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Shallow Water Multibeam System Testing for Object Detection Over a Defined Reference Surface

Abstract:

The Coast Survey Development Laboratory and Office of Marine and Aviation Operations have determined the need to create a long-term quality assurance test site where accuracy, repeatability and resolution of various hydrographic systems could be examined empirically and compared to National Ocean Service and International Hydrographic Organization standards. Located in Shilshole Bay, the chosen test site's bathymetric properties and convenient position just outside of Seattle, Washington make it an ideal proving ground. Various natural and man-made reference objects, ranging in size from 62 m x 5 m x 10 m to 2 m x 1 m x 1 m (L x W x H), are randomly distributed over a uniform composition, gently sloping bottom with depths between 12 and 30 meters. Divers surveyed many of the identified objects for position, dimension and least depths. This object information was combined with multibeam and backscatter imagery data taken from a RESON 8101 to create a "Reference Surface" using the operational methodology described by J.E. Hughes Clarke[1].

The first systems to be examined were the RESON 8101 and the SEABEAM 1180 from the NOAA Ship RAINIER launches. They were run on a defined test course at 4, 8, and 11 knots. After CARIS-based processing, acquired data were compared to the reference objects for both object detection capability and object size (diver measured to system measured). Coverage density (pings/m^2) and footprint coverage patterns were also examined and correlated to object detection capability. This was accomplished by using a high resolution CARIS-generated Side Scan Sonar (SSS) mosaic and a digital terrain model imported into/from a GIS and overlaying it with ellipses representing a first order approximation of the sounding footprints acquired by the system. As expected, graphical results indicated that as sounding density decreases as a function of increased speed, object detection capability decreases. This is visually observed in the overlaying of ellipsoidal footprints atop of the SSS mosaic: Spacing is increased between pings and relatively small objects are not ensonified if the vessel speed is too high for the ping rate.

Using this visualization process over a well-defined region provides an empirical proof of beam coverage and aids in comparison of different systems.

[1] Hughes Clarke, J.E. and Godin, A., 1993, Investigation of the roll and heave errors present in *Frederick G. Creed* – EM1000 data when using a TSS-335B motion sensor: DFO Contract Report FP-707-3-5731.

Introduction:

The Shilshole Reference Surface (SRS) is the first reference surface to be created by Coast Survey Development Laboratory (CSDL) constructed with a methodology which minimizes systematic errors and has object dimensions and least depths measured by divers. The compelling reason behind creating such a surface is long-term quality assurance in which accuracy, repeatability and resolution could be tested and compared to NOS and IHO standards during the lifetime of systems. With such a surface, one can understand system capabilities as a complete and integrated unit, from the DGPS system and attitude sensors to the multibeam transducers themselves. This allows informed decisions to be made when defining vessel-operating procedures to optimize system usage. For example, an empirical determination of maximum vessel speed, which maintains optimal object detection, can be made. Also, such a surface allows for the determination of which individual system or even configuration is introducing errors in acquisition.

The methodology of creating a reference surface was developed by Dr. John Hughes Clarke and others at the University of New Brunswick School of Geomatics (UNB) in the early 1990's to ensure the accuracy of data acquisition by minimizing the time latency errors and attitude errors inherent in any given multibeam system through thorough comparison to high-density sounding surfaces constructed from near-nadir multibeam swaths. UNB's methods were utilized in the creation of the SRS along with diver measurements of known objects and least depth measurements on those objects.

Located just outside the Seattle, Washington ship canal in Shilshole Bay, the SRS is an ideal combination of large manmade objects and a small number of variously-sized glacial erratics scattered over a smooth sandy bottom that slopes with a 5.2 % grade to the northwest. Depths range from 12 to 30 meters. The region which bounds the SRS is a rectangle with its major axis rotated 32˚ from the north to the west. The northern corner of the SRS is located at North American Datum (NAD83) latitude 47˚ 40' 29.61" N, longitude 122˚ 25' 19.68" W; an eastern corner of 47˚ 40' 21.77" N, 122˚ 25' 12.55" W; a southern corner of 47˚ 40'17.45" N ,122˚ 25' 22.81" W; and a western corner of 47˚ 40' 25.32" N, 122˚ 25' 30.06" W. The length of the major axis is 285 m and the length of the minor axis is 255 m for a total area of 72675 m^2. This small region is easily surveyed in ¼ of day with a conventional multibeam system, allowing for several system tests to be conducted in a day with a previously integrated system, or time for system integration in the morning before conducting acquisition of data in the afternoon. Over the past 3 years the launches of the NOAA Ship RAINIER have conducted their patch tests over this area, which ensures that the bathymetry is fairly constant with respect to time and weak Puget Sound currents.

The SRS site information is to be freely available to equipment manufacturers for system development and testing of new equipment, and to contractors interested in comparing their systems against a known baseline. The Office of Marine and Aviation Operations (OMAO) and the Office of Coast Survey will facilitate such data acquisition in return for copies of the data for internal usage. To date, Kongsberg-Simrad has tested the EM2000, and Thales-Tenix has tested their LIDAR system.

NOAA Equipment Used for Bathymetric Definition:

RAINIER survey launch RA-6 was used for the acquisition of multibeam data and sound velocity profiles for the reference surface definition. RA-6 was equipped with a hull-mounted Reson 8101 in 1998[1], including option 033, Angle-Independent Imagery, and option 040, Extended Range Projector. The Reson 8101 is a 240 kHz multibeam system that measures relative water depths across a 150° swath, consisting of 101 individual 1.5° x 1.5° beams. Each beam is formed by seven receive elements, rotating from port to starboard such that each group of seven is relatively perpendicular to the received acoustic energy assigned to the beam. The 75-meter range scale was used to maximize the ping rate and thus the along-track resolution.

Survey launch RA-4 was equipped with a hull-mounted SeaBeam 1180 in March 2000 to increase RAINIER multibeam echosounder capacity for depths between fifty and three hundred meters.[2] The transducer assembly consists of two sets of staves, one starboard and one port, each mounted at a 38° angle from horizontal. The SeaBeam 1180 transmits utilizing both transducer arrays pinging into 14 sectors. The receiving beamformer generates 3 narrow beams within each sector with a cross-track beam width of 1.5° and a spacing of 1.25°. Three of these subfans equal one total swath. Hence, there are 14 sectors X 3 beams X 3 subfans resulting in 126 total beams at an acquisition swath width of 151°. The SeaBeam 1180 was used with a swath width of 131° and automatic ranging during testing to achieve maximum ping rate.

Both NOAA survey launches are equipped with Triton-Elics International's Isis software version 4.54 for data acquisition in the eXtendable Triton Format (XTF). Also, both launches use the TSS POS/MV for positioning and attitude sensing. The Reson uses the older Version 2 from 1998 with digital attitude data in TSS format, while the SeaBeam-equipped launch uses the analog output from the newer Version 3 released last year. The analog voltage is used by the SeaBeam beam processing hardware to correct for roll of up to twelve degrees in real time. The SeaBeam hardware is controlled with a special version of Elac-Nautik’s HydroStar Online version 2.9.3 running concurrently with Isis and sharing data with TCP/IP sockets.

HYPACK MAX version 00.5 was used for vessel navigation and overall logging control during data acquisition with both multibeam systems.

A Diver Least-Depth Gage (DLDG) was utilized to obtain least depths over selected rocks and features. The gage utilized was last calibrated on September 5, 2000. The DLDG measures pressure, and is combined with a Conductivity-Temperature-Density profile using internally produced software to determine depth, accurate to within 5cm.

Data Acquisition:

The reference surface was constructed by acquiring a series of mutually orthogonal survey lines, spaced at 100% of water depth, with launch RA-6. These lines were run in both directions to empirically remove time delay artifacts, and the inner 40° of the swath, which is insensitive to roll and minimizes heading errors, was used for sounding selection. During acquisition, a constant speed of 5 knots was used with minimal helm to maintain the line. Currents were not significant, and the ten to fifteen knot winds produced 0.3 to 0.5 meter wind waves with minimal swell.

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[1] Glang, et. al., US Hydrographic Conference, Mobile, Alabama, 1999

[2] Noll, et. al., Multibeam User's Conference, Kiel, Germany, 2000

There was good knowledge of tidal signature. Verified water level data was downloaded from the NOAA Center for Operational Oceanographic Products and Services (CO-OPS). CO-OPS also provided the tidal zone information needed for reducing the data. The primary tide gauge for the reference surface is Seattle, Puget Sound, Washington 944-7130. Tidal correctors are minimal from the primary station, the height corrector ratio is 1.0 and the time lag between the high and low tides are 2 minutes and 3 minutes respectively. The time lags, based off of the zone tidal information, were not applied to the multibeam data due to their insignificance during the neap cycle.

In order to test the systems on vessel's RA-4 and RA-6 against the reference surface, acquisition was conducted with line spacing of 125% of water depth. A total of nine tests were conducted on RA-4 with HydroStar slope factor control varying from Very Steep, Nearly Flat, and Very Flat and speeds varying from 4, 8 and 11 knots. For RA-6, three tests were run on the 75-m range scale with speeds of 4, 8 and 11 knots. Tests were conducted using minimal helm to maintain the line.

Data Analysis

Empirical data was analyzed using the MapInfo GIS and in the HDCS SubSet mode. Three types of analyses were done: Sounding densities, gridded surface comparisons, and dimension and least depth comparisons to diver measured objects.

In order to compute sounding densities, all soundings for survey line 1 were exported from a CARIS map and were then imported into MapInfo. Using the GIS features of MapInfo, all soundings within a square region are summed and then divided by the total area to provide a sounding density. There are some sounding density factors to be dealt with, the largest of which is tidal. If data were acquired during a low tide and compared to data acquired during a higher tide, the data acquired during the low tide would be denser than the data acquired during a higher stage of tide. Corrections applied during processing do not change this fact. If the range of tide is 5 m and the depth of water at low tide is 20 m, there would be a 20% reduction in sounding density from low to high tide for the same line assuming constant spacing of soundings across track.

To compare gridded surfaces, all lines from a given data set were processed in CARIS HIPS and then brought into a CARIS map by selecting shoal-biased with no binning and a cell size of 0.5 m. An exported ASCII data set was then brought into MapInfo for analysis. Using Vertical Mapper, version 2.6, the data set is then gridded to 0.5 m using a rectangular gridding routine and a search radius of 3.0 m. Under this method, the four points, one from each quadrant, nearest the grid node and within the search radius are used to calculate the value of the node using the slopes of connecting sides of the rectangle. Grids for each system test run and the SRS run were created and then saved. Note that similar analysis could have been performed with the Windows NT version of CARIS HIPS Spatial Editor, but the author did not want to interfere with the NOAA Ship RAINIER production processing operations, so the more readily available MapInfo software was used instead.

Comparing the grids was accomplished by subtracting a system test grid from the SRS grid. The resulting grids were then saved and displayed using a fixed color table/depth value file for visual interpretation.

Errors associated with this method are due to the “smoothing” which takes place in the gridding process and the generation of depth values in small regions of no data. Given the high density of soundings in the reference surface, the use of gridded data does not cause analytical errors significant at the depths measured.

The CARIS HIPS SubSet mode was used to compare geographically referenced, fully-corrected soundings from the test runs to the dimensions and least depths of diver measured objects. This software allows the on screen measurement of dimensions and querying of least depth, which allowed the author to estimate the acoustic signature of objects positioned by the divers as well as the least depths on the features.

Results:

Examination of the SRS data in both CARIS HIPS SubSet mode and accompanying eight sun illuminated bathymetric surfaces, with the light sources rotated 45˚ apart, indicate no systematic errors present in the reference data. By using UNB's methodologies for reference surface creation, those errors have been minimized. The bathymetric resolution of the SRS, used in diagram 1 below, is 0.5 m per pixel and is a result of roughly 600% ensonification coverage over the surface. In the diagram, the features of the surface are clearly depicted. Dimensions of small objects depicted in this surface are on the order of 2 m x 2 m x 0.2 m (L x W x H), or about the horizontal size required by NOS Specifications and Deliverables.

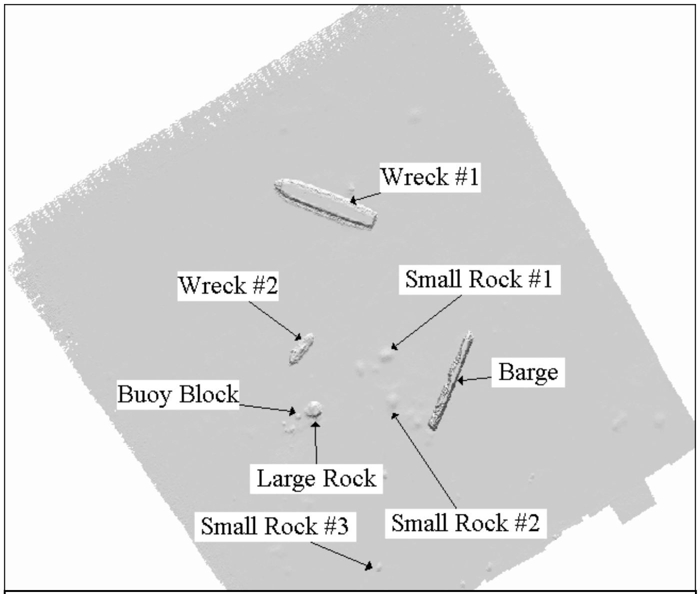

Figure 1 Shilshole Reference Surface

A manual examination of SRS data in CARIS SubSet mode showed that the soundings in a smooth region of the bottom fall within a band of 0.2 m thickness, confirming the overall accuracy of the data falls within NOS accepted tolerances.

System Test Runs

The soundings from the test data RA-6 are within a 0.3-meter (1-foot) thick band in areas of the SRS that do not contain an object. The increase in thickness relative to the SRS is due to the inherent noise of the outer beams. Off-nadir angle filtering for the SRS was performed at 40˚

while filtering for system tests on RA-6 were done at 60˚. Visual inspection of bathymetric surfaces of RA-6 test runs does not indicate any system configuration errors, nor does inspection of the data in CARIS HIPS SubSet mode, although acoustic multi-pathing is present around the hull of the barge. This is especially evident on the differenced grid model surfaces.

The soundings for the system test runs for RA-4 in CARIS HIPS SubSet mode, in similar bottom conditions to RA-6 data, fall in a band of 0.9 m thickness. The thickness of the sounding band is a function of filtering to 60˚ and also attitude errors with TSS's POS/MV Version 3. Visual inspection of the data in CARIS HIPS SubSet mode shows occasional vertical displacements from line to line, and line separation in sun illuminated surfaces characteristic of attitude errors.

Investigation of the RA-4 heave sensor shows a range of +0.6 m to –0.4 m during one series of runs. The weather during this data acquisition was light winds with 0.2- to 0.3-meter waves and no swell. Comparison with the heave sensor on RA-6 (POS/MV Version 2), under similar conditions, show the Version 3 to have 5-6 times the displacement of the Version 2 and that the Version 3 did not tend toward zero soon enough. Also, the range of the Version 2 POS/MV is from –0.07 m to –0.1 m. Further investigation of the Version 3 POS/MV showed that a sharp turn (coming on to line) induces a heave that takes ~160 seconds to go to zero. With lines taking ~60-80 seconds to run, this is a major problem with this data set. The Version 2 POS/MV did not show a similar error. As a result of further investigation by NOAA, TSS and Applanix, cornering period was altered to be more attuned to the motion of these boats.

At this point a hydrographic maxim comes into play: The quality of data from a system is a complicated function of its components. With a questionable attitude sensor on RA-4, determining system trends about RA-4's SeaBeam 1180 multibeam data becomes difficult. Thus, comparisons between NOAA Ship RAINIER's Reson 8101 and SeaBeam 1180 data in this paper should be done with the understanding that the former launch had an attitude sensor configured and operating properly and the latter apparently did not. The Coast Survey Development Laboratory plans to do more testing with both systems on the SRS when NOAA Ship RAINIER returns to Seattle in November 2001.

The SeaBeam 1180 on RA-4 showed difficulty acquiring data when going over a sudden shoal. Its auto range routine is linked to the soundings of the nadir beams. When RA-4 passed over the barge, the range scale appears to change too rapidly for the depth gate and the outer beams were lost. Both acoustic systems experienced multi-pathing in the vicinity of the flat-sided barge.

Sounding Densities

Sounding densities, assuming a flat bottom, of the various systems are a function of vessel speed, range scale (usually linked to nadir depth), and, in the case of the SeaBeam 1180, the slope factor software control. Table 1 below lists the sounding densities per square meter. The values in this table were created by the method described in the Data Analysis section. The depth of water at the location of sampling was approximately 18 m. What is shown in the table is the increase in speed produces a nearly linear reduction in sounding density. The reason for this near linearity is a function of approximate speeds and tidal changes.

Pings per m^2

		Seabeam 1180			Reson 8101
	Slopefactor	Very Flat	Nearly Flat	Very Steep	N/A
Speed	4 knots	3.74	3.33	2.90	6.17
	8 knots	2.30	1.91	1.80	3.64
	11 knots	1.42	1.38	1.28	2.51

Table 1

With the SeaBeam 1180, the Slope Factor control is a multiplicative factor to the base ping rate for a given range scale setting. For example, the Very Flat setting multiplies 1.15 to the base ping rate and the Very Steep setting multiplies 0.75 times the base ping rate.

Sounding density is critical in terms of object detection and delineation. For an IHO order 1 survey, a system must be capable of detecting a 2-meter cubic feature in depths up to 40 m and 10% of depth beyond 40 m. To create a metric for this standard, NOS uses the measurable property of pings per linear meter along-track. In NOS's Specifications and Deliverables Manual, Section 5.3.1, it states that "The hydrographer shall ensure that vessel speed is adjusted so that no less than 3.2 beam footprints, center-to-center, fall within 3 m, or a distance equal to 10 percent of the depth, whichever is greater, in the along track direction." This is obviously a rough standard, but is conservative enough to ensure that natural objects of hydrographic significance are found with confidence.

Vessel speed vice ping rate calculations, using manufacture data of ping rates for given range scale settings, show that the Reson 8101 meets NOS's standard to speeds just under 10 knots in any depth of water. Similar theoretical calculations for the SeaBeam 1180 installation indicate that the speed of advance to meet NOS' Specification for most depths is just under 4 knots.

The primary reason for the lower linear sounding density for the SeaBeam is that it requires 3 physical pings for a single swath. This does not mean that the system lacks the ability to detect objects as defined by IHO Order 1 specifications. The linkage of water depth to ping rate and vessel advance, combined with along-track footprint based on beam width, shows that the bathymetry is adequately ensonified. Visual representations of the Reson 8101 footprint pattern and the SeaBeam 1180 footprint pattern at 8 knots are shown below in Figure 2 and Figure 3, respectively.

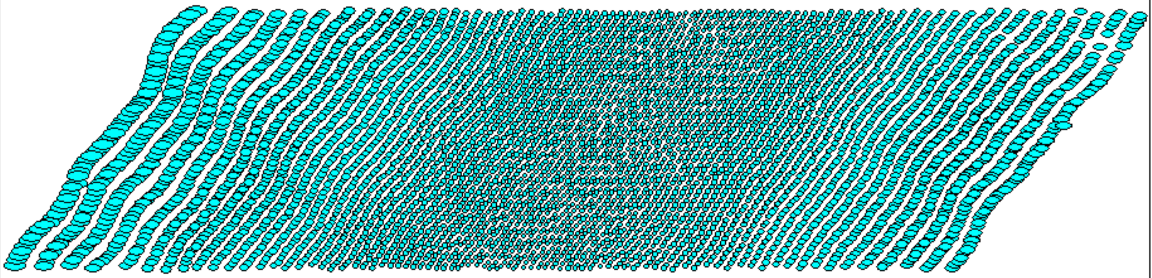

Figure 2 Reson 8101 Footprint Pattern at 8 knots

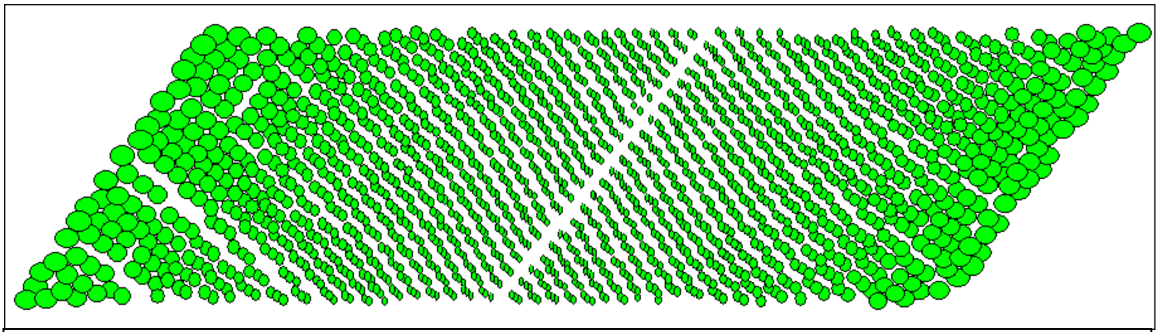

Figure 3 SeaBeam 1180 Beam Footprints at 8 knots

Statistics on these footprint patterns were calculated by selecting a 20-meter by 20-meter square just off nadir. These crude statistics indicate that the sounding density of RA-6 is approximately twice that of RA-4 while the area covered by the footprints is only 25 % greater. Thus, coverage is maintained over the bathymetry by using a SeaBeam 1180, with the resultant loss of resolution in delineating an object with any particular beam. Note that this analysis is based on empirical data, but not generalized with a large statistical sample.

The above data points to the conclusion that NOS may wish to revisit its specification on linear footprint spacing, which was roughly designed to meet IHO Order 1 object detection specifications. The current NOS Specification does not take into account footprint size, or increased ability for a system to ensonify a specified section of the bottom, regardless of vessel attitude, by using beam steering techniques. Note that the NOS standards have "built in" the effects of vessel heading and other error sources. Therefore, the reference surface should similarly be used to compare actual objects to actual data to determine what can be "found" with a particular system and configuration.

Diver Measured Objects Compared to SWMB

In terms of object delineation, the buoy block was used in the analysis. Divers measured the buoy block, a cylinder, which has a radius of 1.4 m and a length of 2.4 m. In CARIS HIPS SubSet mode, seventeen soundings were located on the top of the buoy block using RA-6 at eight knots and there were twelve soundings from RA-4 at eight knots using a Very Flat Slope factor. The soundings from RA-6 showed the buoy block's dimensions to be 2.5 m x 1.9 m x 1.4 m, while RA-4's soundings were a bit less defining showing the object to be 2.9 m x 2.5 m x 1.2 m. The larger footprints increase the size of the object. It is important to realize that the routine used by CARIS to make the Tiff image, using 0.5 m resolution, significantly increased the size of the object's representation. This is an obvious side effect of gridding the point data. In Figure 4, the

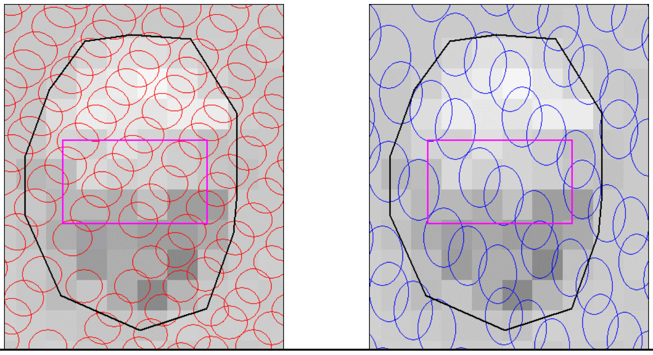

Figure 4 Acoustic vice Actual Buoy Block with Sounding Footprints

black line represents the edge of the buoy block as seen in the Tiff grid images, while the purple rectangle is the size of the buoy block as measured by the divers. As a side note, the number of footprints touching the side of the rectangle is within two soundings of the number counted in CARIS HIPS SubSet mode.

Another very useful object with which to compare multibeam system performance is the large barge, which lies on its side and is 8.9 m wide, 60.3 m long and 8.7 to 12.4 meters off of the bottom. The utility of the barge is its sharp edges that clearly define the vessel but are difficult to readily acquire acoustically. The north corner of the vessel, which has a divers depth of 11.92 meters, can be used for depth calibration. RA-6 and RA-4 systems both provide a depth to that point of 11.74 meters. Static man-made points, such as the barge, make it possible to investigate the use of and errors involved in acoustic sampling, Real Time Kinematic vertical measurements, and tidal corrections as they exist today.

It should be noted that the least depths between the two systems are similar for objects that are detected by both systems, but with the heave issues on RA-4, it is difficult to make definitive statements concerning accuracy.

Gridded Surface Comparisons

Having both a gridded representation of the SRS and a gridded representation of a system test run allows the differencing of the two surfaces to determine errors between the two. The goal is a small error value that is below IHO specification throughout the overlapping regions. In Figure 5 a system test run of RA-6 at 4 knots is subtracted from the SRS.

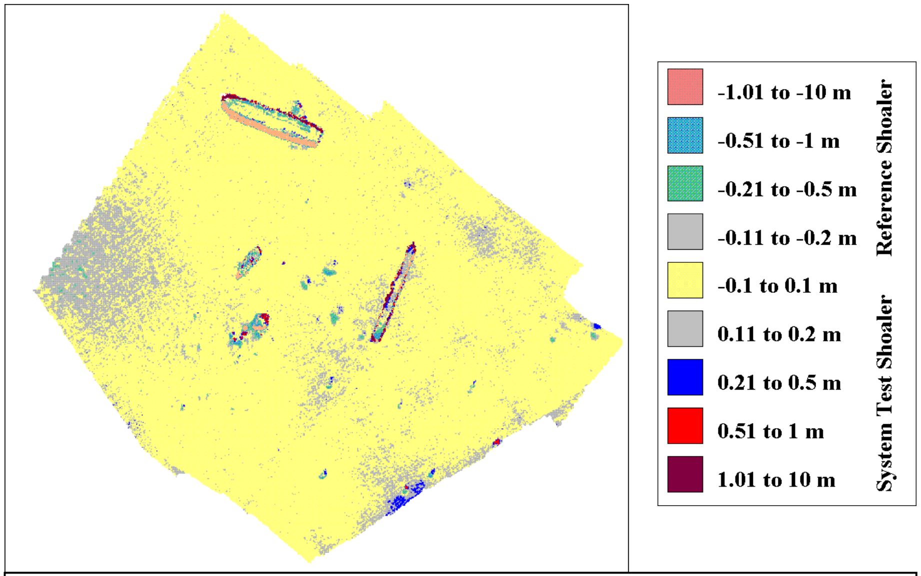

Figure 5 SRS Surface differenced with RA-6 at 4 knots

There appears to be a horizontal positioning error on the order of 1.5-2 meters along a heading of 035˚ from the SRS to the system test run. This horizontal offset falls well within IHO order 1 positioning accuracy limits. It is possible that two different DGPS corrector stations were used between the different days, or that satellite geometry was such that the horizontal shift between the two days was produced.

It is interesting to note that this shift produces a positive vertical difference, on the order of 0.05 meter, between the SRS and the 4-knot system test run on RA-6. The gradient along 035˚ (the slope in a particular direction) is ~2.6%. By multiplying this gradient with the horizontal shift a vertical displacement of 0.05 m is found. This error is not visible in HDCS SubSet mode because of the vertical spread of soundings is on the order of 0.3 meter. Other sources of error should be equal since the same system was used for testing on both days. This five-centimeter displacement is equal to the nominal accuracy of the acoustic measurement of the Reson 8101 and of the water level measurement.

Given the SRS as the true surface, 98.9% of RA-6's system test run at four knots falls within IHO Order 1 Specification for accuracy requirements. The regions of Figure 5 with the largest error are those which represent the edge of an object with significant vertical displacement from the seafloor, which is expected from the horizontal positioning offset discussed above.

Figure 6 below depicts a system test of RA-4 at four knots subtracted from the SRS less another offset of 0.3 m. This additional 0.3 m correction is an average error most likely due to attitude sensor errors, with some portions of a line being high and others low, indicative of a heave problem. With a 0.9 m thickness, the standard deviation of this surface is larger than that of the SRS which is 0.2 m thick. The noise in the test surface appears in the difference grid image as random speckles.

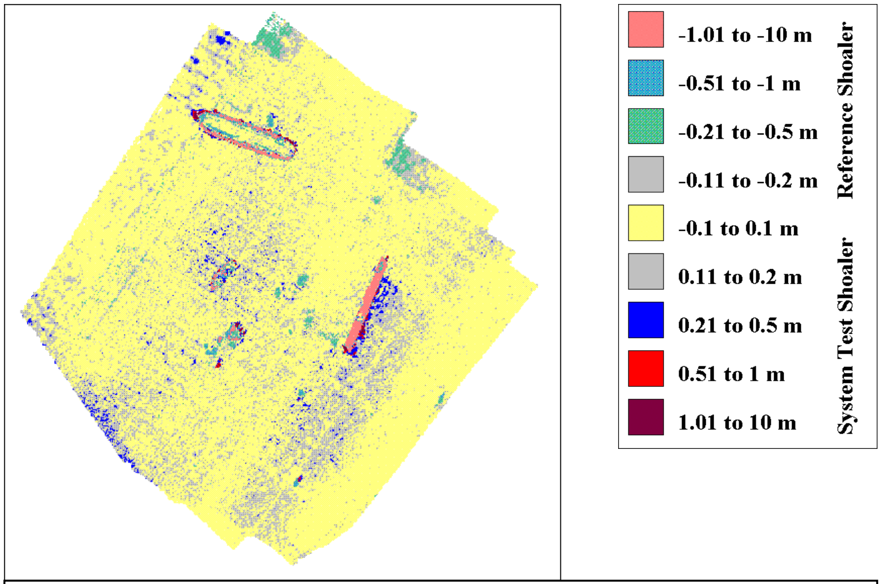

Figure 6 RA-4 at 4 knots differenced with SRS Surface

There are large vertical errors in the region of the barge. This has to do with both the system acquisition software on RA-4 and with the data processing procedures used. During acquisition, the SeaBeam system automatically adjusts the range scale based on the depth of the nadir beams, which tracked the top of the barge with a few center beams but lost the rest of the beams because their return time was too great. Thus, during data cleaning all of the good soundings in the vicinity of the barge were lost in the noise from bad beam detections. In the data processing pipeline, the soundings were binned and exported at 0.5-meter resolution. After being imported into MapInfo, the set was gridded in Vertical Mapper Version 2.6. Then the grid is based on data created from surrounding soundings on the sandy bottom, not the top of the barge.

South of the buoy block there are a series of three smaller rocks. In Figure 6 these are depicted on the SRS as being shoaler. It appears that these objects were not detected by the SeaBeam, yet were acquired by the Reson under similar operating conditions. Analysis shows that the SeaBeam's footprints covered the rocks, yet there was no indication of a vertical displacement. The rocks were smaller than the 2-meter standard, the largest being 1.4 m x 1.4 m x 1.3 m as measured by the Reson. There are plans to physically measure this object this summer.

There is no apparent horizontal difference due to differential GPS between the SRS and the system test of RA-4 at 4 knots. The lack of any apparent shift between the two systems on the various days may be a function of the poorer resolution of the SeaBeam acoustics. Similar to comparing a grid with a cell size of 3 to a grid with a cell size of 0.5, it becomes difficult to see a possible two-meter shift. Given the SRS as the true surface, 98.6% of RA-4's system test run at four knots, less the 0.3 meter empirical correction, falls within the IHO Order 1 Specification for accuracy requirements. The precision of RA-4's soundings is less than that of RA-6's, but that can be attributed to the attitude sensor.

Conclusion:

From empirical analysis of the data acquired by RA-6, it is apparent that the integrated acquisition system of this boat meets and exceeds current IHO Order 1 standards for object detection and is within the depth accuracy requirements of the NOS Specifications and Deliverables. RA-4 appears to meet the standards for object detection, but there was difficulty with accuracy requirements due to attitude errors with the POS/MV Version 3, which are currently under investigation. Coupling either system with a side scan sonar would greatly increase confidence in object detection, per methods promulgated in the NOS Hydrographic Specifications and Deliverables. This would allow the surveying of dredged channels, harbors and any other highly trafficked shoal area with assurance.

With the development of the SRS, system testing and examination can be simplified by having a surface with minimal system errors and a large sounding density to compare against other sets of data. The SRS's proximity to NOAA field units, many hydrographic equipment manufacturers and hydrographic contractors make it an ideal location for conducting such a test. A well-known tidal signature, smooth gently sloping bottom, and various sized objects make it perfect for system testing of shallow water systems, including Real-Time Kinematic vertical measurements.

The increased usage of multibeam aboard small vessels, rather than ships, has shown that high-ping rates can be used to ensure object detection within IHO limits in shallow areas. The Coast Survey Development Laboratory looks forward to testing such systems at the SRS during the next several years. As developers bring better technology to bear on the hydrographic issues of this depth regime, a strong data set similar to those made by the Shallow Survey conference should become available.