

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT MI1001H-CM-N

Holland Harbor to Michigan City, Michigan and Indiana

Introduction

NOAA Coastal Mapping Program (CMP) Project MI1001H-CM-N provides a highly accurate database of new digital shoreline data for a portion of Lake Michigan from Holland Harbor to Michigan City and includes various tributaries. MI1001H-CM-N is a subproject of the project MI1001-CM-N which covers the eastern part of Lake Michigan. 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

The Requirements Branch (RB) of the Remote Sensing Division (RSD) formulated the photographic mission instructions for this project following the guidelines of the Photo Mission Standard Operating Procedures. The instructions discussed the project's purpose, geographic area of coverage, photographic requirements, Global Positioning System (GPS) data collection procedures and guidelines for both kinematic and static surveys, and data recording and handling instructions. RB also created project layout diagrams, flight maps, and input files for the aircraft's flight management system.

Field Operations

The field operations consisted of the collection of static and kinematic GPS data, Inertial Measurement Unit (IMU) data, the acquisition of digital aerial imagery, and the collection of ground control points. Photographic mission operations for MI1001-CM-N were conducted from September 7, 2010 to July 5, 2011 with the NOAA King Air (N68RF) aircraft. Two hundred and four flight lines of color (RGB) imagery, along with simultaneous black & white infrared (IR) imagery, were acquired with an Applanix Digital Sensor System (DSS) 439 aerial camera at a nominal altitude of 10,000 feet, resulting in an approximate ground sample distance (GSD) of 0.35 meters. For subproject MI1001H-CM-N, only seventeen flight lines each of RGB and IR imagery were used.

Quantum Spatial (QS) was contracted by RSD to collect ground control points (GCPs). A total of seven GCPs were established in subproject MI1001H-CM-N using static GPS techniques. Three additional photo-identifiable check points were also occupied at well-defined discrete locations. Survey field work was performed between August 9 and August 11, 2014.

GPS Data Reduction

The GPS/IMU data was processed by RSD personnel to yield precise positions and orientations of camera centers for application as photogrammetric control in the aerotriangulation phase of project completion. A local GPS base station was established for use as a reference station for kinematic GPS processing operations. The position of the base station was determined using the NGS Online Processing User Service (OPUS), which computed fixed baseline solutions from

nearby CORS stations. The airborne kinematic data was processed in May 2012 (2010 imagery) using Applanix POSPAC (ver. 5.4.0) software, and in January 2013 (2011 imagery) using POSPAC (ver. 6.1.0). For further information refer to the Airborne Positioning and Orientation Reports (APORs) that are on file with other project data within the RSD Electronic Data Library.

Aerotriangulation

Routine softcopy aerotriangulation methods were applied to establish the network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. This work was completed by QS personnel in January 2015 utilizing a softcopy photogrammetric workstation. The RGB and IR images were measured and adjusted as a single block. The Intergraph ImageStation Automatic Triangulation (ISAT) software (ver. 5.1) was used to perform automatic point measurements and interactive point measurements of tie points. The photo measurements were then exported to Bingo aerotriangulation software (ver. 6.2) to perform the final bundle block adjustment, and analysis tools within Bingo were used to refine the AT solution and to evaluate the accuracy of the adjustment.

Upon successful completion of the aerotriangulation process, the BINGO software provided the RMS of the standard deviations of the residuals for each aerotriangulated ground point which were used to compute a predicted horizontal circular error of 0.9 meters based on a 95% confidence level. An Aerotriangulation Report was completed and is on file with other project data within the RSD Electronic Data Library.

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

The data compilation phase of the project was initiated by QS personnel in March of 2015. The work was accomplished using a Digital Photogrammetric Workstation (DPW), which is a configuration of computer hardware, modular software components and other associated peripheral devices. The Feature Extraction module was used within BAE Systems' SOCET SET (version 5.6) photogrammetric software. Feature identification and the assignment of cartographic codes were based on image analysis of the project digital images and information extracted from the appropriate NOAA Nautical Charts, U.S. Coast Guard Light List and other ancillary sources. Feature attribution was assigned in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST). Selected features were further modified with additional descriptive information to refine general classification.

Spatial data accuracies for Project MI1001H-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were compiled to meet a horizontal accuracy of 1.8 meters at the 95% confidence level. This predicted accuracy of well-defined points is based on a doubling of the circular error derived from the aerotriangulation statistics.

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

Date	Time (UTC)	Color Imagery		Infrared Imagery		Lake Level
		Roll	Images	Roll	Images	
09-07-2010	18:03 – 18:08	10NC17	6970 – 7000	10NR16	7106 – 7136	176.2
09-07-2010	18:23 – 18:29	10NC17	7001 – 7041	10NR16	7137 – 7177	176.2
09-07-2010	18:35 – 18:38	10NC17	7042 – 7058	10NR16	7178 – 7194	176.2
09-07-2010	18:45 – 18:49	10NC17	7059 – 7082	10NR16	7195 – 7218	176.2
09-07-2010	18:56 – 19:01	10NC17	7083 – 7110	10NR16	7219 – 7246	176.2
09-07-2010	19:04 – 19:07	10NC17	7111 – 7126	10NR16	7247 – 7262	176.2
06-28-2011	15:55 – 15:59	11NC46	13330 – 13363	11NR25	7264 – 7297	176.3
06-28-2011	16:06 – 16:11	11NC46	13364 – 13399	11NR25	7298 – 7333	176.3
06-28-2011	16:14 – 16:15	11NC46	13400 – 13411	11NR25	7334 – 7345	176.3
06-28-2011	16:19 – 16:23	11NC46	13412 – 13441	11NR25	7346 – 7375	176.3
06-28-2011	16:30 – 16:31	11NC46	13442 – 13454	11NR25	7376 – 7388	176.3
06-28-2011	16:43 – 16:45	11NC46	13455 – 13469	11NR25	7389 – 7403	176.3
06-28-2011	16:49 – 16:52	11NC46	13470 – 13486	11NR25	7404 – 7420	176.3
06-28-2011	16:56 – 16:59	11NC46	13487 – 13503	11NR25	7421 – 7437	176.3
06-28-2011	17:07 – 17:09	11NC46	13504 – 13521	11NR25	7438 – 7455	176.3
07-04-2011	21:18 – 21:20	11NC51	17182 – 17198	11NR30	11116 – 11132	176.3
07-04-2011	21:24 – 21:27	11NC51	17199 – 17215	11NR30	11133 – 11149	176.3
07-04-2011	21:33 – 21:36	11NC51	17216 – 17231	11NR30	11150 – 11176	176.3

* Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the Holland station in Michigan. The Low Water Datum (LWD) for Lake Michigan is 176.0 meters.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of QS. The final QC review was completed in August 2015. 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 10.1 software. All project data were evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with RGB and B&W IR images and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following nautical charts were used in the comparison process:

14905, Waukegan to South Haven, MI, 1:120,000 scale, 32nd Ed.
14906, South Haven to Stony Lake, MI, 1:120,000 scale, 25th Ed.
14926, Indiana Harbor to Michigan City, 1:60,000 scale, 13th Ed.
14930, St Joseph and Benton Harbor, MI, 1:10,000 scale, 26th Ed.
14932, Holland Harbor, MI, 1:15,000 scale, 24th Ed.

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

- Ground Control Report
- Airborne Positioning and Orientation Report (APOR)
- Aerotriangulation Report
- Project Completion Report (PCR)
- Project database
- GC11087 in shapefile format
- Chart Evaluation File in shapefile format

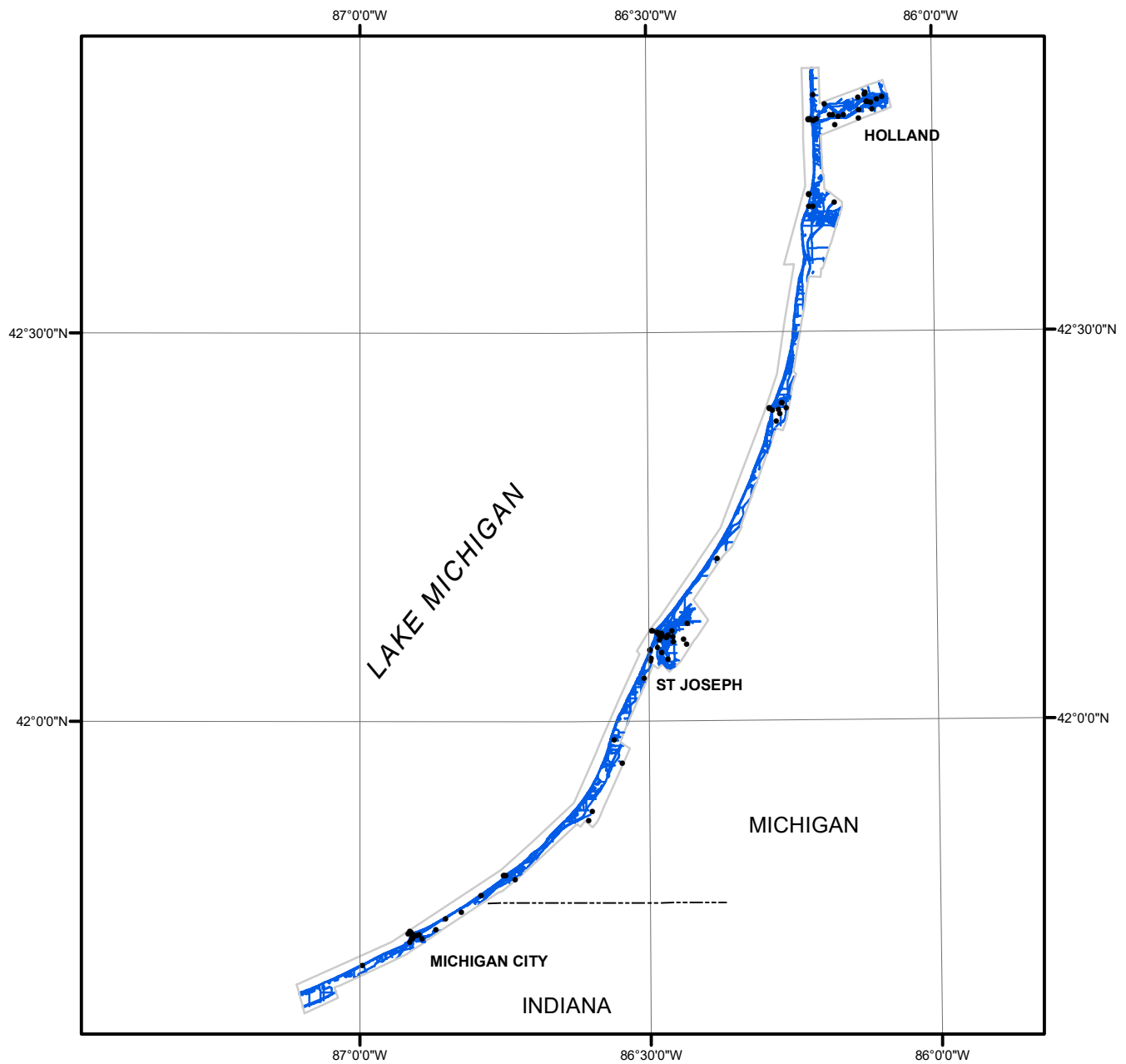
NOAA Shoreline Data Explorer

- GC11087 in shapefile format
- Metadata file for GC11087
- Digital copy of the PCR

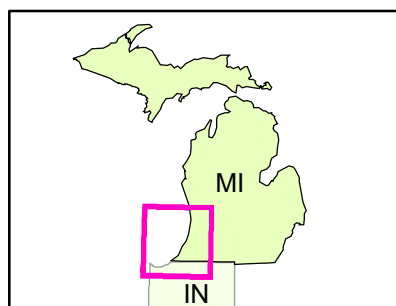
End of Report

HOLLAND HARBOR TO MICHIGAN CITY

MICHIGAN AND INDIANA



Overview



MI1001H-CM-N

GC11087