NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT FL1806A-TB-C

Miami to Thursday Cove, Key Largo, Florida

Introduction

NOAA Coastal Mapping Program (CMP) Project FL1806A-TB-C provides a highly accurate database of new digital shoreline data for an area within the Florida Keys extending from Miami southward to Thursday Cove on Key Largo. Project FL1806A-TB-C is a subproject of a larger project, FL1806-TB-C which includes coverage of the Florida Keys from Miami to Marquesas Keys.

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 NOAA National Geodetic Survey (NGS) 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. 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.

NOAA NGS supplied the lidar-derived MHW and MLLW shapefiles to be segmented, edited, and attributed by Quantum. NOAA NGS also provided shapefiles depicting the shoreline to be mapped and the boundaries of the main project area.

Quantum Spatial (QSI or Quantum) was responsible for the planning, acquisition, and post-processing of aerial imagery and lidar data in order to support photogrammetric processing and feature compilation. This includes the establishment of ground control, the post-processing of airborne GPS data, and calibration of the lidar data. In addition, Quantum provided shapefiles of the flight lines and exposure centers of the imagery to be used for compilation.

Field Operations

Quantum Spatial was contracted to perform field operations in support of their contract with the NOAA Office of Coastal Management (OCM). These field operations consisted of the surveying of ground control and check points (GCPs), and the acquisition and processing of digital aerial

photographs and topographic-bathymetric ("topobathy") lidar data.

A total of 16 GCPs were established in project FL1806A-TB-C using a combination of GPS surveying techniques. One additional photo-identifiable check point was also occupied at a well-defined, discrete location. Survey field work was performed from November 2018 and January 2019. A Ground Survey Report is on file with other project data within the NGS Remote Sensing Division (RSD) Electronic Data Library.

The lidar acquisition phase of the project was conducted by Quantum from November 2018 through March 2019. A total of 97 missions were completed and tidally coordinated within 20% of the Mean Range of tide around MLLW for the entire FL1806-TB-C project. Lidar data was captured at a target point density of two points per square meter using a 550 kHz Riegl VQ-880-G hydrographic airborne laser scanner.

The digital imagery acquisition phase of the project was conducted by Geomni from January to May 2019. A total of 38 flight lines of 4-band imagery were acquired and tidally coordinated within 25% of the Mean Range of tide around MLLW for the entire FL1806-TB-C project; 13 of which fell within the FL1806A-TB-C project area. Imagery was captured with an approximate nominal ground sample distance (GSD) of 0.33 meter through the use of a large format DMCII 230-526 camera with a focal length of 92.00 mm.

GPS Data Processing

Each acquisition aircraft used by Geomni was equipped with either a POSAV Applanix Model 510 IMU and/or a dual frequency Trimble BD960 to collect the ABGPS and IMU data. NGS 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 photo center locations. GPS/IMU processing was accomplished using Waypoint Inertial Explorer (8.60) software. Airborne Positioning and Orientation Reports (APOR) are on file with other project data within the RSD Electronic Data Library.

Lidar Data Processing

The lidar processing phase of the project was performed by Quantum using Riegl's RiProcess 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. Quantum refracted water column points using Riegl's RiHydro tools. The resulting point cloud data were classified using both manual and automated techniques. The final processed lidar products delivered to RSD included a fully classified point cloud, 1-meter resolution tiled topobathy bare earth models, tiled clipped topobathy bare earth models, tiled topobathy standard deviation models in ERDAS imagine file format, 1-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 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 numerous sample sites in the project area to determine the uncertainty of the vectors. Based on this assessment the MHW lidar-derived shoreline vectors meet a horizontal accuracy of 2.2 meters at the 95% confidence level, and the MLLW lidar-derived shoreline vectors meet a horizontal accuracy of 3.1 meters at the 95% confidence level. For further information on the lidar processing refer to the Final Report of Survey on file with other project data within the RSD Electronic Data Library.

Aerotriangulation

The aerotriangulation (AT) phase of the project was performed by Quantum using digital AT methods to establish the network of photogrammetric control required for the compilation phase. Hexagon's ImageStation automated aerotriangulation (ISAT) software was used to perform automatic point measurements and interactive point 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 ISAT 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 at the 95% confidence level of 0.18 m for the 4-band photos. An 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 horizontally referenced to the North American Datum of 1983 (NAD 83).

Compilation

The data compilation phase of the project was initiated by Quantum personnel in July 2019. This work was accomplished using a stereo-enabled PC-based graphics workstation running DAT/EM Summit Evolution (ver. 7.6) digital photogrammetric software. Feature identification, segmentation, and attribution were based on imagery analysis of the processed digital images and information extracted from the appropriate NOAA Nautical Charts, 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 FL1806A-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 0.4 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. 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 *
01/08/2019	19:25 – 19:27	620007	0028 – 0021	0.3 m
01/08/2019	19:41 – 19:45	620008	0020 – 0035	0.3 m
01/08/2019	19:49 – 19:54	620009	0042 – 0023	0.3 m
01/08/2019	20:11 – 20:18	620010	0026 – 0049	0.3 m
01/08/2019	20:21 – 20:28	620011	0055 – 0029	0.2 m
01/08/2019	20:49 – 20:57	620012	0036 – 0061	0.2 m
01/10/2019	20:43 – 20:48	620014	0020 – 0001	0.4 m
01/10/2019	20:51 – 20:57	620015	0002 – 0022	0.3 m
01/10/2019	21:00 – 21:06	620016	0024 – 0001	0.3 m
01/17/2019	16:14 – 16:20	620013	0043 – 0064	0.3 m
01/17/2019	16:26 – 16:28	620019	0009 – 0001	0.3 m
01/17/2019	16:32 – 16:39	620017	0002 – 0026	0.3 m
01/17/2019	16:44 – 16:48	620018	0016 – 0001	0.3 m

* Tide levels are given in meters above MLLW and are based on verified observations recorded by the NOS gauge (8723214) at Virginia Key, Biscayne Bay, FL. The height of the MHW datum at the Biscayne Bay gauge is 0.661 meters above MLLW.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of Quantum. The final QC review was completed in February 2020. 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 Esri's ArcGIS (ver. 10.8.1) 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 chart was used in the comparison process:

- 11463, Sands Key to Blackwater Sound, 20th Ed., Jan. 2017
- 11465, Intracoastal Waterway, Miami to Elliott Key, 41st Ed., Sep. 2020
- 11467, Lake Worth to Deerfield Beach, 45th Ed., Dec. 2019
- 11468, Miami Harbor, 45th Ed., Aug. 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 Control Report
- Airborne Positioning and Orientation Reports (APOR)
- Aerotriangulation Report
- Topobathy Final Report of Survey
- Project database
- GC11511 in shapefile format
- Project Completion Report (PCR)
- CEF in shapefile format

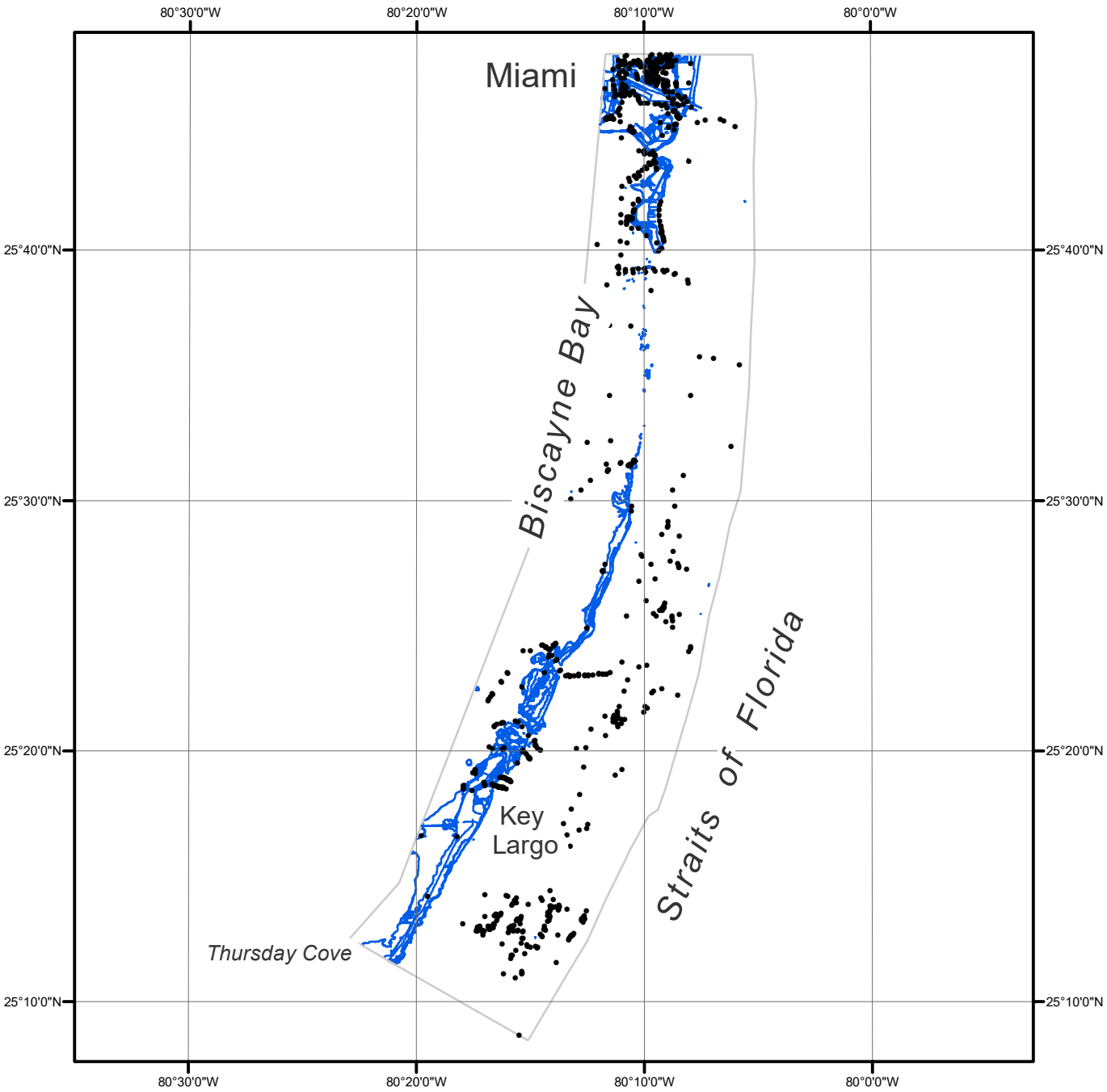
NOAA Shoreline Data Explorer

- GC11511 in shapefile format
- Metadata file for GC11511
- PCR in Adobe PDF format

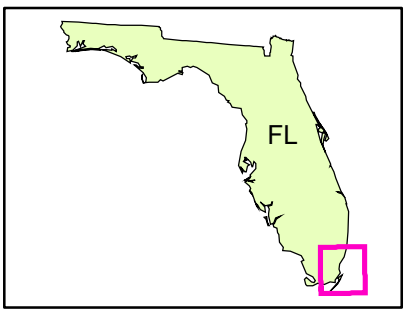
End of Report

MIAMI TO THURSDAY COVE, KEY LARGO

FLORIDA



Overview



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GC11511