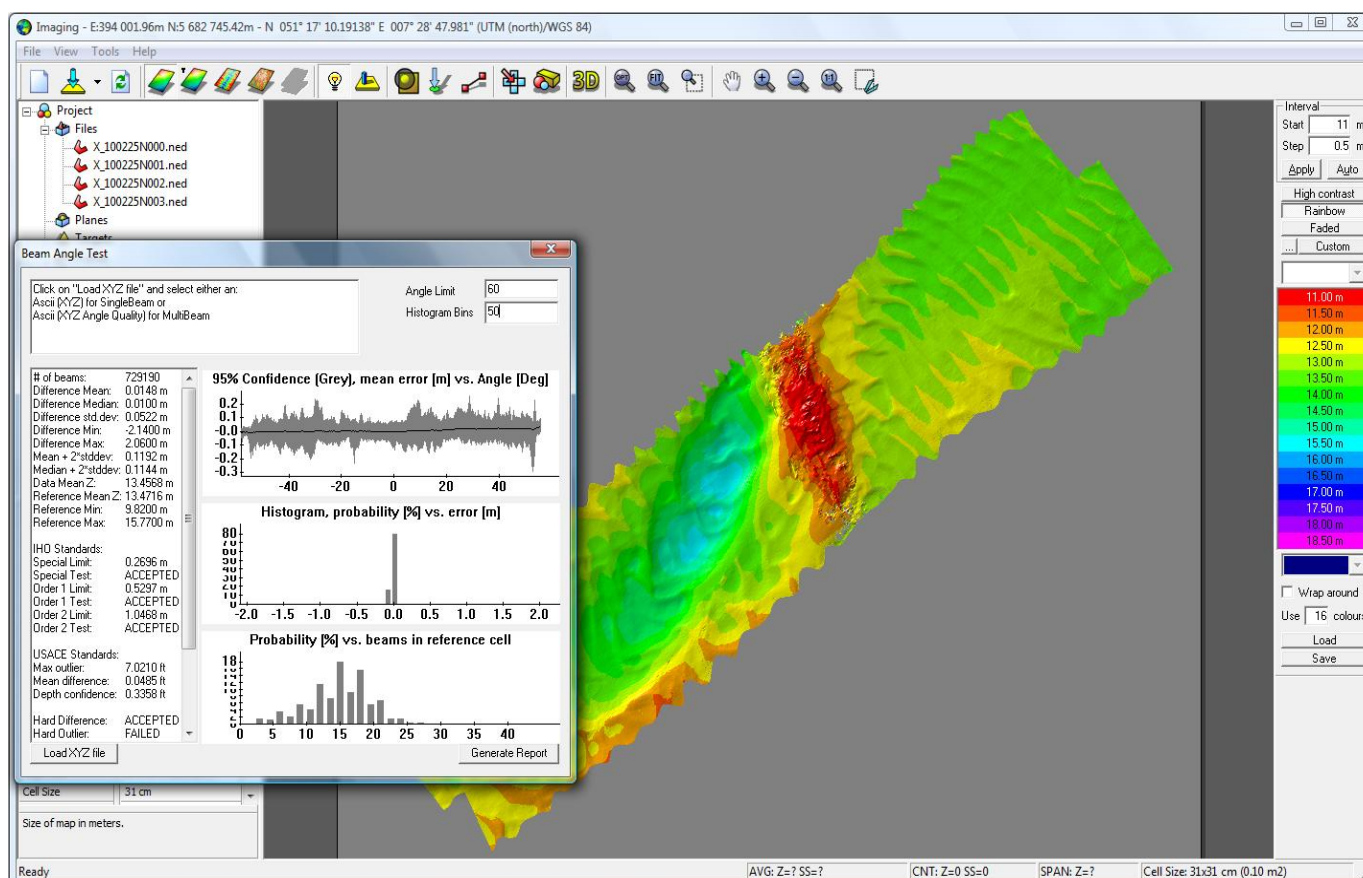


# Tutorial for Performance Testing In Imaging



## Performance Test in Imaging

### 1. Introduction

The Performance Test in Imaging is designed to facilitate a determination of the quality of a hydrographic survey. The hydrographic data could either be acquired by means of single-beam or by means of multi-beam techniques.

### 2. Utilizing the Performance Test Tool

The basis of the test is a base model, that must be superior to the survey that is to be tested. In the present context, this base model is termed the 'Reference Model'. The model/survey, to be tested is termed the 'Test Model' or the 'Test Survey'.

#### 2.1. *Creating a Reference Model*

Bearing in mind that the 'Performance Test' is based on comparing a survey line against a reference model, it is of the outmost importance to attain a good, superior reference model. This can be achieved in different ways:

- By utilizing a superior survey configuration (method, instrumentation etc.)
- By surveying the area with multiple lines and in a variety of directions
- By thoroughly cleaning and editing the surveyed area

The ideal method would probably be to do a combination of the three. As a minimum, however, it is recommended to perform the survey several times over the same area, in multiple directions with a substantial overlap. Before the performance test is done the complete survey system should however be completely calibrated. This would include validation/calibration of attitude sensors as well as performing a patch test through which the mount angles of the multibeam transducer are determined.

The acquisition of the data could be accomplished as depicted in figure 1, below. Once this has been achieved, the data must be cleaned, preferably utilizing the NaviEdit PlaneCleaning method, invoked from the PlanView Editor.

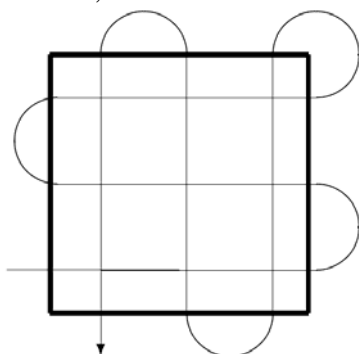


Figure 1 Survey Example for Reference Model

The cleaned reference model must finally be imported into Imaging in the traditional way, by dragging-and-dropping the files in question. An example of a series of files (NED-files from

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NaviEdit), together forming such a reference survey and imported into Imaging, is depicted below in Figure 2.

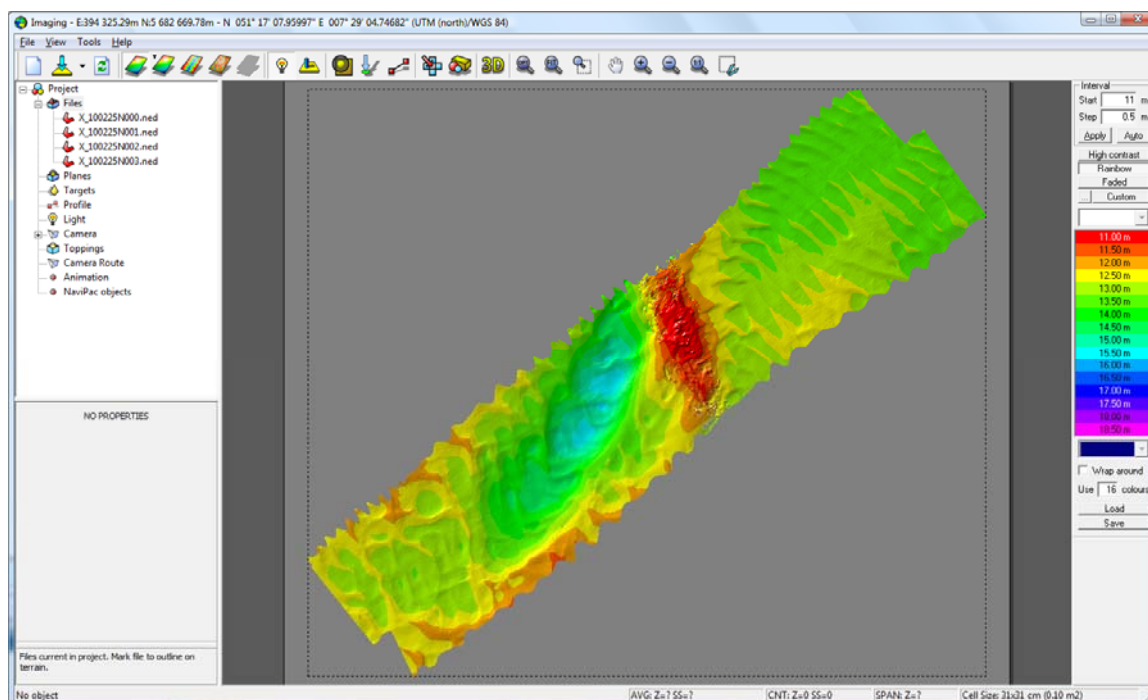


Figure 2 Reference Survey loaded into Imaging

### 2.2. *Creating a Test Survey*

The reference model has to be tested up against a test survey. It is recommended that this survey is not parallel to any of the reference runlines. For example a survey like what is visualised in Figure 3 below.

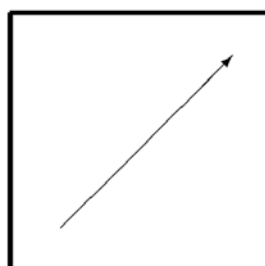


Figure 3 Survey Example for Test Survey

This survey data is exported in an ASCII file containing X,Y,Z, beam angle and beam quality. The format is named 'Ascii XYZ,Angle,Quality' and is exported from NaviEdit as shown below in Figure 4 in NaviEdit.

Alternatively, it is possible to execute the Performance Test against a single-beam observation set. This information must be exported from NaviEdit as an 'ASCII XYZ' file.

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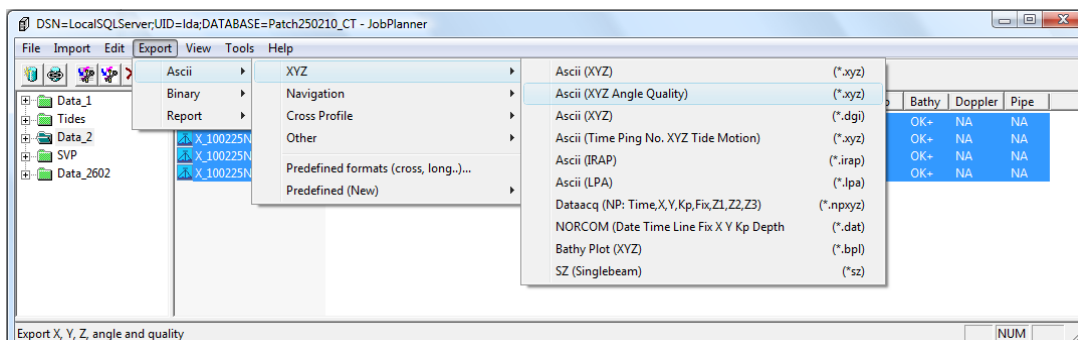


Figure 4 Exporting the ASCII XYZ (Angle Quality) file from NaviEdit

Figure 5 below shows an example from such a file.

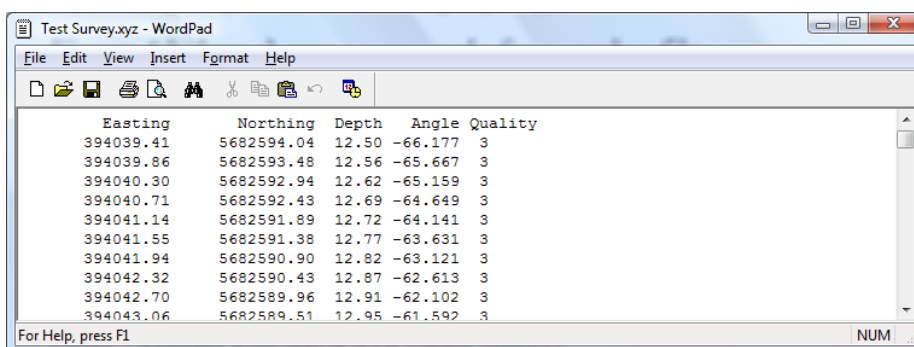


Figure 5 Example from ASCII XYZ (Angle Quality)

### 2.3. Performing the Test

Once the reference model is loaded into Imaging and the test survey has been created, the Performance test can be performed. In Imaging, choose the menu-item 'Tools - Performance Test...' as shown below in Figure 6.

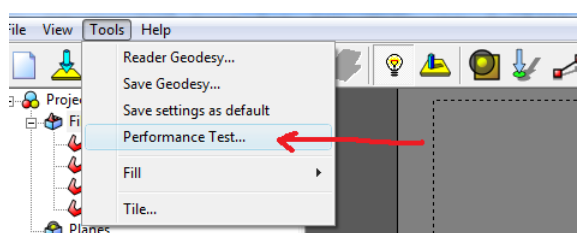


Figure 6 Invoking the Performance test in Imaging

When this has been done, the 'Performance Test window will open as shown below in Figure 7. Note that initially the window is empty.

## Performance Test in Imaging

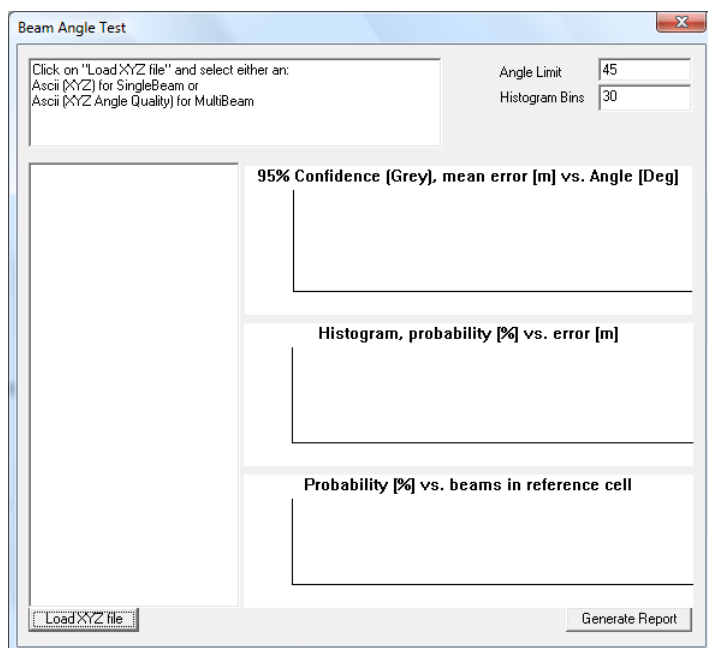


Figure 7 Initial view of the Performance Test Window

As it is stated in the window in the upper left part, the user should now open an XYZ file, representing the survey to be tested. This could either be in the form of an Ascii (XYZ) file, in case of single-beam data, or it could be in the form of an Ascii XYZ (angle quality), in case of multi-beam data.

Press the 'Load XYZ File' button, and select the Test Survey. Once this has been accomplished, the Performance Test window will appear as shown below in Figure 8.

## Performance Test in Imaging

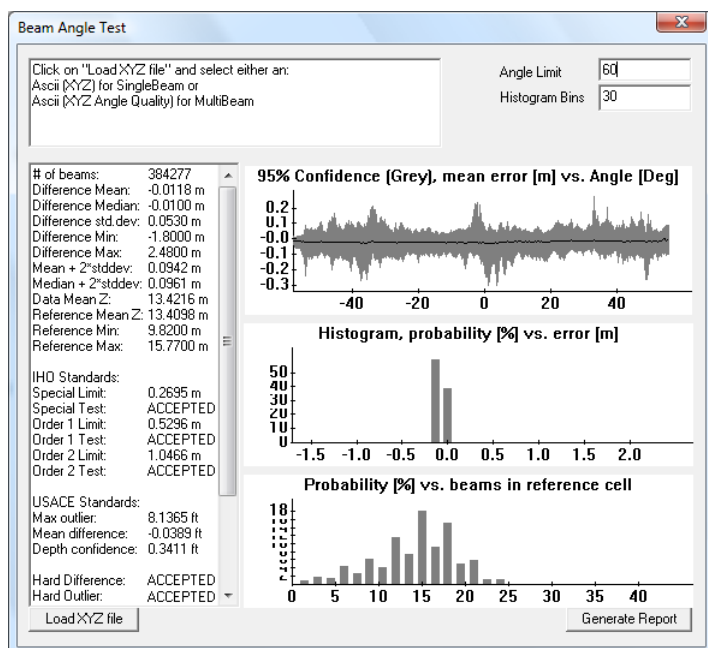


Figure 8 Performance Test window showing results of the test

As it appears, the result of the performance test is given in an alphanumeric window (to the left) that contains various, statistical information all associated with the performance test, as well as in three diagrams (to the right):

- Confidence versus Beam Angle
- Histogram and Probability versus Error
- Histogram, probability vs. beams in reference cell

### 2.3.1. Confidence vs. Beam Angle

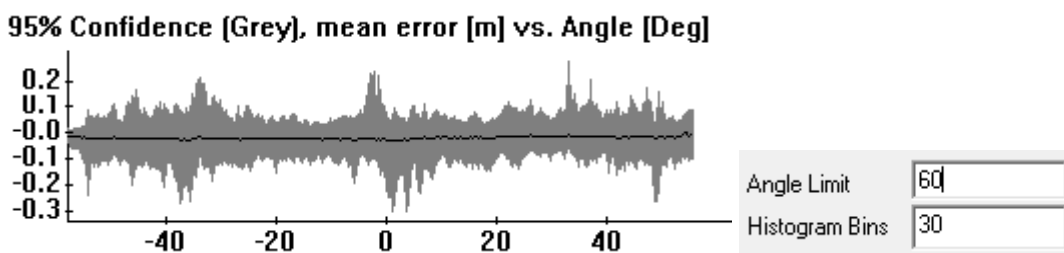


Figure 9 Confidence versus Beam Angle (left), Angle limit and histogram bins (right)

This diagram in Figure 9 above shows the quality of beams as a function of the beam angle. The X-axis is the beam angle (in degrees), whereas the Y-axis depicts the associated error. The black line is the mean error (in meters). The grey area is the depth of 95% of all beams. The 'Angle Limit' option shown to the right in the figure can be used to limit or to expand the angle span (number of beams per scan) and thereby to include or exclude the outer beams from being included in the comparison (performance test).

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In an ideal situation, all 95% values are even and close to 0. This is not the case in the above histogram, however, the magnitude is acceptable, with an average magnitude between 5-10 cm and with maximum values around 20 cm.

### 2.3.2. *Histogram, probability vs. error*

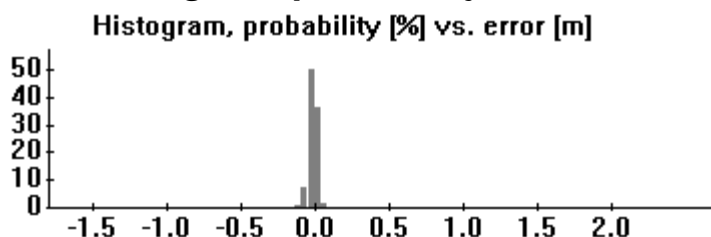


Figure 10 Probability versus error

The histogram shows the error distribution of all beams below the selected limit selected angle. The X-axis is error in meters, whereas the Y-axis and shows probability. The number of bins can be changed by altering the ‘Histogram Bins’ as shown in Figure 9, right above.

The example dataset shows an error distribution that is close to the expected 0-value. This is as expected, bearing in mind the conclusion from the Confidence versus Beam Angle comparison above.

### 2.3.3. *Histogram, probability vs. beams in reference cell*

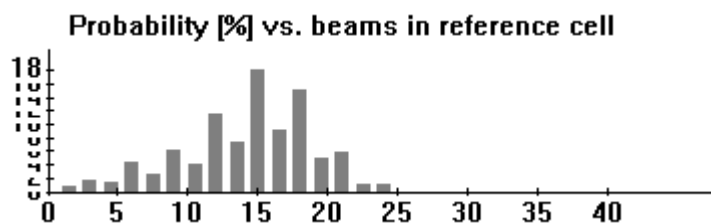


Figure 11 Probability versus Beams in the Reference model

This histogram shows the probability distribution of a given number of beams in the reference model. The X-axis shows number of beams, whereas the Y-axis gives the probability in percent of any given number.

Basically this depicts the validity of the model. The more beams/observations, the more significant the model is.

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### 2.3.4. Statistics

# of beams:	613675		
Difference Mean:	0.0147 m		
Difference Median:	0.0200 m		
Difference std.dev:	0.0520 m		
Difference Min:	-2.1000 m		
Difference Max:	1.8900 m		
Mean + 2*stddev:	0.1186 m	USACE Standards:	
Median + 2*stddev:	0.1240 m	Max outlier:	6.8898 ft
Data Mean Z:	13.4568 m	Mean difference:	0.0481 ft
Reference Mean Z:	13.4715 m	Depth confidence:	0.3343 ft
Reference Min:	9.8000 m		
Reference Max:	15.7700 m	Hard Difference:	ACCEPTED
		Hard Outlier:	FAILED
IHO Standards:		Hard Accuracy:	ACCEPTED
Special Limit:	0.2696 m	Hard Bottom Test:	FAILED
Special Test:	ACCEPTED		
Order 1 Limit:	0.5297 m	Soft Difference:	ACCEPTED
Order 1 Test:	ACCEPTED	Soft Outlier:	FAILED
Order 2 Limit:	1.0468 m	Soft Accuracy:	ACCEPTED
Order 2 Test:	ACCEPTED	Soft Bottom Test:	FAILED

Figure 12 The Alphanumerical Statistical Information

The Alphanumerical, Statistical information, shown in the window to the left in the Performance Test window as well as in Figure 12 above, refer in general terms to requirements to survey as well as to performance testing as these are specified in IHO and in USACE standard compliance.

The general statistics comprise the following information, in sequence:

- **Number of beams:** gives the number of depths/beams in the test survey with the given selection of beams per scan
- **Difference mean:** gives the mean difference between test survey and reference model
- **Difference median:** gives the median difference between test survey and reference model
- **Difference standard deviation:** gives the standard deviation of the difference between the test survey and reference model
- **Difference min:** expresses the minimum difference between the test survey and reference model
- **Difference max:** expresses the maximum difference between the test survey and reference model
- **Mean + 2\* standard deviation:** adds together the mean difference between test survey and reference model and two times the standard deviation of the difference between the test survey and reference model
- **Median + 2\* standard deviation:** adds together the median difference between test survey and reference model and two times the standard deviation of the difference between the test survey and reference model
- **Data mean Z:** expresses the average depth value of the test data
- **Reference mean Z:** expresses the average depth value of the reference model
- **Reference min:** expresses the minimum depth value within the reference model

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- **Reference max:** expresses the maximum depth value within the reference model

The IHO-related statistics are associated with the Special Publication No. 44, 'IHO STANDARDS FOR HYDROGRAPHIC SURVEYS', 5th Edition, February 2008. It comprise the following information, in sequence:

- **Special Limit:** specified in the publication as TVU (Total Vertical Uncertainty) and computed at the 95% confidence level as  $\sqrt{a^2+(b*d)^2}$ . For special order **a** is 0.25 m, **b** is 0.0075 and **d** is the depth. Consequently the 95% confidence limit for Special Order can be calculated to 0.27 m in the example above in Figure 12
- **Special Test:** the maximum allowable value of 0.27 m is compared to the achieved value of 'Mean + 2\* standard deviation' of 0.12 m (see above)
- **Order 1 Limit:** uses the same formula as above, only with **a** being 0.5 m and **b** being 0.013. Consequently the 95% confidence limit can be calculated to 0.53 m for Order1 in the example above in Figure 12
- **Order 1 Test:** the maximum allowable value of 0.53 m for the order is compared to the achieved value of 'Mean + 2\* standard deviation' of 0.12 m (see above)
- **Order 2 Limit:** uses the same formula as in connection with Special Order above, only with **a** being 1 m and **b** being 0.023. Consequently the 95% confidence limit can be calculated to 1.05 m for Order 2 in the example above
- **Order 2 Test:** the maximum allowable value of 1.05 m for the order is compared to the achieved value of 'Mean + 2\* standard deviation' of 0.12 m (see above)

The USACE-related statistics are associated with the 'Engineering and Design, for Hydrographic Surveying, dated April, 1, 2004 from US Army Corps of Engineers. The standards state, that the resultant elevation depth 95% confidence accuracy (1.96 times the standard deviation gives the 95% confidence level, which in turn means that 95 percent of the difference population is less than this value) must meet the following limits for navigation channels and dredging support surveys (note that all limits are given in US Survey feet (1 m = 3.280833 US Survey feet)):

<i>System</i>	<i>Depth</i>	<i>Hard Bottom</i>	<i>Soft Bottom</i>
Mechanical	< 15 ft.	± 0.25 ft.	± 0.25 ft.
Acoustic	< 15 ft.	± 0.5 ft.	± 0.50 ft.
Acoustic	15 ft < 40 ft.	± 1.0 ft.	± 1.0 ft.
Acoustic	> 40 ft.	± 1.0 ft.	± 2.0 ft.
Max Outlier		1.0 ft.	1.0 ft.
Mean Difference (Reference – Test)		± 0.1 ft.	± 0.2 ft.

Associated with these limits, the USACE test comprises the following information, in sequence:

- **Max Outlier:** gives the maximum observed difference between the test survey and the reference model

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- **Mean Difference:** gives the mean observed difference between the test survey and the reference model (in US Survey feet)
- **Depth Confidence:** Expresses the 95% confidence level for the test survey
- **Hard Difference:** comparing the value to the limit of  $\pm 0.1$  ft. The test is ACCEPTED in the example above in Figure 12
- **Hard Outlier:** comparing the value to the limit of 1.0 ft. The test is FAILED in the example above in Figure 12
- **Hard Accuracy:** this compares the 95% depth confidence value of the test survey with the limit for hard bottom of 1 ft (depth > 40 ft.). The test is ACCEPTED in the example
- **Hard Bottom Test:** Compiles the tests in the above for hard bottom. Is passed only if all tests are passed. This is not the case in the example above, since the test is FAILED
- **Soft Difference:** comparing the value to the limit of  $\pm 0.2$  ft. . The test is ACCEPTED in the example above
- **Soft Outlier:** comparing the value to the limit of 1.0 ft for soft bottom. The test is FAILED in the example above
- **Soft Accuracy:** this compares the 95% depth confidence value of the test survey with the limit for soft bottom of 2 ft. (depth > 40 ft.). The test is ACCEPTED in the example above
- **Soft Bottom Test:** Compiles the tests in the above for hard bottom. Is passed only if all tests are passed. This is not the case in the example above, since the test is FAILED

### 3. *Generating The Report*

By clicking on the 'Generate Report' button in the 'Performance Test' window, Imaging will generate a report in PDF-format with the results. As can be seen in Figure 13, these are identical to what is described in the above.

## Performance Test in Imaging

# Multibeam Performance Test

Reference model: TerrainModel

Survey name: Performance Test

From: 394034.28E 394034.28N

To: 394266.02E 394266.02N

Angle limit: 45  
 # of beams: 613675  
 Difference Mean: 0.0147 m  
 Difference Median: 0.0200 m  
 Difference std.dev: 0.0520 m  
 Difference Min: -2.1000 m  
 Difference Max: 1.8900 m  
 Mean + 2\*stddev: 0.1186 m  
 Median + 2\*stddev: 0.1240 m  
 Data Mean Z: 13.4568 m  
 Reference Mean Z: 13.4715 m  
 Reference Min: 9.8000 m  
 Reference Max: 15.7700 m

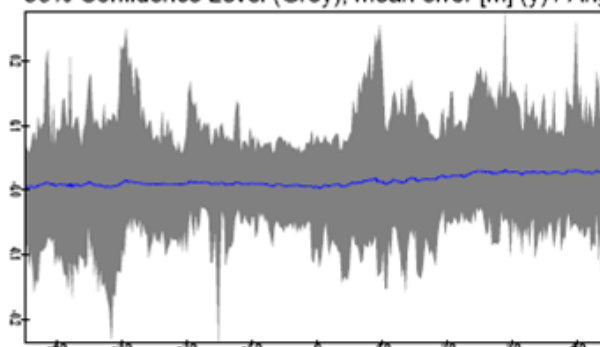
IHO Standards:  
 Special Limit: 0.2696 m  
 Special Test: ACCEPTED  
 Order 1 Limit: 0.5297 m  
 Order 1 Test: ACCEPTED  
 Order 2 Limit: 1.0468 m  
 Order 2 Test: ACCEPTED

USACE Standards:  
 Max outlier: 6.8898 ft  
 Mean difference: 0.0481 ft  
 Depth confidence: 0.3343 ft

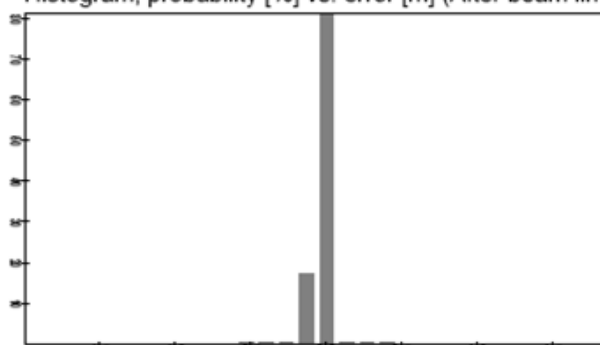
Hard Difference: ACCEPTED  
 Hard Outlier: FAILED  
 Hard Accuracy: ACCEPTED  
 Hard Bottom Test: FAILED

Soft Difference: ACCEPTED  
 Soft Outlier: FAILED  
 Soft Accuracy: ACCEPTED  
 Soft Bottom Test: FAILED

95% Confidence Level (Grey), mean error [m] (y) / Angle (x)



Histogram, probability [%] vs. error [m] (After beam limit)



Histogram, probability [%] vs. beams in reference cell

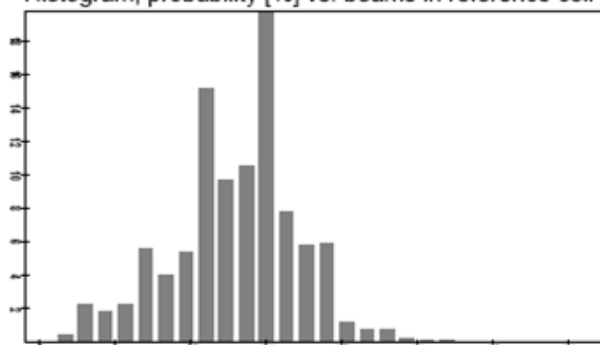


Figure 13 Example of a Performance Test Report