

Establishing Control and Site Calibration for a Construction Site

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Why Do We Need Control and Site Calibrations for Construction Sites?



The Need for Control

- Everything that is constructed is related to a fixed common reference
- Ensures all construction on project "fits" together
- Avoids costly mistakes



Agenda

- Site reconnaissance

 Control point availability
 GNSS base station location

 Performing the calibration
- Office Calibration



Precision GNSS operations

Two components



Base Station Set up over a fixed known point Connected by radio link or via Internet



Rover Moves about the jobsite



Control Point Availability

- Control points are measured to "calibrate" the site for GNSS systems
- Do control points exist on site?
 - Check the site plans for control point lists and locations
 - You need a minimum of three points, but five or more are recommended
- For more information, contact a land surveyor or engineering firm

Google Earth

 $^{\bigcirc}$

Lat, Long, Ht

Import alignment

or

site design

Trimble.

Name: Base Position 1

Google Earth - Edit Placemark

Latitude: 22° 3'22.77"S

Longitude: 118°43'6.47"E

Identify potential black spots

Proposed Base positions

 Δ Base Position 1



Eye alt 564 m 🜔

nagery Date: 9/30/2006 🕗 2006

Control Points

- No control points = no control of position
- If there is no control established on site
 - Survey crews need to place physical control reference points throughout site
 - Perform survey of control points
 - Post process in Business Center HCE
 - Levels need to be run through all control points to get accurate vertical positioning
 - Master list of control points produced for site (csv file with P,N,E,Z,D)

Control Points

If Control does exist:

- Are there enough control points throughout the site?
- Are the control points accessible?
- Is the network of control points in a good geometry?
- Check them!





Bad Control Point Configuration





Optimal Control Point Configuration





- Three points will work, but only yield three baselines
- Geometry could be weak
- Should encompass the entire site





- Four points or more is better, yields six baselines
- Forth point gives an independent height check
- Geometry is strong





- The perfect control point location.
 Seven points, 18 baselines
- Points encompass the site and are balanced around the site





Control point network geometry is key

- **a** = Poor network geometry
 - = Ideal network geometry





- Enclose the project area with control
- More control points and good network geometry can improve site calibration results and identify problems early



Corridor Control Point Network

- Control points should be both sides of the alignment
- Should include horizontal and vertical extremities of the site
- At least one control point per 500m to be included in a calibration



Corridor Based Network





Base Station Location Considerations

Obstructions

- Setup GNSS base station antenna with 360° view of the sky
- If limited try to set up with clear visibility to the south
 - GPS 55° latitude limit
 - GLONASS 65° latitude limit
- Avoid sources of multipath
 - Chain link fence
 - Trees



 Flat, reflective surfaces – metal roofs, glass windows, water



Base Station Location Considerations

Setup GPS base radio link for maximum broadcast range

- Elevate the radio antenna to increase range
- Correct antenna (high gain and low gain)
- Avoid sources of radio frequency interference such as microwave or power lines



- Introduction and explanation
- Requirements

What is a site calibration?

 Defines the relationship between GNSS coordinates and local northing, easting, and elevation

Why is a site calibration required?

- Allows multiple GNSS based rover systems to work in your local site coordinate system
- What is needed for site calibration?
 - Onsite control based on local coordinates



- The calibration locally adjusts the
 - Projection
 - Includes shift grids, projection grids, datum grid
 - Includes Azimuth orientation (such as north or south)
 - Datum
- Site calibration is comprised of two parts
 - Horizontal adjustment
 - Rotate, translate and scale
 - Vertical adjustment
 - Block shift and tilted plane
 - Geoid



Measuring a site calibration will assume

- Projection Transverse Mercator
- Datum WGS84

Horizontal Rotation

- Rotation about project centroid
- Two control points





Horizontal Translation

- Points shifted X and Y
 - Same amount and direction
- One control point



Horizontal Scale

- Ratio
 - GNSS to Local Coordinates
- Two Control Points



Trimbl

Residuals

- Best effort translation between pairs (control and WGS-84)
- SCS900 has a tolerance for calibration
 - Value should be 50% of acceptable project tolerance
 - Tolerance used to test calibration result worst residual





Single Point Site Calibration Requirements

Requires a single, 3D control point – known or 'arbitrary'

- Single point defines coordinate system orientation
- Used when control does not exist
- Recommended for initial site topos and for quick stockpile or volume topos
- Recommend measuring control points to tie to design reference frame later
- Not recommend on long linear projects



= GNSS observation

Multi-point Site Calibration Requirements

- Minimum of three (3D) control points
 - Recommend 5+ control points with good geometry for better results
- Combination of horizontal and vertical points minimums
 - 3 horizontal control points and three vertical control points
 - or
 - 1 vertical + 3 horizontal + Geoid model
- Used when control exists and references a design frame





Tilted Plane

- Models the effect of the local geoid *local* variations in gravity over the site
- Minimizes height residuals on control points after block shift
- Configurable in SCS900 Site Controller Software
 - SCS900 has a minimum of three points, default is five
 - With only three points there is no check and it will zero all residuals to create the tilted plane
- Occurs after two points in access to eliminate height residuals after block shift
- SCS900 and access will only agree when the tilted plane has been applied in both

Geoids

Trimble GeoData folder in SCS900

- Geoid and projections need to be installed on controller either manually or via Business Center - HCE
- Geoids selected when creating site
- Store multiple Geoids in Trimble Geodata folder

Select Coordinate System
Coordinate system:
United Kingdom 🔹
Zone:
OS National Grid (OSTN02)
Geoid:
OSGM02.GGF
Cancel Accept



Why Should I Use a Geoid model?

- Geoids are always good practice
- Geoids will allow you to go outside the project calibration
- Geoids allow for fewer vertical control points
- Allows for more definable vertical component
- Provides better detection of errors in control
- Recommended on long linear projects

Geoids

A geoid height is the separation between the ellipsoid and the geoid at any location on the earth's surface

Trimble D.WEN





Geoids / Ellipsoids / Ground

Model of the Earth



Shift Grids

SHIFT GRID FILES

A standard projection is used to get grid coordinates, then the shift grids are applied to get the correct national coordinates. One .sgf file contains northing and easting shifts

PROJECTION GRID FILES

A standard projection is used to get grid coordinates, then the shift grids are applied to get the correct national coordinates. One .pgf file contains northing and another .pgf file contains easting shifts

DATUM GRID FILES

The shift is applied before the projection. One .dgf file contains the datum shift

Improving calibration results

- Continue to calibrate on additional control points
- Change tolerance
- Edit calibration components after measuring all control points for the calibration by switching on/ off Hz or VT components
- Careful, it is extremely risky to remove one component of a point unless horizontal and vertical components of control were established under separate processes



Site Calibration and Coordinate System

- When using a published coordinate system you can adjust it to suit local conditions by doing a site calibration on top
- Especially good to reduce elevation errors

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Typical Base Station Setups











Setting Up The Base Station



6	meedon type.	Divergorn		
Blu	etooth device:	SPS985, 52064824	8	
Co	Info		5	
Nu	m Base name: SPS	985 Base		
Nu	m Base latitude: 40 Base longitude:	0° 17' 43.75816" N 104° 59' 52 76743" W		
Ra	di Base height: 486	58.451 usft		
Ba	se Base radio: 3: 4 Antenna vertical	69.5000 height: 4.000 usft		
Ba	se Antenna height(/	APC): 4.474 usft		
An	te	ок		
6	rrécoons.	CMRX		
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Setting Up The Rover













Moving the GNSS Base Station

- Before calibration no problem
- After calibration location requirement
 - Must be moved to control point
 - Same rules for calibration obtained under VRS
- SCS900 allows one base move during site calibration

Site Calibration					
Use 'Add Point' to select a control point to start the calibration.					
Add Point	Settings	Move Base	Report		
Point Name	H Residuals	V Residuals			



Move Base

Site Calibration	
Use 'Add Point' to select a nt to start the calibration.	
Add Point Setting Base Report	
Point Name H Residual	



Extending Site Calibration



Conclusion

- Good base station location for good observables
- Adequate number of control points, five or more
- Good geometry among control points



The Less Energetic Way to Calibrate

OFFICE CALIBRATION

- ASCII file of site coordinates N,E,EI
- ASCII file of GPS Lat, Long, Ht
- Same principle as walking on site
- FDM Business Center HCE

8022 Pine Lands ctrl - Notepad	8022 Pine Lands lats longs - Notepad
<u>File Edit Format View Help</u>	File Edit Format View Help
851,5055.805,1111.330,14.561, 852,5128.856,1112.862,14.850, 865,5634.124,1474.209,13.214, 868,5367.543,1541.422,13.860, 873,5181.132,1407.680,14.676, 874,5147.349,1404.189,14.258, 11200,5574.082,1147.071,13.678,	<pre>851gps,-27.291456850,152.961406122,53.640, 852gps,-27.291443286,152.962144108,53.934, 865gps,-27.288183667,152.967248961,52.229, 868gps,-27.287576408,152.964556294,52.864, 873gps,-27.288782789,152.962673053,53.717, 874gps,-27.288814225,152.962331756,53.304, 11200gps,-27.291135833,152.966641519,52.699,</pre>

Correct format in the project settings

📀 Project Settings			×
General Information	- Coordinates		
🝋 Coordinate System	Display order: Easting, Northing, Elevation		
🧮 Units	Relative:	@	
Coordinates	Expand horizontal standard errors:	No	
Angular	- Formatting		
Azimuth			
Vertical Angle	- Decimal precision		
Temperature	Latitude / Longitude:	0.12345	
GPS Time	Coordinates:	0.123	
Chainage	Elevation:	0.123	
Area	Show trailing zeros:	Yes	
i View	Show trailing decimal:	No	
Computations			
Baseline Processing	Latitude / longitude		
RTX Post-Processing	Format:	Decimal degrees	
Network Adjustment	Label latitude / longitude:	Yes	
Eeature Code Processing	Show zero minutes:	Yes	
Abbreviations	Show zero seconds:	Yes	
	Format : The format used to display the latitude / longitude value.		
			OK Cancel

Import both point files

Point names should be similar NOT the same

Start Page Plan View ∆868gps ∆865gps ∆874gps^{∆873}gps ∆11200gps

<u>∧</u>852gps

- Calibration completed and in Project
- Export out to SCS900 using Field Data Module
- Automatically creates the DC file
- No need to walk to all control points!
- BUT CHECK POINT BEFORE USING





SITE CALIBRATION DEMO



QUESTIONS?