NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT FL1703A-TB-N

Intracoastal Waterway, Fort Lauderdale to Golden Beach, Florida

Introduction

NOAA Coastal Mapping Program (CMP) Project FL1703A-TB-N provides a highly accurate database of new digital shoreline data for the coast of Florida, including the Intracoastal Waterway (ICW) from Fort Lauderdale to Golden Beach. Project FL1703A-TB-N is a subproject of a larger project, FL1703-TB-N which extends from Fort Lauderdale to Miami.

The project database consists of information measured and extracted from aerial photographs and metadata related to photogrammetric compilation. Base mapping was conducted in a digital environment using stereo softcopy photogrammetry and associated cartographic practices, supplemented with lidar-derived Mean High Water (MHW) and Mean Lower Low Water (MLLW) data. 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 Remote Sensing Division (RSD) formulated the photographic mission instructions for this project following the guidelines of the Photo Mission Standard Operating Procedures. The instructions discussed the project's purpose, geographic area of coverage, scope and priority, image requirements, Global Positioning System (GPS) data collection procedures and guidelines, instructions for data recording and handling, and mission communication protocols. RB created a Project Layout Diagram, flight maps and input files for the aircraft flight management system.

After completion of the acquisition phase, NOAA tasked the data processing and compilation phase of the project to Quantum Spatial, Inc. (QSI). The RSD formulated the task order 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. The instructions discussed the project's purpose, geographic area of coverage, scope and priority; data processing, accuracy, and compilation requirements; product delivery and reporting instructions; and contact and communication information. NOAA also provided shapefiles depicting the shoreline to be mapped and the boundaries of the main project area.

Field Operations

RSD performed field operations for project FL1703-TB-N consisting of the acquisition of aerial photographs and topobathy lidar, the surveying of ground control points (GCPs) and checkpoints (CPs) and the establishment of base stations to support aerial collection and real-time kinematic (RTK) survey operations.

A total of 126 GCPs were collected for lidar control and 14 GCPs were collected for imagery control. All points were surveyed by RSD using a Trimble Network RTK GPS system. Survey field work was performed between February 23, 2017 and March 10, 2017.

The lidar acquisition was conducted by RSD from February 24, 2017 thru March 10, 2017. The topobathymetric lidar data was collected with a Riegl VQ-880-G system with an average first return point density of 14.69 ppsm and a ground and bathymetric bottom classified return density of 2.59 ppsm.

The aerial imagery acquisition phase of the project was conducted by RSD on March 19, 2017 and March 22, 2017. A total of eleven (11) flight lines were acquired, consisting of 390 color (RGB) images. All imagery was acquired within a ±2 hour time window of the MLW tide stage. The images were acquired at a nominal altitude of 7,500 feet, using the DSS 580 digital camera with a 50 mm lens, resulting in a ground sample distance of 0.24 meters.

GPS Data Processing

GPS/IMU data were processed by RSD personnel to yield precise camera positions and orientations for aerotriangulation of the imagery. A local GPS base station was established for use as a reference station for kinematic GPS processing operations. The position of the base station was determined using the NGS Online Processing User Service (OPUS), which computed fixed baseline solutions from nearby CORS stations. The airborne kinematic data was processed using Applanix POSPAC MMS (ver. 7.1) software in April 2017. For further information refer to the Airborne Positioning and Orientation Report (APOR) that is on file with other project data within the RSD Electronic Data Library.

Lidar Data Processing

RSD collected the raw topobathymetric lidar data for Project FL1703-TB-N, and performed the initial processing and quality control, including calibration and refraction correction. Quantum Spatial, Inc. (QSI) was subsequently contracted by RSD to perform further data processing, accuracy assessment and creation of the deliverable products from the lidar data.

QSI utilized a variety of software for lidar data processing, including TerraScan, TerraModeler, Esri ArcGIS (ver.10.2.2), LAStools, and QSI proprietary software. Data processing included additional quality checks and accuracy assessments of the preliminary swath data, point classification, automated and manual editing of the lidar tiles, QA/QC, and final formatting of the LAS tiles. The final processed lidar products that were delivered to RSD included a fully classified point cloud, one meter resolution tiled topobathymetric bare earth models, tiled clipped topobathymetric bare earth models, tiled topobathymetric standard deviation models in ERDAS Imagine format, one meter resolution tiled DZ orthos in GeoTiff format, a bathymetric void polygon shapefile, an area of interest shapefile, a lidar tile index shapefile, a DEM tile index shapefile, and FGDC compliant metadata files.

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 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 a large number of sample sites in the FL1703A-TB-N subproject area to determine the uncertainty of the derived vectors. Based on this assessment the MHW lidar-derived shoreline vectors meet a horizontal accuracy of 1.2 meters at the 95% confidence level, and the MLLW lidar-derived shoreline vectors meet a horizontal accuracy of 2.3 meters at the 95% confidence level. For further information on the lidar processing refer to the Topobathy Lidar Processing Report on file with other project data within the RSD Electronic Data Library.

Aerotriangulation

The aerotriangulation (AT) phase of project FL1703-TB-N was performed by QSI using digital AT methods to establish the network of photogrammetric control required for the compilation phase. Inpho Match-AT software (ver. 8.0.7.53922) was used to perform automatic point measurements and interactive point measurements of tie points, and the Bingo aerotriangulation software was used for the adjustment. The final adjustment of the block was accomplished by using a rigorous simultaneous least-squares bundle adjustment, and analysis tools within Bingo were used to refine the aerotriangulation solution and to evaluate the accuracy of the adjustment.

The Root Mean Square (RMS) of the standard deviations in both X and Y directions were calculated and used to determine a predicted horizontal circular error of 0.5 meters at the 95% confidence level. An Aerotriangulation (AT) Report is 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

Data compilation for project FL1703A-TB-N was initiated by QSI personnel in September 2018. RSD supplied the lidar-derived MHW and MLLW shapefiles to be edited and attributed by QSI. Additional features were manually compiled from stereo imagery using a Digital Photogrammetric Workstation (DPW), which consists of a stereo-enabled PC-based graphics workstation running the Windows 2010 operating system and a suite of digital photogrammetric software known as DAT/EM Summit Evolution (ver. 7.5). Feature identification, segmentation, and attribution was performed with an Arcmap (ver.10.4) geodatabase using DAT/EM's stereo module, 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 FL1703A-TB-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Stereo compiled cartographic features were compiled to meet a horizontal accuracy of 1.0 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 1.2 meters to 2.3 meters.

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

Date	Time (UTC)	Roll ID	Flight Line	Photo ID	Tide Level *
3/22/2017	15:07 – 15:10	17VC22	145005	3879 – 3900	0.2 m
3/22/2017	15:15 – 15:18	17VC22	145004	3901 – 3922	0.2 m
3/22/2017	15:33 – 15:37	17VC22	145003	3985 – 4006	0.2 m
3/22/2017	15:46 – 15:47	17VC22	145010	4017 – 4024	0.2 m
3/22/2017	15:52 – 15:53	17VC22	145009	4027 – 4034	0.2 m
3/22/2017	16:02 – 16:03	17VC22	145008	4055 – 4062	0.2 m
3/22/2017	16:09 – 16:09	17VC22	145007	4064 – 4066	0.2 m
3/22/2017	16:29 – 16:29	17VC22	145006	4161 – 4163	0.3 m

 * Water levels are given in meters above MLLW and are based on verified observations recorded by the NOS tide gauge at Virginia Key, Biscayne Bay, Florida. The elevation of the MHW tidal datum in the project area varies between 0.62 – 0.82 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 2018. 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 (ver. 10.4) 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:

- 11467, Lake Worth to Deerfield Beach, 44th Ed., Jan. 2017
- 11470, Fort Lauderdale Port Everglades, 40th Ed., Feb. 2014

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
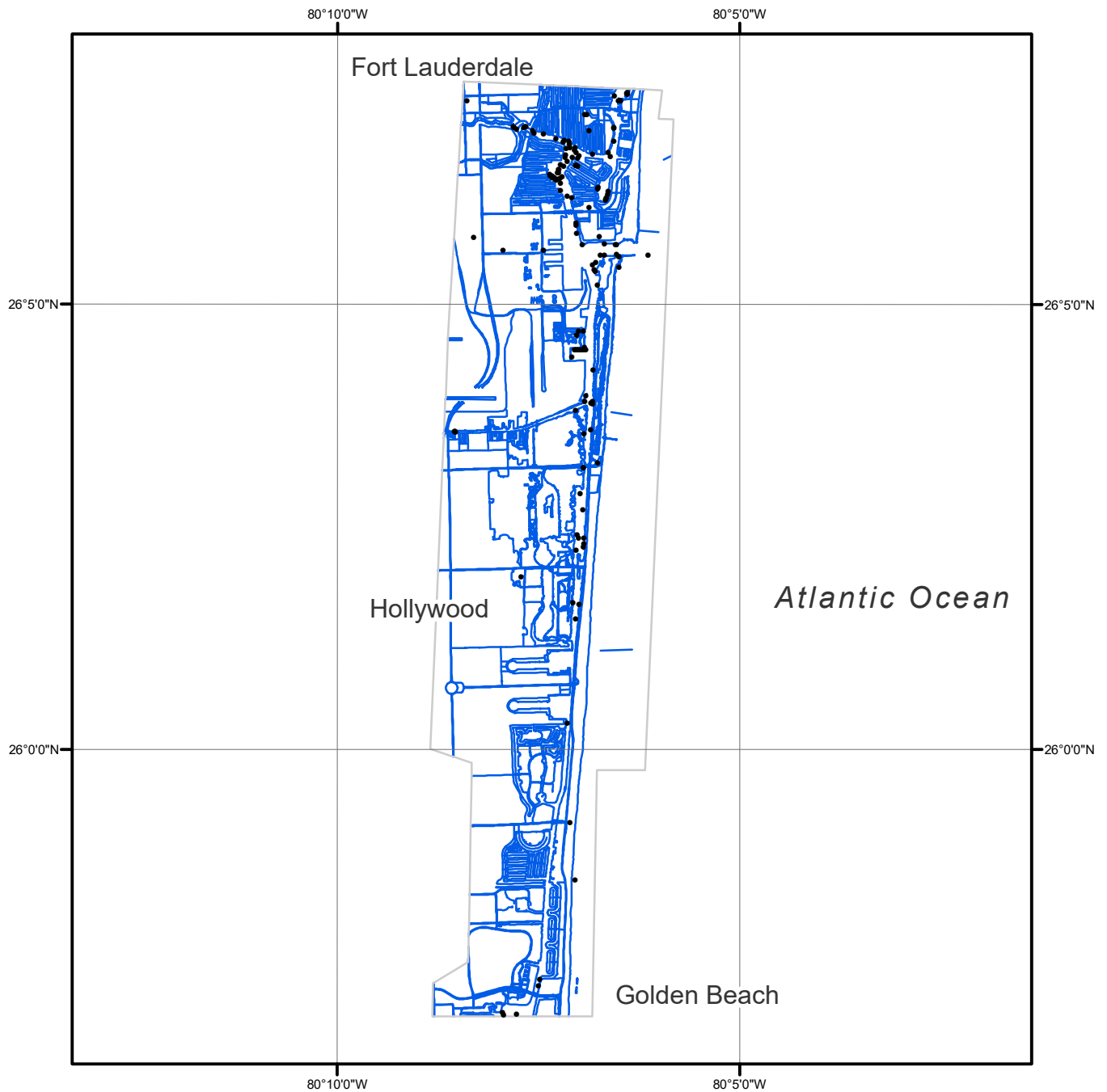- Project database

- Airborne Positioning and Orientation Report (APOR)
- Topobathy Lidar Processing Report
- Aerotriangulation Report
- GC11446 in shapefile format
- Project Completion Report (PCR)
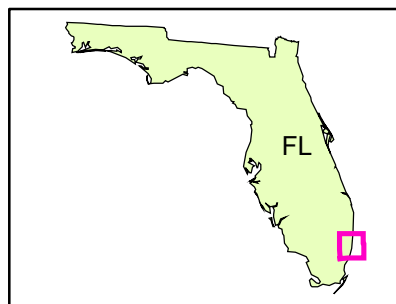- Chart Evaluation File (CEF) in shapefile format

NOAA Shoreline Data Explorer
- GC11446 in shapefile format
- Metadata file for GC11446
- PCR in Adobe PDF format

End of Report

ICW, FORT LAUDERDALE TO GOLDEN BEACH
FLORIDA

80°10'0"W 80°5'0"W

Fort Lauderdale

26°5'0"N 26°5'0"N

Hollywood

Atlantic Ocean

26°0'0"N 26°0'0"N

Golden Beach

80°10'0"W 80°5'0"W

Overview

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

FL

FL1703A-TB-N

GC11446