

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT WA0401A

Cape Flattery to Abbey Island, Washington

Introduction

Coastal Mapping Program (CMP) Project WA0401A provides a highly accurate database of new digital shoreline data for the Northern Pacific Coast. The project includes all shoreline and offshore islands south and west from Cape Flattery to Abbey Island, just south of the Hoh River. WA0401A is a subproject of a larger project WA0401, which includes detailed digital mapping of the Mean High Water Line (MHW), Mean Lower Low Water Line (MLLW), and other coastal features from: Cape Flattery to Cape Disappointment, and includes Grays Harbor, Willapa Bay, and the Offshore Islands in the Pacific Ocean.

Successful completion of the project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric-quality aerial photographs, and a Geographic Cell (GC) 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 photography 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 design of project WA0401 was based on a comparison of image analysis to cartographic detail depicted on the pertinent NOAA nautical charts of the project site. The Remote Sensing Division (RSD) of the National Geodetic Survey, NOAA, formulated the WA0401 Phase II Project Instructions (November 7, 2006) which contains the specific field and photo mission operational guidelines. The instructions, as provided to Science Applications International Corp (SAIC), discussed the project's purpose, geographic area of coverage, scope and priority, compilation, feature attribution, final product preparation, and preparing reports. For Phase II of this project SAIC is acting as a subcontractor to the prime contractor, Tuck Mapping Solutions Inc (TMSI). The first phase (Phase I), which included planning, tide prediction, aerial photography, ground control surveys, airborne GPS surveys, data reduction, and preparing reports, was previously completed.

Nautical charts provided by RSD showed the limits of the compilation. Photo scales for

the color and B&W IR photography were determined by RSD staff to attain the required mapping accuracies on Phase I of the project under a prior contract.

The technical proposal for WA0401 Phase II included a Quality Control plan which described the procedures and requirements that were followed by SAIC and TMSI throughout the project.

Field Operations

SAIC photographic mission operations were conducted between May 25, 2005 and September 27, 2006. Aerial photographic coverage of the project site consisted of natural color and black & white infrared photographs at a nominal scale of 1:40,000. Black and white infrared tide-coordinated photography was conducted at both the mean high water (MHW) and mean lower low water (MLLW) levels. Natural color photographs were acquired at no particular tide levels.

Control for this project was based on three CORS and two standard control stations found in the National Spatial Reference System (NSRS). HTDP was used to adjust the NAD83 [98] positions of the two standard control stations to NAD83 [CORS – Epoch 2002]. In addition to these five station, NAD1983 [CORS96 – Epoch 2002] positions were established on two Plate Boundary Observatory (PBO) CORS by running 10 consecutive days of data through the OPUS and meaning the results.

Control on the new stations was established by means of fast-static GPS. Each of the stations was tied directly to at least two of the seven above mentioned control stations. Each station was occupied at least twice for one hour with a constellation time shift of at least two hours between occupations. Observations were made between August 17th and September 15th, 2005.

The data was then processed and adjusted in Trimble Geomatics Office version 1.63. The 137 non-trivial base lines resulted in accuracies of 0.020 meters in all three dimensions at 95% confidence, exceeding the 0.1 meter horizontal and 0.2 meter vertical accuracy requirements for the project. No unusual circumstance of equipment malfunctions occurred during observations or processing.

See the Photographic Flight Reports and Ground Control Reports for more information.

GPS Data Reduction

GPS data was collected and processed to provide the precise positions of the camera centers for photogrammetric control in the aerotriangulation. The airborne GPS data was collected utilizing a combination of Trimble geodetic receivers and CORS sites. All data was planned to be collected at a 2Hz rate with a 10° horizon mask. The ground monitoring stations were situated approximately every 75km to ensure that each photo center would be within 100km of two stations. Ground monitoring stations were a combination of six permanent CORS, two NSRS stations and one temporary control point. CORS 'NEAH' (AF9672), 'PABH' ((AF9558) and 'P415' (DH093) are in the

national CORS network. CORS 'P401', 'P403' and 'P408' are operated by the Port Plate Boundary Observatory (PBO). NAD 1983[CORS 96 – Epoch 2002] coordinates for the PBO CORS were established by running a minimum of ten 24 hour observations through OPUS and deriving the mean value. NAD 1983[98] values for 'AST A', and 'HQM ARP 2' were shifted to NAD 1983 [CORS – Epoch 2002] with the use of HTDP. Coordinates for temporary point 'QUEETS' were established by submitting twenty-seven hours of data spread over four days to OPUS. Data was collected only during times with a minimum satellite count of 5 and a maximum PDOP of 5.0. Session initialization required 6 satellites for a minimum of 10 minutes prior to photo collection. The kinematic data was processed at 2hz utilizing a precise ephemeris in GrafNav Version 7.60.2425. Data not collected at a 2hz rate was resampled to 2hz using GrafNav's routine.

Aerotriangulation

Routine softcopy aerotriangulation methods were applied to extend the network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. [j][f][k] personnel initiated the softcopy aerotriangulation work in October 2007, utilizing Z/I Imaging's ISDM (Image Station Digital Mensuration) Version 054.03.00.08 and ISAT (Image Station Automatic Triangulation software products. Once the AT data were measured and verified, the data were then processed using [j][f][k]'s PC-RABATS/BRATS software package. The softcopy aerotriangulation work was completed in December 2007.

The natural color photography was flown on May 25, 2005. The MLLW B&W IR photography was flown on May 4 2006. The MHW B&W IR was flown on August 26, 2006, and September 27, 2006. All were processed as individual emulsions. Upon successful completion of the block adjustment, Z/I's ISAT provided the RMS of the standard deviations for all aerotriangulated ground points, which were used to compute a predicted horizontal circular error at the 95% confidence level of 0.6 meters for all adjusted photographs. The Aerotriangulation Report is on file with other project data within the RSD AB Project Archive.

The project database consists of camera calibration data, interior orientation parameters for each frame, airborne GPS antenna position and offset data, adjusted exterior orientation parameters for each frame, positional listing of all measured points, the control file and refined image coordinates as listed in the Project Database section of the Aero triangulation Report. Positional data is based on the North American Datum of 1983 (NAD83), and is referenced to UTM Zone 10 in meters.

Compilation

The data compilation phase of the project was completed by SAIC in February 2009. Digital mapping was performed using Digital Photogrammetric Workstations (DPWs) in conjunction with BAE SOCET SET ver. 5.3.1. Feature identification and the assignment of cartographic codes were based on image analysis of natural color photography and B&W IR photography and information extracted from appropriate NOAA Nautical Charts and the US Coast Guard Light List. Cartographic feature attribution was assigned

in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST) as required.

Cartographic features were compiled to meet a horizontal accuracy of 1.2 meter at the 95% confidence level. This predicted accuracy of compiled, well-defined points is derived by doubling the circular error derived from aerotriangulation statistics.

See table below for information on aerial photographs used for project WA0401A.

Date	Time (UTC)	Roll Number	Frames	Scale (nominal)	Tide Level*
05/25/2005	18:39 – 18:41	0505CN01	177 – 180	1:40,000	0.6
05/25/2005	19:06 – 19:11	0505CN01	190 – 196	1:40,000	1.0
05/25/2005	19:16 – 19:19	0505CN01	197 – 201	1:40,000	1.1
05/25/2005	19:26 – 19:33	0505CN01	202 – 213	1:40,000	1.0
05/25/2005	19:41 – 19:46	0505CN01	214 – 222	1:40,000	1.2
05/25/2005	19:52 – 19:54	0505CN01	223 – 226	1:40,000	1.0
05/04/2006	18:37 – 18:39	0605R03	043 – 046	1:40,000	0.1
05/04/2006	18:46 – 18:50	0605R03	047 – 053	1:40,000	0.1
05/04/2006	19:01 – 19:08	0605R03	054 – 065	1:40,000	0.0
05/04/2006	19:16 – 19:21	0605R03	066 – 074	1:40,000	0.0
05/04/2006	19:28 – 19:30	0605R03	075 – 078	1:40,000	0.0
05/04/2006	19:45 – 19:48	0605R03	079 – 083	1:40,000	0.0
08/26/2006	21:56 – 22:04	0605R06	012 – 023	1:40,000	2.3
08/26/2006	22:09 – 22:15	0605R06	024 – 032	1:40,000	2.4
08/26/2006	22:20 – 22:22	0605R06	033 – 036	1:40,000	2.1
08/26/2006	22:34 – 22:37	0605R06	037 – 041	1:40,000	2.2
09/27/2006	20:45 – 20:49	0605R09	001 – 007	1:40,000	2.2
09/27/2006	20:57 – 20:59	0605R09	008 – 011	1:40,000	2.2

*Tide levels are in meters relative to the MLLW datum, and are based on verified observations from the Neah Bay and La Push tide stations, then adjusted for COOPS Tidal Zoning. The elevations of the MHW datums for the Neah Bay and La Push stations are 2.2 and 2.4 meters above MLLW respectively.

Final Review

An SAIC team and a TMSI team completed the final review in February 2009. The GC was evaluated for completeness and accuracy. The review process included analysis of aerotriangulation results and assessment of the identification and attribution of cartographic features 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 GIS 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:

Chart 18400 Strait of Georgia & Strait Juan de Fuca, 1:200,000 scale, 47th Ed., Oct. /06

Chart 18460 Strait of Juan De Fuca Entrance, 1:100,000 13th Ed., Oct. /06

Chart 18480 Destruction Island to Amphitrite Point, 1:176,253 scale, 31st Ed. Oct. /06

Chart 18485 Cape Flattery, 1:40,000 scale, 16th Ed., Mar. /07

End Products and Deliverables

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

RSD Applications Branch Project Archive:

- Hardcopy of Airborne Positioning and Orientation Report (APOR)
- Hardcopy of Aerotriangulation Report
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10744 file contents

RSD Electronic Data Library:

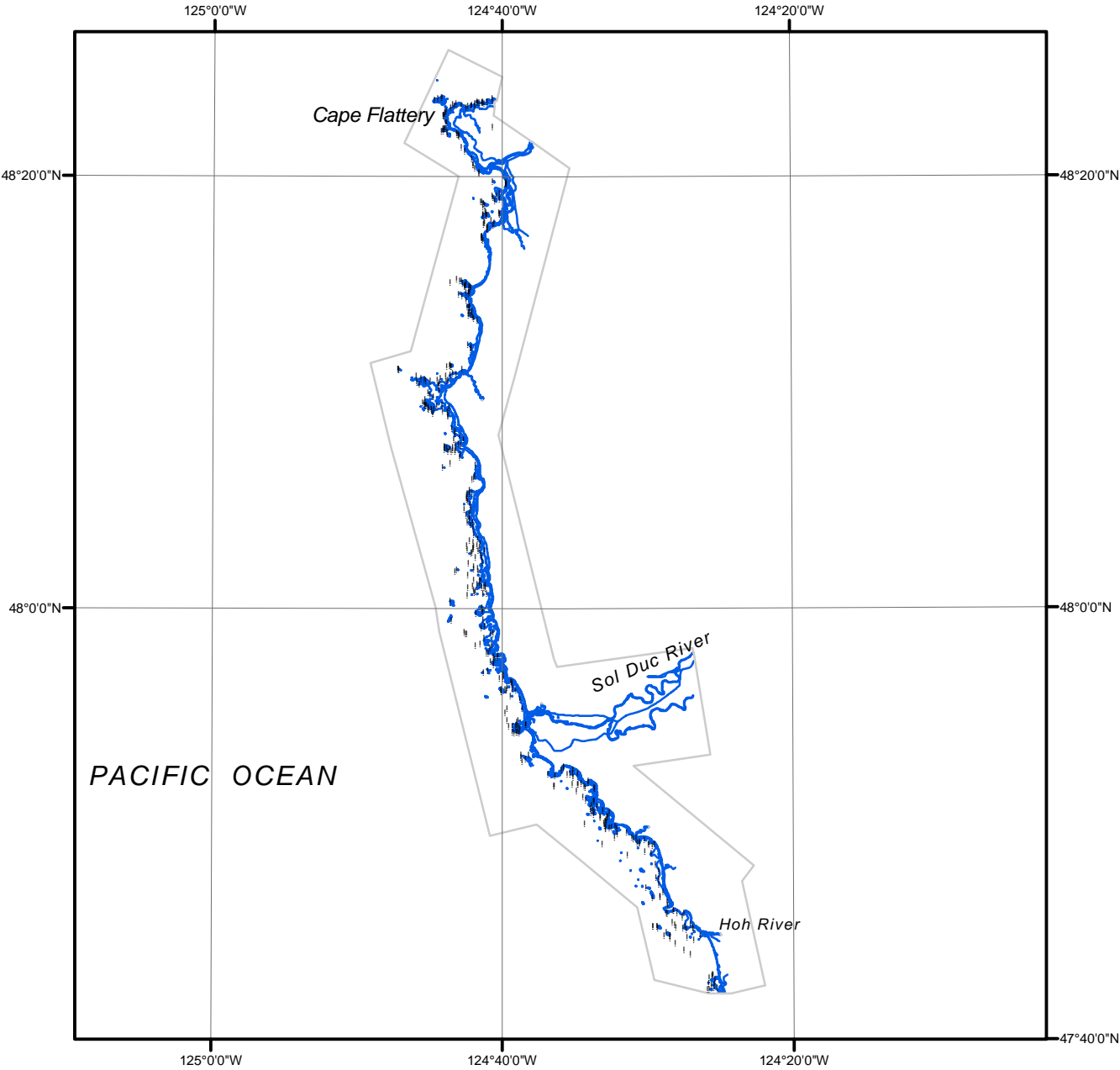
- Project database
- GC10744 in shapefile format
- Digital Copy of Project Completion Report in Adobe PDF format
- CEF in shapefile format

NOAA Shoreline Data Explorer:

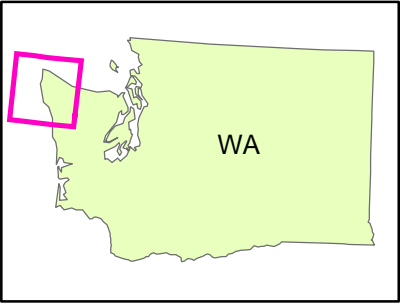
- GC10744 in shapefile format
- Metadata file for GC10744
- Digital copy of the PCR in Adobe PDF format

End of Report

CAPE FLATTERY TO ABBEY ISLAND
WASHINGTON



Overview



WA0401A

GC10744