

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT MI0906E

South Lake St Clair, Anchor Bay to St Lukes Bay, Michigan and Ontario

Introduction

NOAA Coastal Mapping Program (CMP) Project MI0906E provides a highly accurate database of new digital shoreline data for a portion of Lake St. Clair, from just north of the Selfridge Field Boat Launch on the northwestern side of the lake down to the start of the Detroit River, including Peche Island, then continuing along the entire southern side of the lake to just past the Thames River in Ontario, Canada.

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, ground control coordinates, airborne GPS and IMU data, and Photogrammetric Reports to Western Air Maps, Inc. (WAM)/Wilson & Company 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, WAM 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 Reports for AOI 40 and 43, which cover this project area. Following is a brief summary of the field operations as described in those reports.

AOI 40:

Field operations 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 between 8/05/2008 and 08/07/2008 by Photo Science, Inc. Aerial imagery was acquired using a Z/I DMC digital camera operated by Photo Science, Inc. in thirteen flights on 7/31/2008, 8/01/2008, 8/03/2008, 8/12/2008, 8/15/2008, 8/16/2008, 8/18/2008, 8/19/2008, 8/20/2008, 8/21/2008, 8/30/2008, 8/31/2008, and 10/07/2008. Fifty-six (56) 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 satellite based GPS augmentation system), in order to determine precise camera position and orientation parameters.

AOI 43:

The original NGA scope of work had no provision for the survey of ground control points outside the borders of the United States. Since the entire area of AOI 43 is located in Canada, no ground survey work was conducted in this part of the project area. Aerial imagery was acquired using a Z/I DMC digital camera operated by Photo Science, Inc. in four flights on 8/31/2008, 9/02/2008, 9/03/2008, and 9/11/2008. Thirty-one (31) 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/IMU and NAVCOM VueStar data were collected during the image acquisition flights 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, Western Air Maps/Wilson & Company 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 and AOI 43, which cover this project area. 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. 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, Western Air Maps, Inc. (WAM)/Wilson & Company 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 and AOI 43, which cover this project area. Due to the size of the AOI 40 block of photography, AT was performed on these images in two sub-blocks, 40A and 40B, but only the images in sub-block 40B fell within this project area and were used for mapping. Following is a brief summary of the AT tasks described in the report for AOI 40.

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 derived 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.

WAM conducted a spot check of the NOAA provided AT solution for AOI 40 to ensure that the AT results were of sufficient accuracy to proceed with shoreline compilation. This quality assurance step was conducted using Intergraph ISAT software, as the image data sets had been triangulated previously (by Photo Science, Inc) using the same tool. The AOI 43 imagery was completely outside the U.S. (in Canada), and thus aerotriangulation was not performed for this image block. The geometric correction of the AOI 43 imagery was based on ABGPS/IMU solutions only. After the Intergraph data had been converted into a format easily imported into SOCET SET, the image blocks were again inspected to make sure that the data conversion had not introduced errors that would adversely affect data compilation.

The Photogrammetric Reports 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. Western Air Maps Inc./Wilson & Company 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 40B image block.

Positional data is referenced to UTM Zone 17N, North American Datum of 1983 (NAD83).

Compilation

The data compilation phase of this project was initiated by Western Air Maps, Inc. /Wilson & Company in December, 2009. Digital mapping was performed using SOCET for ArcGIS (Version 9.3.1) and SOCET SET (Version 5.5.0) software. Feature identification and attribution within the Geographic Cell (GC) was based on interpretation of the project imagery, and information extracted from the appropriate NOAA nautical charts, the US 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.

To expedite delivery and to assure quality, WAM delivered pilot compilation areas for review and comment. Upon receiving NOAA review comments, the pilot area shapefiles were finalized and then used as templates for the remaining compilation of shoreline in the project area. This quality assurance step was felt to be necessary to ensure that there would be no confusion regarding how the shoreline needed to be compiled. This particular production step was clearly defined in the project instructions as well as in the quality assurance/quality control plan submitted by WAM and approved by NOAA at the start of the project.

Spatial data accuracies for the U.S. portion of Project MI0906E were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features in AOI 40 were compiled to meet a horizontal accuracy of 0.3 meters at the 95% confidence level. This predicted accuracy of compiled, well defined points is calculated by doubling the circular error derived from the aerotriangulation statistics. Due to the lack of ground control, aerotriangulation was not performed for AOI 43 images, and spatial data accuracies for features compiled from those images could not be determined according to standard FGDC practices. Instead spatial data accuracies for these features were estimated based on commonly expected results of ABGPS/IMU derived EO parameters, and on a comparison with three control stations in the Canadian Spatial Reference System Database. Cartographic features in AOI 43 were compiled to meet a horizontal accuracy of 2.0 meters at the 95% confidence level based on this estimate.

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

Date	Time (UTC)	AOI Block	Line Number	Photo Numbers	GSD (Nominal)	Lake Level *
8/19/2008	19:59 – 20:05	40	80045	58 – 18	0.30m	175.1
8/19/2008	20:18 – 20:19	40	80046	14 – 20	0.30m	175.1
8/19/2008	20:23 – 20:25	40	80046	44 – 55	0.30m	175.1
8/19/2008	21:00 – 21:01	40	80047	48 – 43	0.30m	175.1
8/19/2008	21:04 – 21:05	40	80047	18 – 13	0.30m	175.1
8/19/2008	21:15 – 21:16	40	80048	10 – 16	0.30m	175.1
8/20/2008	14:12 – 14:16	40	80044	53 – 27	0.30m	175.1
8/30/2008	15:55 – 15:56	40	80050	10 – 05	0.30m	175.0
8/30/2008	16:42 – 16:43	40	80051	08 – 03	0.30m	175.0
8/30/2008	16:51 – 16:52	40	80049	07 – 12	0.30m	175.0
8/31/2008	13:35 – 13:38	40	80043	26 – 45	0.30m	175.0
8/31/2008	16:04 – 16:06	40	80044	26 – 16	0.30m	175.0
9/2/2008	14:55 – 14:56	43	81010	62 – 68	0.30m	175.0
9/2/2008	15:11 – 15:13	43	81009	68 – 56	0.30m	175.0
9/2/2008	15:50 – 15:51	43	81011	65 – 62	0.30m	175.0
9/2/2008	20:43 – 20:47	43	81008	72 – 50	0.30m	175.0
9/3/2008	13:42 – 13:44	43	81007	45 – 56	0.30m	175.0
9/3/2008	13:45 – 13:47	43	81007	63 – 74	0.30m	175.0
9/3/2008	14:00 – 14:00	43	81006	67 – 64	0.30m	175.0
9/3/2008	14:02 – 14:04	43	81006	51 – 40	0.30m	175.0
9/3/2008	14:23 – 14:24	43	81005	33 – 41	0.30m	175.0
9/3/2008	14:49 – 14:49	43	81010	59 – 61	0.30m	175.0
9/3/2008	15:13 – 15:13	43	81009	71 – 69	0.30m	175.0

* Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the St. Clair Shores, MI 9034052 Tide Station, for both the AOI 40 and 43 flights. The Low Water Datum (LWD) for the portion of Lake St. Clair covered by this project is 174.4 m. above IGLD 1985.

Quality Control / Final Review

Western Air Maps, Inc. personnel conducted quality assurance (QA) reviews during all phases of project completion. The final review was completed in July, 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 ArcGIS 9.3.1 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 chart was used in the comparison process:

- 14850, Lake St. Clair, MI, 1:60,000 scale, 54th Ed., Feb./11
- 14853, Lake St. Clair & St. Clair River (Small-Craft Book Chart), 1:15,000 scale, 17th Ed., Mar./08

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 Aerotriangulation Report
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10804 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project database
- GC10804 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

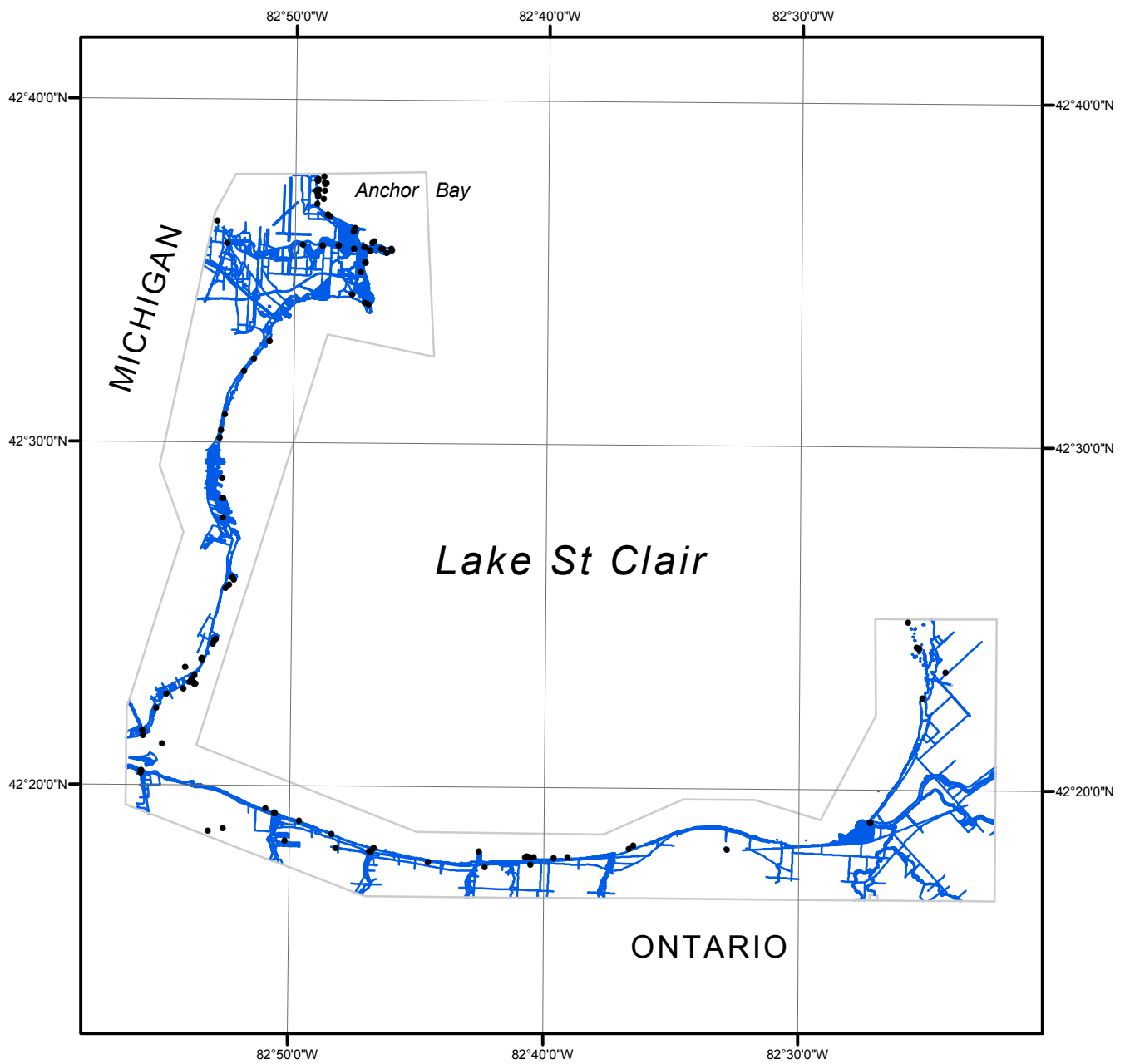
NOAA Shoreline Data Explorer

- GC10804 in shapefile format
- Metadata file for GC10804
- Digital copy of the PCR in Adobe PDF format

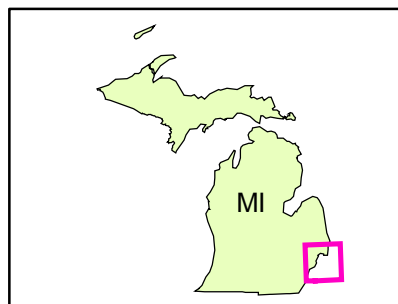
End of Report

SOUTH LAKE ST CLAIR, ANCHOR BAY TO ST LUKES BAY

MICHIGAN AND ONTARIO



Overview



MI0906E

GC10804