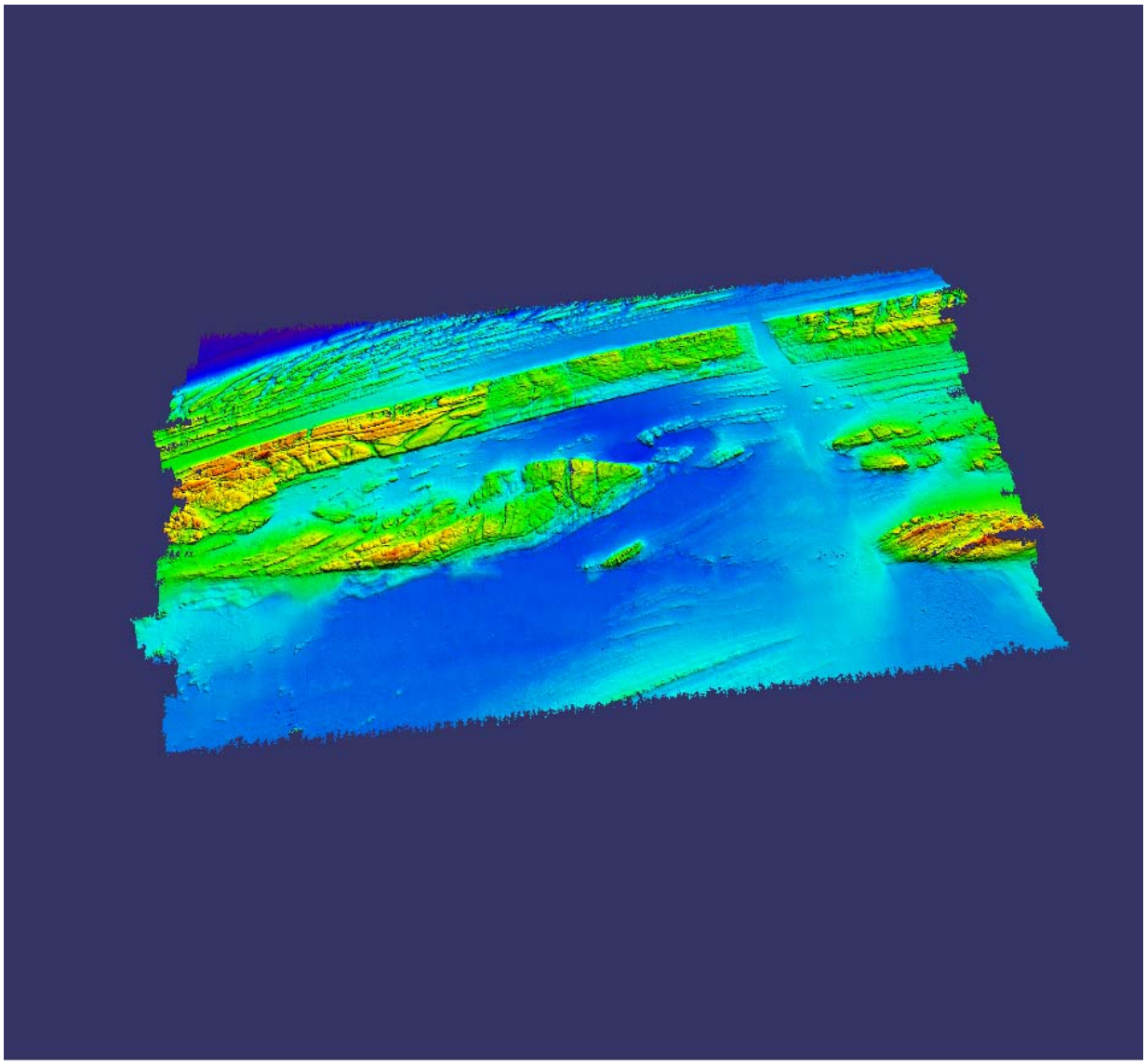
Navigation Response Team 6
Hydrographic Systems Readiness Review
2007



Digital terrain model of an area in Half Moon Bay, California, gridded at 1- meter resolution. This area was surveyed in support of the Safe Seas exercise performed in August 2006.

Hydrographic Systems Readiness Review

NOAA Navigation Response Team 6

2007

Prepared by:

eric m moore

Digitally signed by eric m moore
DN: cn=eric m moore, email=eric.m.moore@noaa.gov, o=NOAA S/V BAY HYDROGRAPHER, ou=NOAA/NOS/OCS/HSD/OPS, c=US
Date: 2007.05.21 12:46:40 -08'00'

Eric M. Moore
Physical Scientist Technician,

Date

Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Coast Survey
Navigation Services Division

Table of Contents

List of Appendices

List of Figures

Introduction

NOAA Navigation Response Team 6 (NRT6) is a mobile hydrographic survey team that operates in the southwestern region of the United States. The primary survey platform for NRT 6 is NOAA launch S3003, a 27-ft vessel built by SeaArk of Monticello, Arkansas, and delivered to NOAA in 2004. NRT 6 is staffed by three physical scientist technicians.

NRT 6's primary mission includes acquiring hydrographic survey data used to update NOS nautical charts. The team is also equipped to rapidly respond to navigationally significant events such as natural disasters, vessel groundings and other incidents. NRT 6 responds to survey requests in the state of California, made by harbormasters, pilots, and other stakeholders. Hydrographic surveys are performed using multibeam, side scan, and single beam sonars, and diver investigations. Land-based surveying of shoreline features is performed using a backpack-mounted GPS receiver and handheld processing unit. A 32-ft trailer serves as a mobile field office, and is equipped with several data processing workstations.

The purpose of this report is to establish the hydrographic survey capabilities of NRT6, and identify and address any deficiencies in those capabilities before beginning survey operations in the San Francisco Bay area. A Hydrographic Systems Readiness Review (HSRR) is typically performed annually on all NOAA hydrographic platforms. For the spring of 2007, the start of operations in a new location coincides with the period of time to assemble the HSRR package. Vessel offsets will be addressed in section 1. Section 2 will describe vessel hardware systems, including echosounders, side scan sonar systems, position, attitude, and heave sensors, sound-velocity probes, and other oceanographic and survey equipment. This section will include calibration reports and detail firmware versions for each piece of equipment. Section 3 details computer operating systems, survey acquisition and processing software, and additional software used to support hydrographic survey operations. The final section of this report is a description of survey-relevant experience for each member of NRT6.

1. Vessel

1.1 Vessel Static Offsets

On June 17, 2006, a team from the National Geodetic Survey, NGS, performed a complete survey of the vessel and relevant hydrographic equipment. See Appendix 1 for the POS/MV Components Spatial Relationship Survey Field Report.

1.2 Vessel Dynamic Offsets

1.2.1 Static Draft

The static draft of the transducer is the distance from the waterline to the phase center of the transducer. This distance was determined during the same NGS survey performed to determine the static offsets. The waterline was determined by referencing a line of marine growth around the hull. The static draft was determined to be 1.637m. See Appendix 1 for the POS/MV Components Spatial Relationship Survey Field Report for further notes on this survey.

1.2.2 Dynamic Draft

Multibeam data were collected in January 2007 for the reference surface method of determining delta draft. Methods outlined in chapter 1.4.2.1 of the FPM were used during data acquisition and processing. Upon final processing of the data, it was clear that final delta-draft values were unusable. Values across all three reference areas varied greatly, and did not appear to follow a traditional settlement and squat pattern. Several variables may have confounded this test, including varying bottom contours, uncorrected tidal and current effects, and vessel motion. NRT6 will continue to use the current values in the CARIS HVF, as they are still valid, and the vessel will be undergoing a transducer fitting before any SWMB survey work begins. A new transducer and IMU configuration is planned, warranting a new instrument offset survey, patch test, reference surface, and dynamic draft test.

2. Hardware Systems

A wiring diagram detailing survey equipment configuration may be found in Appendix 3.

Figure 1: Rack-mounted survey hardware. From top to bottom: Odom CV Echosounder, Applanix POS/MV, Kongsberg Simrad 3000 multibeam sonar processing unit, Klein 3000 TPU, APC uninterrupted power supply, and Klein workstation.

2.1 Position, Attitude and Heading Sensors

S3003 is equipped with an Applanix Model 320 Version 4 POS/MV, interfaced with controller software installed on the Hypack computer. A Trimble DSM 132 provides differential correctors to the POS/MV, and is also interfaced on the Hypack computer via Trimble TSIP talker software. The Inertial Measurement Unit (IMU) is located in the hatch just forward of the door, a protected location that is spatially close to the vessel's center of motion (see photograph). The antennae are located on the top of the cabin, on mounts that raise them, off of the deck. The antenna for the Trimble receiver is located on the top of the mast.

Figure 2: View of top of house on Launch S3003. Center GPS antenna is used by Trimble DSM 132 receiver, and two lower antennae are used by the POS/MV.

2.1.1 GAMS Calibration

A GAMS calibration was performed on March 23, 2006. The results are as follows:

Baseline Vector: x: 0.017m, y: 1.524m, z: -0.017m
Two Antennae Separation: 1.525m

2.2 Sound Speed Measurement Instruments

2.2.1 Sea-Bird SeaCat SBE 19+ CTD Profiler

NRT 6 collects conductivity, temperature, and density (CTD) data using an SBE 19+ to determine sound speed profiles, which are used to correct multibeam sonar data. The SBE19 generates a raw hexadecimal file (*.hex), which is used by VELOCWIN, a NOAA in-house program that coverts .hex files to files used to correct multibeam data. VELOCWIN is discussed in the Data Processing Software section, 3.3.

2.2.2 Odom Digibar Pro

Continuous sound speed measurements at the face of the multibeam transducer are necessary to correct for the geometry of a flat transducer array. This is achieved by mounting an Odom Digibar Pro on the same pole as the Simrad EM3000 transducer. The speed of sound is measured by a wet-end probe and sent to a display, which then passes the data on to the Hypack computer.

2.3 Manual Depth Measurement Equipment

2.3.1 Sounding System Comparison

A comparison between the echosounders on NRT 6 and a lead line has not been recently performed. A lead line will be created for a manual depth check once the multibeam transducer has been reconfigured.

2.4 Vertical Beam Echo Sounder

2.4.1 Odom CV Echosounder

The Odom CV is a single-beam echo sounder, operating at 208 kHz with an 8° beam. Unlike previous Odom Echotrac models, the CV has no display or paper record on the actual processor; rather, sounding data is displayed in Hypack. VBES data are collected infrequently, as both multibeam and side scan sonar may be operated simultaneously.

2.5 Multibeam Echosounder (MBES) System

2.5.1 Kongsberg Simrad EM 3000

S3003 uses a Kongsberg Simrad EM 3000 multibeam echosounder. The sonar head is mounted on a retractable pole on the starboard side of the vessel. The EM 3000 collects sounding and backscatter data at 300 kHz with 127 receive beams, which provide an optimal swath of 120°.

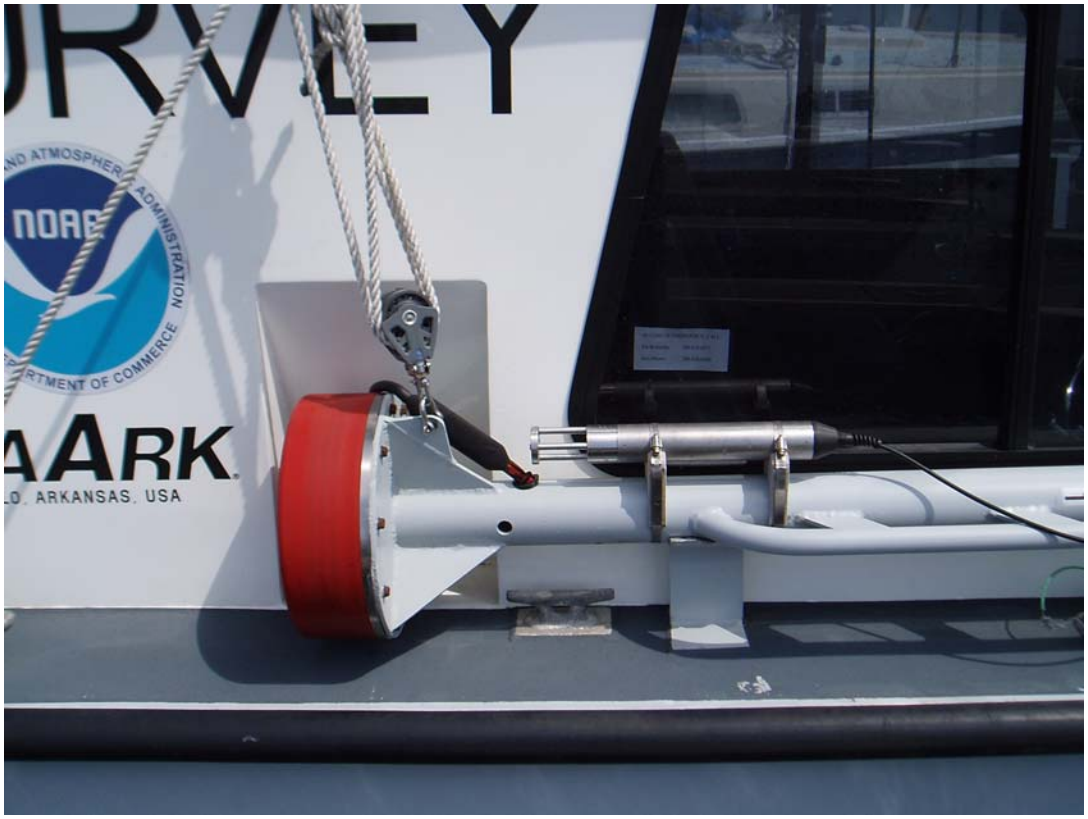


Figure 3: Simrad EM 3000 pole-mounted transducer and Odom Digibar probe.

2.5.1.1 Patch Test and Reference Surface

Correctors determined from the last patch test were applied on May 23, 2005. Despite the absence of obvious artifacts in data collected since this date, and that no major changes in vessel configuration have occurred, a more recent patch test will be performed prior to survey operations in 2007. A new patch test will either determine new offsets, or validate values used since 2005.

A new reference surface examination will also need to be performed. This test may be conducted over upcoming survey areas.

2.6 Side Scan Sonar (SSS) System

NRT 6 operates a Klein 3000 side scan sonar system, used for the detection of submerged wrecks and obstructions. The system operates at 500 kHz and 100 kHz, and is able to provide side scan data from ranges between 25 and 450 meters; typical surveys see the SSS used in high frequency mode, with range scales between 50 and 100 meters, as specified in the HSSD section 6.2.4. The system consists of a towfish, deployed from a rotating boom on the aft deck (see figure 4). The towfish is connected to a slip ring attached to an electric winch, which is connected to the Transceiver and Processing Unit (TPU). The TPU is networked to a workstation that allows the user to control various parameters, view SSS imagery and record sonar files. Measurements to the towpoint can be

found in the NGS survey report (Appendix 1), and a calibration report for the system is found in Appendix 3.

Figure 4: Klein 3000 SSS Towfish.

2.7 Trimble GPS Backpack

A Trimble GPS backpack is used for shore-based survey operations. The system consists of a backpack-mounted Trimble Pro XRS GPS receiver and antenna, interfaced by a Trimble TSC1 hand-held data logger. The TSC1 data logger

3. Software Systems

3.1. Computer Operating Systems

NRT 6 has five workstations: three workstations are located in the office trailer, and two are in survey launch S3003. Both computers in the survey launch are dedicated to sonar acquisition and navigation, and run Windows 2000. The three office computers are used for sonar data processing, survey planning and report writing, and administrative work. Two computers run Windows XP operating systems, while the third and newest computer runs Windows XP 64-bit edition. Please reference Appendix 4 for detailed computer specifications.

3.2 Data Acquisition Software

MBES and VBES data are collected on S3003 using HYPACK, a software suite that interfaces with sonar and navigation hardware, displays survey lines over charts and background information, plots the vessel location, and creates sonar data files. See Appendix 5 for Hypack device configuration models.

SonarPro is a data acquisition program run on a separate computer, and is used to interface with the SSS, display sonar data, and create sonar data files. SonarPro is a program created by Klein Associates, and is provided with the Klein 3000 system.

3.3 Data Processing Software

All three office-based workstations are loaded with CARIS HIPS & SIPS; the two older computers use CARIS HIPS & SIPS 6.0, while computer using the Windows XP 64-bit operating system wasn't loaded with processing software until the release of CARIS HIPS & SIPS 6.1, due to incompatibility issues with previous CARIS versions. All computers have been updated with the latest CARIS hotfixes. Please see Appendix 8 for the HIPS vessel file (HVF) report and uncertainty estimate details.

All PC's are also loaded with Pydro and MapInfo, programs used for survey planning and preparation, survey feature and data management, and descriptive report compilation. VELOCWIN version 8.80 is loaded on the Hypack computer, and is used to generate *.svp files from *.hex files generated by the SBE19+.

4. Hydrographic Personnel

Navigation Response Teams require that each member is involved in data acquisition and processing, and all other areas of survey operations. NRT6 has had several personnel changes during the 2006 field season. As of April 1, 2007, the team was at its full complement of three members.

Appendix 1: POS/MV Components Spatial Relationship Survey Field Report

US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

NOAA SURVEY VESSEL S3003
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY
FIELD REPORT

Kendall L. Fancher
JUNE 18, 2006

NOAA SURVEY VESSEL S3003
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

PURPOSE

The primary purpose of the survey was to accurately determine the spatial relationship of various sensors, and a the components of a POS MV navigation system aboard NOAA survey vessel S3003.

PROJECT DETAILS

This survey was conducted in San Diego, California on the 17th of June, 2006. The weather was cool and overcast in the morning, with warm and clear conditions in the afternoon. The vessel was hauled out of the water and placed in a boat yard to conduct this survey. The vessel was leveled up side to side using a level along the transom, located at the rear of the vessel.

INSTRUMENTATION

The Leica (Wild) TC2002 precision total station was used to make all measurements.

Technical Data:

Angle Measurement

Resolution	0.03 seconds
Smallest unit in display	0.1 seconds

Standard Deviation

Horizontal angle	0.5 seconds
Vertical angle	0.5 seconds
Distance measurement	1mm + 1ppm

Standard “peanut” prisms were used as sighting targets. Prisms were configured to have a zero mm offset.

PERSONNEL

Kendall Fancher NOAA/NOS/NGS/GSD/I&M BRANCH
(540) 373-1243

NOAA SURVEY VESSEL S3003
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

ESTABLISHING THE REFERENCE FRAME

A primary reference point, CL0, was recovered along the centerline of the boat and near the physical center of the boat – inside the cab. This point was stamped "CL0". To conduct this survey a local coordinate reference frame was established where the Northing (Y) axis runs along the centerline of the boat and is positive from the primary reference point towards the bow of the boat. The Easting (X) axis is perpendicular to the centerline of the boat and is positive from the primary reference point towards the right, when looking at the boat from the stern. The Up (Z) axis is positive in an upward direction from the primary reference point.

A temporary control point, TP1, was established behind the vessel. The instrument was set up at TP1 in alignment with CL0 and a dimple set at the center of the keel. The Y value of TP1 was assumed to be zero. Determination of the X value for TP1 was accomplished by measuring the horizontal distance from CL0. Determination of the Z value for TP1 was accomplished by trigonometric leveling from CL0.

ESTABLISHING ALL OTHER POINTS

While occupying TP1, a bearing of 0.0000 was input into the instrument and CL0 was used for initialization. After initialization was conducted, angular and distance measurements were taken to establish the following points; CLS, GPSS, GPSP, NAVGPS, IMU, SSST, MB, and TP2. TP1and TP2 are temporary points set off of the boat. Additionally, up (Z) values were determined for the following points; WLPSS and WLSS. The established coordinates for TP2 were stored internally in the instrument.

While occupying TP2, the previously determined bearing to TP1 was recalled and initialization was conducted to TP1. After initialization was conducted, angular and distance measurements were taken to establish the following points; CLB, IMUSB, and IMUSS. Additionally a Z value was determined for WMPB. The established coordinates for TP3 were then stored internally in the instrument.

While occupying TP3, the previously determined bearing to TP2was recalled and initialization was conducted to TP2. After initialization was conducted, angular and distance measurements were taken to establish a Z value for WMSS.

FIELD OBSERVATIONS TO SENSORS

OBSERVED - FROM	OBSERVED TO
	TP1 Observed

POINT	e (m)	n (m)	u (m)	POINT	e (m)	n (m)	u (m)
TP1	100.000	86.238	98.695	*CL0*	100.000	100.000	100.000
TP1	100.000	86.238	98.695	*TP2*	94.458	105.354	98.739
TP1	100.000	86.238	98.695	*CLS*	100.002	97.222	99.710
TP1	100.000	86.238	98.695	*MB1*	101.348	102.967	98.425
TP1	100.000	86.238	98.695	*SSST*	100.523	95.984	102.830
TP1	100.000	86.238	98.695	*IMU*	100.130	100.309	99.867
TP1	100.000	86.238	98.695	*NAVGPS*	100.003	99.521	103.263
TP1	100.000	86.238	98.695	*GPSP*	99.234	101.287	102.492
TP1	100.000	86.238	98.695	*GPSS*	100.761	101.289	102.484

				TP2 Observed			
				POINT	**e (m)**	**n (m)**	**u (m)**
TP2	94.458	105.354	98.739	*CLB*	100.022	104.593	101.149
TP2	94.458	105.354	98.739	*MB1*	101.364	102.949	98.423
TP2	94.458	105.354	98.739	*SB*	99.853	100.304	99.348
TP2	94.458	105.354	98.739	*SSST*	100.518	95.958	102.842
TP2	94.458	105.354	98.739	*IMU*	100.135	100.261	99.865
TP2	94.458	105.354	98.739	*NAVGPS*	100.010	99.491	103.277
TP2	94.458	105.354	98.739	*GPSP*	99.241	101.259	102.495
TP2	94.458	105.354	98.739	*GPSS*	100.764	101.270	102.498
TP2	94.458	105.354	98.739	*TP3*	105.803	107.150	98.406

				TP3 Observed			
				POINT	**e (m)**	**n (m)**	**u (m)**
TP3	105.803	107.150	98.406	*CLB*	100.024	104.595	101.153
TP3	105.803	107.150	98.406	*MB1*	101.369	102.944	98.440
TP3	105.803	107.150	98.406	*SB*	99.854	100.299	99.352
TP3	105.803	107.150	98.406	*SSST*	100.522	95.961	102.840
TP3	105.803	107.150	98.406	*IMU*	100.144	100.267	99.871
TP3	105.803	107.150	98.406	*NAVGPS*	100.012	99.493	103.279
TP3	105.803	107.150	98.406	*GPSP*	99.243	101.260	102.497
TP3	105.803	107.150	98.406	*GPSS*	100.768	101.267	102.504

DISCUSSION

All coordinates are contained in spreadsheet "S3003.xls. Included in this spreadsheet is the IMU GPS antenna separation value, as determined by inverse between the averaged positions of the two GPS antenna. After reviewing the check positions, the accuracy of the unadjusted values for all objects is better than 0.028(m) X, 0.030(m) Y, and 0.008(m) in the Z. The positions determined for each sensor was averaged, which yielded position accuracies for all objects of better than 0.010(m) X, 0.015(m) X, and 0.004(m) in the Z.

The positions given for all GPS antenna are to the top center of the antenna. To correct the Z value contained in the spreadsheet for each antenna to the electronic phase center, I recommend the following steps be taken;

1) Measure the total height of each antenna type. This information is probably located on the antenna or with equipment documentation.
2) Investigate to find the electronic phase center offset of the antenna. This information is probably located on the antenna or with equipment documentation. This value may also be available at the NGS website for antenna modeling.
3) Subtract the total height of the antenna from the spreadsheet Z value for each antenna. This will give you a Z value for the antenna ARP (antenna reference point)
4) Then add to this value the electronic phase center offset value appropriate for the antenna model.

Station Listing

CL0- CENTERLINE PRIMARY REFERENCE POINT
An existing punch mark set in top of the housing for a hatch, located in the cab. Stamped "CL0".

CLB- CENTERLINE REFERENCE POINT BOW
A punch mark set in top of a cleat, near the bow of the vessel. Stamped "CLB".

CLS- CENTERLINE REFERENCE POINT STERN
A punch mark set in top of the center rib in the generator hold. Stamped "CLS".

NOAA SURVEY VESSEL S3003
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

MB- MULTIBEAM TRANSDUCER REFERENCE POINT
The center of the bottom of the Multibeam Transducer.

SB- SINGLE BEAM TRANSDUCER REFERENCE POINT
The center of the bottom of the Singlebeam Transducer.

SSST- SIDE SCAN SONAR REFERENCE POINT

A punch mark set in top of the swing arm, and directly over the pivot point for the Side Scan Sonar sheave. The correction from the punch mark to the center of the Side Scan Sonar cable is 0.390(m) and has been accounted for in the spreadsheet value for this sensor.

IMU- IMU REFERENCE TARGET
Center of a target affixed to the top of the IMU housing.

IMUPB- IMU CORNER REFERENCE POINT
The top corner of the port side and bow side, of the IMU housing.

IMUPS- IMU CORNER REFERENCE POINT
The top corner of the port side and stern side, of the IMU housing.

IMUSB- IMU CORNER REFERENCE POINT
The top corner of the starboard side and bow side, of the IMU housing.

IMUSS- IMU CORNER REFERENCE POINT
The top corner of the starboard side and the stern side, of the IMU housing.

NAVGPS- NAVIGATION GPS ANTENNA REFERENCE POINT
The top center of the navigation system GPS antenna.

GPSP- POS GPS ANTENNA REFERENCE POINT
The top center of the port side GPS antenna for the POS system.

GPSS- POS GPS ANTENNA REFERENCE POINT
The top center of the starboard side GPS antenna for the POS system.

WMPB WATER LEVEL REFERENCE POINT
A line drawn in coincidence with a stain around the perimeter of the vessel, near the bow and on the port side of the vessel.

NOAA SURVEY VESSEL S3003
POS MV COMPONENTS SPATIAL RELATIONSHIP SURVEY

WMPS WATER LEVEL REFERENCE POINT
A line drawn in coincidence with a stain around the perimeter of the vessel, near the stern and on the port side of the vessel.

WMSB WATER LEVEL REFERENCE POINT

A line drawn in coincidence with a stain around the perimeter of the vessel, near the bow and on the starboard side of the vessel.

WMSS WATER LEVEL REFERENCE POINT
A line drawn in coincidence with a stain around the perimeter of the vessel, near the stern and on the starboard side of the vessel.

	Observed Position			Conversion to Vessel Reference Frame				
Name	**e (m)**	**n (m)**	**u (m)**	**x**	**y**	**z**	**Z corrections**	**z**
CENTERLINE PRIMARY REFERENCE POINT	**100.000**	**100.000**	**100.000**	0.000	0.000	0.000	0	0.000
CENTERLINE REFERENCE POINT B	**100.006**	**104.630**	**101.141**	-0.006	4.630	1.141	0	-1.141
CENTERLINE REFERENCE POINT S	**100.002**	**97.222**	**99.713**	-0.002	-2.778	-0.287	0	0.287
MULTIBEAM REFERENCE POINT	**101.346**	**102.983**	**98.139**	-1.346	2.983	-1.861	0.29	1.571
SINGLE BEAM REFERENCE POINT	**99.829**	**100.357**	**99.058**	0.171	0.357	-0.942	0.29	0.652
SIDE SCAN SONAR REFERENCE POINT	**100.509**	**96.006**	**102.443**	-0.509	-3.994	2.443	0.39	-2.053
IMU	**100.124**	**100.313**	**99.867**	-0.124	0.313	-0.133	0	0.133
IMU PORT AND BOW CORNER	**100.046**	**100.377**	**99.867**	-0.046	0.377	-0.133	0	0.133
IMU PORT AND STERN CORNER	**100.046**	**100.246**	**99.867**	-0.046	0.246	-0.133	0	0.133
IMU STARBOARD AND BOW CORNER	**100.205**	**100.376**	**99.865**	-0.205	0.376	-0.135	0	0.135
IMU STARBOARD AND STERN CORNER	**100.202**	**100.245**	**99.865**	-0.202	0.245	-0.135	0	0.135
GPS NAVIGATION ANTENNA	**99.997**	**99.536**	**103.265**	0.003	-0.464	3.265	0	-3.265
IMU GPS PORT SIDE ANTENNA	**99.230**	**101.301**	**102.485**	0.770	1.301	2.485	0	-2.485
IMU GPS STARBOARD SIDE ANTENNA	**100.751**	**101.307**	**102.488**	-0.751	1.307	2.488	0	-2.488
WATER MARK PORT SIDE, NEAR BOW			**100.025**			0.025	0	-0.025
WATER MAKR PORT SIDE, NEAR STERN			**100.096**			0.096	0	-0.096
WATER MARK STARBOARD SIDE NEAR BOW			**100.04**			0.035	0	-0.035
WATER MARK STARBOARD SIDE NEAR STERN			**100.107**			0.107	0	-0.107
						0.066	0	-0.066

		Converted Position			Holding the IMU as the Origin		
POINT	Name	x	y	z	dx	dy	dz
CL0	CENTERLINE PRIMARY REFERENCE POINT	0.000	0.000	0.000	0.124	-0.313	-0.133
CLB	CENTERLINE REFERENCE POINT B	-0.006	4.630	-1.141	0.118	4.317	-1.274
CLS	CENTERLINE REFERENCE POINT S	-0.002	-2.778	0.287	0.122	-3.091	0.154
MB	MULTIBEAM REFERENCE POINT	-1.346	2.983	1.571	-1.222	2.670	1.438
SB	SINGLE BEAM REFERENCE POINT	0.171	0.357	0.652	0.295	0.044	0.519
SSST	SIDE SCAN SONAR REFERENCE POINT	-0.509	-3.994	-2.053	-0.385	-4.307	-2.186
IMU	IMU	-0.124	0.313	0.133	0.000	0.000	0.000
IMUPB	IMU PORT AND BOW CORNER	-0.046	0.377	0.133	0.078	0.064	0.000
IMUPS	IMU PORT AND STERN CORNER	-0.046	0.246	0.133	0.078	-0.067	0.000
IMUSB	IMU STARBOARD AND BOW CORNER	-0.205	0.376	0.135	-0.081	0.063	0.002
IMUSS	IMU STARBOARD AND STERN CORNER	-0.202	0.245	0.135	-0.078	-0.068	0.002
NAVGPS	GPS NAVIGATION ANTENNA	0.003	-0.464	-3.265	0.127	-0.777	-3.398
GPSP	IMU GPS PORT SIDE ANTENNA	0.770	1.301	-2.485	0.894	0.988	-2.618
GPSS	IMU GPS STARBOARD SIDE ANTENNA	-0.751	1.307	-2.488	-0.627	0.994	-2.621
AWM	AVERAGE WATER MARK			-0.066			-0.199

Note--Z values to IMU, GPS antenna, Multibeam Transducer, and Single Beam Transducer does not include correction to electronic phase center!

Note--Units equal Meters

Inversed length of the IMU GPS antenna separation **1.521**

Appendix 2: Side Scan Sonar Calibration Table

Side Scan Sonar Calibration

Field Unit: Navigation Response Team 6

Date of Test: December 18, 2006

Calibrating Hydrographer(s): Eric Moore, Julia Uhlendorf, Edmund Wernicke

SIDE SCAN SYSTEM INFORMATION

Side Scan System: Klein System 3000

System Location: Launch S3003

TPU Serial Number: 351

Towfish Serial Number: 450

Cable Type: Kevlar-coated coaxial cable

Date of Most Recent EED / Factory Checkout: August 2006

Date of Most Recent Pressure Sensor Verification (if applicable): Not certain

VESSEL INFORMATION

Sonar Configuration: Towed

Cable Measurement System (if applicable): Dynapar cable counter

Date of Current Vessel Offset Measurement / Verification: June 18, 2006

Date of Current Cable Measurement / Verification (if applicable): August 2006

TEST INFORMATION

Test Date(s) / DN(s): December 18, 2006 / 352

System Operator(s): Eric Moore, Julia Uhlendorf

Wind / Seas / Sky: Calm seas, light breeze

Locality: San Diego Bay

Sub-Locality: Area West of Harbor Island

Description of Bathymetry: Edge of Channel

Bottom Type: Sandy

Approximate Water Depth: 14m

Description of Target: Buoy block

Approximate Target Size: 1.5m^3

TEST INFORMATION (continued)

Target Position: Lat:32.70632285, Long:-117.2261558

Description of Positioning Method: SWMB (Simrad EM3000)

Estimated Target Position Error: 7.8m CARIS Hz TPE value

Approximate Survey Speed: 2.5 kts**.**

Approximate Towfish Altitude: 12m

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
sonar_data061218115600	North	3
sonar_data061218120100	North	2.5
sonar_data06121812030	South	2.5
sonar_data061218120600	North	2.5
sonar_data061218120800	South	2
sonar_data061218121200	North	2.75
sonar_data061218121800	East	2.5
sonar_data06121812200	West	2.25
sonar_data061218122300	East	2.5
sonar_data061218122400	West	2.5
sonar_data06121812300	South	2.5

TEST RESULTS

Number of Passes on Target: 13

Successful Target Detections: 11

Mean Detected Position: Lat: 32.70632553, Long: -117.2261479

Distance from Mean Position to True Position: 0.785m

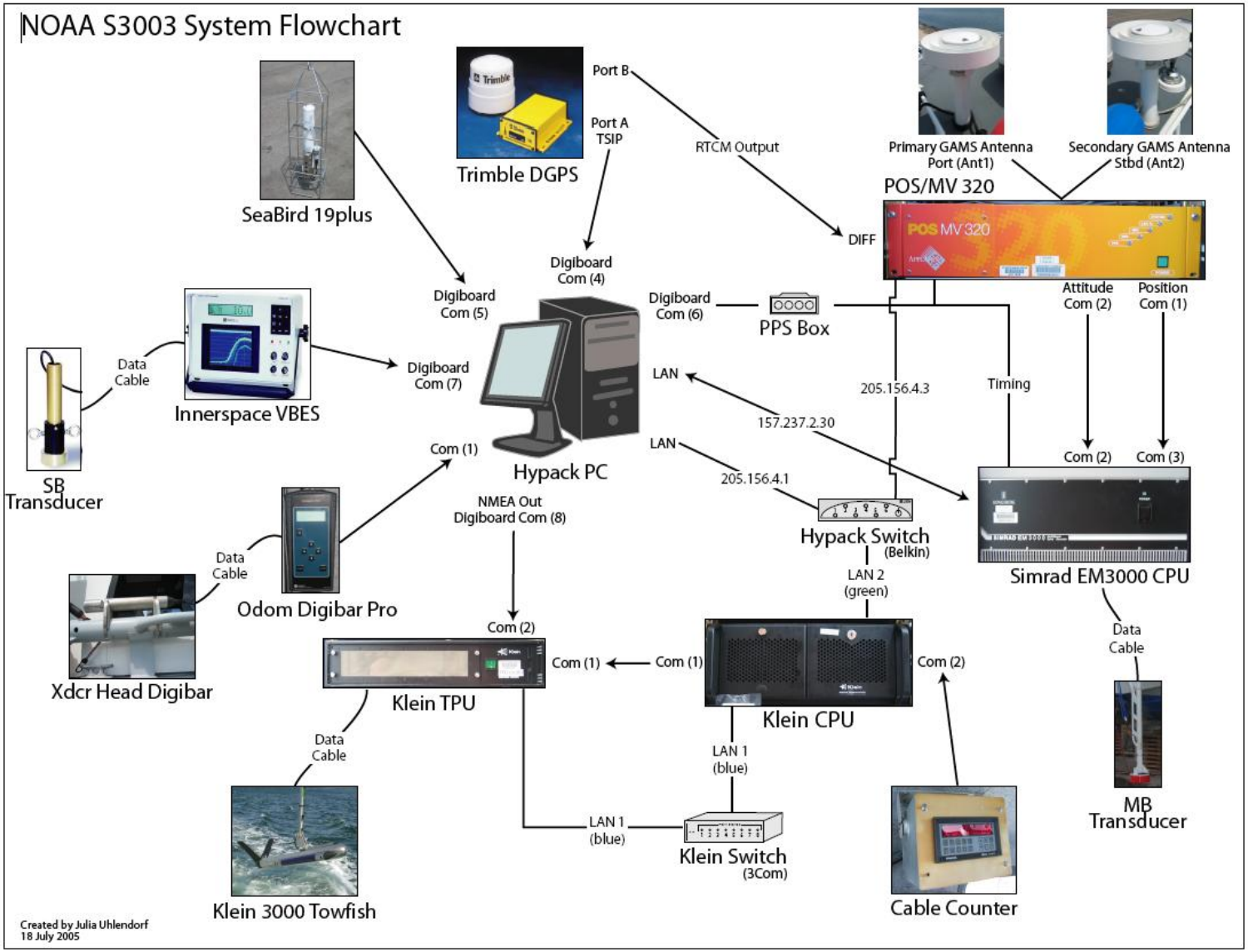
Approximate 95% Confidence Radius: 4.57m

NARRATIVE

This SSS calibration test was performed in accordance with chapter 1.5.7.1.2 of the Field Procedures Manual. The resulting distance between the mean detected position and the "true" position, as well as the resulting 95% confidence radius indicate that the SSS system

is accurately positioning SSS imagery, and is in agreement with the horizontal positioning of SWMB data. This test suggests low systematic errors, and that most of the horizontal positioning error associated with the SSS system is random in nature. Results of this test confirm that SSS data recorded with this system are well within the OCS specification of a 10m 95% Confidence Radius for towed systems.

Appendix 3: Survey Systems Diagram for Launch S3003


NOAA S3003 System Flowchart
SeaBird 19plus
Trimble DGPS
Port B
Port A
TSIP
RTCM Output
Primary GAMS Antenna
Port (Ant1)
Secondary GAMS Antenna
Stbd (Ant2)
POS/MV 320
DIFF
Digiboard
Com (4)
Digiboard
Com (5)
Digiboard
Com (6)
PPS Box
Attitude
Com (2)
Position
Com (1)
Data
Cable
Innerspace VBES
Digiboard
Com (7)
SB
Transducer
Hypack PC
LAN
205.156.4.3
Timing
157.237.2.30
LAN
205.156.4.1
Com (1)
Com (2)
Com (3)
NMEA Out
Digiboard Com (8)
Hypack Switch
(Belkin)
Simrad EM3000 CPU
LAN 2
(green)
Data
Cable
Odom Digibar Pro
Xdcr Head Digibar
Com (2)
Com (1)
Com (1)
Com (2)
Klein TPU
Klein CPU
Data
Cable
LAN 1
(blue)
MB
Transducer
LAN 1
(blue)
Klein Switch
(3Com)
Klein 3000 Towfish
Cable Counter
Created by Julia Uhlendorf
18 July 2005

Appendix 4: POS/MV Calibration Report

```
Input/Output Ports Set-up

COM1
Baud Rate=9600
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Flow Control=None
Output Select=NMEA
NMEA Output=HDT,ZDA,GGA
Update Rate=1 Hz
Talker ID=IN
Roll Positive Sense=Port Up
Pitch Positive Sense=Bow Up
Heave Positive Sense=Heave Up
Input Select=None

COM2
Baud Rate=19200
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Flow Control=None
Output Select=Binary
Binary Output
Update Rate=100 Hz
Frame=Sensor 1
Formula Select=SIMRAD 3000 (TSS)
Roll Positive Sense=Port Up
Pitch Positive Sense=Bow Up
Heave Positive Sense=Heave Up
Input Select=None

COM3
Baud Rate=9600
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Flow Control=None
Output Select=None
Input Select=Base 1 GPS
Base GPS Input
Input Type=RTCM 1 or 9
Line=Serial

Ethernet Logging Control
Logging Group Select=111,113
Logging Control
Output Rate (groups 1, 102, 103)=20 Hz

Ethernet Realtime Output Control
Output Group Select=1,3,4,7,10,102,111,112,113
Output Control
Output Rate (groups 1,102, 103)=25 Hz

Events
Event 1=Negative Edge Trigger
```

```
Event 2=Negative Edge Trigger

GAMS Parameter Setup
Two Antenna Separation (m)=1.529
Heading Calibration Threshold (deg)=0.500
Heading Correction (deg)=0.000
Baseline Vector
X Component (m)=0.018
Y Component (m)=1.529
Z Component (m)=-0.014

Heave Filter
Heave Filter
Heave Bandwidth (sec)=20.000
Damping Ratio=0.707

Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Ref. to IMU Lever Arm
X (m)=0.000
Y (m)=0.000
Z (m)=-0.000
IMU Frame w.r.t. Ref. Frame
X (deg)= 0.000
Y (deg)=0.000
Z (deg)=0.000
Ref. to Primary GPS Lever Arm
X (m)=-0.009
Y (m)=-0.006
Z (m)=0.057
Ref. to Vessel Lever Arm
X (m)=0.000
Y (m)=0.000
Z (m)=0.000
Ref. to Centre of Rotation Lever Arm
X (m)=0.000
Y (m)=0.000
Z (m)=0.000
Sensor Mounting
Ref. to Aux. 1 GPS Lever Arm
X (m)=0.000
Y (m)=0.000
Z (m)=0.000
Ref. to Aux. 2 GPS Lever Arm
X (m)=0.000
Y (m)=0.000
Z (m)=0.000
Ref. to Sensor 1 Lever Arm
X (m)=0.000
Y (m)=0.000
Z (m)=0.000
Sensor 1 Frame w.r.t. Ref. Frame
X (deg)=0.000
Y (deg)=0.000
Z (deg)=0.000
Ref. to Sensor 2 Lever Arm
X (m)=0.000
```

```
Y (m)=0.000
Z (m)=0.000
Sensor 2 Frame w.r.t. Ref. Frame
X (deg)=0.000
Y (deg)=0.000
Z (deg)=0.000

Tags, Multipath & AutoStart
Time Tag 1=UTC Time
Time Tag 2=POS Time
AutoStart=Enabled
Multipath=Low

Statistics
POS Version= MV-320,VER4,S/N2160,HW2.7-6,SW03.20-
Aug31/05,ICD03.13,OS425B14,IMU2,PGPS13,SGPS13,RTK-0,THV-0,DPW-0
GPS Receivers
Primary Receiver=BD950;SN:4435A43289,v.00211,channels:24
Secondary Receiver=BD950:SN:4435A43279,v.00211,channels:24
Statistics
Total Hours=272.4
Total Runs=96
Average Run (hours)=2.8
Longest Run (hours)=65.5
Current Run (hours)=2.3

Navigator Configuration
Frame Control=User Frame
Auxiliary GPS Position=Normal
Primary GPS Measurement=Normal
GAMS=unchecked Disable GAMS Solution

POS Internet Address
POS Internet Address=205.156.004.003
Subnet Mask=255.255.255.000

Gps Receiver Configuration
Primary GPS Receiver
Primary GPS
GPS Output Rate=1 Hz
GPS 1 Port
Baud Rate=9600
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Auto Configuration
Enabled
Secondary GPS Receiver
Secondary GPS
GPS Output Rate=1 Hz
GPS 2 Port
Baud Rate=9600
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Auto Configuration
Enabled
```

```
User Parameter Accuracy
RMS Accuracy
Attitude (deg)=0.050
Heading (deg)=0.100
Position (m)=2.500
Velocity (m/s)=1.000
```

Appendix 5: Hydrographic Systems Inventory

Hydrographic Vessel Inventory

Field Unit: NOAA NRT 6

Effective Date: April 2007

Updated Through: May 2007

SURVEY VESSELS	
Vessel Name	S3003
Hull Number	S3003
Call Letters	N/A
Manufacturer	SeaArk
Year of Construction	2003
Type of Construction	Aluminum Hull
Length Overall	27'
Beam	8'
Draft	18"
Date of Effective Full Vessel Static Offset Survey	18-Jun-06

Organization which Conducted the Effective Full Offset Survey	National Geodetic Survey
Date of Last Partial Survey or Offset Verification & Methods Used	6/18/2006, total station
Date of Last Static Draft Determination & Method Used	6/18/2006, observed waterline growth
Date of Last Settlement and Squat Measurements & Method Used	5/23/2006, reference surface
Additional Information	

Hydrographic Hardware Inventory

Field Unit: NRT 6

Effective Date: 5/1/2007

Updated Through: 5/1/2007

SONAR & SOUNDING EQUIPMENT

Equipment Type	Manufacturer	Model	Serial Number	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information
Multibeam Echosounder	Kongsberg	Simrad EM 3000	1518	EM 3000 Controller v1.0.91				
Side Scan Sonar	Klein	System 3000	351	Sonar Pro v8.0				
Single Beam Echosounder	Odom	Echotrac CV	23042					

POSITIONING & ATTITUDE EQUIPMENT

Equipment Type	Manufacturer	Model	Serial Number	Firmware and/or Software Version	Version Install Date	Date of last Calibration	Date of last Service	Additional Information
GPS Aided Inertial Navigation	Applanix	POS/MV 320 V4	2160	firmware ver 2.7-6				
DGPS Receiver	Trimble	DSM212H	0220296441					

SOUND SPEED MEASUREMENT EQUIPMENT								
Equipment Type	**Manufacturer**	**Model**	**Serial Number**	**Firmware and/or Software Version**	**Version Install Date**	**Date of last Calibration**	**Date of last Service**	**Additional Information**
Sound Speed Profiler	Sea-Bird	SeaCat 19+	19P37217-4676					
Sound Speed Probe	Odom	Digibar Pro	98,213					
Sound Speed Probe	Odom	Digibar Pro	98214					
TIDES & LEVELING EQUIPMENT								
Equipment Type	**Manufacturer**	**Model**	**Serial Number**	**Firmware and/or Software Version**	**Version Install Date**	**Date of last Calibration**	**Date of last Service**	**Additional Information**
Trimble GPS Backpack	Trimble	TSC 1 Data Logger	0220253427					

Hydrographic Software Inventory

Field Unit: NRT6

Effective Date: 5/1/2007

Updated Through: 5/1/2007

COMPUTERS									
Machine Name		Computer #1	Computer #2	Computer #2	Klein PC	Hypack PC			
Location		Office	Office	Office	Launch	Launch			
Make/Model		Dell Precision 490	Dell Optiplex GX270	Dell Optiplex GX270	Klein PC	HP Pavilion			
Date Purchased		9/6/2006	3/6/2007	3/6/2007	?	?			
Date of Last Rebuild		N/A	N/A	N/A	N/A	N/A			
Processor		Intel Xeon	Pentium 4	Pentium 4	Pentium 3	Pentium 4			
RAM		4 GB	3.62 GB	2.5 GB	523 MB	1 GB			
Video Card		Nvidea Quadro NVS 285	Nvidea Gforce FX5200	Nvidea Gforce FX5200	Matrox G450	Nvidea Gforce FX 5200			
Video RAM		256 MB	128 MB	128 MB	32 MB	228 MB			

Comments		Eric's PC	RAM upgraded in May 2007 Laura's PC	RAM upgraded in May 2007 Ed's PC	Klein PC issued with Klein 3000 package				
SOFTWARE LICENSES									
Software Package		**License Numbers**							
Acquisition	SonarPro	no license #							
	HYPACK MAX KEY	199984							
Processing	CARIS KEY 1	CW9604619							
	CARIS KEY 2	CW9604220							
Support	MapInfo								
OPERATING SYSTEM PACKAGE: Windows XP (example)									
Machine Name		Computer #1	Computer #2	Computer #3					
Operating System Installations & Updates (Date)	Windows XP Pro-64bit	9/1/2006							
	Windows XP Pro		6/1/2006	6/1/2006					
ACQUISITION SOFTWARE PACKAGE: HypackMAX (example)									
Machine Name		Hypack							
Installations & Update	4.3.51.0	6/1/2006							
ACQUISITION SOFTWARE PACKAGE: SonarPro									

Machine Name		Klein							
Installations & Update	SonarPro v8.0	3/1/2007							
PROCESSING SOFTWARE PACKAGE: CARIS HIPS/SIPS									
Machine Name		Computer #1	Computer #2	Computer #3					
Software Installations & Updates (date)	CARIS 6.1	5/1/2007	5/1/2007	6.0 still installed					
	Hotfixes	5/1/2007	5/1/2007						
PROCESSING SOFTWARE PACKAGE: Pydro									
Machine Name		Computer #1	Computer #2	Computer #3					
Software Installations & Updates (date)	6.4.9			12/1/2006					
	6.10beta	2/1/2007							
	7.1.0		4/1/2007						
PROCESSING SOFTWARE PACKAGE: MapInfo									
Machine Name		Computer #1	Computer #2	Computer #3					
Software Installations & Updates (date)	MapInfo 8.0		6/1/2006	6/1/2006					
	MapInfo 8.5	12/1/2006							
SUPPORT SOFTWARE PACKAGE: MS Office									
Machine Name		Computer #1	Computer #2	Computer #3					
Installations & Update	Office 2002	9/1/2006	6/1/2006	6/1/2006					

SUPPORT SOFTWARE PACKAGE: Adobe Acrobat Professional									
Machine Name		Computer #1	Computer #2	Computer #3					
Software Installations & Updates (date)	Acrobat v5		6/1/2006	6/1/2006					
	Acrobat v8	2/1/2007							

Hydrographic Personnel Roster

Field Unit: **NOAA NRT6**

Effective Date: **Apr-07**

Updated Through: **1-May**

SURVEY DEPARTMENT

Name and Rate	Current Position	Years of Hydrographic Experience	Notes
Eric Moore	Physical Scientist Tech	5	Team Lead
Edmund Wernicke	Physical Scientist Tech	19	
Laura Pagano	Physical Scientist Tech	2	REMSA Contractor, began working with team in April 2007

NOTES:

Appendix 6: HYPACK Configuration

```
Device=POS net
Device Setup

Update frequency (ms) = 50

Type=Position, Heading, Speed, Sync. Clock, Heave comp
Option=Record raw data, Record quality data

Driver=c:\hypack\devices\PosMV.dll

Connect
Connect to= Network
Protocol=UDP
Function=Server
Read Port=5602
Write Port=5602

Offsets
Latency time (sec)=0.000
Starboard (m/ft)=0.00
Forward (m/ft)=0.00
Height (m/ft)=0.00
Yaw (deg)=0.00
Roll (deg)=0.00
Pitch (deg)=0.00

Setup
Use PPS for timing, COM6
Record group 102
Get Heave from group 102


Device=Echotrac CV
Device Setup

Update frequency (ms) = 50

Type= Echosounder, Other
Connect
Connect to= Network
Protocol=UDP
Function=Server
Read Port=1600
Write Port=1601

Offsets
Latency time (sec)=0.000
Starboard (m/ft)=0.00
Forward (m/ft)=0.00
Height (m/ft)=0.00
Yaw (deg)=0.00
Roll (deg)=0.00
Pitch (deg)=0.00

Setup
Frequency = High
```

```
Device=NMEA Out
Device Setup

Update frequency (ms) = 200

Type= Position, Heading, Speed, Output
Options=Record Raw Data, Record Data Quality, Record Message, Paper
Annotation

Connect
Connect to=Serial
Settings=COM84800,n,8,1

Offsets
Latency time (sec)=0.000
Starboard (m/ft)=0.00
Forward (m/ft)=0.00
Height (m/ft)=0.00
Yaw (deg)=0.00
Roll (deg)=0.00
Pitch (deg)=0.00

Setup
Heading=VTG
GLL Decimal Places=4
Sentences to Generate=VTG,RMC
```

Appendix 7: HVF Vessel Report

Vessel Name: NRT6_S3003_EM3000_NAD83
Vessel created: The vessel file was not saved at the time this report was generated.

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2005-143 00:00

Transducer #1:

Pitch Offset: 1.450
Roll Offset: 0.090
Azimuth Offset: 3.600

DeltaX: 1.332
DeltaY: 3.014
DeltaZ: 1.232

Manufacturer: Simrad
Model: em3000
Serial Number: 1518

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2005-143 00:01

Transducer #1:

Pitch Offset: -0.590
Roll Offset: 0.060
Azimuth Offset: 0.000

DeltaX: 1.332
DeltaY: 3.014
DeltaZ: 1.232

Manufacturer: Simrad
Model: em3000
Serial Number: 1518

Navigation Sensor:

Time Stamp: 2005-143 00:00

Comments RP to IMU
Latency 0.760
DeltaX: 0.127
DeltaY: 0.310
DeltaZ: 0.118

Manufacturer: Applanix
Model: POSMV Ver. 3
Serial Number: 676

Time Stamp: 2005-143 00:01

Comments RP to IMU
Latency 0.040
DeltaX: 0.127
DeltaY: 0.310
DeltaZ: 0.118

Manufacturer: Applanix
Model: POSMV Ver. 3
Serial Number: 676

Gyro Sensor:

Time Stamp: 2005-143 00:00

Comments
Latency 0.000

Heave Sensor:

Time Stamp: 2005-143 00:00

Comments RP to IMU
Apply Yes
Latency 0.000
DeltaX: 0.127
DeltaY: 0.310
DeltaZ: 0.118

Offset: 0.000

Manufacturer: Applanix
Model: POSMV Ver. 3
Serial Number: 676

Pitch Sensor:

Time Stamp: 2005-143 00:00

Comments (null)
Apply Yes
Latency 0.000
Pitch offset: 0.000

Manufacturer: Applanix
Model: POSMV Ver. 3
Serial Number: 676

Roll Sensor:

Time Stamp: 2005-143 00:00

Comments (null)
Apply Yes
Latency 0.000
Roll offset: 0.000

Manufacturer: Applanix
Model: POSMV Ver. 3
Serial Number: 676

Draft Sensor:

Time Stamp: 2005-143 00:00

Apply Yes
Comments (null)
Entry 1) Draft: 0.000 Speed: 0.000
Entry 2) Draft: 0.002 Speed: 3.100
Entry 3) Draft: 0.010 Speed: 3.899
Entry 4) Draft: 0.014 Speed: 4.599
Entry 5) Draft: 0.020 Speed: 5.301

Entry 6) Draft: 0.030 Speed: 5.900
Entry 7) Draft: 0.035 Speed: 6.500
Entry 8) Draft: 0.042 Speed: 7.000
Entry 9) Draft: 0.044 Speed: 7.400

Time Stamp: 2006-343 00:00

Apply Yes
Comments
Entry 1) Draft: 0.000 Speed: 0.000

TPE

Time Stamp: 2005-143 00:00

Comments
Offsets

Motion sensing unit to the transducer 1
- X Head 1 1.205
- Y Head 1 2.700
- Z Head 1 1.114

Motion sensing unit to the transducer 2
- X Head 2 0.000
- Y Head 2 0.000
- Z Head 2 0.000

Navigation antenna to the transducer 1
- X Head 1 1.205
- Y Head 1 2.700
- Z Head 1 1.114

Navigation antenna to the transducer 2
- X Head 2 0.000
- Y Head 2 0.000
- Z Head 2 0.000

Roll offset of transducer number 1 0.000
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.005
Motion sensing unit alignment errors
Gyro:0.000 Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 4.000

Transducer timing error: 0.000
Navigation timing error: -0.170
Gyro timing error: 0.000
Heave timing error: 0.000
PitchTimingStdDev: 0.000
Roll timing error: 0.000
Sound Velocity speed measurement error: 0.500
Surface sound speed measurement error: 0.300
Tide measurement error: 0.010
Tide zoning error: 0.100
Speed over ground measurement error: 0.250
Dynamic loading measurement error: 0.000
Static draft measurement error: 0.010
Delta draft measurement error: 0.010
StDev Comment: `é_e Ïae`õaePõae°ðae €ae@íae°k\eàZ\e€Óaea

Svp Sensor:

Time Stamp: 2005-143 00:00

Comments RP to SV Probe
Svp #1:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 1.332
DeltaY: 3.014
DeltaZ: 1.232

SVP #2:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Time Stamp: 2005-143 00:01

Comments
Svp #1:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 1.332
DeltaY: 3.014
DeltaZ: 1.232

SVP #2:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

WaterLine:

Time Stamp: 2005-143 00:00

Comments RP to WL
Apply Yes
WaterLine -0.050
