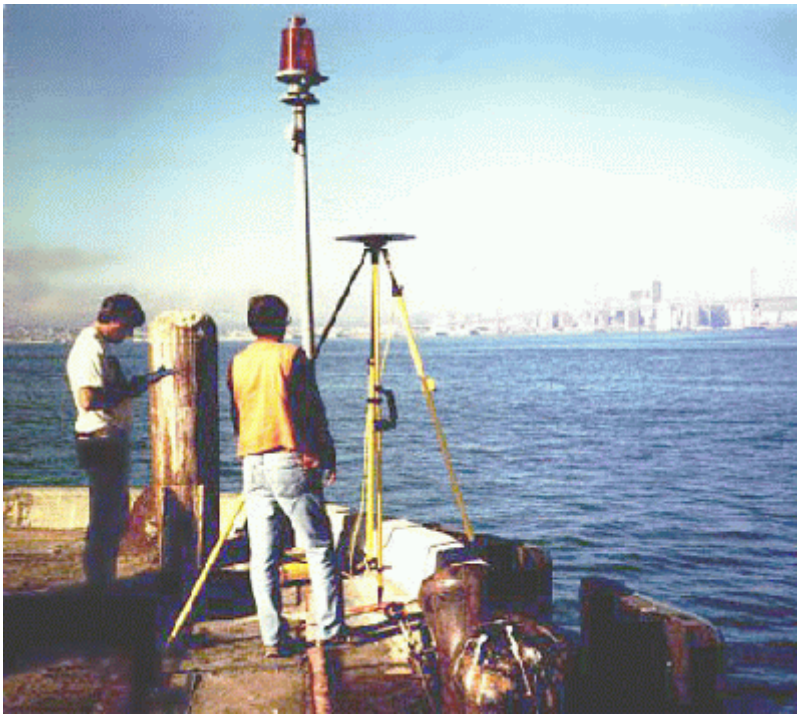
Version 10, June 16, 2003

SCOPE OF WORK
HEIGHT MODERNIZATION AND LIDAR SURVEYS

for

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY



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1. INTRODUCTION

This Scope of Work lists requirements for ground surveys needed to support the Height Modernization Program (HTMOD), which is administered by the National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA). In addition, LIght Detection And Ranging (LIDAR) survey(s) may be required.

2. ADMINISTRATION

2.1 SPECIFICATIONS - This Scope of Work provides general standards and specifications for the surveys required by NGS. In addition, the Contractor shall be issued a set of Project Instructions for each survey. **The Project Instructions will take precedence over this Scope of Work since the Project Instructions provide detailed and often unique information about each Height Modernization Project.** The requirements for reporting deviations, unusual circumstances, etc., described in the following paragraphs, apply to the Scope of Work and to the Project Instructions.

2.2 CONVENTIONS - The following conventions have been adopted for these project specifications. The verb "shall" means that compliance is required. The verb "should" denotes a recommendation. The contraction "N/A" means not applicable. The term "position" means horizontal position (latitude and longitude) unless specified otherwise. The term "elevation" means the distance of a point above a specified datum, measured along the direction of gravity. The term "vertical" refers to the direction in which the force of gravity acts. The term "height" means the distance, measured along a perpendicular, between a point and a datum. See
Section 4. Use the U.S. Survey Foot (3.28083333333 feet = 1 meter) for any length conversions.

2.3 GENERAL REQUIREMENTS - The Contractor shall provide all labor, equipment, supplies, material, and transportation to produce and deliver data and related products as required under this Scope of Work, except as shown in Section 3.

2.4 MODIFICATIONS - All requests for modifications shall be submitted by the Contractor in writing to the Contracting Officer (CO) prior to the Task Order due date and as soon as possible. Send a copy to the NGS Points of Contact (POC) listed in Section 14.

2.5 UNUSUAL CIRCUMSTANCES - The Contractor shall notify the CO and NGS of any unusual circumstances that occur during the performance of this Scope of Work or Project Instructions which might affect the deliverables or their quality (see Section 6). Especially note any deviation from this Scope of Work or Project Instructions.

2.6 REPORTS - Thorough reporting is required. The Contractor shall submit a weekly project status report (see Section 13.5) and a Project Completion Report (see Section 10.9) to the contacts in Section 14. In addition, a Quality Control Plan (see Section 6), a HTMOD Survey Plan (see Section 10.3), and/or a LIDAR Survey Plan (see Section 11.3) shall be submitted.

2.7 ORIGINAL DATA - Observation logs and other original records generated during this project are legal records which will be retained for data accountability and stored in the National Archives. Original logs and records shall be submitted and shall be original, legible, neat, clear, accurate, and fully completed in indelible black ink. Original data shall be saved, unmodified, whether in hand-written or computer-recorded form. In the original records (paper or digital), nothing is to be erased or obliterated. All available spaces on the recording forms should be completed. If a mistake is made on a form, draw a single line ~~through the mistake~~ and write the correction above or to the side. If space is too limited to permit a field correction, restart with a new log sheet; however, do not recopy the form in the office in order to make a "clean" copy. An explanatory note should be made for all corrections to the original recorded figures. It is essential that all hand-recorded information be neat and legible. All editing of computer-recorded data shall be done on a copy of the original. Submit the original version of the data, not a handmade copy, a photo-copy, or a digital copy.

3. GOVERNMENT SUPPLIED MATERIALS

The following items will be supplied, if applicable:

3.1 TRANSMITTAL LETTER,

3.2 PROJECT INSTRUCTIONS,

3.3 BRASS DISKS - Disks with factory NGS standard lettering,

3.4 LOGO CAPS - Caps for 3D rod marks, with standard NGS lettering (fits 5" or 6" inside diameter, schedule 40 PVC pipes)

See Attachment A for explanations of items listed above.

4. REFERENCE SYSTEMS

The following Reference Systems shall be used:

4.1 HORIZONTAL REFERENCE - The North American Datum of 1983 and year of the latest observations which is abbreviated NAD83 (YYYY). Note: the year of observations is on the NGS Data Sheet next to the latitude and longitude.

4.2 VERTICAL REFERENCE -

Orthometric heights - The North American Vertical Datum of 1988 (NAVD 88); for information on NAVD 88, see: http://www.ngs.noaa.gov/PUBS_LIB/NAVD88/navd88report.htm

Ellipsoidal heights - NAD 83 (GRS 80)

4.3 REFERENCE SYSTEM - Use the National Spatial Reference System (NSRS), see http://www.ngs.noaa.gov/INFO/OnePagers/One-Pager_NSRS.pdf .

Survey control shall be tied to the NGS National Continuously Operating Reference Station (CORS) system. For information on CORS, see: http://www.ngs.noaa.gov/CORS/ .

For information on the High Accuracy Reference Network (HARN), see:
http://www.ngs.noaa.gov:80/faq.shtml .

4.4 GEOID MODEL - GEOID 99, or a later, current version

For GEOID information see: http://www.ngs.noaa.gov/GEOID/GEOID99/ .

For explanations of many of the terms in Section 4, see: http://www.ngs.noaa.gov:80/faq.shtml .

5. REFERENCES AND GLOSSARY

5.1 REFERENCES - Note, the Contractor shall become thoroughly familiar with the following references:

a. NOAA Technical Memorandum NOS NGS-58 "Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards: 2 cm and 5 cm)."
Available on-line at: http://www.ngs.noaa.gov/PUBS_LIB/NGS-58.html .

b. A Guide for Establishing GPS-Derived Orthometric Heights (Standards: 2 cm and 5 cm).
For information see Attachment B.

c. Input Formats and Specifications of the National Geodetic Survey Data Base, the "Blue Book." Available on-line at: http://www.ngs.noaa.gov/FGCS/BlueBook/ .
d. NOAA Manual NOS NGS 1 "Geodetic Bench Marks." Available on-line at: http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs.pdf .

e. File Naming Convention - See Web site in Section 8.2.

f. Visibility diagram - For information about visibility obstruction diagrams, see: http://www.ngs.noaa.gov/PROJECTS/FBN/ (click on "Forms," then click on "Visibility Obstruction Diagram").

5.2 GLOSSARY - Geodetic Glossary, NGS, 1986 (not available on the WWW). For a printed copy, telephone NGS at (301) 713-3242 or email: info_center@ngs.noaa.gov

6. QUALITY CONTROL

The Contractor shall check all data to ensure that it is complete, reliable, and accurate. Note, accuracy requirements may be in the Project Instructions. The Contractor's personnel shall become thoroughly familiar with the Scope of Work; the Attachments; the Project Instructions; the definitions of surveying terms; and the material covered in the other references and publications, as required. See Section 5 for a list of References and Glossary.

QUALITY CONTROL PLAN - Prior to beginning survey work on this project, the Contractor shall submit a written Quality Control Plan (QCP) **covering all work**. The QCP shall describe how the Contractor shall meet the technical specifications required for the project. The QCP shall include at least the following requirements: a check of all manual computations (including check marks and initials), a check of all manual data computer entries, a check of file formats, and a check of all reports and data submitted. The contractor shall also describe how data will be backed up and how it will be ensured that original data are not modified. See Section 13, Deliverables.

Comments on quality control and a copy of the Quality Control Plan will be included in the Final Project Report.

7. DATA FORMATS

7.1 HTMOD ORIGINAL DATA - Original, raw digital data shall be submitted and their formats shall be documented in the Final Project Report. Original paper records shall also be submitted; see Section 2.7. Observations for positioning marked points shall be submitted in Blue Book format.

7.2 HTMOD FINAL DATA - Final project data shall be submitted in Blue Book format, or in other formats specified by this SOW (for example, digital photographs).

7.3 LIDAR DATA - Submit original unprocessed data and processed data. Provide an explanation of all file formats.

8. DATA MEDIUM AND FILE NAMING CONVENTION

8.1 DATA MEDIUM - CD-ROM.

8.2 FILE NAMING CONVENTION FOR GPS GROUND SURVEYS- See the naming convention for FBN projects on NGS' Web site at: http://www.ngs.noaa.gov/PROJECTS/FBN/

8.3 FILE NAMING CONVENTION FOR LIDAR SURVEYS - Provide an explanation for all file names and formats.

9. SURVEY METHODOLOGY

GPS ground surveying methods shall be used for HTMOD work specified in References A and B, Section 10, and the Project Instructions. If a LIDAR survey is required by the Project Instructions, LIDAR data shall be collected from an airborne platform(s) with ground GPS survey support; see Section 11.

10. SURVEY WORK FOR HEIGHT MODERNIZATION

10.1 PURPOSE - Height Modernization brings the horizontal, vertical, and gravity control networks together in a unified national positioning system, joined and maintained by GPS technology and administered by NGS. A state-of-the-art National Spatial Reference System (NSRS), with NAVD 88 as its elevation reference, can provide the Nation with a common, consistent set of real-time geographical coordinates (reference points). The application of this national positioning system can provide:

a. Improved aircraft navigational aids and approach and landing procedures,
b. Advanced surface transportation control and monitoring,
c. Highly efficient fertilizer and pesticide spreading, resulting in reduced run-off water pollution,
d. More accurate modeling of storm surge and pollution trajectories,
e. Increased accuracy for improved resource management decision making, and
f. Improved disaster preparedness and earthquake detection.

A Height Modernization project may include: planning, reconnaissance, mark recovery, mark setting, GPS observations, spirit leveling, LIDAR observations, data processing, data analysis, data adjustment, data submittal in specified formats, preparing reports, writing manuals and other training aids explaining the work, and providing training on how to accomplish the work.

10.2 RECONNAISSANCE - Reconnaissance shall be performed in accordance with NGS-58 and "A Guide for Establishing GPS-Derived Orthometric Heights" (see Section 5.1) and by following the guidelines in Attachment D, Height Modernization Station Selection Guidelines.

a. CONTROL STATIONS - The following types of control stations (survey marks) will be considered for use in these projects:

1. HORIZONTAL:

- All control stations with a stability quality code of A or B (see Attachment D for an explanation of stability codes), and
- All high accuracy GPS control stations including: CORS, FBN, CBN, HARN, and PACS.

2. VERTICAL:

- All first-order and second-order NAVD 88 vertical control stations (bench marks) within the project area, sufficient to provide vertical control for the project.

All horizontal and vertical points used as control must be part of the NSRS.

b. DATABASE SEARCH - NGS and U. S. Coast and Geodetic Survey (USC&GS) (former name for NGS) station descriptions are contained in the NGS database and are available via the NGS Web site. A database search shall be made for all control stations within the project area (defined in the Project Instructions) meeting any of the above criteria. Directly access the NGS Integrated Data Base (NGSIDB) using the NGS Web site at: http://www.ngs.noaa.gov/datasheet.html. Note, the Project Instructions may also require searching the databases of other organizations (for example, a state survey office).

c. MARK RECOVERY

1. SEARCH - The contractor shall make an extensive physical search in the field for all control stations found in the above database search(s). See Attachment K for diagrams of NOAA survey disks. Before an existing mark is used, its description shall be thoroughly checked to confirm the station's identity, stability, and location, and to provide input for an updated description or recovery note. Stamping shall not be done on existing disks or logo caps. The contractor shall prepare digital updated descriptions or recovery notes for all NSRS marks searched for and all marks used in the project. See paragraph below entitled "MARK RECOVERY DEFINITION."

2. VISIBILITY - All horizontal and vertical stations selected must have adequate GPS satellite visibility. The visibility should be minimally restricted from 15 degrees above the horizon to the zenith, in all directions; see Attachment D for details. Minor obstructions are acceptable, but must be depicted on the Visibility Obstruction Diagram. For new stations, select a site relatively free of present and future anticipated obstructions. Utility poles in the GPS field of view are tolerable, and they provide security and a reference to help locate the mark. Set new marks at least 2 meters from a pole, to the south if possible. Likewise, existing marks within 2 meters of a pole should not be used. Marks should not be set or used if within 5 meters of a chain link fence.

3. MARKS OF OTHER ORGANIZATIONS - Other marks may be used if they meet the stability, visibility, spacing, accuracy, and other requirements.

4. MARKS ON PRIVATE PROPERTY - The Contractor shall contact property owners and obtain permission before using or setting a mark on private property. Take care to return the landscape to the original condition. Do NOT include the name and phone number of the property owner in the station description unless the land is owned by a business, or the owner requests to have the information included in the description.

5. HORIZONTAL CONTROL - A sufficient number of high accuracy stations (as required by NGS-58 and/or Attachment B) shall be recovered to provide horizontal control for the project. If the distribution is inadequate, the contractor shall then recover A-order, B-order, first-order, or second-order horizontal control stations (in that order) **established with GPS**, limiting the search to the number and/or area needed to provide enough control for the project. If there is still insufficient horizontal control for the project, the contractor shall extend the area of the search until enough control is found. Notify NGS of this situation immediately.

6. VERTICAL CONTROL - A sufficient number of high accuracy stations shall be recovered to provide vertical control for the project. If the distribution is inadequate, the contractor shall expand the recovery area. Consult "Guidelines for Establishing GPS-Derived Orthometric Heights," SOW, Attachment B to determine the required number and spacing of bench marks

7. BENCH MARK SPIRIT LEVEL TIES - If the reconnaissance indicates that the number and/or distribution of bench marks with good sky visibility is inadequate, spirit level ties may be made to transfer an elevation from a bench mark to a nearby existing or new survey point that does have good sky visibility. Every effort should be made to recover existing bench marks before using this method. Transferring elevations to existing horizontal control marks is preferable to setting new marks. Temporary marks shall not be used. The project instructions may require these ties to be made using first-, second-, or third-order specifications and standards. For third-order ties, see Attachment N.

8. MARK RECOVERY DEFINITION - The "recovery" of a control station includes a physical visit to the station to determine its usability by checking its identity, ascertaining its unmoved position, and determining its condition, stability, visibility, etc. and to prepare a digital updated description or recovery note in NGS format. To ascertain its identity, check the mark type, disk type, and stamping against the NGS data sheet. To ensure its position, measure the distances from the reference marks and/or the distances from the reference points and Witness Post. Also, the angle between the reference marks could be checked. Station descriptions and recovery notes must be submitted in computer-readable form using WDDPROC software available on-line at: http://www.ngs.noaa.gov/PC_PROD/DDPROC4.XX/ddproc.index.html. See detailed instructions in Attachment H.

9. MARKS RECOVERED BUT NOT USABLE - For marks which are recovered but are positively not usable due to complete tree canopy, etc., the recovery requirements may be reduced to just a simple recovery note such as, "RECOVERED AS DESCRIBED. THE MARK CAN NOT BE OCCUPIED BY GPS DUE TO COMPLETE TREE CANOPY." For marginally usable marks, fulfill the normal recovery requirements including Visibility Diagram, photographs, etc. because the mark may be needed depending on other marks in the area.

d. VISIBILITY DIAGRAM - For all marks, recovered and proposed, the contractor shall prepare a visibility obstruction diagram using the form found at: http://www.ngs.noaa.gov/PROJECTS/FBN/ (click on "Forms," then click on "Visibility Obstruction Diagram").

e. PENCIL RUBBINGS - Rubbings are no longer required during the recovery of a survey mark. Rubbings are required at the time of each observation at that station.

f. PHOTOGRAPHS

1. RECOVERED STATIONS- The contractor shall take at least three photographs of each existing control station per Attachment I.
2. PROPOSED SITES OF NEW STATIONS - Two photos, see Section 10.2g.
3. NEW STATIONS AFTER SET - Three photos, see Section 10.4.
4. CONCRETE MARK HOLE - One photo, see Section 10.4.

g. PROPOSED NEW STATION SITES - It is highly preferable to use existing marks rather than set new marks. The contractor shall propose sites for new stations as required and propose the type of mark to be set in the "Comments/recommendations" column of the "Station Table", see Section 10.3. Preliminary digital descriptions shall be prepared as well as visibility diagrams. Take two photographs of proposed sites, one at eye level, oriented vertically downward showing the ground in the area of the proposed mark (photo #2) and one oriented horizontally showing the nearest satellite obstruction or identifying feature if no obstructions (photo #3). After the mark is set, capture photo #1 and update others as required. Note, see Attachment I for digital photograph requirements.

h. GPS POSITIONS - Obtain a hand-held GPS (pseudo-range) position for all marks found and for proposed sites for new marks. Include this position in the text of recovery notes and descriptions. Data format: DDD MM SS.ss. Upon returning to the station, the Contractor shall use the description to find the station and not rely strictly on the GPS position.

i. DESTROYED SURVEY MARKS - Metal survey disks which have been moved, are very loose, or otherwise damaged so that they can no longer serve as survey marks are to be removed, have updated recovery notes written describing the mark as destroyed, and the disk sent to NGS. A mark shall not be described as destroyed unless the disk is found and returned to NGS.

j. DAMAGED SURVEY MARKS - Any existing disk which is selected to be used should be repaired if found loose or with edges exposed. Any work done to repair a disk shall be described completely in the digital recovery note. Extreme care shall be taken not to alter the existing horizontal or vertical position of the disk. Disk longevity can be increased substantially by simply adding highway epoxy or the equivalent when the edges of a disk are exposed, thus preventing ice from forming under the disk and/or a vandal from prying the disk from its location.

For all marks used in this survey, perform mark maintenance as stated above, including replacing logo cap lids if missing. Contact NGS for recommendations in unusual cases. Notify NGS of any other marks that need mark maintenance. Examples of mark maintenance problems include: loose disk, exposed edge of disk, missing logo cap, missing logo cap lid, exposed edge of concrete monument, or imminent danger of destruction.

k. MARKS NOT FOUND - As stated in Section 10.2c, the contractor shall make an extensive physical search for all control stations found in the database search(s). If the mark is not found, enter the number of person-hours spent searching into the digital recovery note. Do not state that the mark is destroyed simply because it was not found. If strong evidence exists that the mark has been destroyed, state the evidence.

10.3 HTMOD SURVEY PLAN - After reconnaissance but prior to mark setting or observations, the contractor shall submit a HTMOD Survey Plan (one paper copy and one digital copy).

to the NGS Point of Contact (POC). NGS will review the Plan as soon as possible, normally within ten work days, and will send the contractor written comments and/or approval. The contractor shall not begin mark setting or data collection until the Plan is approved by NGS. The Plan will include at least the following sections:

ITEM	FORMAT
a. Text with summary of survey planning,	Paper & digital
b. Station table (see details below and sample at Attachment M),	Paper & digital
c1. Original recovery notes on NGS Station Description/ Recovery Note Form	Paper
c2. Digital recovery notes from WDDPROC	Paper & digital
d1. Original descriptions on NGS Station Description/ Recovery Note Form	Paper
d2. Digital preliminary station descriptions (WDDPROC)	Paper & digital
e. GPS satellite visibility diagrams, for old and proposed new stations,	Paper
f. Project Sketch, to scale (different symbols for old and new station locations), and indicating how stations are connected during the primary, secondary, & local surveys,	Paper & digital
g. Digital photographs, print all for one mark on one page	Paper & digital
h. Proposed instrumentation (receivers and antennas),	Paper & digital
i. Proposed data collection and processing software, and	Paper & digital
j. Detailed GPS observation plan	Paper & digital.

Note, printouts of the NGS station data sheet are not required.

The Station Table will include the station designation (name), PID (Permanent Identifier), type (FBN, PACS, etc.), establishing agency, order, stability, condition at recovery, and comments/recommendations. For new stations, include the proposed name in the "Name" column, identify them as "proposed" in the "Type" column, and **indicate the proposed type of mark (rod, concrete, disk in bedrock) in the "Comments/Recommendations" column.** For existing stations, the name and PID must be used exactly as listed in the NGS database and must be this way in all survey records. For existing stations found but not proposed to be used, state the reason(s) in the "Comments/Recommendations" column. See sample in Attachment M.

If the existing high accuracy GPS horizontal control stations are of sufficient accuracy and distribution, the primary network of 5-hour sessions may not be required. Contact NGS.

10.4 MARK SETTING - After the HTMOD Survey Plan is approved by NGS, the Contractor may begin field work. Marks shall be set to NGS specifications for type, length, material, stability, stamping, driving, etc. outlined in "Geodetic Bench Marks" and Attachments E, F, and G. Per Attachment G, Section C11, the rod is driven to refusal, or until a driving rate of 60 seconds per foot is achieved. After this is achieved, the minimum acceptable length for the required "B" stability rod mark is normally 4 meters; see reference "Geodetic Bench Marks," page 27, Table 3 (in other words, a rod driven to refusal that is less than 4 meters long is not acceptable). The preliminary station descriptions shall be updated after the mark is set, and photograph #1 (close-up, see Attachment I) shall be captured along with updates of other photographs, as required. For concrete marks, take a photograph after the hole is dug and before the concrete is poured showing a level rod in the hole (to show the depth of the hole). The file name for this photo will start with "RE" for reconnaissance; see Attachment I.

10.5 GPS POSITIONING PROCEDURES - GPS data shall be collected using GPS equipment meeting the following criteria: the receiver model shall have been evaluated against the Federal Geodetic Control Subcommittee (FGCS) test network, shall be a state-of-the-art, dual-frequency receiver with high quality C/A code or P code pseudo-ranges, shall be capable of measuring full wavelength L2 carrier phase, shall function acceptably in an Anti-Spoofing environment, and shall consist of a geodetic quality antenna with ground plane designed to reduce multi-path, and shall have an antenna model that has been calibrated by NGS.

a. TRIPODS - Fixed height tripods must be used. Tripods with multiple height settings should be set to the highest position. All tripods shall be tested for stability, plumb alignment (straightness of center pole), and height verification at the beginning and end of the project. All tripods shall be examined for stability with each use. Ensure that hinges, clamps, and feet are secure and in good repair. Also, check, and adjust if necessary, the position of the bubble in the circular vial.

b. GUIDELINES - The Contractor shall follow guidelines for establishing GPS-derived heights documented in NOAA Technical Memorandum NOS NGS-58 (ellipsoidal) and Attachment B (orthometric). **Note, use 45 minute observation periods rather than the 30 minutes specified in NGS-58 for stations other than "control stations and primary base stations."**

c. OBSERVATION FORM - The Contractor shall use the NGS GPS observation form found at: http://www.ngs.noaa.gov/PROJECTS/FBN/ (Click on "Forms," then click on "GPS Observation Log").

d. PENCIL RUBBINGS - The contractor shall capture a pencil rubbing of a marks' stamping (disk or logo cap) each time the mark is occupied for observations. Use the form found at: http://www.ngs.noaa.gov/PROJECTS/FBN/ (Click on "Forms," and then click on "Pencil Rubbing Form"). When not feasible to make the required rubbing, a sketch of the mark shall be substituted accurately recording all markings.

10.6 VECTOR PROCESSING (See also NGS-58)

a. CONTROL AND BASE STATIONS - Vector processing shall be performed using the latest version of NGS software package PAGE-NT or equivalent. The equivalent of PAGE-NT is subjective, and is based on the software's ability to correct for the same systematic errors that PAGE-NT corrects, apply the NGS required antenna phase pattern variations, and reproduce the same results as PAGE-NT. This determination will be made by NGS.

The NGS PAGE-NT software package and User's Manual are available via anonymous FTP from NGS (see Attachment C). Follow the vector processing guidance below and the PAGE-NT User's Manual.

Vectors shall be processed using a 15-degree elevation mask

The grouping of vectors into processing sessions for each day of observations is determined by two factors: 1) the required reference station and 2) the distance of each solved station from the reference station. This vector distance determines the final solution type to be run in PAGE-NT. Reference station requirements are detailed in the sections below. Use the following table for grouping vectors into sessions according to vector length:

PAGE-NT Final Solution Type Determination

Vector Distance for Processing Session	Final Solution Type
less than 5km	L1 Fixed
5-100km	Ion-Free Fixed

IGS precise orbit data and NGS National CORS data must be used in data processing. For information on downloading CORS data and ephemeris data from NGS via the Internet, see Attachment C.

International Earth Rotation Service Terrestrial Reference Frame (ITRF) station coordinates shall be used for all vector reductions. Information about ITRF is available on the NGS Web site, under "PRODUCTS and SERVICES." See: http://www.ngs.noaa.gov/products_services.shtml . The current ITRF epoch must be used in computations. If ITRF coordinates are not available for the reference stations, transform coordinates from NAD 83 with NGS program HTDP.

The Antenna Height value entered into the PAGE-NT "Station Information" menu "Up" field is the distance from the monument to the Antenna Reference Point (ARP). For example, 2.000 meters is the Height-of-Instrument for some fixed height tripods. The monument for a CORS is generally coincident with the ARP; therefore, 0.000 is entered for a CORS station unless an offset is listed on the CORS coordinate sheet. PAGE-NT will automatically add a constant factor for the ARP to L1 phase center distance when it merges the data.

Review the PAGE-NT generated plots and text outputs to analyze each processing session. PAGE-NT's overall RMS-of-fit of the post-fit, double-difference residuals should not exceed 2.0 cm. Investigate individual satellites with a relatively high RMS or where integers can not be fixed. Also review the files for input errors such as improper reference station coordinates, antenna height errors, or improper station names. Check all manual input and indicate that it has been checked by placing "check marks" next to each entry; the checker shall also initial each page.

b. SECONDARY AND LOCAL STATIONS - For these stations, vector processing can be performed using the GPS manufacturer's latest version of the vector processing software package, with NGS approval.
Vectors shall be processed using a 15-degree elevation mask.
Refer also to publication NGS-58.

10.7 VECTOR ANALYSIS - For control and primary network requirements, the difference in ellipsoid height between repeat observations shall not exceed 5.0 cm.

For secondary and local network requirements, the difference in ellipsoid height between repeat observations shall not exceed 2.0 cm. See NOS NGS-58 for further explanation.

10.8 ADJUSTMENT PROCESSING - For computation of the positions and ellipsoid heights, the control and primary networks will be combined into one top level network, and the secondary and local networks shall be combined into one lower level network. The control used will include all CORS, FBN/CBN stations, and any stations adjusted in previous levels of the project. Four adjustments are required for each of these two levels of the network, each consisting of: (1) free (minimally constrained) with one control station fixed, (2) constrained with all CORS stations fixed, (3) constrained with all control stations fixed (horizontal and ellipsoidal heights), and (4) final free with accuracies.

For computation of the orthometric heights, the top level and lower level networks shall be combined and adjusted as one network. Two adjustments are required for this network: (1) free with one control station (with NAVD 88 orthometric height) fixed, and (2) fully constrained with all vertical control fixed.

For further explanation see NGS-58 and Attachment B. Regarding the fully constrained vertical adjustment, the contractor shall begin by performing an adjustment with all bench marks fixed and analyzing the results to determine which bench marks agree and which don't. After non-fitting bench marks are eliminated, a new adjustment will be performed and the results sent to NGS, with explanations, for approval.

CHECKING PROGRAMS - Execute the following four programs and submit the output:

COMPGB - tests the consistency and compatibility of the two required files, i.e., the B-file (GPS Project and Station Occupation Data) and the G-file (GPS Vector Data Transfer file) for a GPS project.

OBSDES - compares a horizontal Blue Book Description data set with its respective Blue Book Observation data set. OBSDES produces a list of error messages along with the description data set record and observation data set information.

OBSCHK - checks the Blue Book B-file and the G-file.

CHKDESC - validates all descriptions in a description (*.DSC) file.

10.9 DATA SUBMITTAL - Final project data shall be submitted in Blue Book format. The Project Sketch, descriptions, photos, project adjustments, reports, etc., shall be both paper and digital, if possible. Submit all original data records, see Sections 2.7, 7.1, 10.3, and 13.

10.10 MANUALS AND TRAINING - The contractor may be required to produce manuals and other training aids (such as Power Point presentations) explaining the Height Modernization process in portions or in its entirety. In addition, the contractor may be required to conduct training courses using the above materials.

11. SURVEY WORK FOR LIDAR SURVEYS

11.1 PURPOSE - LIght Detection And Ranging (LIDAR) airborne surveys may be required. This work may include the survey of LIDAR calibration sites, airports, shoreline, and/or ground control. These types of work may require high data density and high data accuracy. In addition, data for the tops of features and/or ground surface may be required. LIDAR calibration may be required over calibration test sites, and ground control in the operational area may be required. Standard safety procedures and regulations shall be followed.

11.2 RECONNAISSANCE - The project area will be defined in the Project Instructions. Project planning shall be based on parameters supplied in the Project Instructions. Very high accuracy and very high density spot spacing may be required. One or more ground GPS base stations within 40km of the project area shall be required. The contractor shall perform a database search for high accuracy GPS control stations in the project area and then perform ground recovery of the required station(s). See Section 10.2 for additional information on database searches and mark recovery.

11.3 LIDAR SURVEY PLAN - After reconnaissance but prior to observations, the contractor shall submit a LIDAR Survey Plan to the NGS POC. NGS will review the Plan as soon as possible, normally within five work days, and will send the contractor written comments and/or approval. The contractor shall not begin data collection until the Plan is approved by NGS. The Plan shall include at least the following sections:

a. Text with summary of survey planning,
b. Flight line layout,
c. Flight parameters: altitude, speed, scan angle, scan rate, forward tilt, laser pulse rate, beam divergence, aircraft, etc.,
d. Planned spot spacing, size, and accuracy,
e. Plan for calibration,
f. List of hardware (brand and models) and software (brand and versions), and
g. Ground Station Table (see below).
h. Summary of data collection procedures, and
i. Summary of data processing procedures.

The Ground Station Table will include the station designation (name), PID (Permanent Identifier), type (FBN, PACS, etc.), establishing agency, order, stability, condition at recovery, and comments/recommendations. Include proposed name and monument type of any new stations to be set and identify them as "proposed" in the "type" column. For existing stations, the name and PID must be used exactly as listed in the NGS database and must be this way in all survey records.

11.4 AIRCRAFT GPS POSITIONING AND ORIENTING PROCEDURES - All LIDAR data will be positioned using kinematic GPS and oriented with an inertial system. The contractor will report heights of antenna, and model and serial numbers of all equipment used.

The inertial system must be capable of outputing and recording the sensor attitude, in all three axes, at least 200 times per second and to provide data accurate to 25 arc seconds.

KINEMATIC GPS - All LIDAR data shall be positioned using airborne kinematic GPS using at least two GPS receivers. Receivers must be dual-frequency, geodetic quality receivers which are capable of collecting carrier phase data at one second intervals for post-processing and time-tagging LIDAR data. Data shall be collected from a minimum of four satellites, (five or more preferred) at both the aircraft and the ground GPS station. All data must be collected with a PDOP of less than seven. The GPS receivers must be equipped with the appropriate type of antenna. The vector from the aircraft GPS antenna to the LIDAR data collection point must be accurately measured. The entire LIDAR-GPS system should be capable of determining the three-dimensional position of the LIDAR data collection point within 0.5 meter relative to the National Spatial Reference System (NSRS). The aircraft should maintain GPS satellite lock throughout the entire flight mission. If satellite lock is lost, on-the-fly ambiguity methods may be used to recapture lock while airborne. Report these instances, procedures used, and any other unusual occurrences.

11.5 GROUND STATION POSITIONING PROCEDURES - The ground GPS station must be a monumented station accurately tied to the NSRS, positioned to 0.1 meter accuracy or better, and should be within or near to the project area. An existing or new station may be used. Additional ground GPS receivers may be required. The contractor shall collect, process, and submit the ground and airborne GPS data, both original data and final processed data.

a. EXISTING GROUND STATION - Set up the ground-based receiver over a known, permanently marked, high accuracy NSRS survey point and run it continuously during the photo mission. For an existing NSRS station, write a digital recovery note in NGS format and take three photographs as specified in Attachment I (use the FBN station option). Prepare a GPS visibility diagram. Carefully measure the height of antenna.

b. NEW GROUND STATION - A new station must be positioned relative to the NSRS by tying to one or more NGS CORS by static, dual-frequency geodetic GPS methods. If the distance to the nearest NGS CORS is less than 50 miles, use at least two independent sessions, each two hours long. If the distance to the nearest NGS CORS is greater than 50 miles, use at least two sessions, each four hours long. NSRS stations other than an NGS CORS may be used with NGS approval. Make a separate tripod set-up and height measurement for each GPS session. Take extreme care in recording the accurate height of the antenna.

For a new station, write a digital station description in NGS format. The station shall be marked with a permanent mark to NGS specifications. Take three photographs as specified in Attachment I (use FBN station option). Prepare a GPS visibility diagram. Data shall be submitted in NGS "Blue Book" format. For additional specification guidance on mark setting, GPS observations,
data processing, and data submittal, see the "General Specifications for Aeronautical Surveys, Volume I, Establishment of Geodetic Control on Airports" at:
http://www.ngs.noaa.gov/AERO/aerospecs.htm#vol1. Also, static observations may be processed using the NGS "On-Line User Positioning Service" (OPUS) found at:
http://www.ngs.noaa.gov/OPUS/index.html .

11.6 LIDAR DATA COLLECTION - The contractor shall perform daily (preferably for each flight) equipment calibrations.

11.7 LIDAR DATA PROCESSING - When the project instructions call for high accuracy, the contractor shall take special care in processing the LIDAR data, especially with regard to editing spikes, which may actually be real features. Data processing, especially data cleansing and filtering methods, shall be fully described in the Final Project Report.

11.8 LIDAR DATA ANALYSIS - The contractor shall prepare a data quality analysis, including an error budget, and include this in the Final Project Report. This analysis will include a comparison of LIDAR data with ground truth data.

11.9 LIDAR PRODUCTS - Required products may include: contour maps, Digital Elevation Models (DEM), Triangulated Irregular Networks (TINS), and intensity images.

12. FINAL PROJECT REPORT

12.1 HTMOD - The Final Project Report for HTMOD surveys shall contain at least the following sections:

a. An overview discussion of the planning, field work, data collection, data processing, adjustment, and data error analysis. This discussion should include a summary of the results, problems encountered, conditions affecting progress, and any unusual circumstances. Include comments on any deviations from the HTMOD Survey Plan, Project Instructions, or this SOW (include comments from weekly Status Reports).

b. A written description and analysis of the quality control performed; tables showing check positions; a listing and analysis of all unusual circumstances, discrepancies, and deviations; and the Quality Control Plan.

c. A listing of personnel who worked in the field and/or were involved with the data processing for this project.

d. A listing of the brand, model number, and serial number of all survey equipment (GPS receivers, antennas, levels, etc.) used in the project. List the quantity, brand, type, and height of fixed height tripods used. Include any instrumentation used for differential leveling if done.

e. A listing of all software, including version, used during the project.

f. A final station list: use a table format to list each station and each observation session for the station.

g. A final Project Sketch (Vector Diagram): update the vector diagram submitted with the HTMOD Survey Plan (see Section 10.3). Submit only a large size, readable plot (approximately 24 x 32 inches). Include processing session designations on the vectors if feasible. Note, a digital vector diagram may be required.

h. The vector processing scheme, observation time for the vector, solution type (ion-free, fixed, etc.), and final RMS for the vector. Provide any comments on problems encountered or anomalies with the processing session.

i. A list of the comparison of all repeat base lines.

j. A detailed description of the project adjustment. Discuss each of the adjustments separately, including fixed control and the source of the coordinates, ellipsoid heights, and NAVD 88 elevation used.

k. A completed Project Submission Checklist, see Attachment J. Also available on-line at: http://www.ngs.noaa.gov/FGCS/BlueBook/ (Click on "Annex L" and scroll down to page 9).

l. Recommendations for future projects.

12.2 LIDAR - The Final Project Report for LIDAR surveys shall contain at least the following sections:

a. A written summary of the project with sub-section covering: planning, field work (aerial and ground), data collection, calibration, data processing, calibration analysis, data error analysis, and product creation. This discussion shall include a summary of the results, problems encountered, any unusual circumstances, and conditions affecting progress. Include comments on any deviations from the LIDAR Survey Plan, Project Instructions, or this SOW (include comments from weekly Status Reports).

b. A written description and analysis of the quality control performed; tables showing check positions; a listing and analysis of all unusual circumstances, discrepancies, and deviations; and the Quality Control Plan.

c. A table showing each flight line with at least the following information: date, time, altitude, airspeed, scan angle, scan rate, laser pulse rates, weather, and comments.

d. A listing of personnel who worked in the field and/or were involved with the data processing for this project.

e. A listing of the brand, model number, and serial number of all equipment (including LIDAR, GPS receivers, antennas, etc.) used in the project. Also list the quantity, brand, type, and height of fixed height tripods used.

f. A listing of all software, including version, used during the project.

g. A final station list: use a table format to list each station occupied and each observation session for the station.

h. A map showing the coverage of the project.

i. Recommendations for future projects.

13. DELIVERABLES TO NGS

13.1 LABOR, EQUIPMENT, ETC. - The contractor shall provide all labor, equipment, supplies, materials, and transportation to produce and deliver the products as required under this Scope of Work, except as shown in Section 3. Note, government supplied items are listed in Section 3.

13.2 GOVERNMENT SUPPLIED ITEMS - The contractor shall return all government supplied records (listed in Section 3) and all unused survey marks and logo caps to NGS.

13.3 QUALITY CONTROL PLAN - Before any field work begins, the Contractor shall submit to NGS a Quality Control Plan covering all work (see Section 6). NGS will review this plan and respond with an approval or comment letter (or email) as soon as possible, normally within ten working days. If a QC Plan was submitted as part of the original submission in response to the Federal Business Opportunities announcement, this requirement may be simply an update of the earlier version. Submit paper and digital copies.

13.4 SURVEY PLAN - Before any mark setting or GPS observations begin, the Contractor shall submit a HTMOD and/or LIDAR Survey Plan (see Sections 10.3 and 11.3) to NGS. NGS will review this plan and respond with an approval or comment letter (or email) as soon as possible, normally within ten working days. Field work may commence after the Contractor receives the approval letter (or email) and the Task Order, if required. See Section 10.3 for a listing of which items are to be submitted on paper and which in digital format.

13.5 PROJECT STATUS REPORTS - The Contractor shall submit project status reports via email to the NGS contacts in Section 14 every Monday afternoon by 2:00 P.M. Eastern Time, from the date of the Task Order until the work is complete. These reports shall include the percentage complete for each of the major portions of the work, the status of other work, where work is underway, where work is completed (with dates completed), and any unusual circumstances and/or deviations from this Scope of Work. Include the expected date of completion. This report should be brief and contain the current information in the text of the email. Be sure to include the prime contractor's firm name on all reports.

13.6 HTMOD PROJECT SKETCH (VECTOR DIAGRAM) - Submit a vector diagram showing all computed vectors. Submit only a large size, readable plot (approximately 24 x 32 inches). Include processing session designations on the vectors if feasible. Submit a paper version and a digital version, if possible.

13.7 FIELD LOGS - Submit the original version of all the observation logs, pencil rubbing forms, hand-written station descriptions/recovery notes, visibility diagrams, digital photographs, etc.

13.8 VECTOR PROCESSING OUTPUT - Submit paper copies of the COMBINED.SUM files for any processing sessions that were difficult to process or produced questionable results. Submit paper copies of any other files requested by NGS for quality control.

13.9 REPORTS - Submit a Final Project Report covering HTMOD surveys; see Section 12.1. Submit a Final Project Report for LIDAR surveys; see Section 12.2

13.10 HTMOD ADJUSTMENT AND CHECKING PROGRAMS - Submit a paper copy of the output for programs COMPGB, NEWCHKOB, OBSCHK, OBSDES, CHKDESC, BBACCUR, and ELLACC. Submit paper copies of all ADJUST files. Also, submit the digital data sheet or coordinate file for stations used for fixed control during the adjustment (CORS log/coordinate sheets, NGS data sheet for HARN and bench mark coordinates, etc.).

13.11 ORIGINAL HTMOD DATA - Submit all the original, raw data, RINEX data, precise ephemeris, and vector files. Include the CORS RINEX data files used for processing. For all RAW and RINEX data files not named by their occupied station four character ID, submit an index of station names to RAW and RINEX file; see Section 10.9.

13.12 DESCRIPTIONS - Submit the finalized description file from the NGS WDDPROC software. Submit both paper and digital formats. This includes the recovery notes submitted with the Survey Plan and the final version of the descriptions of new marks, written after the marks are set. Note, descriptions and recovery notes should be written by one person and checked, in the field, by another.

13.13 ORIGINAL LIDAR DATA- One file for each flight.

13.14 LIDAR PROCESSED DATA - Data and products as required by Project Instructions. May include: contour maps, DEMs, TINS, intensity images, and/or edited data files.

13.15 LIDAR PLANNING INFORMATION - Including flight maps and any other planning documents.

13.16 TRANSMITTAL LETTER - For all hardcopy data being sent via express mail, regular mail, etc., prepare a transmittal letter listing all items being sent. Include a copy of the transmittal letter within the data package and send a second copy to the receiving office via FAX or mail. The receiving office will check the data package against the letter, sign and date it, and FAX it back to the sender. Be sure to include the prime contractor's firm name on all transmittals and communications. See sample Transmittal Letters in Attachment L.

14. POINTS OF CONTACT - Send all technical reports, comments, questions, data, etc. to the first POC.

George E. Leigh
Contracts Technical Manager
National Geodetic Survey, NOAA
ATTN: N/NGS; SSMC3, Sta. 8613
1315 East-West Highway
Silver Spring, Maryland 20910
301-713-3167
email: George.Leigh@noaa.gov

Steve J. Frakes
National Geodetic Survey
Spatial Reference System Division
ATTN: N/NGS; SSMC3 Sta. 8853
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3194 ext 111
email: Steve.Frakes@noaa.gov