NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT LA0501A

Western Vermilion Bay

Introduction

NOAA Coastal Mapping Program (CMP) Project LA0501A provides a highly accurate database of new digital shoreline data for the western portion of Vermilion Bay and surrounding coastal areas. The project extends from the entrance of Freshwater Bayou Canal northward to Four Mile Cutoff. Project LA0501A is a subproject of a larger project, LA0501, which extends from Freshwater Bayou Canal eastward to Cypremort Point, and includes all of Vermilion Bay and Marsh Island.

Two previous NGS shoreline mapping projects fall within the boundaries of this project. One covers Freshwater Bayou Canal, and the other covers a portion of the Gulf Intracoastal Waterway (GIWW) including the port of Intracoastal City. Inspection of these areas in the new imagery revealed no significant shoreline changes, and therefore no recompilation occurred.

Successful completion of this project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric-quality aerial photographs, and 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

AERO-METRIC, INC. formulated the photographic missions for this project following the guidelines of the Coastal Mapping Program Specifications for Shoreline Mapping and the Project Instructions prepared by NOAA dated February 22, 2005. The guidelines discussed the project's purpose, geographic area of coverage, scope and priority; photographic requirements; flight line priority; Global Positioning System (GPS) data collection procedures and guidelines for both kinematic and static surveys; data recording and handling instructions; and contact and communication information.

The project limits were provided by NOAA on hardcopy Nautical Chart 11345 and also in digital ArcView Shapefile format. These sources were used to depict the approximate locations of the shoreline to be mapped. AERO-METRIC, INC. created a Project Layout Diagram, flight maps and input files for the aircraft's flight management system.

Field Operations

AERO-METRIC acquired imagery for LA0501A on several dates between November 2006 and March 2008. All imagery was acquired with either a Piper Navajo PA31-310 or an Aero-Commander fixed wing aircraft using a Zeiss RMK TOP 15 camera equipped with Forward Motion Compensation, serial number 145852 (lens serial number 145902), with calibrated focal lengths of 153.048 mm (calibration date 1/16/2004) and 153.035 mm (calibration date 1/19/2007). The current USGS calibration reports for the camera were submitted to NOAA.

Color (CN) and Black and White Infrared (BWIR) imagery was collected for this project with thirteen flight lines for each film medium at 1:30,000 scale with 60% forward overlap and 30% sidelap between parallel strips, along with the simultaneous collection of kinematic GPS and IMU positioning and orientation data. CN film was acquired at tide stages at or below the MHW level. The BWIR film was acquired at tide stages at or below allowable tolerances of MLLW level. Flight crews coordinated with ground personnel who were monitoring shoreline conditions to determine if conditions were suitable for imagery acquisition.

The airborne positioning was based on two NSRS (National Spatial Reference System) stations and one NGS CORS (Continually Operating Reference Stations) station. The NSRS stations were DATUM (PID AV0999) and L 044 (PID AU3429). The CORS station was KJUN CORS ARP (PID AJ7830). Reconnaissance of the two NGS stations, DATUM and L 044, was done prior to the photography acquisition portion of the contract near the end of October 2006. One personnel arrived on the site on October 27, 2006 to set panels over the two NGS monuments and two panels were set along the southeastern coast line of Marsh Island. A chartered helicopter from RotorCraft Leasing, LLC was used to gain access to Marsh Island. After the photography was acquired and processed, the two panels on Marsh Island were not located on the imagery. Two photo identifiable points were selected and surveyed to replace the missing targets. Two field personnel returned to the site on January 23, 2007. Photo ground check points were established by GPS static observation methods and verified with OPUS derived solutions. One surveyor observed the two NGS stations (DATUM and L 044) as the other surveyor used a chartered helicopter (RotorCraft Leasing, LLC) to observe the two photo identifiable points on Marsh Island.

The two NGS differential base stations (Station DATUM and L 044) were deployed and used to capture simultaneous GPS data in the project area and were left running until the data was acquired for the two photo identifiable points. The shortest session of data acquisition was two hours. Data from each of these occupations were sent to OPUS and verified for quality. In addition, GPS data was downloaded from a nearby CORS station (KJUN) during the imagery acquisition. All base stations were observed with dual frequency GPS receivers. The number of GPS satellites tracked by the aircraft was four or more at all times and the PDOP never exceeded 7.0. The sun angle for all photography was at or above 30 degrees above the horizon. Weather conditions were clear during the flight mission. Minimum visibility at time of exposure exceeded 8 miles. The maximum range from the nearest base station used for any one session was less than 50 kilometers.

The GPS trajectories had three-dimensional RMS values less than 0.07 meters.

GPS observations were measured using one Wild/Leica SR399 (serial # 446), one Wild/Leica SR530 (serial # 34735), and two Wild/Leica SR9500 (serial #'s 20413 and 25000) dual frequency, multi-channeled receivers and Wild/Leica antennas. All receivers collected L1/L2 frequencies at 5 second or faster epoch rates. All antenna heights were measured from the top of the observed ground point to the antenna reference point (ARP) of the GPS antenna. NGS GPS observation forms and digital pictures were completed on site and all data was downloaded onto laptop computers.

See Aerial Photography Report for NOAA, Vermilion Bay LA, NGS Project No. LA0501, dated April 28, 2008.
See Ground Photo Control Report for NOAA, Vermilion Bay LA, NGS Project No. LA0501, dated February 5, 2007. (Revised April 24, 2007.)

GPS Data Reduction

GPS data was processed to provide accurate positions of camera centers for application as photogrammetric control in the aerotriangulation phase of the project. All of the baselines were processed using LEICA Geo Office (LGO) version 4.0 on January 24, 2007. Baselines greater than 15km in length were processed using L3 (iono-free) solutions and lesser length baselines using L1+L2 solutions. All ambiguities were solved. All baselines were processed using a Hopfield tropospheric model and antenna calibration files provided by the National Geodetic Survey. Baseline vectors were outputted in ASCII GeoLab format and a least squares adjustment was performed using GEOLAB GPS Environment version 2.4d on January 24, 2007.

The processing of the airborne positioning data was carried out using Applanix POSPac version 4.31. The raw airborne data was logged in a series of time sequential files each approximately 12.2 MB in size. The first step in the processing stream was to combine these files together and then extract them into individual data files that contain the raw GPS data, raw IMU data and camera event times. During this step the raw GPS data and the raw IMU data were checked for any lapses in data continuity. When the data extraction was completed the next step was to process the airborne GPS data. For this project a total of two GPS trajectories were processed and then combined to create the final GPS positions for the aircraft antenna. For each base station the forward and reverse solutions were combined using a weighting scheme based upon the quality of the solution for each epoch. The combined solutions from each base station were then combined to create the final position file.

The GPS data was processed using a 10-degree elevation cutoff. The L2 frequency was utilized for kinematic ambiguity resolution as well as for ionospheric correction of the long trajectory. No satellites were rejected from the solution and the general quality of the airborne GPS trajectories was excellent. The RMS of the sensor position was less than 0.04 meters horizontally and less than 0.06 meters vertically. Most base station to aircraft vectors were processed using a fixed ambiguity solution.

The next step in the processing flow was to take the final GPS trajectory and blend this with the IMU data collected during the mission. This step was carried out using the program POSProc that is part of the POSPac suite. The general theory behind the POSProc processing was to create a blended solution that utilizes the strengths of the two systems to create an optimum solution. The blending of these solutions was done in three steps. First the data was processed forward in time, and then reverse in time, and finally these two solutions were blended to create the final output. The other task that POSProc did in this step was to transfer the measurements from their source to the perspective center of the camera. The end result of the POSProc processing was an SBET (Smoothed Best Estimated Trajectory) file. This file contained x,y,z coordinates as well as roll, pitch and yaw orientation angles for every 0.005 seconds during the entire mission.

The final step in the data processing stream was to create x,y,z coordinates and roll, pitch and yaw orientation angles for the exact moment the camera shutter opened for each image. This step was accomplished using POSEO. The undulations for each exposure station were calculated from Geoid03 and the final EO file was outputted with UTM Zone 18 coordinates in NAD83 and NAVD88 elevations. Coordinates and elevations were expressed in meters. The results of this step produced a text file which could be imported to a software package for the airborne triangulation process. The reformatted form of the POSEO is contained in the Aerotriangulation Report for LA0501.

See Airborne Positioning and Orientation for Aerial Photography Report for NOAA, Vermilion Bay LA, NGS Project No. LA0501, dated April 28, 2008.

For details regarding the deployment, collection and processing of the static GPS data see *See Ground Photo Control Report for NOAA, Vermilion Bay LA, NGS Project No. LA0501, dated February 5, 2007. (Revised April 24, 2007.).*

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 initiated by AERO-METRIC, Inc. personnel in July 2008. The softcopy analytical aerotriangulation was done using the Zeiss Image Station Automatic Triangulation (ISAT) program installed on a Dell PWS670 workstation, running under Windows XP Professional, Version 2002 Service Pack 2. The Dell workstation has a xeon cpu processing at 3.20 Ghz, and it has 2.00 gb of memory. The ISAT program includes automatic point matching (measuring) and the PhotoT least squares-simultaneous-robust bundle-block adjustment. The point matching and bundle adjustment were done as a block of photos. The automatic point matching was done in photos along a strip and in photos of overlapping strips. The photo coordinates from point matching were used with the ABGPS exposure stations and ground-surveyed control in the robust bundle-block adjustment, which automatically detected and removed any large point-matching errors. Corrections for atmospheric refraction and earth curvature were enabled in the adjustment. The total number of images provided by NOAA was 450,

but 72 of these were photos covering only water. Points were measured manually in weak areas, in models with small land area or platforms within the water. Four ground-surveyed horizontal-and-vertical check points were also measured manually.

Since the color film was acquired nearly a year before the BWIR film, the color imagery was aerotriangulated and mapped separately. After the BWIR film was acquired, this imagery was added to the color aerotriangulation as a “combined” adjustment. One hundred eighty-three (183) color film image points were transferred to the BWIR imagery to tie the BWIR imagery to the color aerotriangulation solution. Randomly, thirteen (13) of these color image points along with the four (4) surveyed ground check points were left as check points in the final combined adjustment. The resulting RMS in X,Y, and Z of these check points were 0.255m, 0.220m, and 0.213m, respectively. Upon successful completion of the aerotriangulation process, the ISAT 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 0.4 meters based on a 95% confidence level. An Aerotriangulation Report was written and is on file with other project data within the RSD Applications Branch (AB) Project Archive.

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).

See LA0501 Vermilion Bay LA, BWIR and Color Film, NOAA Aerotriangulation Report, dated July 2008.

Compilation

Compilation of LA0501A was accomplished by the AEROMETRIC, INC. Geospatial Department during the period of February 2007 through March 2009. Digital mapping was accomplished using DAT/EM Summit Evolution digital photogrammetric workstations with DAT/EM Capture for MicroStation software. Feature identification and attribution within the Geographic Cell (GC) were based on image analysis of 1:30,000 scale photographs and information extracted from the appropriate NOAA nautical charts, 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.

Spatial data accuracies for Project LA0501A were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were compiled to meet a horizontal accuracy of 0.8 meters at the 95% confidence level. The predicted accuracy of compiled, well defined points is derived by doubling the circular error derived from aerotriangulation statistics.

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

Date	Time (UTC)	Roll Number	Photo Numbers	Scale (nominal)	Tide Level*
11-03-06	1548-1550	0623CN03	106-109	1:30,000	0.3 m
11-03-06	1555-1603	0623CN03	110-125	1:30,000	0.3 m
11-03-06	1606-1612	0623CN03	126-140	1:30,000	0.3 m
11-03-06	1617-1623	0623CN03	141-153	1:30,000	0.3 m
11-03-06	1627-1623	0623CN03	154-166	1:30,000	0.2 m
11-03-06	1637-1639	0623CN03	167-171	1:30,000	0.3 m
11-03-06	1645-1649	0623CN03	172-180	1:30,000	0.3 m
11-03-06	1748-1800	0623CN03	232-255	1:30,000	0.3 m
11-04-06	1524-1535	0623CN03	324-347	1:30,000	0.2 m
11-04-06	1539-1553	0623CN03	348-374	1:30,000	0.2 m
11-04-06	1601-1611	0623CN03	375-398	1:30,000	0.1 m
11-04-06	1548-1550	0623CN03	399-418	1:30,000	0.1 m
11-04-06	1548-1550	0623CN03	419-446	1:30,000	-0.2 m
10-30-07	1640-1642	0723R01	1-5	1:30,000	0 m
10-30-07	1650-1658	0723R01	6-21	1:30,000	-0.1 m
10-30-07	1705-1707	0723R01	22-25	1:30,000	-0.1 m
10-30-07	1726-1733	0723R01	26-40	1:30,000	-0.1 m
10-30-07	1738-1744	0723R01	41-53	1:30,000	-0.1 m
10-30-07	1754-1803	0723R01	54-73	1:30,000	0 m
10-30-07	1810-1815	0723R01	74-82	1:30,000	-0.1 m
2-08-08	1608-1622	0823R01	1-24	1:30,000	0 m
2-08-08	1830-1843	0823R01	25-48	1:30,000	-0.1 m
2-08-08	2012-2018	0823R01	49-61	1:30,000	-0.1 m
3-16-08	1440-1450	0823R02	147-174	1:30,000	-0.1 m
3-16-08	1456-1505	0823R02	175-201	1:30,000	0 m
3-16-08	1526-1529	0823R02	211-216	1:30,000	0 m
3-16-08	1539-1547	0823R02	217-240	1:30,000	-0.1 m

* Tide levels are given in meters above MLLW and are based on actual observations at the Freshwater Canal station, at the Cypremort Point station and at various substations throughout the project area with corrections applied from the above mentioned reference stations. The mean tide range in the project area varied between 0.4m and 0.5m.

Quality Control / Final Review

The final review was initiated by senior members of the AERO-METRIC, INC. Geospatial and Imaging/Terrain Departments in May 2009. Data review consisted of on-line and off-line evaluations of digital compilation and hard-copy products. The on-line review was comprised of reviewing stereo models and digital images of the largest scale nautical charts available on SUMMIT Evolution stereoplotters for cartographic feature codes selection, positional accuracies of features, and nomenclature. The Geographic Cell (GC) was evaluated for completeness and accuracy. 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 off-line evaluation compared hardcopy plots of project data with the largest scale nautical charts available and the natural color photographs and the black and white infrared photographs. All project data was evaluated for compliance to CMP requirements.

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

11349 Vermilion Bay and Approaches 1:80,000 43rd Ed., May /07
11350 Wax Lake Outlet to Forked Island 1:40,000 27th Ed., June /08
including Freshwater Bayou Extension 1:80,000

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 GC10663 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project database
- GC10663 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

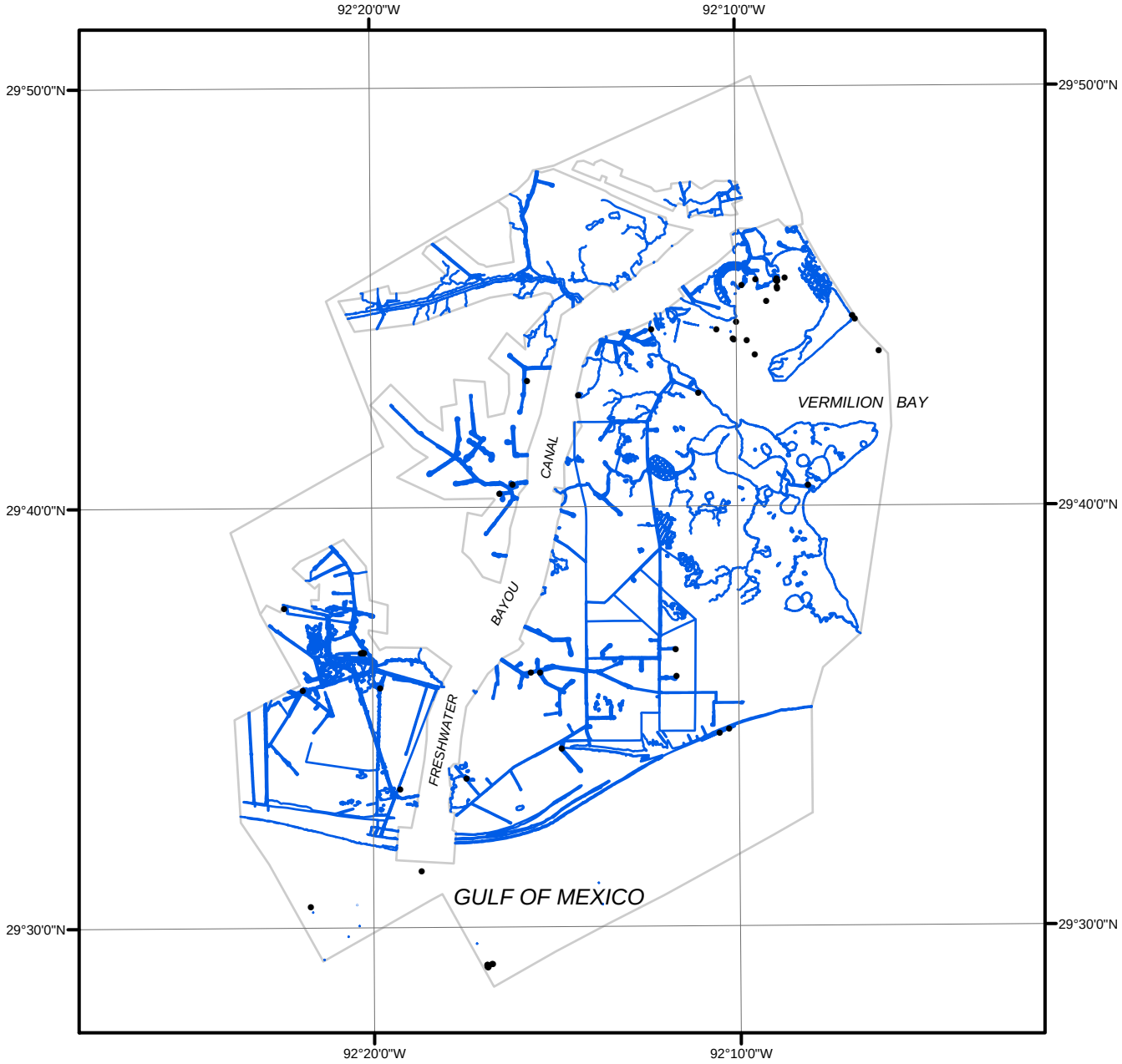
NOAA Shoreline Data Explorer

- GC10663 in shapefile format
- Metadata file for GC10663
- Digital copy of the PCR in Adobe PDF format

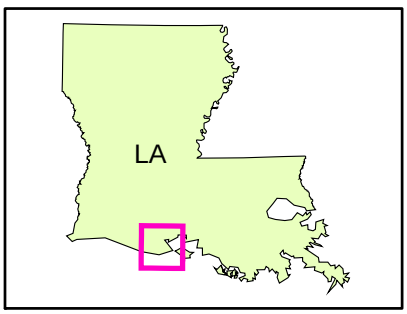
End of Report

WESTERN VERMILION BAY

LOUISIANA



Overview



LA0501A

GC10663