2010 DAPR NRT-4

NOAA FORM 76-35A

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Survey

Data Acquisition & Processing Report

Field Unit: **Navigation Response Team 4**

Operational Area: **Hampton Roads, Virginia**

LOCALITY

State: Virginia

General Locality: Norfolk

Sub-locality: APM Terminal Basin

2010

CHIEF OF PARTY

LT STEPHEN C KUZIRIAN, NOAA

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DATE

NOAA FORM 77-28 (11-72) U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY NUMBER:
HYDROGRAPHIC TITLE SHEET	**N/A**

INSTRUCTIONS: The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

State:	**Virginia**		
General Locality:	**Norfolk**		
Sub-Locality:	**APM Terminal Basin**		
Scale:	**N/A**	Date of Survey:	**18 Dec 2009, 09 Mar 2010**
Instructions Dated:	**N/A**	Project Number:	**N/A**
Vessel:	**NOAA NRT-4, S1211**		
Chief of Party:	**LT Stephen C Kuzirian, NOAA**		
Surveyed by:	**NRT-4**		
Soundings by:	**Kongsberg Simrad EM 3002 multibeam echosounder**		
	ODOM CV2 Echosounder		
Graphic record scaled by:	**N/A**		
Graphic record checked by:	**N/A**		
Protracted by:	**N/A**	Automated Plot:	**N/A**
Verification by:	**Atlantic Hydrographic Branch Personnel**		
Soundings in:	**Meters at MLLW**		

Remarks:
1) All Times are in UTC.
2) This is a DAPR to accompany all Hydrographic Survey Projects for calendar year 2010.
3) Projection is UTM Zone 18. NAD83

Data Acquisition and Processing Report

to accompany
Field Season 2010 Survey Operations in Hampton Roads, VA

NOAA Navigation Response Team 4
LT Stephen C. Kuzirian, OIC

A. EQUIPMENT

With the exception of sound speed profiler calibration reports, all calibration data were acquired by Navigation Response Team 4 (NRT-4) personnel during the months of December, 2009 and March 2010. NRT-4 data acquisition systems include side scan sonar (SSS), multibeam echosounder (MBES), vertical beam echosounder (VBES), position and orientation system (POS) surface sound speed sensor (SSVS), sound speed profilers (SVP) and a GPS backpack. Vessel description and offset measurements are described in Appendix II. Any subsequent deviations from this report will be addressed in the respective survey Descriptive Reports.

Methods used to test and calibrate all equipment were determined by the hydrographer in accordance with the Hydrographic Survey Specifications and Deliverables, and the Field Procedures Manual with due consideration given to system performance limitations, time availability, and vessel and crew safety.

A.1 Bathymetric Sounding Equipment

A.1.1 Odom Echotrac CV 200 Vertical-Beam Echosounder

S1211 is equipped with an Odom CV 200 vertical beam echosounder (VBES). The Odom echosounder has a single-frequency (appx 200kHz) unit with a digital recorder. This unit transducer operates at 208 kHz with a circular beam footprint of 8° at the –12 dB point. The transducer is controlled using the CV controller software and interfaced with Hypack via an Ethernet connection. VBES data are logged in Hypack survey.

A.1.2 Kongsberg Simrad EM3002 Multibeam Echosounder

For shallow water bathymetry S1211 is equipped with a hull-mounted Kongsberg Simrad EM3002. The EM3002 is a 293 kHz system with an operating depth range of 1m below the transducer to 150m water depth. Transmit beamwidth is 120° acrosstrack and 1.5° alongtrack; receive beamwidth is 30° alongtrack and 1.5° acrosstrack. The system has a maximum ping rate of 25 Hz, and a total effective beamwidth of 1.5° alongtrack by 1.5° crosstrack.

The EM3002 Processing Unit performs beamforming, bottom detection and controls the sonar head with respect to gain, ping rate and receive beam angles. The sonar processor also incorporates real time surface sound speed measurements for initial beam forming and steering. The EM3002 Sonar Interface Software (SIS) application is designed to run under Microsoft Windows, and provides control and monitoring of the EM3002 and the sensors connected to the Processing Unit. SIS can also be used to run the Built-In Self Test (BIST) programs of the system. Sound velocity profiles are applied to the data through SIS during data acquisition. Sonar parameters and vessel speed are adjusted as necessary to ensure adequate coverage in accordance with the NOS Specifications and Deliverables and the Project Instructions.

Main scheme MBES line plans generally run parallel to bathymetry contours using a line spacing as directed in the NOAA Field Procedures Manual (FPM) and Specs and Deliverables.

Data are acquired using Hypack Hysweep. Hypack *.HSX data, when converted in Caris, cannot have Caris SVP files correctly applied to them.

A.1.3 Leadline

Leadlines are used for single beam and multibeam echosounder comparisons. Reports for the leadline comparisons are included in Appendix V.

A.2. Side Scanning Imagery Sonar

A.2.1 L-3 Klein System 3000

The L-3 Klein System 3000 includes the Model 3210 towfish, 35m of Kevlar reinforced tow cable, the Transceiver and Processing Unit (TPU) with VX Works operating system, and a Klein PC workstation with SonarPro. The Model 3210 towfish (fig 3) operates at a nominal frequency of 500/100 kHz and has a vertical beam angle of 40 degrees. Klein TPU contains a network card for transmission of the sonar data to the Klein acquisition computer. The acquisition software (SonarPro) is capable of saving raw data in SDF and/or XTF format.

The SSS towfish is deployed from a davit arm located on starboard quarter using a Dayton electric-hydraulic winch spooled with approximately 50 meters of cable. Tow cable is led from the winch upward along the davit arm. The tow cable at the winch is connected electro-mechanically to a deck cable through a slip ring assembly. Cable out is controlled manually and is computed by the DynaPro cable counter by the number of revolutions of the cable drum sheave. The cable counter data is inputted directly into SonarPro through the klein acquisition computer. Cable-out is adjusted to 4.0 meters before deployment of the towfish to account for the distance from the water surface to the wheel.

Line spacing for side scan sonar (SSS) operation is prepared as directed in the NOAA Field Procedures Manual and Spec's and Deliverables.

To minimize towing gear stress, and reduce strumming, towed SSS operations are typically limited to approximately 6 knots speed-over-ground. Turns to port require the towfish be drawn in to prevent the tow cable from swinging into the outboard propellers.

A towfish altitude of 8-20% of the range scale is maintained during data acquisition. Altitude is adjusted by cable out, and vessel speed.

Confidence checks are performed daily by observing changes in linear bottom features extending to the outer edges of the digital side scan image, features on the bottom in survey area, and by passing aids to navigation. Daily rub tests are also conducted.

A.3 Vessel Position and Orientation Equipment

A.3.1 Trimble DSM212L DGPS Receiver

S1211 carries a Trimble DSM212L Differential GPS receiver. USCG beacons are used for horizontal position control. The DSM212L is an integrated 12-channel GPS receiver and dual-channel differential beacon receiver. The beacon receiver can simultaneously monitor two beacon stations if within broadcast range. Correctors are received from only one beacon station during data acquisition.

Receiver parameters are configured using Trimble TSIPTalker and included; number of visible satellites (4 SV's), positional dilution of precision (PDOP < 8), maximum pseudo range corrector age (#30 sec), and satellite elevation mask (8 deg). Receiver parameters and configuration are monitored throughout data acquisition.

Position quality is monitored by the operator using the POS/MV v.4 controller software. The primary positional quality monitored is HDOP. Where HDOP exceeds 2.5, the data are examined during post-processing, and if necessary, positions interpolated or rejected.

A.3.2 TSS POS/MV Position & Orientation Sensor

An Applanix POS/MV 320 Version 4 is used to determine vessel position and orientation. NRT-4 uses the POS/MV for both data acquisition purposes (bathymetry and imagery) and navigation purposes. Position accuracy and quality are monitored by the operator during data acquisition using the POS/MV Controller software to ensure compliance with NOS Hydrographic Surveys Specifications and Deliverables. The POS/MV combines GPS and Inertial Measurement Unit (IMU) sensor data into an integrated navigation solution. There are two navigation algorithm designs incorporated into the system. In the first algorithm the GPS receiver is strictly a sensor of the GPS observables, i.e. the navigation functions in the GPS receiver are not used. In the second algorithm, GPS position and velocity solution are processed to aid the inertial navigator. The system will automatically switch between the two algorithms to ensure appropriate performance. The POS/MV is capable of delivering data including: Geographic position (latitude, longitude and altitude), Heading, Attitude (roll and pitch), Vertical displacement (heave), Velocity, Acceleration, and Angular rate of turn.

Within the IMU are three solid-state linear accelerometers and three solid-state gyros arranged in a triaxial orthogonal array. This configuration allows for the accelerometers to sense acceleration in all three directions, and three gyros to sense angular motion around all three axes centered on the IMU. The POS Computer System (PCS) receives these measurements from the IMU and uses them to compute the measurements of motion. Pitch and roll measurements are computed by the IMU after sensor alignment and leveling. The IMU mathematically simulates a gimbaled gyro platform and applies the angular accelerations to this model to determine roll and pitch. Position and attitude data are logged in the raw data file during acquisition. True Heave is based on a two sided filter, making use of both past and present vertical motion data to compute a heave estimate. True heave is applied in post processing.

The PCS utilizes data from both the IMU and the two GPS receivers to compute a highly accurate vessel heading. The IMU determines heading during aggressive maneuvers and is not subject to short-period noise. However, IMU accuracy diminishes over time. The two GPS receivers allow the PCU to calculate vessel heading using carrier-phase differential position measurements. The PCU computes a vector between the two fixed antennas and provides azimuth data using the GPS Azimuth Measurement Subsystem (GAMS). GPS heading data is accurate over time, but is affected by short-period noise. Heading accuracy for the system is ±0.02°.

A.4. Shoreline - ENC Validation Equipment

A.4.1 Trimble GPS GeoXH

NRT-4 is equipped with a Trimble GPS GeoXH Handheld Unit for shoreline and ENC validation. TerraSync software is used to process shoreline data (see sec A.5). The data logger may contain a custom data dictionary that allows feature objects and their corresponding attribution to be collected using the IHO S57 standard.

A.5. Software

Survey planning is done using Mapinfo. Mapinfo allows the user to import raster nautical charts (RNC) survey limits, pertinent AWOIS item positions and search radii, as well as allowing the user to create line plans that can be exported to Hypack format.

Hypack Inc. Hypack MAX is used for vessel navigation and line tracking during acquisition of bathymetry and imagery data. All VBES and MBES data are acquired in Hypack *.hsx format for raw data files.

MBES data are acquired via Hypack Hysweep. Vessel offset configurations, attitude data, and (with the exception of EM3002 data see A.1.2) sound speed profiles are applied during post-processing.

Raw sound velocity data are processed using Velocwin, supplied by NOAA Hydrographic Systems and Technology Program (HSTP). Velocwin uses raw conductivity, temperature, and pressure measurements to create a sound velocity profile.

All bathymetry and imagery data are processed using Caris HIPS & SIPS. Caris software applies vessel configurations, allows the user to apply tide, sound speed, and true heave corrections, calculates total propagated uncertainty (TPU), and allows the user to determine bias error values in calibration mode. Caris uses a combined uncertainty model to estimate a bathymetric surface and generate a digital terrain model (DTM).

Imagery data are processed and examined using Caris HIPS & SIPS v.7.0.

Bathymetry data and imagery features are managed using Pydro. This program was created by the NOS Hydrographic Systems and Technology Programs N/CS11 (HSTP) using the Python 23 programming language to interface with the HIPS and SIPS data directly.

Bathymetry data and imagery features can be exported from Pydro in MIF/MID (MapInfo Interchange) format, and imported into MapInfo.

Trimble’s TerraSync and Hypack ENC Editor is the software utilized in mapping operations in support of Shoreline Verification, Detached Positions (DP’s), and Electronic Navigational Charts (ENC) data acquisition using a Trimble GeoXH. The GeoXH is capable of 30 – 50cm accuracy post processed.

A complete list of software and versions is included in Appendix I.

B. DATA PROCESSING AND QUALITY CONTROL

B.1. Multibeam Echosounder Data

Raw multibeam data are converted to HDCS format in Caris HIPS. Transformation parameters pertaining to the source of the attitude packet is stored in the log file located in line directory of the HIPS data. After conversion, True heave, and Tide corrections are applied to the dataset and Total propagated uncertainty (TPU) is calculated. TPU is calculated using the Caris implementation of the multibeam error model.

Vessel heading, attitude, and navigation data are reviewed and edited in line mode. Fliers or gaps in heading, attitude, or navigation data were manually rejected or interpolated for small periods of time.

Vessel static and Dynamic offsets are applied to the data during the conversion and post processing procedures. The dynamic draft for a vessel of this size is typically quite small (0.5-2cm). Nonetheless, NRT-4 follows HSTP suggestions to maintain a consistent engine trim during survey operations. The trim indicator has been marked to insure the trim is set correctly for operations.

After data conversion and application of correctors, all sounding data have estimates of uncertainty in three dimensions attached to them. Uncertainty associated with sensor data (Heave, Pitch, Roll, Position, Heading, Sound speed, and Tide) as well as uncertainties in static and dynamic offsets measurements are used to calculate the total uncertainty for each sounding. These uncertainty-attributed depth measurements are inputted into the Combined Uncertainty Bathymetry Estimator (CUBE) algorithm. The end result of which is a mathematical estimate of the bathymetric surface. The CUBE surface products are then used to evaluate MBES coverage, and to further check for systematic errors such as tide, sound velocity, or attitude and timing errors.

The resolution chosen for finalized CUBE surfaces is 0.5m, as per recommendations by HSTP. Once the CUBE surface has been finalized, they are inserted into pydro for feature evaluation.

B.2. Single-Beam Echosounder Data

VBES data are acquired concurrently with both MBES data and SSS data. In cases where VBES data are not the primary source of bathymetry, i.e. MBES data are also acquired; VBES data are used only for troubleshooting or confidence check purposes. In these cases, the raw VBES data are submitted for archival purposes only. These data should not be used in the creation of final hydrographic products.

In cases where VBES data are the primary source of bathymetry VBES data are processed, passed through quality control, and submitted for the purposes of product creation. Following acquisition, single-beam echosounder data are converted from raw format to HDCS using Caris HIPS 7.0. Each line is viewed in Caris HIPS Single Beam Editor against the digital trace of the

VBES data. Selected soundings are scanned for missed depths. Additional selected soundings are inserted where necessary to define peaks and abrupt changes in slope.

After review and cleaning, Caris HIPS is used to merge depth, position and attitude data with sound velocity, tide, vessel offset, dynamic draft correctors and TPU values to compute the corrected depth and position of each sounding. All soundings are reviewed again in HIPS Subset Mode. Data are compared with adjacent lines and crosslines for systematic errors such as tide or sound velocity errors. Caris HIPS uncertainty weighted and/or swath angle grids are created for VBES data at 2m resolution.

B.3. Side Scan Sonar Data

Side scan sonar data are converted from *.SDF (SonarPro raw format) to SIPS format using Caris SIPS 7.0.

Post-processing side scan data includes examining and editing fish height, vessel heading (gyro), and vessel navigation records. Towfish navigation is recalculated using Caris SIPS 7.0. Tow point measurements (J-arm and cable out), fish height, and depth are used to calculate horizontal layback.

After towfish navigation is recalculated, side scan imagery data are slant-range corrected to 0.1m with beam pattern correction. The slant-range corrected side scan imagery data are closely examined for any targets. Targets are evaluated as potential contacts based on apparent shadow length and appearance; particularly targets which appear to be anthropogenic in origin. Contacts are selected and saved to a contact file for each line of SSS data. Contact selection includes measuring apparent height, selecting contact position, and creating a contact snapshot (*.tif) image.

Targets are exported to the line file and inserted into Pydro for feature evaluation and correlation with associated bathymetry data.

C. CORRECTIONS TO ECHO SOUNDINGS

C.1. Sound Speed

C.1.1 SBE19Plus CTD profiler and Digibar Pro

Speed of sound through water is determined by a minimum of one cast every four hours of MBES data acquired, in accordance with the Standing Letter Instructions and NOS Specifications and Deliverables for Hydrographic Surveys. S1211 is equipped with an Odom Digibar Pro surface sound velocity sensor to measure sound speed at the mutibeam transducer head. For water column sound speed profiles NRT-4 uses an Odom DigibarPro profiler. Raw conductivity, temperature, and pressure data are processed using Velocwin which generates sound velocity profiles for Caris HIPS (*.svp) and Kongsberg SIS (*.asvp). With the exception of Simrad EM3002 data, sound speed correctors are applied to bathymetry data in Caris HIPS during post processing. Calibration reports for the Odom Digibar profilers are included in Appendix IV.

C.2. Vessel offsets and Dynamic Draft Corrections

Sensor offsets are stored in the Caris HIPS Vessel Configuration File (NRT4_S1211_EM3002_MBES & NRT4_S1211_Echotrac_VBES) and are applied to MBES & VBES data in postprocessing.

Vessel offset measurements were made by National Geodetic Survey on S1211 in Alpena, MI on June 25, 2009 (see Appendix II). Dynamic draft measurements for S1211 were made on 18 December 2009 (see Appendix IX).

The following table lists each Vessel Configuration File.

Table 1: Vessel Configuration Files

S3002 Caris Vessel Configuration Files: 09 March 2010, DN 068

HVF Name	Survey System
NRT4_S1211_EM3002_MBES	Kongsberg Simrad EM3002 Multibeam Processing Unit
NRT4_S1211_Echotrac_VBES	Odom Echotrac C/V 200
NRT4_S1211_Klein3000_SSS_100	Klein 3000 Side Scan Sonar High Frequency
NRT4_S1211_Klein3000_SSS_200	Klein 3000 Side Scan Sonar High Frequency

C.3. Pitch, Roll, Azimuth and Navigation Timing Errors

Static pitch, roll, azimuth and navigation latency biases for the Simrad EM3002 were determined during Patch Tests conducted on 09 March 2010 in the APM Terminal Basin, Portsmouth, VA (see Appendix IX).

C.4. Water Level Corrections

Tide data are downloaded from the Center for Operational Oceanographic Products and Services (CO-OPS) website (http://tidesandcurrents.noaa.gov/olddata/) and applied via a zone definition file (*.zdf) provided by CO-OPS for each project. Approved final tides are applied by field personnel upon receipt.

D. APPROVAL SHEET

Data Acquisition and Processing Report
Navigation Response Team 4
Great Lakes/Mid-Atlantic Region

For all Hydrographic Surveys & ENC Validation conducted during
Field Season 2010, Hampton Roads, VA

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during this project in accordance with the most recent editions of; Hydrographic Manual, Hydrographic Survey Guidelines, Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Respectfully,

Stephen C Kuzirian LT/NOAA

Stephen C Kuzirian, LT/NOAA
Team Lead
NOAA NRT-4