

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT NC1902D-TB-C

Outer Banks, Roanoke Island to Cape Hatteras, North Carolina

Introduction

NOAA Coastal Mapping Program (CMP) Project NC1902D-TB-C provides a highly accurate database of new digital shoreline data extending from Roanoke Island to Cape Hatteras, North Carolina. NC1902D-TB-C is a subproject of a larger acquisition project, NC1902-TB-C, extending from Cape Henry to Cape Hatteras, North Carolina. Project NC1902-TB-C is also part of a larger project which includes two additional acquisition projects, NC1901-TB-C and NC1903-TB-C, all of which cover areas that were determined to be impacted by Hurricane Florence from Cape Henry to Winyah Bay, South Carolina. 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

The Requirements Branch (RB) of the NOAA National Geodetic Survey (NGS) Remote Sensing Division (RSD) designed Project NC1902-TB-C and formulated project instructions following the guidelines of the “Scope of Work, Shoreline Mapping for the Coastal Mapping Program” (SOW), Version 14A. 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. RSD provided a shapefile and maps of the project area, and tide coordination time windows for data acquisition.

Quantum Spatial Inc. (QSI) was contracted to provide the planning, acquisition, and post-processing of aerial imagery and ground surveys for aerial imagery checkpoints; lidar acquisition, processing, classification; ground survey activities including checkpoints for use in independent vertical accuracy testing; aerotriangulation (AT); feature compilation and quality control. QSI tasked the digital aerial imagery acquisition to their subcontractor, Surdex Corporation, and compilation to subcontractor Fugro.

Field Operations

The field operations for Project NC1902-TB-C consisted of the surveying of ground control and check points, and the acquisition of digital aerial photographs and topographic-bathymetric (topobathy) lidar data. Ground control/check points were established in Project NC1902-TB-C using a combination of fast-static, real-time kinematic, and post-processed kinematic Global Positioning System (GPS) techniques. Survey field work was performed between November 2019 and June 2020 by QSI personnel. This phase of project completion is described in QSI’s Ground Survey Reports for lidar and imagery. These are on file in RSD’s Electronic Data Library with all of the other project reports.

Lidar acquisition was performed by QSI, with support from Aerial Filmworks, from November 2019 through August 2020. The topobathy lidar data was captured at a target point density of ≥ 4 points per square meter using the Riegl VQ-880-GII, VQ-880-G+, and Leica Chiroptera 4X sensor systems. For more information refer to QSI's Lidar, Digital Imagery & Shoreline Mapping report for NC1901, NC1902, & NC1903-TB-C.

Acquisition of digital imagery, kinematic GPS data, and Inertial Measurement Unit (IMU) data was performed by Surdex Corporation. Aerial survey operations included the acquisition of 101 lines of imagery within ± 3 hours of low tide using a Leica ADS100 (RGB/NIR) 4-band camera system from January to April 2020. A subset of ten flight lines were used for NC1902D-TB-C. All aerial images were acquired at a nominal altitude of 12,000 feet, giving a ground sample distance (GSD) of 0.33 meters. For more information on imagery acquisition refer to QSI's Hurricane Florence NC1901/NC1902/NC1903 Data Acquisition Summary Report.

GPS Data Processing

GPS/IMU data were processed by QSI personnel to yield precise sensor positions and orientations of the imagery as inputs for the AT phase. The aircraft used to acquire data was equipped with a Novatel SPAN IMU unit to collect ABGPS and IMU data. The collection relied on CORS stations to calculate the differential (DGPS) solution and final photo center locations. Novatel Inertial Explorer (ver. 8.8) software was used to process the data and obtain a tightly coupled GNSS/INS solution. For further information refer to the NC1901/NC1902/NC1903 Hurricane Florence Airborne Positioning and Orientation Report (APOR).

Lidar Data Processing

The lidar processing phase of the project was performed by QSI using Riegl's RiProcess or Leica's Lidar Survey Studio (LSS) software to facilitate bathymetric return processing. Once bathymetric points were differentiated, they were spatially corrected for refraction through the water column based on the angle of incidence of the laser. QSI refracted water column points using a combination of Riegl's RiHydro tools, Leica LSS, and proprietary software. The resulting point cloud data were classified using both manual and automated techniques.

RSD received classified lidar tiles covering the project area and used NOAA VDatum software to convert the vertical datum of the lidar points from NAD83 ellipsoid to local MHW and MLLW tidal datums. QT Modeler and custom ArcGIS Scripts were used to produce bare earth MHW and MLLW digital elevation models at a 1-meter grid resolution and to create and format the MHW and MLLW vectors into shapefile format.

The lidar point cloud was first compared to ground control points of a higher accuracy to determine vertical uncertainties for the data set, then compared to the morphologic slope around the derived shoreline at many sample sites in the NC1902-TB-C project area to determine the uncertainty of the derived vectors. Based on this assessment, RSD personnel determined that the lidar-derived shoreline vectors meet horizontal accuracies at the 95% confidence level of 3.8 and 4.2 meters for MHW lidar-derived shoreline contours, and 5.9 and 7.5 meters for MLLW contours. For further information refer to QSI's Lidar, Digital Imagery & Shoreline Mapping report for NC1901, NC1902, & NC1903-TB-C.

Aerotriangulation

The AT phase of the project was initiated by QSI personnel in May 2020 using digital AT methods to establish the network of photogrammetric control required for the compilation phase. Leica's XPro AT software was used to perform automatic and interactive measurements of tie points. The final adjustment of the block was accomplished by using a rigorous simultaneous least squares bundle adjustment, and analysis tools within XPro were used to refine the AT solution and to evaluate the accuracy of the adjustment. The Root Mean Square (RMS) of the standard deviations in both X and Y directions was calculated and used to determine a predicted horizontal circular error at the 95% confidence level of 0.42 meters for the 4-band photos.

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). An AT Report was completed and is on file with other project data within the RSD Electronic Data Library.

Compilation

The data compilation phase of the project was initiated by Fugro personnel in October 2021. This work was accomplished using a Digital Photogrammetric Workstation (DPW), which consists of a stereo-enabled PC-based graphics workstation running the Windows 2010 operating system and DAT/EM Summit Evolution (ver. 7.6) digital photogrammetric software. Feature identification, segmentation, and attribution within the GC were based on image analysis of the project imagery and information extracted from the appropriate NOAA nautical charts, US 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 NC1902D-TB-C were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features extracted from stereo imagery were compiled to meet a horizontal accuracy of 0.8 meters at the 95% confidence level. This predicted accuracy of compiled, well-defined points is derived by doubling the circular error calculated from the AT statistics. A limited number of features were extracted from orthoimagery using Automatic Feature Extraction methods, and were conservatively estimated to meet a horizontal accuracy of 5.0 meters. Accuracies of lidar-derived features are described above.

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

Date	Time (UTC)	Flight Line	Photo ID	Tide Level *
01/08/2020	17:30 – 17:52	930015	BL001/NL001	N/A
02/02/2020	14:18 – 14:38	930018	BL001/NL001	0.4 m
02/02/2020	14:42 – 14:56	930017	BL001/NL001	0.4 m
02/02/2020	15:01 – 15:20	930016	BL001/NL001	0.4 m
02/28/2020	19:59 – 20:10	930019	BL001/NL001	0.4 m

02/28/2020	20:13 – 20:21	930020	BL001/NL001	0.3 m
02/28/2020	20:26 – 20:35	930021	BL001/NL001	0.3 m
03/01/2020	13:59 – 14:11	930038	BL001/NL001	0.1 m
03/01/2020	14:15 – 14:31	930039	BL001/NL001	0.2 m
03/01/2020	14:34 – 14:49	930040	BL001/NL001	0.2 m

* Tide levels are given in meters above MLLW and are based on verified observations recorded by NOAA gauge 8652587 at Oregon Inlet Marina, NC (water level observations were not available on 01/08/2020). The elevation of MHW at Oregon Inlet is 0.317 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 December 2021. The review process included analysis of AT 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 (ver. 10.8.2) 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:

- 11555, Cape Hatteras – Wimble Shoals to Ocracoke Inlet, 43rd Ed., Sep. 2018
- 12204, Currituck Beach Light to Wimble Shoals, 39th Ed., Jun. 2018
- 12205, Cape Henry to Pamlico Sound, incl. Albemarle Sound, 35th Ed., Feb. 2017

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

- Ground Survey Reports for Lidar and Imagery
- Hurricane Florence Acquisition Summary Report
- Lidar, Digital Imagery & Shoreline Mapping Report
- Airborne Positioning and Orientation Report (APOR)
- Aerotriangulation Report
- Project database
- GC11603 in shapefile format
- Project Completion Report (PCR)
- CEF in shapefile format

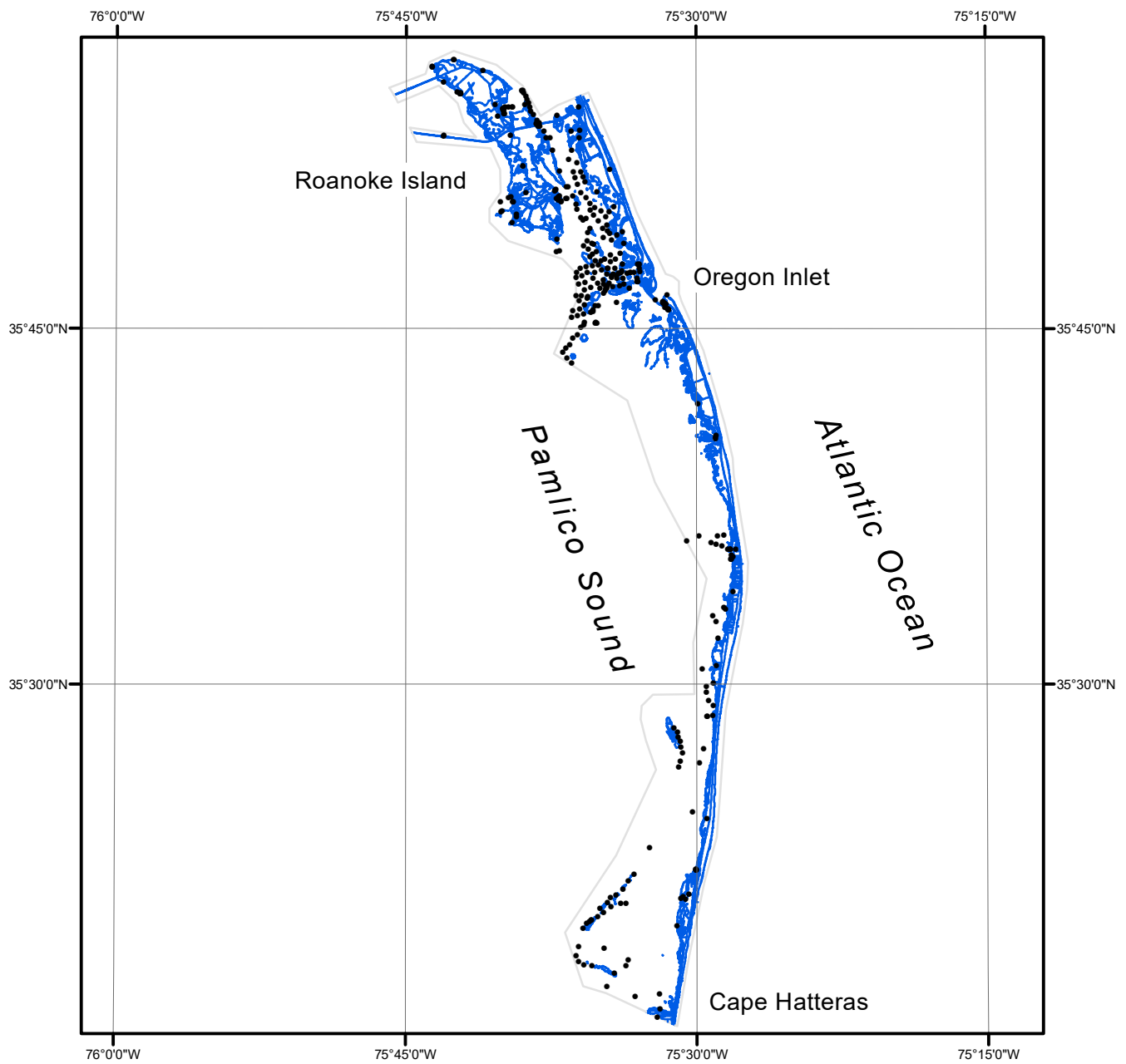
NOAA Shoreline Data Explorer

- GC11603 in shapefile format
- Metadata file for GC11603
- PCR in Adobe PDF format

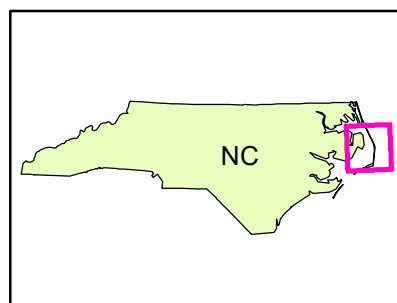
End of Report

OUTER BANKS, ROANOKE ISLAND TO CAPE HATTERAS

NORTH CAROLINA



Overview



NC1902D-TB-C

GC11603