A Technique for using Backscatter Imagery to Calibrate your Multibeam sonar

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Checking the values using backscatter data

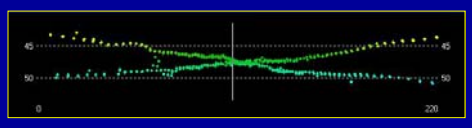
- The collection of Backscatter is co-located with the Multibeam sensor.
- No position errors would be in the data
- The imagery will inherit the motion of the vessel.
- Distinct features on the seafloor can be used in determining Latency, Pitch and Yaw.
- Use this method to check Patch Test results from traditional method of using bathymetry.

Methodology

1. Process the bathymetry through the standard patch test method
2. Mosaic the data lines individually at the highest resolution you can. In my tests, I used 20cm
3. Locate a feature that lies perpendicular to the direction of the line.
4. Features such as a submerged log or a large rock can be used
5. Use multiple features and take an average of results.

The standard Patch Test

- Requires collecting bathymetry data over a series of lines to determine the mounting offsets between the sonar and IMU or time delay from the GPS system



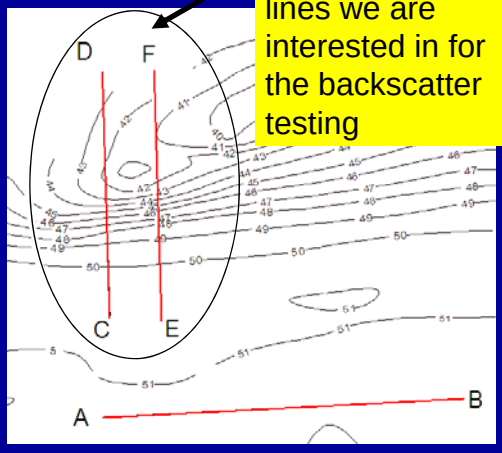
Why do it?

Overlapping lines will show data artifacts. Even a small bias can create a large depth mis-match

From the EM1110-2-1003 field guide for the USACE Requirements

•Patch tests are performed after initial installation, and periodically thereafter if sensors are modified, to quantify any residual biases from the initial system alignment.

Patch Testing a Multibeam



- **Roll: Line A-B**
  - Reciprocal lines, flat bottom. Survey speed.
- **Pitch: Line C-D**
  - Reciprocal lines, sloping bottom. Survey speed.
- **Yaw: Lines C-D, E-F**
  - Offset lines, sloping bottom. Survey speed.
- **Latency: Line C-D**
  - Same line and direction, differing speed, sloping bottom.

Order of Tests
(note the change)
- Latency
- Pitch
- Roll
- Yaw

Running the calibration lines

Traditional test procedures:

- Test in the deepest water available. Note: it does not necessarily need to be inside the survey area required for SV casts
- Except for latency, run lines at your normal survey speed.
- Run each test twice to confirm results. Average multiple tests for final results.

For imagery verification: **Collect Backscatter Data while running these lines**

It's part of most systems today, and we'll see how it can be used to verify the results from the bathymetry

6

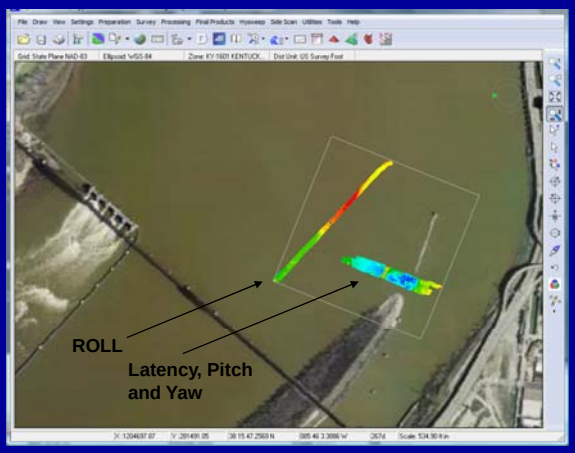
Using backscatter data

- Two Patch Test areas were examined to determine if the backscatter provided corresponding information of the offsets.
- Each data set was run through the normal process, running MBMAX and getting the results for each of the tests.
- Afterwards, the backscatter method was used
- THE RESULTS….

Area 1: Ohio River

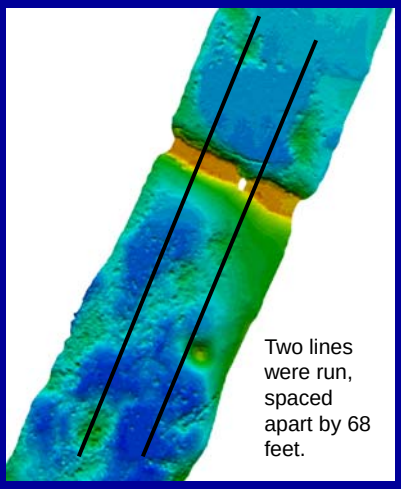
system used: Reson 8125

- An area on the Ohio River by Louisville was used for the Patch Test Area.
- The roll was done in the middle of the river; the other tests were conducted over a submerged pipeline



Survey area

- The patch test results from MBMAX:
- Latency 0.0
- Pitch -3.35
- Roll -0.55
- Yaw 0.2



Water depth 15 feet to 25 feet

Latency Verification

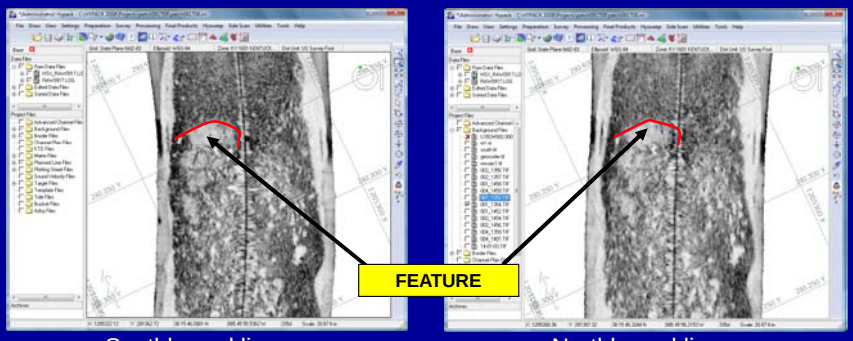
- Latency was determined to be less then 50 ms through the Patch Test.
- Multiple tests with the system were run and the results were repeatable in the 0 – 50 ms range.
- Using the higher end value of 50 ms, we would expect to have a horizontal shift of 0.50 feet with a vessel speed difference of 6 kts

Speed (ft/sec) *latency (sec) = Distance

10 ft/sec * 50 ms = 0.50 feet

Latency Verification

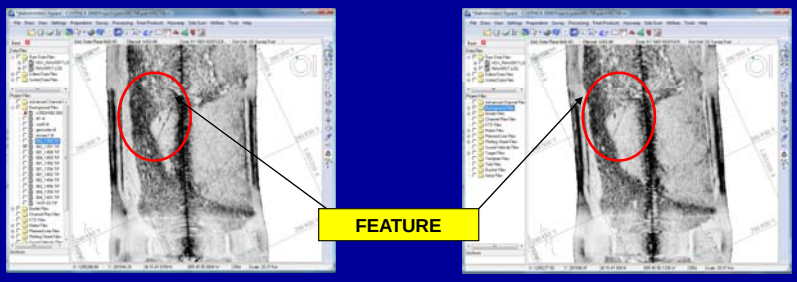
- Linear feature running perpendicular to the line.
- Overlaying the two images show shift of the feature in the direction of travel of less then 0.5 foot
- Latency is computed to be less then 50ms



Southbound line Northbound line

Pitch Verification

- Pitch: The traditional method looks for a slope or feature on the seafloor. Running reciprocal lines, an object on the seafloor will have a horizontal displacement.
- The Patch Test would resolve this distance and report it as pitch angle
- Using sidescan imagery, located a small but distinguishable feature.

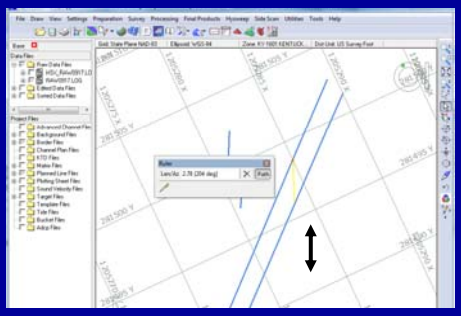


South bound line North bound line

Pitch Verification

- Drawing a line segment over the feature

  (In HYPACK, use the line editor to make a segment)
- Measuring the distance in the direction of the survey line showed the distance between the two lines (and the movement of the feature) of 2.78 feet.



Pitch Verification

Distance measured = 2 * tan (pitch) * water depth

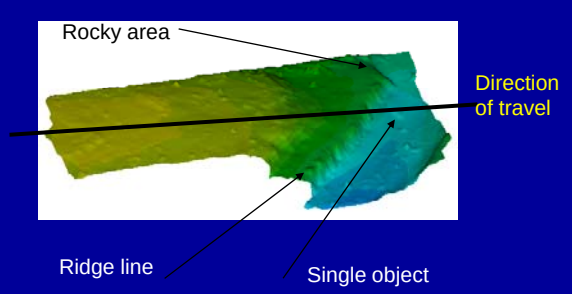
- Solving for pitch using the backscatter data resulted in a value of -3.32 degrees.
- From the traditional Patch Test, the pitch value was determined to be -3.35 degrees. A step size of 0.05 degrees was used while running the patch test. The uncertainty is half that amount. The result is -3.35 +/- .025 degrees.

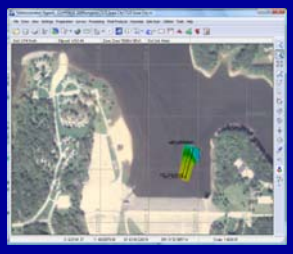
Area 2: Iowa River

system used: Reson 7125

The section was not flat, but had a ridgeline, dropping the depth by more then 3 meters.

- Upon processing of the backscatter data, three possible features that could be used for patch test verification were located



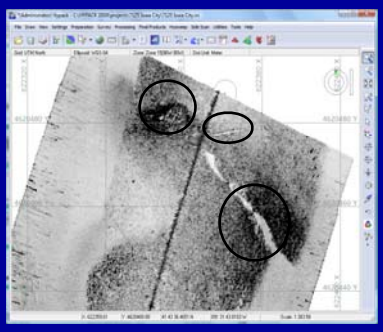


Pitch Verification

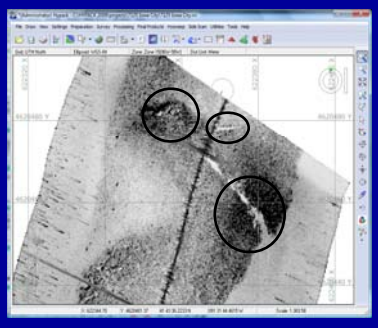
Features found on the backscatter:

1. Ridgeline
2. rock outcrop
3. linear feature

We'll use each one used for Pitch verification

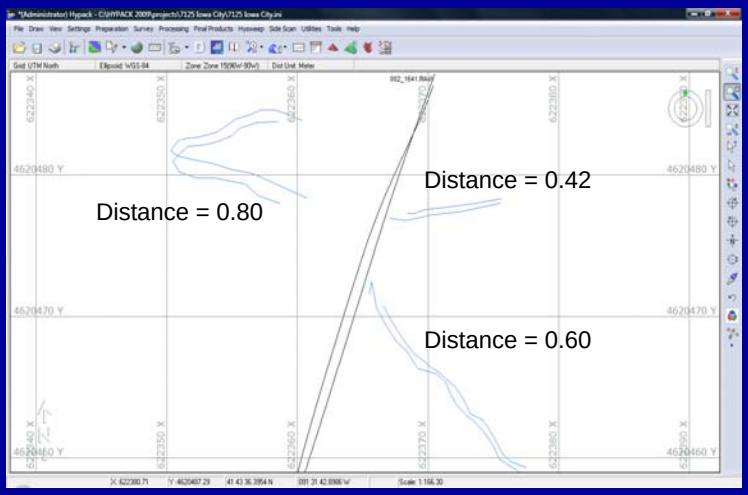


1640 line



1641 line

Pitch Verification



Horizontal shift (in meters) for each feature from line 1641 to line 1642

Area 2 - Pitch Verification

This time, the results varied a bit. The distance and computed pitch angle: Note the rock outcrop showed the largest distance, which I attributed to poor measurement due to the feature not having sharp edges.

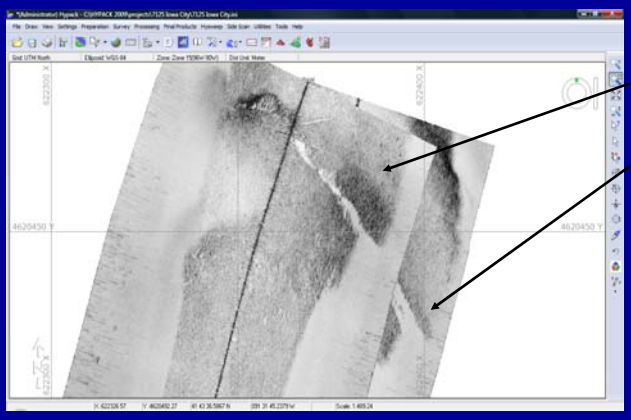
Linear feature:	42 cm	Pitch = -1.25 deg
Ridge line:	60 cm	Pitch = -1.81 deg
Rock outcrop	80 cm	Pitch = -2.41 deg

Distance measured = 2 * tan (pitch) * water depth

The Pitch value of the 2 sections (line and ridge) averaged together resulted in -1.53 degrees

Yaw Verification

Using the Two adjacent lines, a YAW verification was attempted using the backscatter imagery.



A line was drawn on the southern end of the ridge line.

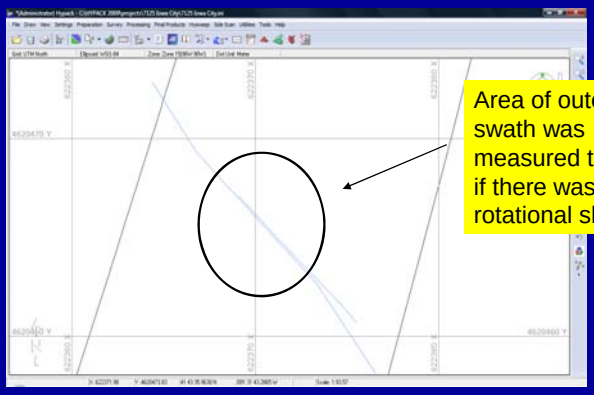
Overlapping the two segments showed an almost perfect alignment

Yaw Verification

The total distance of overlap = 8 meters. The horizontal offset found was 13 cm.

The YAW (rotation) at would result in 0.9 degrees.

tan (yaw) = 0.13 / 8 meters



Area of outer swath was measured to see if there was any rotational shift

Results from AREA 2

Backscatter resulted in a Pitch value of -1.53 degrees (+/- 0.3 deg) and a Yaw value of 0.9 degrees (+/-0.7 deg)

Note: The 0.3 and 0.7 degree uncertainty was determined by using a 20cm resolution of imagery. Lowering the resolution would be possible with a better data set.

- Processing the data within MBMAX, the results obtained were:
- Latency = 0
- Pitch = -1.5
- Roll = -1.85
- Yaw = 0

Overall differences between the two methods

- Both these cases provide an additional check to the value obtained using the bathymetry. Other analysis has shown similar results.
- Differences between Multibeam Data Patch test and Backscatter Imagery

Data Set	ROLL	Latency	PITCH	YAW
MB Sys 1	Not det.	< 25 ms	-0.03	-0.2
MB sys 2	Not det.	< 25 ms	-0.03	0.9

Conclusion

1. Roll cannot be determined in this test method and Yaw is sometimes difficult.
2. A single linear feature is best. Large rock outcrops will work, but they need delineated features (sharp edges).
3. The feature must be perpendicular to the direction of travel.
4. A water depth of 10 – 20 meters is ideal. It provides a large angular difference (greater then positional errors), while preserving imagery resolution.
5. Finding an object isn't easy, but if there is one on the survey line, try this method.

Thank you