NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT NC1406C-TB-C

Back Bays, False Cape to Norfolk, Virginia

Introduction

NOAA Coastal Mapping Program (CMP) Project NC1406C-TB-C provides a highly accurate database of new digital shoreline data for portions of the back-bays and marshes, and some areas of outer coastline and harbors, extending from False Cape to Norfolk, Virginia. Project NC1406C-TB-C is a subproject of a larger project, NC1406-TB-C, which includes a portion of the eastern coastline of the United States directly impacted by Hurricane Sandy from Avon, North Carolina to Parramore Island, Virginia. The Geographic Cell (GC) may be used in support of the NOAA Nautical Charting Program (NCP) as well as geographic information systems (GIS) for a variety of coastal zone management applications.

Project Design

NC1406C-TB-C was designed to support the application of topographic and bathymetric (topo-bathy) data acquired under the Sandy Supplemental Topo-Bathy Project. The NOAA National Geodetic Survey (NGS) Remote Sensing Division (RSD) formulated the Project Instructions for this project following the guidelines of the "Scope of Work, Shoreline Mapping for the Coastal Mapping Program" (SOW), Version 14A, dated October 24, 2012, as well as the guidelines of the "Scope of Work for Shoreline Mapping In Support of Public Law No: 113-002, Disaster Relief Appropriations Act 2013, Light Detection and Ranging (LIDAR) and Digital Camera Imagery Requirements." The instructions discussed the project's purpose, geographic area of coverage, scope and priority; data acquisition, processing, accuracy, and compilation requirements; product delivery and reporting instructions; and contact and communication information.

Field Operations

The field operations for NC1406C-TB-C were conducted as part of the Sandy Supplemental Topo-Bathy Project NC1408-TB-C, in which Quantum Spatial, Inc. (QSI) was a subcontractor to Dewberry Consultants, LLC. For that project QSI was responsible for the planning, acquisition and post-processing of aerial imagery and LIDAR data to support photogrammetric processing and feature compilation. This included the establishment of ground control, the post-processing of airborne GPS data and calibration of the LIDAR data.

A total of four (4) ground control points (GCPs) were established in project NC1406C-TB-C using a combination of traditional static, fast-static, rapid-static, real-time kinematic, and post-processed kinematic GPS techniques. One (1) additional photo-identifiable check point was also occupied at a well-defined, discrete location. Survey field work was performed between September 2013 and July 2014. A Ground Survey Report is on file with other project data within the RSD Electronic Data Library.

The aerial photography acquisition phase of the project was conducted by QSI between January 2013 and April 2014. A total of 81 flight lines of natural color imagery were acquired within a tolerance of 25% of the Mean Lower Low Water (MLLW) tide stage. Of the 81 flight lines acquired, six (6) were used in project NC1406C-TB-C. Imagery was captured with an approximate nominal ground sample distance (GSD) of 0.3 meters through the use of three large format Intergraph Z/I Digital Mapping Cameras (DMCs) with a focal length of 120 mm.

The LIDAR acquisition was conducted between November 2013 and July 2014 and consisted of a total of 262 LIDAR acquisition missions for airborne laser point cloud data covering the entire Sandy project area with an average point density of ≥ 4 pulses per square meter and a 50% swath overlap, though only 24 of these flights collected data over the NC1406C-TB-C project area. Topo-bathy Green LIDAR and topographic Near-Infrared (NIR) LIDAR were captured in tandem through the use of three Riegl VQ-820G sensors (topo-bathy), and a Riegl 480 or two Leica ALS50-II (topographic) sensors. The topo-bathy data was used to derive the MHW and MLLW shorelines, while the NIR data was used as an aid to developing the water surface model necessary for applying refraction corrections to the topo-bathy data.

The flight lines on the ocean side were required to be collected twice, once within 20% of the mean range of tide around MLLW, and once within 30% of the mean range of tide around Mean High Water (MHW), but the flight lines on the estuarine side of the shoreline had no tide-coordination requirement. The contractor's plan for the project, however, called for all lines to be collected at both MLLW and Higher Water (HW – defined as everything not collected at MLLW) tide levels, with near-shore lines flown at a height of 600 meters above ground level (AGL) and lines over ocean waters at 300 m. AGL. For further information about all field operations see the Final Report of Survey on file within the RSD Electronic Data Library.

GPS Data Processing

Each acquisition aircraft used by QSI was equipped with either a POSAV Applanix Model 510 IMU or a dual frequency Trimble BD960 to collect the Airborne Global Positioning System (ABGPS) and Inertial Measurement Unit (IMU) data. NGS Continuously Operated Reference Stations (CORS) and several cooperative CORS stations were used for base stations on the project, with at least two of these CORS stations being used to process each POSAV dataset to achieve the final image center locations. For further information refer to the Airborne Positioning and Orientation Report (APOR) on file with other project data within the RSD Electronic Data Library.

LIDAR Data Processing

LIDAR point cloud data for all of the areas acquired for the Sandy Supplemental Topo-Bathy Project were processed from January 2014 to September 2015. Riegl RiProcess software was utilized to transform the LIDAR point cloud into a mapping projection and to check the calibration stability. Terrasolid software was used for assessing relative and absolute accuracies between overlapping lifts and relative with each lift, initial point cloud classification, editing of the LIDAR point cloud, and for classification of water surface, erroneous returns, bathymetric surface and bare earth points. Refraction correction was performed through Dewberry's LIDAR Processor. Additional quality control (QC), point classification, and formatting were performed with GeoCue, Terrasolid, and Global Mapper software. NOAA VDatum software was used to convert the vertical datum of the LIDAR points from NAD83 ellipsoid to local MHW and MLLW tidal datums. QTModeler and custom ArcGIS Scripts were used to produce bare earth

MHW and MLLW digital elevation models (DEMs) at a 1 meter grid resolution and to create and format the MHW and MLLW vectors into shapefile format.

The LIDAR point cloud was compared to higher accuracy ground control points to determine vertical uncertainties of the data set and then compared to the morphologic slope around the derived shoreline at 91,460 sample sites in the project area (63,748 points for MHW and 27,712 points for MLLW sites) to determine the uncertainty of the vectors. Based on this assessment the MHW LIDAR derived shoreline vectors meet a horizontal accuracy ranging from 1.1 to 2.8 meters at the 95% confidence level, and the MLLW LIDAR derived shoreline vectors meet a horizontal accuracy ranging from 1.3 to 4.2 meters at the 95% confidence level.

Aerotriangulation

The aerotriangulation (AT) phase of the project was performed by QSI using digital AT methods to establish the network of photogrammetric control required for the compilation phase. The images from all 81 flight lines were adjusted in three separate blocks. Project NC1406C-TB-C was covered entirely by block one containing flightlines 300 through 345. The Intergraph ImageStation Automatic Triangulation (ISAT) software (ver. 6.1) was used to perform automatic point measurements and interactive point measurements of tie points. Upon successful completion of the aerotriangulation process, the ISAT software provided the RMS of the standard deviations of the residuals for each aerotriangulated ground point, which were used to compute a predicted horizontal circular error of 0.2 meters based on a 95% confidence level for block one. For further information see the Aerotriangulation Report on file with other project data within the RSD Electronic Data Library.

The project database consists of project parameters and options, camera calibration data, interior orientation parameters, ground control parameters, adjusted exterior orientation parameters, and positional listing of all measured points. Positional data is referenced to the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD88).

Compilation

The data compilation phase of project NC1406C-TB-C was initiated by QSI personnel in June 2016. NGS supplied the LIDAR derived MHW and MLLW shapefiles to be edited, attributed and generalized by QSI. Additional features were then manually compiled using stereo imagery. This work was accomplished using a Digital Photogrammetric Workstation (DPW), which consists of a stereo-enabled PC-based graphics workstation running the Windows 2007 operating system and a suite of digital photogrammetric software known as DAT/EM Summit Evolution (version 7.0). Feature identification, segmentation, and attribution occurred within an Arcmap 10.2 geodatabase using DAT/EM's stereo module, and were based on imagery analysis of the processed digital images and information extracted from the appropriate NOAA Nautical Charts, the U.S. Coast Guard Light List and other ancillary sources. Feature attribution was assigned in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST), which provides the definition and attribution scheme for the full range of cartographic features pertinent to the CMP. Selected features were further modified with additional descriptive information to refine general classification.

Spatial data accuracies for project NC1406C-TB-C were determined according to standard Federal Geographic Data Committee (FGDC) practices. Stereo compiled cartographic features were compiled to meet a horizontal accuracy of 0.4 meters at the 95% confidence level. This

predicted accuracy of compiled, well defined points is derived by doubling the circular error calculated from the aerotriangulation statistics. The LIDAR derived features had horizontal accuracies that varied depending on location and shoreline type ranging from 1.3 meters to 3.0 meters.

The following table provides information on the imagery used to complete this project:

Date	Time (UTC)	Strip ID	AT Frame #s	Index Frame ID	GSD	Tide Level*
02/27/2014	15:26 – 15:32	30-340	0074 – 0039	1944 – 1979	0.3 m	0 m
02/27/2014	15:52 – 15:59	30-341	0038 – 0073	2055 – 2090	0.3 m	0 m
02/27/2014	16:33 – 16:37	30-345	0014 – 0001	2091 – 2104	0.3 m	0.1 m
02/27/2014	16:42 – 16:47	30-344	0001 – 0035	2105 – 2139	0.3 m	-0.1 m
02/27/2014	16:52 – 17:01	30-343	0035 – 0001	2140 – 2174	0.3 m	-0.1 m
02/27/2014	17:05 – 17:07	30-342	0001 – 0017	2175 – 2191	0.3 m	-0.1 m

*Tide levels given in meters above MLLW and are based on verified observations recorded by the NOS tide gauge at the Chesapeake Bay Bridge Tunnel and the Sewells Point stations in Virginia. The height of the MHW tidal datum in the project area varies between 0.740 – 0.777 meters above MLLW.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of QSI. The final QC review was completed in November 2016. The review process included analysis of aerotriangulation results and assessment of the identification and attribution of digital feature data within the GC according to image analysis and criteria defined in C-COAST. The quality control process concluded with an inspection of topological connectivity within the GC using ArcGIS 10.5 software. All project data was evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with project imagery and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following nautical charts were used in the comparison process:

- 12205, Cape Henry, Pamlico Sound, VA, 1:80,000 scale, 35th Ed. (w/1:10,000 scale inset)
- 12208, Approaches to Chesapeake Bay, VA, 1:50,000 scale, 17th Ed.
- 12222, Chesapeake Bay, Cape Charles to Norfolk Harbor, VA, 1:40,000 scale, 55th Ed.
- 12245, Hampton Roads, VA, 1:20,000 scale, 69th Ed.
- 12254, Chesapeake Bay, Cape Henry to Thimble Shoal Light, VA, 1:20,000 scale, 50th Ed.
- 12255, Naval Amphibious Base Little Creek, VA, 1:5,000 scale, 18th Ed.

End Products and Deliverables

The following specifies the location and identification of the products generated during the completion of this project:

Remote Sensing Division Electronic Data Library

- Airborne Positioning and Orientation Report (APOR)
- Ground Survey Report

- Final Report of Survey
- Aerotriangulation Report
- Project Completion Report (PCR)
- Project database
- GC11236 in shapefile format
- CEF in shapefile format

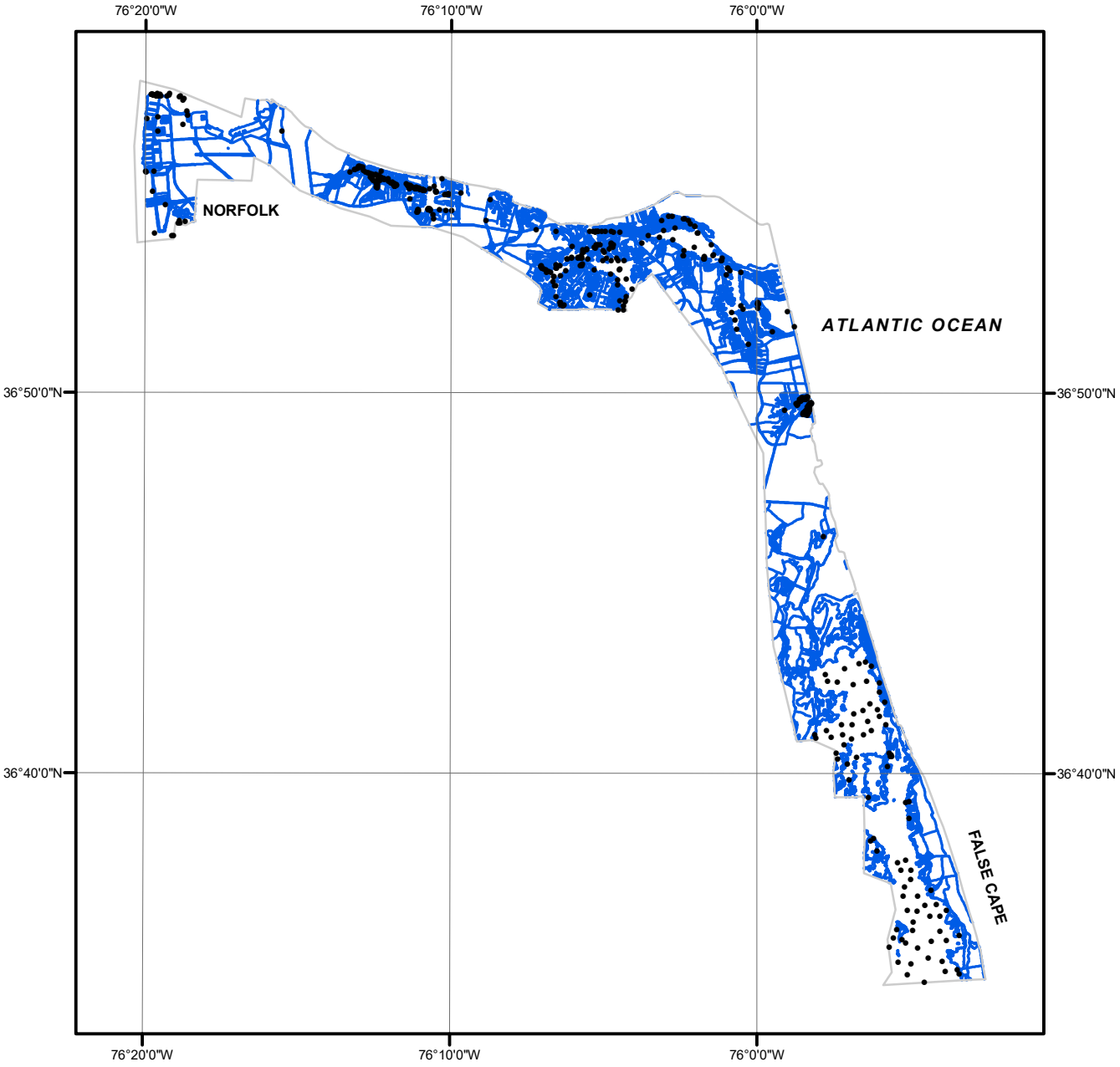
NOAA Shoreline Data Explorer

- GC11236 in shapefile format
- Metadata file for GC11236
- PCR in Adobe PDF format

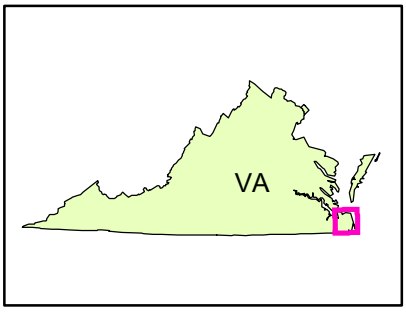
End of Report

BACK BAYS, FALSE CAPE TO NORFOLK

VIRGINIA



Overview



NC1406C-TB-C

GC11236