NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT OH0906C

Lake Erie, Port Clinton to Huron, Ohio

Introduction

NOAA Coastal Mapping Program (CMP) Project OH0906C provides a highly accurate database of new digital shoreline data for the west end of Lake Erie from Port Clinton to Huron, Ohio, including the Sandusky Bay. Project OH0906C is a sub-project of a larger project, OH0906, which includes shoreline mapping from Belle Isle, Michigan on the Detroit River to Conneaut, Ohio, on the south shore of Lake Erie at the Pennsylvania state line.

Successful completion of this project resulted in digital feature data of the coastal zone which complements the Nautical Charting Program (NCP) as well as geographic information systems (GIS) for a variety of coastal zone management applications.

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.

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 13B, dated January 2008. 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.

This project used digital aerial imagery previously acquired under a contract with the National Geospatial-Intelligence Agency (NGA). The purpose of the NGA project was to produce digital ortho-rectified images maps of the U.S./Canada border regions in the Great Lakes. NOAA recognized the value of using the NGA project data for updating the nautical charts under the Coastal Mapping Program, and arranged with NGA to obtain the original stereo imagery and associated positioning data needed for photogrammetric mapping.

NOAA forwarded all of the NGA provided project imagery, aerotriangulation output data, and ground control coordinates, airborne GPS and IMU data, and Photogrammetric Reports to Aero-Metric, Inc. in order to support photogrammetric processing and feature

compilation. NOAA also provided shapefiles depicting the shoreline to be mapped, the boundaries of the main project and sub-project compilation areas, and flight lines and exposure centers of the imagery to be used for compilation.

Field Operations

Since all source data was provided by NGA through NOAA, AeroMetric was not required to perform any field operations in connection with this project. The field operations that were performed by NGA's contractor (3001, Inc.) and their sub-contractor (Photo Science, Inc.) are described in detail in their Photogrammetric Report for AOI 40, which covers this project area. Following is a brief summary of the field operations as described in those reports.

Field operations for the AOI 40 area included the surveying of ground control points (GCPs) and the acquisition of aerial imagery. Coordinates of thirty-three (33) GCPs were established using static and rapid-static GPS techniques. Survey field work was performed on 8/05/2008 – 8/07/2008 by Photo Science, Inc. Aerial imagery was acquired using a Z/I DMC digital camera operated by Photo Science, Inc. in twenty flights between 7/29/2008 and 10/7/2008. Thirty-six (36) lines of panchromatic, RGB, and NIR imagery were acquired at an approximate altitude of 9,840 feet above mean terrain, resulting in a nominal pan-sharpened image resolution of 0.30 meters GSD. Airborne GPS and Inertial Measurement Unit (IMU) data were collected during the image acquisition flights, along with NAVCOM VueStar data (a global satellite based GPS augmentation system), in order to determine precise camera position and orientation parameters.

GPS Data Reduction

Since pre-processed GPS and IMU data was provided by NGA through NOAA, AeroMetric was not required to perform any GPS data reduction for this project. All GPS/IMU data processing tasks were completed by Photo Science, Inc. and are described in detail in their Photogrammetric Reports for AOI 40. Following is a brief summary of the GPS/IMU data processing tasks described in those reports.

Final GCP coordinate values were determined utilizing precise point positioning techniques using Applanix TerraPOS (ver. 1.2) software and the NGS Online Positioning User Service (OPUS). Though the NAVCOM VueStar system provided decimeter level GPS navigation information in real time, the airborne GPS (ABGPS) data was post-processed using TerraPOS software to improve on the real time results. The Applanix POSPac (AIR) software (ver. 5.1) was used to process the IMU data, and with the POSProc and POSEO modules, the post- processed GPS was combined with the IMU data to compute an optimally accurate navigation solution, and final exterior orientation (EO) parameters (x, y, z, omega, phi, kappa) for each photograph.

Aerotriangulation

Since final exterior orientation values for each photograph were provided by NGA through NOAA, AeroMetric was not required to perform any Aerial Triangulation (AT) for this project. All AT tasks were completed by Photo Science, Inc and are described in

detail in their Photogrammetric Reports for AOI 40. Following is a brief summary of the AT task described in those reports.

Z/I Mission software (ver. 1.4.0.10) was used to export the frame exposure information collected during the flights, and convert it into ImageStation Photogrammetric Manager (ISPM) format. Intergraph ISPM software (ver. 5.2) was used to create a project from these frame exposure files. Z/I Post Processing System (PPS) software (ver. 5.3) was then utilized to produce 8-bit GeoTIFF images from the raw image data collected during the flights, and corrected EO parameters from ABGPS/IMU data were incorporated.

For each DMC virtual image stereo pair, correlated points were generated by an automatic point- matching algorithm using Intergraph ImageStation Automatic Triangulation (ISAT) software (ver. 5.1). Similarly, for each block of images, tie points (photo-identifiable points that occur in the overlap between adjacent flight lines) were automatically generated and GCPs were measured. The ISAT software was then used to develop a least squares bundle adjustment for each block, using the generated tie points, measured GCPs, and post-processed ABGPS/IMU solution as observations. The results of the bundle adjustment were then checked to verify compliance with the accuracy requirement of the project.

The Photogrammetric Report provided by NGA's contractor included accuracy analyses of their resultant orthophoto images, but did not include full accuracy assessments of the least squares bundle adjustments. Therefore AeroMetric used the ISAT output "control" files, which were provided with the rest of the project data, to compute the horizontal accuracy according to NOAA specifications. The "control" file provided the standard deviations of the residuals for each aerotriangulated ground point. From these standard deviation values the root-mean-square (RMS) for both X and Y coordinates was computed, and these were used to compute a predicted horizontal circular error at the 95% confidence level of 0.13 meters for AOI 40. Positional data is referenced to UTM Zone 17N, North American Datum of 1983 (NAD83) in meters.

Compilation

The data compilation phase of the project was initiated by AERO-METRIC, INC. in June 2010. Digital feature extraction was completed in a softcopy stereo environment using DAT/EM Systems International Summit Evolution software (ver. 5.5), and Bentley Systems MicroStation V8. All coding and classification of features occurred within the MicroStation environment as features were collected, and was based on interpretation of the project imagery, and on information extracted from the appropriate NOAA nautical charts 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 OH0906C were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were

compiled to meet a horizontal accuracy of 0.3 meters at the 95% confidence level. The predicted accuracy of compiled, well defined points is calculated by doubling the circular error derived from the aerotriangulation statistics.

The following table provides information on aerial photographs used in the project completion:

Date	Time (UTC)	AOI Block	Line Number	Photo Numbers	GSD (nominal)	Lake Level*
7/31/2008	13:29 - 13:30	40	80022	61 - 64	0.30 m.	174.3
7/31/2008	14:19 - 14:21	40	80021	18 - 06	0.30 m.	174.3
7/31/2008	14:30 - 14:32	40	80020	03 - 16	0.30 m.	174.3
7/31/2008	15:28 - 15:30	40	80019	14 - 03	0.30 m.	174.3
7/31/2008	15:38 - 15:40	40	80022	09 - 19	0.30 m.	174.3
8/1/2008	13:21 - 13:22	40	80018	08 - 12	0.30 m.	174.3
8/16/2008	14:52 - 14:52	40	80023	66 - 64	0.30 m.	174.2
8/16/2008	14:58 - 15:00	40	80023	22 - 11	0.30 m.	174.2
8/16/2008	15:10 - 15:12	40	80024	13 - 24	0.30 m.	174.2
8/16/2008	15:19 - 15:20	40	80024	64 - 67	0.30 m.	174.2
8/16/2008	15:31 - 15:32	40	80025	66 - 69	0.30 m.	174.2
8/16/2008	15:37 - 15:39	40	80025	29 - 15	0.30 m.	174.2
8/16/2008	15:50 - 15:59	40	80026	18 - 70	0.30 m.	174.2
8/16/2008	16:08 - 16:16	40	80027	72 - 21	0.30 m.	174.2
8/18/2008	13:46	40	80022	20	0.30 m.	174.2
8/18/2008	14:04 - 14:11	40	80028	23 - 68	0.30 m.	174.2
8/18/2008	14:29 - 14:36	40	80031	71 - 24	0.30 m.	174.2
8/18/2008	14:47 - 14:50	40	80029	24 - 43	0.30 m.	174.2
8/18/2008	14:53 - 14:55	40	80029	61 - 68	0.30 m.	174.2
8/18/2008	15:02 - 15:07	40	80032	72 - 43	0.30 m.	174.2
8/18/2008	15:09 - 15:10	40	80032	33 - 23	0.30 m.	174.2
8/18/2008	15:23 - 15:27	40	80030	24 - 48	0.30 m.	174.2
8/18/2008	15:37 - 15:40	40	80033	75 - 58	0.30 m.	174.2
8/18/2008	15:45 - 15:46	40	80033	30 - 21	0.30 m.	174.2
8/18/2008	15:58 - 16:00	40	80035	16 - 26	0.30 m.	174.2
8/18/2008	16:18 - 16:20	40	80036	26 - 16	0.30 m.	174.2
8/18/2008	16:31 - 16:32	40	80034	17 - 26	0.30 m.	174.2
8/18/2008	16:40 - 16:40	40	80034	73 - 75	0.30 m.	174.2
8/18/2008	16:46 - 16:48	40	80029	60 - 44	0.30 m.	174.2

* Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the Marblehead station in Ohio. The Low Water Datum (LWD) for the portion of Lake Erie covered by this project is 173.5 m. above IGLD 1985.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion. The final QC review was completed in January 2011. 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 MicroStation software. All project data was evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with natural color photographs and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following nautical charts were used in the comparison process:

> 14830, West End of Lake Erie, 1:100,000 scale, 32nd Ed., Jul/07
> 14842, Port Clinton to Sandusky, small craft/various scales, 15th Ed., Jan/08
> 14843, Huron Harbor, 1:5,000 scale, 23rd Ed., Feb/04
> 14844, Islands in Lake Erie; Put-In-Bay, 1:40,000 scale, 32nd Ed., Feb/04
> 14845, Sandusky Harbor, 1:10,000 scale, 27th Ed., Nov/03

End Products and Deliverables

The following specifies the location and identification of the products generated during the completion of this project:

RSD Applications Branch Archive
- Hardcopy of the Photogrammetric Report
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10815 file contents, attached to PCR

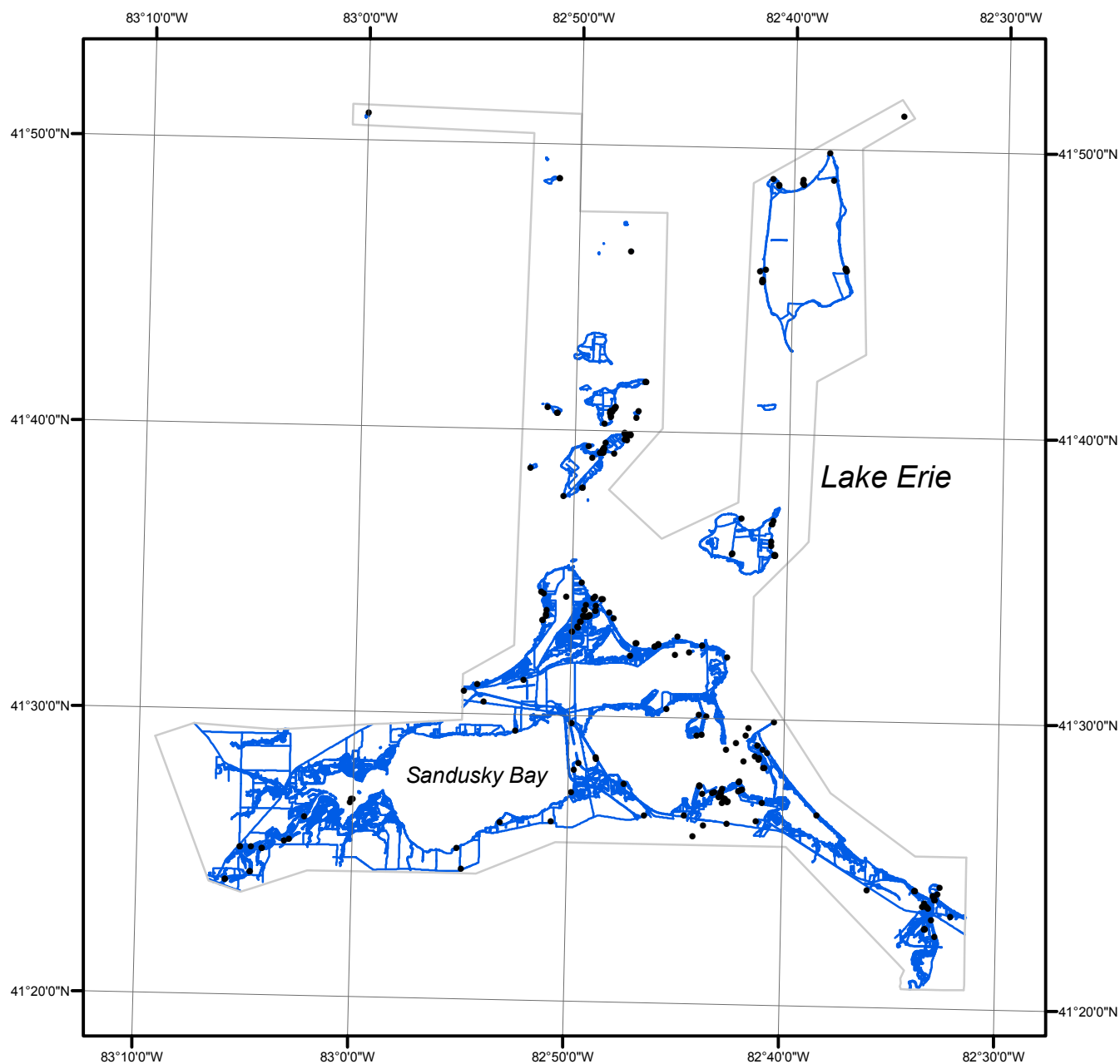### Remote Sensing Division Electronic Data Library
- Project Database
- GC10815 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- Chart Evaluation File in shapefile format

NOAA Shoreline Data Explorer
- GC10815 in shapefile format
- Metadata file for GC10815
- Digital copy of the PCR in Adobe PDF format

End of Report

LAKE ERIE, PORT CLINTON TO HURON,

OHIO

Lake Erie

Sandusky Bay

Overview

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GC10815