OGUG Meeting August 18, 2023
"User Based Low Distortion Projections
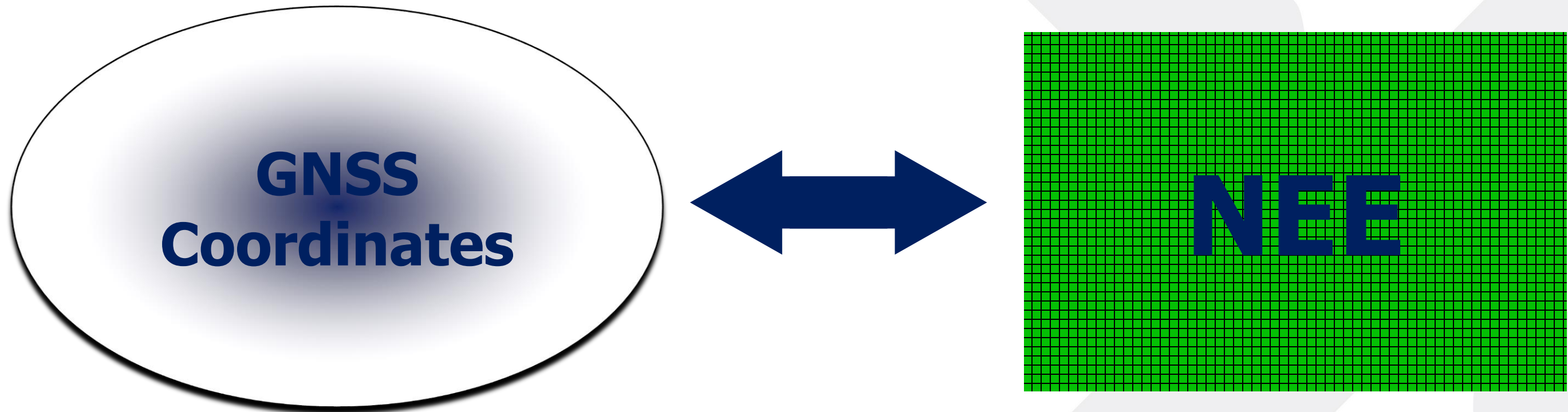Utilizing Site Calibration/Localization Routines"

OREGON GNSS USERS GROUP
SERVING SURVEY & GIS PROFESSIONALS

GNSS Site Calibration/Localization 101

Bob Green, PLS Frontier Precision
Bob@frontierPrecision.com

GNSS Site Calibration

GNSS Coordinates ↔ **NEE**

Allows GNSS Geodetic Coordinates - Latitude, Longitude and Ellipsoid Height to Interface with your Local Project Grid Coordinates – North, East and Elevation

Project Settings

← Job properties: GNSS SITE CALIBRATION TRAINING ☆

Job path ...\Projects\GNSS SITE CALIBRATION TRAINING\GNSS SITE CALIBRATION TRAINING.job

Properties

Coord. sys.	No projection / no datum
Units (Dist.)	US survey feet
Linked files	None
Active map	None
Feature library	None
Cogo settings	Ground
Additional settings	Off
Media file	Previous point
Reference	?
Description	?
Operator	?

Change to "Grid" for "Ground Grid" after Site Calibration

≡ No projection/no datum

Site calibration
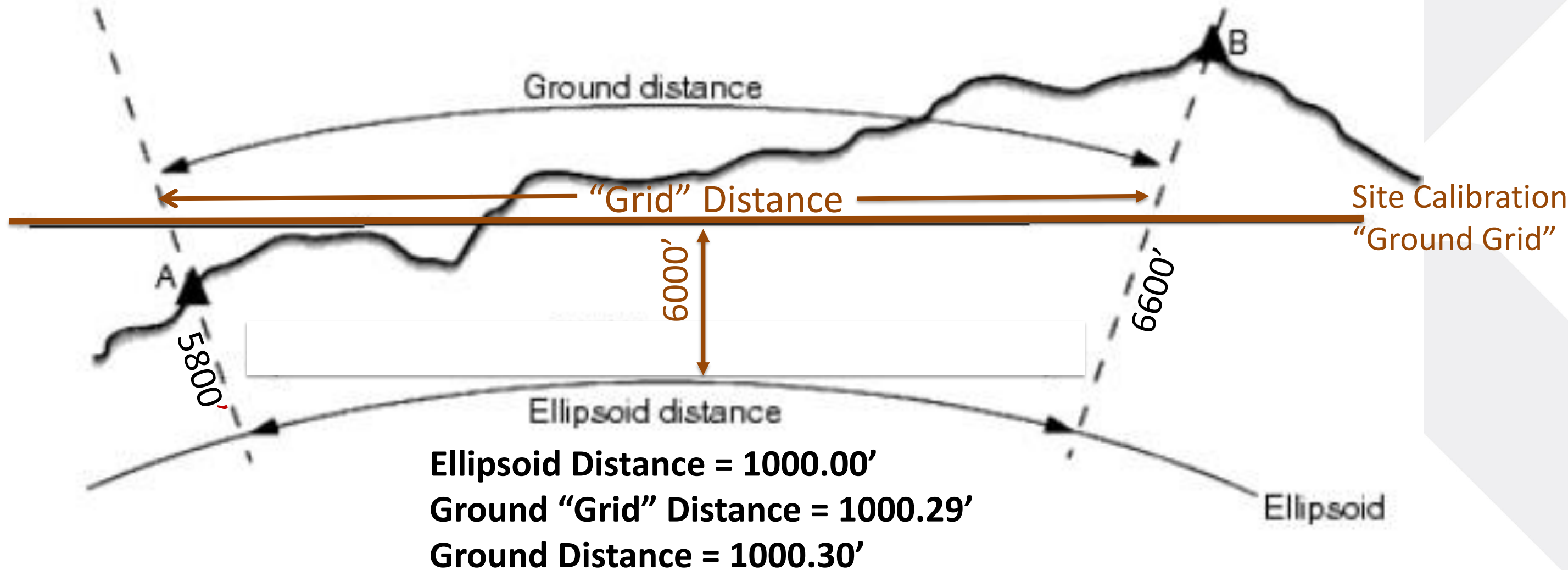
Coordinates
Ground ▼

Use geoid model
☑

Project height
6000.000sft ▶

Geoid model
GEOID18 (CONUS) ▼

Ground = Right Answer!
Grid = Wrong Answer!
It's That Simple!!

100' Change = +/- 5PPM
or 0.005 in 1000 Linear Feet

COGO Settings

Ground distance

"Grid" Distance

Site Calibration
"Ground Grid"

6000'

5800'

6600'

Ellipsoid distance

Ellipsoid

A

B

Ellipsoid Distance = 1000.00'
Ground "Grid" Distance = 1000.29'
Ground Distance = 1000.30'

Calibration Process

- **Datum Transformation**

- **Define Projection**

- **Horizontal Adjustment**

- **Vertical Adjustment**
  - Geoid Model (Optional)

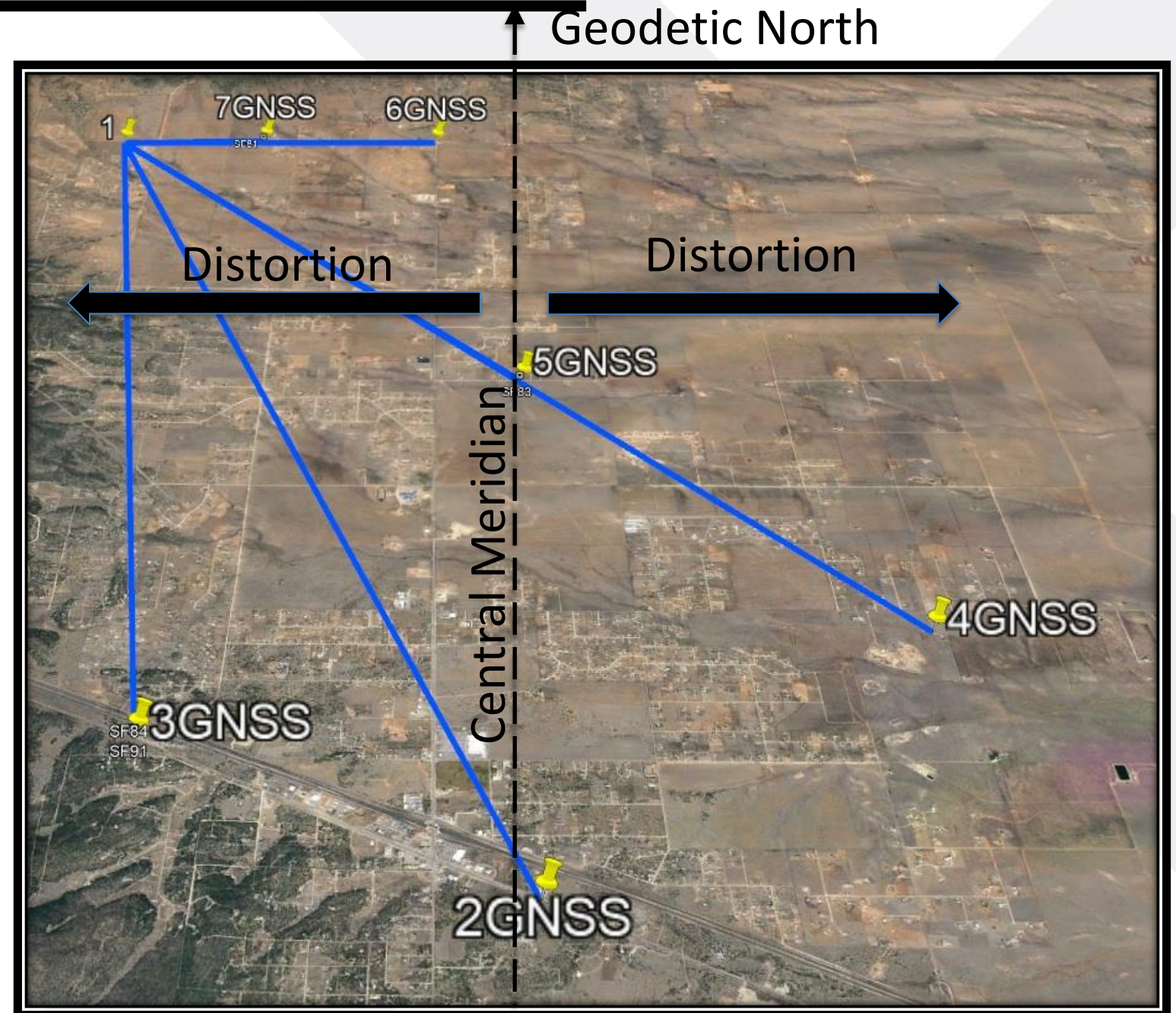# Datum Transformation

Global
L,L,H

↔

Local
L,L,H

- Two basic types
  - 3 parameter
  - 7 parameter

Some GNSS Manufactures Field/Office SW now incorporate 14 P Time Dependent Transformations
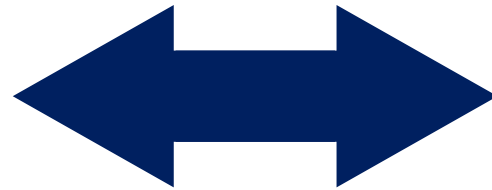
Define Projection

LAT, LONG ↔ NORTH, EAST

• **Mapping projections are used to represent positions on the curved surface of the earth as points on a *flat* surface or plane.**

Commonly Used Mapping Projections

Plane

Point of Origin

Ellipsoid

Tangent Plane
Local Plane

Apex of Cone

Axis of Cone & Ellipsoid

Lines of intersection
Lines of Latitude
"Parallels"

Ellipsoid

Intersecting Cone
2 Parallel Lambert

Axis of Ellipsoid

Central Meridian

Axis of Cylinder

Ellipsoid

Intersecting Cylinder
Transverse Mercator

Calibration Process

✖**Datum Transformation**

✖**Define Projection**

- **Horizontal Adjustment**

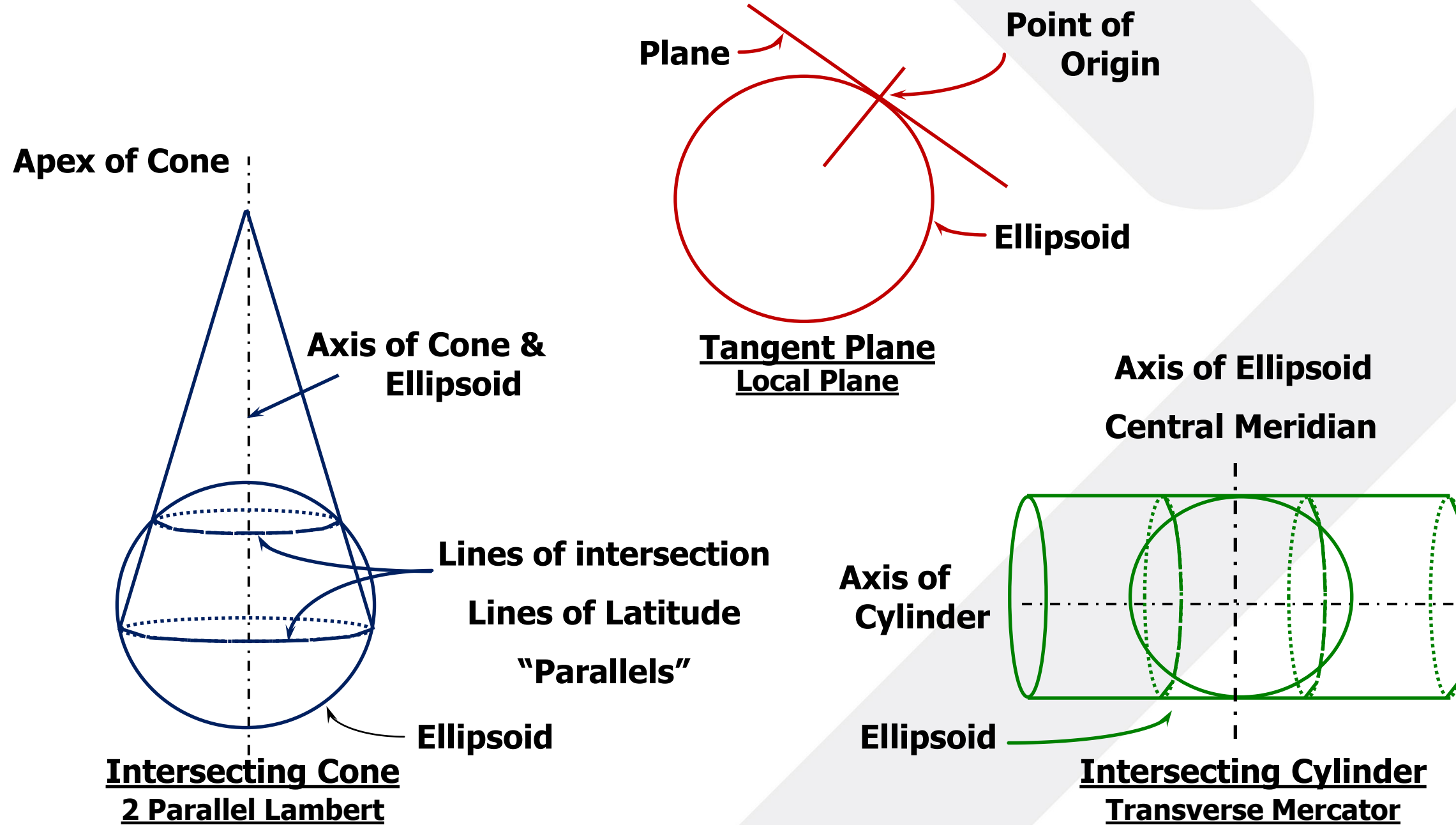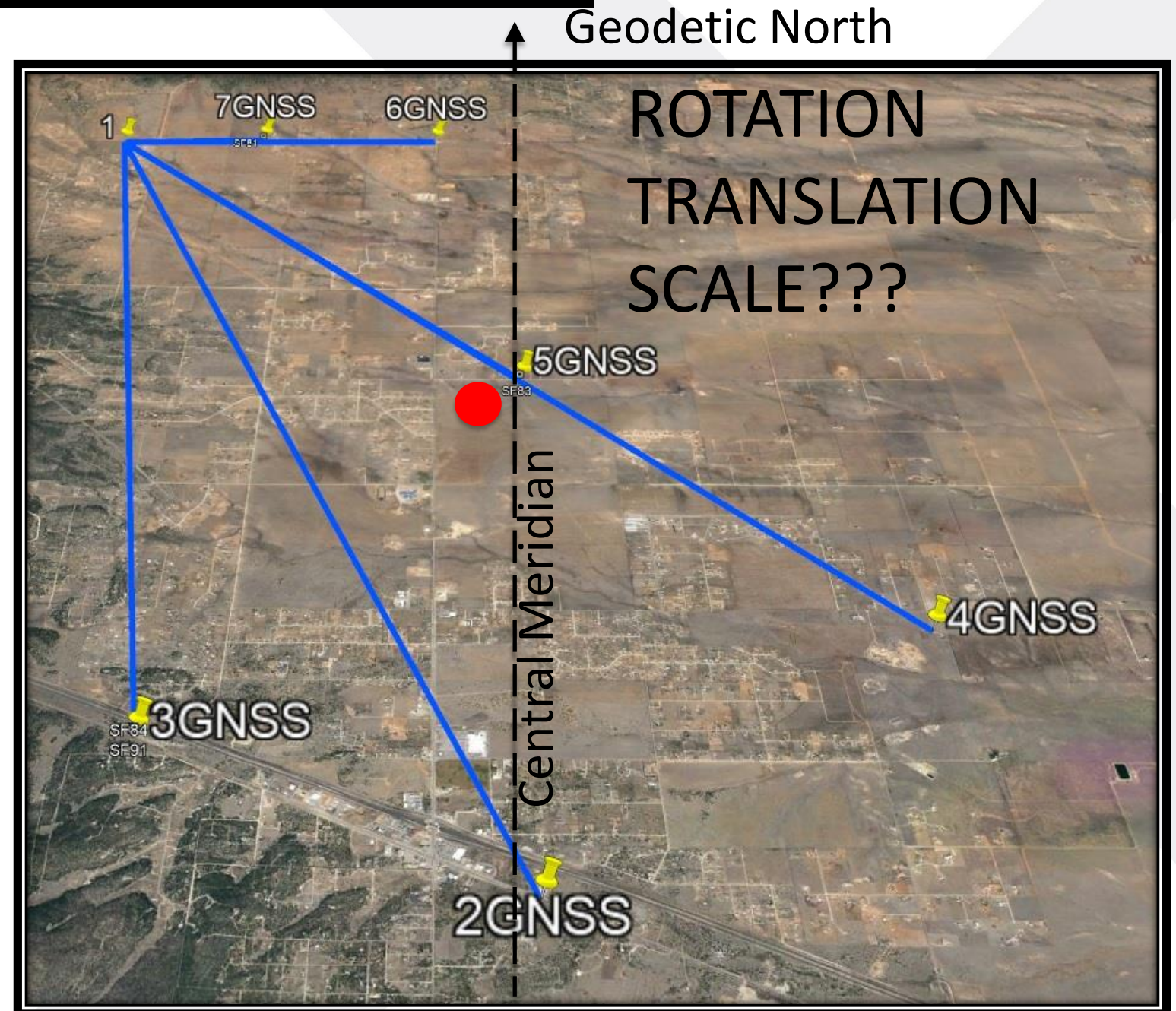- **Vertical Adjustment**
  - Geoid Model (Optional)

Geodetic North

ROTATION
TRANSLATION
SCALE???

1   7GNSS   6GNSS

5GNSS

4GNSS

3GNSS

2GNSS

Central Meridian
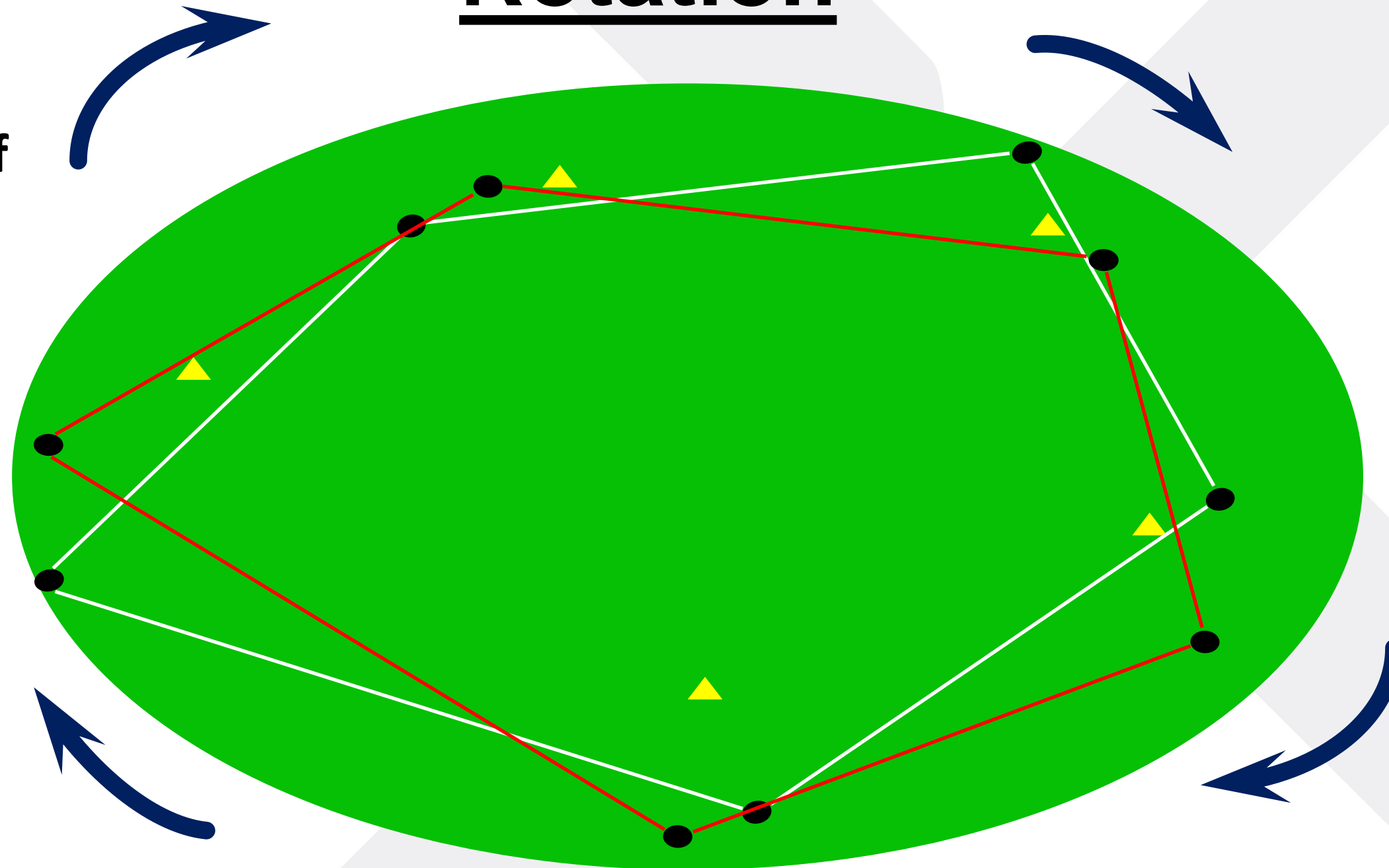
Horizontal Adjustment

- At least 3 horizontal control points are required for a HZ adjustment
  - Rotation for "Basis of Bearings" can be done with 2 points
    - Be Careful!!!!
    - 1st 3D/ 2nd 2D

- Minimum 5 points are recommended with Good Geometry Horz and Vert
  - Linear Projects

● = GPS observation

▲ = Control Point

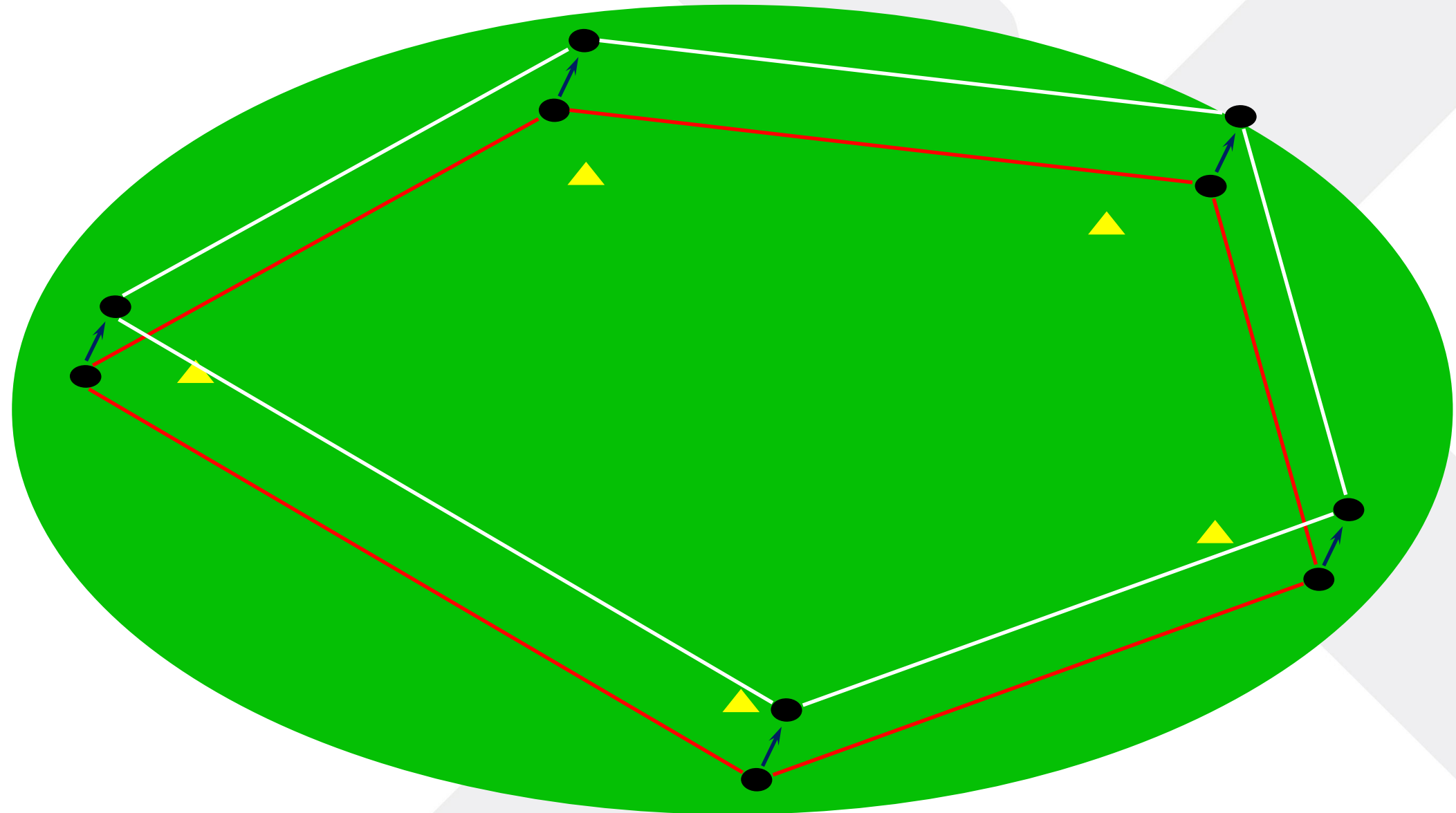![Oregon GNSS Users Group - Serving Survey & GIS Professionals]
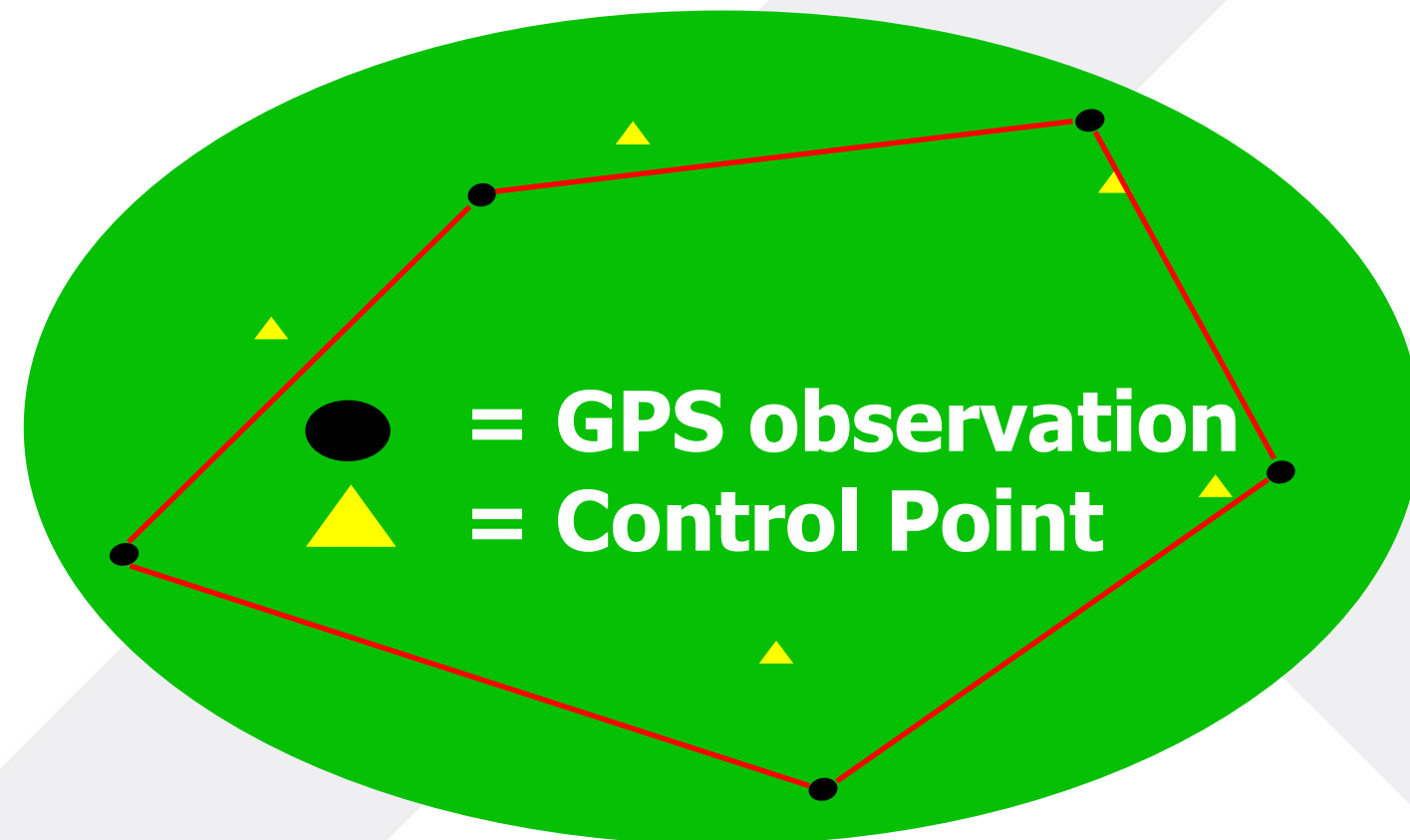
Rotation

- **The "Origin" of the Rotation is the Mathematical Center of the Control**

- **Rotation is the angular relationship between Geodetic North and your Grid North.**

Translation

North and East "shift" to best align the Geodetic components (LLH) with the Grid values (NEE). Usually small values.

Scale
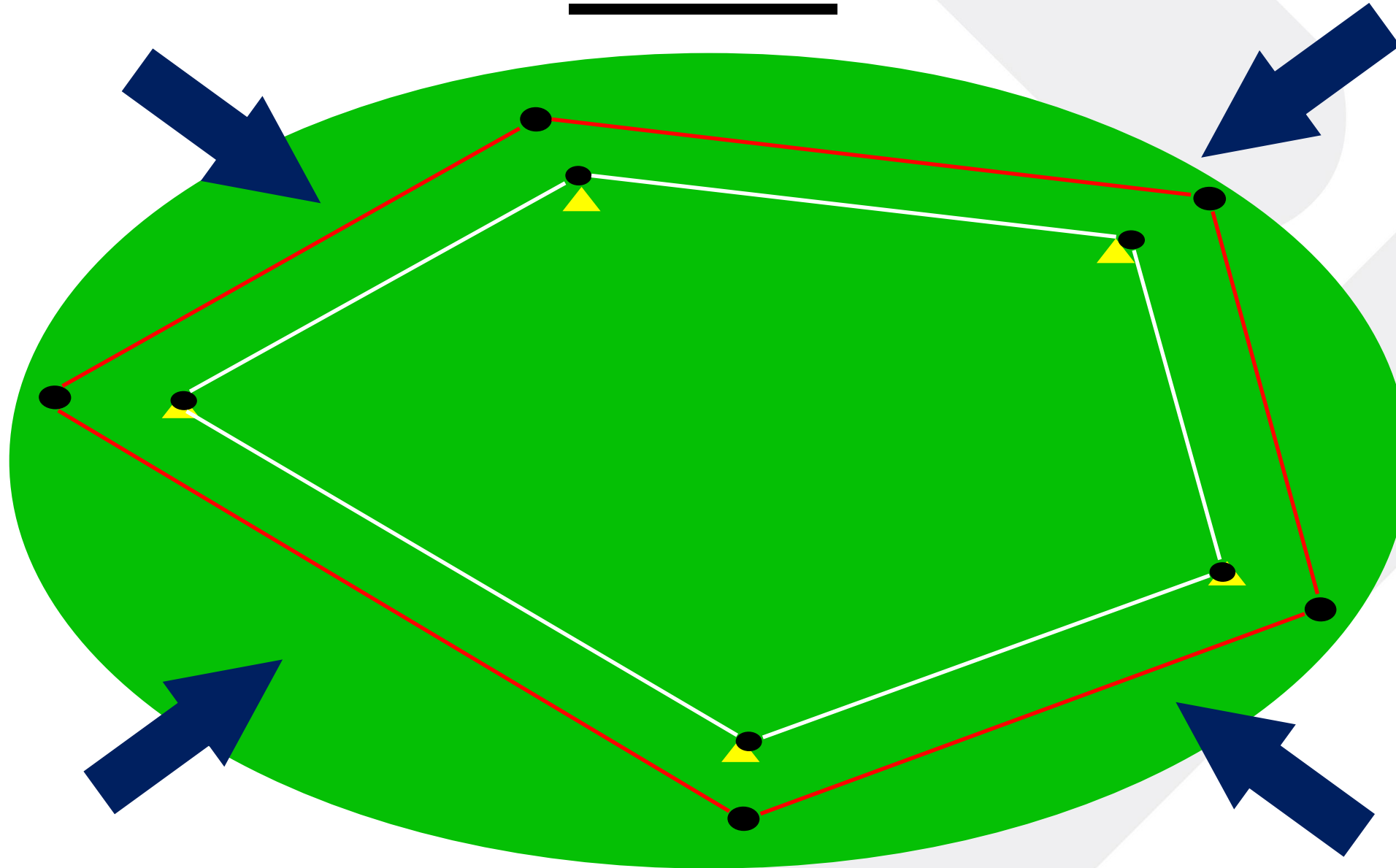
Horizontal Residuals
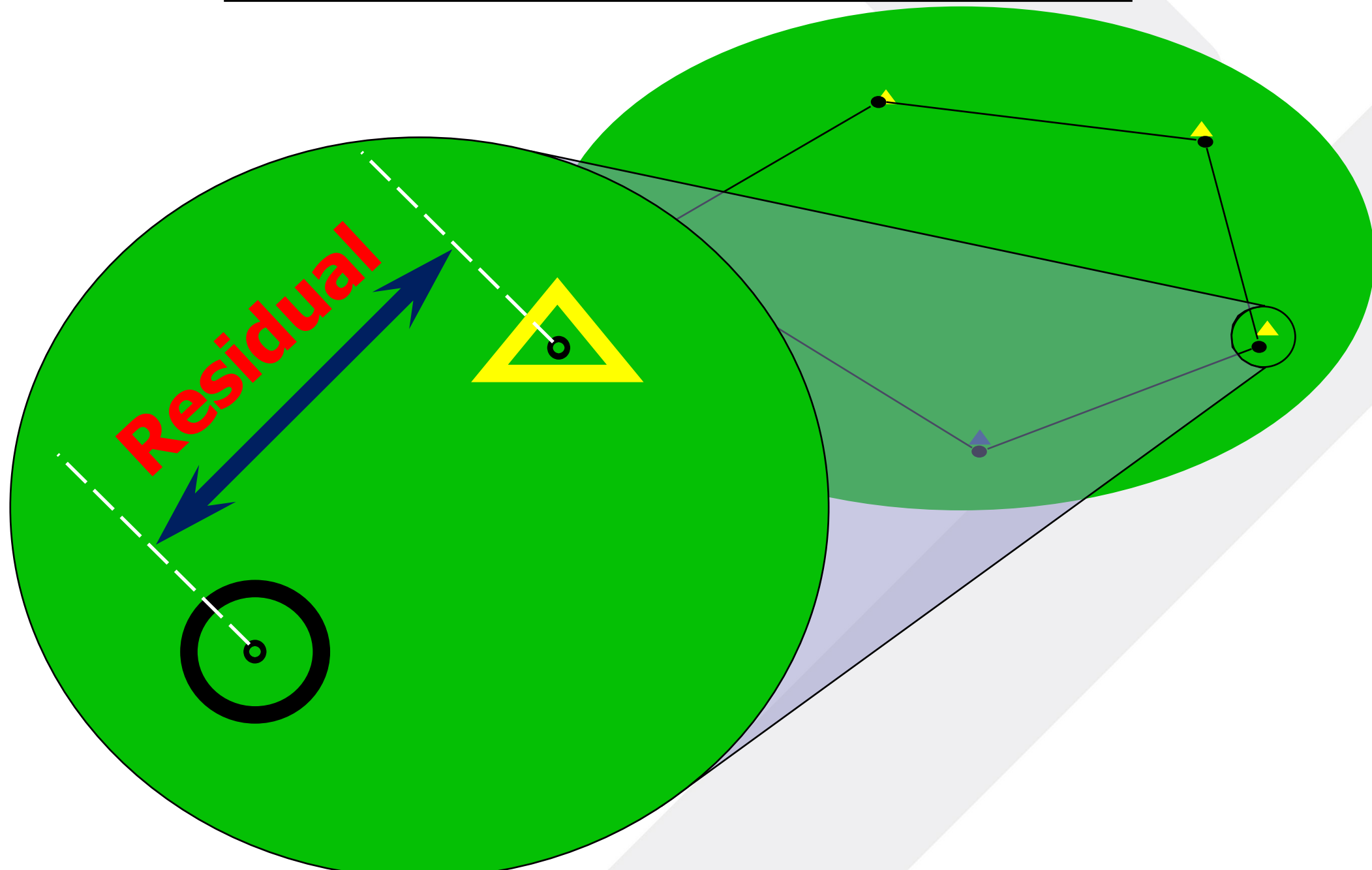
Calibration Process

✖ **Datum Transformation**

✖ **Define Projection**

✖ **Horizontal Adjustment**

- **Vertical Adjustment**
  - Geoid Model (Optional)

OREGON GNSS USERS GROUP
SERVING SURVEY & GIS PROFESSIONALS
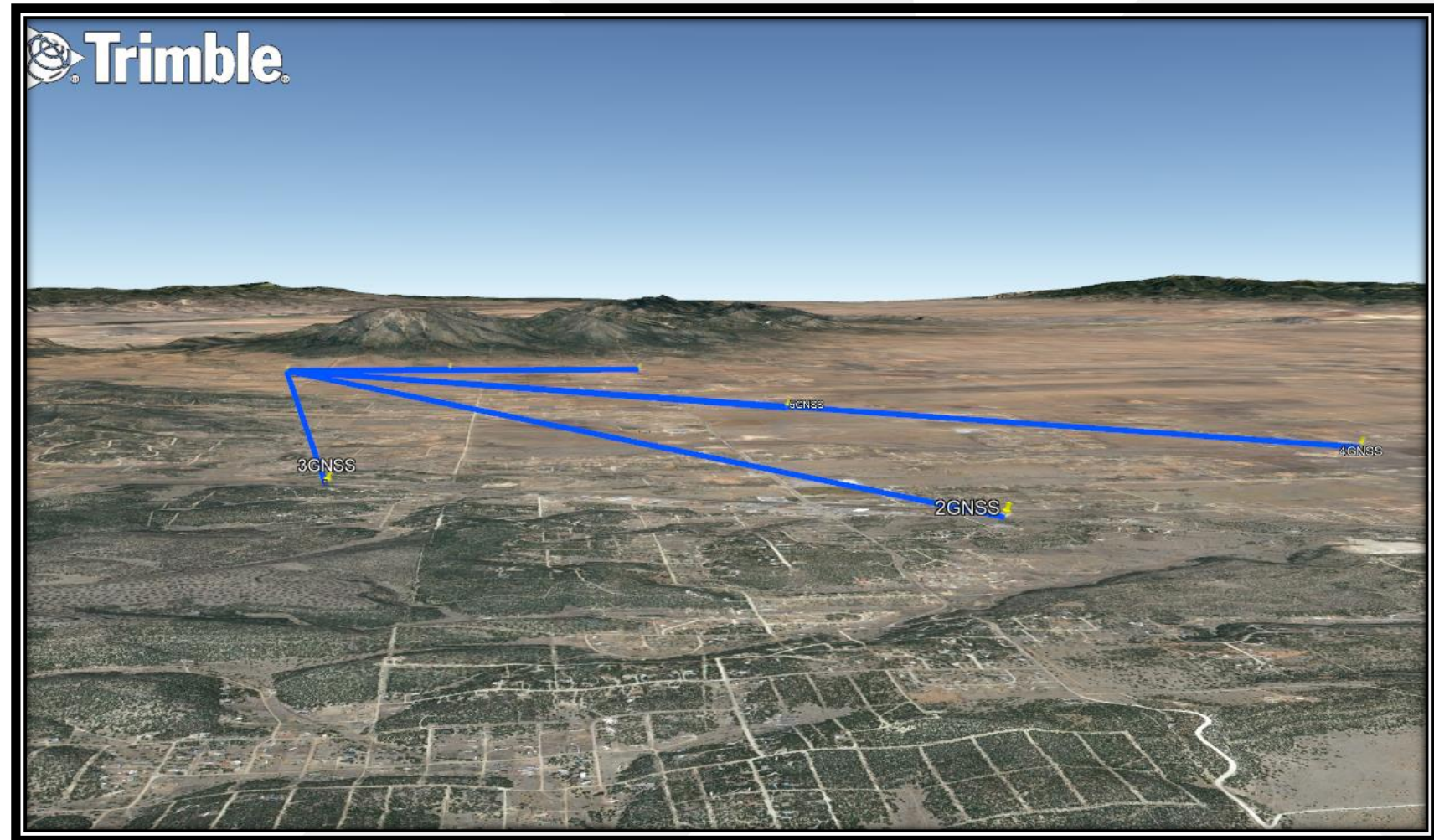
e = Orthometric Height
H = Ellipsoid Height
N = Geoid Height
e = H - N

The Geoid

Earth's Surface

Ellipsoid
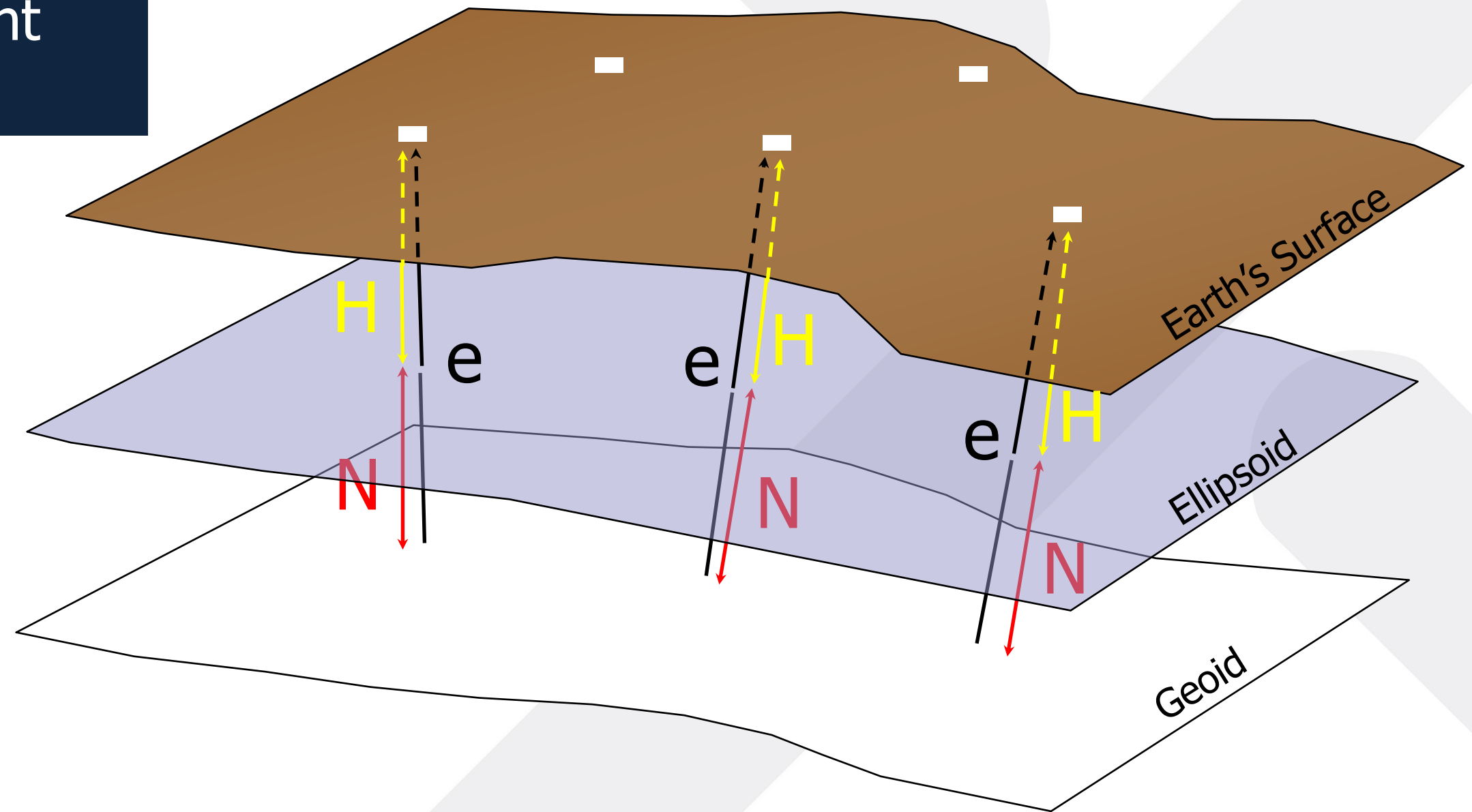
Geoid

The Geoid Model

- A gridded surface that approximates the Geoid
- Some commonly used Geoid Models:
  - Geoid 03
  - Geoid 09
  - Geoid 12B
  - Geoid 18
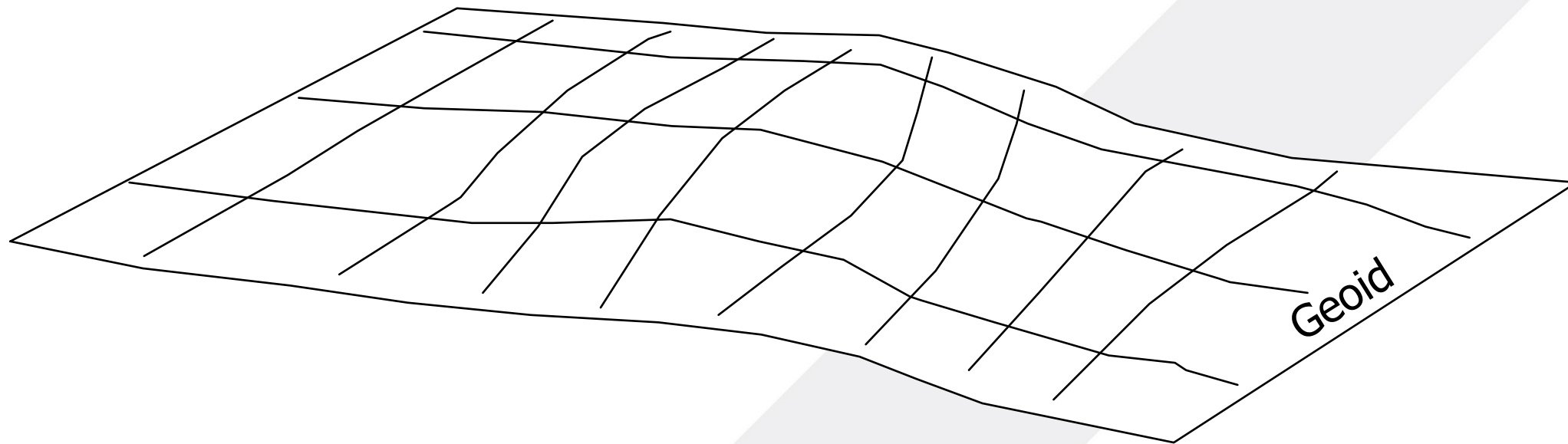
Geoid

Geoid 18 Converted .GRD File


```
24.000000   58.000000   -130.000000 -60.000000 0.016667  0.016667

-39.715    -39.737    -39.759    -39.780    -39.801    -39.820
-39.839    -39.856    -39.873    -39.890    -39.909    -39.930
-39.952    -39.974    -39.997    -40.019    -40.041    -40.063
-40.084    -40.106    -40.127    -40.148    -40.170    -40.192
-40.214    -40.235    -40.257    -40.277    -40.297    -40.316
-40.334    -40.352    -40.369    -40.388    -40.407    -40.428
-40.450    -40.472    -40.496    -40.519    -40.542    -40.564
-40.585    -40.605    -40.624    -40.641    -40.659    -40.677
-40.697    -40.720    -40.746    -40.775    -40.806    -40.840
-40.873    -40.906    -40.937    -40.966    -40.993    -41.017
-41.039    -41.060    -41.082    -41.104    -41.127    -41.151
-41.175    -41.199    -41.220    -41.237    -41.251    -41.262
-41.271    -41.280    -41.289    -41.300    -41.314    -41.331
-41.350    -41.371    -41.394    -41.418    -41.443    -41.468
-41.495    -41.523    -41.552    -41.582    -41.613    -41.643
-41.673    -41.701    -41.727    -41.751    -41.773    -41.794
-41.812    -41.830    -41.847    -41.863    -41.879    -41.894
-41.909    -41.923    -41.936    -41.949    -41.962    -41.975
-41.987    -42.001    -42.014    -42.028    -42.041    -42.055
-42.069    -42.083    -42.097    -42.111    -42.126    -42.143
-42.160    -42.179    -42.198    -42.219    -42.239    -42.260
-42.281    -42.300    -42.319    -42.336    -42.352    -42.367
-42.382    -42.396    -42.411    -42.426    -42.441    -42.455
-42.468    -42.481    -42.493    -42.504    -42.515    -42.527
```
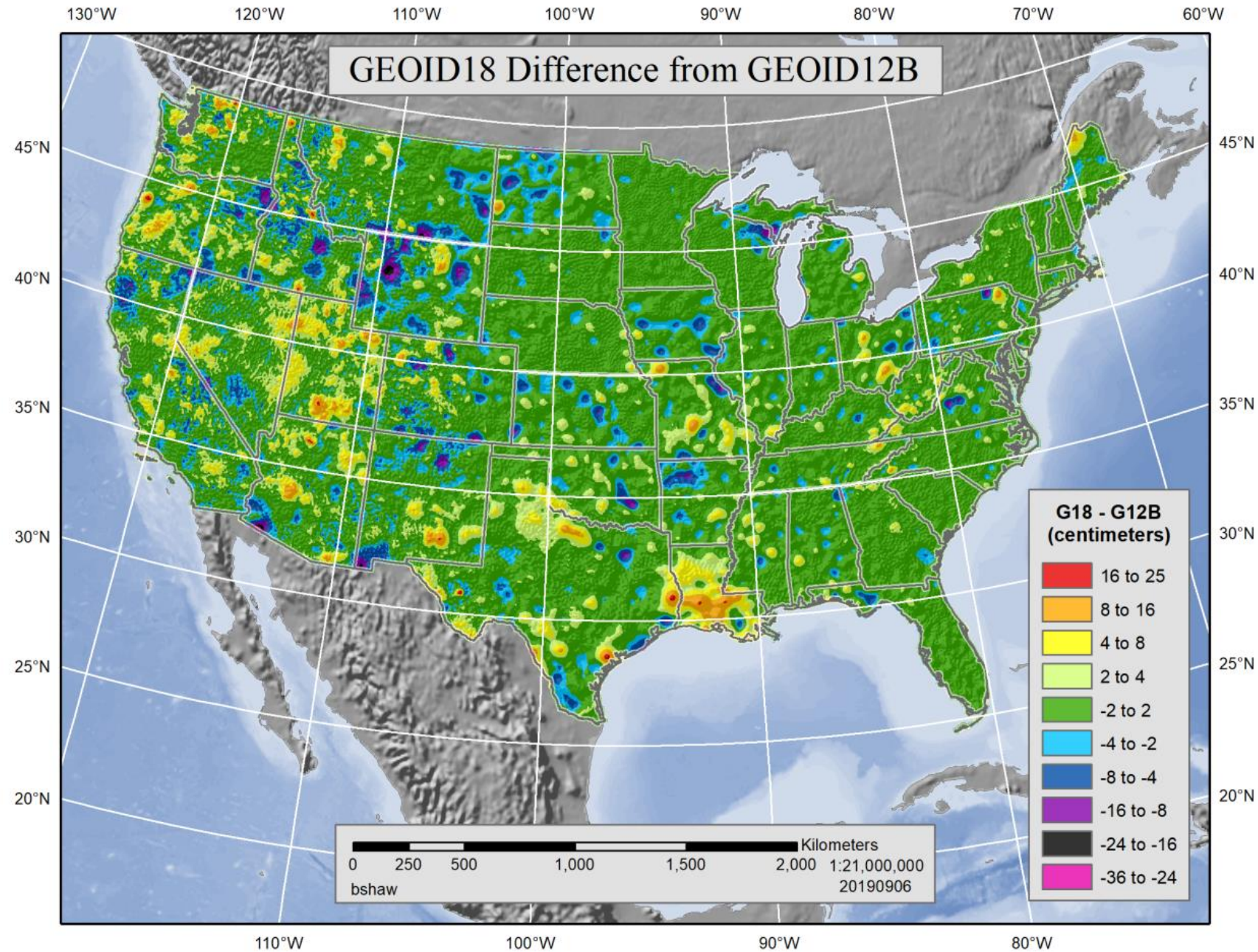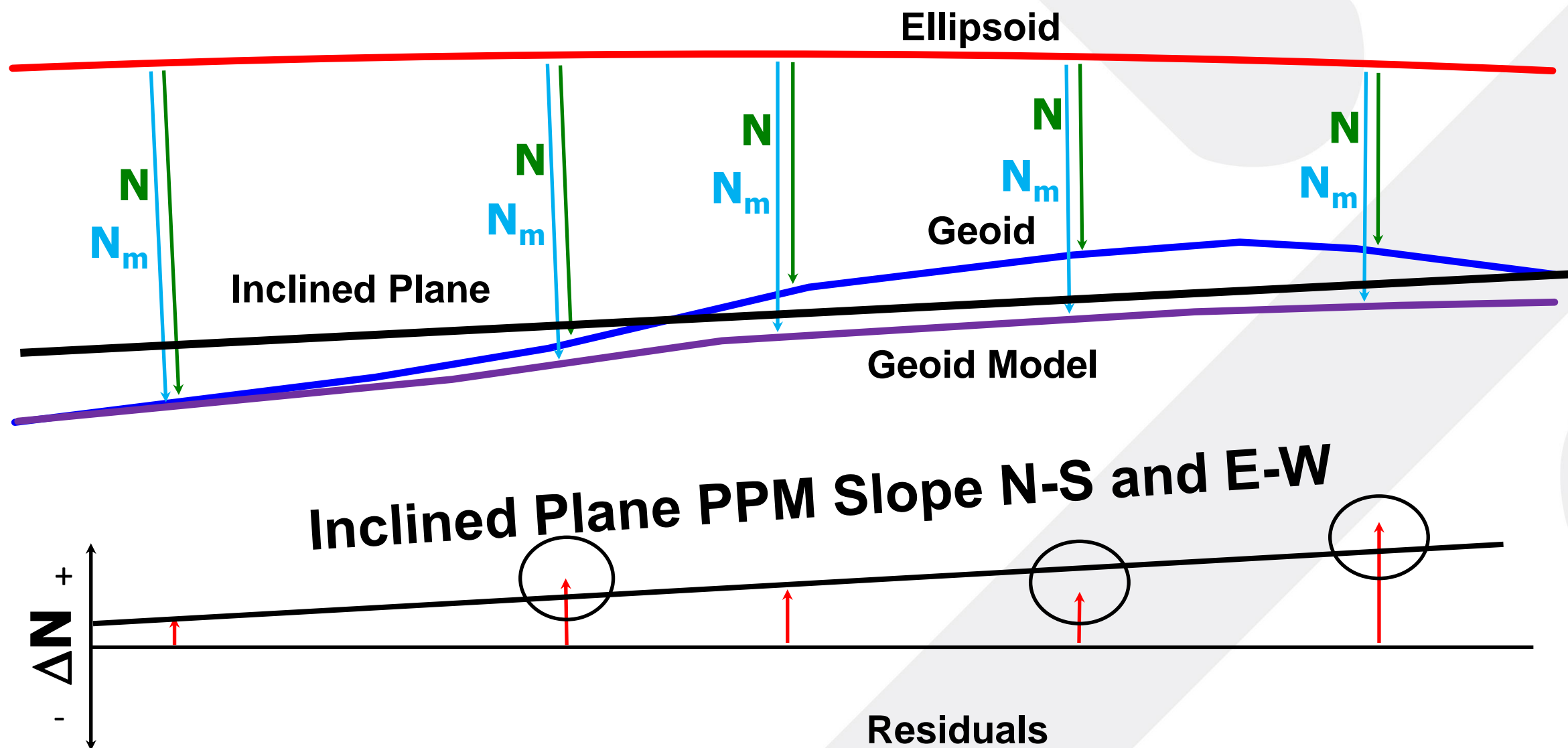
Site Calibration Routine
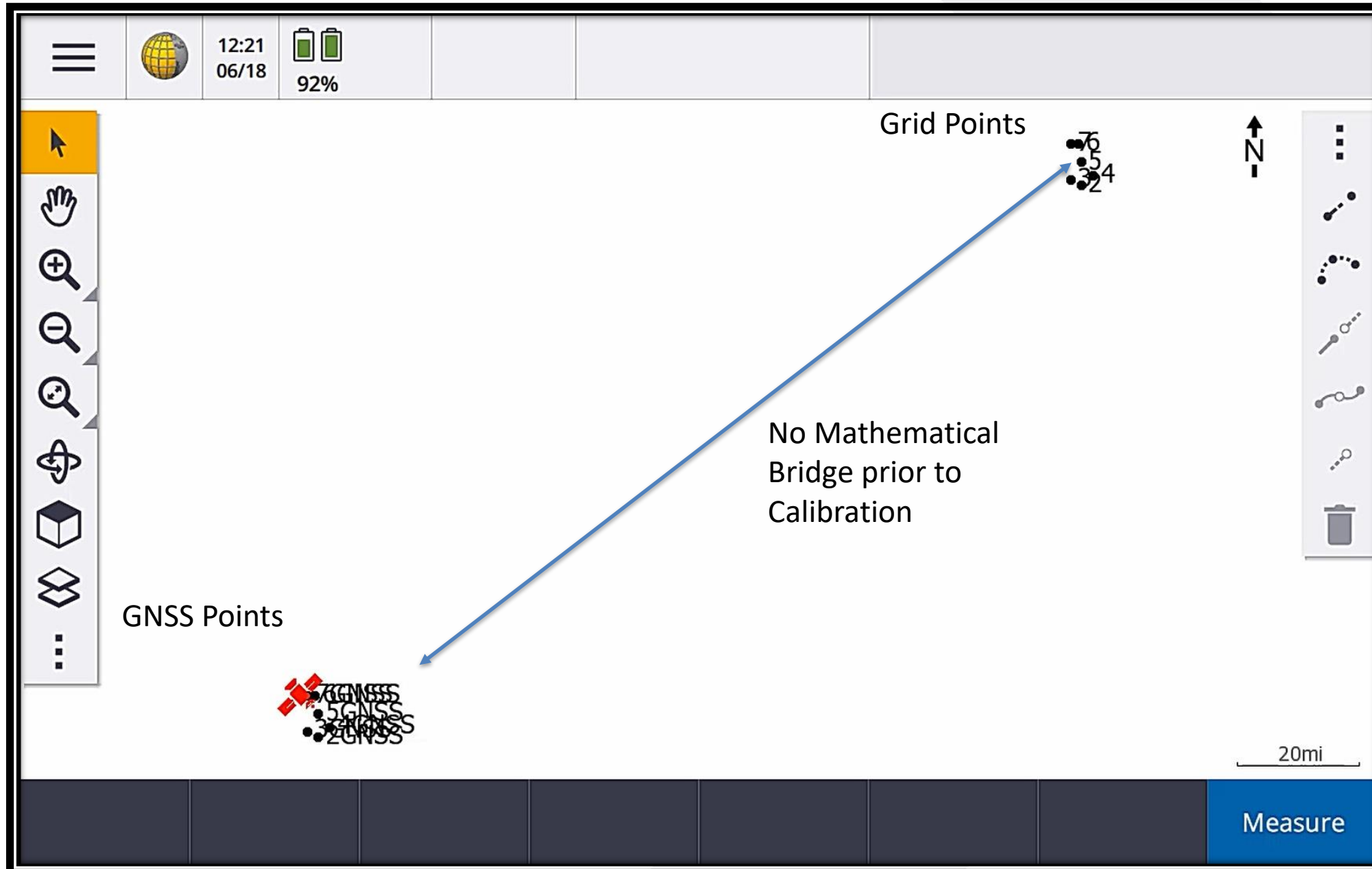
Site Calibration Routine

Trimble Access

← Calibration point

Grid point name | Code
5 ▶ | SF 83

GNSS point name | Code
5GNSS ▶ | SF83

Use
Horizontal & vertical ▼

Off

Vertical only

Horizontal only

Horizontal & vertical

- First Point Pair Defines Projection
- Should be on N-S Center of Project
- Adding Additional Point Pairs will NOT Alter Projection Parameters

Site Calibration Routine

Site Calibration Report

GPS Calibration Report

Job name:	Site Calibration Training Data	Trimble General Survey version:	20.00
Creation date:	2020-06-18	Distance/Coord units:	US survey feet
Geoid model:	GEOID18 (Conus) Fixed	Project location height:	6600.000

Projection Parameters

Projection type	Transverse Mercator
Origin latitude	35°06'46.55987"N
Origin longitude	106°10'57.51634"W
False northing	496399.477sft
False easting	660553.705sft
Scale	1.00000000
South azimuth	No
Grid coordinates	Increase North-East
Local ellipsoid semi-major axis	20925604.474sft
Local ellipsoid flattening	1/298.25722

Geodetic and Grid value of first Point Pair in Calibration

Datum Transformation Parameters

Transformation type	3 Parameter
Translation X	0.000sft
Translation Y	0.000sft
Translation Z	0.000sft
Source ellipsoid semi-major axis	20925604.474sft
Source ellipsoid flattening	1/298.25722

In almost all cases Translation should be all zeros

Horizontal Adjustment Parameters

Northing coordinate of rotation center	490252.705sft
Easting coordinate of rotation center	658747.624sft
Rotation about the center point	-0°02'19"
Translation north	-1.206sft
Translation east	4.137sft
Scale factor	0.99999335

Mathematical center of project control

Normally 1.0000000 but we applied a very, very small scale.

Vertical Adjustment Parameters

Northing coordinate of origin point

Site Calibration Report

Vertical Adjustment Parameters

Northing coordinate of origin point	496399.449sft
Easting coordinate of origin point	660553.677sft
Vertical separation at origin	4.935sft
Slope north	0.641ppm
Slope east	1.065ppm

First vertical point used in Calibration.
When using a Geoid Model these PPM's Should be small.

Geoid Model Definition

GEOID18 (Conus) Fixed

Residual Differences Between GPS And Known Coordinates

Summary

	Maximum error	Root Mean Square error	Point
Horizontal	0.052sft	0.012	3GNSS
Vertical	0.027sft	0.005	5GNSS
Three-dimensional	0.052sft	0.013	3GNSS

Never Changes   **Changes subject to Calibration**   **Never Changes**

Point Residuals

GPS point		Calculated point		Control point	
Point	5GNSS			Point	5
Latitude	35°06'46.55987"N	Northing	496399.449sft	Northing	496399.477sft
Longitude	106°10'57.51634"S	Easting	660553.677sft	Easting	660553.705sft
Height	6492.666sft	Elevation	6561.731sft	Elevation	6561.758sft
		Horizontal error	0.040sft	Type	Horz and Vert
		Vertical error	0.027sft	Point quality	Survey quality
		3D error	0.049sft		
Point	2GNSS			Point	2

AVAILABLE ON-DEMAND TRAINING COURSES

FRONTIER PRECISION | **ON-DEMAND TRAINING**

Introduction to GNSS Surveying: **FREE** | Trimble RTX – The Next Utility: **FREE** | GNSS Modernization: **FREE**

Understanding & Incorporating NGS OPUS Solutions: **$75.00** *(1.5 hours)*

How to Prepare for the NGS 2022 Datum: **$75.00** *(1.5 hours)*

Capitalizing on RTK & Infill in Trimble Access: **$75.00** *(1.5 hours)*

GNSS Site Calibrations in Trimble Access: **$125.00** *(2.5 hours)*

Trimble Business Center - Getting Started: **$225.00** *(4.5 hours)*

Trimble Business Center - CAD Functions: **$195.00** *(4.5 hours)*

Feature Coding in Trimble Access & Trimble Business Center: **$195.00** *(4.5 hours)*

Introduction to Baseline Processing & Network Adjustments: **$195.00** *(3 hours)*

Trimble Business Center - Surface Models: **$150.00** *(3 hours)*

Trimble Business Center - Scanning Module: **$250.00** *(5 hours)*

www.frontierprecision.com/ondemand