Survey Quality GPS Equipment

1. SCOPE

The purpose of this document is to describe a Survey Quality GPS Surveying System for use by <FILL IN HERE>. Descriptions and details vary, but <FILL IN HERE> requires that the system meet certain minimum standards without prejudice towards any particular manufacturer.

<FILL IN HERE> is seeking a satellite positioning system that will perform to strict accuracy and efficiency standards. The proposed system must meet specified requirements and demonstrate specified performance to be considered for purchase. Alternate offerings will not be considered. All components shall be new, and the latest model or release in current production.

The Positioning System must utilize the NAVSTAR Global Positioning System (GPS) Satellites. The Positioning System will be dual frequency and will be supplied with sufficient batteries, antennas, and cables to consider the system complete by manufacturer's standards. The system must be capable of data collection for Real-Time Code Differential operation and Real-Time Carrier Phase positioning. Post-processing software for GPS raw data must be made available as an option.

2. GPS Receiver

The GPS receiver is the physical device that tracks the satellites and computes positions. The receiver is the core of a GPS surveying system. Typical GPS receiver components include batteries, memory, cables and serial ports. Requirements for a Survey Quality GPS receiver are listed below.

2.1. Satellite Tracking

The Positioning System must utilize the NAVSTAR Global Positioning System (GPS) Satellites. This system must have 12 independent channels, and must track all five observables (L1 CA Code, L1 Carrier Phase, L1 P-Code, L2 Carrier Phase, and L2 P-Code), from every GPS satellite in view. All of the above must be tracked with full - *not half* - carrier wavelengths. The GPS dual-frequency system must permit uninterrupted operation when Anti-Spoofing (AS) is activated or deactivated. When AS is enabled, the system must automatically compensate for AS without compromising the data in any way. When AS is disabled, the receiver must automatically revert to P-Code operation without any data loss.

The GPS receiver must utilize Z Tracking technology for reconstruction of the P Code when that signal is encrypted. Z Tracking is a technique whereby the Y-code on both the L1 and L2 signals is separately correlated with a receiver-generated replica of the P-

code. The result creates an "estimate" which is used to "filter" the encrypted signal. The result is a 13dB improvement over cross correlation techniques and a 3dB improvement over code correlation plus squaring. Z-Tracking techniques provide for the "best performance in the presence of A-S" (as quoted from Hofmann-Wellenhof, Lichtenegger, and Collins, 1997. *GPS Theory and Practice, Fourth, revised edition.* SpringerWienNewYork).

The RF section of the receiver shall feature a dual bit A to D conversion processing capability, normally found in military equipment. This is necessary for operations under or near high voltage power lines or transmitters. The bidder may be asked to demonstrate their receiver system to verify this level of jam immunity.

2.2. Power and Batteries

The power consumption of the GPS receiver must be 6.0 Watts or less while tracking 12 satellites.

A single internal battery shall be supplied, that enables the GPS receiver to continuously track all satellites in view for at least 9.5 hours @ 25º C.

The GPS receiver must utilize a rechargeable, internal Lithium ION battery capable of operating in temperatures ranging from -20C to +50C.

The weight of the internal Lithium Ion battery shall be no more than 1 lb.

The Lithium ION battery must be fully contained within the receiver when the receiver is operational and must also be removable from the receiver to allow for convenient charging. The combination of the receiver and installed battery must be waterproof (to Mil-Spec 810E, wind driven rain and dust).

The Lithium Ion battery must be removable by hand, without the use of any special tools.

The output voltage of the battery shall be at least 10.8 Volts and its capacity must be at least 5.4 Amp hours.

The Lithium ION battery must have an integral capacity indicator that is completely independent of the GPS receiver to assure batteries are fully charged at the beginning of the day.

The Lithium ION battery must be able to communicate its capacity information on-demand directly to the receiver for display to the user without removal of the battery from the GPS receiver.

The GPS receiver must have the capability to be powered via an external power source, and must be able to be connected to both internal and external power simultaneously. The GPS receiver must draw power from the external power port first when a suitable power source is available. The receiver must automatically switch power sources when either the internal or external source is removed. The receiver must not allow any data to be lost when switching between internal and external power supplies.

2.3. Memory

The GPS receiver must employ industry standard Type II PCMCIA memory card technology for raw GPS Data storage.

The GPS receiver must be supplied with a PCMCIA memory card with a minimum size of 16 MB

The GPS receiver must be upgradeable to an 85 MB PCMCIA memory card

The PCMCIA card must operate in temperatures ranging from -40C to +85C.

The PCMCIA card must be housed within the GPS receiver during operation of the system, and the combination of the receiver and installed PCMCIA memory card must meet or exceed MIL spec 810E, for rain driven rain and dust.

The PCMCIA card must be removable by hand, without the use of any special tools.

2.4. Physical and Environmental

The GPS receiver, without battery, must not exceed 3.5 lbs, and must not exceed 3" in height, 7.75" in width, and 8.75" in depth.

The GPS receiver must be durable in extreme climate conditions and must meet mil specs for impact, moisture, and dust (MIL-STD 810E). The GPS receiver must fully operate in temperatures ranging from -30C to +55C.

2.5. Operational Interface

The receiver shall have an external power button that can be used to power the unit on and off. The power-off switch logic must include a delay that will prevent power-off if the button is accidentally activated.

The GPS receiver shall have an alphanumeric LED display at least 8 characters in width and a control interface with at least three buttons. Receiver display shall be capable of displaying satellite information, receiver settings, survey status and system troubleshooting information. The receiver display and buttons shall allow for entering survey information via an interactive menu.

The GPS receiver shall have a minimum of three blinking LED indicators for display of mission critical status information. A minimum of one LED should be used to display the number of satellites being tracked. A minimum of one LED should used to display the rate of data recording. A minimum of one LED should be used for display of radio reception, should an optional internal radio be present.

Icons should represent the function of each blinking LED indicator so they can be identified from a distance.

The GPS receiver must be capable of using the LED display and control interface for the following functions without the need to connect to an additional handheld device or PC of any kind:

- setting up a real-time kinematic (RTK) GPS base station.
- setting up and executing static GPS survey
- setting up and executing a stop and go kinematic GPS survey
- displaying the number of satellites tracked and used to compute a position, satellite geometry (DOP)
- displaying available memory
- displaying available internal battery power
- setting recording intervals, site IDs, elevation mask, minimum satellite mask, epoch counter and antenna heights
- clearing receiver memory
- setting receiver to factory defaults
- serial port communication rate
- audible beep on/off
- language selection from the choices of: English, Spanish, French, German, and Italian
- file starting, stopping, restarting, listing and deletion
- saving of receiver settings preventing loss when the receiver is power cycled.

2.6. Hardware Interface

The receiver shall have a minimum of four bi-directional RS-232 serial communication ports capable of operating at rates up to 115,200 baud. A minimum of three RS-232 ports must be capable of providing 12 Volts DC for external sensor power management tasks. A minimum of three RS-232 serial ports must be capable of being programmed independently from the other serial ports. This means that a minimum of three ports must be capable of performing separate and independent tasks *simultaneously and at different baud rates.*

The receiver must have a type TNC antenna connection for GPS RF input.

The receiver must have an external power port with input voltage range of 10-28VDC

The receiver must have exterior mounting fixtures that allow the receiver to be firmly attached to a 2 ¼" range pole or a shoulder strap.

The receiver must have a storage area for quick reference cards, or other mission critical documentation so this information will always be available when the receiver is being operated in the field.

2.7. Operational Capabilities

The GPS receiver must support raw GPS data logging intervals from 0.1 to 999.5 seconds for static post-processing.

The GPS receiver must support raw GPS data logging intervals from 0.1 to 999.5 seconds for stop-and-go kinematic post-processing.

The GPS receiver must be supplied with RTCM message (types 1/2/3/6/9/16) output capability.

The GPS receiver must be supplied with real-time kinematic (RTK) base output capability. The RTK base messaging must include industry standard message types 18/19/22 for real-time centimeter level positioning. RTK base messaging should also include proprietary compact RTK message format. User must be able to enable all RTK base message types using only the receiver front panel interface (no external controller).

The GPS receiver must be supplied with advanced RTK rover algorithms capable of typical initialization times less than 3 seconds with 99.9% reliability. Bidders may be asked to prove compliance with this requirement in a head to head demonstration at a location chosen by <FILL IN NAME>.

The GPS system must be capable of performing RTK surveys and simultaneously collecting GPS raw data for post-processing.

3. GPS Antennas

The GPS system must employ a lightweight satellite receiver (GPS) antenna utilizing multipath mitigation techniques. The rover GPS antenna must not exceed 1.9 lbs, and must include an internal ground plane for better performance under multipath conditions in locations of reflected signal. The base GPS antenna must feature an optional, removable, external ground plane that must not exceed 16 inches in diameter. The optional removable ground plane must be supplied with a protective carrying case.

The GPS antenna must operate in temperatures ranging from -40C to +65C.

The GPS antenna must be submersible in water and pass IPX 7 tests for submersion.

The GPS antennas supplied with the system must be durable and be able to withstand a 2-meter “range pole drop” to concrete or “tripod drop” to concrete.

The GPS antennas supplied with the system must have a TNC female connector.

The GPS antenna must be able to be mounted in various configurations including:

- standard surveying tripod.
- vehicle magnetic mounts
- standard surveying range pole
- standard 5/8”x11 threaded mounts

The GPS antennas supplied with the system must be passive, and accept 5-15VDC from through the TNC connector.

The GPS antenna must provide 38dB ± 3dB signal strength for both L1 and L2 GPS frequencies.

4. Survey System

The GPS system must be able to utilize Carrier Phase Measurements to resolve the Carrier Phase Ambiguities and produce centimeter level accuracy . The system must be able to utilize either the manufacturer's proprietary differential message or the RTCM message 18 and 19 industry standard differential messages for real-time kinematic (RTK) operation. The GPS system must meet the following minimum accuracy requirements. Bidders may be asked to prove compliance with this requirement in a head to head demonstration at a location chosen by <FILL IN NAME>.

4.1. Static Survey Accuracy

- Horizontal RMS: 5mm + 1ppm (times baseline length)
- Vertical RMS: 10mm + 1ppm (times baseline length)

4.2. Kinematic Survey Accuracy

- Horizontal RMS: 1cm + 1ppm (times baseline length)
- Vertical RMS: 2cm + 1ppm (times baseline length)

4.3. Real-Time Carrier Phase Differential Accuracy

- Horizontal RMS: 1cm + 2ppm (times baseline length)
- Vertical RMS: 2cm + 2ppm (times baseline length)

4.4. System Packaging

System packaging refers to all the additional items supplied with the GPS receiver, data collector and radios to enable mobile, human carried RTK operation, including transporting the system to and from the job site.

System should be supplied standard with a backpack for carrying the RTK rover in the field.

Hardware required to completely mount the RTK rover system on a 2 ¼" range pole must be available as an option.

A padded carry case that contains and protects the basic system components (system receiver, antenna, battery, cables and HI measuring device) must be supplied with each system.

A separate padded carry case that contains and protects the basic RTK system components (radios, radio antennas, data collectors, brackets) must be supplied with each system.

The protective carry case should convert into a backpack for foot travel to remote survey locations.

A hard shell shipping case must be provided with each system and both of the padded carry cases should fit completely within the hard shipping case.

An external frame backpack designed to accommodate at least 25 lbs must be available as an option.

RTK rover must be supplied with a forward reading level bubble that allows the user to keep their head up while leveling the range pole so the user can maintain awareness of possible jobsite hazards.

5. Data Radio

Data radios enable receiver-to-receiver communication needed for real-time centimeter level positioning. A base radio transmitter is required for the GPS receiver outputting real-time messages and a radio receiver is required for each real-time rover using those messages. The following are minimum requirements for data radios to be used for GPS real-time centimeter level positioning.

5.1. Physical Requirements

Rover radio must fit entirely inside the GPS receiver and the combination of the GPS receiver and internal radio must pass MIL Spec. 810E for wind driven rain and dust.

Base and rover radios must be supplied with omni-directional antennas with a minimum gain of 3dB

Base and rover radios must have an external power switch.

Base and rover must have a minimum input voltage range of 9-16 VDC

Base and rover radios must have a minimum operating temperature range from –30º C to +60º C

Base and rover radios must meet ANSI/ASAE EP455 shock and vibration specifications

Base and rover radios must meet IEC 144/855420 I.P. 66 environmental specifications for water and dust intrusion.

Base and rover radio must both have at least one RS-232 data port capable of 38400-baud communication speed.

5.2. Operational Requirements

Base radio must have a method of changing radio channels in the field without the use of any external devices.

Base and rover radios must be capable of up to 19,200 bps over-the-air link rate.

Base radio supplied must be capable of transmitting at 0.5 watts or 2 - 35 watts.

Base radio must be capable of operating as a repeater.

Base and rover radio must be capable of 12.5 KHz resolution with a frequency stability of ± 2.5ppm

Base and rover sensitivity must be a minimum of –116dBm (12 dB SINAD)

6. Data Collector

The data collector is a hand held computer capable of running an assortment of software that interfaces directly with the GPS system. Software running on the data collector enables the GPS receiver to be utilized for complex surveying tasks such as construction stakeout and topographic mapping. The following are minimum requirements for a data collector and application software for use with a real-time GPS surveying system

6.1. Hardware

Data collector must have a minimum operating temperature range of -20ºC to +60ºC

Data collector must survive 1.2 meter drop on to concrete on all faces and corners.

Data collector must be submersible and pass IP67 specification.

Data collector must utilize a RISC processor with a minimum CPU clock speed of 133MHz and a minimum clock speed of 192 MHz must be offered as an option.

Data collector must be supplied standard with a minimum of 16Mb DRAM and at least 32Mb DRAM must be offered as an option.

Data collector must be supplied standard with minimum of 16Mb non-volatile memory and at least 128MB must be offered as an option.

Data collector must utilize a passive touch screen that can be activated by either a stylus or finger.

Data collector must utilize a display screen with a minimum of 320 X 240 pixels.

Data collector must utilize an integral display heater for cold weather use.

Data collector must utilize a full 57 element keyboard with separate alpha and numeric keys.

Data collector must have three serial ports. One port must be RS-232 DB9, one port must be capable of an Ethernet 10baseT network connection and one port must be infra-red (IrDA).

Data collector must include an integrated microphone and speaker.

Data collector must have quick-charge functionality that enables at least 90% capacity in one hour.

Data collector must include exterior contact for a cigarette lighter adapter.

Data collector must have internal batteries that can power the unit for a minimum of 40 hours on a single charge.

Data collector must have internal battery charger and internal battery that are fully sealed in the unit.

6.2. Software

Data collector software must have the capability to control GPS receivers, conventional optical total stations and robotic optical total stations.

Data collector software must run on standard, open architecture operating systems such as windows CE or DOS.

Data collector software must have functionality to setup a base and rover GPS RTK system.

Data collector software must have functionality to set RTK base on an unknown point and to solve for the point after occupying known control with the rover.

Data collector software must have the functionality to display GPS receiver status information.

Data collector software must have an extensive library of standard map projections, datums and coordinate systems including user-defined coordinate systems.

Data collector software must have the functionality to create local coordinate systems based on as few as one 3-d point.

Data collector software must have the functionality to perform full 7 parameter coordinate transformations.

Data collector software must have the functionality to use Geoid99 corrections for elevation and to use location specific sub-grids of the whole Geoid99 file.

Data collector software must have the functionality to organize data into jobs or projects to enable convenient reliable storage and use of critical survey data. Software must include functionality to manage jobs such as create, edit and delete.

Data collector software must have the functionality to import and export coordinate files.

Data collector software must have extensive coordinate geometry functionality including intersections, offsets, triangle solutions and area calculations.

Data collector software must have extensive stakeout functionality including points, alignments, slope staking, curves, road layout, grading and DTM staking.

Data collector software must have functionality to tag collected data points with attribute information.

Data collector software must be supplied with associated Windows (95/98/NT) PC utility software to allow for file transfer, survey data edit, survey data display, output file type conversions and coordinate system manipulations.

7. Post-Processed Survey Software (optional)

The post processing survey software provided with the system shall be compatible with 32 bit operating systems like Windows 95,98 and Windows NT. The program(s) must

have a graphical user interface to allow the users ease of operation. The software must include modules to perform:

- mission planning to determine the best time of day to survey.
- downloading and uploading of data through either a standard PCMCIA card reader drivers, or through serial operations.
- processing in a logical and organized fashion to reduce the user's uncertainty.
- integrated blunder detection to help prevent basic user errors
- error analysis functionality to ensure proper characterization of survey results
- rigorous transformations and least squares adjustments.
- standard and user definable projections to plane coordinates.
- output to various standard file formats and user defined formats
- project reporting forms in common word processing software formats to facilitate professional presentation of GPS survey results.
- on-line help functionality to ensure users quick access to specific program information.

8. User Documentation

The system shall be supplied with a receiver operation and reference manual that documents the setup of the surveying system .

The system shall be supplied with a technical reference manual that documents the full functionality of the serial interface of the receiver.

The system shall be supplied with application guides that document how to perform static, stop and go kinematic, and real-time kinematic GPS surveys.

The system shall be supplied with laminated quick reference cards that document the receiver display menus in a form that can easily used in the field.

9. Warranty

Equipment must be supplied with a 1 year limited warranty that covers defects in material or workmanship of the GPS receiver

Equipment manufacturer must provide free firmware updates to the customer for up to 1 year after the delivery of the equipment.

Equipment manufacturer must provide free software updates for PC software supplied with the system for up to 1 year after the delivery of the equipment.

Equipment manufacturer must provide any software upgrades that may become available for the PC software supplied with the system for up to 90 days after the delivery of the equipment.

10. Customer Support

Equipment manufacturer must provide technical support via phone (1-800 number), web page and e-mail at no additional cost to the customer.

Equipment manufacturer must make on-site training available for the customer at a price to be specified in the bid.

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