February 19, 2004
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Digital Imagery Acquisition Requirements

SCOPE OF WORK FOR SHORELINE MAPPING
UNDER THE
NOAA COASTAL MAPPING PROGRAM

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

DIGITAL IMAGERY ACQUISITION REQUIREMENTS

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DIGITAL IMAGERY REQUIREMENTS

1. GENERAL

The Coastal Mapping Program (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 present on National Oceanic and Atmospheric Administration (NOAA) nautical charts and is considered authoritative when determining the official shoreline for the United States. The CMP is administered by the National Geodetic Survey (NGS), National Ocean Service (NOS), NOAA. This Scope of Work defines requirements for digital imagery acquisition and processing to support the CMP. Project Instructions will provide project-specific information.

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 recommended. All times shall be recorded in Coordinated Universal Time (UTC). Any request to deviate from this Scope of Work shall be submitted in advance in writing for possible approval by NGS.

2. GOVERNMENT

A PROPERTY OF DATA – All original data and imagery, from the instant of acquisition, and other deliverables required through this contract including final images, are and shall remain the property of the United States Government. This includes image collection outside the project area.

B. The government will provide to the Contractor:

1. PROJECT INSTRUCTIONS – Project Instructions are a separate document providing specific project information, containing any unique project requirements, and may have the following attachments:
   a. Small scale maps showing the coastline and/or coastal ports to be acquired;
   b. Tide coordination time windows for image acquisition, see Section 7.
2. DIGITAL IMAGERY ACQUISITION REQUIREMENTS (this document)
3. REJECTED IMAGERY – If images are rejected by NGS (for reasons that may include, but are not limited to, flooding, smoke, snow, over-exposure, cloud cover, distortion, sun angle), NGS will send sample images upon request showing the problem areas.

3. IMAGERY TESTING AND STANDARDS

3.1 DIGITAL IMAGERY TEST – The Contractor shall acquire and deliver images over a section of coastline and/or coastal ports which is similar to the contract work. The test data set shall include all bands used for imagery collection. NGS will review this imagery test as soon as possible and notify the Contractor of the results of the review. The Contractor shall not proceed with continued imagery collection until it has received approval from NGS. If NGS rejects the imagery test, a repeat test shall be required. See 12C and separate Project Instructions.

3.2 GEODETIC STANDARDS FOR IMAGE PROCESSING

A. The horizontal datum is the North American Datum 1983 (NAD 83).
B. The vertical datum is the North American Vertical Datum of 1988 (NAVD 88).
C. The geoid model to be used in converting GPS-derived ellipsoid heights to NAVD 88 orthometric heights is Geoid 99 or the most current version. For GEOID information see: www.ngs.noaa.gov/GEOID/GEOID99/geoid99.html.
D. Contractor shall record all processing steps and software used including version number.
E. Contractor shall use either the rapid or precise IGS orbit ephemeris for GPS processing.

3.3 DATA FORMAT STANDARDS

A. The format of the digital imagery deliverables shall be uncompressed TIFF images.
B. The media for the deliverables shall be DVD, portable hard drive, or secure FTP server, depending on feasibility of data transfer and the amount of data. Contractor shall maintain a copy of the data until NGS acknowledges receipt.

4. EQUIPMENT AND MATERIAL

4.1 DIGITAL IMAGING SYSTEM

A. SPECIFICATIONS
    1. The sensor shall be a geometrically stable and calibrated system suitable to use for high-accuracy photogrammetric mapping.
    2. The sensor shall be high enough resolution and have a large enough Field of View (FOV) to provide the required Ground Sample Distance (GSD) and stereo coverage of a ground swath defined in the Project Instructions.
B. MAINTENANCE – The Contractor shall supply certification to NGS before the project is commenced to prove that preventive maintenance and system calibration have been satisfactorily completed for the digital sensor.
C. CALIBRATION – See section 5.
D. IMAGE COLLECTION – The digital imaging system shall acquire visible (RGB) and/or infrared, or Color Infrared (G, R, IR) imagery depending on the Project

Instructions. The raw image is defined as the data that is retrieved from the sensor system before any conversion to processed format. If any radiometric image enhancement is performed on the raw images following image collection, the raw images must be submitted along with enhanced images. All use of contrast, brightness, and other radiometric image enhancements shall be discussed in the final report.

E. MALFUNCTIONS – All digital imaging system malfunctions shall be recorded, and NGS notified. A malfunction is defined as a failure anywhere in the digital sensor that causes an interruption to the normal operation of the unit. Also, any malfunctions of the GPS or Inertial Measurement Unit (IMU) collection systems shall be recorded and reported directly to NGS.

4.2 INERTIAL MEASUREMENT UNIT

If an IMU is employed in the digital imaging system, the IMU shall be capable of determining the absolute orientation (roll, pitch, and yaw) and meet or exceed the following performance specifications:

A. Post-processed accuracy in roll and pitch: 20"

B. Post-processed accuracy in heading: 30"

4.3 GLOBAL POSITIONING SYSTEM

Carrier-phase L1 and L2 airborne kinematic GPS shall be acquired and used along with IMU measurements (if IMU is used) in processing trajectories. The performance specification for post-processed positioning solution accuracy shall be no worse than 30cm relative to the National Spatial Reference Frame.

The GPS antenna shall be an FAA-approved antenna (following appropriate safety and structural air-worthiness considerations) suitable for geodetic quality carrier-phase L1 and L2 reception and installed in accordance with FAA airframe modification requirements. Antenna should be located in a location near the camera to minimize lever arm lengths, and also in a location to provide optimal GPS signal quality and continuous reception in an appropriate, unobstructed location on the plane.

4.4 AIRCRAFT

A. PLATFORM TYPE – All equipment shall be connected, attached, mounted and secured to the aircraft airframe in a manner to provide a safe environment for the crew. The type of aircraft and the aircraft tail number used shall be stated on the digital sensor Flight Log (Appendix A) and all aircraft and airframe modifications used in the performance of this Project shall be maintained and operated in accordance with all regulations required by the Federal Aviation Administration. Any inspections or maintenance of the aircraft for performance of this Project which results in missed data collection shall not be considered as an excusable cause for delay. The Contractor shall ensure that the aircraft has a proven service ceiling, with operating load (fuel, crew, sensor, and other required equipment), of not less than the highest altitude required to acquire the data.

B. PORT OPENING – The design of the port opening(s) in the aircraft shall be such that the field of view is unobstructed when a sensor is mounted with all its parts above the outer structure. The field of view shall, so far as is practicable, be shielded from air turbulence and from any outward flows, such as exhaust gases, oil, etc.

C. OPTICAL FLAT – NGS recommends that an optical flat not be used. If an optical flat is used, the physical characteristics of the window (such as size, thickness, smoothness, flatness, parallelism, glass quality, and optical transmissivity) shall be reported to NGS prior to use. The optical flat shall meet the following specifications:

1. Optical quality;
2. Mounted in material eliminating mechanical stress to the window;
3. Free of blemishes, dirt, significant scratches, etc.;
4. Shall not degrade the resolution or the accuracy of the camera.

Any optical flat should meet the American Society of Photogrammetry and Remote Sensing Aerial Photography Standards, 1995, which states, "If an aircraft camera has a port glass it shall be preferable 50mm thick but not less than 37mm thick. The surface finish shall be 80/50 or better. Glass material shall be polished crown, group category M. Mil Specs Mil-W-1366F (ASG) October 1975, C-1 optical quality or better."

5. SYSTEM CALIBRATION

The digital imaging system shall be calibrated along with a calibration report submitted. Any incomplete reports shall be cause for rejection of the data. Calibration reports for each digital imaging system used shall be supplied to NGS at the beginning and if the system is removed and remounted during the project. The contractor shall follow manufacturer's specifications for appropriate calibration and recalibration.

The calibration reports shall cover each of the following topics:

A. SYSTEM CALIBRATION – System calibration shall address geometric performance. Parameters to be tested include calibrated focal length, lens distortion parameters, and principal point location. Also, any radiometric calibration parameters and files shall be provided to NGS. Some of these procedures and parameters may be unique to a manufacturer since hardware varies from manufacturer to manufacturer. The IMU-to-camera alignment shall be checked. Also, updated IMU misalignment angles should be provided as evaluated.

B. BORESIGHT CALIBRATION VALUES – The boresight calibration is the determination of relative orientation between camera and IMU reference frames.

If IMU georeferencing will be used, boresight calibration shall be performed according to manufacturer specifications for each project or any time the camera or IMU is mounted or removed. The contractor shall supply NGS with a boresight calibration report indicating the method used in boresighting and the final values.

C. DETERMINATION OF OFFSETS – The sensor-to-GPS-antenna offset vector components ("lever arm") shall be measured. The offset vector shall be determined with an absolute accuracy (1σ) of 1.0 cm or better in each component. By convention, this vector is measured from the incident nodal point of the camera lens to the GPS antenna phase center in the coordinate system of the camera. The offset vector components shall be redetermined each time the sensor or aircraft GPS antenna is moved or repositioned in any way.

6. MISSION PLANNING AND CLEARANCES

6.1 MISSION PLANNING

A. COVERAGE AND PARAMETERS – The Contractor may be required to plan flight lines for the project area (described in the Project Instructions) and ensure complete coverage of the project area. The mission planning parameters, including: ground space distance, endlap, sidelap, flying speed, flying height, GPS, visibility, and tide-coordination, shall be considered in planning. NGS may supply recommendations and/or requirements for planning parameters in the Project Instructions.

B. IMAGE ACQUISITION STANDARDS
1. PDOP/VDOP shall be <3.
2. Aircraft bank angle shall not exceed 15 degrees.

C. GROUND SAMPLE DISTANCE – The ground sample distance (GSD) is the area on the ground represented by each pixel in a digital image. The GSD depends on the project, though 20 to 60 cm should be considered typical. See Project Instructions for final parameters.

D. FLYING HEIGHT AND SPEED – Flying height depends on the required GSD. See Project Instructions. Manufacturer's specifications should be followed for flying speed. If forward motion compensation (FMC) is not used, flying speed shall be limited to keep image smear below 15%. The maximum speed over ground (SOG) for push broom sensors should not exceed manufacturer's guidelines.

E. SIDELAP – Adjacent images shall have a minimum sidelap of 30% of the mean image width if the camera mount provides correction for crab, otherwise 40%. See Project Instructions for final parameters.

F. ENDLAP – Consecutive images in a flight line shall have a minimum endlap of 60% of the mean image width if the camera mount provides correction for crab, otherwise 70%. This section does not apply to push broom sensors. See Project Instructions for final parameters.

G. CRAB – While collecting digital imagery, the camera shall be compensated for crab of the aircraft, with a resultant error not exceeding +/- five (5) degrees, as measured from the average line of flight, and the differential between any two successive exposures shall not exceed +/- five (5) degrees.

H. TILT – Care shall be taken to keep tilt (departure from the vertical) of the camera to a minimum. Tilt shall not exceed +/- five (5) degrees for any photographic frame. The average tilt for the entire project shall not exceed +/- one (1) degree.

I. DIGITAL IMAGE COLLECTION PLAN REPORT

1. PROPOSED FLIGHT LINES – Prior to data acquisition, the Contractor should submit, if tasked, paper map(s) clearly showing all proposed flight lines, and include coverage, scale, tide stage, proposed ground control, and project area boundaries. Also included shall be information about flying height and flying speed over ground. Prepare a separate, one-sheet map for each stage of the tide. The base map shall be the largest scale nautical chart covering the entire project area, if possible.
2. ACTUAL LINES FLOWN – Similar map(s) showing the actual flight lines as flown shall be included in the Final Report, see Section 12.1 P 3.

6.2 FLIGHT CLEARANCES

The Contractor shall comply with all required Federal Aviation Administration Regulations, including obtaining all required clearances.

7. WEATHER CONDITIONS AND TIME OF YEAR

7.1 WEATHER

No clouds or cloud shadows shall appear on the photographs. High, thin overcast (clouds) will be permitted above the flying altitude if it does not cause ground mottling or a discernable reduction in light levels and/or ground object shadows. Digital imaging shall not be conducted when clouds or cloud shadows appear in the scene or if the land-water interface is obscured by snow, ice, 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.

7.2 TREE LEAVES

Any stage of leaf coverage is acceptable as long as the land-water interface is not obscured.

7.3 WELL-DEFINED IMAGES

Imagery collection shall be undertaken only when the land-water interface can be well-defined. Imagery shall not be attempted where the ground is obscured by clouds, haze, smoke, smog, dust, snow, sleet, rain, etc. Also, imagery shall not be conducted when the ground, and especially land-water interface, is covered by water (flood), snow, or ice.

7.4 VISIBILITY

The minimum visibility at the time of exposure is eight (8) miles. Imagery shall not be collected when a haze is present. Visibility is determined by looking at objects on the ground toward the sun. The distance at which the detail of ground objects is clearly defined is the visibility. If the visibility is satisfactory, details of ground objects shall be clearly defined at the edge of the view through the drift sight (assuming the system makes use of a drift sight which may not be the case for some automated digital systems).

7.5 TIME OF DAY

Time of day is determined by the sun angle which shall not be less than 30 degrees above the horizon at the time of exposure. The Project Instructions may require a larger sun angle for certain projects. Ideally, the sun angle should be between 30 and 45 degrees for shoreline photography. Photography should be collected while the sun is over the water so that any shadows created by elevated objects will point inland and will not obscure the shoreline.

The size and number of hot spots (no sun shadow points) and "sun spots" (bright, sun reflectance areas) on the water and shoreline must be kept to a minimum and eliminated if possible because these bright spots can obscure important features. During flight planning, flight line directions and times should be arranged to preclude the occurrence of these spots in critical areas of the photographs (especially shoreline and near shoreline areas).

Sun angles for a given day can be determined from a "Solar Altitude Diagram" or from appropriate computer software. For on-line sun angle solutions, see the U.S. Naval Observatory's WWW site: http://aa.usno.navy.mil/ which computes sun altitudes and sun azimuths for U.S. locations and world-wide positions.

7.6 TIME OF YEAR

Consideration of the season should be taken into account when trying to image the ground surface. Project Instructions may discuss seasonal fluctuations in sandy beach dynamics. Beach profiles and morphology can significantly vary in response from the energy presented upon the system in relation to the sequencing and fluctuations of weather events and patterns.

8. TIDE COORDINATION

8.1 IMAGE COLLECTION TIDE CONDITIONS

Image collection may need to be at tide-coordinated stages depending on the required tide stage defined by the Project Instructions. Imagery shall not be collected during strong onshore winds, high waves or other anomalous weather conditions. Contractor shall acquire, analyze, and submit an offshore buoy report and other weather data for the project area during time of data acquisition (National Data Buoy Center: www.ndbc.noaa.gov, National Climatic Data Center: lwf.ncdc.noaa.gov/oa/ncdc.html).

8.2 WINDOWS

A. NGS-SUPPLIED – The government may supply image acquisition time/tide windows for each coastal area to be mapped, or the contractor may be tasked with window determination. These "windows" cover an extended range of possible flying dates. These time/tide windows will be determined by NGS initially to help ensure that all data meet the NGS tolerances for tide-coordinated image acquisition. If tide windows for additional dates are required, contact NGS.

B. CONTRACTOR-DETERMINED – If required by the Project Instructions, the Contractor shall determine predicted acquisition time/tide windows (data acquisition times for tide coordination) for MHW and/or MLLW. Note, MHW is the mean of 18.6 years of high water and is not the high water level for any given day, except by coincidence. The same holds true for MLLW time/tide windows. The Project Instructions may also require the Contractor to install and/or monitor tide gages in the project areas for either real-time or post-flight tidal height comparisons.

8.3 REQUIREMENTS

The Contractor shall acquire imagery within the given time/tide windows as required and shall produce a table showing the times of the time/tide windows and the times of the data acquisition. Be sure to take into account time zones, daylight savings time, and to use Coordinated Universal Time (UTC).

9. POSITIONING AND ORIENTATION

9.1 POSITIONING

A. GPS COLLECTION

1. All imagery shall be positioned using kinematic GPS using dual frequency receivers and oriented with an inertial navigation system.
2. All kinematic GPS (KGPS) solutions should use differential, ionosphere-free, carrier-phase combinations with phase ambiguities resolved to their integer values.
3. Aircraft trajectories shall be processed using carrier-phase GPS. Dual L1

and L2 frequency receivers and one-second collection shall be used.

4. All KGPS shall use at least two ground stations. The ground stations shall be accurately tied to the NSRS (stations in the NGS database); shall be positioned to 0.1 meter accuracy, or better; shall be within or near the project area; and shall be within 100 kilometers of the entire project area. Additional ground GPS stations may be required, and CORS (continually operating reference stations) can be used as ground stations. The ground stations should be positioned on opposite sides of the operating area. The ground stations shall be positioned, or the flight path arranged, so that during flight operations the aircraft will pass within 10 kilometers to each ground station at least once.
5. The maximum GPS baseline shall not exceed 100 kilometers at any time during flight. Regardless of aircraft flight time, GPS ground station data shall be collected for four hours.
6. Ground station data shall be submitted to OPUS (Online Positioning User System – http://www.ngs.noaa.gov/OPUS/) for positioning in the NSRS, except where ground station is located over a known monument.

B. GPS SOLUTION PROCESSING

1. The Contractor shall collect, process, and submit the ground and airborne GPS data, both raw data and final processed data.
2. Differential KGPS solutions for the aircraft shall be obtained independently using each ground station.
3. These independent KGPS solutions shall be compared to display their differences in the north-south, east-west, and vertical components during the operational portions of the flights.
4. The RMS of these differences shall not exceed 5cm in the horizontal and 10cm in the vertical.
5. The KGPS solutions shall model the tropospheric delay using average surface meteorological values at the ground stations collected near the midpoint of operations.
6. The final KGPS solution will be an average of the separate ground station solutions.

C.. ANTENNA

1. The GPS receivers should be equipped with antennas that have been calibrated by NGS. A choke-ring antenna to minimize multipath is preferred but not required.
2. The antenna height shall be accurately measured.

9.2 GROUND-BASED GPS RECEIVER

A. MARK – The ground-based receiver shall be set up over a known (or to-be-determined) marked base station and shall run continuously during the mission. If a known base station is used, it must be in the NGS database and hence part of the

National Spatial Reference System (NSRS).

B. OBSERVATIONS – The position of an existing mark shall be checked by processing one GPS session and comparing the computed position with the NGS published position. A new mark shall be referenced to the NSRS by tying to one or more NGS Continuously Operating Reference Stations (CORS), High Accuracy Reference Network (HARN) stations, or Primary Airport Control Stations (PACS) by static GPS methods. If the distance to the nearest reference receiver is less than 100 kilometers, use at least two independent sessions, each 2 hours long. If the distance to the nearest NGS CORS is greater than 100 kilometers, use at least two sessions, each 4 hours long. Make a separate tripod set-up and height measurement for each session. Take care in the accurate recording of the height of the antenna both before and after the flight. Record all heights, equipment serial numbers, etc. on the NGS forms: Visibility Obstruction Diagram and GPS Observation Log. For a listing of these and other forms on the NGS WWW site see: www.ngs.noaa.gov/PROJECTS/FBN/. Also, static observations may be processed using the NGS "On-Line User Positioning Service" (OPUS) found at: www.ngs.noaa.gov/OPUS/index.html. Observations to establish a new, permanent mark shall be submitted in NGS "Blue Book" format.

C. RECOVERY – For an existing NSRS station, write a digital recovery note in NGS format using NGS software WDDPROC. For a new, permanent station write a digital station description in NGS format using WDDPROC. For a new, temporary mark write a brief description adequate to recover the station. Take three photographs of the base station (photographs of the CORS station are not required).

For additional specification guidance on mark setting, GPS observations, data processing, and data submittal in NGS format, see the "General Specifications for Aeronautical Surveys, Volume I, Establishment of Geodetic Control on Airports" at:

- www.ngs.noaa.gov/AERO/Supinst.html, and
- www.ngs.noaa.gov/FGCS/BlueBook/, and
- www.ngs.noaa.gov/PROJECTS/FBN/.

9.3 AIRCRAFT GPS RECEIVER

A. GPS OBSERVATIONS – The aircraft's GPS receiver shall be able to collect carrier phase observations and record, at least, once per second, from a minimum of four satellites (five or more preferred) at both the aircraft and the ground GPS receivers, for off-line processing. All data shall be collected with a Position Dilution of Precision (PDOP) of less than 3 at a minimum elevation mask angle of 10 degrees. After the post–processing, the GPS observation and ephemeris files are used to determine a flight path trajectory.

B. GPS LOCK – The aircraft shall maintain GPS satellite lock throughout the entire flight mission. If satellite lock is lost, on-the-fly ambiguity resolution methods may be used to recapture lock, while airborne. Report these instances, procedures used, and any other unusual occurrences.

9.4 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.

10. DATA LABELING

All DVDs shall be labeled with the project name, collection date(s), Contractor name, and disk contents. Digital imagery DVDs shall be able to be easily matched with the corresponding flight log.

11. DATA SHIPMENT AND PROCESSING

11.1 SHIPMENT

The Contractor shall ship final deliverables directly to NGS. Copies of the Flight Log and the raw navigation files may be made and used by the Contractor to produce and check the final deliverables. Raw digital images shall be sent on different DVDs or hard disks from all other data.

11.2 NGS NOTIFICATION

The same day as shipping, the Contractor shall notify NGS of the data shipment's contents and date of shipment by transmitting to NGS a paper or digital copy of the data transmittal letter via email or fax.

11.3 DELIVERY DATE

All deliverables shall be received by NGS, as specified, no later than the date in the Project Instructions.

12. DELIVERABLES

A. LABOR, EQUIPMENT AND SUPPLIES – The Contractor shall provide all labor, equipment (including aircraft and digital imaging system), supplies and material to produce and deliver products as required under this document.

B. DIGITAL IMAGE COLLECTION SURVEY PLAN – Prior to data acquisition, submit a proposed Digital Image Collection Survey Plan which specifies the data collection parameters to be used and contain a map of the flight lines and the project coverage area, including flying height and speed over ground, focal length, ground space distance, sidelap, and endlap. The separate Project Instructions supplied by NGS will define the project area(s) and may define the flight lines, ground space distance, endlap, sidelap, and other requirements. See Section 5. NGS will review the proposed mission planning reports, normally within five business days, and will respond in writing with approval and/or comments. The Final Report shall contain map(s) showing the flight lines and boundaries of imagery actually collected.

C. DIGITAL IMAGERY TEST – The Contractor shall acquire and deliver images

over a section of coastline and/or coastal ports which are similar to the contract work. The test data set shall include all bands used for imagery collection. Tide coordination may be required. See section 3.1 and separate Project Instructions.

D. RAW IMAGES – Submit the raw images on separate media from other deliverables.

E. DIGITAL IMAGERY PRODUCTS – Required products may include radiometrically-enhanced images, ortho-rectified images and mosaics. The Project Instructions will specify which additional products, if any, are required.

F. FLIGHT REPORTS – Submit the completed, original Flight Logs with the data, and a copy directly to NGS. For a sample flight log see Appendix A.

G. AIRBORNE POSITIONING AND ORIENTATION – The Contractor shall submit the original, raw GPS and IMU data files and processed trajectory files directly to NGS, to arrive at NGS along with the raw data points and final products. If IMU georeferencing is employed, submit the exterior orientation file with the EO parameters. See sections 4 and 9.

H. GPS POINTS – Submit an organized list of all GPS points used for the project as base stations, ground control, and check points. Indicate which GPS points are existing ground control and which stations are newly positioned relative to the NSRS. See Project Instructions and sections 4.3 and 9.2.

I. TIDE COORDINATION TABLE – Supply table(s) showing the actual times of acquisition flights and the tide coordination time "windows." See Section 8. Explain any discrepancies.

J. CALIBRATION REPORTS – The calibration reports shall contain, at a minimum, the following information:
   a. The date the calibration was performed.
   b. The name of the person, company, or organization responsible for performing the calibration.
   c. The methods used to perform the calibration.
   d. The final calibration parameters or corrections, including any boresight calibration values, determined through the calibration procedures.

K. SENSOR MAINTENANCE – Provide maintenance history before completing project directly to NGS of the sensor to be used for acquiring images. See Section 4.1 B.

L. SENSOR PORT WINDOW – Report the physical characteristics of any port

window used to NGS. See Section 4.4 B.

M. DATA SHIPMENT REPORTING – The Contractor shall notify NGS of each data shipment's contents and date of shipment by transmitting to NGS a paper or digital copy of the Flight Log (marked "copy" at the top) and a copy of the data transmittal letter via email or facsimile. This shall be done the same day the data is shipped to the data processing contractor. See Section 14.

N. UNUSUAL CIRCUMSTANCES – The Contractor shall also notify NGS of any unusual circumstances that occur during the performance of this project which might affect the deliverables or their quality and especially of any deviation from this project. This may be included in the weekly email required below, unless urgent.

O. STATUS REPORTS – The Contractor shall submit project status reports via email to the Contractor Officer's Technical Representative (COTR) contacts in Section 14 every week, until the work is complete. These reports are due at NGS by 2:00 p.m. Eastern time each Monday. These reports shall include a summary of completed data acquisition, with dates completed; data shipped, and dates; and any unusual circumstances, equipment malfunctions, and/or any disturbance of the sensor. A weekly status report is required even if no progress has been made, starting from when the task order is received and ending when NGS accepts all deliverables for that task order.

P. FINAL REPORT

The Contractor shall supply to NGS a Final Report incorporating all of the information in this Deliverables section including, at least, the sections suggested below:

1. Work performed under this contract, discuss each deliverable including: the maximum range from the base station, standard deviation and residuals in GPS trajectories, and an explanation of the DVD labeling;
2. Equipment used to perform this work, including hardware models and serial numbers, calibration reports, and software names and versions (include aircraft and digital imaging system info);
3. Flight line map(s), and project coverage area;
4. Discussion of data quality including quality assurance (QA)/quality control (QC) procedures;
5. Ground Control Report, including a station list in table format;
6. Airborne navigation and kinematic GPS Report;
7. Weather, solar altitude, and time of year;
8. Tide Coordination Report and Table;
9. Any unusual circumstances or problems, including equipment malfunctions (including those already reported);

10. Any deviations from this Digital Imaging SOW, including those already reported;
11. Any recommendations for changes in the Digital Imaging SOW for future work.

13. REVIEW

Images and other deliverables not meeting these specifications may be rejected.

14. POINT OF CONTACT

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15. GLOSSARY

CMP - Coastal Mapping Program
CORS - Continuously Operating Reference Stations
FOV - Field of View
GPS - Global Positioning System
GSD - Ground Sample Distance
IMU - Inertial Measurement Unit
MHW - Mean High Water
MLLW - Mean Lower Low Water
NGS - National Geodetic Survey
NOAA - National Oceanic and Atmospheric Administration
NSRS - National Spatial Reference System
OPUS - Online Positioning User System
PACS - Primary Airport Control Station
SACS - Secondary Airport Control Station
SOW - Scope of Work
UTC - Coordinated Universal Time