NOAA FORM 76-35A

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

HORIZONTAL AND VERTICAL CONTROL REPORT

Type of Survey **Navigable Area**

Project **OPR-D304-FH-12**

Time Frame **July 2012 - December 2012**

LOCALITY

State **Virginia**

General Locality **Approaches to Chesapeake Bay, VA**

Sublocality

2012

CHIEF OF PARTY

LCDR Benjamin K. Evans, NOAA

LIBRARY & ARCHIVES

DATE

NOAA FORM 77-28 (11-72)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HYDROGRAPHIC TITLE SHEET

REGISTRY No
H12423, H12424, H12501, H12502, H12503, H12504, H12505, D00173

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

FIELD No
NOAA Ship *Ferdinand R. Hassler*

State Virginia

General Locality Approaches to Chesapeake Bay, VA

Sub-Locality N/A

Scale 1:40,000 **Date of Survey** July 2012 - December 2012

Instructions dated 9/18/2012 **Project No.** OPR-D304-FH-12

Vessel NOAA Ship *Ferdinand R. Hassler*

Chief of party LCDR Benjamin K. Evans, NOAA

Surveyed by LT Samuel F. Greenaway, NOAA LT Madeleine M. Adler, NOAA SHST David T. Moehl

Soundings by echo sounder, hand lead, pole RESON 7125

Graphic record scaled by N/A

Graphic record checked by N/A **Automated Plot** N/A

Verification by Atlantic Hydrographic Branch

Soundings in Meters at MLLW

REMARKS: All times are in UTC. Projection is UTM Zone 18N.

This is a basic Navigable Area Survey.

TABLE OF CONTENTS

Acronyms and Abbreviations

ARP – Antenna Reference Point
CO-OPS – Center for Operational Oceanographic Products and Services
CORS – Continuously Operating Reference Station
DGPS – Differential Global Positioning System
Dn – Julian Day Number
ERS – Ellipsoidally-Referenced Survey
FPM – Field Procedures Manual
GPS – Global Positioning System
HSSD – Hydrographic Surveys Specifications and Deliverables
IAKAR – Inertially Aided Kinematic Ambiguity Resolution
ITRF – International Terrestrial Reference Frame
kHz – kilo Hertz
MHW – Mean High Water
MLLW – Mean Lower Low Water
NAD83 – North American Datum of 1983
NAVD88 – North American Vertical Datum of 1988
NGS – National Geodetic Survey
NOAA – National Oceanic and Atmospheric Administration
NOS – National Ocean Service
NWLON – National Water Level Observation Network
POS/MV – Position and Orientation System for Marine Vessels
PPK – Post Processed Kinematic
RTK – Real-Time Kinematic
SBET – Smoothed Best Estimate of Trajectory
TPU – Total Propagated Uncertainty
USCG – United States Coast Guard
UTC – Coordinated Universal Time
UTM – Universal Transverse Mercator
WGS84 – World Geodetic System 1984

OPR-D304-FH-12
Horizontal and Vertical Control Report
Approaches to Chesapeake Bay, Virginia
July 2012 – December 2012
NOAA Ship Ferdinand R. Hassler (S250)
Chief of Party: LCDR Benjamin K. Evans, NOAA

INTRODUCTION

This report applies to surveys D00173, H12423, H12424, H12501, H12502, H12503, H12504 and H12505 located in the Approaches to Chesapeake Bay, Virginia. These surveys were performed by the crew of the NOAA Ship Ferdinand R. Hassler under project OPR-D304-FH-12 Approaches to Chesapeake Bay, as specified in the Hydrographic Survey Project Instructions (March 2, 2012) and Change 1 of these instructions (September 18, 2012).

This supplemental report to survey project OPR-D304-FH-12 outlines methods used for collection, processing and application of three-dimensional position and water level correctors on bathymetric data. The format and content of this report varies from traditional Horizontal and Vertical Control Reports outlined in section 8.1.5.2 of the HSSD.

PROJECT PARAMETERS

1. Datum: North American Datum of 1983, Zone 18

2. Chart Datum: Soundings reduced to MLLW

3. Differential Correctors for real-time navigation: United States Coast Guard DGPS beacon, Driver, Virginia (289kHz)

4. Filing naming structure: In order to differentiate attitude data recorded by the Internal Motion Unit (IMU) from the ship's two hulls, positioning data file names followed the YYYY-DDD-S250* naming convention (where * is either "S" or "P", signifying data from the starboard or port hull, respectively).

Smooth Best Estimate Trajectory Solution

To improve horizontal and vertical positioning, Applanix POSPac MMS software v.6.1 was used during post-processing to produce Smoothed Best Estimate of Trajectory (SBET) solutions using an Inertially Aided Kinematic Ambiguity Resolution (IAKAR) solution relative to ITRF00.

The POSPac Smart Base processing method was used to produce the SBET solutions over the course of the entire project. The SmartSelect option was used, which manually computes and downloads a network based on available data.

All surveys in this project are at least 10 nautical miles offshore and could only be encompassed in the Smart Base network by using baselines outside of the 100 km maximum, specified in Section 9.1.1.1 of the NOS HSSD.

No other correction procedure yielding similar accuracy (such as Single Base) was possible in this area. As a result, a virtual base station was developed.

The OCS limit of 100 kilometers was exceeded to allow the network to encompass the survey area. Applanix has determined that encompassing the survey area with distant stations is preferable to limiting the network to closer stations that do not fully encompass the survey area. Figure 1shows an example of a network used, including Continuously Operating Reference Stations (CORS), baselines and project survey grounds.

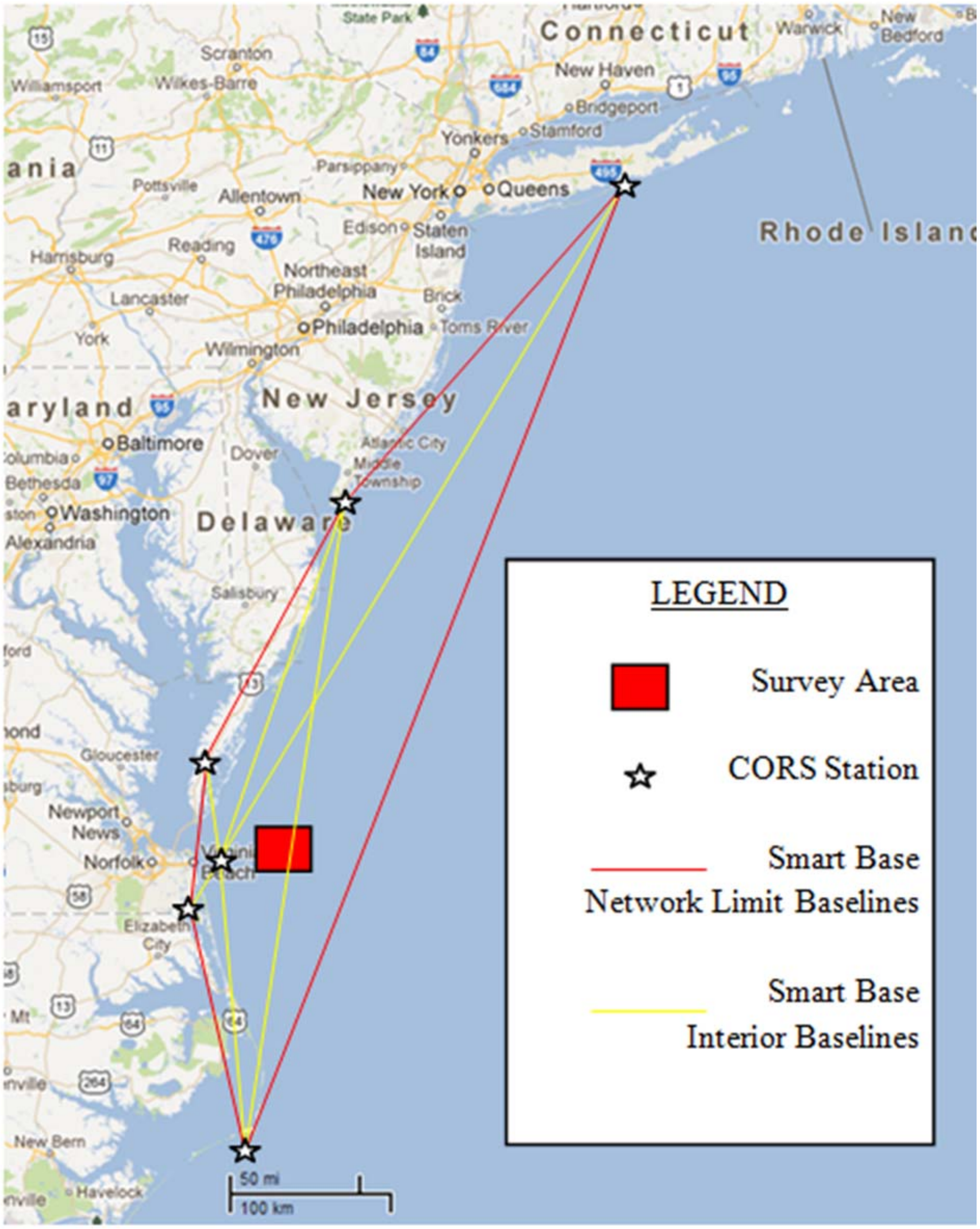

Figure 1: Example of Smart Base network geometry for OPR-D304-FH-12

After a QC process to ensure data reliability, SBET and error files were exported to NAD83 datum using POSPac MMS export function. SBET and error files are given .sbet and .smrmsg extensions, respectively.

METHODOLOGY

Two separate vertical control methods were used in project OPR-D304-FH-12 to reduce data to Mean Lower Low Water (MLLW) levels. Vertical Datum Transformation (VDatum) was used to transform from ellipsoid referenced soundings to MLLW when acceptable 3-D GPS-derived solutions existed. When reliable GPS derived heights were not available, Discrete Zoning was used. CO-OPS provided zoning files and verified tide station values were used for zoned tide reduction. The OPR-D304-FH-12 VDatum Evaluation report, submitted under Appendix I of this report, outlines the comparison techniques and results performed for this project. Appendix I also includes the signed memorandum, approving the recommendations put forth in the VDatum Evaluation report.

Table 1outlines the use of VDatum and Discrete zoning methods.

Vertical Transformation Method		
Survey	Vdatum	Discrete
H12423		X
H12424		X
H12501		X
H12502	X	
	except lines:	Port 2012-252 20120908_200733
		Stbd 2012-255 20120911_085811
		Stbd 2012-257 20120913_121325
H12503	X	
H12504	X	
	except lines:	Stbd 2012-287 20121013_085559
H12505		X
D00173	X	
*X indicates primary method used		

Table 1: Project sheets and primary mode of deriving waterline

<u>GPS Tides</u>

VDatum was the primary method used to compute water levels for sheets D00173, H12502, H12503 and H12504.

The Load Attitude and Navigation tool in CARIS HIPS was used to load the navigation, height and attitude data from the SBET files. GPS Tides were processed using the VDatum separation file provided by HSD OPS[1] with CARIS HIPS Compute GPS Tide tool. After SBET files and GPS tides were computed, CARIS HDCS lines were Sound Velocity Corrected (to apply attitude) and Merged (to apply navigation). Specific settings are shown in Figure 2. For surveys reduced to MLLW using ERS methods, the Apply GPS Tide box was selected during the Merge process. After the application of GPS Tides, the vertical solutions were examined for errors or artifacts.

[1] Rev1 applied to surveys H12504 and H12505 per D304-FH-12_revised_SEP.pdf submitted with individual survey's project correspondence folder.

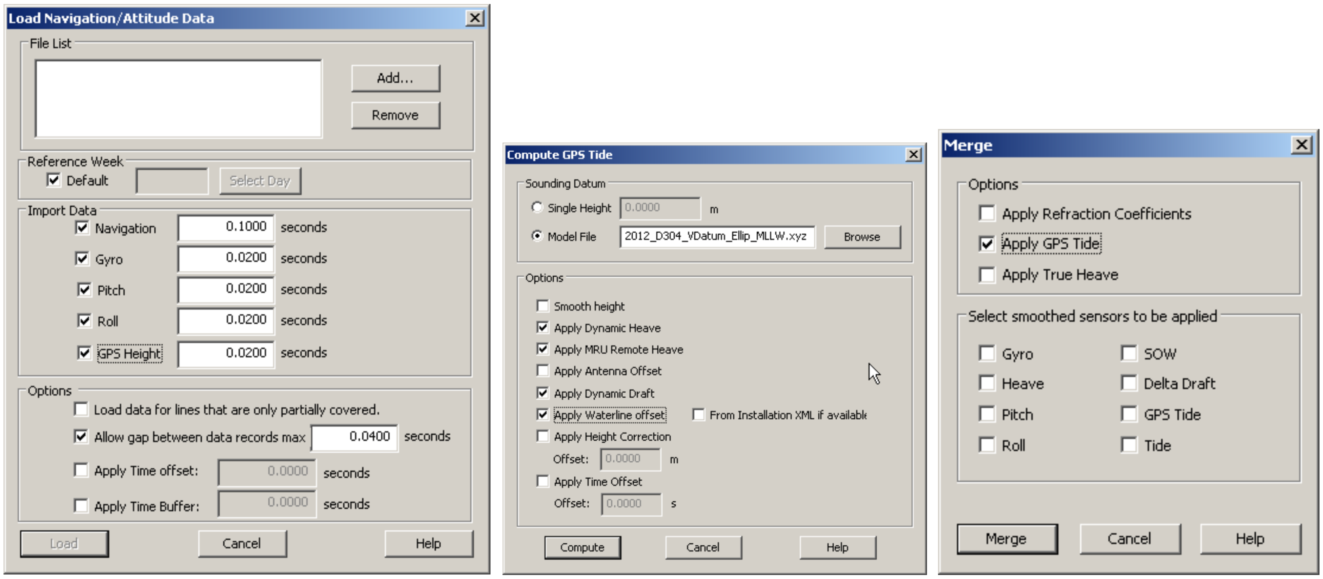

Figure 2: CARIS SBET Application Options. Merge dialog shows "Apply GPS Tide" button checked, this was done only on data being referenced to MLLW via ellipsoidal processing techniques

Post-processed uncertainty estimates (SMRMSG files) for position, height and attitude were applied using the CARIS HIPS Load Error tool and used during the calculation of TPU by checking Error Data for the uncertainty source in the HIPS Compute TPU tool. Figure 3 shows specific options chosen during CARIS application of SMRMSG data:

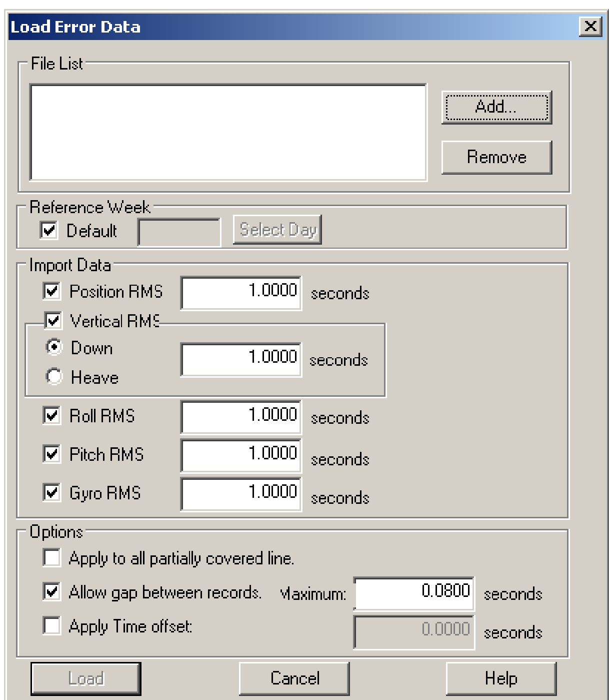

Figure 3: CARIS SMRMSG error loading parameters

For all data reduced to MLLW using VDatum, a zoning uncertainty value of 0.081 meters was used in the CARIS HIPS Compute TPU process in accordance with the project instructions.

Verified Tides

Discrete zoning is the primary method for vertical control for sheets H12423, H12424, H12501 and H12505. The active NWLON station at Duck, North Carolina (865-1370) is the reference station. This station was damaged during Hurricane Sandy (October 29, 2012) and taken offline for repairs. The station remained offline until the end of November. *Hassler* did not acquire any data on this project during this outage. The station was operating normally when operations resumed in December 2012.

After receiving the final tide notes from CO-OPS, verified tides were downloaded and applied using the CARIS HIPS Load Tide tool. The preliminary zoning file was accepted as final for all sheets within this project. The zoning uncertainty to be applied during Compute TPU was not provided by CO-OPS due to lack of available water level time series data. The value from the previous year adjoining project (OPR-D304-FH-11), 0.09 meters, was used for this project.

CASE-BY-CASE DATA MODIFICATIONS

Interpolation of GPS Tide Errors Using SBETs

In limited areas throughout the survey, errors in the GPS-derived vertical position solution led to vertical errors in the associated soundings. These altitude errors were located by examining the surface for areas of high standard deviation. CARIS Subset Editor and Attitude Editor were used to isolate the error in these cases to a GPS height error.

These errors are most apparent in the “GPS Tide” record generated in CARIS. This record is calculated during the “Calculate GPS Tide” process by removing the inertial generated heave record (Trueheave) from the post-processed GPS height solution (from the applied SBET) and applying the datum-ellipsoid transformation model. The resultant record should contain both the tidal signal and any loading or dynamic draft effects. In cases where there was both an apparent vertical error in the corrected soundings and the GPS Tide record had physically unreasonable jumps or anomalies, the GPS Tide anomalies were rejected in CARIS Attitude Editor and the resultant gap linearly interpolated. For short duration anomalies contained wholly within the line, this rejection and interpolation could be done simply in Attitude Editor.

For lines where GPS tide anomalies extended beyond the end of the line, this simple interpolation approach was not feasible because the heave record, and thus the derived GPS height record, does not extend beyond the end of the line. In these cases, the SBET attitude was reapplied with a buffer beyond each end of the line. The GPS height was smoothed through application of a 60 second moving average (effectively removing heave without reliance on the inertial data) and the GPS height re-calculated with the smoothed GPS height shown in Figure 4. These extended GPS tide records were then interpolated in a similar fashion as described above.

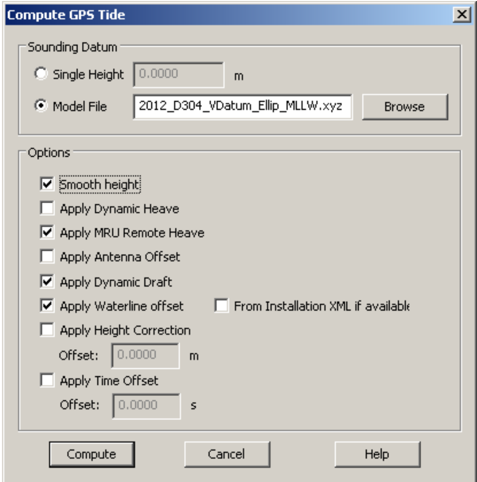

Figure 4: Compute GPS Tide - Interpolated Options

GPS Height Interpolated Lines							
Survey	Vessel	Dn	Line	Survey	Vessel	Dn	Line
H12502	Port	253	_052534	H12503	Port	267	_050830
			_060806			268	_131439
		256	_175640			269	_142919
			_183429		Starboard	268	_041818
		257	_165620				_120524
		271	_114027				_131439
	Starboard	252	_010824				_152117
		253	_064636			269	_161909
		256	_001107				_181746
			_183429	H12504	Starboard	286	_185218
		257	_140950			345	_225301
			_145000			346	_183719
			_165619				
		266	_183542				
		271	_114026				

Table 2: Project sheets and lines which the GPS height was interpolated

Applanix True Heave

Experimentation was conducted during the field season on the reliability of internally logged Trueheave files in the POS M/V. Downloading these files while concurrently logging the internal file, which is required for 24 hour operation, causes data gaps.

Some of these data gaps were corrected by applying the concurrently logged Ethernet files when available. In few cases it was necessary to completely remove the TrueHeave record from the CARIS HDCS directory and apply real time heave correctors. Table 3 outlines the primary Trueheave file format used and any exceptions.

Trueheave Application				
Survey	File Format	Exceptions		
		Vessel	Dn	Line (i, e, n)
H12423	Internal	Port	240	20120827_023848 (e)
				20120827_113730 (e)
				20120827_162551 (e)
H12424	Internal	Port	197	20120715_212725 (n)
				20120715_224558 (n)
			199	20120717_101657 (n)
				20120717_142922 (n)
			289	all lines ethernet
		Starboard	199	20120717_175925 (n)
			289	all lines ethernet
H12501	Internal	Port	241	20120828_224322 (e)
			242	20120829_160709 (n)
				20120829_180302 (n)
				20120829_225403 (n)
			243	20120830_114626 (n)
			251	20120907_150753 (n)
H12502	Internal	Port	252	20120908_200733 (n)
			256	20120912_061131 (n)
			257	20120913_101504 (n)
		Starboard	255	20120911_085811 (n)
H12503	Internal	Port	284	20121010_063428 (e)
		Starboard	267	20120923_190804 (e)
			269	20120925_025333 (e)
H12504	Ethernet	Starboard	288	20121014_111608 (i)
H12505	Ethernet	No exceptions		
D00173	Ethernet	No exceptions		

Table 3: Project sheets and associated Trueheave files used. NOTE: i, e, n = Internal, Ethernet, None

LETTER OF APPROVAL

The letter of approval for this report and all accompanying data follows on the next page.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NOAA Marine and Aviation Operations
NOAA Ship *Ferdinand R. Hassler* S-250
439 West York Street
Norfolk, VA 23510

March 20, 2013

MEMORANDUM FOR: LT Abigail Higgins, NOAA
Chief, Atlantic Hydrographic Branch

FROM: LCDR Benjamin K. Evans, NOAA
Commanding Officer, NOAA Ship *Ferdinand R. Hassler*

TITLE: Approval of OPR-D304-FH-12 Horizontal and Vertical Control Report

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during acquisition and processing of horizontal and vertical control data in accordance with the Hydrographic Manual, Fourth Edition; Field Procedures Manual, April 2012; and the NOS Hydrographic Surveys Specifications and Deliverables, as updated for April 2012. Additional guidance was provided by applicable Hydrographic Technical Directives. All data and reports are respectfully submitted to Atlantic Hydrographic Branch.

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

In addition, the following individuals were responsible for oversight of acquisition and processing of this data:

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LT Madeleine M. Adler, NOAA
Field Operations Officer

____

LT Samuel F. Greenaway, NOAA
Executive Officer (Field Operations Officer during acquisition)