NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT AK0202

CORONATION ISLAND
SOUTHEAST PANHANDLE, ALASKA

Introduction

This project was undertaken to provide digital shoreline mapping for NOAA nautical charts and other uses. The project includes the area around Coronation Island and the Spanish Islands in the Southeast Panhandle of Alaska.

The area is depicted within NOAA nautical chart 17402. The project includes planning, aerial photography, ground check survey, aerotriangulation, compilation, and writing reports.

Aerial photography, along with position and orientation data, was acquired over the portion of the area that indicated the existence of rocks, shoals, or islands.

The project database consists of information measured and extracted from Airborne GPS/IMU controlled aerial photography. Project survey data is referenced to the North American Datum of 1983 (NAD 83). Aerotriangulation was conducted in soft copy using a Pentium 4CPU, 3.00 GHz computer with ERDAS IMAGINE 8.6 – OrthoBase Pro, and INPHO MATCH AT software. Compilation was accomplished using Zeiss P1 and P3 Analytical stereoplotters. Preliminary review was performed on Pentium 4CPU, 2GHz computer workstations using MicroStation software. The final editing and formatting was completed using ArcMap software. Preliminary Shapefiles were submitted for NOAA's review. We incorporated the review comments into the digital files and delivered Final Shapefiles.

Project Design

The project was designed by AERO-METRIC, INC. and AeroMap U.S., a division of Aero-Metric, Inc. The design was based on Coastal Mapping Program Specifications for Shoreline Mapping and Project Instructions prepared by NOAA, March 11, 2002. Project Instructions were revised October 7, 2002 in accordance with contract negotiations.

The project limits for Coronation Island, in decimal degrees, are:

-134.025   56.0448
-134.025   55.8215
-134.383   55.8215
-134.383   56.0448

The project limits were overlaid on NOAA Nautical Chart 17402, and were used to depict the approximate locations of shorelines to be mapped. Five flight lines were planned to adequately cover landforms in stereo within these map limits but to exclude 'water only' areas. The flight lines were planned with 25% sidelap to adequately cover the relief exhibited by the terrain, and forward overlap was planned at 80% (a departure from the normal 60% forward overlap) to accommodate anticipated solar reflection from the water. Photography was planned for 1: 30,000 scale natural color coverage and was not tide coordinated.

The sun angle requirement is for photography acquisition when the sun angle is not less than 30 degrees above the horizon. Weather conditions shall be suitable for acquisition of photography with no clouds or cloud shadows and when well-defined images can be obtained. Snow cover away from the shoreline was permissible. Minimum visibility at the time of exposure shall be 8 miles.

Airborne GPS/IMU control was planned for the project. The inertial measurement unit (IMU) was considered essential because some islands and rocks were considered too small and too scattered to adequately support an aerotriangulation solution. Base stations were planned for deployment on published geodetic control marks in the Southeast Alaska village of Klawock at the airport. All photography acquired for the project, including all of Coronation Island, lies within 90 km of the base station.

Ground checkpoints were planned at four locations. These check points were to be surveyed by John Oswald & Associates, LLC (JOA). Since we planned to use photo ID points rather than pre-marked locations, JOA selected 3 to 4 check points at each of the 4 locations with the idea that some of these points could be rejected horizontally or vertically if the photogrammetrist could not read them well. Check points were used only as ground checks and were not used to control the photography.

Field Operations

The photographic mission for Coronation Island was conducted August 6, 2003 with a Piper Navajo Chieftain (PA 31-350) aircraft. Natural color photography was acquired using a Zeiss TOP aerial camera. There was no attempt to coordinate photography with tide levels, however all photography was captured below the Mean High Water level based on NOAA predicted tide levels at Sitka. Photography was acquired at the nominal scale of 1: 30,000 simultaneously with collection of kinematic GPS and IMU positioning and orientation data. Two differential base stations were deployed and used to capture simultaneous GPS data at Klawock Airport at Stations AKWA and KLAWOCK.

Check surveys were conducted from May 6 through May 9, 2003 by JOA using GPS observations. GPS observations were obtained with four Topcon 20 channel Legacy E dual frequency GPS/GLONASS receivers with Topcon Legant II antennas. Checkpoints were reported as NAD 83 coordinates and ellipsoid heights (CORS96, epoch 2002.0) based on GPS ties to Annette, Biorka, and Level Islands CORS. For AK0202, Coronation Island, Stations 'End 1922', 'No 1922', and 'Middy 1939' were recovered and observed. New positions were determined for these stations as well. Networks of 3 to 4 receivers were run concurrently with a minimum common observation of 30 minutes. At least one of the stations at each ID location was observed for a minimum of 2 hours. All receivers logged five-second epochs for both GPS and GLONASS data.

Data was downloaded from the Topcon Legacy receivers using Pentium III laptop computers with Javad download software, PCCDU version 2.1. Data was processed with NGS online processing suite, OPUS and Terrasat's GeoGenius 2000. A minimum angle of 15 degrees above the horizon was selected as the cut-off elevation for all carrier phase observations.

See Ground Survey Report for AK0202, Coronation Island (Dated June 20, 2003 and submitted July 8, 2003)
See Aerial Photography Final Report for AK0202, Coronation Island (Dated July 2004 and submitted July 30, 2004)

GPS Data Reduction (Airborne)

The position of the existing marks, AKWA and KLAWOCK, were used as base station sites for this project and were checked by processing static baselines to three CORS stations. In the adjustment, the three CORS stations AIS1, LEL1 and GUS2 were held fixed in three dimensions to their published NAD83 coordinates and ellipsoidal heights.

With validation for stations AKWA and KLAWOCK, it was possible to proceed with the processing of the airborne positioning data. The processing of the airborne positioning data was carried out using the suite of software supplied by Applanix that is collectively called POSPac. POSPac version 4.02 was used for the processing of this data set.

The raw airborne data is logged in a series of time sequential files. The first step in the processing stream is to combine these files and then extract them into individual data files that contain the raw GPS data, raw IMU data and camera event times. It is during this step that the raw GPS data and raw IMU data is checked for any lapses in data continuity.

When the data extraction is completed, the next step is to process the airborne GPS data. For this project a total of four 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 12.5-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. The general quality of the airborne GPS trajectories was excellent. The solutions were all fixed integer and the trajectory comparisons were less than 5 centimeters.

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 is carried out using the program POSProc that is also part of the POSPac suite. The general theory behind the POSProc processing is to create a blended solution that utilizes the strengths of the two systems to create an optimum solution.

The blending of these solutions is done in three steps. First the data is processed forward in time, then reverse in time, and finally the two solutions are blended to create the final output.

The other task that POSProc does in this step is to transfer the measurements from their source to the perspective center of the camera.

The end result of the POSProc processing is an SBET (Smoothed Best Estimated Trajectory) file. This file contains 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 is to create x,y,z coordinates and roll, pitch and yaw orientation angles for the exact moment the camera shutter opened for each picture. This step is carried out using POSEO. The undulations for each exposure station were calculated from Alaska Geoid 99 and the final EO file was output with NAD83-UTM Zone 8 coordinates and pseudo NAVD88 elevations. Coordinates and elevations were expressed in meters. The results of this step produce a text file which can be imported to a software package for the aerotriangulation process.

The reformatted form of the POSEO is contained in the Final Aerotriangulation Report for AK0202 dated Dated January 2004, revised March 31, 2004 and submitted April 21, 2004.

See Airborne Positioning and Orientation Report for AK0202, Coronation Island (Dated April 2004 and submitted July 21, 2004)
See Final Aerotriangulation Report for AK0202, Coronation Island (Dated January 2004, Revised March 31, 2004 and submitted April 21, 2004)

Aerotriangulation

AeroMap U.S. acquired photography on August 6, 2003 at a nominal scale of
1: 30,000. Photography was good quality with 80% endlap and 25% sidelap. Another NOAA contractor completed the scanning at 25 microns and digital copies were delivered to AeroMap. The camera used was a Zeiss RMK TOP 15 with Forward Motion

Compensation, serial number 145841, with calibrated focal length of 153.272 mm. The current camera calibration report for this camera (dated November 28, 2000 by the US Geological Survey) was submitted to NOAA.

As anticipated, the southern edges of exposures taken over water exhibit sun glare. The 80% endlap mitigates the glare and strengthens the aerotriangulation by capturing triple overlap over many of the scattered islands. Use of the Applanix GPS/IMU also proved valuable for successful completion of the aerotriangulation due to the large expanses of water, and scattered islands and rocks.

Aerotriangulation was conducted in soft copy using a Pentium 4CPU, 3.00 GHz computer with ERDAS IMAGINE 8.6 – OrthoBase Pro, and INPHO MATCH AT software. The aerotriangulation was a simultaneous bundle adjustment using Airborne GPS/IMU data. Automatic tie point generation in OrthoBase Pro was used for each strip, and then was used to tie strips together. Automatic tie point generation worked well within strips but some models required manual supplemental tie points to tie the strips together. This was especially true for models that are nearly all water with only a few small islands to use for tie point locations. Cross strip tie points also worked well but again were manually supplemented to provide more strength for the photogrammetric solution.

Water points were measured through the project areas to indicate level. When the models were set, there were some discrepancies in water elevations in OrthoBase Pro. The refined image coordinates were imported into MATCH-AT and water points were measured on multiple exposures to strengthen the photogrammetry. MATCH-AT's aerotriangulation was run to auto-select more tie points. The final run was performed with MATCH-AT, which gives better results when using the GPS/IMU input files.

Ground surveyed checkpoints were measured for quality control analysis. Due to the 80% endlap, some checkpoints fall on as many as eight exposures. Predicted accuracy for the horizontal circular error at 95% confidence level is 0.6 m or less.

The project database consists of project parameters and selected options, camera calibration data, control file data, refined image coordinates, Airborne GPS data, IMU orientation angles of camera centers, adjusted exterior orientation parameters for each frame, a positional listing of all ground points used in the projects, and a stereo model review. Positional data is based on the North American Datum of 1983, and is referenced to the UTM Coordinate System.

See Final Aerotriangulation Report for AK0202, Coronation Island (Dated January 2004, Revised March 31, 2004 and submitted April 21, 2004)

Compilation

The Compilation Phase of AK0202 Coronation Island was accomplished by the AERO-METRIC, INC. Photogrammetry Department during the period of January through March 2004. Digital mapping was accomplished using Zeiss P1 and P3 Analytical Plotters.

Software used was Zeiss' PCAP and Boeing Autometric's KDMS mapping system. Feature identification and the assignment of cartographic codes were based on image analysis of 1:30,000 scale natural color and color negative photographs and information extracted from the appropriate NOAA Nautical Charts, US Coast Guard Light List and US Geological Survey quadrangles. Cartographic feature attribution was assigned in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST). Nomenclature was assigned to selected cartographic features to refine general classification.

Cartographic features were compiled to meet a horizontal accuracy of 3.0 meters at a 95% confidence level. The cartographic features were produced according to procedures that have been demonstrated to produce data of this accuracy.

Corrections based on NOAA comments were made during the period of June through August 2004.

The following provides information on aerial photographs used in the project completion process:

LOCATION	FILM TYPE	DATE	TIME (UTC)	ROLL NUMBER	PHOTO NUMBER	SCALE (NOMINAL)	STAGE OF TIDE
Coronation	Color Neg.	08-06-03	2159-2201	0314CN02	115-122	1:30,000	0.24m
Coronation	Color Neg.	08-06-03	2207-2208	0314CN02	123-130	1:30,000	0.27m
Coronation	Color Neg.	08-06-03	2214-2218	0314CN02	131-147	1:30,000	0.27m
Coronation	Color Neg.	08-06-03	2227-2230	0314CN02	148-160	1:30,000	0.31m
Coronation	Color Neg.	08-06-03	2235-2238	0314CN02	161-171	1:30,000	0.36m

The "Stage of Tide" is referenced to MLLW. The range of tide (MLLW to MHW) is 2.2m (7.2').

As the compilation was being completed, preliminary review of the data collected was performed on Pentium 4CPU, 2GHz computer workstations using MicroStation software. Paper check plots were produced and edited off-line. Corrections and additions were incorporated and the final editing and formatting was completed using ArcMap software. Preliminary Shapefiles were submitted for NOAA's review. Review comments were received and a second version of the Preliminary Shapefiles was submitted. There were some minor corrections that needed to be incorporated before the Final Shapefiles were prepared and submitted.

Final Review

Senior members of the AERO-METRIC, INC. Photogrammetry and Graphics Departments initiated the final review in February 2004. The digital cartographic feature file (DCFF) was evaluated for completeness and accuracy. Data review consisted of an on-line and off-line evaluation of digital compilation and hard copy products. The on-line review comprised of reviewing stereo models on a Zeiss P1 for cartographic feature codes selection, positional accuracies of features, and nomenclature. The cartographic

feature attribution was judged to conform to C-COAST specifications. The off-line evaluation compared hard copy plots of project data with the largest scale nautical chart available and with the natural color photographs. NOAA nautical chart 17402 Alaska – Southeast Coast, Southern Entrances to Sumner Strait, 1:40,000, 10th Edition was used for the chart comparison process.

Project Final Data and Products

The following specifies the location and identification of the products generated during the completion of this project:

RSD Applications Branch Project Archive
  -Hard copy of Ground Survey Report
  -Hard copy of Aerial Photography Final Report
  -Hard copy of Airborne Positioning and Orientation Report
  -Hard copy of Aerotriangulation Report
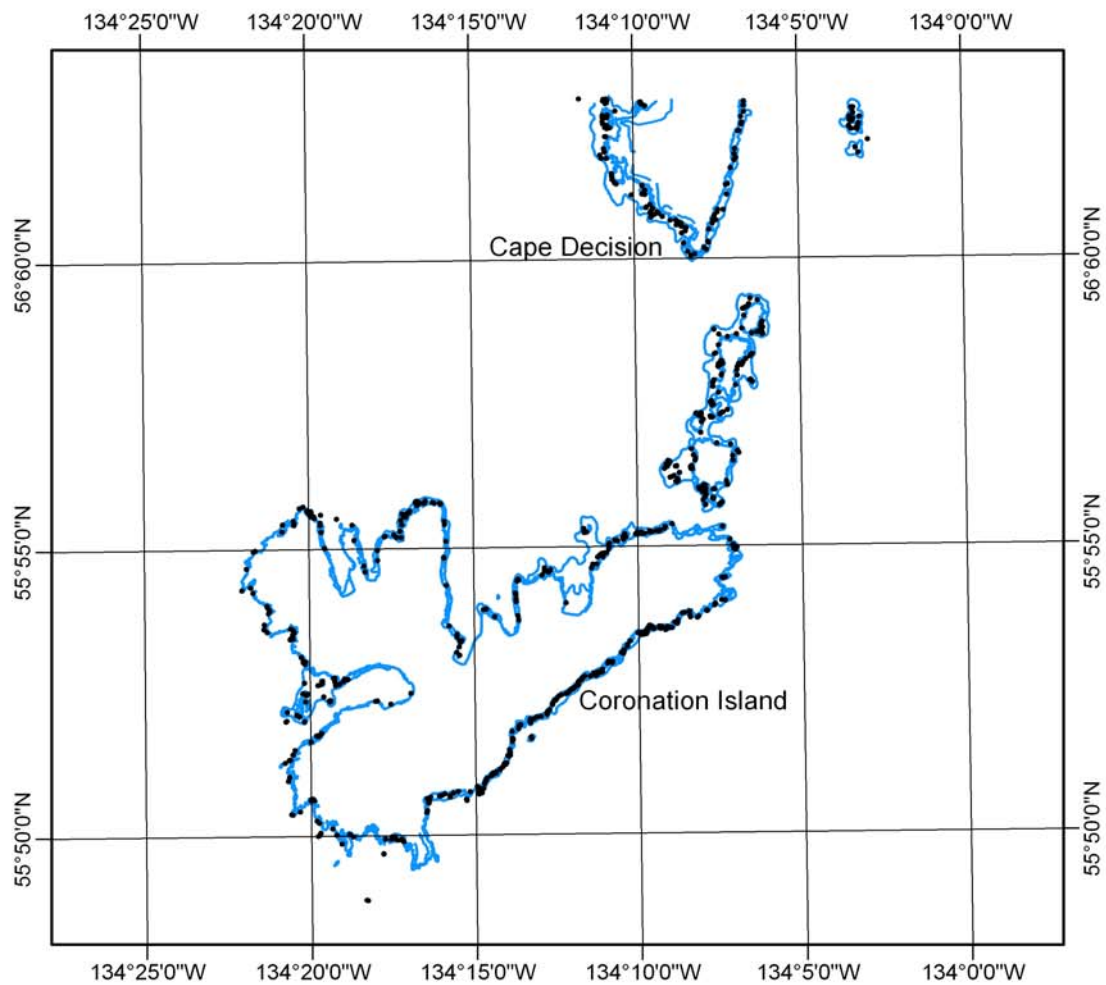 -Hard copy of the Project Completion Report, including the Project
   Completion Diagram

RSD Electronic Data Library:
  -Project Database
  -DCFF: GC-10546
  -Digital copy of DCFF in Shapefile format
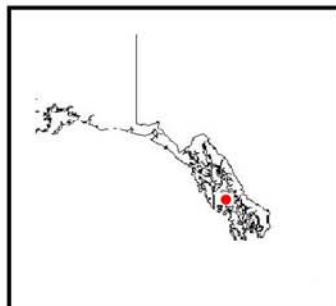 -Digital copy of Project Completion Report in Adobe PDF Format

NOAA Shoreline Data Explorer
  -DCFF: GC-10546
  -Metadata file for GC-10546
  -Digital copy of the Project Completion Report in Adobe PDF Format

CORONATION ISLAND
ALASKA

134°25'0"W 134°20'0"W 134°15'0"W 134°10'0"W 134°5'0"W 134°0'0"W

56°60'0"N

Cape Decision

55°55'0"N

Coronation Island

55°50'0"N

134°25'0"W 134°20'0"W 134°15'0"W 134°10'0"W 134°5'0"W 134°0'0"W

Overview Map

AK0202

GC10546