NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT FL1802A-TB-N

Intracoastal Waterway, Highland Beach to Lake Park, Florida

Introduction

NOAA Coastal Mapping Program (CMP) Project FL1802A-TB-N provides highly accurate digital shoreline data for a portion of the Intracoastal Waterway from Highland Beach to Lake Park, in Florida. Project FL1802A-TB-N is a subproject of a larger acquisition project, FL1802-TB-N, which provides coverage of the Intracoastal Waterway from Highland Beach to Fort Pierce, Florida. 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

Project FL1802-TB-N was designed by the Requirements Branch (RB) of the Remote Sensing Division (RSD) to provide topographic-bathymetric (topobathy) lidar-derived elevation products in addition to standard GCs. RB 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, imagery and lidar 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.

Field Operations

The field operations consisted of acquisition of topobathy lidar data, digital aerial imagery, static and kinematic GPS data, and Inertial Measurement Unit (IMU) data. Static GPS data were collected to support aerial data acquisition and processing operations, as well as to assess the accuracy of post-processed lidar data.

Lidar Data Acquisition

Three hundred Seventy lines of Topographic/Bathymetric (topobathy) lidar were acquired in June 2018 using a Riegl VQ880G lidar system on board the NOAA Twin Otter Aircraft (N57RF). The data was collected at a nominal altitude of 1,300 feet with a 50% swath overlap (planned single swath point density = 9 pt/m^2).

Digital Aerial Imagery Acquisition

Thirty-three lines of natural color (RGB) and near-infrared (NIR) digital aerial imagery were collected in April 2019 using an Applanix Digital Sensor System DSS560/580 camera onboard the NOAA King Air aircraft (N68RF). Eleven lines were collected at a nominal altitude of 4,500 feet with a ground sample distance (GSD) of 0.14 m. (RGB) and 0.16 m. (NIR), and 22 lines were collected at 7,500 feet with GSD of 0.23 m. (RGB) and 0.26 m. (NIR). The imagery was collected within +/- 2 hours of the MLW tide stage. Five lines of the high altitude RGB imagery were used for this sub-project. The NIR imagery was not used.

GPS Data Processing

GPS and IMU data were processed by RSD personnel to yield precise sensor positions and orientations for direct georeferencing (DG) 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 (ver. 8.3) software in May 2019. For further information refer to the Airborne Positioning and Orientation Reports (APOR) on file with other project data within the RSD Electronic Data Library.

The processed GPS/IMU data were used to derive precise exterior orientation (EO) values of the digital aerial imagery camera centers required for digital feature extraction. The predicted horizontal accuracy of the imagery was determined by propagating sensor EO and image measurement uncertainties through the photogrammetric collinearity equations using an Exterior Orientation Total Propagated Uncertainty (EO-TPU) tool developed by NGS. Using this tool, the predicted horizontal uncertainty at the 95% confidence level was calculated to be 0.59 meters. Stereo-models were examined in order to verify the quality of the DG data and ensure acceptable levels of parallax for mapping purposes.

Lidar Data Processing

Lidar point cloud data were processed in June 2018 using the following RSD lidar data processing workflow. 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 to assess relative and absolute accuracies between overlapping flight missions and relative with each mission, 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 RB Lidar Processor. Additional quality control (QC), point classification, and formatting were performed with GeoCue, Terrasolid, and Global Mapper software packages. NOAA VDatum software was used to transform the vertical reference 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 ground control points of a higher accuracy in order to assess vertical uncertainty, and then combined with the morphologic slope around the derived shoreline to assess corresponding horizontal uncertainties. Based on this assessment, the MHW lidar-derived shoreline vectors meet a horizontal accuracy of 1.9 meters, and the MLLW lidar-derived vectors meet a horizontal accuracy of 2.1 meters, both at the 95% confidence level.

Compilation

Data compilation was completed in November 2019 by RSD personnel, and was accomplished in two phases: automated extraction from topobathy lidar and manual extraction using digital stereo imagery.

1) Automated/lidar approach: MHW and MLLW shoreline vectors (in shapefile format) were delineated using the approach described in the preceding section of this report. Subsequently, project orthoimagery was used to review, edit, and attribute the vectors. The lidar-derived shoreline data were limited to terrain features at the land/water interface.
2) Manual/imagery approach: MHW (“Shoreline”) and MLLW (“Contour”) lidar-extracted shapefiles were then reviewed, and additional features significant to nautical charting, such as engineered, elevated features, bulkheads, piers, bridges, landmarks, etc., were compiled from stereoscopic imagery using the Feature Extraction module of BAE’s SOCET SET (ver. 5.6) photogrammetric software. Selected features were further modified with additional descriptive

information to refine general classification. All shapefiles were integrated into a single GC using Esri's ArcGIS (ver. 10.7) software. Cartographic features compiled from the stereo imagery were compiled to meet a horizontal accuracy of 1.2 meters at the 95% confidence level. This predicted accuracy of well-defined points is derived by doubling the horizontal uncertainty computed using the EO-TPU tool discussed above.

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

Date	Time (UTC)	Color Imagery		Tide Level*
		Roll	Strip / Images	
4-21-2019	22:06 – 22:08	19VC21	45-001 / 3577 – 3594	-0.1 m
4-21-2019	22:13 – 22:16	19VC21	45-002 / 3595 – 3612	-0.1 m
4-21-2019	22:22 – 22:29	19VC21	45-005 / 3613 – 3657	-0.1 – 0.0 m
4-21-2019	22:34 – 22:40	19VC21	45-004 / 3658 – 3702	-0.1 – 0.0 m
4-21-2019	22:46 – 22:49	19VC21	45-003 / 3703 – 3724	0.0 m

* Tide levels are given in meters above MLLW and were calculated using the Pydro software tool with a TCARI grid referenced to verified water level observations at the time of photography from various NOS gauges in the vicinity of the project. The height of the MHW tidal datum in the project area varies between 0.63 – 0.86 meters above MLLW.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by senior CMP personnel. The final QC review was completed in December 2019. The review process included analysis of DG results and assessment of the identification and attribution of 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 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:

- 11459, Port of Palm Beach and Approaches, 2nd Ed., Nov. 2018
- 11466, Jupiter Inlet to Fowey Rocks, 40th Ed., Dec. 2016
- 11467, Lake Worth to Deerfield Beach, 44th Ed., Jan. 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

- Airborne Positioning and Orientation Reports (APOR)
- Project database
- GC11568 in shapefile format
- Project Completion Report (PCR)
- CEF in shapefile format

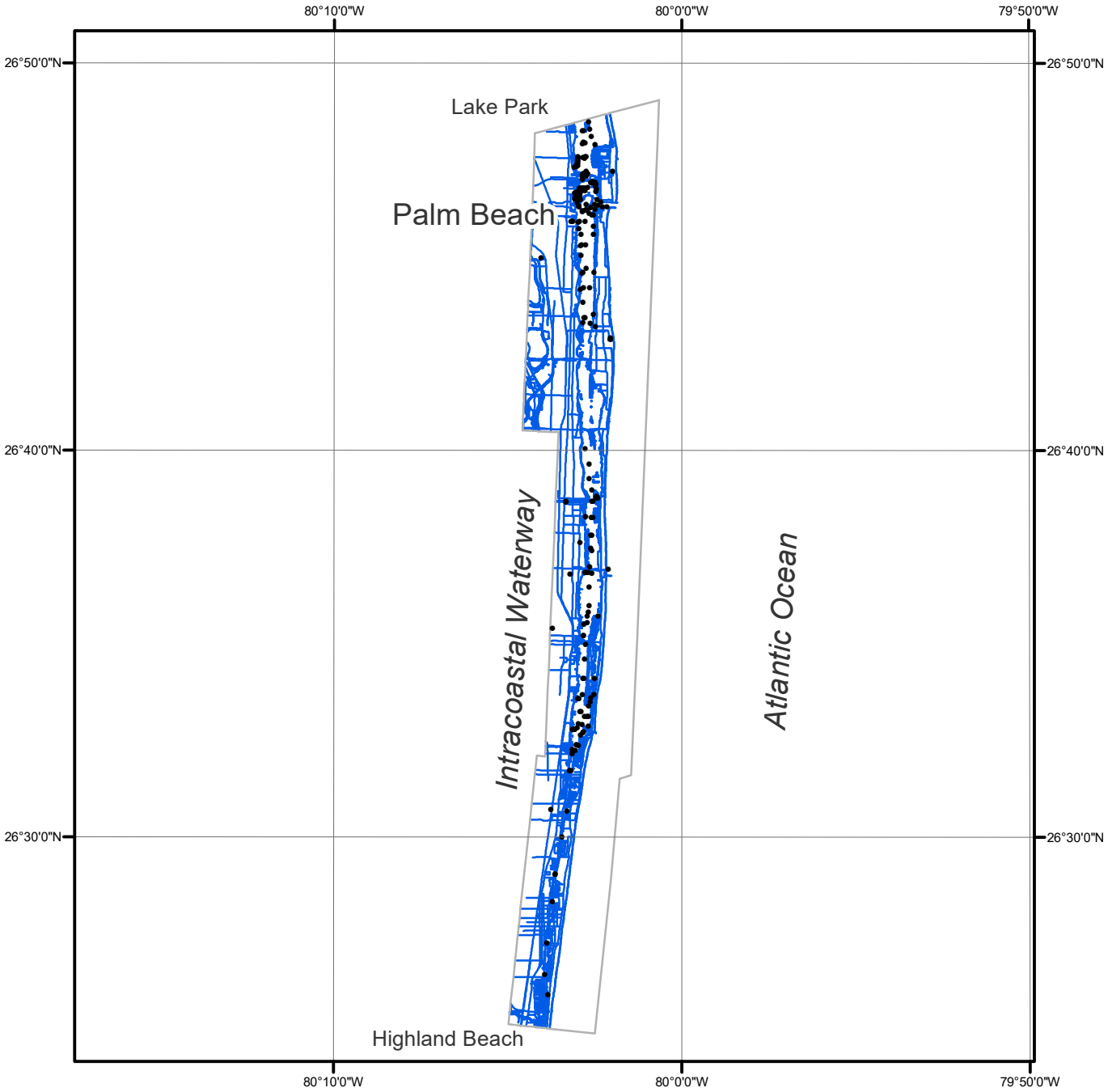
NOAA Shoreline Data Explorer

- GC11568 in shapefile format
- Metadata file for GC11568
- PCR in Adobe PDF format

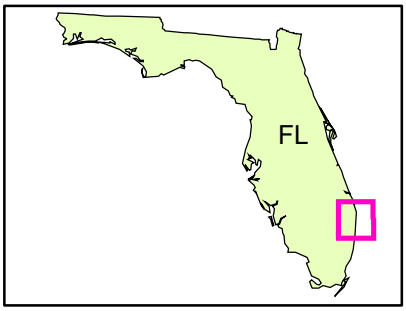
End of Report

INTRACOASTAL WATERWAY, HIGHLAND BEACH TO LAKE PARK

FLORIDA



Overview



FL1802A-TB-N

GC11568