

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

## ***PROJECT NC0801D***

### ***Rodanthe to Hatteras Inlet, North Carolina***

#### **Introduction**

Coastal Mapping Program (CMP) Project NC0801D, located along the Outer Banks of eastern North Carolina, extends from Rodanthe southward to Hatteras Inlet. The project includes Cape Hatteras and Hatteras Marina. The approximate bounding coordinates are 35°10' to 35°36' latitude, and 75°26' to 75°48' longitude. The project is part of the larger NC0801 acquisition project that extends from Cape Henry, Virginia to Ocracoke Island, North Carolina.

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

#### **Project Design**

The Requirements Branch (RB) of the Remote Sensing Division (RSD) formulated the photographic mission instructions for this project supplementary to the Photo Mission Standard Operating Procedure Version II (7/1/1993), the GPS Controlled Photogrammetry Field Operations Manual (1/2/1996), and the Light Detection And Ranging (LIDAR) Requirements Version 5 (7/3/2003). The instructions discussed the project's purpose, geographic area of coverage, scope and priority; photographic and LIDAR 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. RB created a Project Layout Diagram, flight maps and input files for the aircraft flight management system.

#### **Field Operations**

The field operations consisted of acquisition of aerial LIDAR data, digital aerial imagery, static and kinematic Global Positioning System (GPS) data, and Inertial Measurement Unit (IMU) data. Static GPS data were collected to support aerial data collection and processing operations as well as to assess the accuracy of post-processed imagery and LIDAR products.

The airborne survey operations were conducted March 17-27, 2008 with the NOAA Cessna Citation (N52RF). Twenty-Seven strips of natural color digital images were acquired at a flying height of 1,500 meters, for a nominal ground sample distance (GSD) of 0.17 meters with an Applanix Digital Sensor System (DSS-439). Additionally, tandem strips of LIDAR data were collected, using an Optech ALTM 3100 Topographic LIDAR sensor, for those areas

corresponding to the outer coastline. LIDAR postings were collected at a nominal density of 1 posting per square meter.

Note that all aerial data and imagery was intended to be collected with water levels at or below the MLLW tide stage based on NOS tide predictions. Unfortunately there were no tide gauges operating in the Cape Hatteras area at the time of the survey, so actual tide levels for the NC0801D images could not be determined.

### **Airborne GPS/IMU Data Processing**

GPS and IMU data were processed by RSD personnel to yield precise camera positions and orientations in order to provide a control network necessary for aerotriangulation. A local fixed base station at Newport News International Airport (PHF1) and a CORS station (NCPI, Pea Island) were used as base data for the GPS/IMU post-processing. The airborne kinematic data was processed using Applanix POSPAC (ver. 4.4) software in March-April of 2008. An Airborne Positioning and Orientation Report was written and is on file with other project data within the RSD Applications Branch (AB) Project Archive.

### **Ortho-image Processing**

Ortho-images (RGB) were created with the DSS-439 imagery and associated image Exterior Orientation (EO) data using Applanix RapidOrtho software. United States Geological Survey (USGS) National Elevation Data (NED) were utilized as models to rectify the data.

Multiple field-surveyed check points were established using static GPS positioning methods, to assess the accuracy of the orthoimage data. Fifty (50) check points were surveyed in the Virginia Beach, VA area and twelve (12) check points were surveyed in the Frisco, NC area. Using these check points, the accuracy of the ortho-images was computed to be **2.0 meters** circular error at the 95% confidence level (CE95).

### **LIDAR Data Processing**

LIDAR point cloud data were processed using the combined chain of:

- 1) Optech's *Project Dashboard* pre-processing software to place the LIDAR point cloud into a mapping projection,
- 2) Terrasolid's suite of LIDAR calibration and editing software to correct alignment, remove erroneous returns, and classify bare earth points,
- 3) NOAA's VDatum software to convert the vertical datum of the bare earth points from NAVD88 to local MHW, and
- 4) GeoCue LIDAR processing software to produce MHW digital elevation models (DEM) at 1m pixel resolution.

The journal article "Lidar-Derived National Shoreline: Empirical and Stochastic Uncertainty Analyses" (2010), published in the *Journal of Coastal Research*, contains more detailed information, and is on file in the RSD Project Archive.

## Aerotriangulation

The aerotriangulation (AT) task was initiated by RSD personnel in January of 2010 utilizing a Digital Photogrammetric Workstation (DPW). Image measurements and block adjustments were performed using BAE Systems' SOCET SET (SS, version 5.4.1) photogrammetric software. AT procedures were accomplished using the Multi-Sensor Triangulation (MST) module of SS. The Automatic Point Measurement (APM) algorithm, within MST, was used to collect tie points, and a simultaneous solve adjustment was then performed. The predicted horizontal circular error, using all measured image points, was computed to be **0.21 meters** at the 95% confidence level (CE95). Positional data for this project is referenced to the North American Datum of 1983 (NAD 83). An Aerotriangulation Report was written and is on file with other project data within the RSD Project Archive.

## Compilation

The data compilation phase of this project was performed between September 2009 and November 2010 and was performed in the following three distinct technical phases:

- 1) *LIDAR MHW Shoreline approach* – A MHW shoreline vector (in shapefile format) for the outer coastline, from Rodanthe to Ocracoke Island, was delineated using the MHW DEM discussed above and a Raster-to-Vector (R2V) script implemented within ESRI's ArcGIS 9.3 software. The shapefile table was then edited to create attribute fields compatible with the RSD interim shapefile format. Subsequently, the ortho-images were used to review/edit/attribute the LIDAR shoreline vector. The LIDAR shoreline was limited to sandy, natural MHW shoreline features along the outer Atlantic Ocean coastline and to portions of Hatteras Inlet. LIDAR was not utilized to delineate engineered features such as bulkheads, piers, bridges, or the backshore areas of Pamlico Sound.

The LIDAR shoreline was compared to higher accuracy field transects, acquired at three sample sites in the larger NC0801 project area. Based on this comparison, the LIDAR derived shoreline vectors meet a horizontal accuracy of **4.5 meters** at CE95. This procedure is described in fuller detail in the journal article referenced above.

- 2) *Semi-Automated Feature Extraction (AFE) approach* – For compilation of the backshore marshes, an AFE method was performed using the ortho-images discussed above in combination with an object-based image analysis approach from within the ENVI Feature Extraction (Fx) software. ENVI Fx allows the user to interactively create and classify objects, based on image rules that meet in-situ criteria, and then run a R2V algorithm to convert the classified objects to an ArcGIS polygon shapefile. Upon completion of the AFE process, the polygon shapefile was imported into ArcGIS and 1) *aggregated* to merge polygons separated by less than the standard minimum distance, 2) *converted* to a polyline format, 3) *smoothed* and *simplified*, and 4) *edited* to create attribute fields (within the table) compatible with the RSD interim shapefile format. As in the LIDAR phase, ortho-images were used to review/edit/attribute the AFE shoreline vectors. The AFE shoreline was limited to marsh shorelines in the backshore areas of Pamlico Sound.

Features compiled from the AFE method meet a horizontal accuracy of **2.0 meters** at

CE95, as stated above in the Ortho-image Data section.

Note: The shape files, created in phases 1 and 2 above, were *merged* within ArcGIS to create a single “Shoreline” shapefile in the RSD interim format. This *merged* file was then imported into SS and a Feature Database (FDB), consisting solely of MHW and Marsh shoreline features, was created.

- 3) *Manual Compilation approach* –Monoscopic and stereo methods - the FDB, created above, was subsequently populated with additional features compiled using the SS Feature Extraction software module in combination with the Orthoimages. This served to integrate all coastal features within a single FDB. The manual data compilation phase utilized the *traditional* RSD digital mapping approach of manual interpretation integrated within a “heads-up” digitizing environment. As in phase 2 above, features compiled here meet a horizontal accuracy of **2.0 meters** at CE95.

In the areas where important navigational features were identified, an Aerotriangulation (AT) was accomplished in order to confirm the compiled features using a higher accuracy data source. The AT’ed area extended from Buxton to Ocracoke Island and encompassed Hatteras Inlet, Hatteras Inlet Tower, Hatteras Marina, the Ocracoke and Hatteras Ferry Terminals as well as Cape Hatteras and the Cape Hatteras Lighthouse (see the NC0801D AT report). The compiled features in this area were reviewed and edited using the higher accuracy stereo-models and therefore meet a horizontal accuracy of **0.4 meters** at CE95 - calculated by doubling the circular error derived from AT statistics.

Feature attribution, for all three phases above, 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.

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

Date	Time (UTC)	Roll Id	Strip	Frames	GSD
3/17/2008	16:41 – 16:44	08NC86	25-072	18475 – 18511	0.17 m
3/17/2008	16:51 – 17:05	08NC86	25-085	18512 – 18651	0.17 m
3/17/2008	17:10 – 17:18	08NC86	25-086	18652 – 18778	0.17 m
3/17/2008	17:24 – 17:26	08NC86	25-073	18779 – 18813	0.17 m
3/18/2008	15:08 – 15:13	08NC87	25-067	19293 – 19378	0.17 m
3/18/2008	15:18 – 15:24	08NC87	25-066	19392 – 19477	0.17 m
3/18/2008	15:29 – 15:34	08NC87	25-065	19478 – 19563	0.17 m
3/18/2008	15:40 – 15:45	08NC87	25-064	19580 – 19665	0.17 m
3/18/2008	15:49 – 15:55	08NC87	25-063	19666 – 19751	0.17 m
3/18/2008	16:00 – 16:06	08NC87	25-062	19771 – 19856	0.17 m
3/18/2008	16:12 – 16:21	08NC87	25-089	19857 – 19984	0.17 m
3/18/2008	16:27 – 16:29	08NC87	25-080	19985 – 20012	0.17 m
3/20/2008	17:52 – 17:53	08NC88	25-079	20790 – 20797	0.17 m
3/20/2008	17:59 – 18:01	08NC88	25-078	20798 – 20827	0.17 m
3/21/2008	14:15 – 14:17	08NC89	25-071	21540 – 21576	0.17 m
3/21/2008	14:23 – 14:32	08NC89	25-084	21577 – 21703	0.17 m
3/21/2008	14:37 – 14:45	08NC89	25-087	21704 – 21831	0.17 m
3/21/2008	14:51 – 14:53	08NC89	25-074	21832 – 21865	0.17 m
3/25/2008	19:22 – 19:30	08NC90	25-088	22097 – 22221	0.17 m
3/25/2008	19:39 – 19:41	08NC90	25-076	22222 – 22254	0.17 m
3/25/2008	20:46 – 20:48	08NC90	25-077	22969 – 22990	0.17 m
3/26/2008	14:19 – 14:21	08NC91	25-075	23211 – 23244	0.17 m
3/27/2008	16:28 – 16:36	08NC93	25-083	27836 – 27956	0.17 m
3/27/2008	16:41 – 16:47	08NC93	25-061	27957 – 28043	0.17 m
3/27/2008	16:52 – 16:57	08NC93	25-060	28064 – 28150	0.17 m
3/27/2008	17:01 – 17:07	08NC93	25-059	28151 – 28237	0.17 m
3/27/2008	17:11 – 17:17	08NC93	25-058	28261 – 28347	0.17 m

## Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of AB. Final QC review was completed in July 2010, including analysis of aerotriangulation results, assessment of the spatial placement of the LIDAR and AFE derived shorelines from within the stereo viewing environment, 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 9.3 software. All project data was evaluated for compliance to CMP requirements.

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

11555, Cape Hatteras - Wimble Shoals to Ocracoke Inlet, 40<sup>th</sup> ed., Apr. /06

## **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 Airborne Positioning and Orientation Report (APOR)
- Hardcopy of the Aerotriangulation (AT) Report
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10846 file contents, attached to PCR
- Hardcopy of journal article, "Lidar-Derived National Shoreline: Empirical and Stochastic Uncertainty Analyses" by White et al

### **Remote Sensing Division Electronic Data Library**

- Project database
- GC10846 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

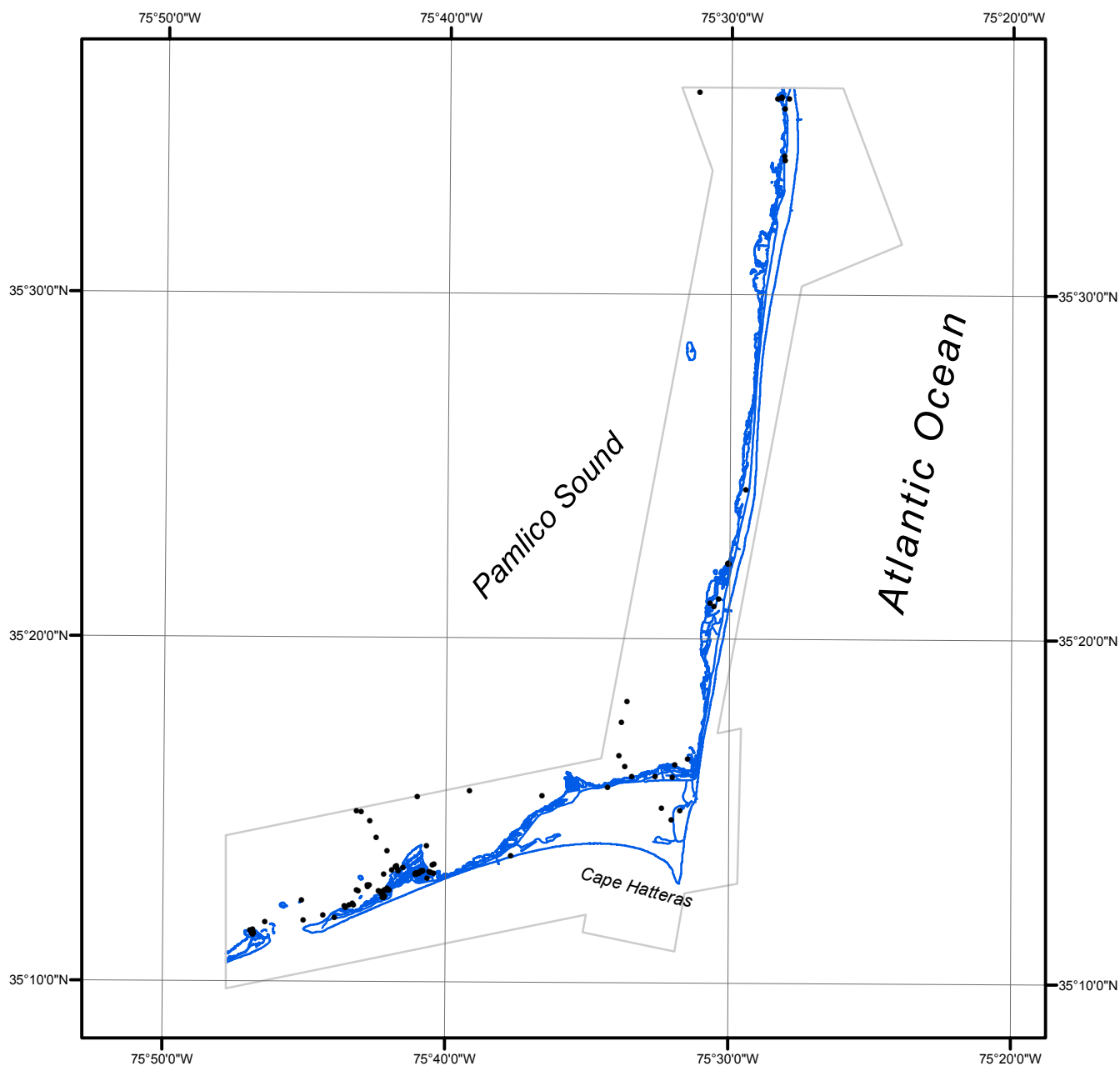
### **NOAA Shoreline Data Explorer**

- GC10846 in shapefile format
- Metadata file for GC10846
- Digital copy of the PCR in Adobe PDF format

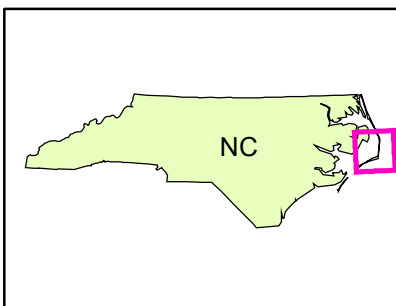
## **End of Report**

# RODANTHE TO HATTERAS INLET

## NORTH CAROLINA



Overview



NC0801D

GC10846