Trimble DIMENSIONS 2014

Establishing Control and Site Calibration for a Construction Site

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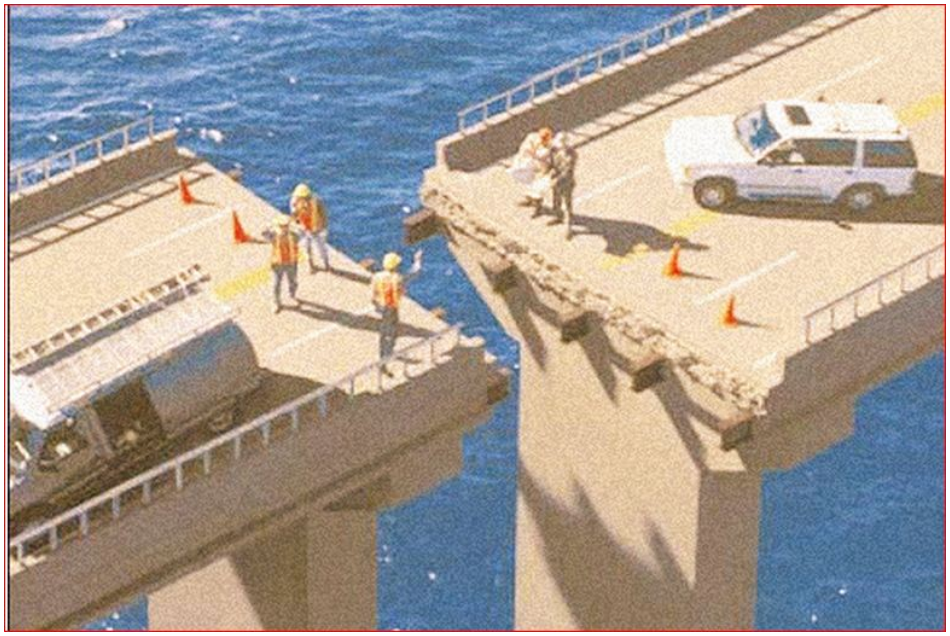
HCC-6344

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

Connected by radio link or via Internet

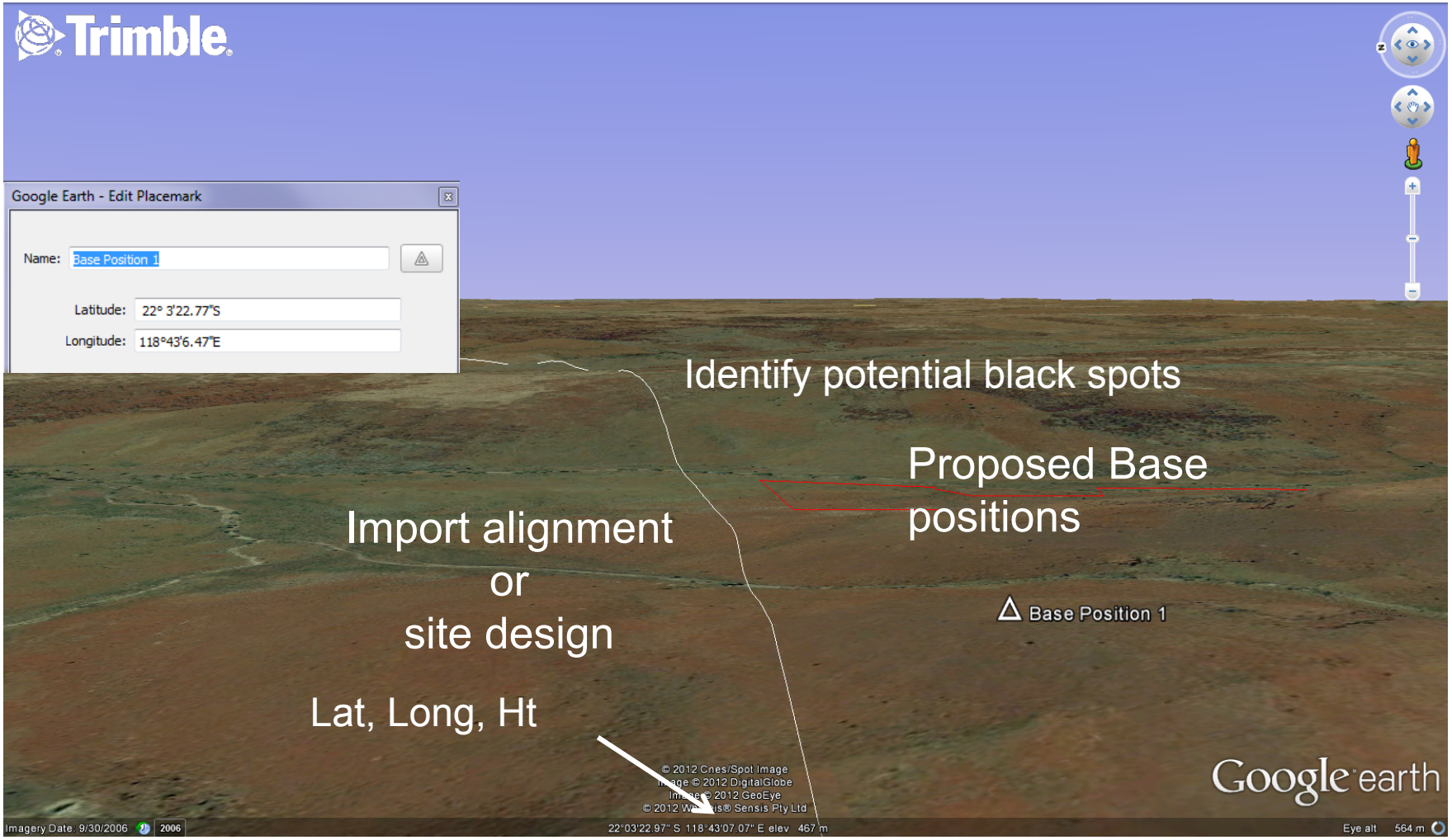
Base Station
Set up over a fixed known point

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



Control Points

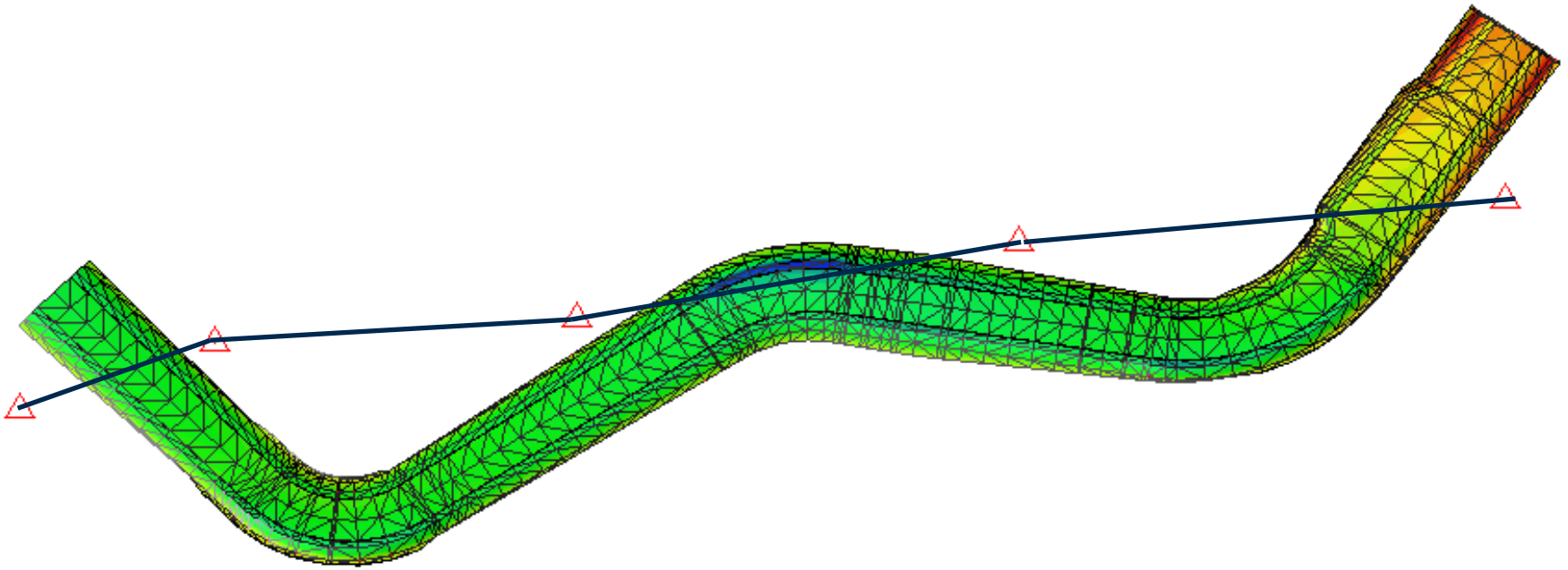
- No control points = no control of position
- If there is no control established on site
  - Survey crews need to place physical control reference points throughout site
  - Perform survey of control points
  - Post process in Business Center – HCE
  - Levels need to be run through all control points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

Control Points

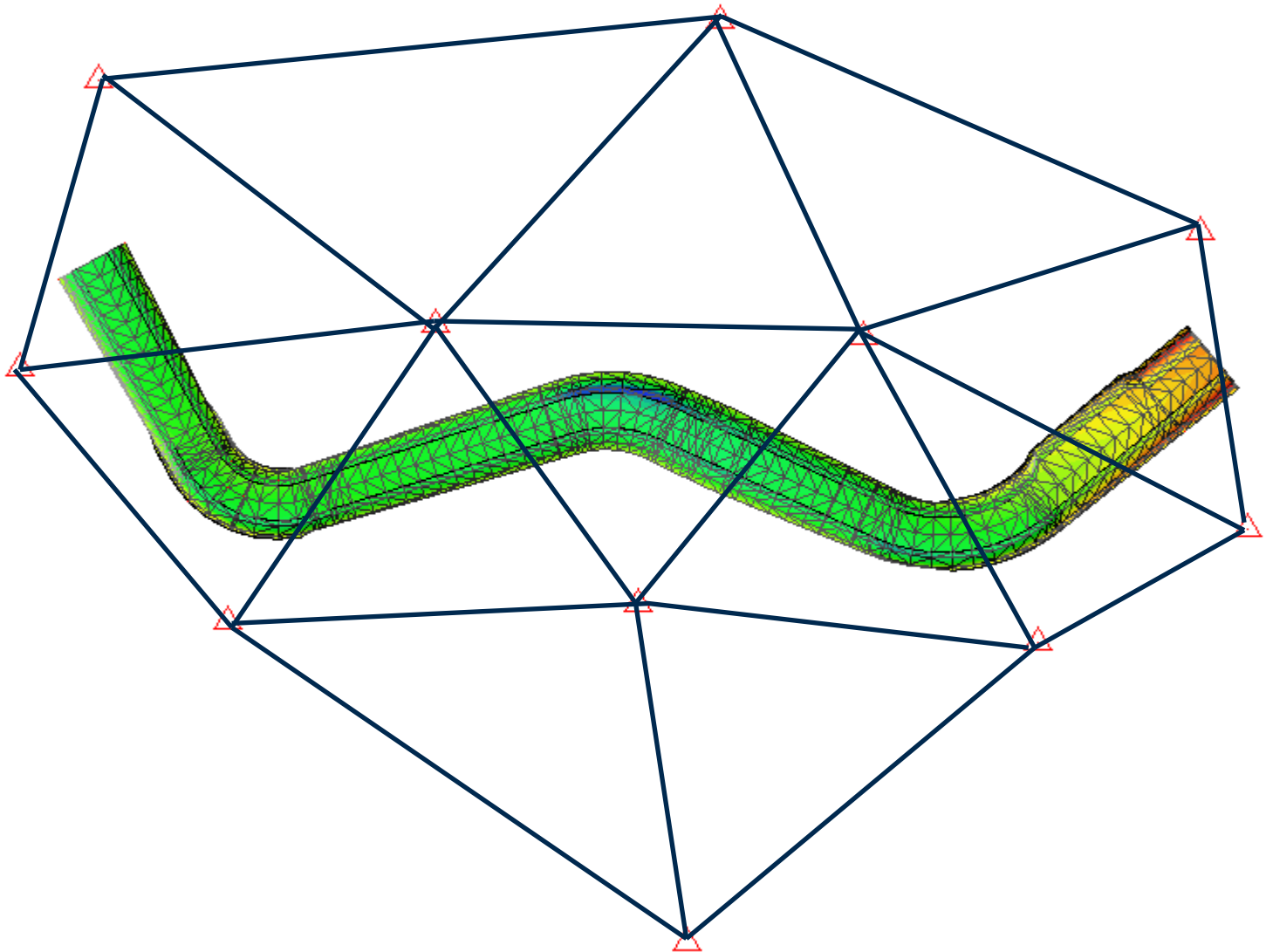
If Control does exist:

- 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

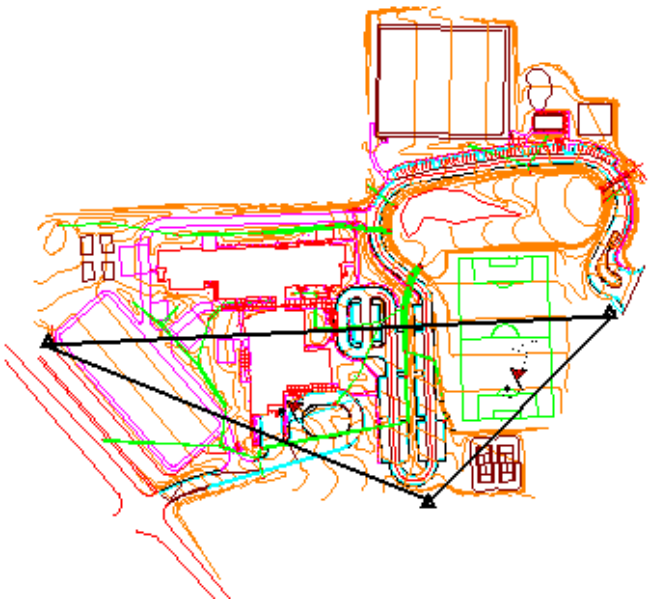


Optimal Control Point Configuration



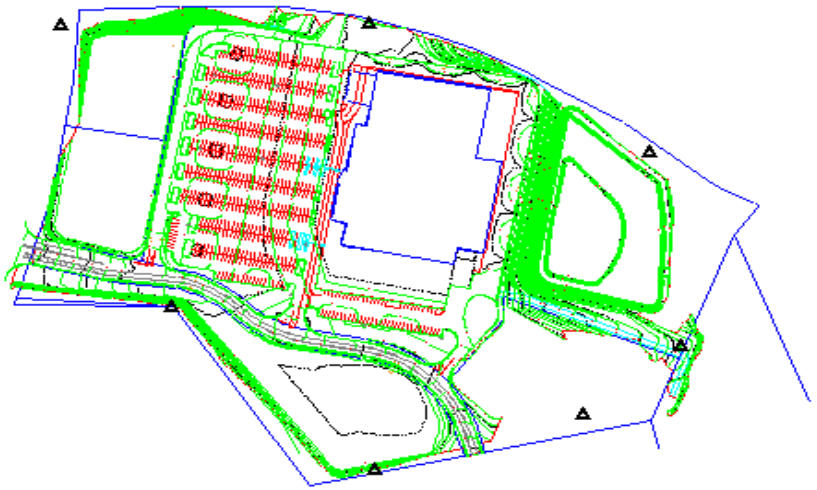
Control Point Locations

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



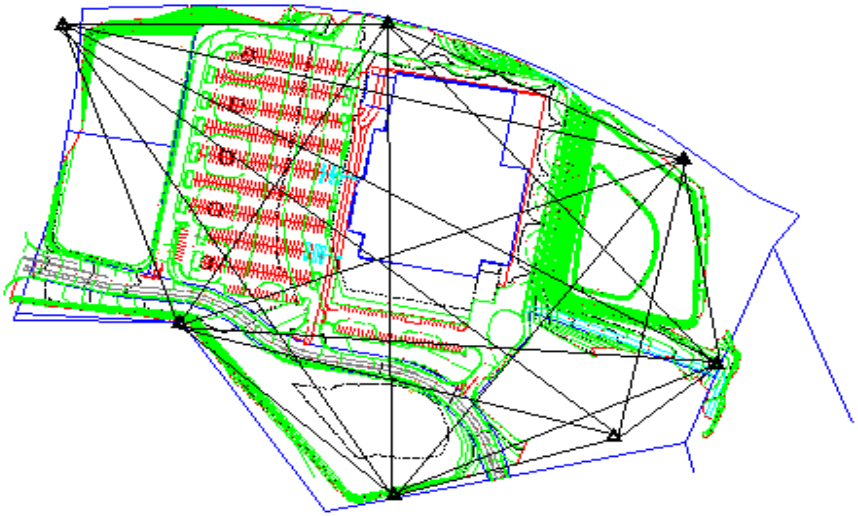
Control Point Locations

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



Control Point Locations

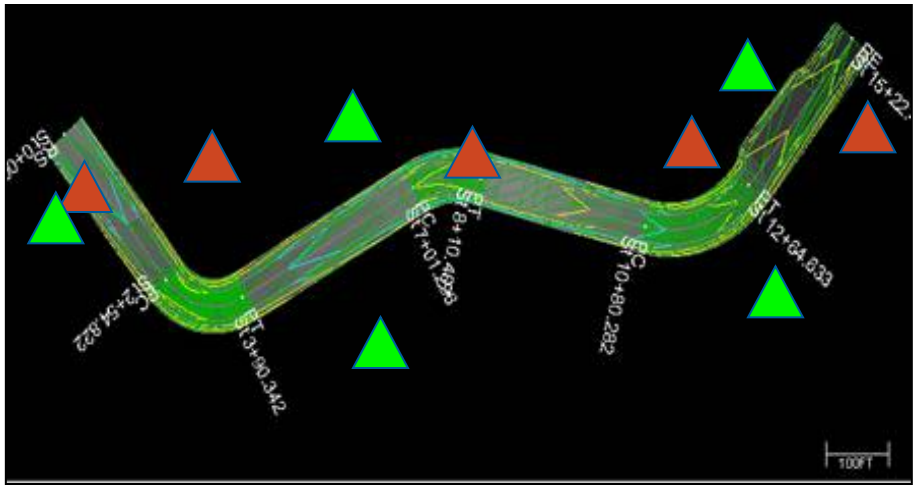
- The perfect control point location. Seven points, 18 baselines
- Points encompass the site and are balanced around the site

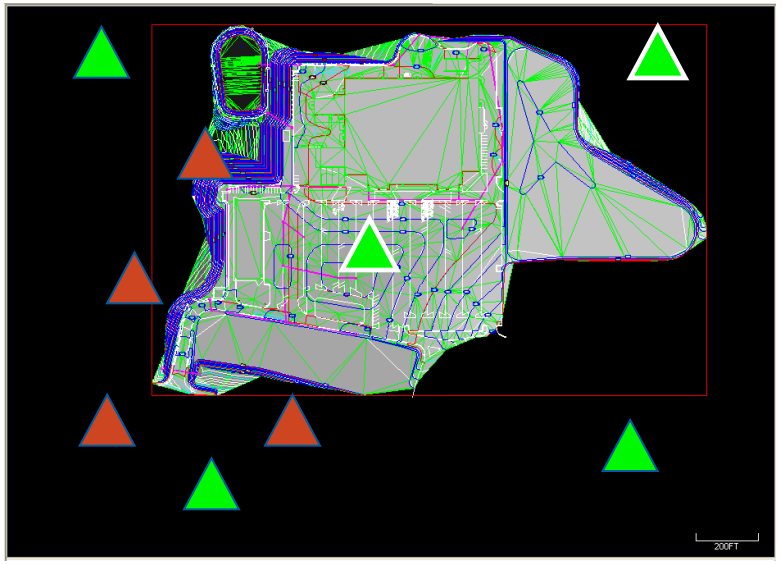


Control Point Locations

Control point network geometry is key

- = Poor network geometry
- = Ideal network geometry



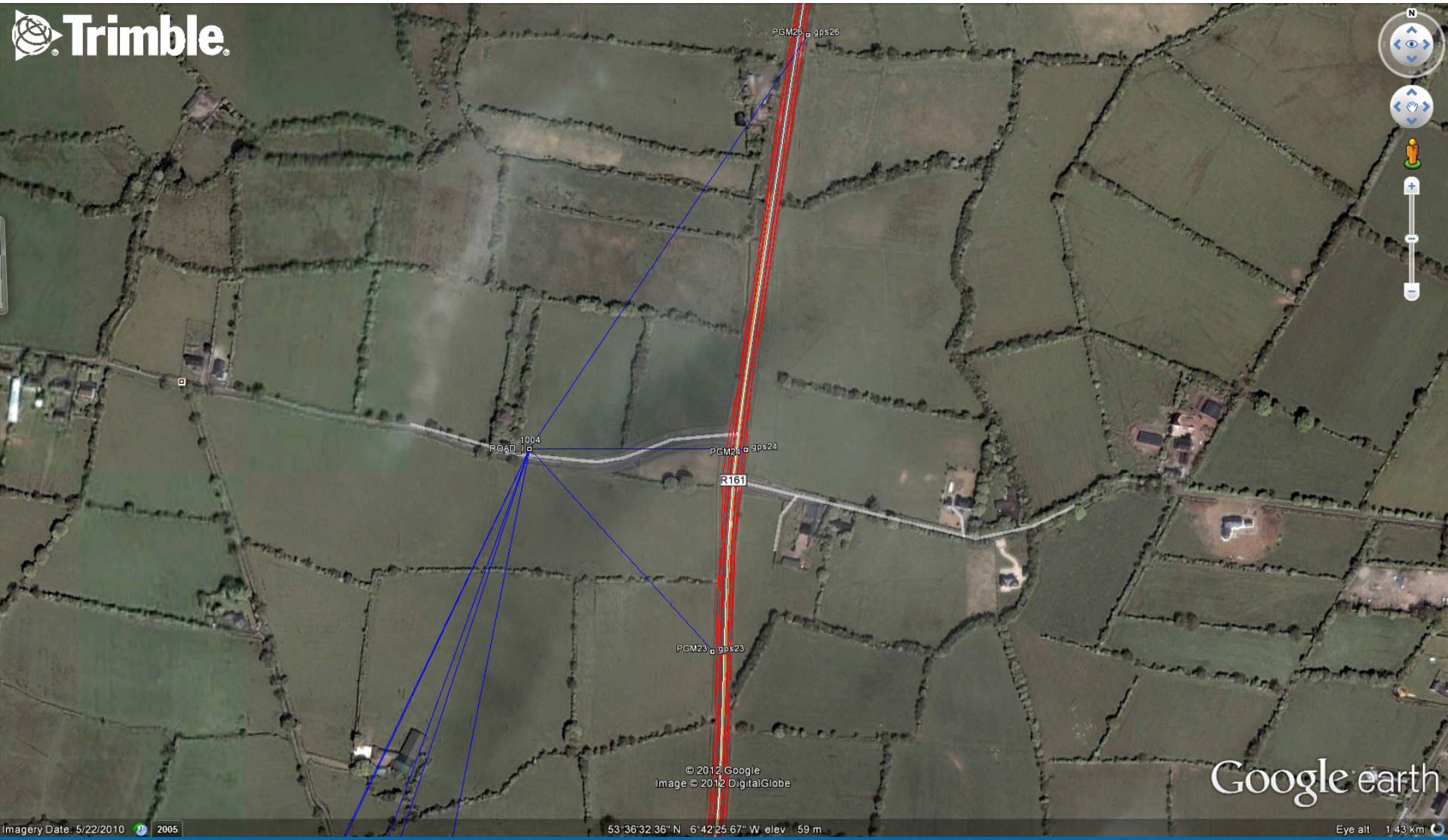


- Enclose the project area with control
- More control points and good network geometry can improve site calibration results and identify problems early

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

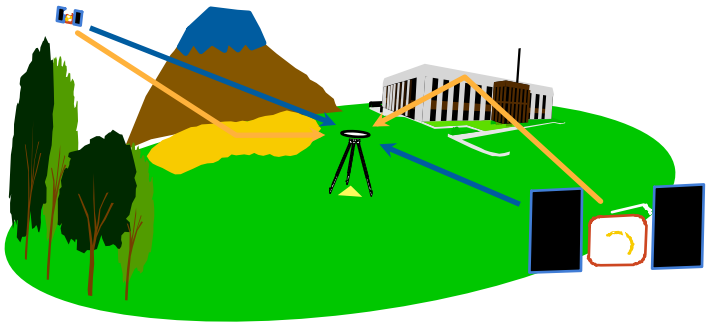
Corridor Based Network



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

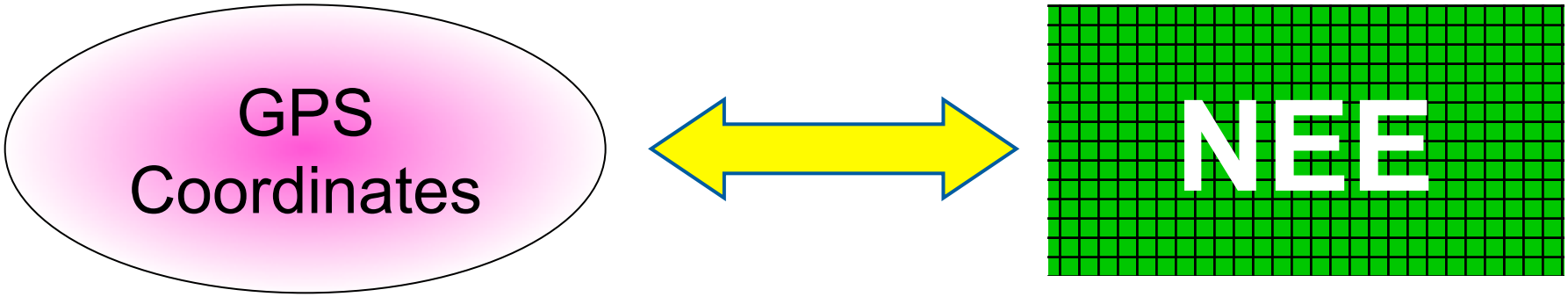
- Elevate the radio antenna to increase range
- Correct antenna (high gain and low gain)
- Avoid sources of radio frequency interference such as microwave or power lines

GNSS Site Calibration

- Introduction and explanation
- Requirements

GNSS Site Calibration

- **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**



GNSS Site Calibration

- 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

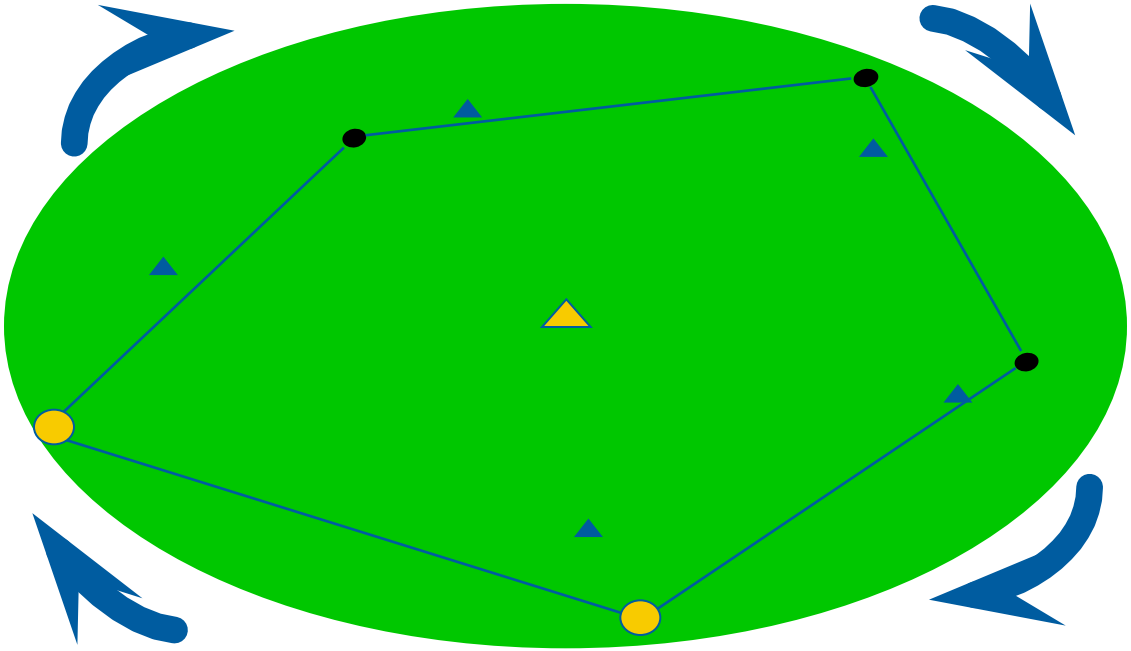
GNSS Site Calibration

Measuring a site calibration will assume

- Projection – Transverse Mercator
- Datum – WGS84

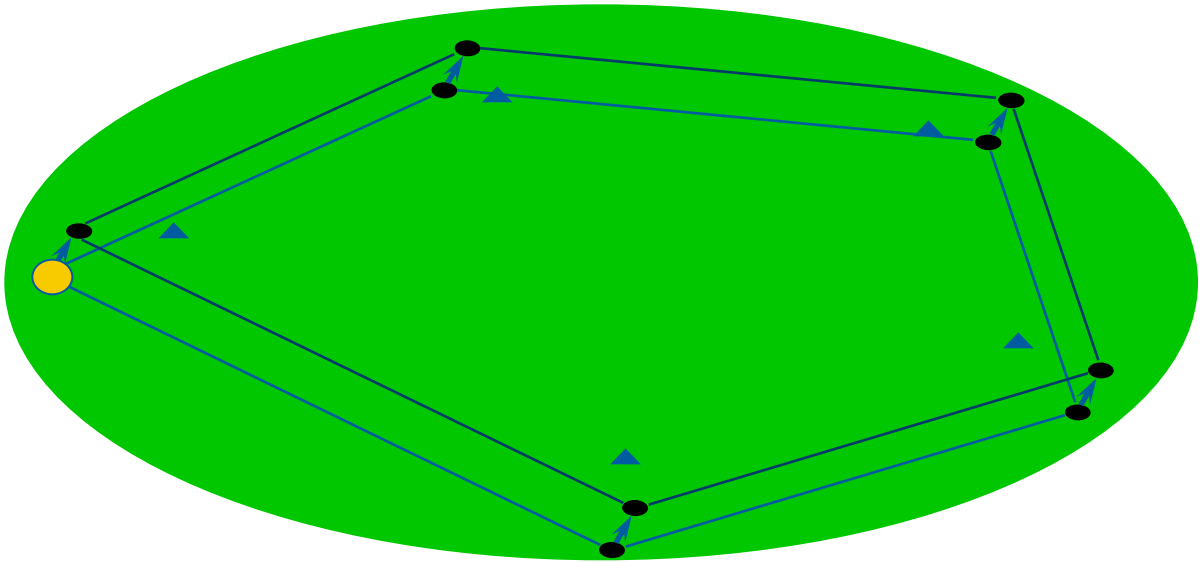
Horizontal Rotation

- Rotation about project centroid
- Two control points



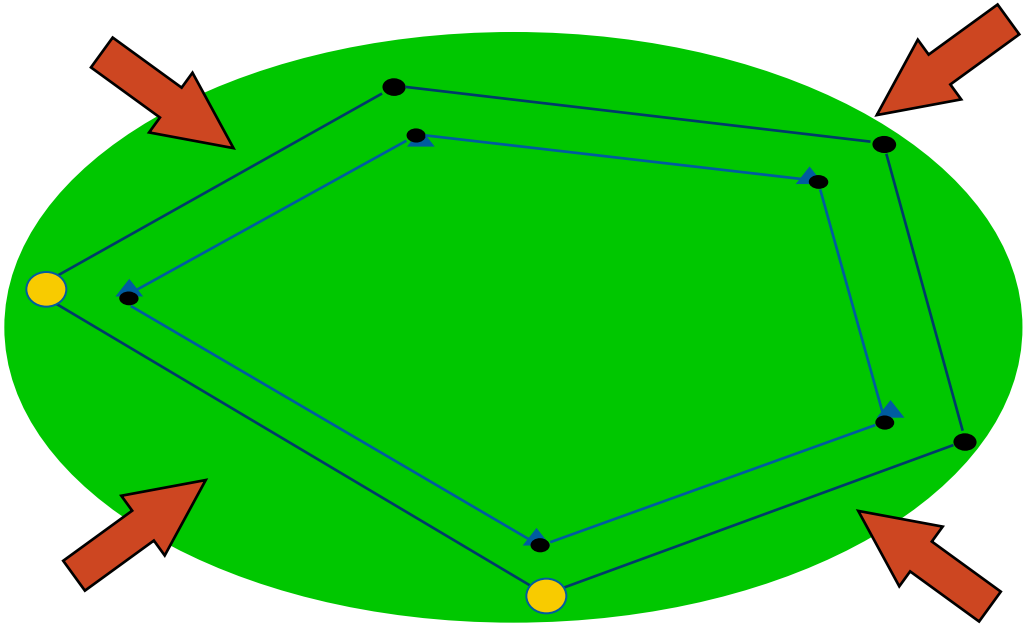
Horizontal Translation

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



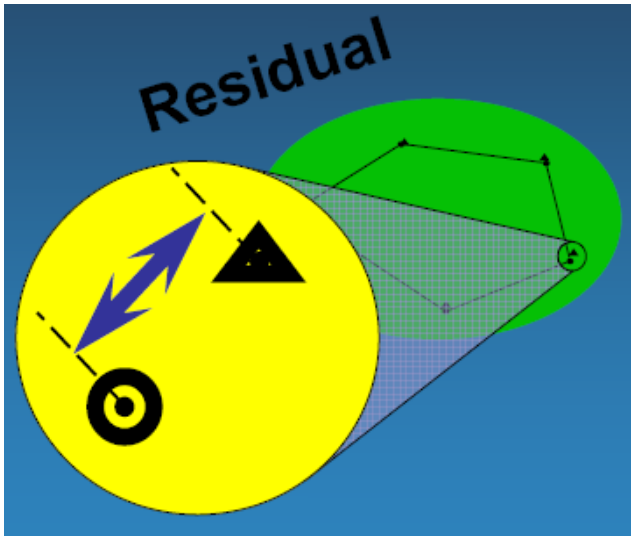
Horizontal Scale

- Ratio
  - GNSS to Local Coordinates
- Two Control Points



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

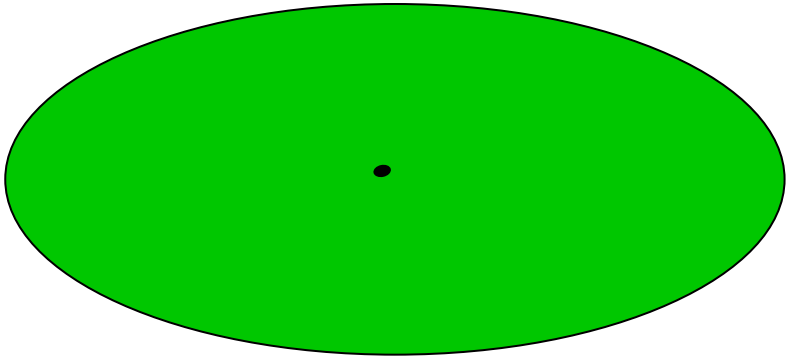


Single Point Site Calibration Requirements

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



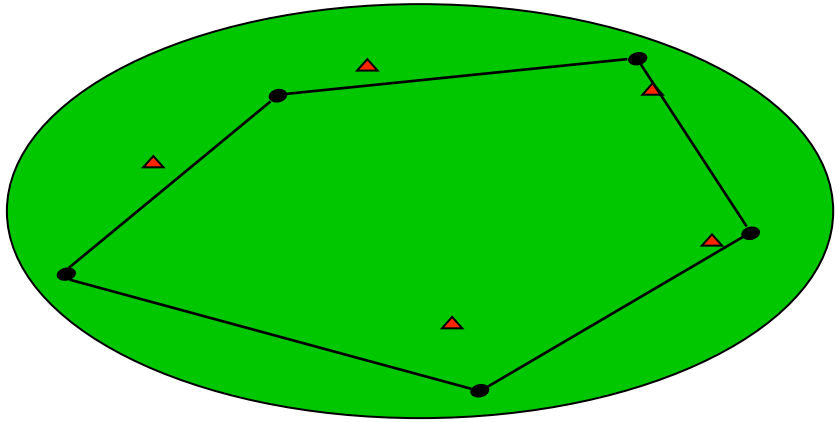
Multi-point Site Calibration Requirements

- 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

● = GNSS observation

▲ = Control Point



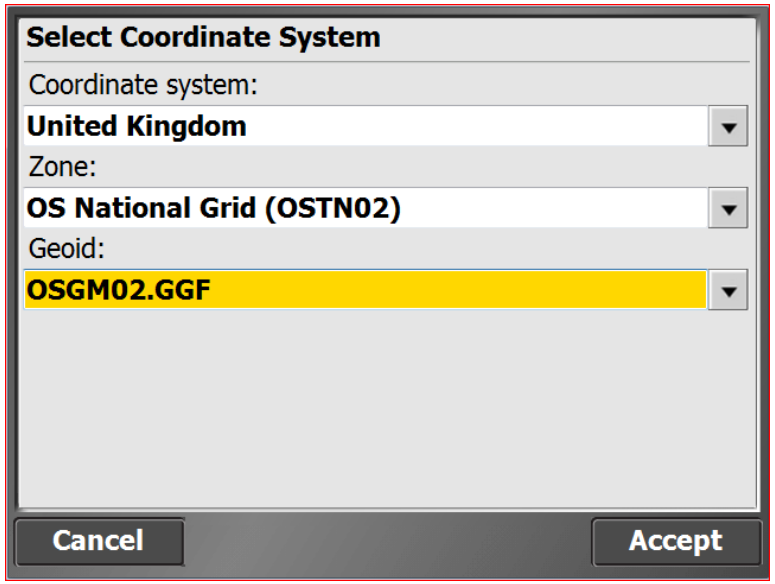
Tilted Plane

- 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

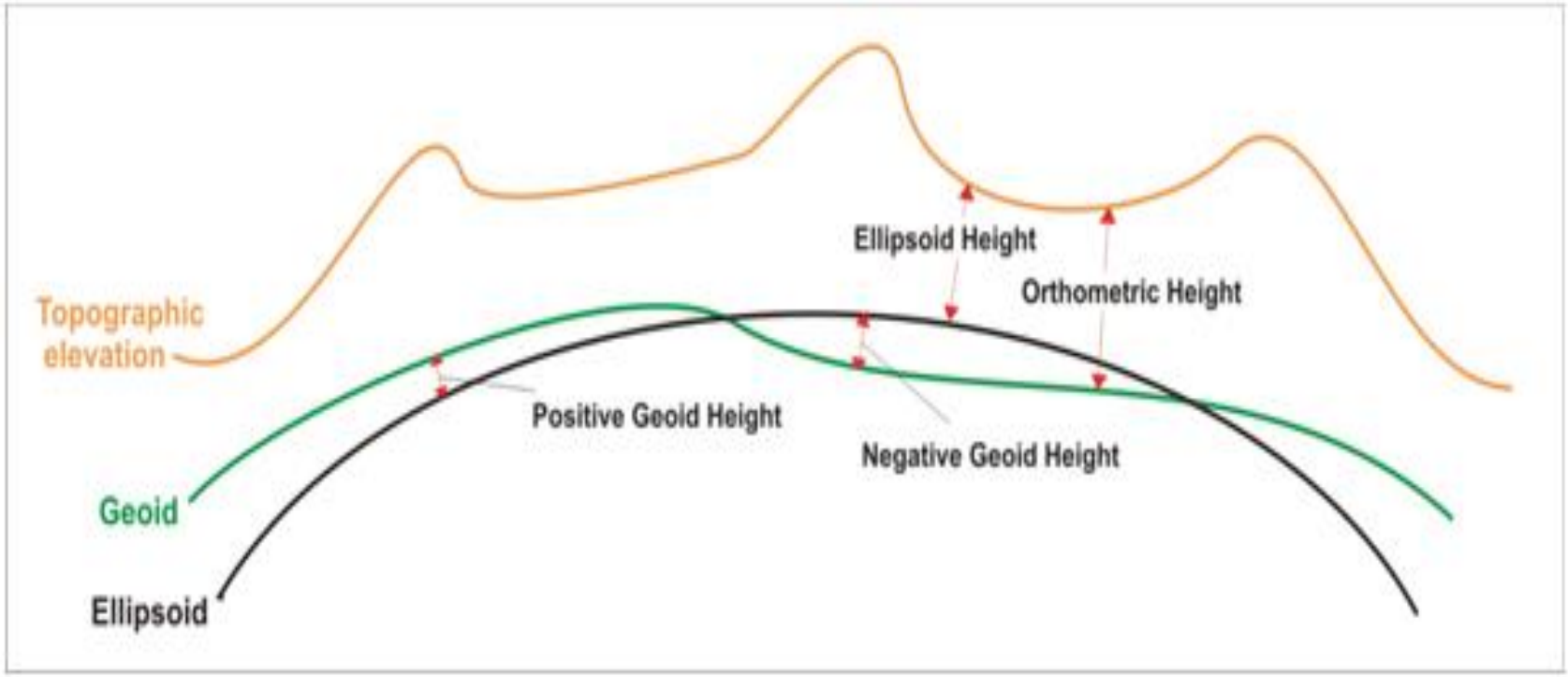


Why Should I Use a Geoid model?

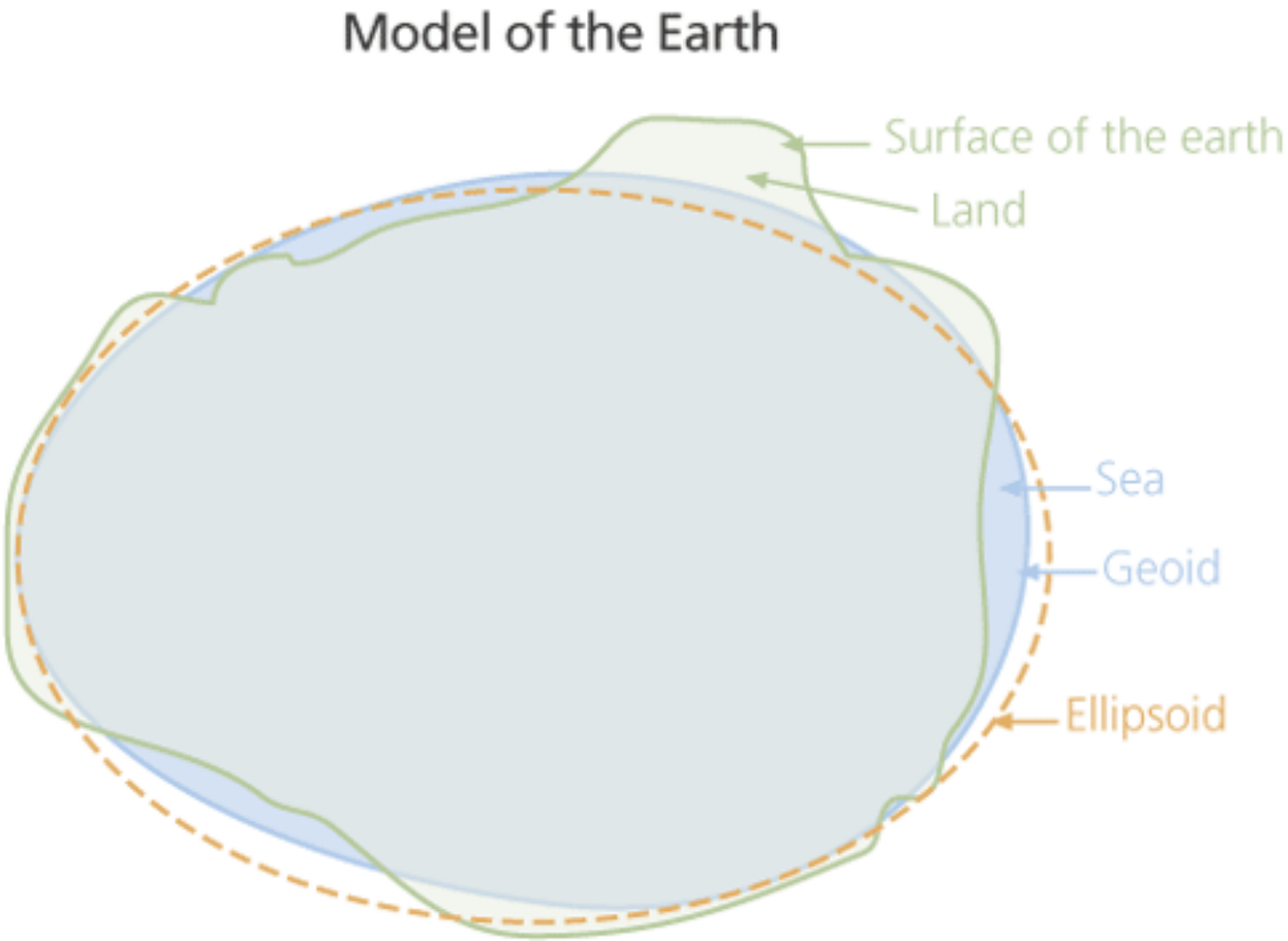
- Geoids are always good practice
- Geoids will allow you to go outside the project calibration
- Geoids allow for fewer vertical control points
- Allows for more definable vertical component
- Provides better detection of errors in control
- Recommended on long linear projects

Geoids

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



Geoids / Ellipsoids / Ground



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

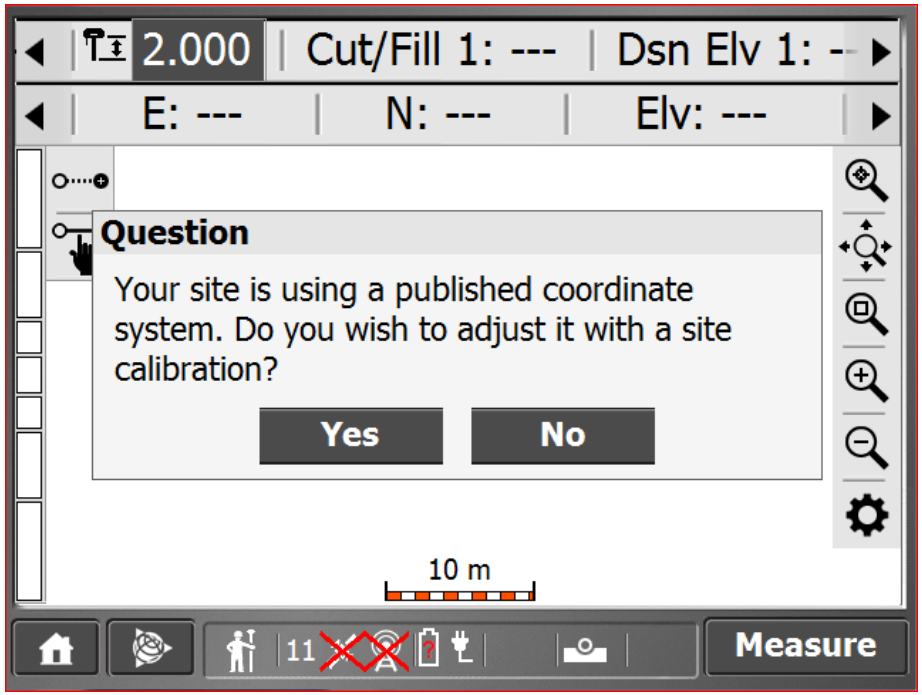
GNSS Site Calibration

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

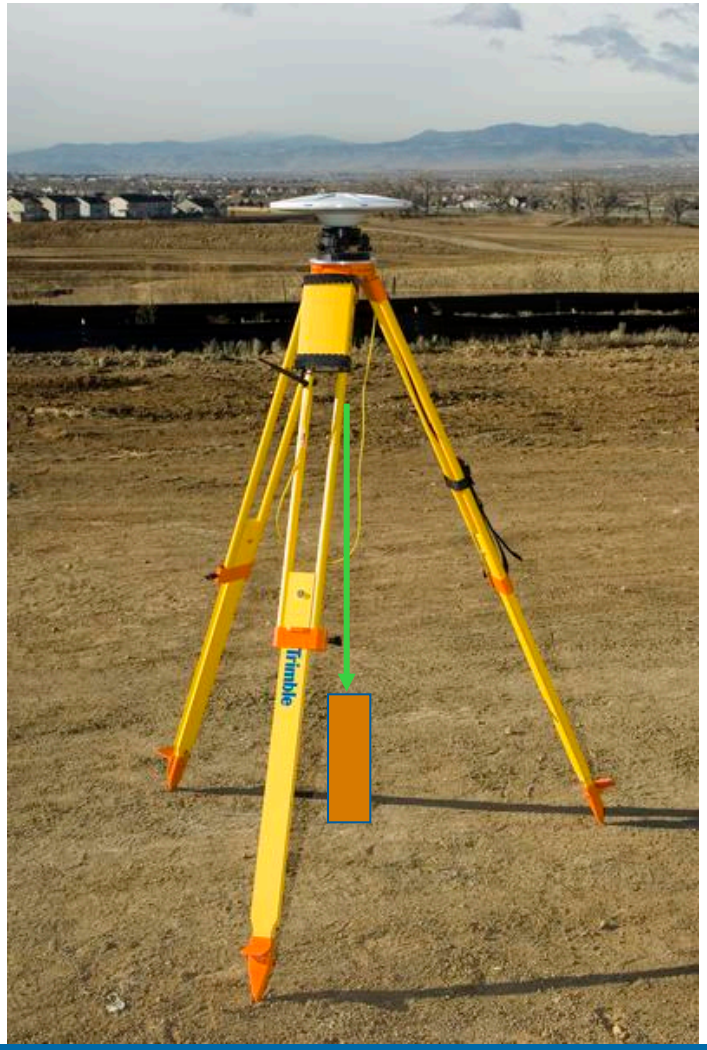
Site Calibration and Coordinate System

- 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



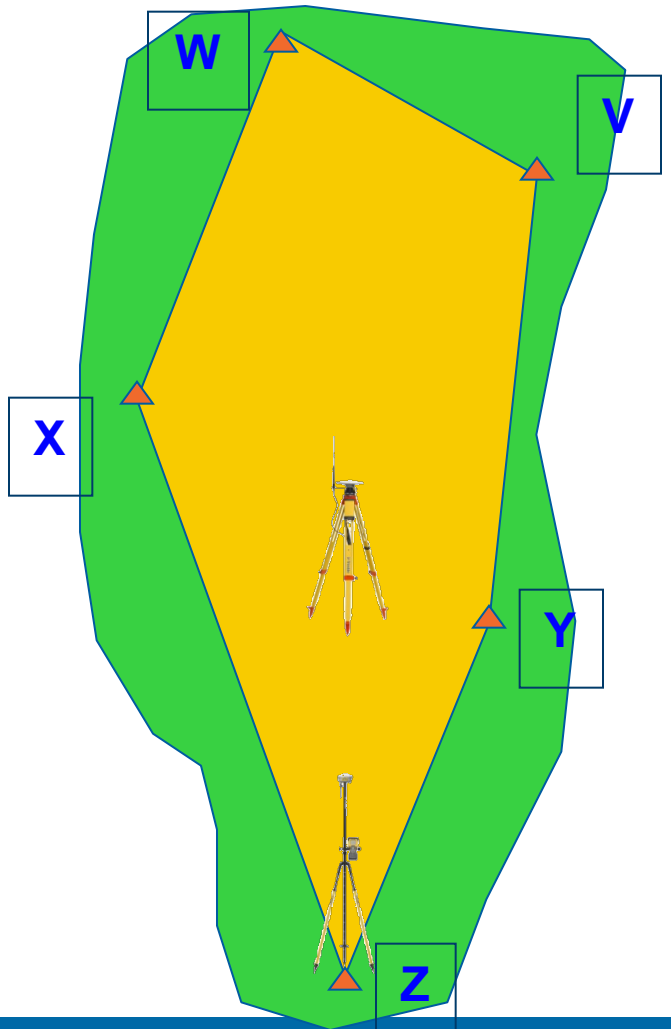
Typical Base Station Setups

Setting Up The Base Station



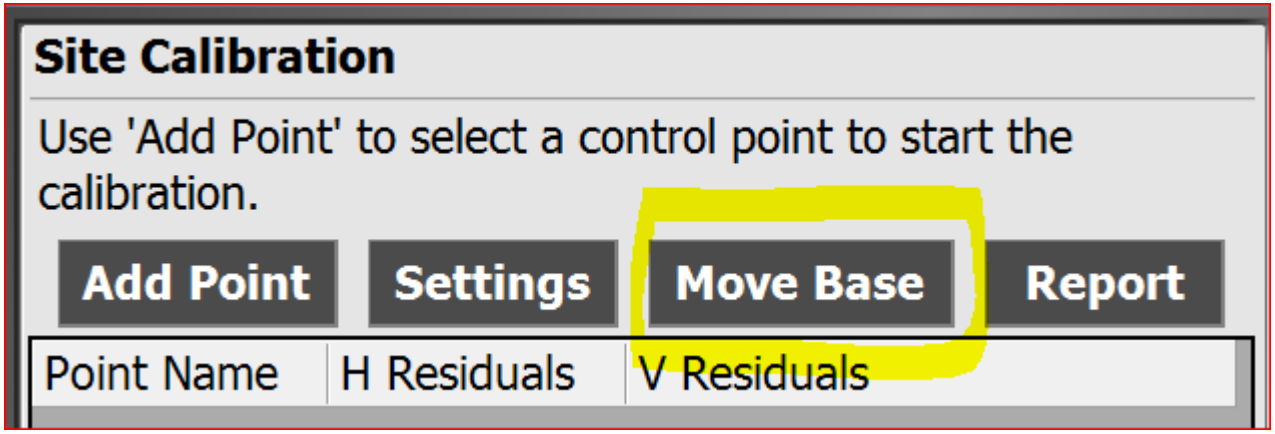
Setting Up The Rover

GPS Site Calibration

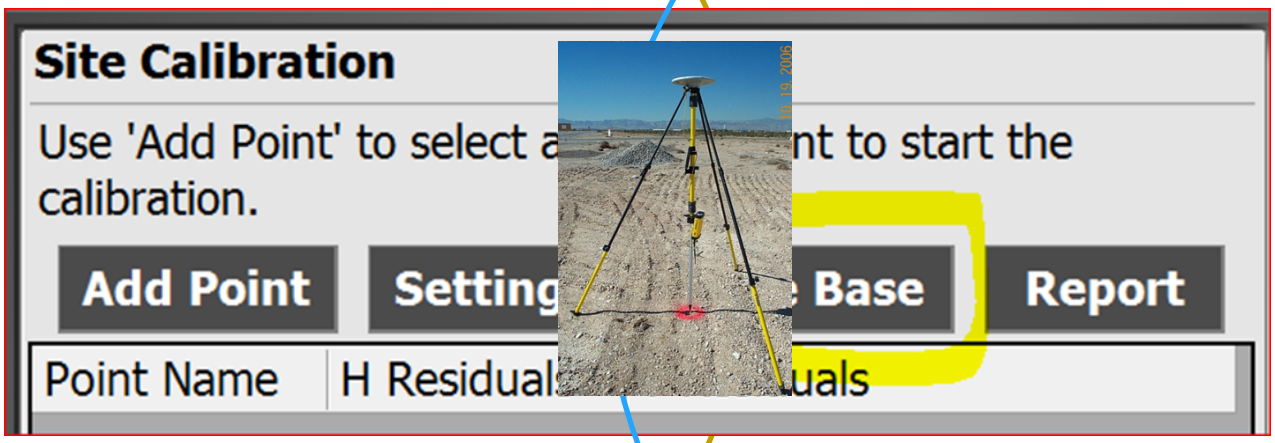


Moving the GNSS Base Station

- 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



Move Base


Site Calibration
Use 'Add Point' to select a
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calibration.
Add Point
Setting
Base
Report
Point Name
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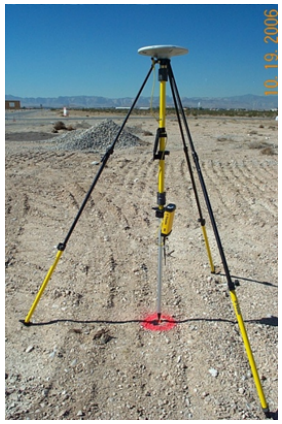
Extending Site Calibration



Phase 1
Site Cal 1

Phase 2
Site Cal 1 + Site Cal 2

Conclusion

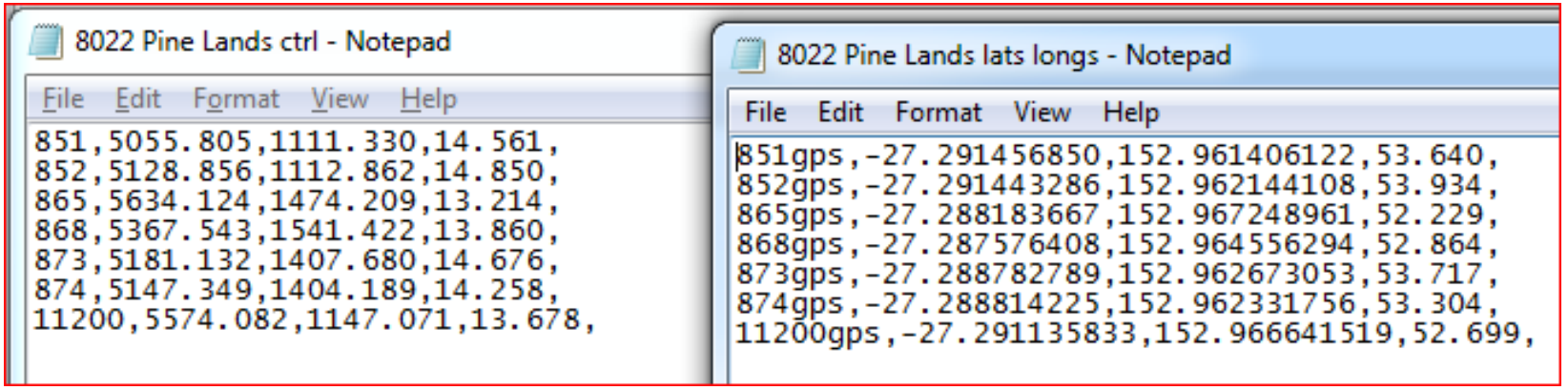
- Good base station location for good observables
- Adequate number of control points, five or more
- Good geometry among control points

The Less Energetic Way to Calibrate

OFFICE CALIBRATION

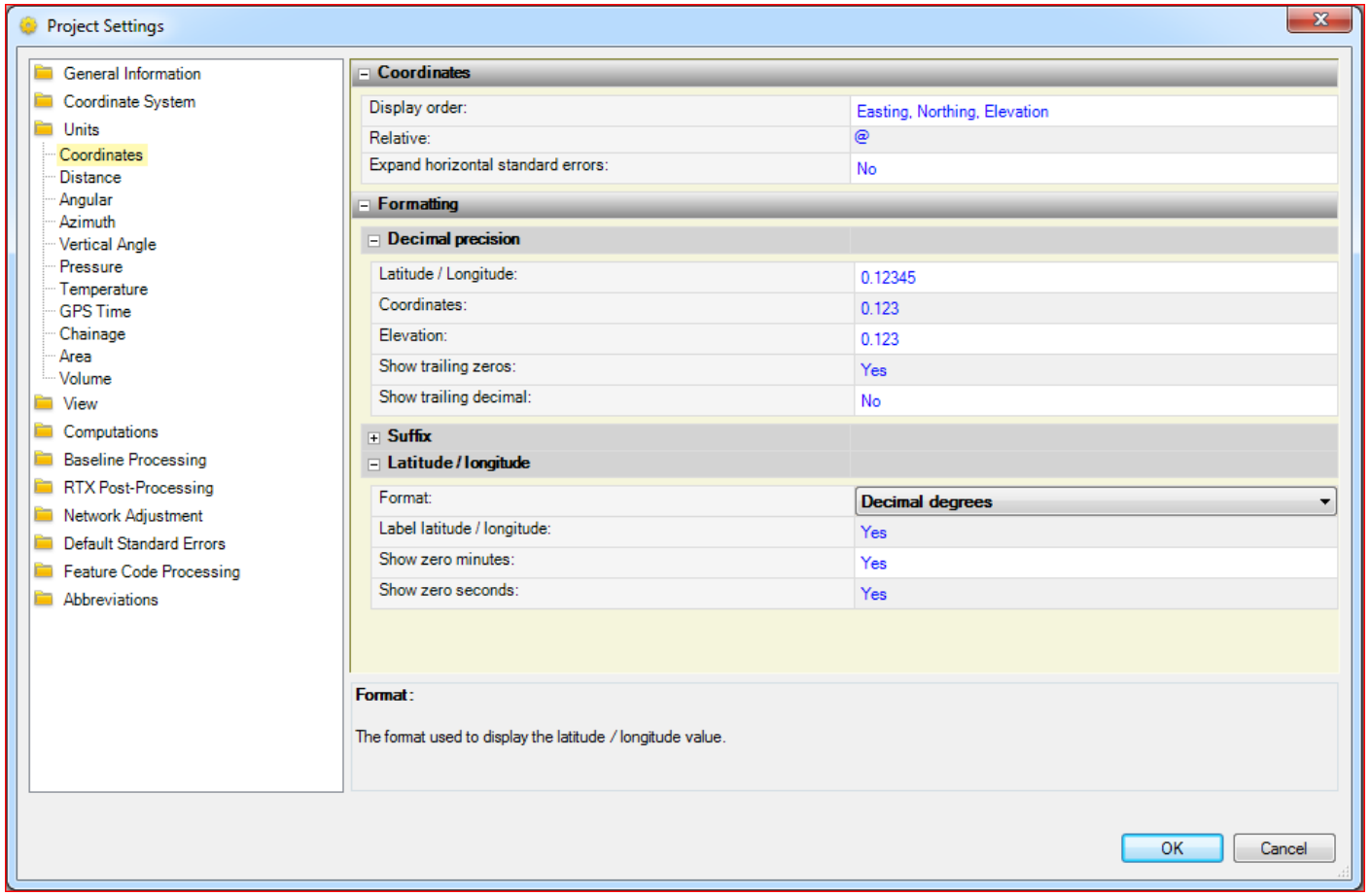
Office Calibration

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



Office Calibration

Correct format in the project settings

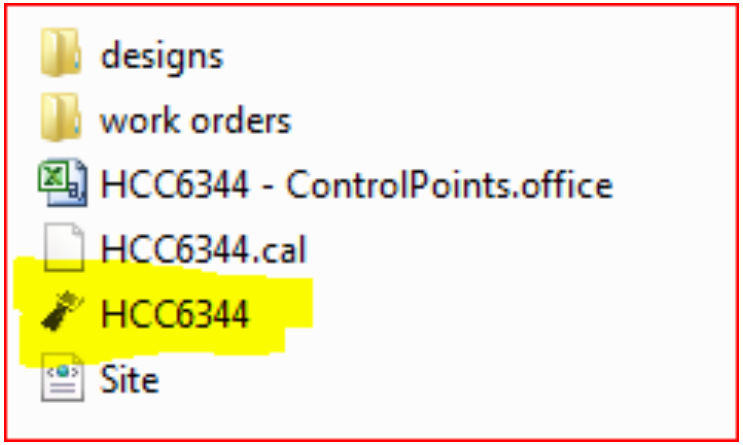


Office Calibration

- Import both point files
- Point names should be similar NOT the same

Office Calibration

- 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?