

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

## ***PROJECT WA1401A-CM-N***

### ***Hood Canal, Port Townsend to Dabob Bay, Washington***

#### **Introduction**

NOAA Coastal Mapping Program (CMP) Project WA1401A-CM-N provides highly accurate digital shoreline data for Hood Canal, from Port Townsend to Dabob Bay, Washington. This project is a subproject of a larger project, WA1401-CM-N, which covers Hood Canal from Port Townsend to Annas Bay, Washington. 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**

Photographic mission instructions for WA1401-CM-N were formulated by the Requirements Branch (RB) of the Remote Sensing Division (RSD) following the guidelines of RSD's Photo Mission Standard Operating Procedures. The instructions discussed the project's purpose, geographic area of coverage, scope and priority, image requirements, Global Positioning System (GPS) data collection procedures and guidelines, instructions for data recording and handling, and mission communication protocols. RB created a Project Layout Diagram, flight maps and input files for the aircraft flight management system.

#### **Field Operations**

The field operations consisted of the collection of static and kinematic Global Positioning System (GPS) data, Inertial Measurement Unit (IMU) data, and the acquisition of aerial imagery. The tide coordinated photographic mission operations were conducted in July and August 2014 for the Mean High Water (MHW) imagery, and in June and July 2014 for the Mean Lower Low Water (MLLW) imagery, with the NOAA King Air (N68RF) aircraft. Nineteen strips each of color (RGB) and infrared (IR) digital images, at both the MHW and MLLW tide stages, were acquired concurrently with an Applanix Digital Sensor System (DSS) 439 dual camera system at a nominal altitude of 10,500 feet, resulting in an approximate ground sample distance (GSD) of 0.37 meters.

#### **GPS Data Reduction**

The GPS/IMU data was collected and processed by RSD personnel to yield precise positions and orientations of camera centers for direct georeferencing (DG) of the imagery as well as to provide a control network necessary for aerotriangulation. 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 kinematic GPS data was processed using Applanix POSPAC (ver. 6.2) software in July, 2014 for MLLW imagery and August and September, 2014 for MHW imagery. For further information refer to the

Airborne Positioning and Orientation Reports (APOR) on file with other project data within the RSD Electronic Data Library.

## **Direct Georeferencing Data Processing**

The processed GPS/IMU data were used to derive precise exterior orientation (EO) values of the camera centers suitable for digital feature extraction. The predicted horizontal accuracy of the imagery was determined by propagating sensor EO and image measurement uncertainties through the photogrammetric collinearity equations using the Exterior Orientation Total Propagated Uncertainty (EO-TPU) tool developed by NGS. Using this tool, the predicted horizontal uncertainty at the 95% confidence level for all project imagery was calculated to be 1.5 meters. NGS third-order geodetic control was used to verify the horizontal integrity of the directly georeferenced (DG) data. All stereo models were examined and found to have acceptable levels of parallax for mapping purposes. All positional data is referenced to the North American Datum of 1983 (NAD 83).

## **Aerotriangulation**

Routine softcopy aerotriangulation methods were applied to establish a 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 performed by RSD Applications Branch (AB) personnel in December 2016 utilizing a softcopy photogrammetric workstation. Color imagery covering the portion of the project within the port area of Bangor, Washington, was measured and adjusted using the Multi-Sensor Triangulation (MST) module of BAE Systems' SOCET SET (v 5.6.0) software. Upon successful completion of this process, the MST module provided the standard deviations for each aerotriangulated ground point, which were used to compute a predicted horizontal circular error at the 95% confidence level of 0.4 meters. An Aerotriangulation Report with a diagram depicting the block of adjusted imagery was written and is on file with other project data within the RSD Electronic Data Library.

## **Compilation**

The data compilation phase of this project was accomplished by a member of AB in January 2017. The Feature Extraction module was used within SOCET SET (v 5.6.0) 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), 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 WA1401A-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features compiled from the aerotriangulated imagery, covering the port area of Bangor, were compiled to meet a horizontal accuracy of 0.8 meters at the 95% confidence level. This predicted accuracy of compiled well-defined points is derived by doubling the circular error calculated from the aerotriangulation statistics. The rest of the feature data within this project was compiled to meet

a horizontal accuracy of 3.0 meters at the 95% confidence level, a predicted accuracy derived by doubling the horizontal uncertainty calculated from the EO-TPU tool.

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

Date	Time (UTC)	Color Imagery		Infrared Imagery		Tide Level*
		Roll	Images	Roll	Images	
6-30-2014	19:03 – 19:05	14NC57	12024 – 12037	14NR48	08775 – 08788	0.0 – 0.1 m
6-30-2014	20:18 – 20:19	14NC57	12264 – 12271	14NR48	08999 – 09022	-0.2 m
6-30-2014	20:39 – 20:41	14NC57	12303 – 12315	14NR48	09054 – 09066	-0.2 – 0.0 m
6-30-2014	20:46 – 20:47	14NC57	12316 – 12325	14NR48	09067 – 09076	-0.1 m
6-30-2014	20:52 – 20:55	14NC57	12326 – 12347	14NR48	09077 – 09098	-0.1 m
6-30-2014	21:00 – 21:03	14NC57	12348 – 12367	14NR48	09099 – 09118	-0.1 m
6-30-2014	21:08 – 21:10	14NC57	12368 – 12380	14NR48	09119 – 09131	0.0 m
6-30-2014	21:15 – 21:18	14NC57	12381 – 12403	14NR48	09132 – 09154	0.0 m
6-30-2014	21:22 – 21:25	14NC57	12404 – 12425	14NR48	09155 – 09176	0.1 m
6-30-2014	21:30 – 21:31	14NC57	12426 – 12434	14NR48	09177 – 09185	0.1 m
7-26-2014	16:35 – 16:38	14NC58	12435 – 12451	14NR49	09186 – 09202	-0.1 – 0.0 m
7-26-2014	16:42 – 16:44	14NC58	12452 – 12468	14NR49	09203 – 09219	-0.2 – 0.0 m
7-26-2014	16:49 – 16:53	14NC58	12469 – 12496	14NR49	09220 – 09247	-0.2 – 0.0 m
7-26-2014	16:59 – 17:01	14NC58	12497 – 12511	14NR49	09248 – 09262	-0.1 m
7-26-2014	19:01 – 19:04	14NC59	12882 – 12900	14NR50	09630 – 09648	-0.2 m
7-26-2014	19:10 – 19:15	14NC59	12901 – 12936	14NR50	09649 – 09684	-0.1 – 0.1 m
7-26-2014	19:20 – 19:21	14NC59	12937 – 12946	14NR50	09685 – 09694	0.2 m
7-26-2014	19:28 – 19:29	14NC59	12947 – 12956	14NR50	09695 – 09704	0.0 m
7-26-2014	23:36 – 23:39	14NC60	13030 – 13051	14NR51	09778 – 09799	2.6 – 2.8 m
7-26-2014	23:43 – 23:47	14NC60	13052 – 13074	14NR51	09800 – 09822	2.7 – 2.9 m
7-26-2014	23:51 – 23:53	14NC60	13075 – 13083	14NR51	09823 – 09831	2.7 – 2.9 m
7-26-2014	23:57 – 23:58	14NC60	13084 – 13093	14NR51	09832 – 09841	2.8 m
7-27-2014	00:03 – 00:06	14NC60	13094 – 13112	14NR51	09842 – 09860	2.7 – 2.8 m
7-27-2014	16:51 – 16:53	14NC61	13302 – 13318	14NR52	10050 – 10066	-0.1 m
8-08-2014	22:07 – 22:10	14NC67	15765 – 15779	14NR58	12513 – 12527	2.7 m
8-08-2014	22:25 – 22:31	14NC67	15789 – 15824	14NR58	12537 – 12572	2.3 – 2.9 m
8-08-2014	22:36 – 22:39	14NC67	15825 – 15841	14NR58	12573 – 12589	2.4 – 2.7 m
8-08-2014	22:46 – 22:48	14NC67	15842 – 15858	14NR58	12590 – 12606	2.5 – 2.7 m
8-08-2014	22:55 – 22:58	14NC67	15859 – 15875	14NR58	12607 – 12623	2.4 m

8-08-2014	23:03 – 23:05	14NC67	15876 – 15885	14NR58	12624 – 12633	2.4 m
8-08-2014	23:11 – 23:15	14NC67	15886 – 15913	14NR58	12634 – 12661	2.4 – 2.9 m
8-09-2014	23:31 – 23:32	14NC68	16287 – 16294	14NR59	13035 – 13042	3.3 – 3.4 m
8-09-2014	23:48 – 23:50	14NC68	16326 – 16338	14NR59	13074 – 13086	2.5 – 3.4 m
8-10-2014	00:14 – 00:15	14NC68	16339 – 16348	14NR59	13087 – 13096	3.4 m
8-10-2014	00:20 – 00:23	14NC68	16349 – 16370	14NR59	13097 – 13118	3.4 m
8-10-2014	00:28 – 00:29	14NC68	16371 – 16383	14NR59	13119 – 13131	3.3 – 3.4 m
8-10-2014	22:56 – 22:59	14NC70	16501 – 16520	14NR61	13249 – 13268	2.8 – 2.9 m
8-10-2014	23:05 – 23:07	14NC70	16521 – 16534	14NR61	13269 – 13282	3.0 m

\*Tide levels are given in meters above MLLW and were calculated using the Pydro software tool with a TCARI grid referenced to verified water level observations at NOS gauges. The height of the MHW tidal datum in the project area varies between 2.39 – 3.17 meters above MLLW.

## Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of AB. The final QC review was completed in February 2017. 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 10.3.1 software. All project data was evaluated for compliance to CMP requirements.

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

- 18458, Hood Canal, South Point to Quatsap Point, 1:25,000 scale, 17th Ed., Oct. 2010
- 18464, Port Townsend, 1:20,000 scale, 25th Ed., Jul. 2006
- 18471, Approaches to Admiralty Inlet, Dungeness to Oak Bay, 1:40,000 scale, 11th Ed., Dec. 2007
- 18476, Puget Sound, Hood Canal to Dabob Bay, 1:40,000 scale, 6th Ed., Sep. 2011
- 18477, Puget Sound Entrance to Hood Canal, 1:25,000 scale, 5th Ed., Aug. 2001

## End Products and Deliverables

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

### Remote Sensing Division Electronic Data Library

- Project database
- Airborne Positioning and Orientation Report (APOR)
- Aerotriangulation Report
- GC11273 in shapefile format
- Project Completion Report (PCR)
- Chart Evaluation File in shapefile format

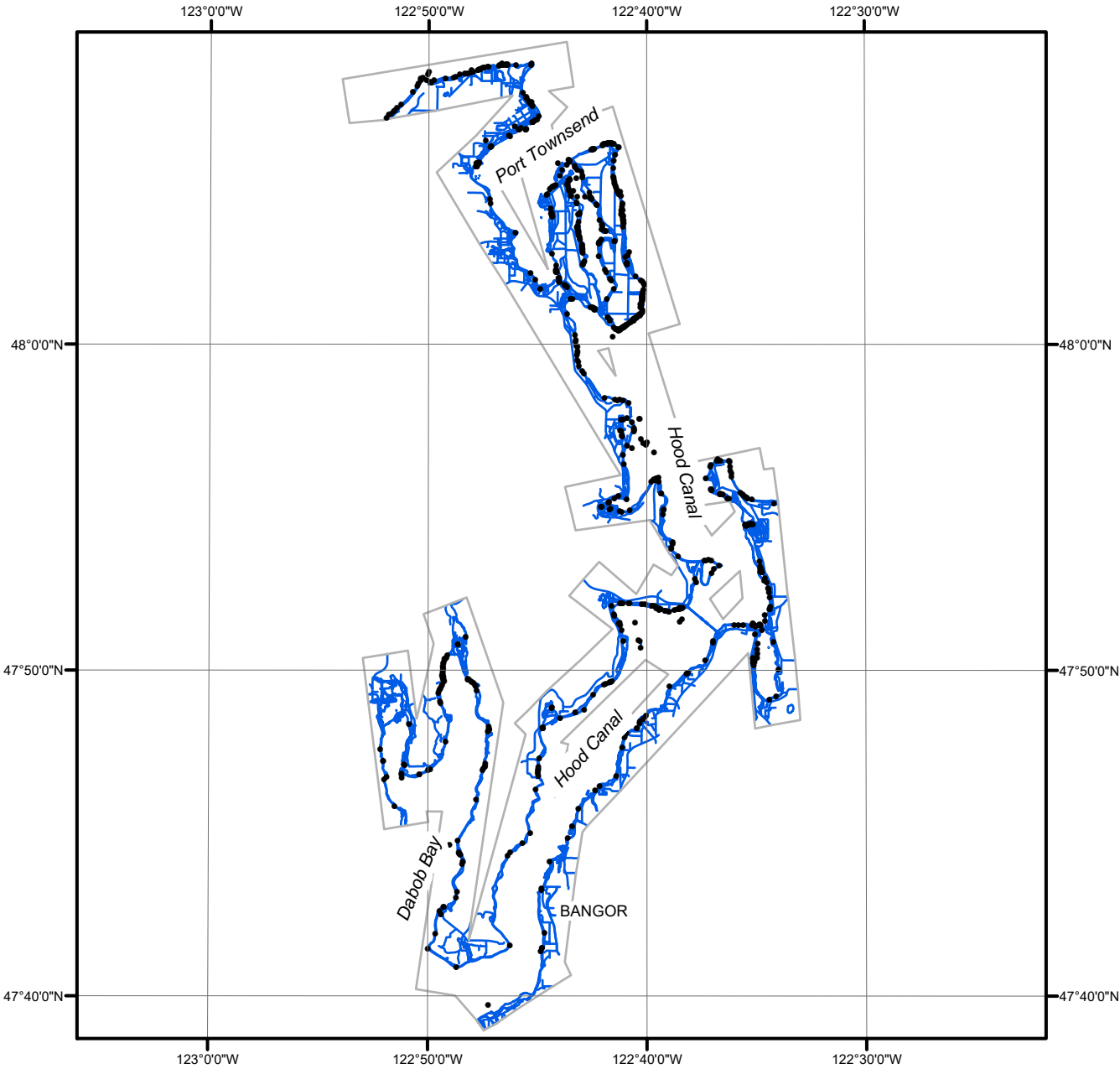
**NOAA Shoreline Data Explorer**

- GC11273 in shapefile format
- Metadata file for GC11273
- Digital copy of the PCR in Adobe PDF format

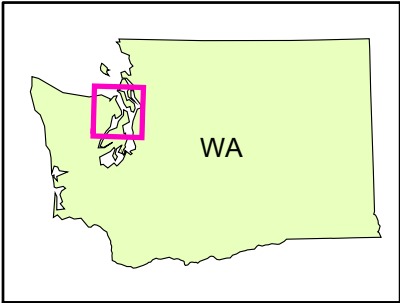
**End of Report**

HOOD CANAL, PORT TOWNSEND TO DABOB BAY

WASHINGTON



Overview



WA1401A-CM-N

GC11273