NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT VI1801A-TB-C

St. Thomas and St. John, U.S. Virgin Islands

Introduction

NOAA Coastal Mapping Program (CMP) Project VI1801A-TB-C provides a highly accurate database of new digital shoreline data for St. Thomas and St. John, U.S. Virgin Islands. Project VI1801A-TB-C is a subproject of a larger project, VI1801-TB-C, which covers the territory of the Virgin Islands of the U.S. in its entirety. 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

NOAA's National Geodetic Survey (NGS) Remote Sensing Division (RSD) 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 also provided shapefiles depicting the shoreline to be mapped and the boundaries of the main project area.

Dewberry Engineers Inc. was responsible for the planning, acquisition, and processing of all imagery and lidar data in order to support feature compilation. This includes the establishment of ground control and the post-processing of airborne GPS data. In addition, Dewberry provided shapefiles of the flight lines and exposure centers of the imagery to be used for compilation.

Field Operations

Dewberry and their subcontractor Leading Edge Geomatics, LLC (LEG) performed field operations for Project VI1801-TB-C consisting of the acquisition of aerial photographs and topographic-bathymetric (topobathy) lidar, as well as the surveying of ground control points (GCPs), accuracy assessment checkpoints (CPs), and the establishment of base stations to support aerial collection and real-time kinematic survey operations.

LEG surveyed 71 ground control points for VI1801-TB-C, to be used for the aerial triangulation of the aerial imagery using Static and RTK GNSS/GPS Surveying methods. Survey field work was performed from January to March 2019. For further information see the Ground Survey Report on file with other project data within the RSD Electronic Data Library.

Dewberry surveyed 20 checkpoints to be used for evaluation of the accuracy of the aerial imagery and lidar data using RTK GNSS/GPS Virtual Reference Station methodology. Survey field work was performed from March to April 2019. For further information see the Check Point Survey Report on file with other project data within the RSD Electronic Data Library.

The lidar acquisition for VI1801-TB-C was conducted by LEG from January through June 2019 and consisted of sufficient flight lines to cover the entire VI1801-TB-C project area with an average point density of ≥ 3 pulses per square meter and a 20% swath overlap. Topobathy green lidar were captured using a RIEGL VQ880-GII topobathy lidar system on a Piper Aztec aircraft. For further information on lidar acquisition and processing see the Topobathy Final Report of Survey within the RSD Electronic Data Library.

Aerial photography acquisition for VI1801-TB-C was conducted between April and December 2019. LEG operated two Cessna 206 aircraft outfitted with Vexcel UltraCam LPrime and UltraCam Falcon Prime aerial mapping cameras. A total of 42 flight lines of digital RGB imagery were acquired and loosely tide-coordinated to be within ±4 hours around low tide. Of these flight lines, a subset of all or part of 14 lines were used for the VI1801A-TB-C subproject. All imagery used for subproject VI1801A-TB-C had a planned ground sample distance (GSD) of 25 cm. For further information see the VI1801A-TB-C Aerotriangulation Report on file within the RSD Electronic Data Library.

GPS Data Processing

Airborne kinematic GPS/IMU data for VI1801-TB-C were processed using a variety of techniques to determine trajectory and exterior orientation data for aerotriangulation of the imagery and processing of the lidar data. A combination of static base stations and CORS stations were utilized as reference stations for the kinematic data processing. The data were processed using Applanix POSPac MMS (ver. 8.4) or Novatel Inertial Explorer (ver. 8.70.3114) software for each mission depending on which aircraft/camera system was used. The processing mode used for each trajectory varied between Singlebase, Multi-Singlebase, Applanix Smartbase, or Smoothed Tightly-Coupled Combined, depending on the software used and the number of viable reference stations available in the vicinity of the trajectory. For further information refer to the Airborne Positioning and Orientation Report (APOR) and the Topobathy Final Report of Survey on file within the RSD Electronic Data Library.

Lidar Data Processing

Lidar point cloud data for project VI1801-TB-C were processed from February through December 2019. 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 for assessing relative and absolute accuracies between overlapping lifts and relative with each lift, 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 Dewberry's lidar processor. Additional quality control (QC), point classification, and formatting were performed with GeoCue, Terrasolid, and Global Mapper software. NOAA VDatum software was used to convert the vertical datum of the lidar points from NAD83 ellipsoid to local MHW and MLLW tidal datums. 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 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 0.7 meters at the 95% confidence level, and the MLLW lidar-derived shoreline vectors meet a horizontal accuracy of 0.9 meters at the 95% confidence level. For further information refer to the Topobathy 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 Dewberry subcontractor LEG 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 and interactive point measurements of tie points and surveyed control points. Additional control points were derived from the topobathy lidar dataset, and used to tie exposed rocks to the main AT block.

The process included automatic point matching and a least-squares-simultaneous-robust bundle-block adjustment consisting of a St. Thomas and St. John main block, and 3 sub-blocks that could not be tied to the main block, which were adjusted separately using manually measured tie points and lidar-derived control points.

For the main block, 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 0.3 meters at the 95% confidence level. Sub-block accuracies were calculated similarly as follows:

21 RI 1 sub-block (Frenchcap Cay): 0.1 meters
21 RI 2 sub-block (Cockroach Island and Cricket Rock): 1.1 meters
21 RI 3 sub-block (Buck Island and Capella Island): 0.4 meters

An AT Report is on file with other project data within the RSD Electronic Data Library. Additionally, 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

Feature compilation for the project was initiated by Dewberry personnel in January 2021. NGS supplied the lidar-derived MHW and MLLW shapefiles to be edited, attributed and generalized. Additional features were then manually compiled using stereo imagery. Compilation was performed using the SOCET for ArcGIS module of BAE's SOCET SET (ver. 5.6) photogrammetric software suite, enabling compilation of features into an Esri Geodatabase where topological and attribution relationships could be enforced. Once compilation was complete, the geodatabase features were exported to shapefile format. 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 subproject VI1801A-TB-C were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features extracted from

imagery were compiled to meet the following horizontal accuracies (meters), calculated at the 95% confidence level, depending on which AT block they were extracted from.

AT Block	Accuracy
St. Thomas/St. John main block	0.6
21 RI 1 sub-block (Frenchcap Cay)	0.2
21 RI 2 sub-block (Cockroach Island and Cricket Rock)	2.2
21 RI 3 sub-block (Buck Island and Capella Island)	0.8

These predicted accuracies of compiled, well defined points are derived by doubling the circular error calculated from the AT statistics. The lidar-derived features had horizontal accuracies that varied from 0.7 meters to 0.9 meters as discussed further above.

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

Date	Time (UTC)	Flight Line #	Photo IDs	Tide Level *
4/13/2019	16:14:54 – 16:19:00	28-002	1004 – 1034	0.1 m
4/13/2019	16:25:18 – 16:30:50	28-003	1003 – 1037	0.1 m
4/13/2019	16:41:43 – 16:42:00	28-017	1005 – 1007	0.1 m
4/13/2019	16:48:38 – 16:48:57	28-016	1005 – 1007	0.1 m
4/18/2019	15:09:25 – 15:17:28	28-004	1015 – 1079	0.1 m
5/15/2019	14:18:56 – 14:19:22	28-005	2084 – 2087	0.1 m
6/3/2019	16:05:57 – 16:10:07	28-010	2039 – 2068	0.0 m
6/3/2019	16:19:16 – 16:28:36	28-011	2005 – 2067	0.0 m
6/3/2019	16:39:48 – 16:40:05	28-012	2040 – 2042	0.0 m
6/3/2019	16:49:16 – 16:49:52	28-013	2004 – 2008	0.0 m
6/24/2019	13:03:31 – 13:04:48	28-006	5006 – 5015	0.2 m
11/23/2019	13:29:43 – 13:32:00	42-018	1001 – 1009	0.3 m
11/23/2019	13:35:37 – 13:36:27	42-018	2006 – 2009	0.3 m
11/23/2019	13:46:21 – 13:47:09	42-019	1008 – 1011	0.3 m
11/23/2019	13:48:28 – 13:50:19	42-019	2003 – 2010	0.3 m
11/27/2019	12:15:28 – 12:17:19	42-020	1001 – 1009	0.4 m
11/27/2019	12:27:46 – 12:30:16	42-019	3001 – 3012	0.4 m
11/27/2019	12:50:24 – 12:55:27	42-020	2001 – 2023	0.4 m
11/27/2019	13:00:58 – 13:01:39	42-019	4001 – 4004	0.4 m
11/27/2019	13:03:30 – 13:04:38	42-019	5001 – 5006	0.4 m
11/27/2019	13:10:30 – 13:12:58	42-018	4001 – 4012	0.4 m
11/28/2019	12:22:52 – 12:24:44	42-020	3001 – 3009	0.4 m
11/28/2019	12:27:21 – 12:28:44	42-019	6001 – 6007	0.4 m
12/8/2019	18:10:14 – 18:10:33	42-019	8002 – 8003	0.2 m
12/8/2019	18:21:35 – 18:22:14	42-019	9001 – 9003	0.2 m

12/8/2019	18:26:20 – 18:26:53	42-018	5001 – 5003	0.2 m
12/8/2019	19:48:25 – 19:48:41	42-019	10001 – 10002	0.2 m
12/8/2019	19:52:18 – 19:53:50	42-020	4001 – 4006	0.2 m
12/8/2019	19:56:39 – 19:57:12	42-019	11001 – 11003	0.2 m

* Water levels are given in meters above MLLW and are based on verified observations recorded by the NOS tide gauge at Charlotte Amalie, VI - Station ID: 9751639. The MHW tidal datum is 0.227 meters above MLLW at the Charlotte Amalie gauge.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of Dewberry. The final QC review was completed in June 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. 10.8.1) 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 charts were used in the comparison process:

- 25641, Virgin Islands - Virgin Gorda to St. Thomas and St. Croix, 29th Ed., Sep. 2013
- 25647, Pillsbury Sound, 12th Ed., Mar. 2014
- 25649, St. Thomas Harbor, 20th Ed., Aug. 2010

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
- Ground Survey Reports
- Airborne Positioning and Orientation Report (APOR)
- Topobathy Final Report of Survey
- Aerotriangulation Report
- Project Completion Report (PCR)
- GC11505 in shapefile format
- CEF in shapefile format

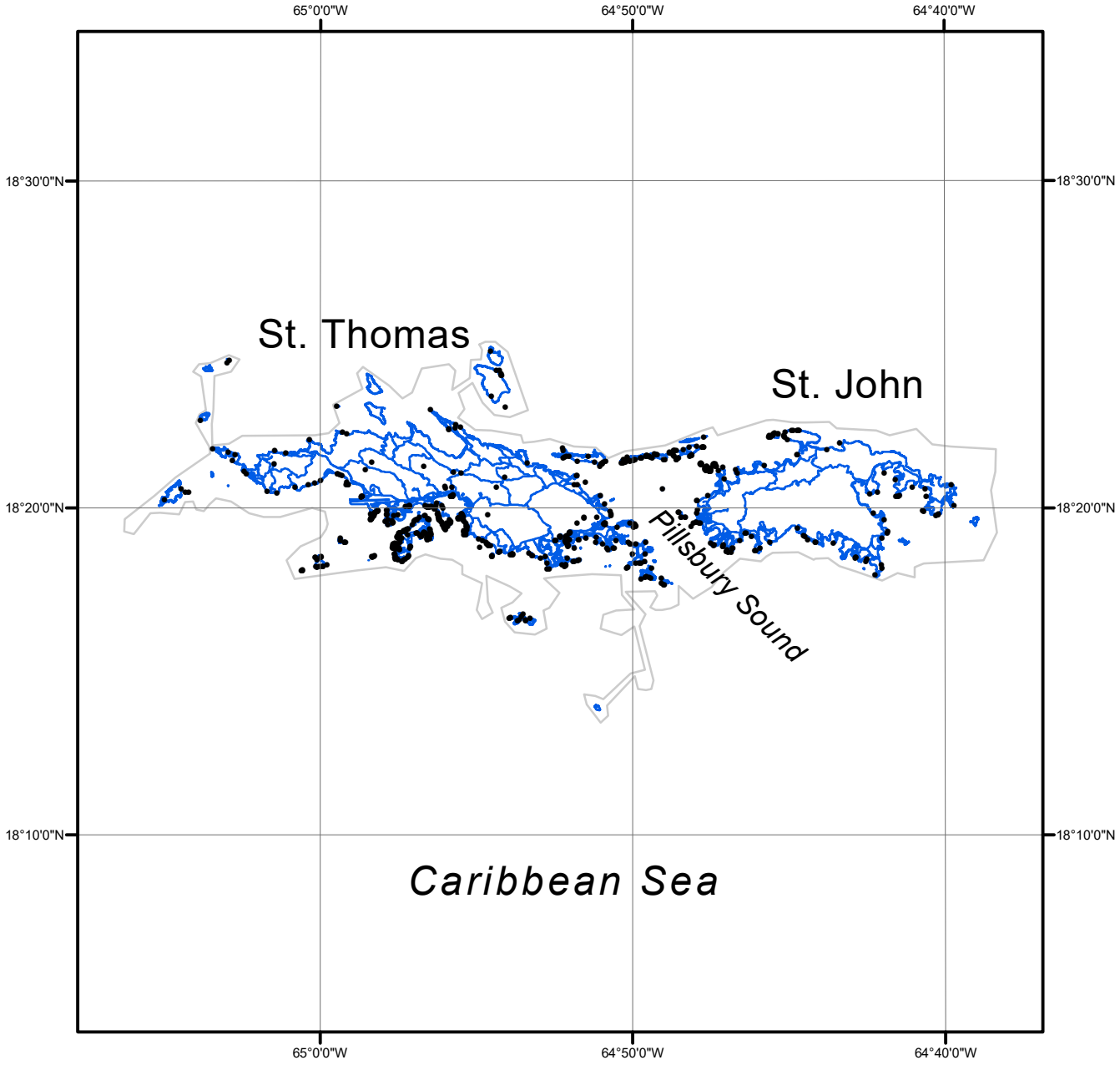
NOAA Shoreline Data Explorer

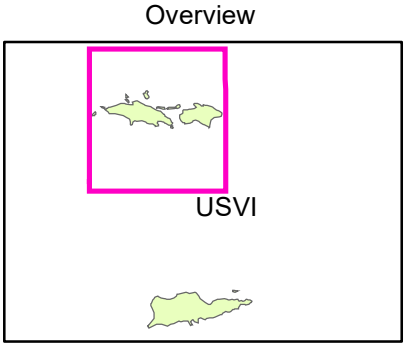
- GC11505 in shapefile format
- Metadata file for GC11505
- PCR in Adobe PDF format

End of Report

ST. THOMAS AND ST. JOHN

U.S. VIRGIN ISLANDS





VI1801A-TB-C

GC11505