

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT MI0906C

St. Clair River, Port Huron to Lake St. Clair, Michigan and Ontario

Introduction

NOAA Coastal Mapping Program (CMP) Project MI0906C provides a highly accurate database of new digital shoreline data for a portion the St Clair River, from Port Huron, MI southwards to where the river delta spills into Lake St. Clair. Near Algonac, MI the project shifts slightly eastward to include only the areas south and east of the St. Clair River South Channel, including Walpole Island, Chenal Ecarté, and Mitchells Bay 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's 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:

Since the NGA project specified that no ground control was to be collected outside the borders of the United States, and this AOI is located entirely in Canada, no ground control was collected. 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's 40 and 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 (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, 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 the Photogrammetric Report for AOI 40. Aerotriangulation was not performed for AOI 43 since it is located entirely within Canada. Due to the size of the AOI 40 block of photography, AT was performed in two sub-blocks, but only the images in sub-block B covered this project area and were used for mapping. Following is a brief summary of the AT tasks described in the report.

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 set had been triangulated previously (by Photo Science, Inc) using the same tool. With the AOI 43 imagery, the geometric correction and the accuracy of the EO parameters with this block of images is based solely on the direct georeferencing of the images using the final trajectory values produced from combining the ABGPS and IMU measurements obtained during the acquisition mission. After the georeferencing data had been converted into a format easily imported into SOCET SET, the images were again inspected to make sure that the data conversion had not introduced errors that would adversely affect data compilation.

The Photogrammetric Report for AOI 40, 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. WAM 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 were computed, and these were used to calculate a predicted horizontal circular error at the 95% confidence level of 0.13 meters for the AOI 40 sub-block B images.

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. (WAM)/Wilson & Company in December, 2009. Digital mapping was performed using SOCET for ArcGIS (Version 9.3) 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 provided 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 a template 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 MI0906C 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. The 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 following table provides information on aerial photographs used in the project completion:

Date	Time (UTC)	AOI Block	Line Number	Photo Numbers	GSD (Nominal)	Water Level*
8/19/2008	19:20:59-19:22:35	40	80055	1-10	0.30m	175.0(4)
8/19/2008	19:22:46-19:25:15	40	80055	11-25	0.30m	175.2(3)
8/30/2008	14:31:14-14:33:03	40	80052	80-68	0.30m	175.9(1)
8/30/2008	14:33:12-14:35:57	40	80052	67-49	0.30m	175.6(2)
8/30/2008	14:36:06-14:39:54	40	80052	48-23	0.30m	175.2(3)
8/30/2008	14:40:03-14:40:52	40	80052	22-17	0.30m	175.0(4)
8/30/2008	14:51:39-14:54:10	40	80056	1-15	0.30m	175.2(3)
8/30/2008	15:16:49-15:18:07	40	80053	7-14	0.30m	175.0(4)

8/30/2008	15:18:18-15:22:33	40	80053	15-39	0.30m	175.2(3)
8/30/2008	15:22:43-15:23:56	40	80053	40-47	0.30m	175.5(2)
8/30/2008	15:43:07-15:44:38	40	80050	92-82	0.30m	175.9(1)
8/30/2008	15:44:47-15:46:27	40	80050	81-70	0.30m	175.5(2)
8/30/2008	15:51:30-15:52:16	40	80050	37-32	0.30m	175.0(4)
8/30/2008	16:04:57-16:06:24	40	80054	5-13	0.30m	175.0(4)
8/30/2008	16:06:35-16:09:05	40	80054	14-28	0.30m	175.2(3)
8/30/2008	16:30:17-16:31:57	40	80051	89-78	0.30m	175.9(1)
8/30/2008	16:32:06-16:34:51	40	80051	77-59	0.30m	175.5(2)
8/30/2008	16:35:00-16:38:41	40	80051	58-34	0.30m	175.2(3)
8/30/2008	16:38:51-16:39:37	40	80051	33-28	0.30m	175.0(4)
9/03/2008	13:46:21-13:47:13	43	81007	69-74	0.30m	175.0(4)
9/03/2008	13:59:01-14:00:38	43	81006	74-64	0.30m	175.0(4)
9/03/2008	14:27:35-14:29:36	43	81005	58-70	0.30m	175.0(4)
9/03/2008	14:29:46-14:30:16	43	81005	71-74	0.30m	175.2(3)
9/03/2008	14:37:14-14:38:04	43	81004	39-34	0.30m	175.2(3)
9/03/2008	14:38:14-14:40:23	43	81004	33-20	0.30m	175.0(4)
9/03/2008	16:02:47-16:03:48	43	81002	7-1	0.30m	175.1(3)

* Water levels are given in meters above IGLD 1985 and are based on verified observations at the following NOS stations: (1) Dry Dock – 9014087, (2) St. Clair State Police – 9014080, (3) Algonac – 9014070, and (4) St. Clair Shores – 9034052. The Low Water Datum (LWD) for Lake St. Clair is 174.4 m., and the LWD for the applicable portion of the St. Clair River varies between 174.6 m. at Algonac, and 175.5 m. at Dry Dock station.

Quality Control / Final Review

Western Air Maps, Inc. (WAM)/Wilson & Company personnel conducted quality assurance (QA) reviews during all phases of project completion. The final QC review was completed in October 2010. 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 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:

- 14850, Lake St. Clair, MI, 1:60,000 scale, 53rd Ed., Sep/06
- 14852, Saint Clair River, MI, 1:40,000 scale, 46th Ed., Jun/06
- 14853, Detroit R., Lake St. Clair and St. Clair R., MI, 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 Photogrammetric Report
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10802 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project database
- GC10802 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

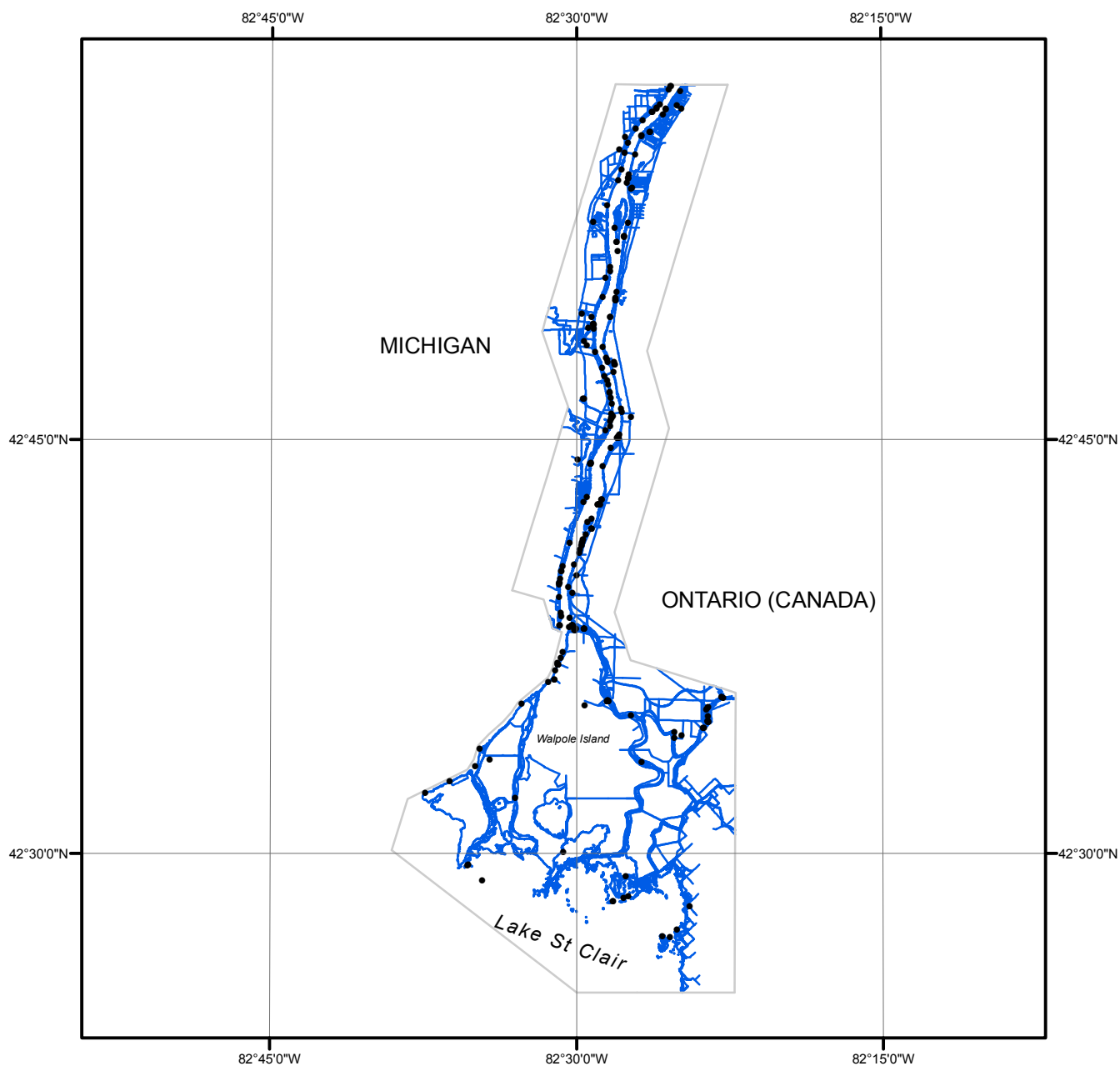
NOAA Shoreline Data Explorer

- GC10802 in shapefile format
- Metadata file for GC10802
- Digital copy of the PCR in Adobe PDF format

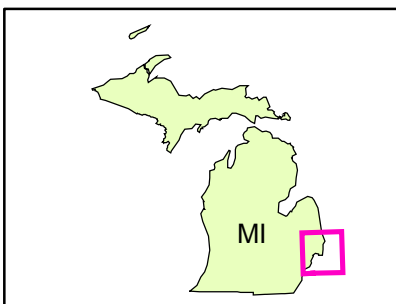
End of Report

ST CLAIR RIVER, PORT HURON TO LAKE ST CLAIR

MICHIGAN AND ONTARIO



Overview



MI0906C

GC10802