

# **NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT**

## ***PROJECT FL1701A-TB-N***

### ***Saddlebunch Keys to Cudjoe Key, Florida***

#### **Introduction**

NOAA Coastal Mapping Program (CMP) Project FL1701A-TB-N provides highly accurate digital shoreline data for a portion of the Florida Keys from Saddlebunch Keys to Cudjoe Key. Project FL1701A-TB-N is a subproject of a larger acquisition project, FL1701-TB-N, which extends from Saddlebunch Keys eastward to Torch Keys. 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 Dewberry. 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**

The field operations consisted of acquisition of topographic/bathymetric (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*

A total of 113 lines of topobathy lidar were planned. Lidar data was acquired in October 2016 using a Riegl VQ880G lidar system on board a NOAA Twin Otter aircraft (N48RF). The data was collected at a nominal altitude of 1,300 feet with a 50% swath overlap and an aggregate nominal point density of 18 pulses per square meter.

### *Digital Aerial Imagery Acquisition*

Nine lines of natural color (RGB) and near-infrared (NIR) digital aerial imagery were collected in February 2017 using an Applanix Digital Sensor System DSS580/560 camera onboard the NOAA King Air aircraft (N68RF). All lines were collected at 7,500 feet with GSD of 0.24 (RGB) and 0.27 (NIR) meters. The imagery was collected within +/- 2 hours of the MLW tide stage. 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 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 Reports (APOR) on file with other project data within the RSD Electronic Data Library.

### **Lidar Data Processing**

RSD performed the initial processing and quality control for the raw topobathymetric lidar data for Project FL1701-TB-N, including calibration and refraction correction. Dewberry was subsequently contracted by RSD to perform further data processing, accuracy assessment and creation of the deliverable products from the lidar data.

Dewberry utilized a variety of software for lidar data processing, including TerraScan, TerraModeler, Esri's ArcGIS, LAStools, and Dewberry 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 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 2.6 meters, and the MLLW lidar-derived vectors meet a horizontal accuracy of 3.4 meters, both at the 95% confidence level.

## Aerotriangulation

The aerotriangulation (AT) phase of the project was performed by Dewberry using digital AT methods to establish the network of photogrammetric control required for the compilation phase. Inpho Match-AT software was used to perform automatic point measurements and interactive point measurements of tie points.

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. The predicted horizontal accuracy for FL1701-TB-N is 0.1 meters. 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 referenced to the North American Datum of 1983 (NAD 83).

## Compilation

Data compilation for project FL1701A-TB-N was initiated by Dewberry personnel in August 2018. RSD supplied the lidar-derived MHW and MLLW shapefiles to be edited and attributed by Dewberry. Additional features were manually compiled from stereo imagery using the Feature Extraction module of BAE's SOCET SET (ver. 5.6) digital photogrammetric software suite. Feature identification, segmentation, and attribution were performed within an Esri geodatabase using the SOCET for ArcGIS module of SOCET SET, 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 FL1701A-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 0.2 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 following table provides information on the imagery used to complete this project:

<b>Exposure Date</b>	<b>Exposure Time (UTC)</b>	<b>Roll #</b>	<b>Flight Line / Photo ID</b>	<b>Tide Level*</b>
2-FEB-2017	14:57 – 15:01	17VC07	45-001 / 725 – 749	0.1 m
3-FEB-2017	14:11 – 14:15	17VC08	45-009 / 984 – 1007	0.1 m
3-FEB-2017	14:20 – 14:23	17VC08	45-008 / 1008 – 1031	0.1 m
3-FEB-2017	14:31 – 14:35	17VC08	45-006 / 1056 – 1079	0.1 m
3-FEB-2017	14:40 – 14:44	17VC08	45-007 / 1080 – 1103	0.1 m

3-FEB-2017	14:52 – 14:55	17VC08	45-005 / 1128 – 1151	0.1 m
3-FEB-2017	15:00 – 15:03	17VC08	45-004 / 1152 – 1175	0.1 m
3-FEB-2017	15:12 – 15:16	17VC08	45-003 / 1199 – 1223	0.1 m
3-FEB-2017	15:21 – 15:25	17VC08	45-002 / 1224 – 1248	0.1 – 0.2 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 NOS gauges. The MHW tidal datum in the project area ranges from 0.48 to 0.57 meters above MLLW.

## Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by senior Dewberry personnel. The final QC review was completed in February 2019. The review process included analysis of AT 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:

- 11445, Bahia Honda Key to Sugarloaf Key, 31<sup>st</sup> Ed., May 2012
- 11446, Sugarloaf Key to Key West, 33<sup>rd</sup> Ed., Jan. 2013
- 11448, Big Spanish Channel to Johnston Key, 15<sup>th</sup> Ed., Aug. 2006

## 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

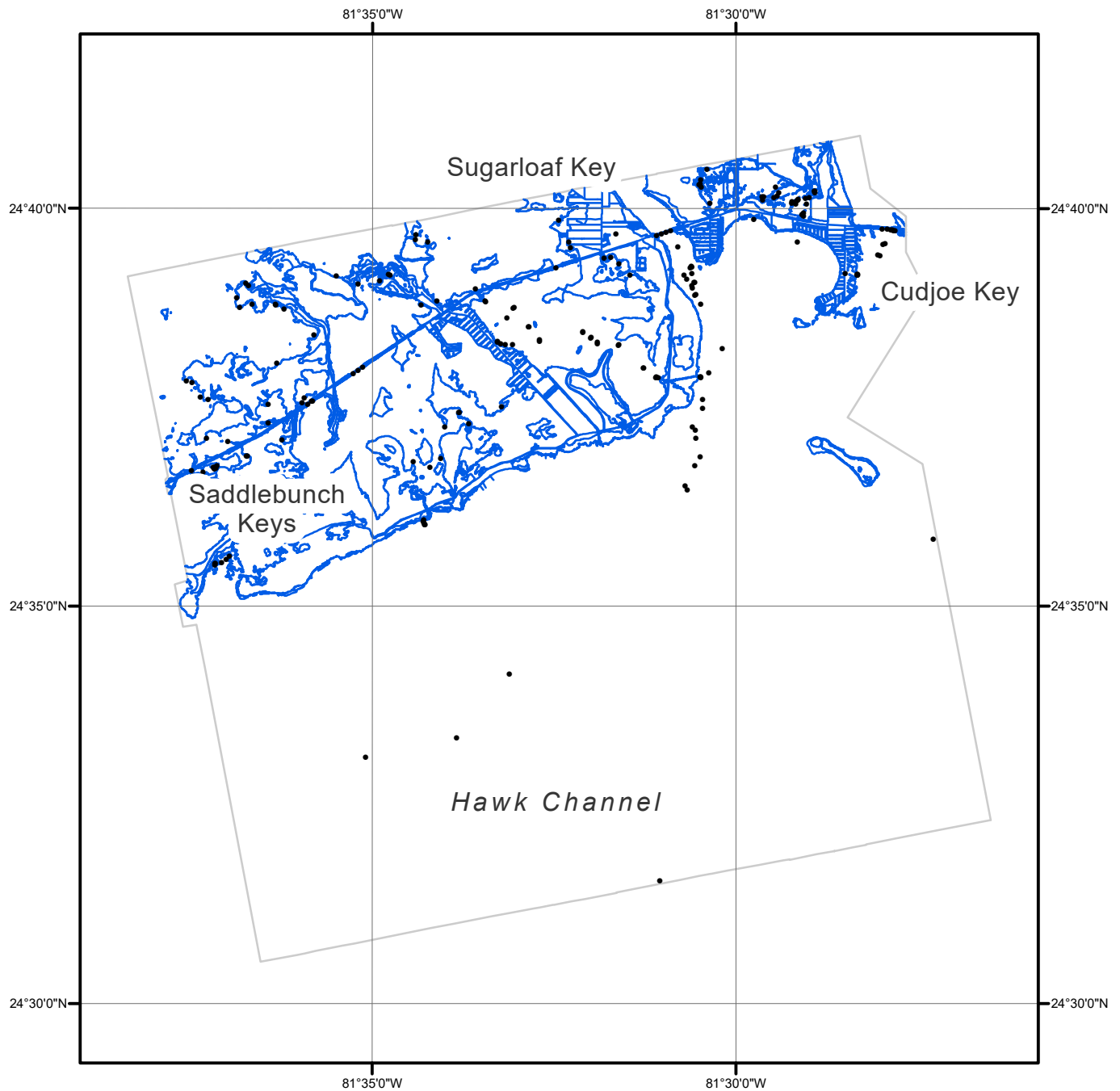
- Airborne Positioning and Orientation Reports (APOR)
- Topobathy Lidar Processing Report
- Aerotriangulation Report
- Project database
- GC11380 in shapefile format
- Project Completion Report (PCR)
- CEF in shapefile format

### NOAA Shoreline Data Explorer

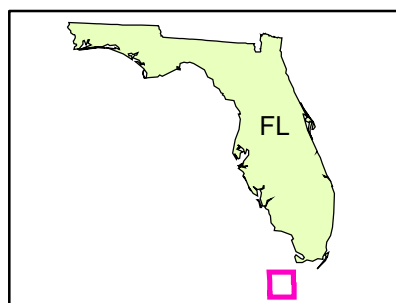
- GC11380 in shapefile format
- Metadata file for GC11380
- PCR in Adobe PDF format

## End of Report

# SADDLEBUNCH KEYS TO CUDJOE KEY FLORIDA



Overview



FL1701A-TB-N

GC11380