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About this Manual

This manual is organized into three main sections:

- **Getting Started** introduces the basic features of the Vulcan 3D Measurement System, so you can begin measurement as quickly as possible.
- **Advanced Usage** addresses specific topics of interest, such as advanced calibration; measurement tool configuration; reference frame transformation; data collector operation; best practices; cleaning and maintenance; and diagnostics and troubleshooting.
- **Survey 3D-I Reference** provides additional details on system functions.

First-time users will be able to begin basic operation after reading *Getting Started*. More experienced users will find the detail provided in *Advanced Usage* and *Reference* useful.

In addition, important information is highlighted throughout this manual:

Notes offer detailed information on specific topics, and

Best Practices are designed to help you achieve maximum performance.

Transmitter Warning Labels

SAFETY AND SYSTEM CARE

Please read the following information *before* operating the Vulcan 3D Measurement System. Carefully observe all warnings included in this manual and displayed on the system.

POWER

- Vulcan uses rechargeable Nickel/Metal Hydride (Ni-MH) batteries. Use the manufacturer's specified charger only. Do not open, dispose of in fire or short circuit the battery. Such actions could cause the battery to ignite, explode, leak or get hot, which could cause personal injury.
- You may use alkaline D cells in the transmitter if required as a backup, but the battery life will be shortened to 3-4 hours. Do not attempt to recharge alkaline batteries with the AC adapter. Doing so could damage the transmitter.
- Avoid pinching or walking on power cords and cables. Take extra care with plugs, connectors, and points where cables exit components. Frayed or damaged cables should be replaced.
- Do not use extension cords unless they are in good condition and meet appropriate safety ratings (UL in the USA). All metal plugs should be covered when inserted into extension cords.
- During electrical storms, or during extended periods of non-use, system components should be disconnected from electrical outlets to minimize the potential for damage from power surges.
- Ensure the receiver system power is OFF when connecting or disconnecting any power or data cables.

GENERAL

- Use only components designed for the system.
- Handle the system carefully; do not remove casings from system components.
- Although the rotating lasers meet Class I laser certification, avoid staring directly into the laser apertures of the transmitter with a telescope, binoculars, transit, camera, or other optical magnification device.
- Keep loose clothing, hair, and other objects away from the rotating laser head of the transmitter.
- Do NOT put your finger(s) in the rotating laser head. Doing so could result in *minor* injury or property damage.
- Do not expose the system to water.

- The measurement tool is a precision optical device. Do not use the optical receiver as a handle when any of the pole extensions are attached. Excessive load or shock to the optical receiver can cause misalignment and measurement error. Please contact your local dealer if you suspect the system has been damaged.
- Remove the battery tray from the transmitter and store it in its designated case location prior to shipping or during transport.

FCC DECLARATION OF CONFORMITY

The transmitter laser has been tested and found to comply with the limits for a Class B digital device for radio noise for digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communication, and is pursuant to part 15 of the Federal Communication Commission (FCC) rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. The laser generates radio frequency. If it is not used in accordance with the instructions, it may cause harmful interference to radio or television reception. Such interference can be determined by turning the laser off and on. You are encouraged to try eliminating the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the laser and the receiver.

For more information, consult your dealer or an experienced radio/television technician.

LASER SAFETY

The United States Government of Devices for Radiological Health (CDRH) has classified this laser as a Class I and Class II laser product. These classifications are the safest ones available in that the Vulcan transmitter uses laser energy similar to that used in a compact disc player. Class I and Class II certification means that NO risk of injury exists when this laser product is used in accordance with the instructions in this manual.

Caution: Do not point any optical device, such as a telescope, binoculars, transit, or camera, toward the lasers while the transmitters are operating.

No OSHA or ANSI requirements with regard to signs, warning labels, or operator's licensing are needed because of the laser's low operating power.

Transmitter label showing compliance marking.

Laser apertures are located on the spinning head of the transmitter.

LIMITED WARRANTY

This warranty applies to all Vulcan ™ 3D position measurement products and spare parts for such products (collectively, Products) marketed by Arc Second, Inc. (Arc Second). This warranty applies for the benefit of the original purchaser and all subsequent owners of any Product during the warranty period applicable to such Product.

This warranty covers any failure, under normal use and service, caused by defects in materials or workmanship, provided that the owner has complied with the terms of this warranty. This warranty does not cover any failure caused by improper installation, operation, storage, use, accident, other casualty, negligence, repair or maintenance or modification by anyone other than an authorized representative of Arc Second or other circumstances beyond Arc Second's reasonable control. The warranty period is for one (1) year after delivery to the original purchaser of the Product.

Subject to the terms of this warranty, Arc Second will, at its option and at no cost to owner, repair or replace any Product or part thereof affected by a covered failure. The owner is responsible for the use and maintenance of the Product in accordance with the applicable user instructions for the Product. The owner must notify Arc Second or its authorized distributor of any failure which may be covered by this warranty immediately after such failure is discovered or by reasonable care could have been discovered. The owner shall follow instructions of Arc Second or said distributor regarding return of the Product or part thereof for inspection and shall pay the costs associated with shipping the Product to and from the place of inspection.

THIS WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES WHATSOEVER, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE. The exclusive remedy provided in this warranty shall not be deemed to have failed of its essential purpose so long as Arc Second is willing and able to repair or replace any covered Product or part.

Arc Second's liability, and the owner's remedies, with respect to breaches of warranty shall be limited to the ARC SECOND RESPONSIBILITIES described above, and in no event shall Arc Second's liability exceed the purchase price of the warranted Product or part involved. Arc Second shall not be subject to any other obligations or liabilities, whether arising out of breach of contract, warranty, tort (including negligence), strict liability or other theories of law, with respect to Products or parts sold by Arc Second or any undertakings, acts or omissions relating thereto. Without limiting the generality of the foregoing, Arc Second specifically disclaims any liability for property damages, penalties, special or punitive damages, damages for lost profits or revenues, loss of use costs, spoilage of material or for any other types of economic losses. ARC SECOND SHALL NOT BE LIABLE FOR AND SPECIFICALLY DISCLAIMS ALL CONSEQUENTIAL, INCIDENTAL, AND CONTINGENT DAMAGES WHATSOEVER.

Overview

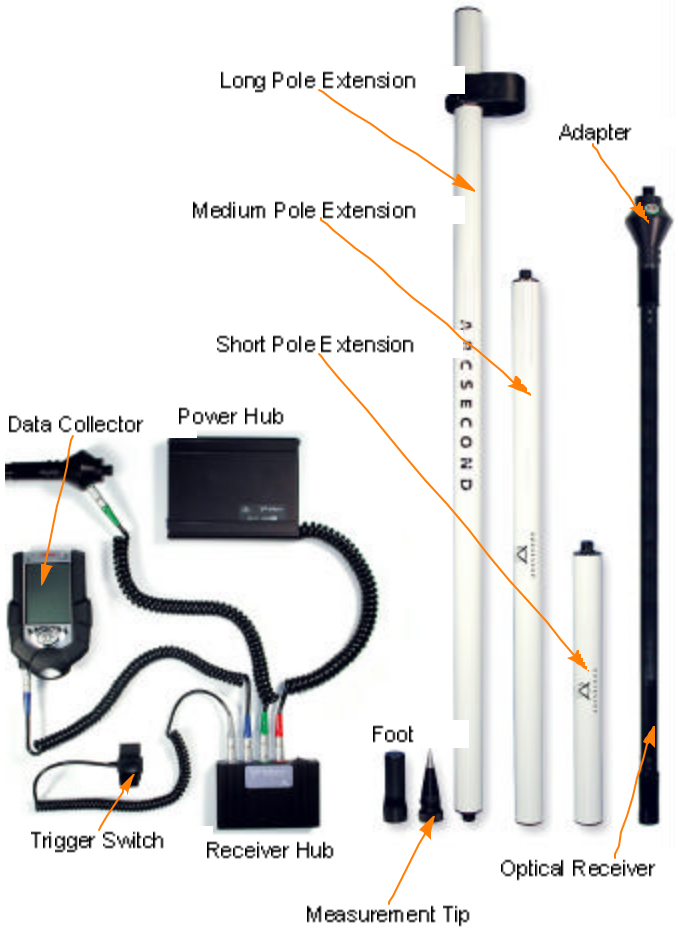
This section introduces the Vulcan 3D Measurement System and its components. It provides basic information so you can set up the system and begin measuring quickly.

System Components

The Vulcan 3D Measurement System contains the following components: pole measurement tool, transmitters, measurement tool batteries and charger, and data collector.

Pole Measurement Tool

The pole measurement tool consists of an optical receiver, a measurement tip, three pole extensions, a data collector, a power hub, a receiver hub, a trigger switch, three connector cables, and a belt pack.



Pole Measurement Tool Components

Transmitters

Vulcan includes two laser transmitters.

Vulcan Transmitters

The transmitters are shipped with rechargeable nickel/metal-hydride (Ni-MH) batteries and a charging unit.

Transmitter Battery Tray and Charger

Insert the batteries as shown in the battery tray diagram, noting positive and negative polarity. The transmitter has reverse polarity protection. If you put the batteries in wrong, no damage occurs to the transmitter, but it does not work. Allow one minute to recover after the batteries have been installed correctly.

Measurement Tool Batteries and Charger

The pole measurement tool is shipped with two rechargeable Ni-MH batteries and a charging unit.

Measurement Tool Batteries and Charger

Caution: Batteries should be removed when storing the transmitters or measurement tool more than 30 days.

Some states or local areas have regulations regarding the disposal of rechargeable batteries. Please be sure to follow regulations in your area.

Data Collector

The Vulcan 3D Measurement System uses a Windows PocketPC™ palm-sized computer (PDA) as a data collector.

Included with your Vulcan shipment is a CompactFlash memory card, a PCMCIA adapter, and a computer interface cable (serial or USB). Please refer to the PDA owner's manual for PDA usage information not covered in this manual.

Data Collector Components

Check system status.

Remove from boot.

Charge data collector.

INITIALIZING THE DATA COLLECTOR

The data collector may need to be initialized prior to first use. This process involves charging the data collector, initializing the PocketPC operating system, and loading the Survey 3D-I™ software.

Survey 3D-I software is loaded on the data collector prior to factory shipment. However, the data collector requires periodic recharging to maintain programmed data. If a data collector is idle for a period of approximately two weeks, volatile memory is erased and the software must be reloaded.

The data collector recharges automatically during Vulcan operation.

To check the status of your system, press the first (bottom-left) button on the data collector. If the Survey 3D-I software does not start, you need to reload the system.

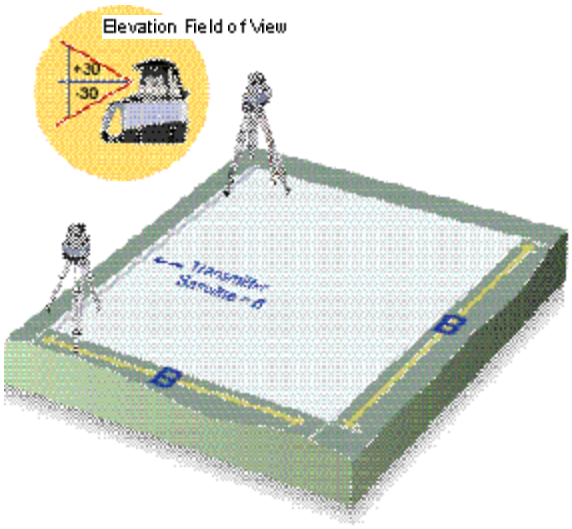
To reload the system:

- Remove the data collector from the protective boot and fully charge the system using the AC adapter provided with the PDA.
- Once the data collector is charged, initialize the operating system by following the PocketPC™ setup wizard. (See the PDA documentation included with your Vulcan shipment for additional information.)
- Return the data collector to the protective boot and follow the procedures outlined in “Installing Survey 3D-I Software” in *Advanced Usage*.

Setting Up a Work Area

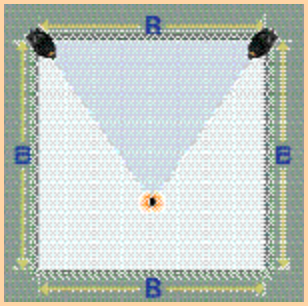
The Vulcan 3D Measurement System operates by triangulating the position of the optical detectors relative to the transmitters. Optimum system performance is obtained by positioning the transmitters to ensure good triangulation geometry to the desired measurement point.

A nominal work area is defined as a square of length B, where B is an imaginary line connecting both transmitters. Try to position the transmitters so that the measurement area is completely enclosed by the nominal work area.

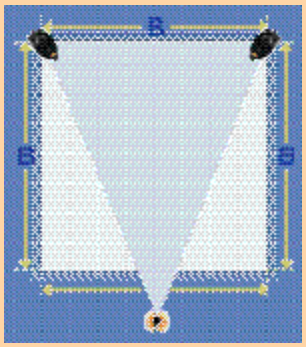


Nominal Work Area

To ensure good geometry, position the transmitters so there is an approximately 90° convergence angle at the center of the measurement area and ensure that all desired measurements lie within the work volume.

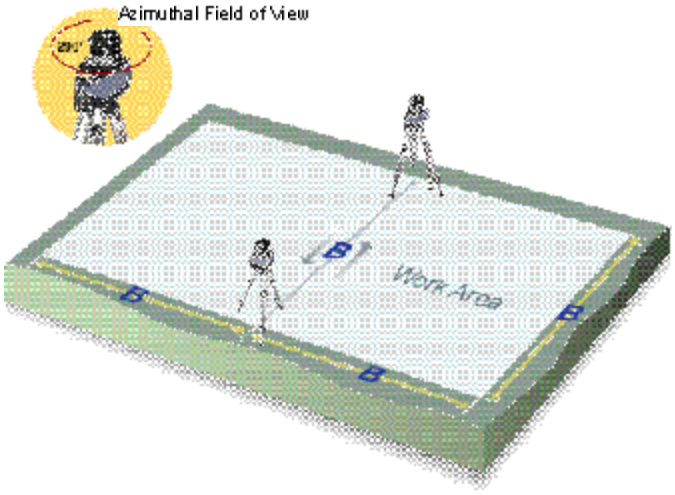


Good Triangulation Geometry



Poor Triangulation Geometry

The length of the usable work area can be doubled by placing the transmitters to bisect the measurement area and yield a nominal work area of B wide by 2B long. You can measure on both sides of the baseline, but take care not to make measurements between the transmitters, as poor measurement geometry degrades system performance.



Two-Sided Work Area

The minimum operating distance of the measurement tool to a transmitter is approximately 2 m (7 ft). The maximum operating distance to a transmitter is approximately 50 m (165 ft).

You must Calibrate the system when you set up a new work area. Methods for performing this task are described later in this section.

SETTING UP THE TRANSMITTERS

Each transmitter mounts to a tripod or other structure using a 5/8” by 11” threaded recess in its base. Secure attachment to a stable base is important to prevent transmitter movement during system operation.

The measurement tool stops operating if transmitter movement is detected following calibration.

Vulcan Transmitter on Tripod

Transmitter batteries do not need to be removed for recharging. The recharger can be plugged into the battery tray while it is installed in the transmitter. However, transmitter operation is disabled during charging.

VULCAN TRANSMITTER OPERATION

Transmitter Keypad

- ***Ready LED**: flashes to show the transmitter’s operational status. Red indicates the transmitter is getting ready, green indicates the transmitter is ready for use.*
- ***Power Button**: turns the transmitter on and off.*
- ***Battery Status LED**: flashes to show the approximate charge of the batteries. Green indicates batteries are ready, yellow indicates batteries are low, red indicates batteries are too low to operate the transmitter.*
- ***Service LED**: flashes red when the transmitter needs servicing.*

.ASSEMBLE POLE COMPONENTS

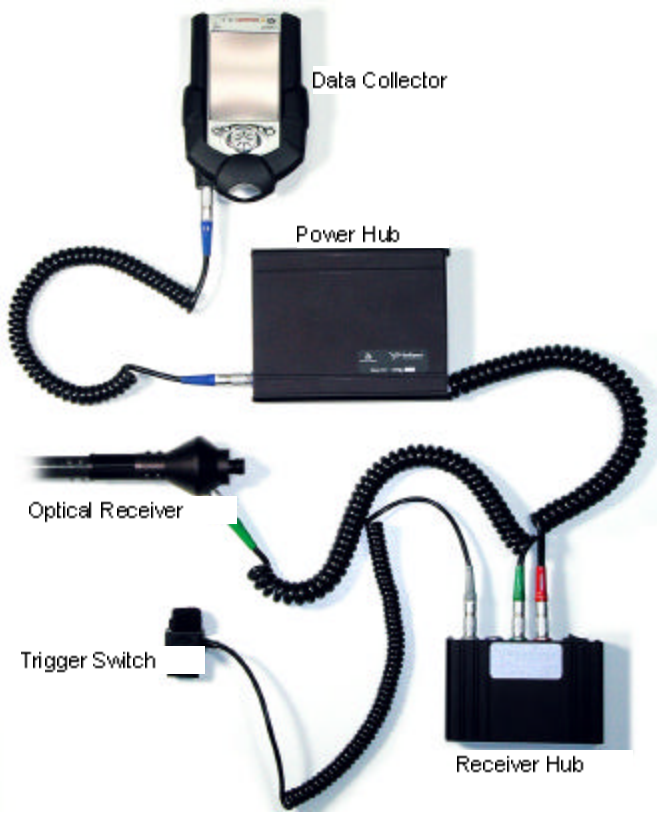
Attach optical receiver to pole extensions

Attach measurement tip.

Attach trigger switch.

SETTING UP THE POLE MEASUREMENT TOOL

To set up the pole measurement tool, assemble pole components, assemble components on the belt pack, and attach cable connectors.



ASSEMBLE POLE COMPONENTS

Connect the components of the pole measurement tool as shown.

ASSEMBLE COMPONENTS ON THE BELT PACK

The belt pack is shipped with the power hub and receiver hub already attached in a standard configuration. These components can be moved to suit your preferences.

Connect the carabineer on the belt pack as desired and connect the data collector to the carabineer.

Attach Cable Connectors

- Connect the power hub to the receiver hub (Red).
- Connect the data collector to either the power hub or the receiver hub (Blue).
- Connect the optical receiver to the receiver hub (Green).
- Connect the trigger switch to the receiver hub (Gray).

Belt Pack with Cable Connectors Attached

Ensure that system power is off when connecting or disconnecting any of the cables.

Do not force the connection of any cable. All connectors are color coded and differentiated by number of pins. Excessive force can result in pin damage.

To remove connectors, pull back on the knurled sleeve to release the connector hooks and pull the connector out of the socket.

Detaching Cable Connectors

Pull back on the knurled sleeve to release the connector hooks.

Power on the pole measurement tool.

Main Menu

Error Screen

USING SURVEY 3D-I™

Before using Survey 3D-I, power-on the transmitters and the measurement tool. To start the program, press the first button on the data collector or press Start, at the top of the screen; then select Survey 3D-I from the list. The program initializes the measurement tool and displays the Main menu.

The Main menu displays the following options:

Setup: Allows you to enter various setup parameters for the system.

Measure: Provides access to the measurement functions of the system.

Quit: Exits the program.

Several icons are displayed throughout the program and are used to navigate between the various screens:

Back: Returns you to the previous screen.

Back Arrow: Returns you to the previous screen.

OK: Saves any changes or performs “enter” function for measurement.

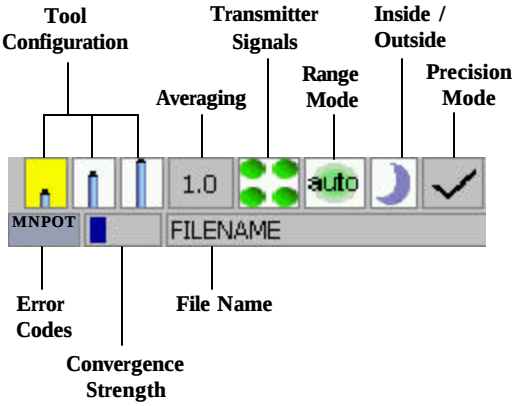
Save: Saves any changes.

Cancel: Cancels any changes.

If the Error Screen displays on startup, the receiver hub is not communicating with the data collector. Check power and cable connections, restart the receiver hub, and then restart Survey 3D-I.

USING THE STATUS BAR

The Status Bar appears at the bottom of all measurement screens, whether the user is in Measurement or Calibration mode. The Status Bar displays critical operational and diagnostic information. In addition, you can change several key system settings directly on the Status Bar, thus avoiding the need to navigate to other system screens.

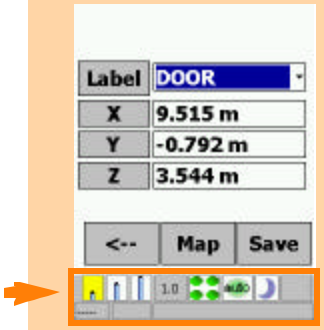


Tool Configuration: You may view or change the current configuration of your measurement tool without leaving the measurement screens. To change the current setting, press the appropriate Pole icon(s). The current settings will be indicated by yellow highlighted Pole Icons.

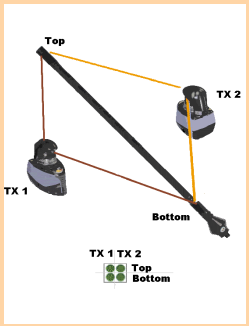
Averaging: The system updates its position approximately 8 times per second. However, you may elect to average the position calculation over several seconds to get a more stable (i.e., repeatable) measurement. To adjust the position averaging (displayed on the Status Bar), use the up/down arrows on the PDA, each press is a 0.5 second increment or decrement.

Increasing the the averaging can improve the precision of a measurement, but also increases measurement latency.

Transmitter Signals indicate whether the optical receiver has line-of-sight from both of its detectors to both transmitters. (See "Setting a Range" for details.) Four indicator dots appear at the bottom of the screen if you are receiving the transmitter signals properly.



Status Bar on Measurement Screen



Dots indicate when detectors are receiving transmitter signals, that is, when detectors on optical receiver have clear lines of sight to the transmitters.

Range Mode: The range mode adjusts the sensitivity of the system to account for distance from transmitter and changes in ambient light. In Auto mode the system will adjust the range automatically. However, in some ambient light conditions or when working in a small (15m or less) work area, it may be necessary to switch the range mode from Auto to Manual. In the Manual mode, you may adjust the range from 1-50 meters (or yards) to correspond to your current setup.

Under bright fluorescent lights and in work areas 15 meters or smaller, the range value may need to be reduced to 10 or less.

Inside / Outside: The system performs better when optimized for inside or outside use (i.e., shade or sun). You may configure the system by simply toggling this status bar button.

Precision Mode: Precision Mode is activated by pressing the box on the right side of the Status Bar. This mode allows users to make multiple measurements of a single point and to use the averaged measurement as the final reading.

Precision Mode minimizes the impact of "tip" offsets due to long tool configurations or worn system components. This method is also recommended for users trying to achieve the highest levels of precision and accuracy.

File Name: The name of the current data set (file) appears in the bottom right hand box of the Status Bar. If no data set is open, the box will be blank.

Convergence Strength: This indicator shows the approximate "strength of figure" for the intersection of angles between the receiver and the two transmitters. The signal will show three boxes near 90 degrees intersection, and drop off as the angle gets larger or smaller.

This indicator should only be used as complementary information, not as a strict guide by itself. The user may increase averaging and use precision mode to counter the effects of poor geometry on most measurements.

Diagnostic Codes: The bottom left box of the status bar displays the diagnostic codes when a measurement problem occurs. The codes include Multi-path (M), Noise (N), Pulse Overflow (O), Position Tolerance (P), and Tool Tolerance (T) (see "Diagnostics and Troubleshooting" in *Advanced Usage*).

CALIBRATING THE SYSTEM

Access Calibration functions from the Setup menu.

The Vulcan 3D Measurement System must be calibrated on your worksite before you take any measurements. The calibration process calculates the positions of your transmitters and establishes the coordinate reference frame.

In the calibration menu, there are two setup options (Quick and Resection), and a Set Scale function which, after performing a Quick Setup, allows you to reference an accurately measured scale distance to improve system performance. Using the Set Scale function after a Quick Setup is the most accurate method of calibrating the system..

During each calibration, various target points are sampled (measured) by Vulcan. Samples should be distributed throughout the worksite volume. Recommended geometries for each calibration technique are included with their descriptions.

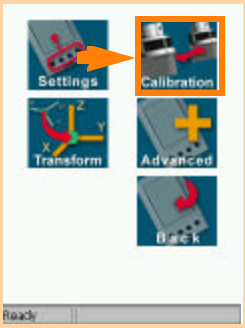
Allow the transmitters to warm up for approximately five minutes before sampling target points.

It is important to hold the optical receiver as still as possible during each calibration sample. An accessory such as a surveyor's bipod is useful for this purpose. Vulcan monitors the standard deviation of the measured angles from the transmitters. If these standard deviations exceed a specified value, the system attempts to recollect the angles. After four unsuccessful attempts, the system directs you to hold the measurement tool steady and try again. (For more information about setting/viewing standard deviation thresholds, refer to "Advanced Settings" in *Survey 3D-I Reference*.)

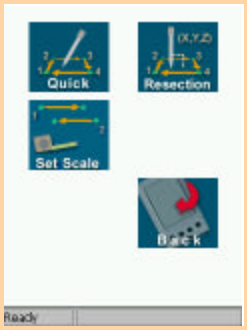
During system calibration, the Auto-Range function will not allow the user to collect a calibration point within 6 meters of a transmitter. For short baseline setups (<15m) switch the Range Setting from Auto to Manual and use a manual setting of 10 or less.

Quick is the easiest calibration method, as it requires no external data such as control points or scale distances. However, it provides a less accurate calibration and is most effective for small work areas.

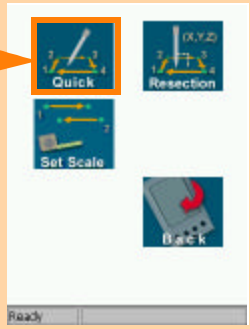
Select Setup.



Select Calibration.

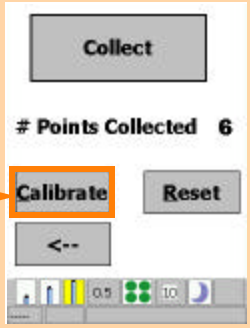


Calibration Menu



Access the Quick calibration method from the Calibration menu.

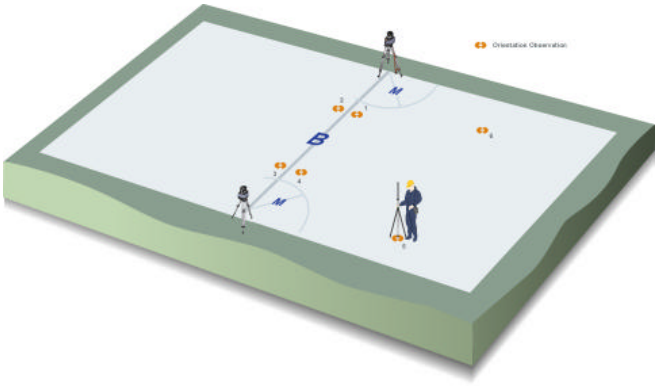
Check for indicator dots, then press Collect to measure points.



Press Calibrate after collecting a minimum of six points.

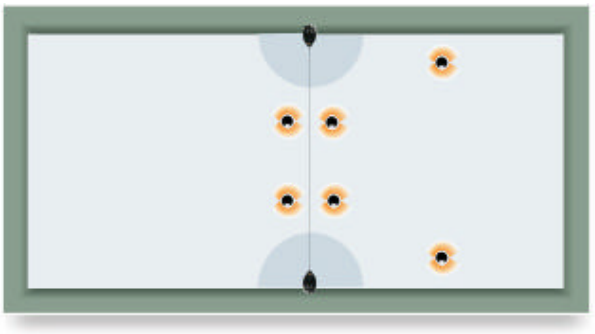
During Quick calibration, Vulcan uses the distance between the two detectors on the optical receiver (approximately ½ m) to determine the distance between the transmitters.

- Sample at least six targets in the work area as shown below. Make sure that points 1-4 are at least 6 meters from the nearest transmitter and about 1-2 meters off the baseline (B). Points 5 and 6 should be about B/2 away from the Baseline (i.e., in the middle of the work area). No observation should be more than 40 meters from either transmitter.



Setup Observations

The standard setup requires a minimum of six observations. However, in some cases the user may choose to do more for a two-sided work area (e.g., add points 7 & 8 to mirror points 5 & 6).



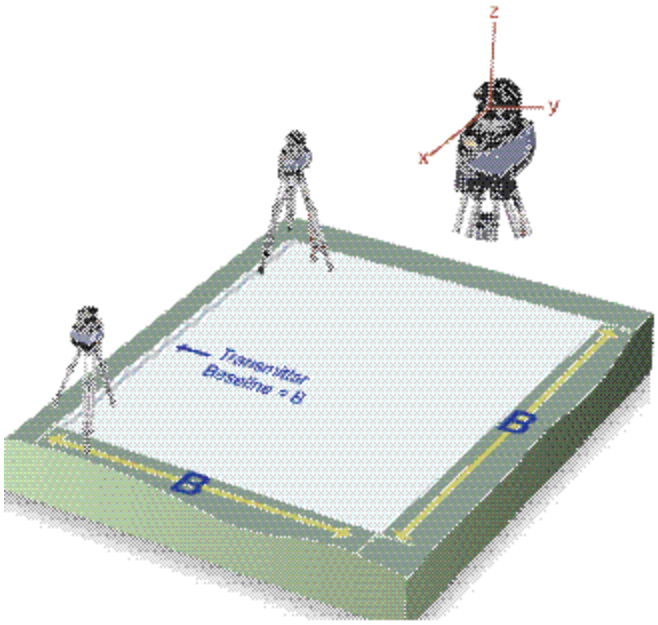
Bird's Eye View -- Setup Observations

- When measuring targets, make sure the optical receiver is held vertical and steady and that all four indicator dots appear on the status bar. If the indicator dots do not appear, ensure you have a clear line-of-sight to the transmitters. If you are working with a baseline of 15 meters or

shorter, you may need to use the manual Range option on the Status bar, with a setting of 10 as a starting point.

- Press Calibrate after all sampling is complete. The system computes the transmitter positions and reports Calibration Success or Failure. For information on viewing calibration results, see "Advanced Settings" in *Survey 3D-I Reference*.
- Proceed to the Measure menu.

Quick Calibration establishes a default coordinate system based on the origin at transmitter 1, the z-axis coinciding with the "spin" axis of transmitter 1, and the x-axis direction through transmitter 2. (See "Advanced Settings" in *Survey 3D-I Reference* to determine which transmitter is designated as transmitter 1.)



- Use a bipod or some other method to stabilize the optical receiver.
- Position the optical receiver vertically while collecting calibration points.
- Follow the guidelines for best sample geometry.
- Following calibration, measure a known distance to ensure scale is set accurately.

The Quick calibration algorithm sets coordinate scale by referencing the detector to detector distance on the optical receiver (~½ meter). Any errors in measuring this scale will be amplified by the ratio of your baseline distance / detector - detector distance. Use caution when performing Quick calibrations with baseline distances greater than ten meters. If greater accuracy is required, you should use the Set Scale feature described below.

Your system has been factory tuned to provide the most accurate scale measurement in the most common setup configuration. For most accurate results, roughly level the transmitters and position them at a height so that the optical receiver is in plane with the transmitters during calibration.

Align the Optical Receiver In-Plane with the Transmitters

If you must deviate from this setup configuration for line-of-sight reasons—for example, tilting the transmitters or extending their height—use the Set Scale option or Resection Calibration.

Set Scale improves the Quick calibration by allowing you to reference one or more scale distances on the worksite. Defining two points and measuring the distance between the points with a tape measure is a good way to obtain a longer scale distance. (See “Long Scale Calibration” in *Advanced Usage*.)

Resection requires the known (x,y, z) coordinates for a minimum of four target points. In addition, the measurement tool must be plumbed and rotated at each point. Resection is suited for users who have access to known “control” points on a site or other 3D measurement systems with which to establish an accurate “control” grid.

TAKING MEASUREMENTS

The Measure menu is used to access functions for measuring point coordinates, distances, angles, and areas. Data and label file functions can also be accessed from this menu. (For more information on specific functions, see the *Survey 3D-I Reference* section.)

MEASURING COORDINATE POINTS

The **XYZ(NEZ)** function allows you to measure the 3D coordinates of any point you touch with the measurement tip.When you select this function, the data collector displays the current coordinate location of the measurement tip. Measurement points can be saved to an open data set by pressing Save on the data collector or by pressing the trigger switch on the measurement tool.

Save Points by Pressing the Trigger Switch

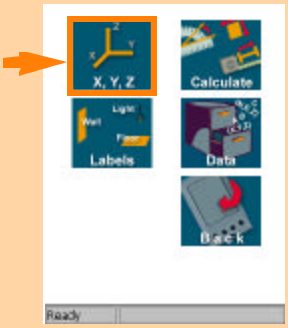
A data set must be open to store point information. If there is no active data set Vulcan prompts you to open one when you first attempt to save a point. The name of the active data set is displayed on the right side of the status bar at the bottom of the data collector screen. (See “Managing Data”.) Collected points are numbered sequentially in your data set, starting from 1.

You can attach a unique label to any measurement by selecting a label from the drop-down label field at the top of the measurement screen. (See “Using Labels”.)

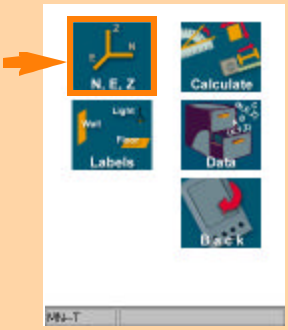
The Map function displays a map of the work site, including the location of transmitters and stored points and the current position of the measurement tool. (See “Using Map and Navigation Functions”).

Survey 3D-I allows the use of the Northings, Eastings and Elevation (NEZ) data display format commonly used in surveying. To change coordinate display format, select Coord from the Settings menu and then press the radial button for NEZ.

Select Measure.

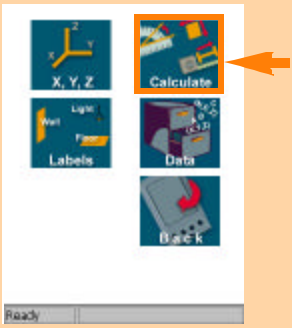


Select XYZ.



Select NEZ.

Select Measure.



Select Calculate.

Calculate Menu

CALCULATING DISTANCE, ANGLE, AND AREA MEASUREMENTS

The **Calculate** menu provides access to several additional measurement functions including distance, angle and area measurement.

DISTANCE

The **Distance** function enables you to measure the linear distance between two points. To activate this function, position the measurement tool on the initial point and press Start. As you move around the work area, the display shows three distances:

- XY is the distance between the two points projected onto the X-Y plane.
- XYZ is the distance between the two points.
- Z is the Z-direction distance of the second point from the first point

To freeze the measurements on the screen, press Pause. To reactivate distance measurements, press Run.

ANGLE

The **Angle** function enables both Azimuth (horizontal) and Elevation (vertical) angle measurement. Azimuth measurement is based upon an initial bearing line created by specifying the start and end points. Elevation angle is measured from any start point. You can freeze the screen at any time by pressing Pause. To reactivate angle measurements, press Run

AREA

The **Area** function allows measurement of any area defined by three or more points. As you select points around the perimeter of an area, the system display the area's calculated size. You can proceed in either a clockwise or counter-clockwise direction, but all points on the perimeter must be taken in geometric sequence.

The Area function always calculates the area projected in the X-Y plane.

MANAGING DATA

A data set must be created/selected prior to storing point data in XYZ(NEZ) mode. The current active data set name is displayed on the right side of the status bar.

The **Data** function is used to create, delete, and view data sets (files). You can open an existing data set by selecting its name from the displayed list. To create a data set, select New and enter a name using the keypad.

To enter a character, press the appropriate key in quick succession until the desired character appears. Pause briefly before entering the next character. To clear your last entry, press C; to save your entry, press OK; to return to the previous screen, press Cancel.

The following options appear on the data set screen:

New: Creates a new data set. Press NAME to enter the name of the set, then press Save. The new data set appears in the list.

Delete: Deletes a data set. Select the name of the data set from the list by touching it; it is then shown as Current. Press Delete, and confirm the selection. The set is removed from the list.

There is no Undo function. Once you have deleted a data set, it is gone. Be sure to back up your data sets to the CompactFlash card before deleting any of them from within Survey 3D-I.

View: Displays the contents of the current data set.

From the View screen, you can create New points, Delete points, or Edit points. The New function displays the XYZ screen, where you can label and store new points. The Edit screen also displays the XYZ screen, where you can change the label or coordinates of the selected point. You must select points before deleting or editing them. To select all the points, press All.

You can also select points and Go To them using the Map screen. (See "Using Map and Navigation Functions".)

USING LABEL SETS

Vulcan allow you to save XYZ(NEZ) position measurements with alphanumeric labels. Labeling points, either uniquely or as groups, significantly eases later data use.

Labels may be created directly from the XYZ(NEZ) function by pressing Label. Labels created from this screen are stored

Use the keypad for data entry.

Data Set Screen

View Data Screen

Label Set Screen

Selecting a Label

Point with Label Selected

in the currently active label set. If no label set is designated, new labels are stored in the default label set. Pressing the drop arrow in the label display area allows you to select from a list of labels in the current set.

The **Labels** function is used to create, delete, and view label sets (files). You can open an existing label set by selecting its name from the displayed list. To create a label set, select New and enter a name using the key-pad.

The following options appear on the label set screen:

New: Creates a new label set. Press NAME to enter the name of the set, then press Save. The new label set appears in the list.

Delete: Deletes a label set. Select the name of the label set from the list by touching it; it is then shown as Current. Press Delete, and confirm the selection. The set is removed from the list.

The default label set cannot be deleted.

View: Displays the contents of the current label set.

From the View screen, you can create New labels, Delete labels, or Edit labels. The New function creates a new label and saves it in the current label set. The Edit function allows you to change the selected label. You must select labels before deleting or editing them. To select all labels in a label set, press All.

- For the most efficient data collection, prepare label sets before beginning the measurement process. Creating labels in the field can be time-consuming.
- You can also create label sets “off-line” using Microsoft Notepad on your PC. Simply create a .txt file and type a single label on each line. Copy the file from your PC to the Program Files/ Survey 3DI/Labels directory of your data collector.

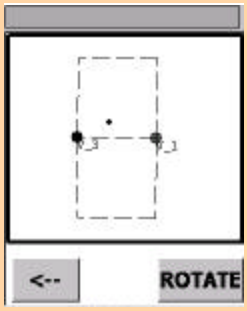
USING MAP AND NAVIGATION FUNCTIONS

The Map function, accessed from the XYZ(NEZ) screen, displays a map of the work site including the locations of the transmitters, collected points, and the measurement tool.

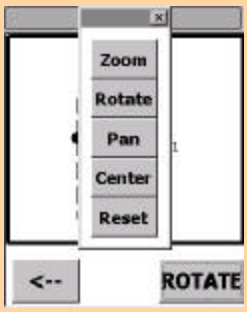
You can change the map display using Zoom, Rotate, Pan, Center, or Reset. The selected function is displayed on the lower right of the map screen. To select a different function, press the current function name and then select from the drop-down list. To activate the selected function, tap on the touch screen. For those functions with two directions tap the top, bottom, left, or right of the screen.

To display previously collected points in Map mode highlight the desired points in the data set using the Data:View function. The selected points will be visible on the Map when reentered from the XYZ(NEZ) Screen.

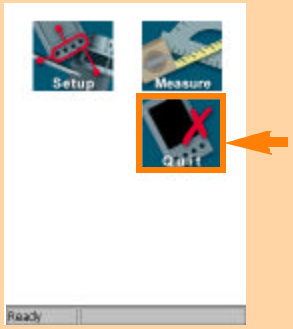
The Go To function, accessed from the Data screen, allows you to navigate to selected points. In addition to normal display functions (Zoom, etc.), you can also select 2D or 3D navigation mode. The display automatically changes to a close-in navigation screen as the target is approached and beeps when within tolerance. Close-in and beep settings can be changed in the Advanced Settings screen.



Map Screen



Map Screen Options



Exit Survey 3D-I.

Power off measurement tool.

Power off data collector.

SHUTTING DOWN

You can exit the Survey 3D-I program at any time by selecting Quit. To restart the program, access it through the Start menu on the bottom left of the data collector screen or by pressing the first button on the data collector.

Power off the measurement tool, data collector, and transmitters before storing the system. Recharge the transmitter and measurement tool batteries as required.

System Charging: Transmitter Batteries

System Charging: Measurement Tool Batteries

Place the data collector on charge if you plan to leave the system idle for extended periods (~two weeks). Always transfer collected data to your PC or to the flash card before storing the data collector.

The data collector requires only periodic recharging. However, the surest method to prevent loss of programmed memory is to always place the data collector on charge.

Remove the battery trays from the transmitters and store them in the designated case location during shipping or transport.

Always store the optical receiver in the case when not in use. Laying the optical receiver on the floor or leaning it against a wall for prolonged periods may shift the receiver from its factory calibration.

ADVANCED CALIBRATION

As discussed in *Getting Started*, calibration is the process of calculating the position and orientation of the Vulcan transmitters on your work site. This procedure must be completed prior to performing any data measurements. The calibration procedure also sets the initial local coordinate reference frame of the measurement volume. This reference frame may be changed after calibration. (For more information see: "Changing the Reference Frame".)

The calibration options provided are Quick and Resection. However, you have the option of augmenting the Quick calibration by measuring long scale distances in the Set Scale function. The following chart details the primary differences between the three methods.

	Quick	Quick + Scale	Resection
Recommended Baseline	10 m or less	Up to 35 m	Up to 35 m
Relative Accuracy	Low - Moderate	High	High
Control Points Required[1]	None	None	4
Scale Distance Required[2]	None	1 or 2	None
Receiver Leveling Required	No	No	Yes
Bipod Required	Highly Recommended	Highly Recommended	Yes
Target Samples	6 minimum	6 minimum (+ 2 to define scale distance)	4

Notes:

1 Control points must be accurately measured in all three dimensions (X, Y, Z).

2 Scale distance may be provided using a tape measure or a known distance between two control points.

During each calibration, the Vulcan 3D Measurement System samples several target points. A minimum of six samples is required for Quick and Long Scale, though performance will improve with additional sampling. (Resection is limited to four control points). Target points should be distributed throughout the work volume. Recommended geometries for each calibration technique are included with the descriptions. During each calibration sample it is important to hold the

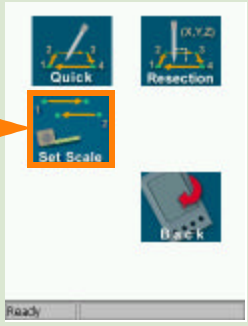
optical receiver as still as possible. An accessory such as a surveyor's bipod is useful for this purpose.

In the Advanced Settings screen, you can review the results of the calibration process and also change the Pass/Fail criteria for some of those metrics to help ensure the desired level of performance from the system (see "Advanced Settings" for details).

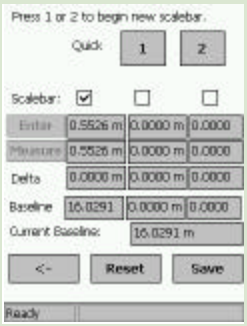
After calibration, the local coordinate reference frame remains intact unless the transmitters are moved. If the transmitters have not been moved since the previous calibration, the system does not require recalibration, even if the measurement tool or transmitters were powered off. If the transmitters have been moved, the system will not perform measurements until recalibrated.

BEST PRACTICES

- Since the Vulcan 3D Measurement System uses triangulation for measurement, it is important to have strong triangulation geometry for accurate calibrations and position measurements. To ensure good geometry, position the transmitters so there is an approximately 90° convergence angle at the center of the measurement area and ensure that all desired measurements lie within the work volume.
- Hold the measurement tool vertical and still while measuring target points. A bipod or other device for supporting the measurement pole is highly recommended for Quick, and should be considered a requirement for high accuracy work. However, you do not need to have the pole perfectly level for Quick. Resection requires a bipod that can be leveled.
- Follow the guidelines for target measurement geometry.
- Ensure that scale distance measurement for Set Scale and control points for Resection are measured as accurately as possible. Vulcan cannot produce measurements at a higher level of accuracy than that of the input data.
- Ensure that transmitters are securely mounted to a stable surface.
- Following calibration, perform a few measurements to verify system accuracy prior to data collection. For Quick calibrations, checking a distance against a tape measure is adequate. For Resection calibration, verify the coordinate values of one or more of the calibration points used.



Access Set Scale from the Calibration menu.



Set Scale screen with Quick scale only.

Set Scale with Quick and [1] scale selected.

QUICK CALIBRATION

Quick calibration provides an easy way to begin measuring. However, this is the least accurate of the calibration methods.

Step-by-step instructions for the Quick calibration method are provided in *Getting Started*.

SET SCALE OPTION

You may greatly improve the accuracy of the Quick calibration method by using the Set Scale option. In the Quick mode, the system uses the distance between the detectors as a known scale or "scale bar." This known distance will set the scale of the system (i.e., tells the system what distance defines a meter, foot, or any other unit of measure for length).

Generally speaking, it's better to have a longer scale bar for work areas with Baselines longer than 15 meters. The Set Scale option allows you to measure one or two long scale distances on the site. Whether you measure one or two scale bars, the process is the same. Push the [1] or [2] button, and the system will prompt you to **Enter** the scale distance. You will then be instructed to **Measure** both end points of the scale bar using the system.

The better the input scale distance, the better the system will be calibrated. Use care when measuring the scale distance: any errors in measurement will be reflected in the scale of the coordinate frame following calibration.

The best technique for measuring a distance of 10-15 meters is usually an accurate steel tape. Make sure the tape is pulled tightly and has minimal sag. Many surveying books describe best practices for measuring with a tape, including corrections for tape tension and temperature changes. For most Vulcan applications, simply pulling a good steel tape tightly will work fine. If you have access to more accurate distance measuring device, such as a laser interferometer, you may use it instead of the tape.

For each end point of the scale bar, you will measure it three times with the pole held in an arbitrary position; the exact orientation of the pole does not matter. This starting orienta-

tion is referred to as the “0-degree” position. You will then rotate the pole 180 degrees and take three more measurements. This orientation of the pole is called the “180-degree” position.

The system will use the average of the six measurements to determine the position of the scale bar end point. By taking six measurements, and rotating the pole, you will minimize any projection errors that may come in due to a slightly bent pole.

The bubble on the 3-foot pole section serves as a good reference when rotating the pole from the 0-degree to 180-degree position.

After measuring the scale bars, you will have the option of selecting each to be used in the calculation of the Baseline distance. One of the key determinants of the calibration process is the Baseline distance, which is directly calculated from the scale bars used.

The objective of measuring scale bars is to determine the Baseline distance as accurately as possible. If you only use one scale bar, the system does not have any “redundant” information to determine how well it measured the distance or to catch blunders (gross mistakes). Typically, the Baseline is best determined by measuring [1] or [2] long scale distances on the site.

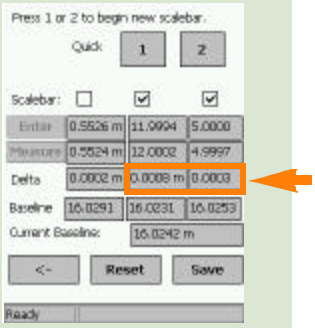
If the scale is measured improperly with a tape (or other device) or entered incorrectly, then the final result will be adversely affected. Consequently, you should take as much care as possible to: (a) measure the scale distance accurately, (b) enter the value correctly, and (c) measure the scale with the system carefully.

Many pre-cautions have been built into the system, like taking six measurements at each end point, to help you get the best measurement possible with the system. However, it’s up to you to measure and enter the scale distance as accurately as possible to begin with.

The system cannot prevent small errors in measuring with a tape or entering the distances improperly. However, the system *will* catch blunders if you compare the calculated baseline using the scale measurements [1] and [2] with the calculated baseline determined *only* with Quick.

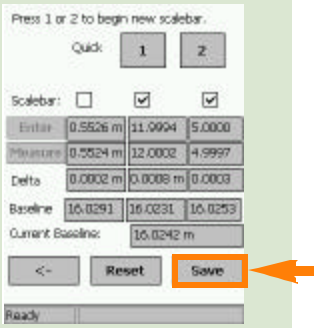
The exact combination of scale bars to use cannot be predicted with certainty since the accuracy of the measurements can be greatly influenced by the user. Generally speaking, if you only measure one long scale bar, the solution will be better if you use this [1] scale only. If you measure two

Set Scale with all three scales selected.



When using more than one scale, pick a combination that minimizes Delta values.

When you use only one scale, the Delta value will be forced to zero - make a field measurement to verify calibration.



Once a final combination of scale bars is selected, press Save to store.

Press Reset to zero-out the measured scale bars.

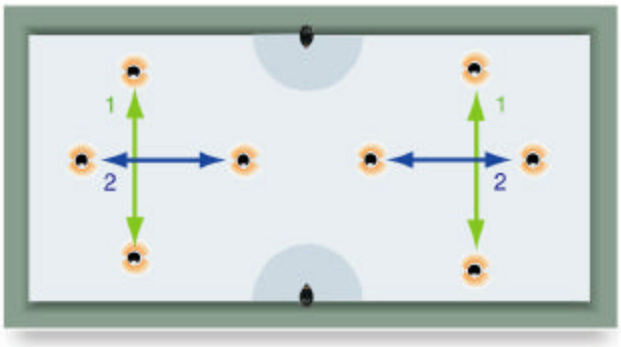
long scale bars [1] and [2], it's generally better to select both of them. Most of the time, you should use the Quick scale bar only when it's the only one measured. However, the Quick only solution will help you catch gross errors (i.e., blunders) in measuring long scale bars (either [1] or [2]).

Make sure that you measure and enter each scale bar BEFORE you select the check boxes on the Set Scale screen. You can then try different combinations to achieve the best scale solution.

When selecting which combination of scale bars to use, look at the Delta distances displayed on the Set Scale screen. When *more than one scale* bar is used, the goal is to minimize these Delta values. Typically, you should strive to see Deltas that are 1 mm or smaller. If you only select *one scale bar*, the Delta value will go to zero since the system "forces" the measured distance to match the entered scale distance. In this case, your best bet is to verify the accuracy of the calibration by measuring a distance on the site, preferably one different than the input scale distance.

Once you are satisfied with a particular combination of scale bars, press the "Save" button to store this configuration. You may reset the measured scale bars by pressing the "Reset" button.

If you only use one measured scale distance, the scale bar should be oriented parallel to the baseline and centered in the work volume if possible. Avoid any target closer than seven meters to any transmitter. If you use a second scale bar, place it perpendicular to the baseline. Any of the scale bars may be on either side of the baseline.



Bird's Eye View: Scale Bar Location Options

The scale distance should be at least ½ the baseline distance up to about fifteen meters. Scale distances longer than fifteen meters are not recommended.

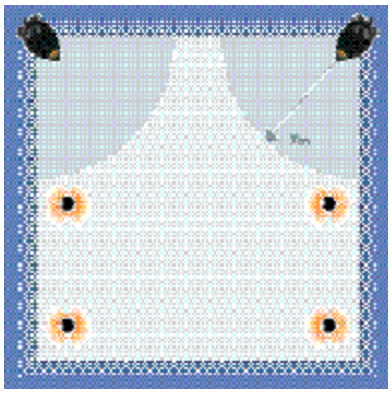
For details on the quality of calibration and on settings for calibration pass/fail criteria see “Advanced Settings”.

After re-measuring the scale distance, measure another known distance on the worksite to ensure scale is set accurately.

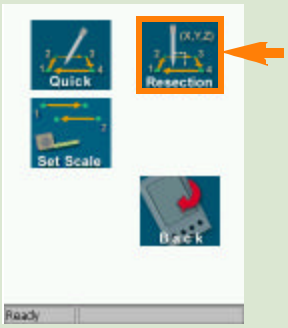
RESECTION

Resection is the most accurate and reliable calibration technique. It employs a Least-Squares algorithm to “best fit” the transmitters onto the work site based on the target measurements (control points) collected and the input coordinate values of those points. Each of the four control points must have its 3D coordinates values (x, y, z) known with respect to a common reference frame. The common reference frame of the target points becomes the local reference coordinate frame of the measurement grid following calibration.

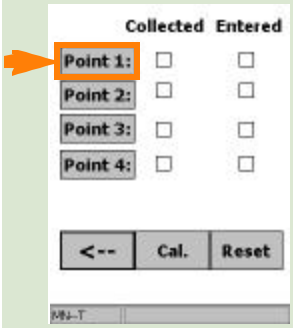
System performance relies on the accuracy of the input points, as well as the location and geometry of those points relative to the transmitters and work area. The system cannot achieve results better than the accuracy of the input points.



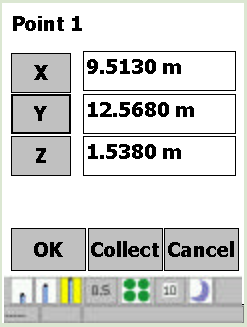
Bird’s Eye View: Resection Calibration



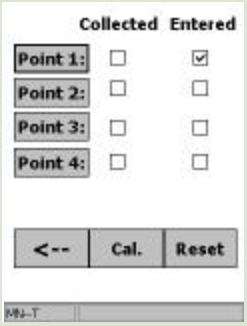
Access Resection from the Calibration menu.



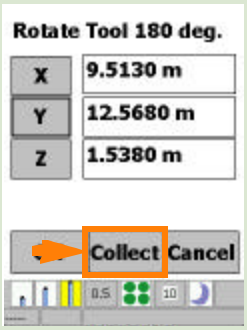
Select a point..



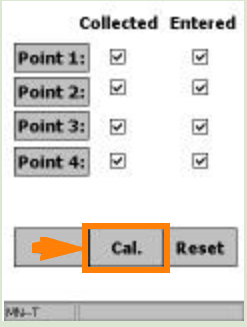
Use the keypad to enter coordinate values for the selected point and press OK.



After entering the coordinates, select the point again and use the measurement tool to collect it.



Rotate the measurement tool 180° and collect the point again.



Press Cal after all four target points are entered and collected.

- For optimum setup, control points should be just inside the perimeter of the worksite.
- The two points closest to the baseline should be no closer than 7 meters to either transmitter.

Because the system is calibrated to the known coordinate values of the points on the work site, care should be taken when "collecting" the calibration points. The measurement tool must be plumbed over each point using the bubble level included with the system, and a bipod or other accessory should be used to hold the measurement tool steady during target point collection. After each point is collected, you are prompted to rotate the tool 180 degrees. Rotating and recollecting allows the system to average two readings to minimize any error in the bubble level.

Press Cal. after collecting four points. The system computes the transmitter positions and reports Calibration Success or Failure.

For details on the quality of calibration and on settings for calibration pass/fail criteria see "Advanced Settings".

After calibration, re-measure the control points with Vulcan to verify setup accuracy.

Measurement Tool Configuration

One of the many benefits of the Vulcan 3D measurement system is the ability to measure "hidden" points—those that are not in line-of-sight to the transmitters. Hidden point are measured by positioning the measurement tip on the desired point while the optical receiver maintains line-of-sight to the transmitters. This process is made even easier by the ability to change pole extension lengths to suit your measurement needs.

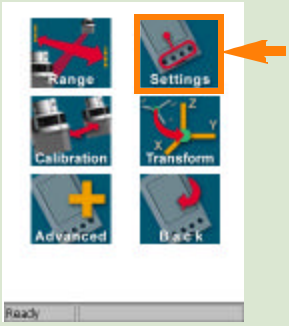
After you configure the mechanical components of the measurement tool, you may need to modify Survey 3D-I tool settings. The Tool Settings screen allows you to reconfigure the Total Projection Length (the length from the lowest active detector to the measurement tip) set in the software. It also allows you to deselect one of the detectors on the optical receiver, when line-of-sight to both detectors is not feasible.

Two of the most common user errors are failure to set projection length properly and failure to re-select two detector operation before taking measurements with the measurement tool tilted. To verify that tool settings are correct, tilt the measurement tool slowly while holding the measurement tip stationary. If you observe significant (> 5 mm) measurement deviation when shifting from vertical orientation, your tool settings are incorrect.

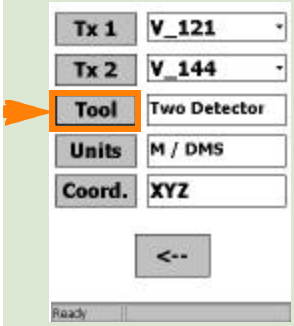
Access Tool settings from the Settings screen (Setup menu). A shortcut to this screen is available by pressing the third button on the data collector at any time while running the Survey 3D-I software.

To access Tool settings from any screen, press the third button on the data collector.

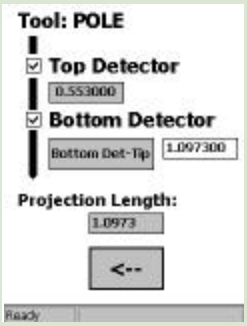
The Tool Settings screen displays the distance between the two detectors on the optical receiver (Det-Det), the distance between the bottom detector and the tip (Bottom Det-Tip), and Total Projection Length (total distance from the lowest active detector to the tip). These values cannot be changed in this screen.



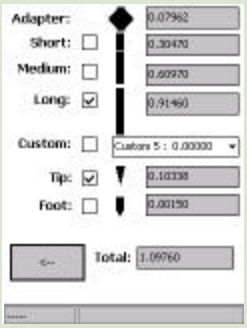
Select Settings from the Setup menu.



Select Tool from the Settings screen.



Tool Settings Screen



Tool Configuration Screen

All lengths are displayed in meters regardless of the working units selected.

Measuring with just the top or bottom detector provides some flexibility when it is difficult to acquire a signal from both transmitters to both detectors. To operate in single detector mode, uncheck the box next to the detector you will not be using.

Single detector mode projects the measured optical detector position the appropriate distance, based upon selected tool configuration, along the coordinate frame z-axis. If your z-axis is relative to gravity, level the measurement tool directly over the point when measuring with either Top or Bottom detector unchecked. If the z-axis is not relative to gravity, using single detector mode is not advised.

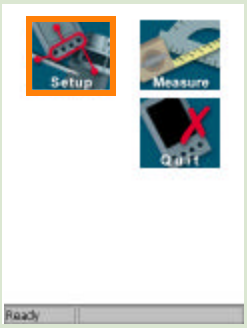
The default configuration of the pole measurement tool is optical receiver/adapter/long pole extension/measurement tip. If you use other pole extensions or custom tips, you must modify the configuration in the Survey 3D-I software. To modify pole measurement tool configuration, press Bottom Det-Tip and use the check boxes to select/de-select a combination of pole extensions and tips to match your configuration.

The values for the three pole extensions, the adapter, and the measurement tip are set at the factory and correspond to the hardware delivered with your system. To edit the values of these settings or add names and values for custom tip hardware or additional pole extensions, go to the Advanced Settings menu.

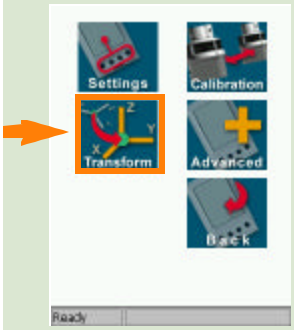
All lengths must be entered in meters. With the exception of custom tips, lengths should not be changed unless you are directed to do so by Arc Second service personnel. Any change to the Det-Det distance will affect Quick calibration accuracy.

The measurement tool calculates the 3D coordinates of each detector and performs a vector projection to the measurement tip. Any mechanical misalignment of the measurement components causes an inaccurate projection. For best results, select measurement tool components to provide the shortest convenient distance from the bottom detector to the measurement tip. As a rule of thumb, you can assume approximately 0.5 mm of "projection error" for every 0.3 m (1 ft) of projection length. For example, a 1 m (3 ft) pole generates approximately 1.5 mm (1/16") of projection error.

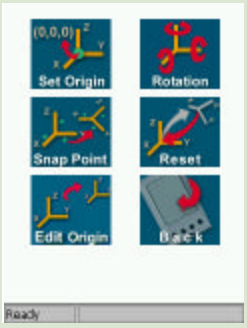
The configuration of the pole measurement tool can also be performed directly from a measurement screen by using the Pole Icons on the Status Bar. Note that the Status Bar only provides the ability to change or combine the 3 (short, medium, and long) pole sections. You should always verify correct tool configurations using the above described functions



Select Setup from the Main menu.



Select Transform.



Transform Menu

REFERENCE FRAME TRANSFORMATIONS

All Vulcan measurements are made with respect to a Cartesian (x, y, z) coordinate reference frame. A reference frame is defined by the location of its origin (x = 0, y = 0, z = 0) and the orientation of its axes.

Following Quick calibrations, the reference coordinate frame origin is defined as the optical center of Transmitter One. The Z-axis corresponds to the spin axis of Transmitter One and the X-Z plane intersects the optical center of Transmitter Two. The Y-axis is defined by right-hand-rule.

Following Resection calibrations, the reference coordinate frame is the same as the coordinate frame of the control points.

There are many times where it is useful to redefine the coordinate frame to suit specific measurement needs. Survey 3D-I provides several Transform functions for this purpose.

All transformation functions involve changing the reference coordinate frame based upon point measurements taken with the Vulcan system. When taking these target measurements follow all guidelines to maximize accuracy including:

- Hold the measurement tool vertical.
- Use Precision mode.
- Hold the measurement tool still (a bipod or other device is recommended).
- Minimize projection length and avoid using multiple pole extensions.
- Increase averaging to at least 3 seconds.
- Verify measurement data is stable prior to collecting the point.
- Use best measurement geometry

You can always reset the coordinate frame back to the original post-calibration setting by pressing Reset.

SET ORIGIN

The Set Origin function relocates the reference coordinate frame origin. It performs a direct translation of the origin to a new location selected with the measurement tool. All coordinate axes remain parallel to their original directions.

ROTATION

Rotation functions allow you to rotate a coordinate axis in either 2D or 3D. The default setting is for a 2D rotation, which allows you to pick a point either on the x-axis or y-axis. The system will use the point on either axis to rotate the reference frame about the z-axis.

If you have an auto-level transmitter, or have leveled your transmitter so that the z-axis is plumb with gravity, you will always want to do 2D rotations to prevent re-aligning the z-axis.

If you select a 3D rotation, the rotation is a two-step process that snaps the selected axis to the measured tip position by rotating about the two non-selected axes in sequence. For example, selecting **Snap X** results in a rotation about the z-axis and a rotation about the y-axis to align the new x-axis with the measured point.

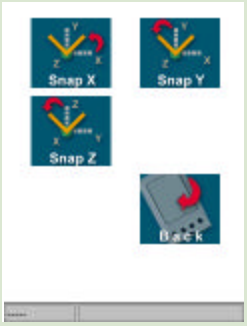
Snap X: Redefines the x-axis by rotating about the z-axis (2D) or the y and z axes (3D).

Snap Y: Redefines the y-axis by rotating about the z-axis (2D) or the x and z axes (3D).

Snap Z: Redefines the z-axis by rotating about the x and y axes (3D).

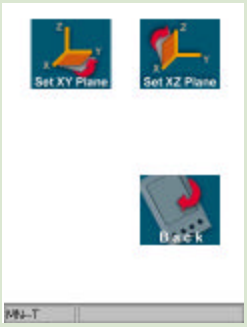
Set Plane: If a 3D Rotation is selected, you will be prompted to "Set Plane" after snapping an axis. This allows you to set a working plane through the newly established axis and either of the other two axes. The selected plane is rotated about the previously snapped axis to intersect with the current tip position of the measurement tool. For example, an XY plane can be established on the floor of a workspace by selecting an origin point on the floor (Set Origin), an axis direction (Snap X or Snap Y), and a plane (Set XY Plane).

Maximize the geometric separation of the target points used to set the origin, axes and planes while staying within good measurement geometry.



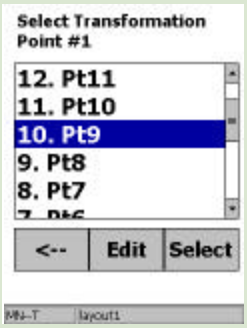
Rotation Menu

SnapX Screen

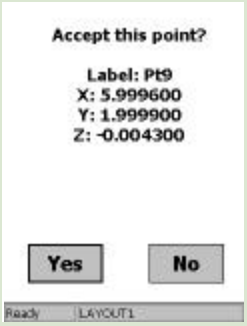


Set Plane Menu

Choose a data set.



Select a point.



Accept the selected point.

SNAP POINT

The Snap Point function allows you to transform (translate and rotate) the coordinate reference frame by using three or more control points defined in a different reference frame. After pressing Snap Point you are directed to select a data set of transformation points. Select the first transformation point, confirm the selection, then measure the target point. Repeat this process for a minimum of three targets, then press Transform. The function conducts a least-squares resection from the current to the target coordinate frame.

Details on the quality of the transformation, as well as settings for transformation pass/fail criteria, are available in Advanced Settings.

Snap Point is useful for tying two different Quick or Long Scale setups into the same coordinate frame.

- Establish at least three repeatable target locations that will be visible from both transmitters in both setups.
- Create a data set of these target locations and measure them with the measurement tool.
- Move the transmitters to the new location, recalibrate and perform a Snap Point using the target data set created from the previous setup.

The quality of the Snap Point transformation is highly dependent upon the quality of the target data. In addition to following general guidance for all transformations do the following:

- Ensure that target points are repeatable.
- Label target measurements with unique, easily identifiable names.
- Ensure that target points are in the best possible measurement geometry for both setups.
- Maximize the geometric distribution of the target points.
- Following the transformation re-measure target points to verify transformation accuracy.
- Use at least four target points.

RESET

Restores the original reference frame established during the calibration procedure.

Stored points are always measured in the current reference frame. Transformation functions do not alter previously collected data in any data set, including the active data set.

DATA COLLECTOR OPERATION

The Vulcan 3D Measurement System uses a Windows PocketPC™ palm-sized computer (PDA) as a data collector. This section introduces you to working with this device as it relates to loading new Arc Second application software, running Arc Second's application software, and transferring data to and from a PC.

FILE STRUCTURE AND COMPONENTS

To view the components of the Survey 3D-I application:

- Power-on the data collector.
- Press the "Q" action (third bottom) button on the data collector.
- Select File Explorer from the pop-up window.
- Use the stylus to click on My Documents, then select My Device.
- Select Program Files.
- Select Survey3DI. The application software and its components are listed.

You can also initiate QStart by pressing the third button on the data collector.

DATA

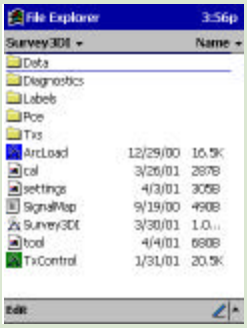
The Data folder contains all data sets that have been generated using Vulcan or loaded from a PC. Data sets are .txt files that contain ASCII comma-delimited values for x, y, z, and label. These files can be viewed or edited using Windows Notepad or Microsoft Excel.

DIAGNOSTICS

The Diagnostics folder contains diagnostic information from the previous system setup. You need this information only if it is requested by Arc Second technical representatives.

LABELS

The Labels folder contains all label sets that were created with the Survey 3D-I program or loaded from a PC. Label files are .txt files, which can be viewed or edited with Notepad or Excel.



Survey 3D-I File Structure

PCE

The Position Calculation Engine (PCE) folder contains the firmware loaded in the Vulcan processor (located in the receiver hub).

TXS

The Txs folder contains parameter files for individual transmitters. The serial numbers of the transmitters provided with your Vulcan 3D Measurement System are required for system operation and should be included in this list.

ARCLOAD

ArcLoad reloads the firmware onto the receiver hub. Use this program only if advised to do so by Arc Second technical representatives.

SURVEY3DI

This is the Survey 3D-I software application.

TXCONTROL

TxControl allows communication with the transmitters via the infrared port. Use this program only if advised to do so by Arc Second technical representatives.

SIGNALMAP

SignalMap is the reference file that determines the values displayed on the Figure of Merit Indicator on the status bar of the Survey 3D-I program.

CAL, SETTINGS, AND TOOL

These files contain various settings for your system and are modified as those settings are changed in the program.

TRANSFERRING DATA

There are two ways to transfer data between your data collector and a PC:

- Use the CompactFlash memory card, or
- Connect your data collector to your PC through Microsoft ActiveSync and using either the serial or USB cable or the infrared port.

USING THE COMPACTFLASH MEMORY CARD

Included with your Vulcan shipment is a CompactFlash memory card, a PCMCIA adapter, and a computer interface cable

(serial or USB). To use the card, your computer must have an available PCMCIA slot. If this is not possible or practical, you can use a CompactFlash memory card reader that connects to your PC via a USB or serial connection.

After you connect the CompactFlash memory card to your PC, use the following procedures to copy a data or label file:

DATA COLLECTOR TO PC

- Insert your CompactFlash memory card into the data collector through the Flash Card port on the CF Card Expansion Pack.
- Exit Survey 3D-I and use File Explorer on your PocketPC to navigate to the Data or Labels Folder in the Survey3DI directory.
- Select Copy for your desired file by pressing and holding the desired file name with the stylus until the pop-up menu appears.

Multiple files can be selected by using the control key on the PocketPC pop-up keypad.

- Use the stylus to navigate back to My Device and select Storage Card.
- Paste the file to the Storage Card by selecting Edit at the bottom left of the screen and selecting Paste from the pop-up menu.
- Remove the CompactFlash memory card and connect it to your PC.
- Use Windows Explorer to move or copy the Data or Label file to the PC. The file can be viewed or edited with Excel, Notepad, or other text editor; or translated to .dxf format with Arc Second Utilities.

PC TO DATA COLLECTOR

- Connect your Storage Card to your PC.
- Use Windows Explorer to copy the desired file(s) from your PC to your Storage Card.

For Survey 3D-I to recognize the file format, it must be in the same format as the files that come from the data collector (i.e., a .txt format with x, y, z, label on each row for Data files and a .txt format with a single label on each row for Label files).

- Insert the CompactFlash memory card into the data collector CF Card Expansion Pack.
- Reverse the method used to copy a file to your PC, Copy the desired file from the Storage Card and Paste into the desired Data or Labels folder.

USING MICROSOFT ACTIVESYNC

The Vulcan system is shipped with the packaging material for your PocketPC. This contains an AC adapter, a serial or USB cable, and a CD containing Microsoft ActiveSync. Follow the instructions provided to install Microsoft ActiveSync on your PC and to connect your PocketPC to your PC, using either the infrared port or the serial cable.

After you connect your PocketPC to your PC, use the following procedures to copy a data or label file:

DATA COLLECTOR TO PC

- Use Explore from Microsoft ActiveSync to select the desired file(s) from the Data or Labels Folders. Right click on the file name and select Copy.
- Use Windows Explorer to navigate to the desired destination directory of the file(s). Right click in the destination directory and select Paste.

PC TO DATA COLLECTOR

- Use Windows Explorer to navigate to the desired file(s). Right click on the desired file(s) and select Copy.
- Use Explore from Microsoft ActiveSync to select the desired destination directory (Data or Labels Folder). Right click in the destination directory and select Paste.

CREATING .DXF FILES

Vulcan is delivered with a PC application program, Arc Second Utilities, which can be installed and used to convert data sets (.txt format) to .dxf format for easy import into CAD software. Arc Second Utilities creates .dxf files with the points from each label on a separate CAD layer. To convert data sets to .dxf format:

- Open Arc Second Utilities on your PC.
- Select Files to Import at the top left of the dialog box.
- Navigate to the desired directory and select the desired file by double-clicking or by clicking once, then clicking on Select.
- Select Output File at the lower left of the dialog box.
- Select a destination directory and input a desired file name, then click on Select.
- Select Translate at the top right of the dialog box. Translation will take a second or two, depending on the file size. A dialog box with the message Translation Complete appears.
- Click on OK, then close Arc Second Utilities.
- To open the .dxf file with a CAD program, right click on the desired .dxf file and select Open With. Select the desired CAD program from the displayed list of available applications.

INSTALLING SURVEY 3D-I

If the data collector batteries discharge, you may need to reinstall Survey 3D-I . This can happen if the unit is not used for more than two weeks at a time and can be avoided by connecting the data collector to the AC adapter during periods of non-use.

You may also need to periodically install software upgrades provided by Arc Second.

Arc Second has provided the installation software and customized transmitter parameter and settings files on your CompactFlash Memory card. Be sure to keep the card and files intact in case you should need to reinstall your software. Should you lose your CompactFlash memory card, contact an Arc Second technical representative to have installation software and default settings sent to you.

The following details how to install your software using the CompactFlash memory card.

CHECK FLASHCARD

- Verify you have the following files located in the ArcSecond directory of the flash card:

  ArcSurveyInstallation.PPC_XXXX.cab
  Settings.asd
  Setup.exe
  Tool.asd
  V_XXX. asd
  V_XXX. asd

File extensions are not visible in PocketPC File Explorer

REMOVE OLD VERSION (IF UPGRADING)

Make sure you have backed up all data sets before performing this step.

If you are performing an upgrade, you should copy the Txs folder, settings, and tool from the data collector to a temporary location on your PC before removing the old software. After the new software is installed, copy the files back onto the data collector to ensure that parameters and settings remain unchanged.

- On data collector press Start then select Settings -> System -> Remove Programs
- Select Survey 3D-I and press Remove. Confirm the deletion.
- Start File Explorer on the data collector and select My Device/Program Files.
- Select and delete the Survey3DI folder. Confirm the deletion.

INSTALL NEW SOFTWARE

- Insert the flashcard into the data collector CF expansion pack.
- Start File Explorer
- Select My Device/Storage Card/ArcSecond.
- Select the setup program.

The application installs automatically and reassigns the left button to start the Survey 3D-I software. The installation program shipped with each system is individually customized, so all settings and tool parameters are updated for your system.

You can compare parameters and settings to the list included with your original documents. If there are any discrepancies, edit the values by following the directions outlined in “Advanced Settings” in the Survey 3D-I Reference.. If you have questions, contact an Arc Second technical representative.

SUMMARY OF BEST PRACTICES

This section summarizes the "Best Practices" notes found throughout the manual and provides a reference of the best practices for calibration, managing data, measurement tool configuration, and reference frame transformations. For more specific information, refer to the corresponding sections of the manual.

CALIBRATION

- Since Vulcan uses triangulation for measurement, it is important to have strong triangulation geometry for accurate calibrations and position measurements. To ensure good geometry, position the transmitters so there is an approximately 90° convergence angle at the center of the measurement area and ensure that all desired measurements lie within the work volume.
- Allow the transmitters to warm up for approximately five minutes before sampling target points.
- Hold the measurement tool vertical and still while measuring target points. A bipod or other device is required.
- Follow the guidelines for target measurement geometry.
- Ensure that scale distance measurement for Set Scale and control points for Resection are measured as accurately as possible. Vulcan cannot produce measurements at a higher level of accuracy than that of the input data.
- Ensure that transmitters are securely mounted to a stable surface.
- Following calibration, perform a few measurements to verify system accuracy prior to data collection. For Quick calibrations, checking a distance against a tape measure is adequate. For Resection calibration, verify the coordinate values of one or more of the calibration points used.

QUICK CALIBRATION

- Use a bipod or some other method to stabilize the optical receiver.
- Position the optical receiver vertically while collecting calibration points.
- Follow the guidelines for best sample geometry.
- Following calibration, measure a known distance to ensure scale is set accurately.

SET SCALE

- The most accurate method for measuring a distance of 10-15 meters is a good steel tape. Eliminate sag by pulling the tape tightly when measuring a distance.
- Generally, it's better to use more than one scale bar if possible. This will give the system redundant information, and will help eliminate blunders.
- When selecting a combination of scale bars to use, look at the Delta distances displayed on the Set Scale screen. When *more than one scale* bar is used, the goal is to minimize these Delta values. Typically, you should strive to see Deltas that are 1 mm or smaller.
- The scale distance should be at least ½ the baseline distance up to about fifteen meters. Scale distances longer than fifteen meters are not recommended.
- After re-measuring the scale distance, measure another known distance on the worksite to ensure scale is set accurately.

RESECTION CALIBRATION

- For optimum setup, control points should be just inside the perimeter of the worksite.
- The two points closest to the baseline should be no closer than seven meters to either transmitter.
- After calibration, re-measure the control points with Vulcan to verify setup accuracy.

MANAGING DATA

- For the most efficient data collection, prepare label sets before beginning the measurement process. Entering labels and creating label sets in the field can be time-consuming.

MEASUREMENT TOOL CONFIGURATION

- Two of the most common user errors are failure to set projection length properly and failure to re-select two detector operation before taking measurements with the measurement tool tilted. To verify that tool settings are correct, tilt the measurement tool slowly while holding the measurement tip stationary. If you observe significant (> 5 mm) measurement deviation when shifting from vertical orientation, your tool settings are incorrect.
- The measurement tool calculates the 3D coordinates of each detector and performs a vector projection to the measurement tip Any mechanical misalignment of the

measurement components causes an inaccurate projection. For best results, select measurement tool components to provide the shortest convenient distance from the bottom detector to the measurement tip. As a rule of thumb, you can assume approximately 0.5 mm of "projection error" for every 0.3 m (1 ft) of projection length. For example, a 1 m (3 ft) pole generates approximately 1.5 mm (1/16") of projection error.

Reference Frame Transformations

All transformation functions involve changing the reference coordinate frame based upon point measurements taken with the Vulcan system. When taking these target measurements follow all guidelines to maximize accuracy including:

- Hold the measurement tool vertical when possible.
- Use Precision measurement mode.
- Hold the measurement tool still (a bipod or other device is recommended).
- Minimize projection length and avoid using multiple pole extensions.
- Increase averaging to 3 seconds.
- Verify measurement data is stable prior to collecting the point.
- Use best measurement geometry

Rotation Transformations

- Maximize the geometric separation of the target points used to set the origin, axes and planes while staying within good measurement geometry.
- Use Precision measurement mode.
- Use 3D rotations with caution, as they will change the direction of the z-axis. If you want the z-axis to be plumb with gravity, always use 2D rotations.

Snap Point Transformations

The quality of the Snap Point transformation is highly dependent upon the quality of the target data. In addition to following general guidance for all transformations do the following:

- Use Precision measurement mode.
- Ensure the target points are repeatable.
- Label the target measurements with unique, easily identifiable names.

- Ensure the target points are in the best possible measurement geometry for both setups.
- Maximize the geometric distribution of the target points.
- Following the transformation re-measure target points to verify transformation accuracy.
- Use a least 4 target points.

CLEANING AND MAINTENANCE

- Keep the system free from exposure to moisture. If the system malfunctions due to exposure to moisture, turn the power off and notify qualified service personnel.
- The system may be cleaned with a damp cloth. Take care not to directly expose system components to water.
- Use only a good quality glass cleaner on a clean, soft cloth to clean all external optical components, and apply minimal pressure. A dry cloth used on the transmitter lenses or detectors on the optical receiver could scratch or damage those surfaces. Keep optical elements free from dirt and other debris so that cleaning is required as infrequently as possible.
- The spinning rotor head is precisely balanced and care should be taken to keep foreign material from sticking to it. If any material is hardened on the rotor head, see your authorized Arc Second dealer for cleaning.
- Clean all corroded battery contacts with a pencil eraser.
- If any component is damaged, disconnect it from its power supply and contact qualified service personnel.

BATTERIES

The system is powered by two types of custom, rechargeable batteries. Each battery type also comes with a custom battery charger. Please observe all warning labels on the batteries and chargers and follow the guidelines described in “Safety and System Care” in the *Introduction* to this manual.

MEASUREMENT TOOL BATTERY AND CHARGER

To remove the battery from the Measurement Tool, loosen the screw on the bottom of the tool handle and slide the battery out. Insert the battery into the SBS3002 Smart Battery Charger. Connect the Switching Mode Power Supply and power cable and plug the power cable into an outlet. The LED indicates the status of the battery as follows:

Off: No battery detected

Green Flash: Fast charging

Green Solid: Fully charged

Yellow Solid: Standby

Red Flash: Error

Power Supply: PS1024 only

The power supply accepts voltages from 100 to 240 volts AC and frequencies from 47 to 63 Hz. No recalibration is necessary. Batteries may be charged singly or in pairs. If charging one battery at a time, you may use either charging bay.

Caution: Connections other than those indicated may result in permanent damage to the unit.

TRANSMITTER BATTERY AND CHARGER

To connect the transmitter battery to its charger, align the red dots on the Lemo connectors and push them together; no twisting is necessary. Plug the charging unit into an outlet.

When connected properly, the solid red “Fast Charge” light illuminates to indicate the battery is being charged. The solid green “Float” light illuminates to indicate a fully charged battery. If neither light illuminates when the unit is plugged in, check all connections. The LED indicates the status of the battery as follows:

Off: No battery detected

Red Solid: Charging (says “Fast Charge”)

Green Solid: Fully charged (says “Float”)

DIAGNOSTICS AND TROUBLESHOOTING

DIAGNOSTIC INDICATORS

The Vulcan 3D Measurement System provides several system diagnostics that are displayed on the status bar. When one of these errors occurs, the appropriate error message is displayed and the coordinate display is blanked.

Status Bar with diagnostic codes.

MULTI-PATH (M)

Occurs when multiple pulses are detected within a single pulse window. Generally the cause of this error is a reflective surface.

To remedy this error, try to block the path between the reflective surface and the detectors on the optical receiver. (Adjusting measurement tool orientation often works.)

NOISE (N)

Occurs when false pulses are detected. This can be caused by sunlight, ambient light, or other sources. This typically occurs when working near the maximum range limits.

To clear the error, change the range setting to a shorter distance.

QUEUE OVERFLOW (O)

Occurs when too many pulses are detected. This most commonly happens when several transmitters (more than 3) are running within line-of-sight of the measurement tool.

The only solution for this is to power off the extra transmitters.

PRECISION TOLERANCE EXCEEDED (P)

This error occurs on a failure of position calculation self-check which exceeds the P tolerance setting. The main cause of this is movement of a transmitter following calibration.

TOOL TOLERANCE EXCEEDED (T)

Occurs when the measured distance between the two detectors does not match the value stored for that tool. This is typically caused by transmitter movement following calibration or by improper tool settings.

TROUBLESHOOTING

DATA COLLECTOR SCREEN REMAINS BLANK

PDA batteries are discharged and the PDA has gone into a prolonged sleep mode.

Use the AC adapter to recharge the PDA then attempt to restart. You may or may not have to reinitialize the PDA and reinstall Survey 3D-I. See “Initializing the data collector”.

MAIN BATTERY LOW WARNING

- Replace the measurement tool battery with one that is fully charged. Restart Survey 3D-I.
- If warning still appears, verify cable connections and that the data collector is fully seated in the boot. Restart Survey 3D-I.

ERROR CONNECTING TO PCE

- Verify cable connections and that the data collector is fully seated in the boot.
- Cycle power to the receiver hub and reset the PDA (reset button is on bottom side of PDA). Restart Survey 3D-I.

DATA COLLECTOR SCREEN BACKLIGHT FLASHING ON AND OFF

PDA battery is below ~30%. Continue to operate the Vulcan 3D Measurement System and when the charge status exceeds ~30% the backlight screen will remain on. For users with 2 serial ports, switch to the port on the PCE hub if PDA is having problems.

RECEIVER HUB SWITCH LED IS FLASHING

This LED flashes to indicate a low battery situation or any fault that halts the Position Calculation Engine (PCE).

The PCE is the computer board located within the receiver hub.

- Replace the measurement tool battery with one that is fully charged.
- Cycle power to the receiver hub and reset the PDA (reset button is on bottom side of PDA). Restart Survey 3D-I.

INDICATOR DOTS DO NOT APPEAR

- Verify transmitters are powered on.

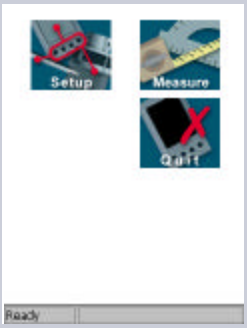
- Check/adjust Range setting. (See “Setting Your Range”)
- Check Transmitter Settings to verify the proper transmitters are selected.
- Cycle power to the receiver hub and reset the PDA (reset button is on bottom side of PDA). Restart Survey 3D-I.

LARGE VARIATION IN MEASUREMENT WHEN POLE IS TILTED

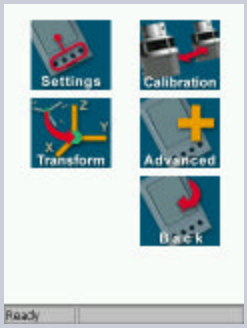
Check Tool settings. (See “Measurement Tool Configuration”).

REPEATED CALIBRATION FAILURE

- Ensure you are following recommended geometry and target spacing as outlined in either “Calibrating the System” or “Advanced Calibration”.
- If performing a Resection calibration, recheck the accuracy of your control points and that they were correctly entered into Survey 3D-I.



Main Menu



Setup Menu

SETUP

Use the **Setup** menu to access the setup functions: Range, Settings, Calibration, Transform, and Advanced.

SETTINGS

The **Settings** screen is used to change or enter new transmitters and to specify measurement tool settings, units of measure, and coordinate frame convention.

TRANSMITTER

Each transmitter, identified by serial number, has individual, factory-set parameter values. If you receive a replacement transmitter, upgrade to a newer version of Survey 3D-I, or use a set of transmitters other than those supplied with the original system, you need to select the transmitter being used, so that correct parameter values are applied by Vulcan.

To select a different transmitter, use the drop down list for Tx 1 or Tx 2 and highlight the desired transmitter serial number. To create a new transmitter, select Tx 1 or Tx 2 and press New at the bottom of the screen. Enter a new transmitter serial number and corresponding factory parameter settings. When all parameters are entered, press Store.

Transmitter parameter values can only be edited in the Advanced Settings menu and should not be changed unless you are directed to do so by Arc Second service personnel.

Use the Settings screen to change transmitters and add new transmitters to the system.

TOOL

This screen supports both the pole and the wand measurement tools. To switch from wand to pole or vice-versa, use the Advanced Settings menu.

The Tool settings screen allows you to configure the pole or wand measurement tool and measure using only the top detector (farthest from the measurement tip) or bottom detector (closest to measurement tip), which provides flexibility when it is difficult to acquire a signal from both transmitters to both receivers. To use only a single detector, select the proper detector from the screen by checking or unchecking the appropriate boxes on the Tool screen. (See "Measurement Tool Configuration" in *Advanced Usage* for more information on using this screen.)

A shortcut to this feature is available by pressing the third button on the data collector at any time while running the Survey 3D-I software.

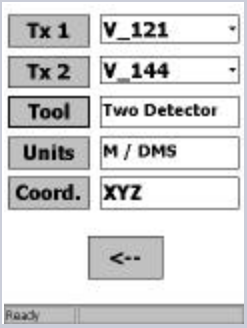
UNITS

The **Units** function allows you to change units of measure used by Vulcan for distance and angular measurement. The default is METERS and DEG MIN.

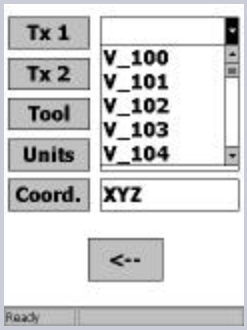
COORD

The **Coord** function allows you to change the naming convention for reference frame axes. The default setting is XYZ. NEZ is a convention commonly used by surveyors. If you choose the NEZ option, the axes change according to these rules: E=X, Y=N, and Z=Z.

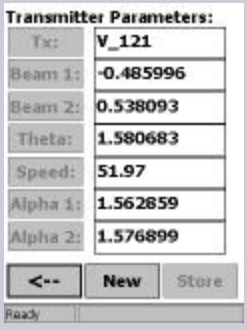
NEZ collected points are stored in Survey 3D-I data sets using the following convention: E, N, Z, Label.



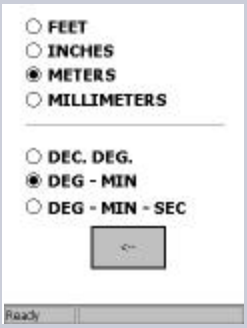
Settings Screen



Select a transmitter.

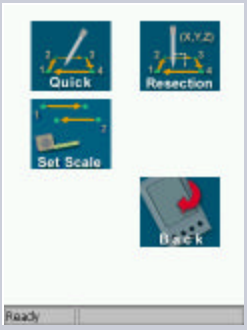


Enter transmitter parameters.



Units Screen

Coord Screen



Calibration Menu

CALIBRATION

Calibration is the process of determining the location of each transmitter on the measurement site. This is accomplished by collecting a series of angular measurements on the site and running the data through calibration algorithms to determine the position and orientation of each of the transmitters. Reported results describing the quality of the solution of the algorithm (metrics) can be viewed from the Advanced Settings menu (see "Advanced Settings" for details). From the Advanced Settings menu, you can also set Pass/Fail criteria for some of the metrics to help ensure the desired level of performance from the system.

The calibration process also establishes the default coordinate reference frame. After calibration, the reference frame remains intact unless the transmitters are moved. If the transmitters have not been moved since the previous calibration, the system does not need to be recalibrated, even if the power has been cycled on the transmitters or the measurement tool. Recalibrate the system whenever the transmitters are moved.

The **Calibration** menu provides access to three calibration methods: Quick, Long Scale, and Resection. The Quick calibration method is described in "Calibrating the System" in *Getting Started*. The Long Scale and Resection methods are described in "Advanced Calibration" in *Advanced Usage*.

TRANSFORM

Transform functions are used to change the location and orientation of the reference frame that Vulcan uses for measurements. The calibration process establishes the initial reference frame for the system. See "Reference Frame Transformations" in *Advanced Usage* for more information on these functions.

SET ORIGIN

The **Set Origin** function moves the origin from its original location to a new point selected with the measurement tool. The origin is "translated" from the first to second location while keeping the axes parallel to their original directions.

ROTATION

The **Rotation** functions rotate the reference frame. Snapping a new axis results in a rotation about the other two axes.

Snap X redefines the x axis by rotating about the y and z axes.

Snap Y redefines the y axis by rotating about the x and z axes.

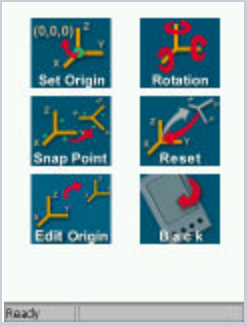
Snap Z redefines the z axis by rotating about the x and y axes.

SNAP POINT

The **Snap Point** function is used to transform (translate and rotate) the reference frame by using three or more reference points defined in another reference frame.

RESET

The **Reset** function restores the original reference frame established during the calibration process.



Transform Menu

Advanced Settings Menu

Wand Tool Advanced Settings

Pole Tool Advanced Settings

ADVANCED SETTINGS

The **Advanced Settings** menu allows you to customize the functionality and performance of the Vulcan system to more specifically meet your application requirements. It also provides an interface for viewing and editing system component default parameters. Please exercise caution when editing default parameters, as they affect system performance. Descriptions of the System Properties that can be accessed through the Advanced Setting menu follow.

All Advanced Settings use metric distance values and angle values in radians; be sure the proper conversion is performed before editing these values.

TOOL

Advanced Tool settings allows you to configure Tool Style, set Detectors Used, and configure the tool accessories attached between the bottom detector and the measurement tip.

Tool Style indicates which type of measurement tool is being used. To change the style, highlight Tool Style, press Edit, and press Switch type. Press the back arrow to return to the tool settings screen.

The Wand configuration supports only one length, while the Pole configuration allows you to edit several pole extensions and as many as five custom measurement tips.

Detectors Used specifies which optical detectors to use for position measurement. “Both”, the standard configuration for Vulcan, provides the most flexibility in measurement, as the measurement tool does not need to be leveled over the desired point. Using only the top or the bottom detector allows measurement when line-of-sight from either of the detectors to one or both of the transmitters is blocked. The single detector mode (top or bottom) requires that the measurement tool be leveled over the desired point. To change detectors used, highlight Detectors Used, press Edit, and use the check boxes to select Top Detector, Bottom Detector, or both.

Bottom Detector to Tip Distance is the projected length from the lower optical detector to the measurement tip. This distance must be correctly set to achieve accurate position measurement. All Detector to Tip values are set at the factory and should not be edited without consulting an Arc Second representative. For the Wand configuration, a single value sets the Bottom Detector to Tip Distance. For the Pole configuration, Bottom Detector to Tip Distance is set by selecting the proper

combination of measurement tip accessories. To change the value, highlight Bottom Detector to Tip Distance, press Edit, then press Bottom Det-Tip. For the Wand configuration, use the keypad to change the distance. For the Pole configuration, use the check boxes to select and deselect the components corresponding to your pole measurement tool assembly.

Detector to Detector Distance is a factory setting and should not be edited without direction from an Arc Second representative. This distance is the length between the two detectors on the measurement tool, which is critical for setting the proper reference coordinate frame scale following a Quick calibration. To change the value, highlight Detector to Detector Distance, press Edit, and enter a new value with the keypad.

The Pole configuration offers several more options for editing than does the Wand configuration.

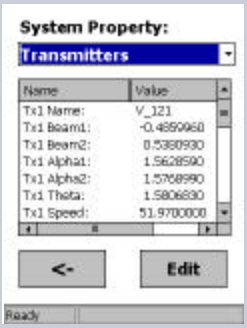
The Short, Medium, and Long values refer to the calibrated lengths of each of the fiberglass pole extension sections that come with the pole measurement tool. If these sections are replaced, the new length of each section must be measured and entered. To change Short, Medium, or Long values, highlight the corresponding choice, press Edit, and enter a new value with the keypad.

The Tip and Foot values refer to the calibrated lengths of the measurement tips that come with the pole measurement tool. Because the foot screws over the top of the measurement tip, Foot can be selected only if Tip is selected. The length value for Foot does not represent its actual length, but rather the length added to the measurement tip. If these parts are replaced, the new length of each section must be measured and entered. To change Tip or Foot values, highlight the corresponding choice, press Edit, and enter a new value with the keypad.

The Adapter value refers to the distance between the optical center of the bottom detector and the mating surface for the measurement tip or pole extensions. This value should not be edited without consulting with an Arc Second representative. To change the value, highlight Adapter, press Edit, and enter a new value with the keypad.

Custom measurement tips 1 through 5 allow advanced users to create customized measurement tips and store the names and length of each in the Survey 3D-I application. If Custom measurement tips are created, an Arc Second representative should be contacted to ensure proper implementation and calibration of each measurement tip. To change a Custom measurement tip value, highlight the desired Custom

measurement tip Length choice, select edit, and enter a new value with the keypad. To change a Custom measurement tip Name, highlight the Custom measurement tip Name choice, press Edit, and use the keypad to enter a name.



Transmitters Screen

Tolerance Screen

TRANSMITTERS

The **Transmitters** screen allows you to view or modify factory-set parameters, positions, and orientations of the transmitters. Parameters, position, and orientation of transmitter 1 (Tx 1) are listed first, followed by those of transmitter 2 (Tx 2).

Name cannot be edited from this screen. To select a different transmitter or create a new transmitter, use the Settings screen.

Beam1, Beam 2, Theta, and Speed are parameters set in the factory for each Vulcan transmitter. Change these values only after consulting with an Arc Second representative. To change Beam1, Beam 2, Theta, or Speed values, highlight the parameter to be changed, press Edit, and enter a new value with the keypad.

Changing the transmitter parameters Beam1, Beam2, Theta, or Speed will affect system performance. Contact an Arc Second representative before modifying these values.

X, Y, and Z are the x, y, and z positions of the optical center of each transmitter. RX, RY, and RZ are the rotations of each of the transmitters about the original reference frame established during the calibration process. These values may be entered or modified for some specific installations and applications of the Vulcan 3D Measurement System or to transfer calibration information from one measurement tool to another. To change X, Y, Z, RX, RY, or RZ values, highlight the parameter to be changed, press Edit, and enter a new value with the keypad.

TOLERANCE

The **Tolerance** screen allows you to adjust measurement tolerances to suit your particular application requirements.

Position Calculation Tolerance is an internal check which verifies that the calculated position is within a specified tolerance. The system uses the strobe pulses and two lasers from each transmitter to calculate position; however, it only needs two lasers from 1 tx and one laser from the other to make the calculation. The redundant information is processed in the background, and a flag appears if the tolerance is exceeded. The flag is shown on any measurement screen and is identified by a “P” on the lower left

corner of the display and a blanking of the coordinate display. (See "Diagnostics and Troubleshooting" in *Advanced Usage*.)

The main cause of an exceeded tolerance is fine movement of a transmitter. The factory setting for Position Calculation Tolerance is 0.010 meter. Depending on the application, this value may need to be changed. For tighter or looser measurement control, the "P" tolerance setting may be reduced or increased, respectively. To change the value, highlight Position Calculation Tolerance, press Edit, and enter a new value with the keypad.

Slight transmitter movement will be detected by Vulcan and will generate a "P" tolerance fault.

Tool Tolerance is an internal check which verifies that the measured distance between the two detectors on the optical receiver is within a certain tolerance of the Detector to Detector Distance setting. If Tool Tolerance is exceeded, a flag appears. The flag is shown on any measurement screen and is identified by a "T" on the lower left corner of the display and a blanking of the coordinate display (see "Diagnostics and Troubleshooting" in *Advanced Usage*). The factory setting for Tool Tolerance is 0.010 meter. If the application requires tighter or looser measurement control, this value can be adjusted accordingly. The main causes for Tool Tolerance to be exceeded are transmitter movement and detector offset (for example, tilting the detector too far toward or away from a transmitter; see "Summary of Best Practices" in *Advanced Usage*). To change the value, highlight Tool Tolerance, press Edit, and enter a new value with the keypad.

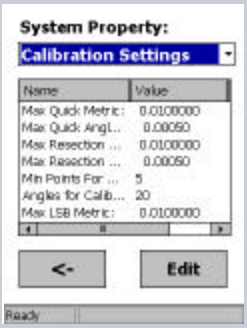
Tolerance checks are detector and NOT measurement tip error checks. For example, an incorrect projection length will yield significant measurement error, but will NOT trigger a tolerance fault.

Averaging Sample indicates the amount of averaging the system performs during measurement. The default value, five, results in a position latency of approximately one second. To change the value, highlight Averaging Sample, press Edit, and enter a new value with the keypad.

CALIBRATION SETTINGS

The **Calibration Settings** screen allows you to set limits and constraints on the input of calibration measurements and the output of the calibration solution.

Max Quick Metric is the RMS of the closure of the calibration measurements for the measurement of each scale bar. The



Calibration Settings Menu

RMS is calculated from the differences in the "actual" scale bar lengths and the "adjusted" scale bar lengths after calibration math has computed the solution. The factory setting is 0.010 meter, which can be lowered to ensure a more accurate calibration. To change the value, highlight Max Quick Metric, press Edit, and enter a new value with the keypad.

Scale bar length for Quick calibration is the detector to detector distance.

Max Quick Angle STD is the standard deviation of the angles measured from each of the transmitters to each of the detectors during Quick calibration measurements. The factory-set value is 0.0005 radians. If you use a bipod or other accessory to hold the measurement tool steady during measurement, Max Quick Angle STD can be lowered accordingly. The lowest value to achieve acceptable results is approximately 0.0001 radians. To change the value, highlight Max Quick Angle STD, press Edit, and enter a new value with the keypad.

Max Resection Metric is the RMS of the closure of the calibration measurements during Resection calibration. The RMS is calculated from the differences in the "actual" coordinates used for the Resection and the "adjusted" coordinates after the Least Squares Resection algorithm has computed the solution. The factory setting, 0.010 m, can be changed if necessary. This value is extremely dependent on the accuracy of the coordinates used for the Resection and on the ability of the user to level the measurement tool over the Resection points. To change the value, highlight Max Resection Metric, press Edit, and enter a new value with the keypad.

Max Resection Angle STD is similar to the Max Quick Angle STD but is used only during Resection calibration. The factory setting is 0.0005 radians. To change the value, highlight Max Resection Angle STD, press Edit, and enter a new value with the keypad.

Min Points for Quick sets the minimum number of target points that must be collected for Quick and Long Scale calibration. The factory setting is five points. More measurements can be taken for calibration and may give a better "fit" of the workspace into the solution. To change the value, highlight Min Points for Quick, press Edit, and enter a new value with the keypad.

You can not perform a calibration until the minimum number of points has been collected.

Angles for Calibration sets the number of averaged angle readings used to determine the final averaged value for a cali-

bration measurement. The factory setting is 20 readings, which presumes you are holding the measurement tool during the measurement process. If you have a stable mount for the measurement tool, this value can be increased accordingly. Arc Second has found diminishing results beyond about 50 readings. To change the value, highlight Angles for Calibration, press Edit, and enter a new value with the keypad.

Max LSB Metric is the RMS of the closure of the calibration measurements for the measurement of each scale bar. The RMS is calculated from the differences in the "actual" scale bar length and the "adjusted" scale bar length after calibration math has computed the solution. The factory setting is 0.010 meter, which can be lowered to ensure a more accurate calibration. To change the value, highlight Max LSB Metric, press Edit, and enter a new value with the keypad.

RESULTS

Results allows you to view the output of calibration algorithms.

Quick Metric is the result of a Quick calibration and is the RMS of the closure of the calibration measurements for the measurement of each scale bar. (Note: scale bar length is the detector to detector distance.) The RMS is calculated from the differences in the "actual" scale bar lengths and the "adjusted" scale bar lengths after calibration math has computed the solution.

Resection Metric 1 is the result of a Resection calibration and is a measure of the quality of the solution for transmitter 1. The Resection Metric is the RMS average of the difference between the "actual" coordinates of the calibration points and the coordinates calculated from each transmitter position using the original raw data that was collected during the calibration. The transmitter position is what is solved during the Least-Squares Resection calibration process. The Resection Metric reflects not only measurement errors during the calibration process, but also any errors in the coordinate values of the "actual" coordinates of the calibration points.

Resection Metric 2 is the same as Resection Metric 1 but for the second transmitter.

Snap Transformation Metric is the result of the Snap Point function found in the Setup:Transform menu. The Snap Transformation Metric represents the RMS error associated with the "corresponding" points used to "snap" two reference frames. The Snap Point Transformation uses a Least-Squares algorithm to "best fit" the two coordinate systems, and the RMS error is a by product of this algorithm.

Results Menu

Transformation Settings Menu

Navigation Screen

Version Screen

Long Scale Bar Metric is similar to the Quick Metric, but is associated with measuring the endpoints of the input scale bar instead of the two detectors at each end of the measurement tool.

TRANSFORMATION SETTINGS

The **Transformation Settings** are system administrator functions that force you to follow certain practices and achieve certain levels when performing coordinate transformations with the Vulcan system. By nature, coordinate transformations are sensitive to geometry and accuracy, and you should apply knowledge of these issues when performing these operations. The performance metric of the previously performed transformation can be found in the Results area of the Advanced Setting menu.

Minimum Points for Snap sets the minimum number of points that must be measured before the transformation can be performed. The minimum that Vulcan requires to generate a solution is three points; however, as many points as desired can be used over this amount. A Least-Squares operation is performed on all the data.

Max Snap Metric sets the maximum allowable metric calculated from a transformation. For example, if a specific application requires certain levels of performance from the system, set this value to a number that corresponds to the application's measurement tolerance requirements. The factory-set value is 0.010 m. For tighter or looser transformation control, this value can be adjusted accordingly. Coordinate transformations are extremely sensitive not only to the geometry of the "corresponding" points but also to the accuracy of the original points and the measured accuracy of those points during the transformation process.

NAVIGATION

The **Navigation** screen allows you to customize the operation of the navigation, or "GO TO" features of Vulcan.

Zoom-In Range indicates the distance value that triggers the zoom-in screen during "GO TO". The default value is 0.25 m. You may want to change this value if you are navigating to a group of points with less than 0.25 m spacing or if you want to zoom in at a distance farther from the target point.

Beep Range indicates the distance value that triggers the "on target" system beep. The factory-set value is 0.003 m.

VERSION

The **Version** screen allows you to determine the hardware and software versions included with your Vulcan 3D Measurement System.

MEASURE

The **Measure** menu is used to access functions for measuring point coordinates; for calculating distances, angles, and areas; and for storing and retrieving data and label sets.

XYZ(NEZ)

The **XYZ(NEZ)** function allows you to measure the 3D coordinates of any point you touch with the measurement tip. You can save the points to an open data set with the Save function or by pressing the trigger on the measurement tool.

CALCULATE

The **Calculate** menu is used to access the calculation functions Distance, Angle, and Area.

DISTANCE

The **Distance** function allows you to measure the linear distance between two points. To activate this function, go to your start point and press Start. As you move around the work area, the display shows three distances:

- XY is the distance between the two points projected onto the X-Y plane.
- XYZ is the distance between the two points.
- Z is the Z-direction distance of the second point from the first point

To freeze the measurements on the screen, press Pause. To reactivate Distance readings, press Run.

ANGLE

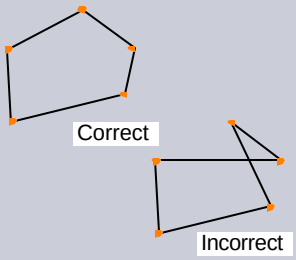
The **Angle** function allows you to measure both Azimuth (horizontal) and Elevation (vertical) angles. You can measure an Elevation angle from any Start point. The angle is measured with respect to a plane parallel to the X-Y plane that also contains the Start point.

Vulcan uses the X-Y plane as the horizontal reference for this function.

Distance Screen

Angle Screen

Area Screen



Measure points in a clockwise or counter-clockwise direction.

To measure an Azimuth angle, however, you need to specify a bearing (direction) from which to measure the angle. Specify a bearing using a Start and an End point.

To measure angles, go to the Angle function. Press Start to begin measuring the Elevation angle from that point immediately. The Elevation angle is also displayed as a % Grade. To measure an Azimuth angle, press End at a point to define a bearing for the Azimuth. All Azimuth angles are measured from the bearing direction, with the positive angle direction being counter-clockwise. You can freeze the screen at any time by pressing Pause. To reactivate Angle measurements, press Run.

AREA

The **Area** function allows measurement of any area defined by three or more points. As you select points around the perimeter of an area, the system display the area's calculated size. You can proceed in either a clockwise or counter-clockwise direction, but all points on the perimeter must be taken in geometric sequence.

LABELS

The **Labels** function allows you to create, delete, and view labels files. See "Using Labels" in *Getting Started* for more information.

DATA

The **Data** function allows you to create, delete, and view data sets. See "Managing Data" in *Getting Started* for more information.

QUIT

You can exit the program at any time by selecting Quit. Remember to power-off all system components and recharge the batteries after each measurement session.

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