

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

## ***PROJECT NY0905A***

### ***Welland Canal, Lake Erie to Lake Ontario, Ontario and New York***

#### **Introduction**

NOAA Coastal Mapping Program (CMP) Project NY0905A provides a highly accurate database of new digital shoreline data for portions of Lake Erie and Lake Ontario, as well as the Welland Canal and various tributaries in Ontario, Canada and New York. Project NY0905A is a sub-project of a larger project, NY0905, which includes shoreline mapping from Port Colborne in Lake Erie to Massena in the St Lawrence River.

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 image 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 Photo Science, 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**

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 AOIs 46 and 50, which cover this project area. Following is a brief summary of the field operations as described in those reports.

### **AOI 46:**

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 between 10/06/2008 and 10/12/2008. Forty (40) 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.

### **AOI 50:**

Field operations included the surveying of ground control points (GCPs) and the acquisition of aerial imagery. Coordinates of twenty-one (21) GCPs were established using static and rapid-static GPS techniques. Survey field work was performed between 08/09/2008 and 08/19/2008 by Photo Science, Inc. Aerial imagery was acquired using a Z/I DMC digital camera operated by Photo Science, Inc. in three flights on 9/24/2008, 09/25/2008 and 10/07/2008. Thirty-five (35) 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**

All GPS/IMU data processing tasks were completed by Photo Science, Inc. for a previous contract with NGA and are described in detail in their Photogrammetric Reports for AOIs 46 and 50, 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**

All AT tasks were completed by Photo Science, Inc. for NGA for a previous contract and are described in detail in the Photogrammetric Report for AOI 50. Aerotriangulation was not performed for AOI 46 since it is located entirely within Canada. The following is a brief summary of the aerotriangulation tasks described in the report for AOI 50.

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 GCP's were measured. The ISAT software was then used to develop a least squares bundle adjustment for each block, using the generated tie points, measured GCP's, 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 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. Therefore Photo Science 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 ISAT "control" file provided the standard deviations of the residuals for each aerotriangulated ground point. From these standard deviation values the root-meansquare (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 0.2 meters for AOI 50. Positional data is referenced to UTM Zone 17N, North American Datum of 1983 (NAD83).

## **Compilation**

The data compilation phase of the project was initiated by Photo Science, Inc. in August 2009. Digital mapping was performed using a DPW in conjunction with the SOCET SET version 5.4.1. All coding and classification of features occurred within the Socet Set 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. Photo Science was also required to edge-match this project to the project NY0501B located along the Niagara River.

Spatial data accuracies for Project NY0905A were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features in AOI 50 were compiled to meet a horizontal accuracy of 0.4 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 and aerotriangulation procedures spatial data accuracies for features within AOI 46 could not be determined according to standard Federal Geographic Data Committee (FGDC) practices, but instead were estimated based on commonly expected results of ABGPS/IMU derived EO parameters, and on a comparison with one benchmark station in the Canadian Spatial Reference System Database. Cartographic features 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:

| <b>Date</b> | <b>Time (UTC)</b> | <b>AOI Block</b> | <b>Line Number</b> | <b>Photo Numbers</b> | <b>GSD (nominal)</b> | <b>Lake Level*</b> |
|-------------|-------------------|------------------|--------------------|----------------------|----------------------|--------------------|
| 09-24-08    | 19:27 – 19:30     | 50               | 86001              | 13-40                | 0.30 m               | 74.7               |
| 09-24-08    | 19:37-19:41       | 50               | 86002              | 113-85               | 0.30m                | 74.7               |
| 09-24-08    | 19:43 – 19:44     | 50               | 86002              | 71-63                | 0.30 m               | †174.0             |
| 09-24-08    | 20:06 -20:07      | 50               | 86003              | 62-69                | 0.30 m               | †174.0             |
| 9-24-08     | 20:09-20:13       | 50               | 86003              | 84-112               | 0.30m                | 74.7               |
| 09-25-08    | 14:23 – 14:24     | 50               | 86005              | 61-66                | 0.30 m               | †174.1             |
| 9-25-08     | 14:29-14:30       | 50               | 86005              | 106-111              | 0.30m                | 74.7               |
| 9-25-08     | 14:36-14:37       | 50               | 86006              | 110-105              | 0.30m                | 74.7               |
| 09-25-08    | 14:42-14:43       | 50               | 86006              | 65-60                | 0.30m                | †174.1             |
| 09-25-08    | 15:10-15:11       | 50               | 86007              | 104-109              | 0.30 m               | 74.7               |
| 9-25-08     | 15:17-15:18       | 50               | 86008              | 109-104              | 0.30 m               | 74.7               |
| 09-25-08    | 15:51-15:52       | 50               | 86009              | 102-107              | 0.30 m               | 74.8               |
| 09-25-08    | 15:58-15:59       | 50               | 86010              | 106-102              | 0.30 m               | 74.8               |
| 09-25-08    | 16:40-16:41       | 50               | 86011              | 101-106              | 0.30 m               | 74.7               |
| 9-26-08     | 14:21-14:22       | 50               | 86012              | 100-105              | 0.30 m               | 74.7               |
| 9-26-08     | 14:29-14:30       | 50               | 86013              | 104-99               | 0.30 m               | 74.7               |
| 9-26-08     | 15:00-15:01       | 50               | 86014              | 97-102               | 0.30 m               | 74.7               |
| 9-26-08     | 15:08-15:09       | 50               | 86015              | 99-94                | 0.30 m               | 74.7               |
| 9-26-08     | 15:38-15:39       | 50               | 86016              | 91-95                | 0.30 m               | 74.8               |
| 9-26-08     | 15:53-15:54       | 50               | 86004              | 67-62                | 0.30 m               | †173.9             |
| 9-26-08     | 15:47-15:51       | 50               | 86004              | 111-83               | 0.30m                | 74.7               |
| 10-7-08     | 15:18-15:19       | 50               | 86019              | 79-83                | 0.30 m               | 74.7               |
| 10-7-08     | 15:57-15:58       | 50               | 86020              | 73-77                | 0.30 m               | 74.7               |
| 10-7-08     | 16:01-16:02       | 50               | 86018              | 89-84                | 0.30 m               | 74.7               |
| 10-11-08    | 15:05-15:06       | 46               | 83004              | 99-97                | 0.30 m               | †174.0             |
| 10-11-08    | 16:17-16:19       | 46               | 83008              | 65-82                | 0.30 m               | †174.0             |
| 10-11-08    | 16:25-16:27       | 46               | 83005              | 108-101              | 0.30 m               | †174.0             |
| 10-11-08    | 17:00-17:03       | 46               | 83010              | 25-52                | 0.30 m               | †174.0             |
| 10-12-08    | 14:37-14:38       | 46               | 83006              | 102-96               | 0.30 m               | †173.9             |

|          |             |    |       |       |        |        |
|----------|-------------|----|-------|-------|--------|--------|
| 10-12-08 | 15:14-15:14 | 46 | 83007 | 87-91 | 0.30 m | †173.9 |
| 10-12-08 | 15:21-15:23 | 46 | 83011 | 15-3  | 0.30 m | †174.0 |
| 10-12-08 | 15:29-15:30 | 46 | 83010 | 45-51 | 0.30 m | †174.0 |

\*Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the Buffalo and Olcott stations in New York. The Low Water Datum (LWD) for the portion of Lake Erie covered by this project is 173.5 m above IGLD 1985. The Low Water Datum (LWD) for the portion of Lake Ontario covered by this project is 74.2 m above IGLD 1985. Water levels for flight lines and exposures not located over or along a Great Lake shoreline may differ depending on the location.

† Lake water level referenced to Olcott station.

## Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion. The final QC review was completed in September 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 Arc GIS 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:

- 14806, Thirtymile Point to Port Dalhousie, 1:80,000 scale, Oct /04
- 14816, Lower Niagara River, 1:30,000 scale, Feb /04
- 14822, Approaches to Niagara Riv./Welland Canal, 1:80,000 scale, Aug /05
- 14832, Upper Niagara River, 1:30,000 scale, Oct. /02

## 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 GC10826 file contents, attached to PCR

### Remote Sensing Division Electronic Data Library

- Project database
- GC10826 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

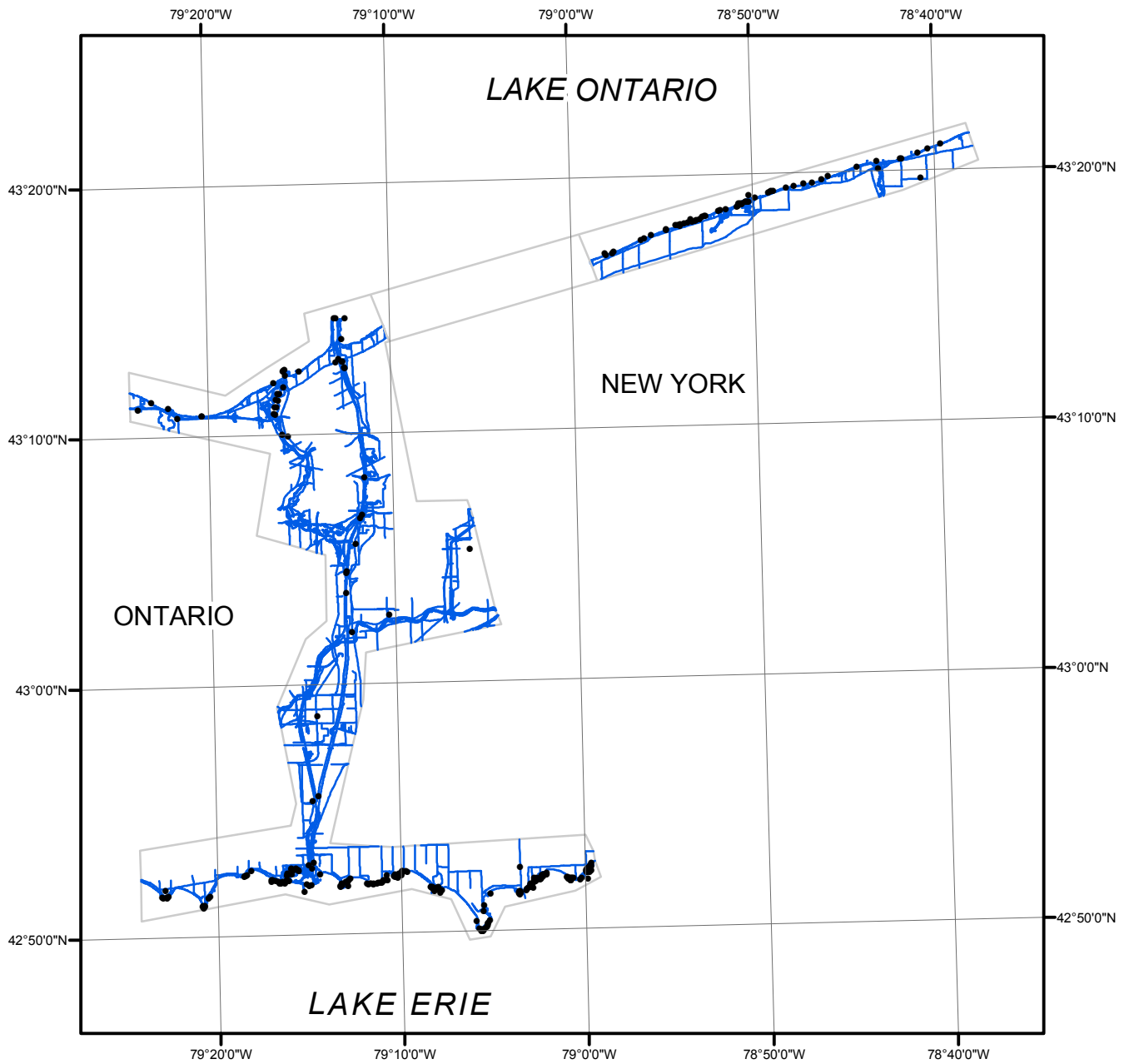
### NOAA Shoreline Data Explorer

- GC10826 in shapefile format
- Metadata file for GC10826
- Digital copy of the PCR in Adobe PDF format

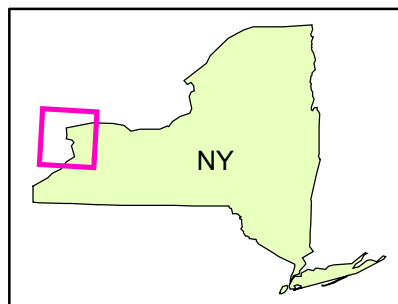
## End of Report

# WELLAND CANAL, LAKE ERIE TO LAKE ONTARIO

## ONTARIO AND NEW YORK



Overview



NY0905A

GC10826