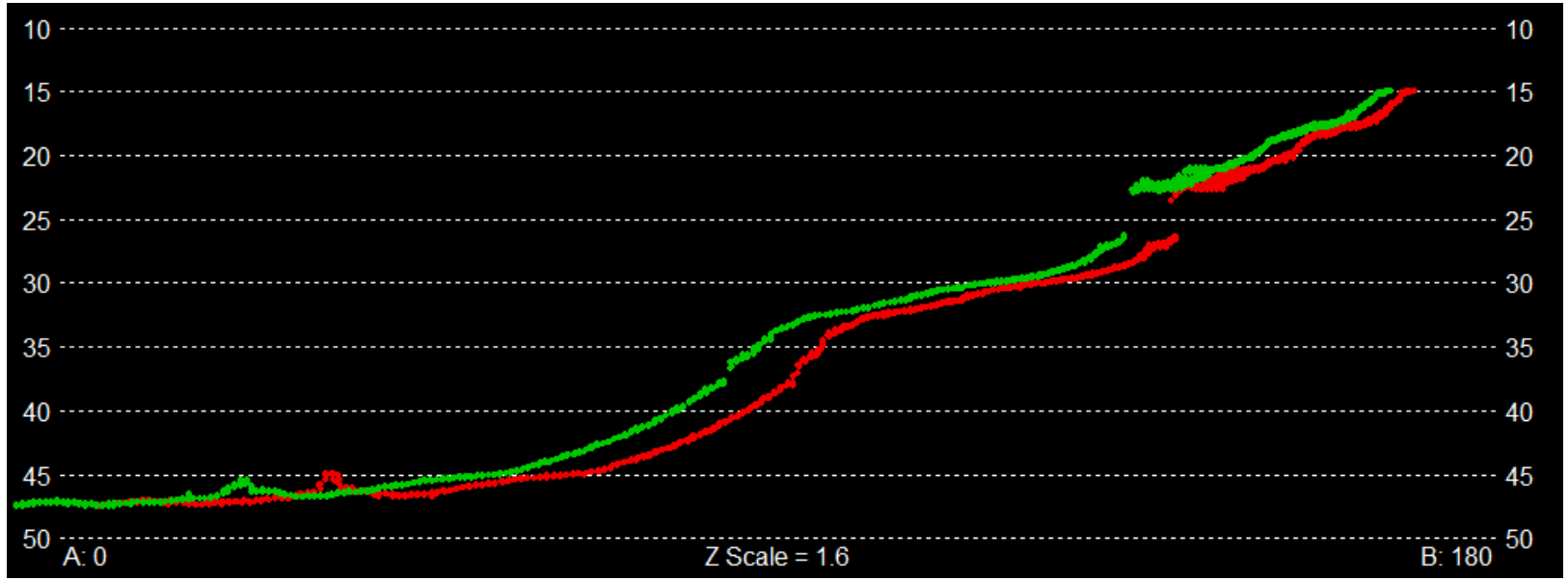
Manual Cross Section Method

- Load all survey lines at once and get to Stage 2
- Select pairs for each Test
- Use the Wrench to cut sections.
- **Roll**: Across track in the flat area.
- **Pitch** and **Latency**: Along track under the sonar head.
- **Yaw**: Along track half way between survey lines.

Latency Test

The Latency Test isn't strictly necessary with modern GPS and Inertial Systems providing the multibeam with UTC timing. Latency is effectively 0.00 when this is done properly.



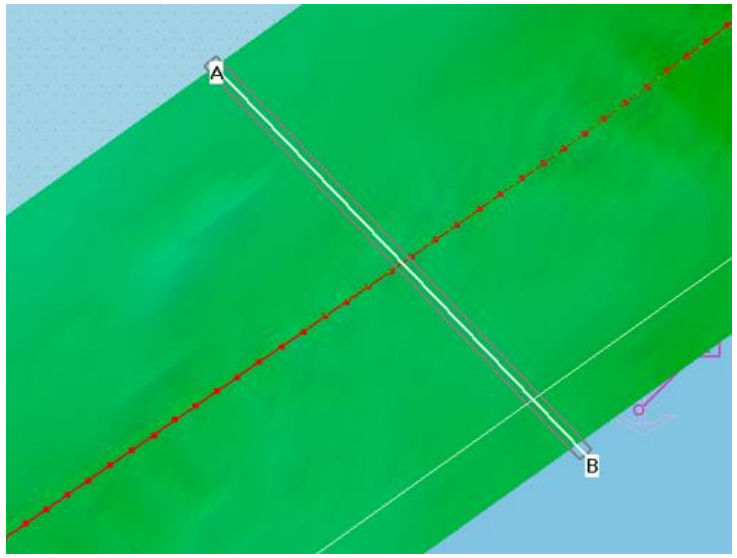


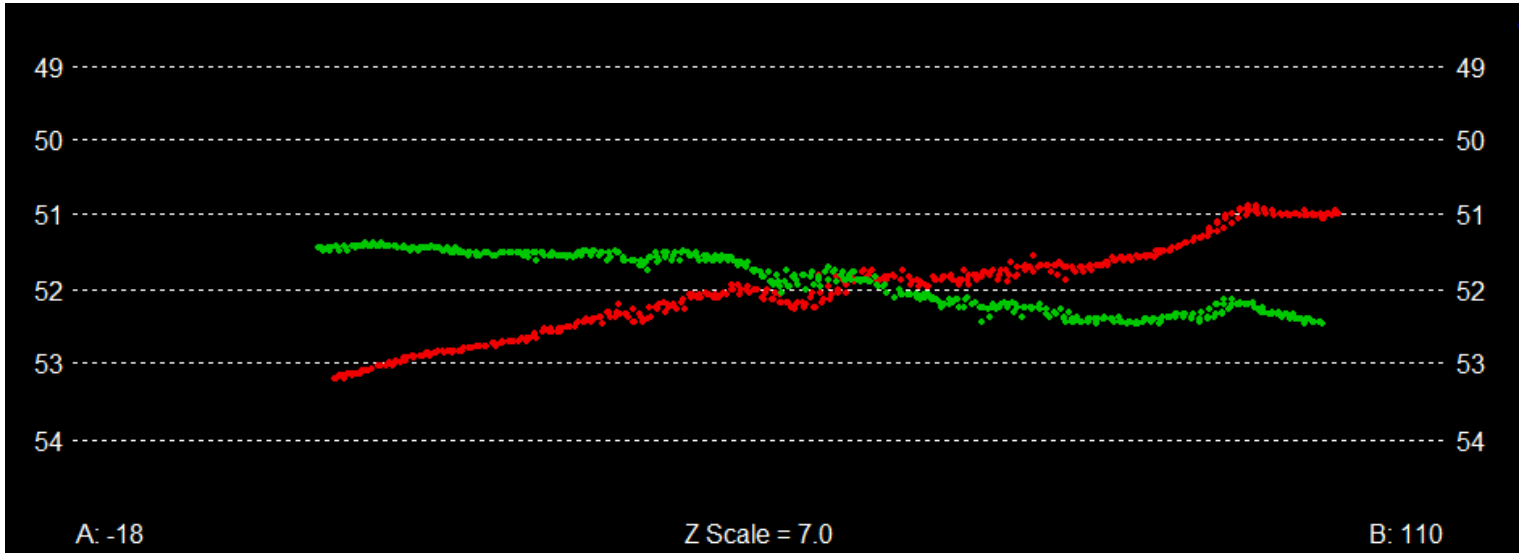
Lines run in the same direction at different speed. Cross section is cut Along-track.
This cross section shows an extreme Latency error. Why a Latency Test should always be done.

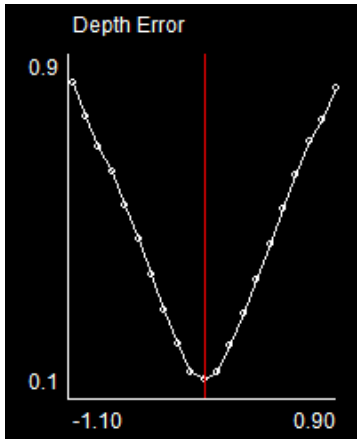
NOTE: Speed of the Vessel should be a twice difference between the files or more (3 kts vs 6 kts)

Roll Test

The Roll Test is very important. Large depth errors are caused by roll misalignment.



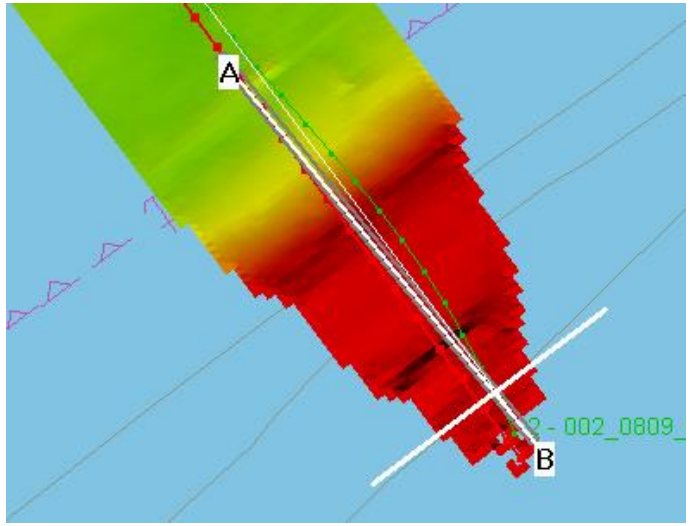


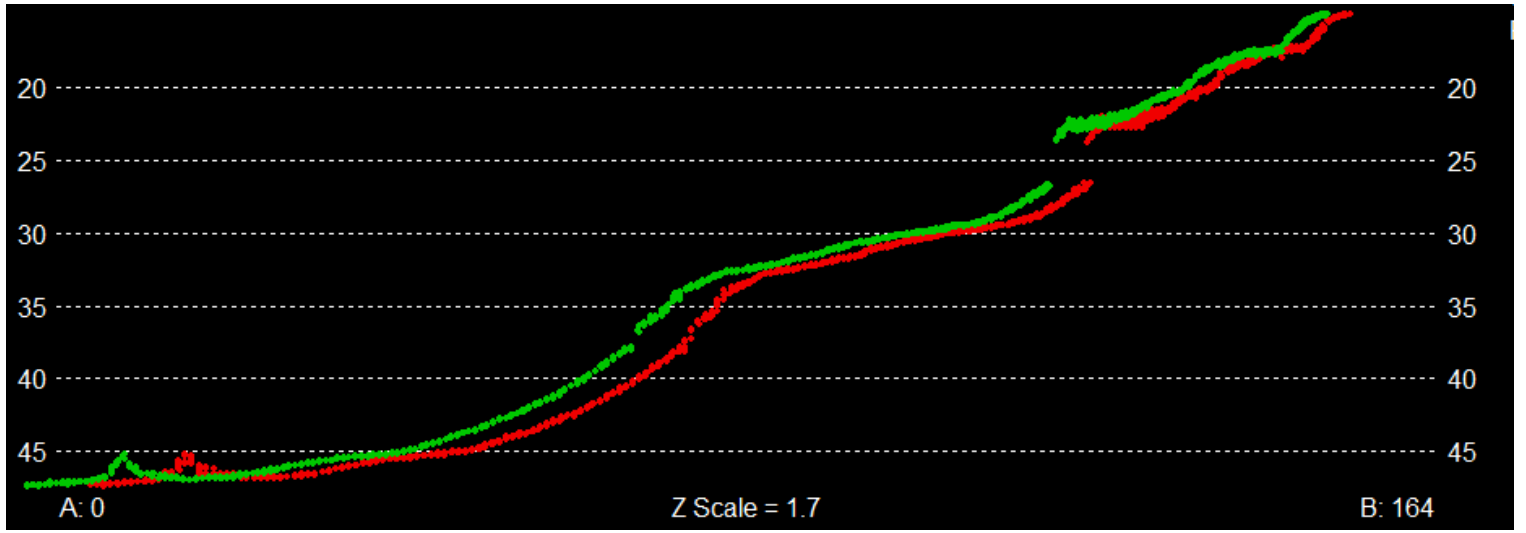


- Reciprocal lines run over a flat area at normal survey speed.
- Cross section is Across-track.
- A misalignment of ‘one degree’ (shown here) will cause a significant depth error (2’ in 52’ of water).

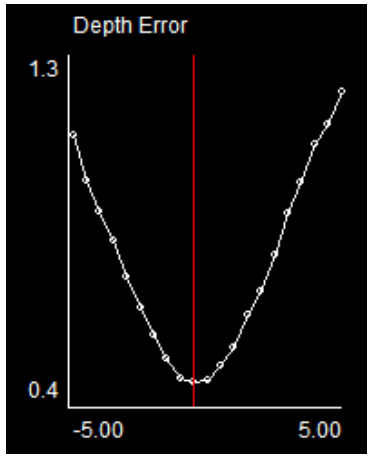
Pitch Test

Pitch misalignment leads to depth and position errors.



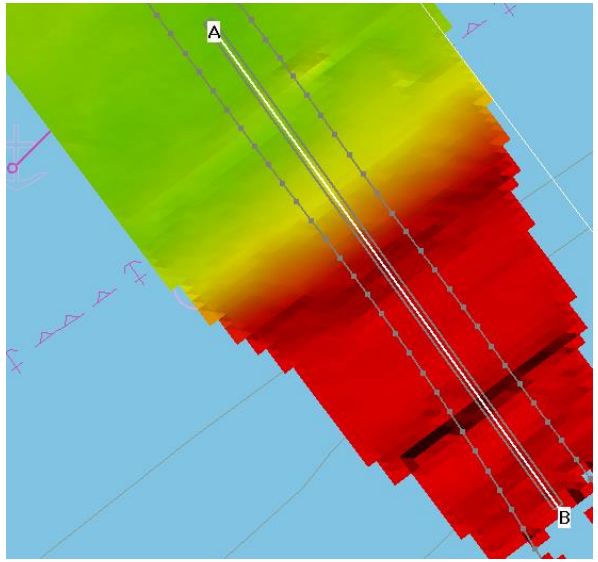


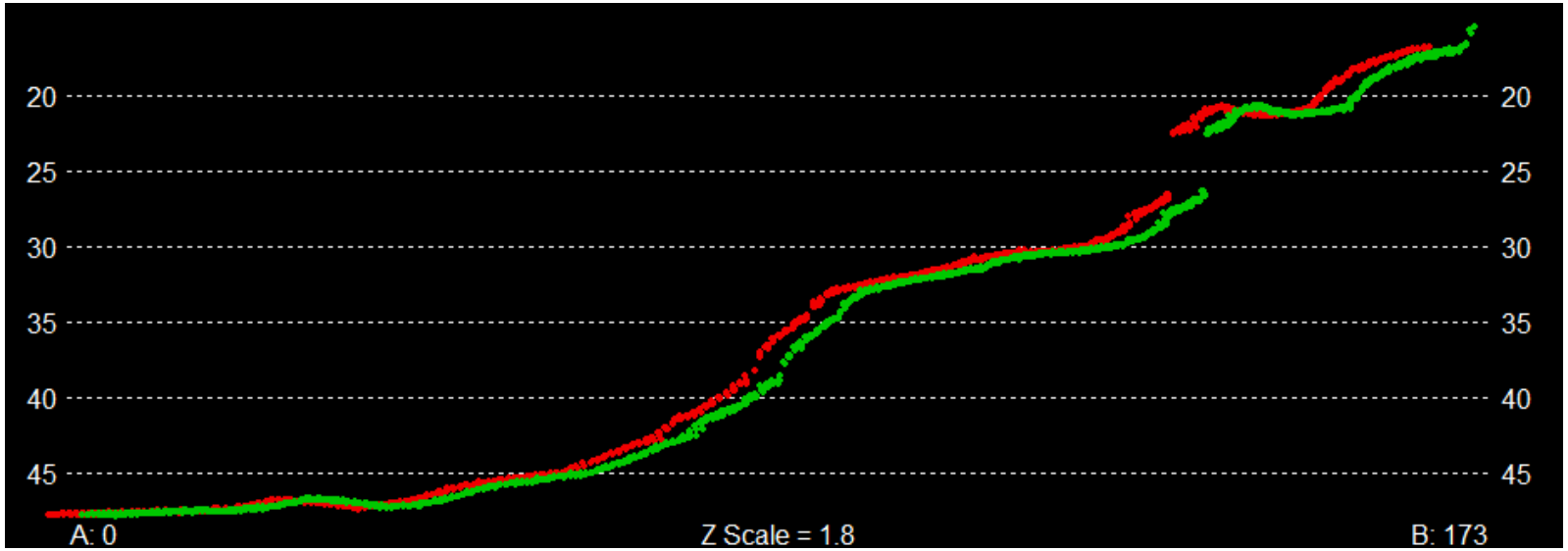
- Reciprocal lines run over changing depth at survey speed.
- Cross section is Along-track.
- A slight angular misalignment adjustment will correct for the separation seen here.
- The Depth Error Curve shows how much misalignment was found



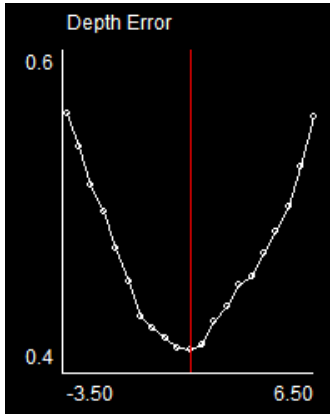
Yaw Test

Yaw misalignment only leads to positions errors.





- Offset lines run in the same direction at survey speed over changing depth.
- Cross section is Along-track.
- Although Yaw misalignment only leads to position errors, depth errors are seen along the cross section.



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Modifications for Dual Head and LiDAR

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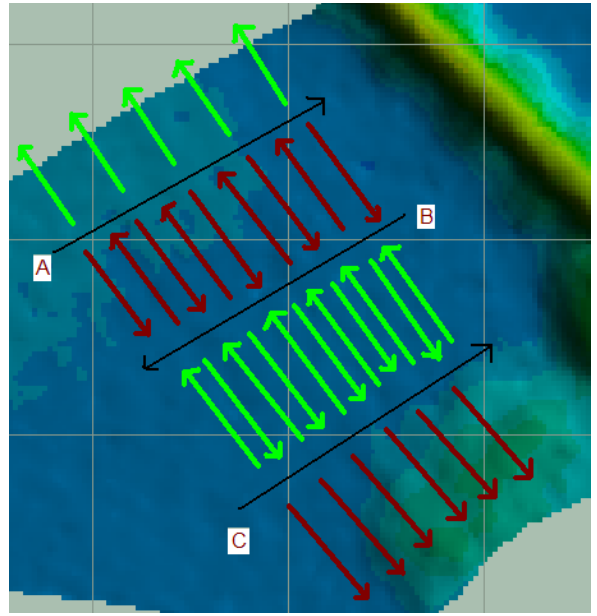
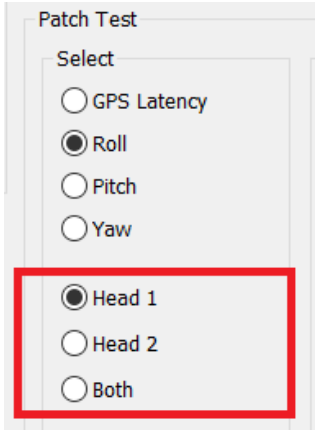
Dual Head MBES Test

- Different geometry of the Heads requires that you **overlap** the **Port** and **Starboard** heads separately.
- **Latency** and **Yaw** still only require **2** lines.
- **Roll** and **Pitch** tests require **3** lines instead of **2**.
- **Yaw** requires a slightly different spacing and Overlap scheme

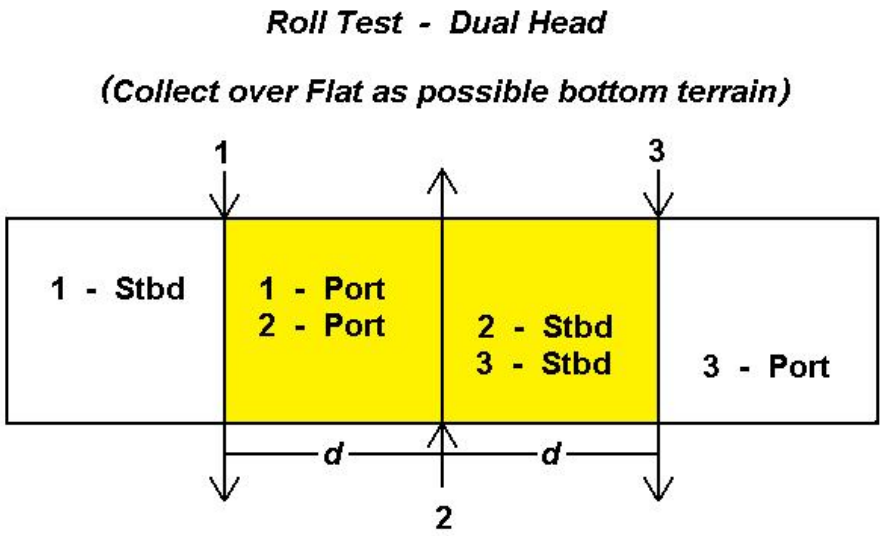


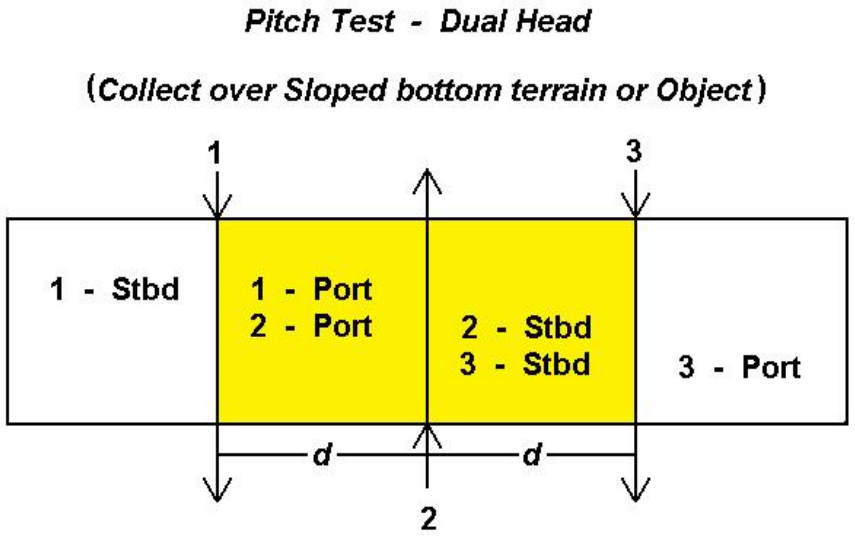
- Some Dual Head systems in engineered mounting frames can be treated as single head.

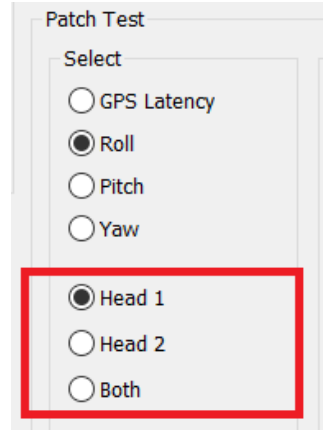
You need to select sonar head in patch test.



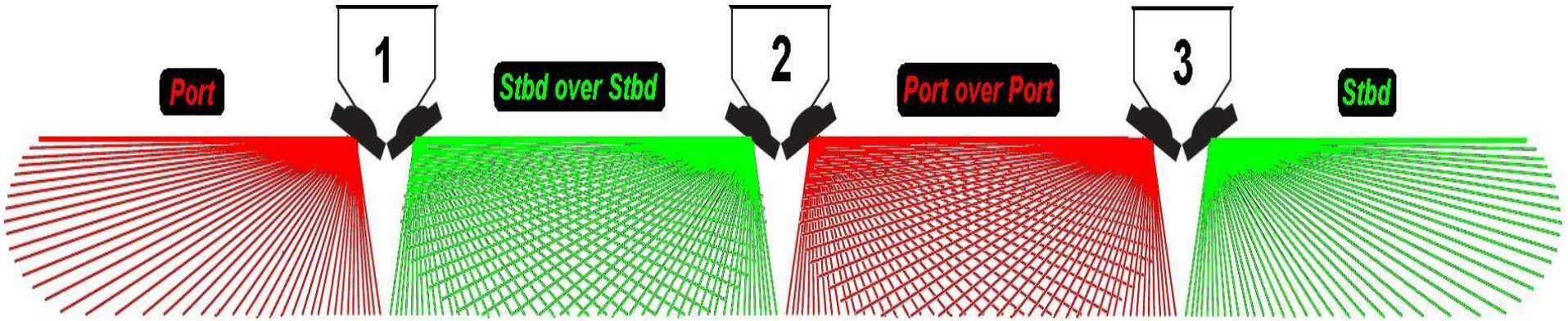
Dual Head MBES Test



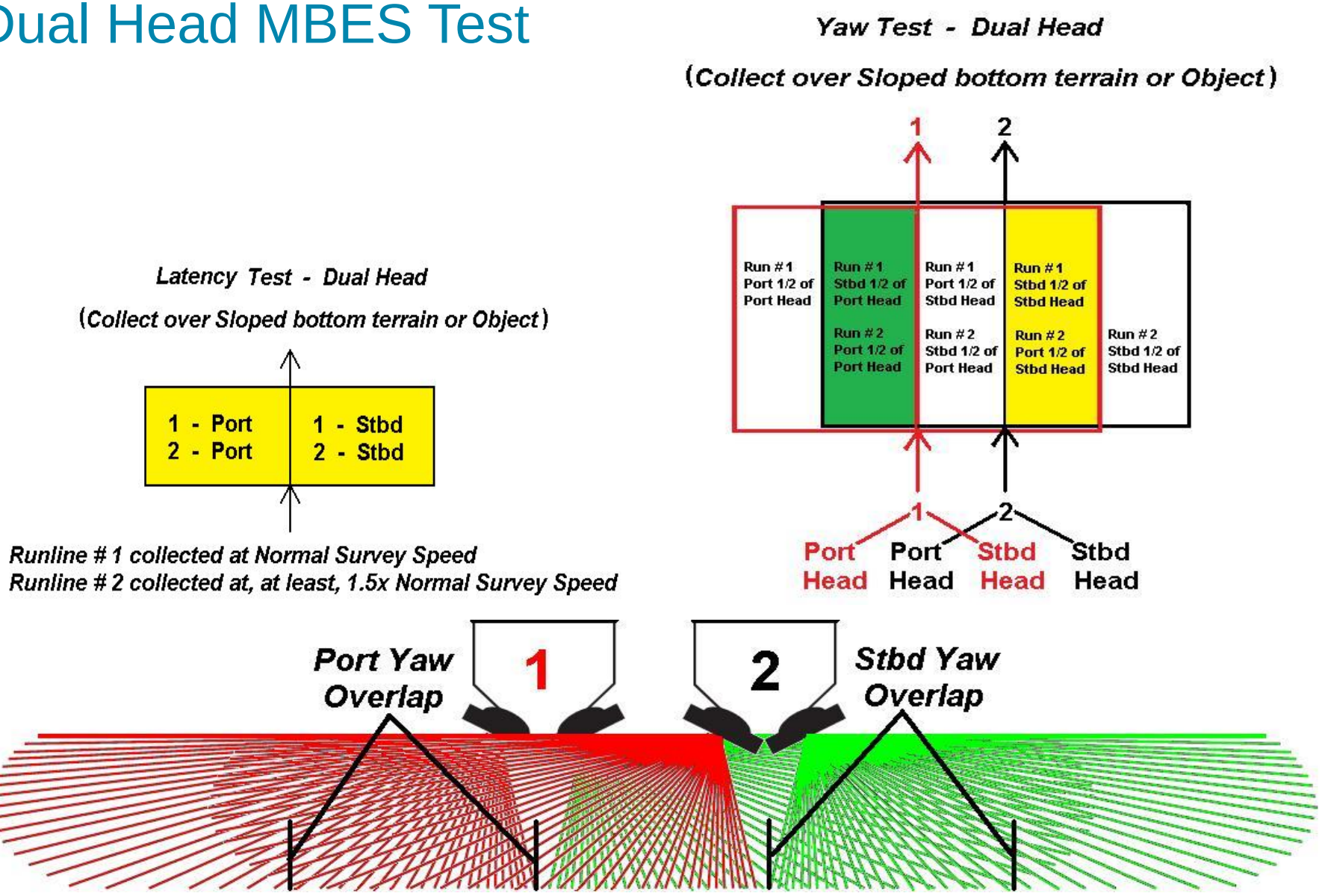


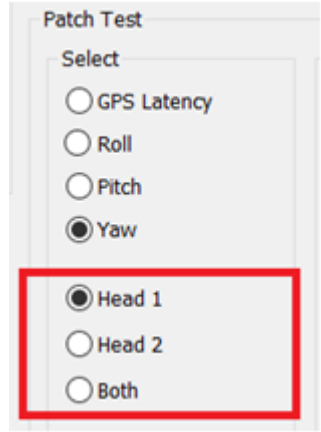


Select the correct Sonar Head when performing the Test



Dual Head MBES Test

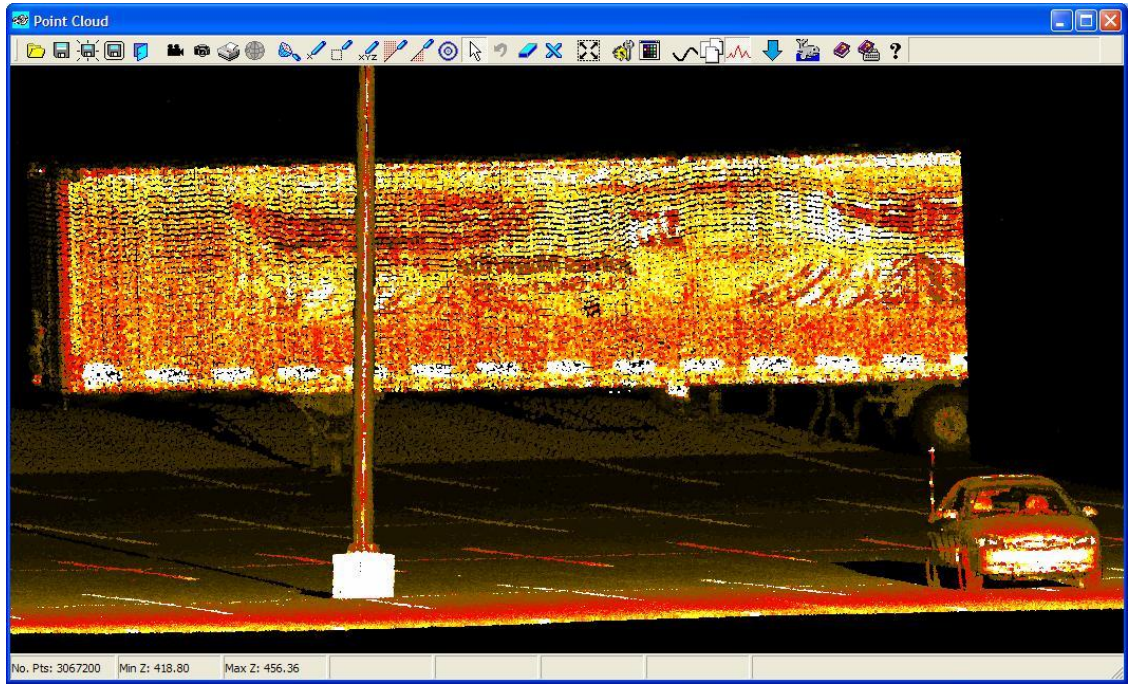




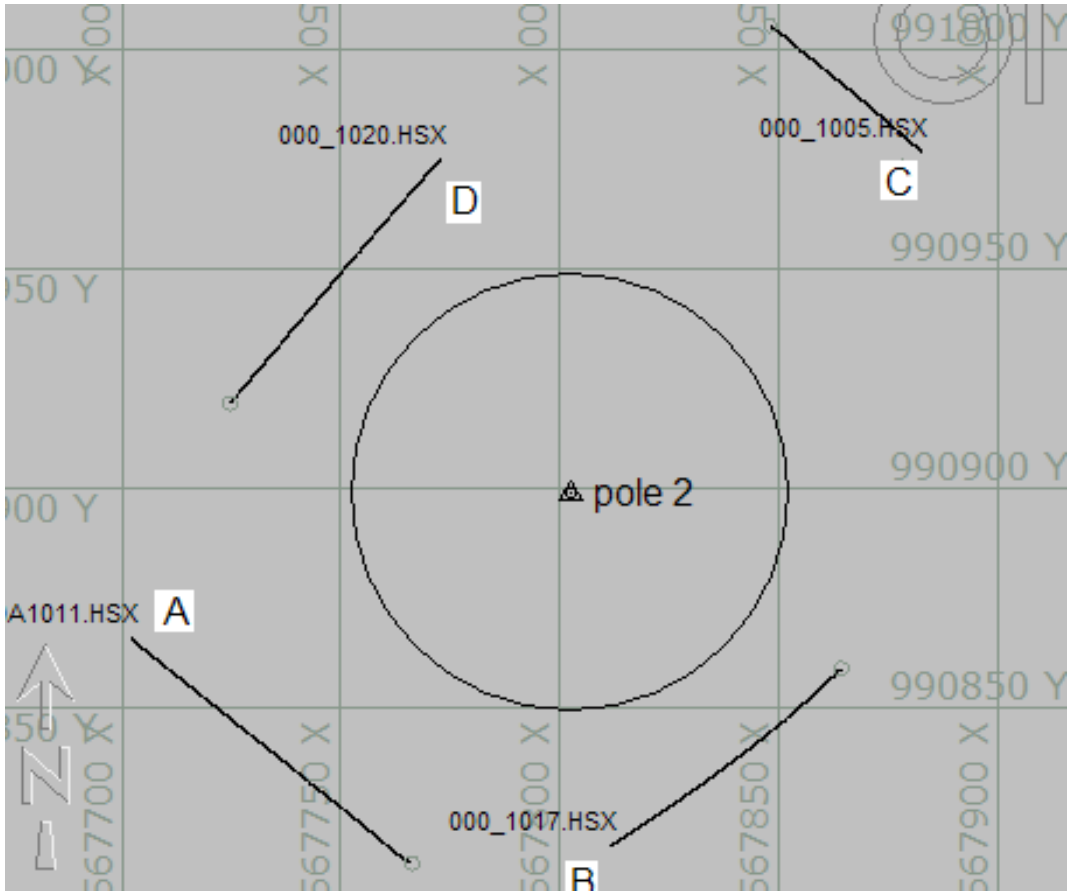
Select the correct Sonar Head when performing the Test

LiDAR Patch Test

- The best patch is a parking lot with light posts. If you need to test in water, find a day marker or piling out of water.



HYPACK® DATA FROM Teledyne-Optech ILRIS scanner.

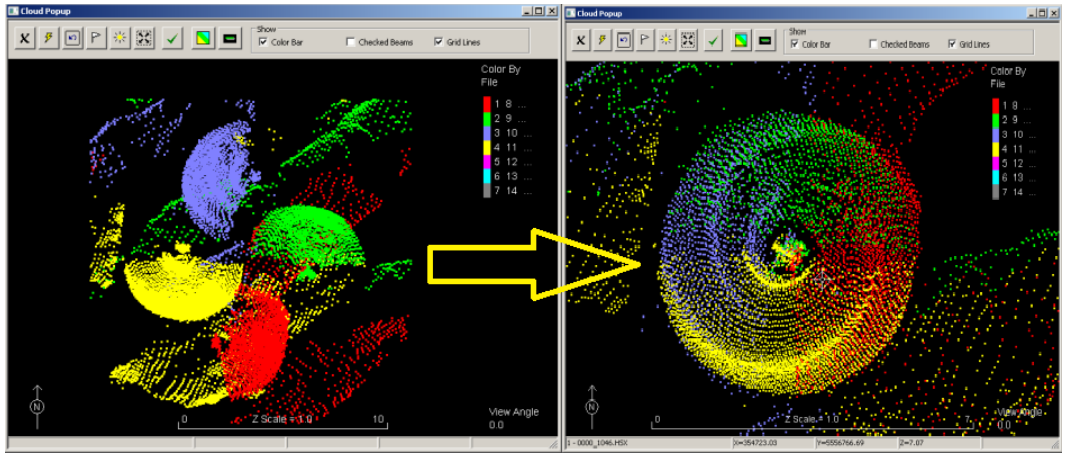


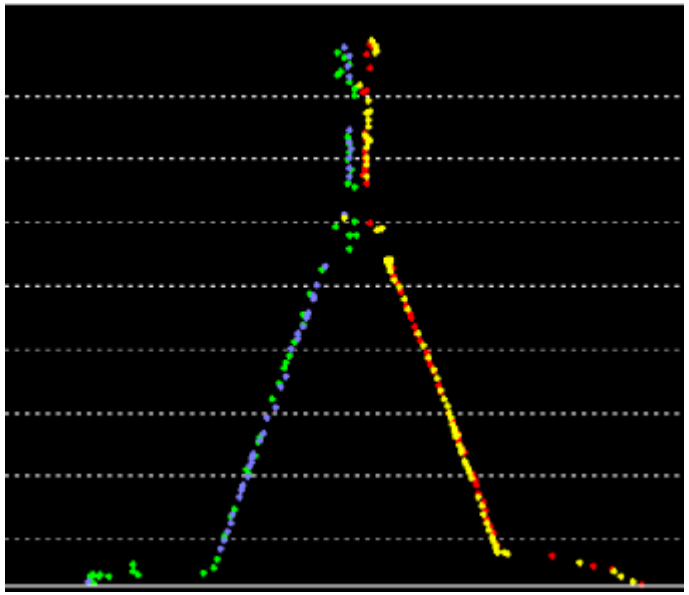
- Line pairs A-C or B-D can be compared for all alignments; Roll, Pitch and Yaw.

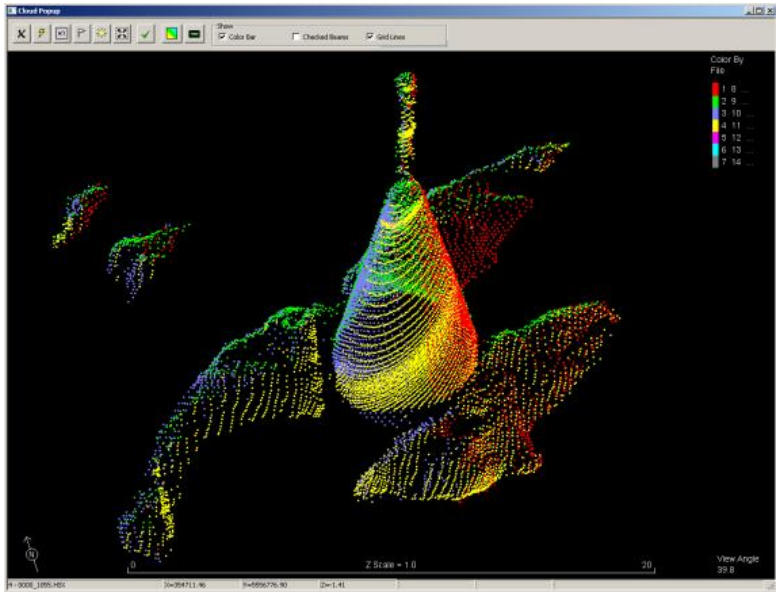
LiDAR Patch Test

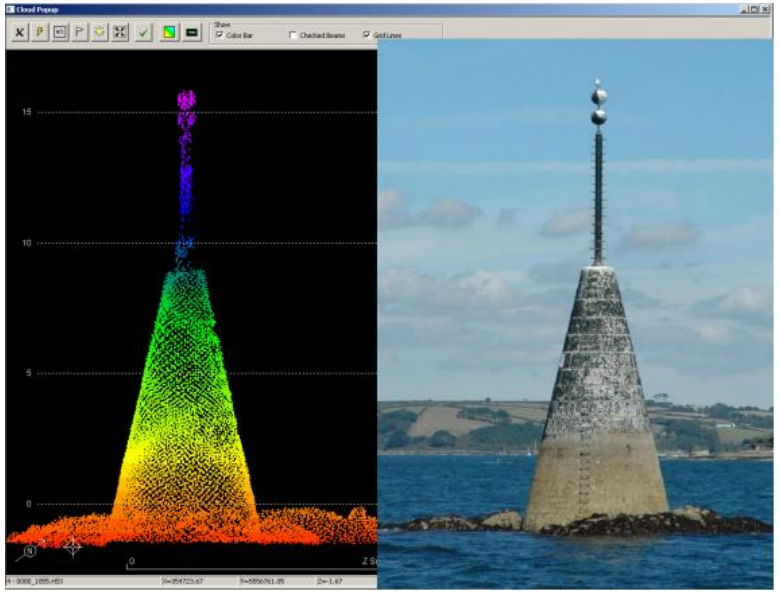
- LIDAR Patch testing runs the ’angular’ tests are run in ‘reverse’ order: Yaw, Roll, then Pitch

- **Yaw** orients the four (4) halves of the Light Pole and its base
- **Roll** levels the flat surface
- **Pitch** makes the Light Pole vertical









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Performance Test

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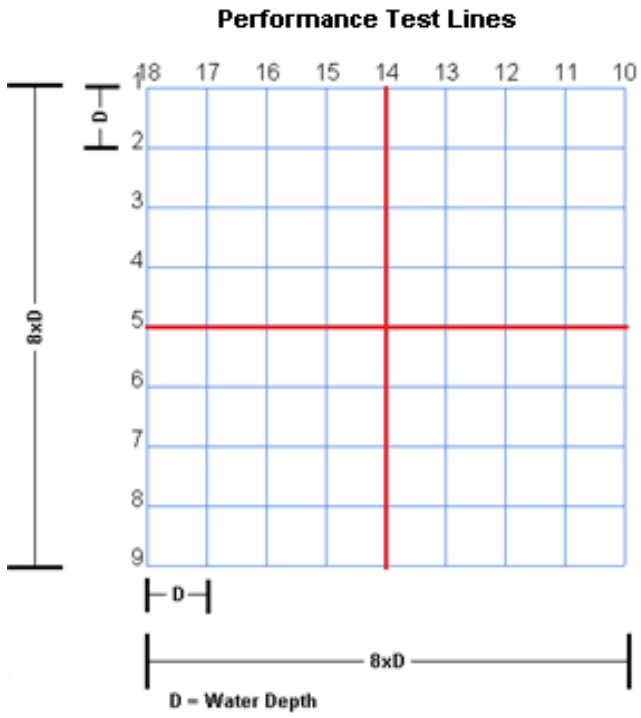
How to Make a Reference Surface

Location - Small area with a flat, uniform bottom



Preparation and Data Collection

- Two sets of 9 parallel lines crossing at 90 degrees.
  (9 parallel lines allows for 150 degree Swath Width Test)
- Line Spacing (Separation) = Water Depth
- Collect data at ONLY a 90 degree Swath (if possible)
- Survey at low or high tide to minimize vertical errors
- SV cast immediately before data collection

Processing

- Reference MTX with 1’ x 1’ cells.
- Edit in MBMAX64. Filter to +/- 45 degrees
- Careful removal of remaining flyers.
- Save to XYZ. One point per cell, average, min 3 points/cell

Check Lines

The Reference Surface need only be done once. The check lines are run periodically to test system performance.

Data Collection

- Run the ‘middle’ lines of each set of perpendicular lines (These lines are shown in red over the Reference Survey.)
- Set Swath Width to the ‘widest’ that you want to test (150 degrees = 7.4 times coverage, hence, the 9 lines)

Check lines

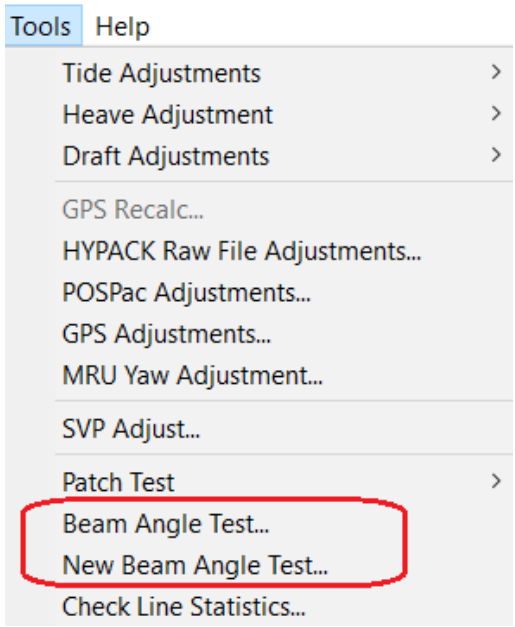
Processing

- Edit in MBMAX64 using the reference MTX from before and with the normal corrections (tide, SV).
- Do NOT apply Angle Filters
- Very ‘minimally’ remove flyers We want test just how ‘repeatable’ ALL the beams are, without removing too many points.
- After editing we’re ready for the Beam Angle Test.

Beam Angle Test

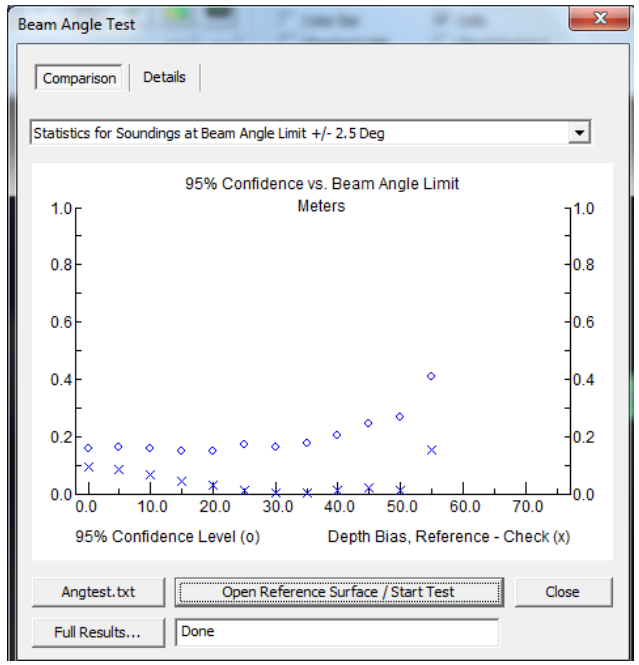
With check lines loaded, run the beam angle test and open the reference XYZ to start test.

All stats are based on reference depth minus check.

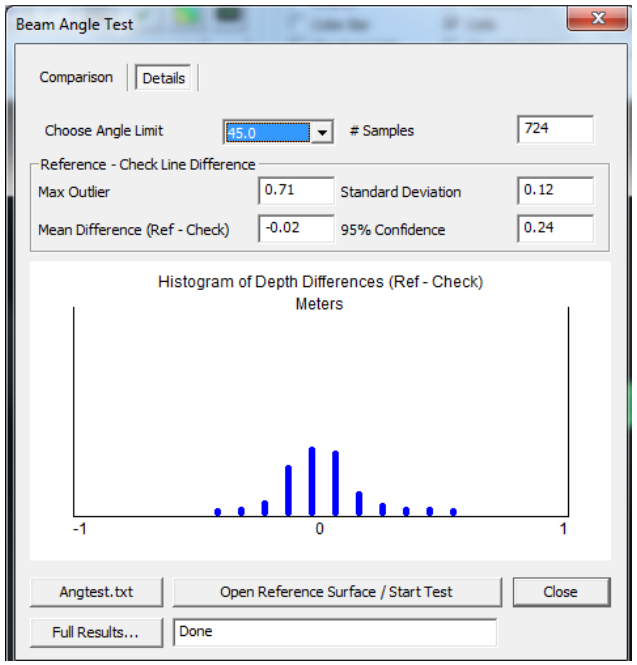


Comparison tab is the overall result

- o's show 'repeatability'
- x's show 'bias'



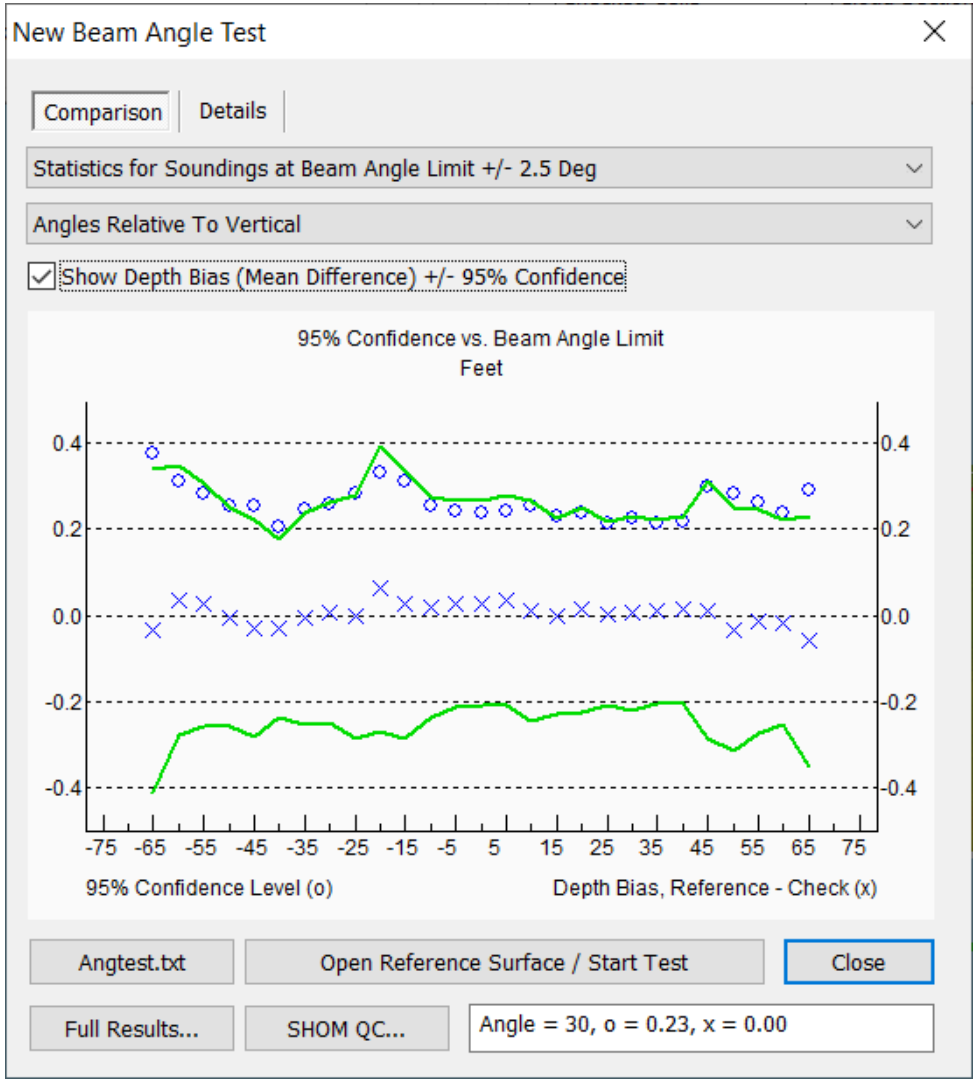
Details tab is result at specific angle range



New Beam Angle Test

Improvements vs. the original test

- Option to show angles relative to vertical.
- Breaks out Port vs Starboard Beams (+/- angles)
- Before, combined both sides and showed averaged values
- Additional **GREEN** line = 95% confidence +/- bias
- SHOM style QC report. A nice summary.



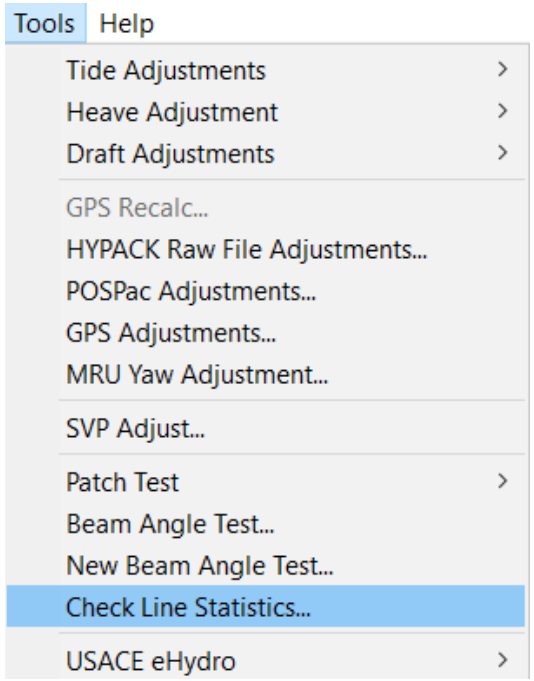
xylem
Let's Solve Water

Multibeam – Single Beam Comparison

HYPACK 2022 – Training Event

Reference Surface

Simple. Reuse the same one used for beam angle testing.

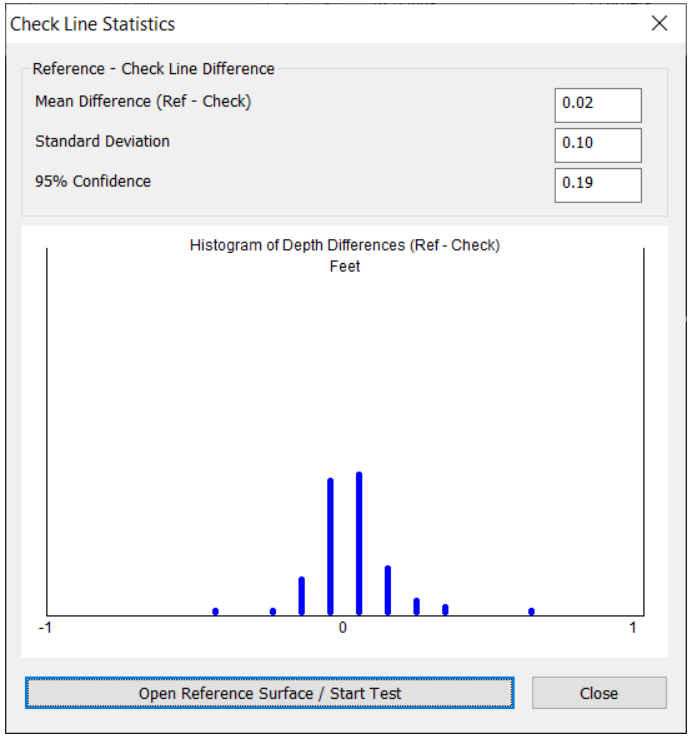


Check Lines

- Run the same ‘middle’, just with a singlebeam echosounder.
- Process to corrected XYZ using HYPACK® SBMAX or SBMAX64.

Check Line Statistics

- Load the SB Check Lines XYZ
- Tools > Check Line Statistics
- Open the Reference XYZ



This is a good test.

Mean Difference = Bias = 0.02’

Thank You !

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