Light Detection and Ranging (LIDAR), Digital Camera Imagery and Shoreline Requirements

SCOPE OF WORK FOR SHORELINE MAPPING

REMOTE SENSING DIVISION
NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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List of Acronyms

ASPRS..... American Society of Photogrammetry and Remote Sensing

CMP.....Coastal Mapping Program

CO ..... Contracting Officer

COR..... Contracting Officer's Representative

CORS.....Continuously Operating Reference Stations

DEM.....Digital Elevation Model

FGDC..... Federal Geographic Data Committee

GSD.....Ground Sample Distance

IWG-OCM.....Interagency Working Group on Ocean and Coastal Mapping

JALBTCX.....Joint Airborne Lidar Bathymetry Technical Center of Expertise

LIDAR .....Light Detection and Ranging

MHW.....Mean High Water

MLLW.....Mean Lower Low Water

NAD ..... North American Datum

NIR.....Near-Infrared

NGS.....National Geodetic Survey

NAVD ..... North American Vertical Datum

NOAA ..... National Oceanic and Atmospheric Administration

NOS.....National Ocean Service

NPS.....Nominal Pulse Spacing

NSRS.....National Spatial Reference System

NSSDA..... National Standard for Spatial Data Accuracy

NVA.....Non-vegetated Vertical Accuracy

OCM.....Office of Coastal Management

POC……Point of Contact

QA……Quality Assurance

QC……Quality Control

RGB……Red, Green, and Blue

RMSE……Root Mean Square Error

RSD……Remote Sensing Division

SOW……Scope of Work

TOMIS……Task Order Management and Information System

USACE……United States Army Corps of Engineers

USGS……United States Geological Survey

UTC……Universal Coordinated Time

VVA……Vegetated Vertical Accuracy

1 Overview

The National Geodetic Survey (NGS) Remote Sensing Division (RSD) Coastal Mapping Program (CMP) requires the collection of airborne topographic/bathymetric lidar and digital camera imagery data to enable accurate and consistent measurement of the national shoreline. The shoreline is defined as the land water interface at a specific tidal datum. Topographic/bathymetric lidar is employed as an accurate, efficient way to collect data for generation of a DEM, which is in turn used to extract vectors for generating the tidal datum shoreline of interest. The CMP works to provide a regularly-updated and consistent national shoreline to define America's marine territorial limits and manage coastal resources. This shoreline is applied to National Oceanic and Atmospheric Administration (NOAA) nautical charts and is considered authoritative when determining the official shoreline for the United States.

This Scope of Work defines requirements for lidar and digital camera imagery data acquisition and processing to support the CMP, for accurate and consistent shoreline. However, NGS recognizes there are many other uses to this data to support additional mapping, charting, geodesy services, marine debris surveys, and for other purposes in coastal states. In addition, NOAA participates with the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM) and the Committee on Marine Transportation Safety to develop common standards for airborne coastal mapping and charting data and products. These standards were developed in conjunction with the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) partner agencies (U.S. Army Corps of Engineers (USACE), U.S. Naval Oceanographic Office (NAVO), and the U.S. Geological Survey (USGS).

The following conventions have been adopted for this document. The term "shall" means that compliance is required. The term "should" implies that compliance is not required, but is strongly recommended. All times shall be recorded in Universal Coordinated Time (UTC).

2 Requirements

The Contractor shall provide topographic/bathymetric lidar data and digital camera imagery for the designated areas as detailed in the provided project boundary shapefile. Data collection, processing, accuracy assessment, and delivery shall be accomplished in accordance with the following specifications. The contractor shall provide all necessary labor, equipment, material, software, and supplies to satisfactorily complete the SOW.

The contractor's proposal shall provide the specific roles of the subcontractors in detail including geography. The proposal shall clearly delineate the price being paid the subcontractor and a statement certifying that the subcontractor has agreed to the scope and pricing.

3 Regulatory Compliance

The Contractor shall comply with all applicable Federal, State, and local regulations.

4 Safety

Operations shall be in full compliance with appropriate federal, state, county, and city safety rules and regulations.

5 Data Coverage

The project area shall be the specified area as detailed in the provided project boundary shapefile. Lidar and digital camera imagery data shall be provided along the designated region of interest. Topographic/bathymetric lidar and digital camera imagery data shall be collected to the extent defined in the project boundary shapefile and specifically seaward from the land/water interface, to the specified extent as detailed in the provided project boundary shapefile except where laser extinction precludes reaching this extent from shore. Shapefiles will be provided to indicate the limits of the project area definition. In the event that poor water clarity and/or related environmental factors make coverage impossible the COR shall be notified as early as possible. In addition, the contractor shall identify (textually and/or graphically) those areas where full coverage was not obtained.

6 Topographic/Bathymetric LIDAR Data Collection and Processing

1. Topographic/Bathymetric lidar shall be collected within the specified area detailed in the provided project boundary shapefile. A lidar sensor capable of collecting both topographic and bathymetric data concurrently shall be utilized. Shapefiles shall be provided to indicate the limits of the boundaries to be surveyed.

2. In the requested survey areas, bathymetric lidar data are required from the water's edge seaward from the land/water interface, to the specified extent as detailed in the provided project boundary shapefile or to laser extinction, whichever comes first. For shoreline mapping and modeling uses, it is particularly important to have good bathymetric data in the very shallow (0-4 m) areas. For this reason, the lidar systems, software, and processing procedures shall enable measurement of bathymetry in this very shallow region. The sensor used for this mapping shall have an operational measurement depth range equal to or greater than a 1.5 secchi depth. Sensors with segmented beams, shall also comply with these specifications.

3. The lidar can be collected day or night.

4. The contractor is encouraged to collect imagery concurrently with the bathymetric lidar to assist in editing, although not required as a deliverable.

5. It is recommended to fly at an altitude as low as possible (within the eye safety parameters established by the sensor manufacturer and applicable regulations), so as to maximize bathymetric returns. A nominal density of 2 points per square meter shall be met, to support the gridding of a 1 meter GSD DEM. The bathymetric or submerged

topographic portion of the lidar collect shall be planned for a nominal density for 2 points per square meter, although it is understood that this density may not be met due to certain environmental conditions that cannot be controlled.

6. The spatial distribution of geometrically usable points is expected to be uniform. Although it is understood that lidar instruments do not produce regularly gridded points, collections should be planned and executed to produce a first-return point cloud that approaches a regular lattice of points, rather than a collection of widely spaced high density profiles of the terrain.

7. NOAA's overarching objective is to obtain clean, seamless (i.e., free of gaps or discontinuities) topographic-bathymetric data across the intertidal zone and shallow nearshore zone. With this overarching objective in mind, the following decision tree shall be used for determining when to collect shoreline flight lines:

    a. Optimal environmental conditions: If the mission crew encounters` optimal environmental conditions for nearshore topo-bathy mapping (defined here to mean exceptional water clarity relative to typical conditions in project site, as well as low wind and wave conditions in the surf and nearshore zones) at any time during the project, then the flight lines shall be flown immediately, to take advantage of the optimal conditions, without concern for stage of tide. If these optimal conditions yield clean, seamless topographic and bathymetric data, free of voids in the intertidal zone and near shore submerged topography, then it may be unnecessary to conduct repeat passes for that flight line; however, this shall be verified with the COR. A repeat pass is recommended to assist in filling in voids due to waves and white water.

    b. All other conditions: In the absence of optimal environmental conditions, the shoreline flightlines shall be tide coordinated to ensure the highest probability of achieving clean, seamless topo-bathy coverage across the intertidal and shallow nearshore zones. This typically requires flying each shoreline flight line twice: once within 20% of the Mean Range of tide around MLLW and once within 30% of the Mean Range of tide around MHW, as well as during favorable water clarity conditions. The Mean Range of tide is defined as the difference in height between mean high water and mean low water. If the contractor wishes to propose an alternate method for achieving the overarching objective (clean, seamless data across the intertidal and shallow nearshore zones) for a particular area, the proposed method shall be discussed with the COR and NGS, and the COR's approval granted, before proceeding.

8. NGS recognizes the uncertainty for bathymetric lidar success along many areas of the coast. The Contractor has complete flexibility to determine the priority, location and schedule of data collection for mapping production, provided the schedule defined in Section 18 is achieved. Contractor has the right to demobilize and remobilize at any

time, provided the schedule defined in Section 18 is achieved and the resulting mapping activities are communicated with the Point of Contact (POC) for Contract Issues.

9. A major consideration in bathy lidar acquisition is water clarity, as high turbidity can hinder or preclude lidar acquisition in many areas of the U.S. Acquisition contractors are responsible for monitoring water clarity conditions in the project sites and determining suitable times for acquisition. Second, as water clarity in a region can vary on time scales from minutes to hours, seasons, and longer, it is important to continually assess local weather events (e.g., rain or winds that can cause sediment re-suspension), tides, currents, and other factors that can affect the probability of success of bathy lidar acquisition.

10. In areas where water conditions are deemed unsuitable for lidar collection, conditions shall be monitored in attempt to seize any opportunity to collect valid data. Some locations may require acquisition opportunities at a significantly different time period to investigate different conditions. Subsequent efforts shall be made to collect valid data, at the discretion of the Contractor. The contractor shall communicate results with the Point of Contact (POC) for Contract Issues.

11. The bathymetric lidar requirement may be eliminated from a task order in areas where persistent turbidity or weather conditions prohibit successful bathymetric lidar data collection. In instances where requirements are eliminated, the task for this area will be utilized to cover other NGS requirements.

12. In areas where bathymetry requirements are eliminated, the topographic data portion shall be collected in accordance with the specifications stated herein, as well as the flight line that intersects the shoreline with specification adhered to as stated in section 7.4.b.

13. Bathymetric lidar points shall meet a vertical RMSE of $QL2_b$ specified in the Draft National Coastal Mapping Strategy 1.0 Document. Table 1 below documents this specification. This SOW does not require IHO feature detection standards to be met, as stated in IHO S-44 TVU standards for Order 1b surveys. However, any seafloor features (e.g., wrecks or submerged rocks) identified in the data are of interest to NOAA, shall not be removed.

    The form of the vertical accuracy specifications given in the table is taken from the International Hydrographic Organization S-44 standard:

$$\pm \sqrt{a^2 + (b \times d)^2}$$

    where:

    - *a* represents that portion of the uncertainty that does not vary with depth
    - *b* is a coefficient which represents that portion of the uncertainty that varies with depth
    - *d* is the water depth

b x d represents that portion of the uncertainty that varies with depth

Vertical positions of subaerial (i.e., topographic) points shall meet the 10 cm accuracy class standard for elevation data as specified in the APSRS Positional Accuracy Standards for Digital Geospatial Data Edition, 1, Version 1.0 – November, 2014. Testing and reporting of vertical accuracies shall follow the procedures for the Non-vegetated Vertical Accuracy (NVA) at the 95% confidence level in all non-vegetated land cover categories combined and reports the Vegetated Vertical Accuracy (VVA) at the 95th percentile in all vegetated land cover categories combined stated in the Standard. A copy of this specification may be found at: http://www.asprs.org/a/society/committees/standards/ASPRS_Positional_Accuracy_Standards_Edition1_Version100_November2014.pdf .

Table 1. Quality level definitions for bathymetric lidar. These definitions are applicable for areas submerged at the time of survey.

Bathy Lidar Quality Level	**Source**	**Vertical accuracy coefficients a,b as in** $\pm\sqrt{a^2 + (b \times d)^2}$	**Nominal Pulse Spacing (m)**	**Point Density (pt/m²)**	**Example Applications**
$QL0_B$	Bathymetric Lidar	0.25, 0.0075	≤0.7	≥2.0	Detailed site surveys requiring the highest accuracy and highest resolution seafloor definition; dredging and inshore engineering surveys; high-resolution surveys of ports and harbors
$QL1_B$	Bathymetric Lidar	0.25, 0.0075	≤2.0	≥0.25	
$QL2_B$	Bathymetric Lidar	0.30, 0.0130	≤0.7	≥2.0	Charting surveys; regional sediment management
$QL3_B$	Bathymetric Lidar	0.30, 0.0130	≤20	≥0.25	General bathymetric mapping; coastal science and management applications Change analysis; deepwater surveys, environmental analysis

$QL4_B$	Bathymetric Lidar	0.50, 0.0130	≤5.0	≥0.04	Recon/planning; all general applications not requiring higher resolution and accuracy

14. Horizontal positions shall be accurate to 1.0m (RMSE)

15. Horizontal Datum - All positions shall be tied to the NSRS via processing with respect to the NGS-managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used. This datum and coordinate system must be used throughout the survey project for everything that has a position or for which a position is to be determined. Those documents used for comparisons, such as charts, junctional surveys, and prior surveys, must be referenced or converted to NAD 83. In addition, all software used on a survey must contain the correct datum parameters.

16. Vertical Datum: All positions shall be tied to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010 ellipsoidal heights in meters.

17. For QA/QC purposes, one cross line is required every 30 kilometers. In areas of the coast where natural or artificial barriers prevent aircraft operations, the cross line(s) shall be collected at the nearest possible location to the required interval, but no closer than 8 kilometers to an adjacent planned cross line.

18. Flight lines shall have a minimum of 20% planned sidelap with adjacent flight lines.

19. In areas where valid bathymetry data are obtained, topographic data should be collected such that the resulting bathymetric and topographic lidar data may be merged later with no discontinuity. Prudence should be exercised by the Contractor to ensure the final bathymetry and topographic data submitted are in agreement with one another.

20. Data gaps due to aircraft motion or building shadows shall be re-flown to fill the voids.

21. The Contractor shall make reasonable “best efforts” to fill voids due to white water and breaking waves near the land-water interface.

22. If airspace restrictions are anticipated or known, the Contractor shall coordinate with the NGS for any needed assistance in obtaining clearance(s). If clearance cannot be

obtained, survey requirements within these areas shall be eliminated and the task order shall be modified in similar manner as presented in Section 6.11.

23. Intensity values are required for each return. The values shall be recorded in the .las files in their native radiometric resolution.

24. Atmospheric conditions shall be cloud and fog-free between the aircraft and ground during all collection operations. Ground conditions shall be snow free.

25. The data shall be provided in accordance with Section 18 by regions, defined by the supplied tiling scheme.

26. The following conditions exist to define the "last day of collection" for metadata and attribution purposes.

    - All lidar data have been collected along the shoreline of the given region.
    - The last day on which the production data were collected within a tile shall be the "last day of collection."

7 Digital Camera Imagery Data Collection and Processing

The following section has been modified from the ***Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program, Attachment Z, Digital Aerial Camera Usage & Data Processing***. Unless otherwise stated below, all other specifications should be adhered to unless discussed with the COR and NGS, and the COR's approval granted, before proceeding.

1. The sensor shall be a geometrically stable and calibrated frame system suitable to use for high-accuracy photogrammetric mapping.

2. RGB/NIR images should be collected in a manner to provide stereo coverage of the area detailed in the provided project boundary shapefile. Any imagery collected for this project, outside of the ground swath defined, shall not be deleted. Since the imagery will likely be collected at a higher altitude, covering a larger swath than the project boundary, all imagery of the frame falling outside of the project boundary shall be processed and shall not be clipped to the project boundary.

3. SIDELAP – Adjacent images shall have a minimum sidelap of 30% of the mean image width.

4. ENDLAP – Consecutive images in a flight line shall have a minimum endlap of 60% of the mean image width.

5. RGB/NIR images should be collected in a manner to produce a resulting ortho-mosaic with a 30cm Ground Sample Distance (GSD).

6. WEATHER - Digital imaging shall not be conducted when clouds or cloud shadow obscure the land-water interface or features of navigational significance in the scene. The land-water interface shall not be obscured by snow, ice, smoke, haze, etc. Storm systems and events (e.g. hurricanes, northeasters, and frontal boundaries) that may cause an increase in water levels, tidal heights, and wave activity shall be avoided.

7. TIME OF DAY - Time of day for digital camera imagery is determined by the sun angle which shall not be less than 25 degrees above the horizon at the time of exposure. If imagery is collected between the months of November and February, the sun angle requirement shall not be less the 20 degrees.

8. Collection of the lidar data is the first priority of this task order and should not be precluded by meeting the RGB/NIR Imagery collection parameters above. The RGB/NIR imagery shall be collected within one month of the lidar collection and within 25% of the Mean Range of tide around MLLW. The temporal period may be relaxed in certain circumstances based on prior approval from the Point of Contact (POC) for Contract Issues.

9. Horizontal positions shall be accurate to ≤ 0.60 meters ($RMSE_x$ and $RMSE_y$)

10. Horizontal Datum - All positions will be tied to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used. This datum and coordinate system must be used throughout the survey project for everything that has a position or for which a position is to be determined. Those documents used for comparisons, such as charts, junctional surveys, and prior surveys, must be referenced or converted to NAD 83. In addition, all software used on a survey must contain the correct datum parameters.

11. Aerotriangulation is required in accordance to Attachment I in Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program

12. The following conditions exist to define the “last day of collection” for metadata and attribution purposes.

    - All digital camera imagery data have been collected along the shoreline of the given region.
    - The last day on which the production data were collected within a tile shall be the “last day of collection.”

8 Topographic/Bathymetric Lidar Point Cloud Cleaning, Classification, and Merge

GOAL: To clean, classify, and merge the collected topographic and bathymetric data acquired along the designated project boundaries. An integrated topographic-bathymetric point cloud dataset is an important component in understanding the land-sea interface and effectively adapting to sea level rise, mitigating impacts from natural hazards, storm surges, and flooding, as well as preserving the integrity of coastal habitats and resources.

1. The topographic and bathymetric point clouds shall be cleaned so that all outliers in the raw data are classified to the appropriate LAS classification scheme as detailed in Appendix 1. Outliers include obvious noise or clutter in the data such as returns from birds or atmospheric particles, or due to electronic noise; however be careful to not reclassify real features, such as offshore rocks, as class 7. In the LAS file, no points shall be permanently removed; rather they should be assigned to the appropriate class.

2. The LAS point cloud shall be bare earth processed for the topographic portion of the data set, with the classification scheme stated in Appendix 1 utilized at a minimum. Jetties and Groins exposed above the water line shall be classified as bare earth. All points representative of submerged topography below a water surface shall be classified as bathymetric point (e.g., seafloor or riverbed).

3. Point classification is to be consistent across the entire project. Noticeable variations in the character, texture, or quality of the classification between tiles, swaths, lifts, or other non-natural divisions will be cause for rejection of the entire deliverable.

4. Topographic and bathymetric lidar data shall be merged to form a single LAS point cloud. The merged LAS elevation data set shall be from the lidar project data available along the entire designated project boundary

5. Horizontal Datum - All positions shall be tied to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used. This datum and coordinate system shall be used throughout the survey project for everything that has a position or for which a position is to be determined. Those documents used for comparisons, such as charts, junctional surveys, and prior surveys, shall be referenced or converted to NAD 83. In addition, all software used on a survey must contain the correct datum parameters.

6. Vertical Datum: All positions shall be tied to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010 ellipsoidal heights in meters.

7. The following conditions exist to define the “last day of collection for metadata and attribution purposes.

    - All lidar data have been collected along the shoreline of the given region.
    - The last day on which the production data were collected within these tiles shall be the “last day of collection.”

9 Topographic/Bathymetric Merged DEM Creation

The contractor shall provide a consistent resolution merged DEM data set from high quality elevation data acquired along the entire project area. The contractor shall prepare a detailed work plan defining their process for performing the data merge and where and how they intend to fill in the data voids, and use of breaklines. The contractor shall also provide a confidence layer (SD of all ground or bathymetric points located within a 1 meter cell size). The contractor shall provide a data void layer showing all areas within the AOI where there is no data.

Issues to consider:

- Data gaps
- Interpolation on points/DEMs
- Synthetic points
- Smoothing vs Best Fit
- Generation of and use of breaklines
- Size of water bodies, rivers to consider

The contractor shall propose a DEM development plan and submit to the COR and NGS, and the COR's approval granted, before proceeding.

10 Quality Assurance

1. The contractor shall perform quality assurance on the final lidar topo/bathy merge LAS products, and provide an independent Quality Assurance report on the qualitative and quantitative quality of the final products as defined in Section 18.

2. The following quality control measure items will be calculated, documented and provided within the Quality Assurance Report.

    a. Bathymetric Portion of lidar Data

        i. Qualitative Assessment: The contractor should employ a qualitative methodology to assess the quality of the data. The process should look for

any anomalies in the data, classification errors, assure there are no obvious bias or elevation shifts between flight lines at the edges, and there are no scan pattern issues or geometric artifacts present in the data.

ii. Overlapping lines and datasets shall be compared to each other and to cross lines and the differences calculated.

iii. Elevations shall also be verified through comparison with ground truth data as described below.

iv. All systematic errors shall be identified and eliminated and remaining errors should have an approximately zero-mean Normal distribution (defined here as abs(μ) < 0.05 m, and abs(skewness) < 1.0), and shall meet a vertical RMSE of $QL2_b$ specified in the Draft National Coastal Mapping Strategy 1.0 Document..

b. Topographic portion of lidar Data

i. Qualitative Assessment: The contractor should employ an interpretive based methodology to assess the quality of the data. The process should look for any anomalies in the data, classification errors, assure there are no obvious bias or elevation shifts between flight lines at the edges, and there are no scan pattern issues or artifacts present in the data.

ii. Overlapping lines and datasets shall be compared to each other and the differences computed.

iii. The relative accuracy requirements listed below shall be calculated and meet the 10 cm accuracy class standard for elevation data as specified in the APSRS Positional Accuracy Standards for Digital Geospatial Data Edition, 1, Version 1.0 – November, 2014.

1. Within-Swath hard Surface Repeatability (Max Diff): 6 cm
2. Swath-to-Swath Non-Veg Terrain (RMSEDz): 8 cm
3. Swath-to-Swath Non-Veg Terrain (Max Diff): 16 cm

iv. Elevations shall also be verified through comparison with ground truth data as described below.

v. All systematic errors shall be identified and eliminated and remaining errors should have an approximately zero-mean Normal distribution (defined here as abs(μ) < 0.05 m, and abs(skewness) < 1.0), and shall meet the 10 cm accuracy class standard for elevation data as specified in the APSRS Positional Accuracy Standards for Digital Geospatial Data Edition, 1, Version 1.0 – November, 2014. Testing and reporting of vertical

accuracies shall follow the procedures for the Non-vegetated Vertical Accuracy (NVA) at the 95% confidence level in all non-vegetated land cover categories combined and reports the Vegetated Vertical Accuracy (VVA) at the 95th percentile in all vegetated land cover categories combined stated in the Standard. A copy of this specification may be found at: http://www.asprs.org/a/society/committees/standards/ASPRS_Positional_Accuracy_Standards_Edition1_Version100_November2014.pdf .

vi. The Quality Assurance report shall provide evaluation results of the point cloud accuracy for bare- earth and low grass and at least two other main categories of ground cover in the study area. For example, these additional categories could be:

1. High grass and crops (hay fields, corn fields, wheat fields);
2. Brush lands and low trees (chaparrals, mesquite, mangrove swamps);
3. Fully covered by trees (hardwoods, evergreens, mixed forests); and
4. Urban areas (high, dense manmade structures)

vii. The contractor may further subdivide and expand the above definitions to better accommodate the predominant vegetation and land cover types in the survey area. The contractor will evenly distribute sample points throughout each category area being evaluated and not group the sample points in a small subarea.

c. Check Points/Ground Truth

For each acquisition region detailed in the provided project boundary shapefile, the contractor shall follow the guidance of recommended number of checkpoints to be used for vertical accuracy testing of elevation datasets and for horizontal accuracy testing of digital orthoimagery data sets from the APSRS Positional Accuracy Standards for Digital Geospatial Data Edition, 1, Version 1.0 – November, 2014. The contractor shall follow the guidance of recommended number of

checkpoints based on project area for NVA and VVA. Checkpoints shall be distributed generally proportionally among the various land cover types in the project. The contractor shall propose a checkpoint acquisition plan for the project area to the COR and NGS, and the COR's approval granted, before proceeding. All raw data, notes and logs shall be provided along with the processed results of each area.

Lidar:

i. The contractor shall provide check points, “discrete areas of ground truth” within the designated region of interest to assist in the interrogation of the bathymetric data set.

ii. The contractor shall provide check points, “discrete areas of ground truth” for the ground cover categories specified in sections 9.b.v-viii, within the designated region of interest to assist in the interrogation of the topographic data set.

iii. Spot elevations to determine the accuracy of the overall dataset should be selected on flat terrain, or on uniformly sloping terrain for 5 meters in all directions from each checkpoint. Whereas flat terrain is preferable, this is not always possible. Whenever possible, terrain slope should not be steeper than a 10 percent grade and should avoid vertical artifacts or abrupt changes in elevation because horizontal errors will unduly influence the vertical RMSE calculations.

iv. The checkpoints shall be collected within a temporal period, close enough to the acquisition of data, which minimizes geomorphic change that can occur between the lidar and checkpoints.

v. Horizontal Datum - All positions shall be tied to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used.

vi. Vertical Control Datum - All positions will be tied to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010 ellipsoidal heights in meters.

vii. The accuracy of the check points should be at a minimum, based on the ASPRS standards, at least three times better than the accuracy of the lidar

they are being used to test. Documentation of all control used shall be provided in the Quality Assurance report.

Imagery:

i. The contractor shall provide horizontal check points at "well-defined points" within the designated region of interest to assist in the interrogation of the imagery data set.

ii. The contractor shall provide horizontal check points at "well-defined points" that represents a feature for which the horizontal position can be measured to a high degree of accuracy and position with respect to the geodetic datum.

iii. For testing orthoimagery, well-defined points shall not be selected on features elevated with respect to the elevation model used to rectify the imagery.

iv. The checkpoints shall be collected within a temporal period, close enough to the acquisition of data, which minimizes change that can occur between the imagery and checkpoints.

v. Horizontal Datum - All positions shall be tied to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used.

The accuracy of the check points should be at a minimum, based on the ASPRS standards, at least three times better than the accuracy of the lidar they are being used to test. Documentation of all control used shall be provided in the Quality Assurance report.

11 Lidar Shoreline Delineation

1. Shoreline Delineation for both Mean High Water (MHW) and Mean Lower Low Water (MLLW) will be performed by NGS/RSD from the contractor provided cleaned, classified and merged topographic/bathymetric lidar point cloud.

12 Shoreline Cleanup, Attribution, and Compilation

1. MHW and MLLW Shoreline will be provided from NGS/RSD to the Contractor for cleanup and feature attribution in conjunction with the project acquired imagery.

2. The contractor will format and attribute the NGS provided shoreline and produce associated deliverables in accordance with requirements stated in the ***Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program***. The MLLW Contour shall be snapped to a Shoreline Feature Class. All cultural features located within the extents of the imagery acquired, shall be collected and included. Unless otherwise stated, all specifications should be adhered to unless discussed with the COR and NGS, and the COR's approval granted, before proceeding. Examples of associated deliverables are the Chart Evaluation File (CEF) and Project Completion Report (PCR).

13 Records and Metadata

The contractor shall document all delivered data and data products (including options if exercised) according to Executive Order 12906 (http://www.fgdc.gov/policyandplanning/executive_order/) for the whole of the project in one metadata product. Specifically, the contractor shall deliver for all data and data products, metadata records which detail all flight lines, flight dates and times, datums, transformations, reprojections, resampling algorithms, processing steps, field records, positional accuracy, and any other pertinent information. The metadata records shall conform to the Content Standards for Digital Geospatial Metadata (FGDC-STD-001-1998) as published on May 1, 2000, by the Federal Geographic Data Committee (FGDC) or to any format that supersedes it as determined by the FGDC (http://www.fgdc.gov/metadata/csdgm/). Profiles and extensions to the standard that have been endorsed by the FGDC shall be used if they are applicable to the data or data products. The metadata records shall contain any and all elements, including those that are considered optional, wherever applicable to the data or data product. The metadata record shall contain sufficient detail to ensure the data or data product can be fully understood for future use and for posterity. The metadata records shall be delivered free of errors in both content and format as determined by the metadata parser (mp) program developed by the United States Geological Survey or an equivalent. The metadata records will be subject to review and approval prior to final acceptance by the Government.

14 Kickoff Meetings

The contractor shall participate in a kickoff meeting with the NOAA NGS within 30 days of contract award unless otherwise agreed upon by NOAA and the contractor. The meeting shall be held at the NOAA Headquarters in Silver Spring, MD. The contractor shall prepare an agenda for this meeting and issue meeting minutes within 7 days after the meeting.

15 IT Requirements

The Certification and Accreditation (C&A) or Assessment and Authentication (A&A) requirements of Clause 48 CFR 1352.239-72 do not apply, and a Security Accreditation Package is not required.

The contractor shall have completed the National Ocean Service (NOS) IT Security Questionnaire within one year prior to a given task order being awarded. NOS shall have evaluated the contractor's response to the questions and found the contractor to be an acceptable IT Security risk.

All media containing deliverables from the contractor shall be scanned by CSC prior to connecting to the network.

16 Contractor Coordination

Communication and coordination between both the contractor and the Government is considered vital to the satisfactory accomplishment of this SOW. The Contractor shall expect periodic interaction with the Government to ensure clear understanding of the anticipated products and satisfactory progress in the delivery of products.

The contractor shall submit monthly progress reports to the Government summarizing progress made and problems encountered. After submittal of each of these reports the contractor shall schedule a conference call with the government to discuss the progress of the project and any issues that need to be addressed. The contractor shall prepare and distribute an agenda for the call and shall distribute the meeting minutes within 5 days of the conclusion of the call.

17 Performance

1. Performance of the bathymetric portion of a task order shall be on the 'best level of effort' criteria as follows: NGS recognizes that there are potential issues that may prevent data collection in the areas identified within this Scope of Work. These include, but are not limited to, terrain, weather / winds, overhanging-vegetation, white water, water clarity, air traffic control, air space restrictions, and similar. The Contractor is not responsible for any gaps in coverage that are caused by such factors that are outside of the Contractor's control and a best level of effort has been followed to fill those gaps.

2. Should any of the total identified linear kilometers specified in the provided project boundary shapefile be eliminated during the course of the project as described in Section 6, parties agree to mutually revise the stated criteria as required by the provisions of the contract.

18 Deliverables

1. Property Of Data

All original data, from the instant of acquisition, and other deliverables required through this contract including final data, are and shall remain the property of the United States Government. This includes data collection outside the project area. These items include the contractor-furnished materials.

2. Provided By Government

The government will provide to the Contractor:

a. A project boundary in a shapefile detailing the region for acquisition of data.

b. i. Small scale maps showing the coastline and/or coastal ports to be acquired.

ii. Tide coordination time windows for data acquisition, if needed.

c. Rejected Data – If data are rejected by NGS, NGS will send sample data upon request showing the problem areas.

3. List of Deliverables

This section contains the complete list of deliverables associated with this project, subject to change. All submitted plans shall be of sufficient detail so that the Government can verify that the contractor has a thorough understanding of the requirements of this SOW. The contractor shall also complete the attached spreadsheet with a percentage of the overall task order that each deliverable represents and the proposed due date for each deliverable. This data will be used to track performance and for approval of invoices. The contractor may propose additional deliverables/ milestones in their technical proposal if they determine they are required. All deliverables, including monthly reports, shall be submitted using OCM's Task Order Management and Information System (TOMIS). The following project deliverables are required.

a. Work Plan – in some instances, the technical proposal may be accepted as the work plan. The work plan should include but is not limited to; potential base station locations, horizontal and vertical accuracy of the base stations, projected maximum baseline length for airborne trajectories, prior calibration reports, process to perform daily calibration checks, flight acquisition etc. The plan shall be in Microsoft Word format and shall include the major milestones and deliverables shown in Gantt chart format.

b. Flight line map and plan of lidar and imagery collecting aircraft. Shapefiles files identifying lidar and imagery acquisition flight lines.

c. Check Point/Ground Truth Plan – including detailed discussion of the number and distribution of checkpoints to be used for vertical accuracy testing of elevation data sets and for horizontal accuracy testing of digital orthoimagery data sets, acquisition strategy and associated uncertainties of checkpoints in Microsoft Word format.

d. Quality Control Plan – including detailed discussion of accuracy assessment methods/plan or other means of proving contract specifications have been met in Microsoft Word format.

e. DEM Development Plan – including detailed discussion of their work plan defining their process for performing the data merge for a consistent resolution DEM, how they intend to fill in the data voids, creation of the confidence layer in Microsoft Word format.

f. Project schedule to include dates for all deliverables.

g. Daily situational reports (sitreps) as an email correspondence. Only required during acquisition phase.

h. Monthly progress reports in a Microsoft Word, Excel or Project format on the 7th day of the month. In some cases a more appropriate regularly scheduled reporting timetable may be substituted contingent on agreement by all parties.

i. A Pilot area of at least 10 km^2 including LAS, imagery, DEMs, shoreline (lines and points) and metadata are required.

j. The raw data shall include, but not be limited to, digital copies of all electronic and paper files generated in the course of the survey, flight sheets, field data collection sheets, raw airborne and ground GPS data, Ground Truth data, GPS processing projects, processed GPS data, project tracking files, raw airborne lidar data, flight plans in GIS or manufacturer format, processed lidar data in manufacturer directory structure and format, crossline dataand an unclassified LAS 1.2 point cloud.

k. Final Products shall include:

    i. Data coverage images of the lidar (Lidar data coverage images will be delivered prior to delivery of elevation data.)
    ii. Cleaned, classified, and merged point clouds in a LAS 1.2 format
    iii. Lidar point cloud metadata
    iv. Topographic/Bathymetric DEM
    v. Topographic/Bathymetric DEM metadata
    vi. GeoTiff RGB/NIR Ortho-mosaic imagery
    vii. GeoTiff RGB/NIR Ortho-mosaic imagery metadata
    viii. RGB/NIR Stereo Imagery - Uncompressed Developed Images (*.tif)
    ix. RGB/NIR Stereo Imagery metadata
    x. Exterior Orientation (EO) Files (*.txt)
    xi. Ground Control Report for Imagery
    xii. Ground Control Report for lidar

xiii. Ground Control Shapefile for Imagery
xiv. Ground Control Shapefile for lidar
xv. Lidar Boresight and Calibration Report and Files
xvi. Camera Boresight Calibration Report and Files
xvii. Camera Calibration Report (Terrestrial Calibrations - Bench calibrations that have the computed distortion values)
xviii. Flight Line Maps for lidar
xix. Flight Line Maps for Imagery
xx. Shapefiles identifying imagery acquisition flight lines.
xxi. Shapefiles identifying lidar acquisition flight lines.
xxii. Shapefiles depicting exposure stations of acquired imagery
xxiii. Electronic Exposure Data (EED) File
xxiv. Tabulation of Aerial Photography
xxv. Photographic Flight Reports
xxvi. Lidar Flight Reports
xxvii. Airborne Positioning and Orientation Report (APOR)
xxviii. Aerotriangulation Report (95% CC computed)
xxix. Feature attributed shoreline shapefiles
xxx. Shoreline metadata
xxxi. Chart Evaluation Files (CEF)
xxxii. Project Completion Report (PCR)
xxxiii. Quality Assurance Report
xxxiv. Final Report of Survey.

All deliverables will be provided on external USB 3.0 capable hard drives that will become the property of the government.

l. All valid data collected during production flight lines shall be processed and used to generate the final products. This includes data that is collected outside of the project specified coastal swath that the scope specifies.

m. Additional information for each of the following products is found in Appendix 1

a) Lidar Data Coverage

b) Cleaned, Classified and Merged Topographic/Bathymetric Point Cloud Data in LAS 1.2 format

c) Topographic/Bathymetric DEM

d) RGB/NIR Ortho-mosaic Imagery

e) RGB/NIR Stereo Imagery

f) Aerotriangulation Report

g) Feature Attributed Shoreline Shapefiles and associated deliverable files

h) Metadata

i) EED File

j) Tabulation of Aerial Photography

k) Photographic Flight Reports

l) Airborne Positioning and Orientation Report (APOR)

m) Quality Assurance Report:

n) Final Report of Survey

19 Product Delivery Schedule

1. During project acquisitions, a daily sitrep as an email correspondence shall be provided by the contractor detailing the day's acquisition activities, location, and mission status.

2. Files to show survey progress are required every other week following start of survey. Near the end of survey period, this frequency shall increase to 1 update per week as directed by the POC. These files shall be provided in a format compatible with ArcGIS.

3. The data coverage product files will be delivered to POC no later than 14 days from the last day of data acquisition. Please see the Data Coverage section for details of this product.

4. Data and product delivery shall be based on regions as described in paragraph 17.2.a.iii

5. For the first two or three areas for which data are delivered, three or four (3-4) files of each product type shall be provided as examples for POC review. This review will focus on the format, structure and naming convention of the files rather than accuracy of the data contained within these files.

6. Following receipt of the sample files, the POC will review and provide comments to the Contractor within 14 days that indicate specific items that require correction of modification to format or content.

7. Final data and product delivery shall be made no later than 90 days after review comments are received by the Contractor.

8. For all other regions, the lidar data deliverables, excluding the coverage files, shall be delivered to POC no later than 120 days from last day of data acquisition. Imagery based products shall be provided no later than 120 days from the last day of data acquisition.

9. The POC will review the final versions of the delivered data for accuracy and completeness and provide comments to the Contractor. Corrections to these issues shall be made and revised files resubmitted within 30 days.

20 Product Delivery Addresses

The deliverables listed above shall be delivered to the COR at the following address. Technical questions shall be addressed to the Technical POC.

NOAA COR

National Geodetic Survey
1315 East West Highway
N/NGS; SSMC-3 Sta. 8622
Silver Spring, MD 20910
Attn: Gregory Stinner
(301)-713-3167 x133
Fax: (301)-713-4315
gregory.stinner@noaa.gov

NOAA Technical POC

NOAA National Geodetic Survey
Remote Sensing Division
1315 East West Highway
N/NGS3 Station 8245
Silver Spring, MD 20910
Attn: Stephen White
(301) 713-1428 x167
Fax: (301)-713-4572
stephen.a.white@noaa.gov

21 Figures and Maps

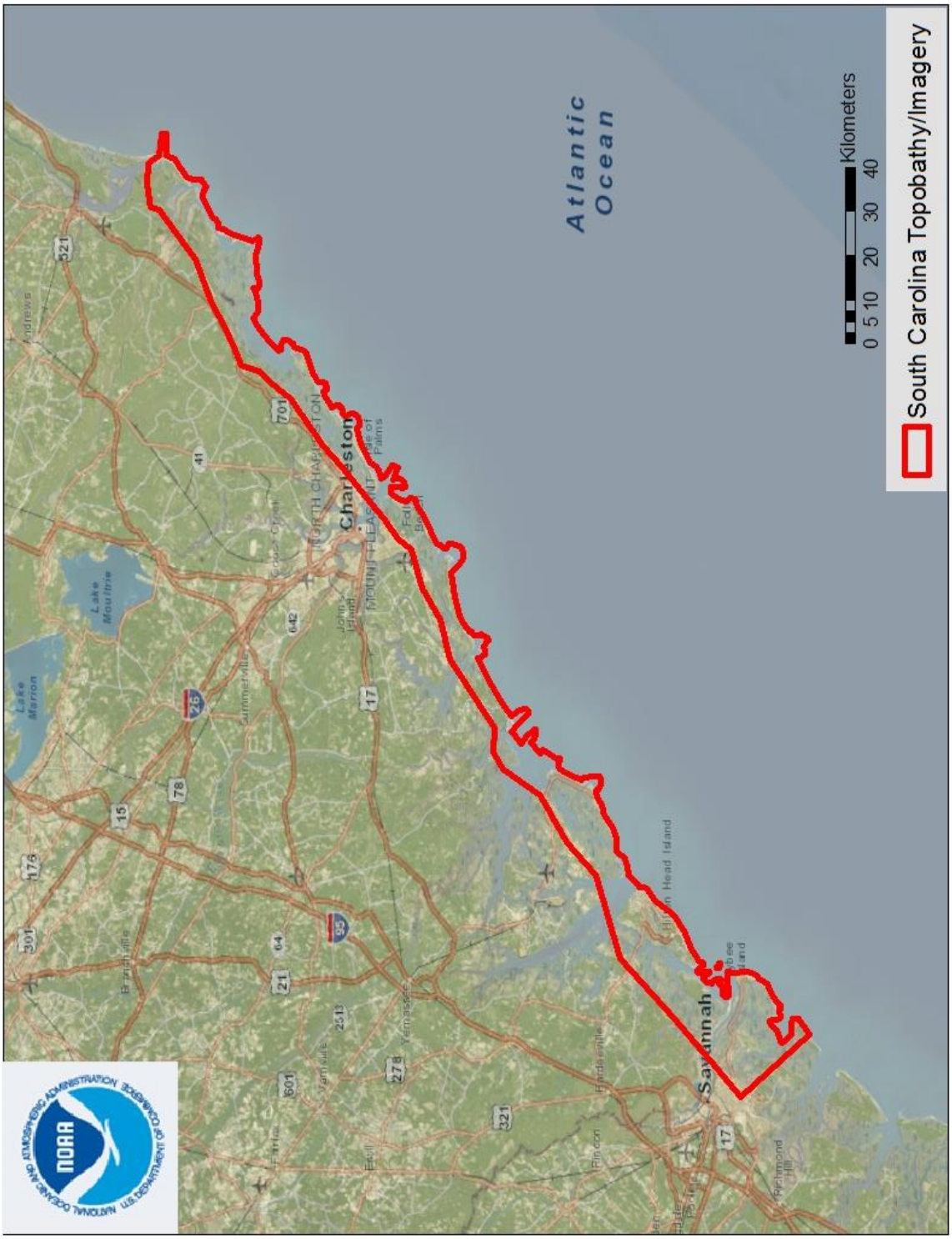

Figure 1. Exact coverage areas for Data collection are TBD

22 Appendix 1

Lidar Data Coverage

One file will be produced per project area that shows areas where valid data were collected. The file will be an elevation raster in GeoTiff format with 5m pixel resolution.

The Horizontal Datum shall be positioned to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used.

The Vertical Datum should be positioned to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010 ellipsoidal heights in meters.

The base naming convention for these files will be "YYYY_ XXXXXXe_YYYYYYYn_lascoverage"; box numbering is provided in the tiling shapefile.

One FGDC compliant metadata file, in xml format, is required per data type.

LAS files

All project swaths, returns, and collected points, fully calibrated, adjusted to ground, and classified, by tiles. Project swaths exclude calibration swaths and other swaths not used, or intended to be used, in product generation. LAS files should be delivered in LAS 1.2 format.

The Horizontal Datum should be positioned to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used.

The Vertical Datum should be positioned to the NSRS via processing with respect to the NGS managed Continuously Operating Reference Stations (CORS) network, and referenced to NAD83(2011)epoch:2010 ellipsoidal heights in meters.

All returns shall be delivered (including vegetation, buildings, etc) with the exception of obvious error points. The LAS file public header block shall include all required fields according to the September 2008 LAS1.2 specification. The LAS file shall also include the mandatory GeoKey DirectoryTag variable length header. See the LAS v1.2 Specification for additional information. The Point Source ID field must be filled out for each record matching an ESRI shapefile vector

format file of the flight lines. The start and stop date/times for each flightline will also be included in the shapefile. Point families (multiple return "children" of a single "parent" pulse) shall be maintained intact through all processing before tiling. Multiple returns from a given pulse will be stored in sequential (collected) order. Each point in the LAS file shall also include the return number, number of returns from the pulse, time, scan angle, and intensity values (native radiometric resolution).

The Point Data Record Format 3 shall be used. The topographic points shall be bare earth processed with the following classification scheme utilized at a minimum. All points representative of submerged topography below a water surface shall be classified as bathymetric point (e.g., seafloor or riverbed).

Classification Value	Meaning
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high; manually identified)
25	Water Column (No Bottom Found)
26	Bathymetric point (e.g., seafloor or riverbed; also known as submerged topography)
27	Water surface (sea/river/lake surface from bathymetric or topographic-bathymetric lidar; distinct from Point Class 9, which is used in topographic-only lidar and only designates "water," not "water surface")
28	Derived water surface (synthetic water surface location used in computing refraction at water surface)
29	Submerged object, not otherwise specified (e.g., wreck, rock, submerged piling)
30	International Hydrographic Organization (IHO) S-57 object, not otherwise specified
31	Denotes bathymetric bottom temporal changes from varying lifts, not utilized in bathymetric point class

All waveform data shall be delivered in the PulseWaves format capable of being read or written by the open-source PulseWaves Tools. More information can be found at http://pulsewaves.org.

Tiled delivery, without overlap, using the Project Tiling Scheme. The base naming convention for these files will be "YYYY_XXXXXXe_YYYYYYYn_las"; box numbering is provided in the tiling shapefile. Tiles shall be 500 meters X 500 meters.

GPS times are to be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each return. Adjusted GPS Time is defined to be Standard (or satellite) GPS time minus 1*109. See the LAS Specification for more detail.

One FGDC compliant metadata file, in xml format, is required per data type.

Topographic/Bathymetric Merged DEM

The following specifications shall be utilized for the topographic/bathymetric merged DEM:

ERDAS Imagine format (with pyramid layers computed internally within the IMG file)

Projection: Majority - UTM zone

Horizontal datum: NAD83(2011)epoch:2010

Vertical datum: NAVD88 (based on utilizing the most recent NGS GEOID available)

Resolution: 1 meter

Units: Meters

Tile layout: Each of these tiles shall cover an areal extent of approximately 5 km X 5km.

One FGDC compliant metadata file, in xml format, is required per image file.

RGB/NIR Ortho-mosaic Imagery

One GeoTiff ortho-mosaic is required for each tile and will contain all images collected within the tile that show land mass or fixed features in the water, such as jetties, breakwaters, etc. Areas containing no imagery will have a transparent background.

The base naming convention for these files will be "YYYY_XXXXXXe_YYYYYYYn_orthomosaic". Each tile shall be 3 km X 3 km, with no gaps or overlap. These files shall be provided in GeoTIFF format and the Horizontal Datum should be positioned to the NSRS via processing with respect to to the NGS managed Continuously Operating Reference Stations (CORS) network, and

referenced to NAD83(2011)epoch:2010. The appropriate UTM coordinate system and zone as designated in the tiling scheme provided shall be used.

One FGDC compliant metadata file, in xml format, is required per image file.

RGB/NIR Stereo Imagery

Stereo Imagery will be delivered in a format capable of loading into BAE's SocetSet or GXP software products. The contractor shall pay special attention to follow all naming conventions in accordance with Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program. The following deliverables shall be included in the RGB/NIR Stereo Imagery package:

- Uncompressed Developed Images (*.tif),
- Exterior Orientation (EO) Files (*.txt)
  - The EO file shall contain at a minimum the following fields:
    - ID, [Image ID needs to be renamed according to the CMP naming convention (ex. 120001_99999)].
    - Time (GPS Seconds of the Week),
    - Latitude(signed Decimal Degrees),
    - Longitude (signed Decimal Degrees),
    - UTM Easting (meters),
    - UTM Northing (meters),
    - Orthometric Height (meters, utilizing the latest NGS GEOID model),
    - Omega (degrees),
    - Phi (degrees),
    - Kappa (degrees),
    - UTM Easting Standard Deviation (meters),
    - Northing Standard Deviation (meters),
    - Height Standard Deviation (meters),
    - Omega Standard Deviation (degrees),
    - Phi Standard Deviation (meters),
    - Kappa Standard Deviation (degrees).
- Terrestrial Calibration Files (*.pdf)
- Boresite Calibration Files (*.html or *.pdf)
- Project Metadata (*.xml)
- AIRBORNE POSITIONING AND ORIENTATION REPORT - The Report shall include at least the following paragraphs:
  – Introduction,
  – Positioning

– Image Collection
– Static Processing
– Kinematic Processing
– Data Sets

– Orientation
– Data Collection
– Data Processing
– Data Sets

– Final Results.

A. INTRODUCTION – Provide an overview of the project and the final processed data sets and list the data sets in table form with the following columns: Dataset ID, Date of Acquisition, Projects covered by the data set, and Description/Flight Line(s) Identification.

B. POSITIONING – Discuss the methodology, the hardware and software used (including models, serial numbers, and versions), the CORS station(s) used, a general description of the data sets, flight lines, dates and times of sessions, the processing (including the type of solution– float, fixed, ion–free, etc.), and the results (discussion of the coordinates and accuracy). Submit a description of the data sets, and the raw and processed data. If the NGS OPUS website was used to process the static data, the Contractor shall provide a copy of the OPUS report. If a known station was used from the NGS database, the Contractor shall identify the station by name and permanent identifier (PID), and provide the published coordinates used in the kinematic position step. If multiple base stations were used, provide processing details, coordinates, and accuracy for all stations.

C. ORIENTATION – Discuss the factors listed above for Positioning.

D. FINAL RESULTS – Describe any unusual circumstances or rejected data, and comment on the quality of the data.

Aerotriangulation Report

An aerotriangulation is required in accordance to Attachment I in Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program. The 95% CC must be reported.

Shoreline Shapefiles

Shoreline Shapefiles and associated deliverables shall be provided in accordance with Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program. Unless

otherwise stated, all specifications should be adhered to unless discussed with the COR and NGS, and the COR's approval granted, before proceeding. Examples of associated deliverables are the Chart Evaluation File (CEF) and Project Completion Report (PCR).

Metadata

Complete metadata will be provided for each of these products. Only one metadata record is needed for each respective deliverable product, i.e., LAS and DEM files. The metadata will be in xml format. Draft version of the metadata will be provided to NOAA for review prior to final data submittal. An example of the minimum content that shall be included is provided as a supplement to this SOW.

Electronic Exposure Data (EED) File

The contractor will need to supply one (1) CSV file per lift. The field Format is absolutely critical because this is the file that is imported into, and populates, the FIF. With respect to the verbiage in Attachment Z, section 12.7 of Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program, the CSV format should be considered the "latest version of the NGS EED file format for digital imagery". An example is provided as a supplement to this SOW. Image ID needs to be renamed according to the CMP naming convention (ex. 120001_99999).

Airborne Positioning and Orientation Report (APOR)

Refer to Attachment C, section 13.4 as well as Attachment Z, section 9.4 of Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program.

Tabulation of Aerial Photography

Refer to ANNEX 7A – SAMPLE, TABULATION OF AERIAL PHOTOGRAPHY in Attachment C - of Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program, for an example of the Tabulation of collected imagery.

Photographic Flight Reports

Please see attachment Z of Version 14A Scope of Work for Shoreline Mapping under the NOAA Coastal Mapping Program, which deals with these deliverables with regard to digital cameras. 12.6 FLIGHT REPORTS – Submit the completed, original Digital Camera Acquisition Log with the data, and a copy to NGS via TOMIS. For a sample Log see Annex 2. (Use the latest version of NGS' Log for digital imagery.

Quality Assurance Report

The Quality Assurance Report shall detail the qualitative and quantitative (absolute, within swath, and between swath) assessment of the cleaned, classified, and merged topographic/bathymetric point cloud deliverable, topographic/bathymetric DEMs, and Ortho-mosaic Imagery.

Final Report of Survey

Report will include, at a minimum:

- Area Surveyed
- Survey Purpose
- Data Acquisition and Processing
    - Equipment used to perform this work, including hardware models and serial numbers, calibration reports, software names and versions (include aircraft, lidar, digital imaging system, and trajectory positioning info), and information on the equipment utilized to determine aircraft to sensor offsets.
        - Data Acquisition Hardware and Software
        - Processing Software
    - Quality Control
        - Survey Methods and Procedures
    - Data Processing Methods and Procedures
        - Field Processing
        - Workflow Overview
        - Trajectory Processing
        - Lidar Processing
        - Lidar Editing
        - Product Creation
        - Imagery Processing
        - Additional Quality Checks (discussion of data quality procedures)
        - Discussion of each deliverable included and a list of delivered files,
        -
    - Corrections to measurements
        - Lidar System Offsets and Calibrations
        - Imagery System Offsets and Calibrations

        - Motion Corrections
        - Environmental Parameters/Processing Settings
        - Vertical Datum Conversions
    - Uncertainty (Accuracy check reports)
- Vertical and Horizontal Control (GPS logs and photos of control points)
- List of problems encountered and any deviations from this SOW, and any recommendation for changes to this SOW for future work.