SEILER
GEOSPATIAL DIVISION

Accuracy with GNSS
What are you getting?

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Seiler Instrument

What We Will Talk About Today

- What coordinate system should I use in my data collector
- Site Calibrations-what's up with that?
  - Tool of the Devil or a Useful Tool?
- Best Practices for Real Time observations
- How to improve confidence in a Real Time observation

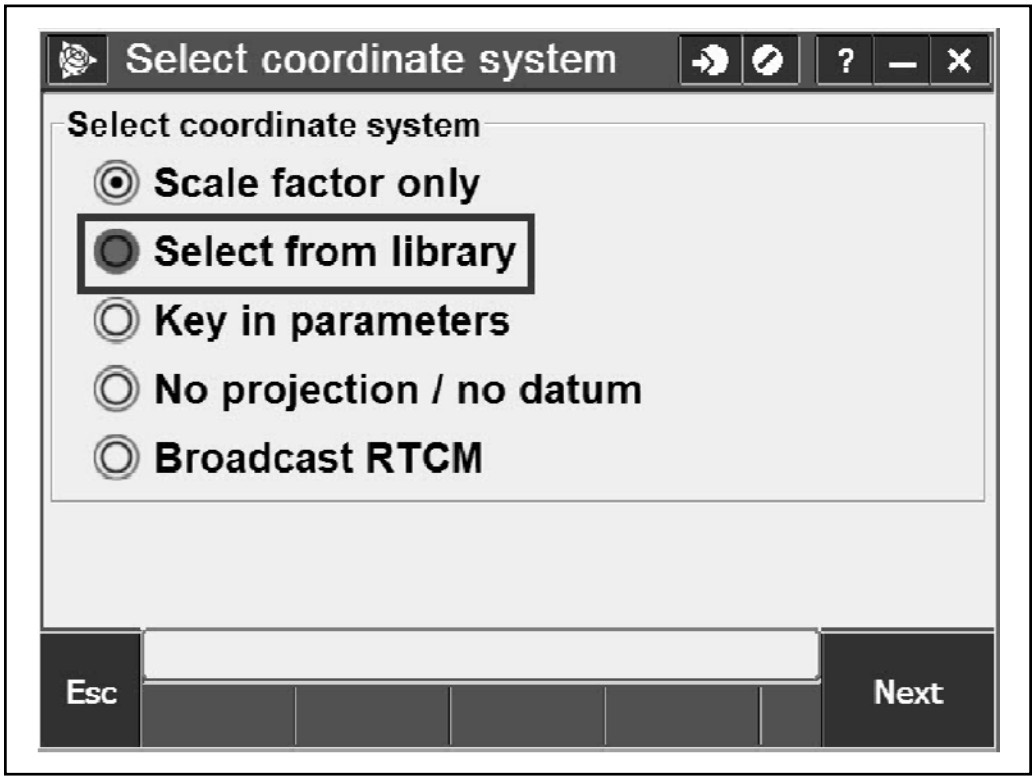
Coordinate Systems

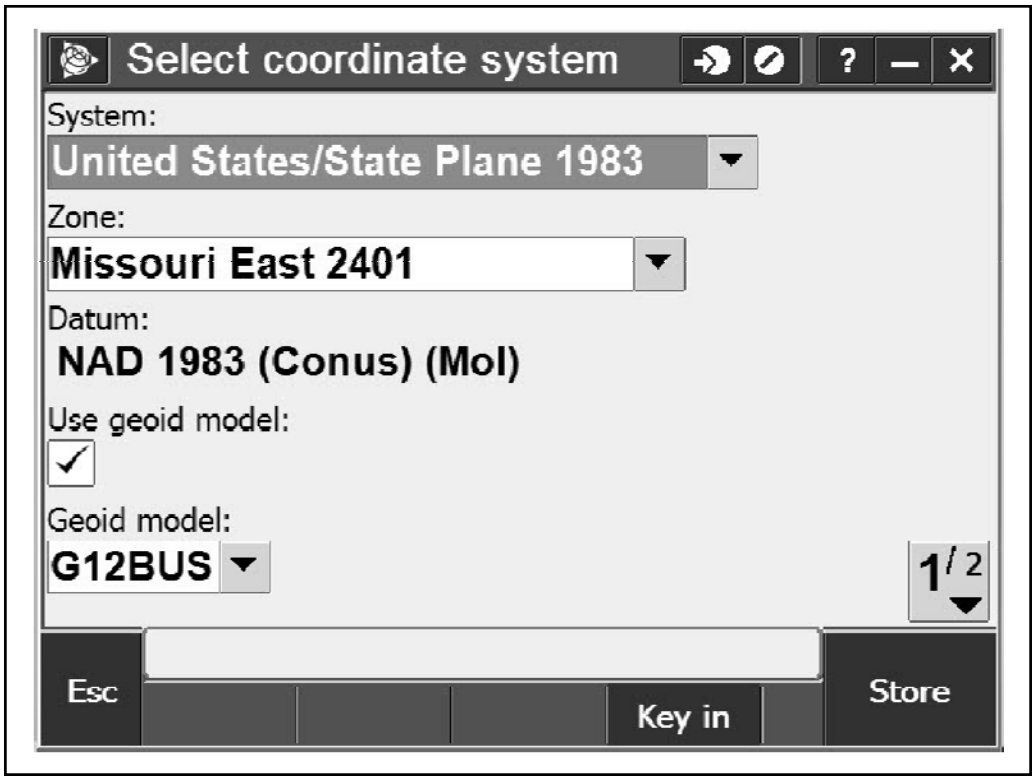
- Does it matter which one you choose?
  - Nothing matters until it does!
  - Everything is significant, but nothing matters…or is it the other way around? That nothing is significant but everything matters?
  - No Projection/No Datum
  - NAD83
  - UTM
  - Scale Factor 1

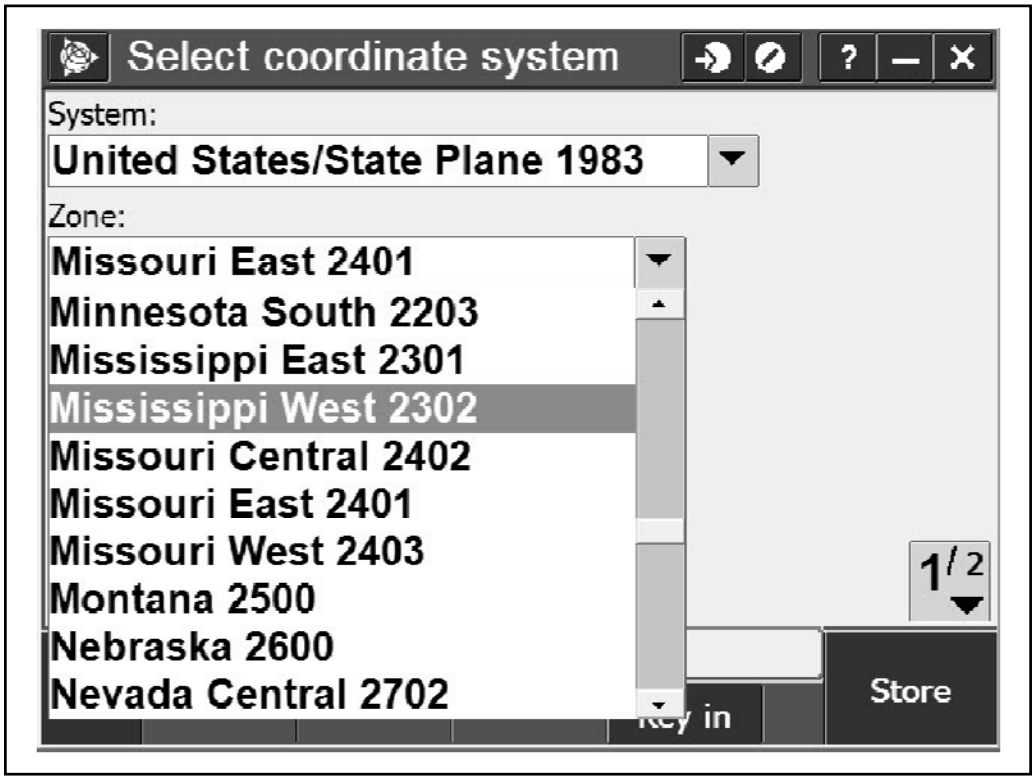

Trimble Access
2:09
kharris.SI
General Survey
Settings
AccessSync
Roads
Tunnels
Land Seismic
Level Me

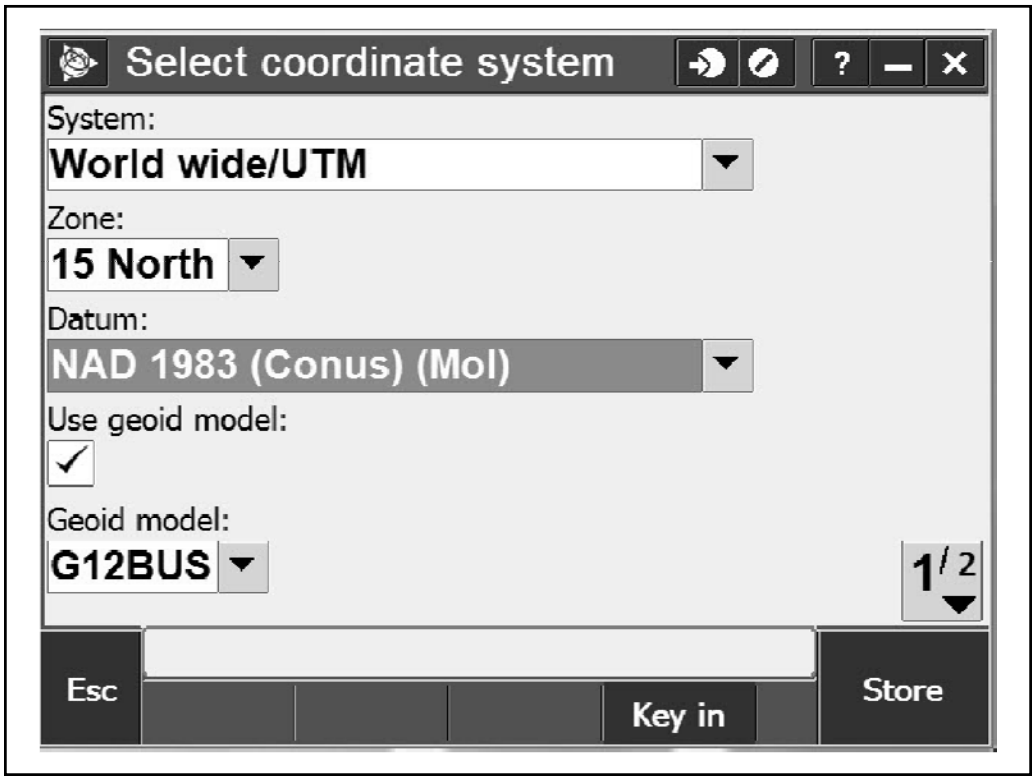

Job: test
Jobs
Key in
Cogo
Measure
Stakeout
Instrument
Map
Menu
Favorites
Switch to
Exit
Enter

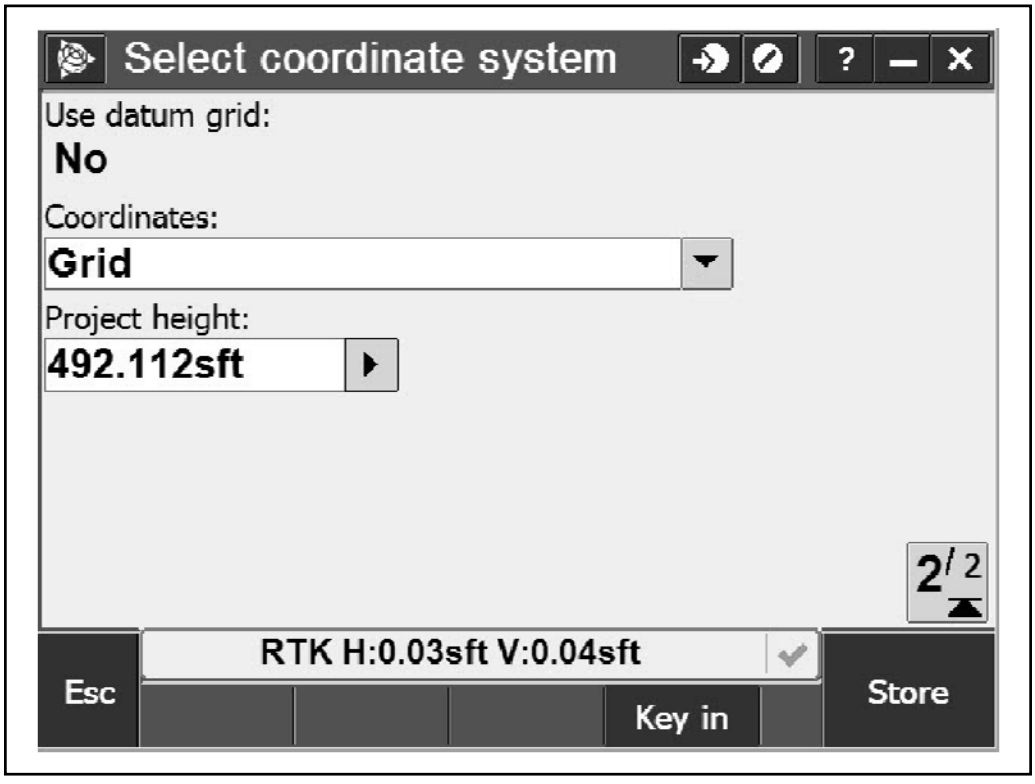

Jobs
New job
Map
Open job
Copy between jobs
Properties of job
Import / Export
Review job
Point manager
QC Graph
Back
Next


Select coordinate system
Select coordinate system
Scale factor only
Select from library
Key in parameters
No projection / no datum
Broadcast RTCM
Esc
Next


Select coordinate system
System:
United States/State Plane 1983
Zone:
Missouri East 2401
Datum:
NAD 1983 (Conus) (Mol)
Use geoid model:
Geoid model:
G12BUS
1/2
Esc
Key in
Store


Select coordinate system
System:
United States/State Plane 1983
Zone:
Missouri East 2401
Minnesota South 2203
Mississippi East 2301
Mississippi West 2302
Missouri Central 2402
Missouri East 2401
Missouri West 2403
Montana 2500
Nebraska 2600
Nevada Central 2702
1/2
Store


Select coordinate system
System:
World wide/UTM
Zone:
15 North
Datum:
NAD 1983 (Conus) (Mol)
Use geoid model:
Geoid model:
G12BUS
1/2
Esc
Key in
Store


Select coordinate system
Use datum grid:
No
Coordinates:
Grid
Project height:
492.112sft
2/2
RTK H:0.03sft V:0.04sft
Esc
Key in
Store

Site Calibrations

Purpose of a site calibration

- LLe to NEE
- Transformation
- Rotation
- Scale
- Best fit
- Set Scale Factor to 1?

Site Calibrations

- What coordinate system to start in
  - What difference it makes
  - No Projection/No Datum
  - NAD83
  - UTM
  - Scale Factor 1

Constraining to Passive Monuments

- Calibrations
- Localizations

Orthometric elevations (heights)

- Use four Benchmarks surrounding site PLUS the geoid model
- Use one Benchmark, use geoid model, check to another Benchmark
- Just use what comes out of the RTN
  - Why are my elevations off by 100 feet?
  - Probably should check at least one Benchmark if possible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Job: test
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Instrument
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Favorites
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Exit
Enter


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Open job
Copy between jobs
Properties of job
Import / Export
Review job
Point manager
QC Graph
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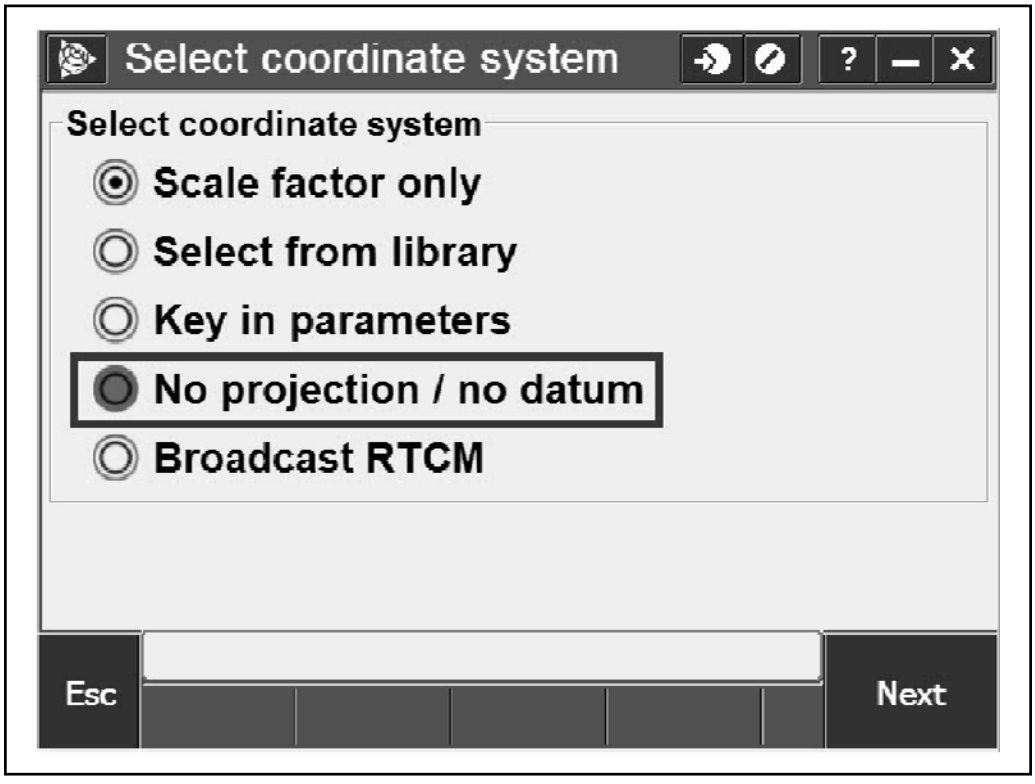
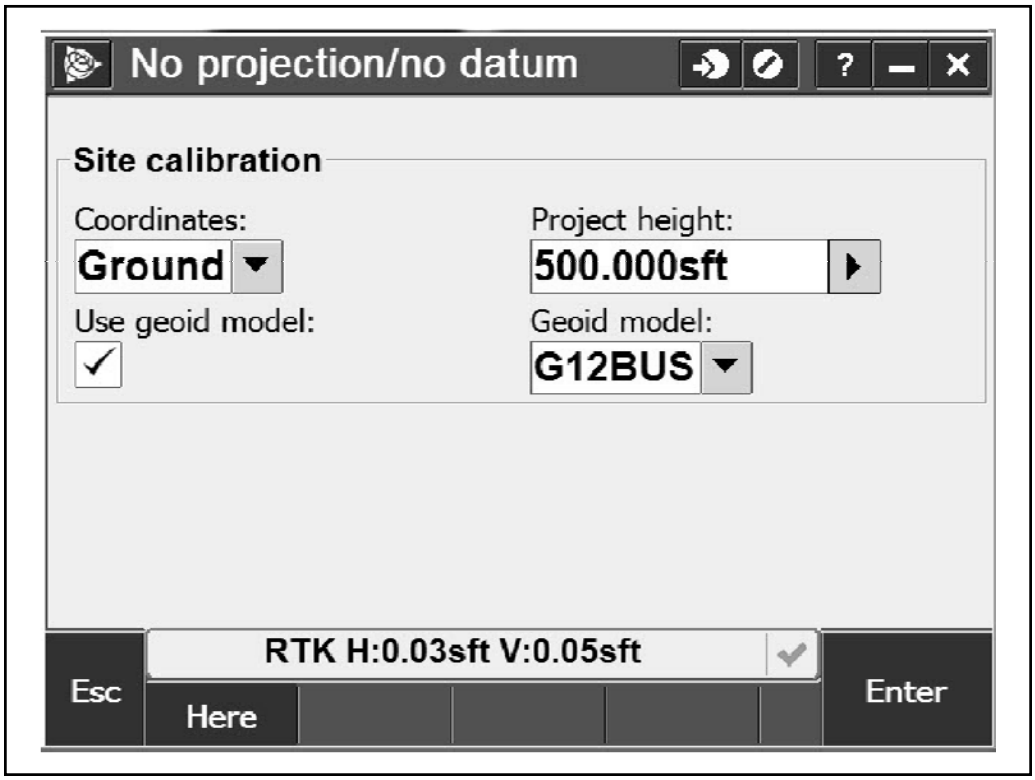

Select coordinate system
Select coordinate system
Scale factor only
Select from library
Key in parameters
No projection / no datum
Broadcast RTCM
Esc
Next


No projection/no datum
Site calibration
Coordinates:
Ground
Project height:
500.000sft
Use geoid model:
Geoid model:
G12BUS
RTK H:0.03sft V:0.05sft
Esc
Here
Enter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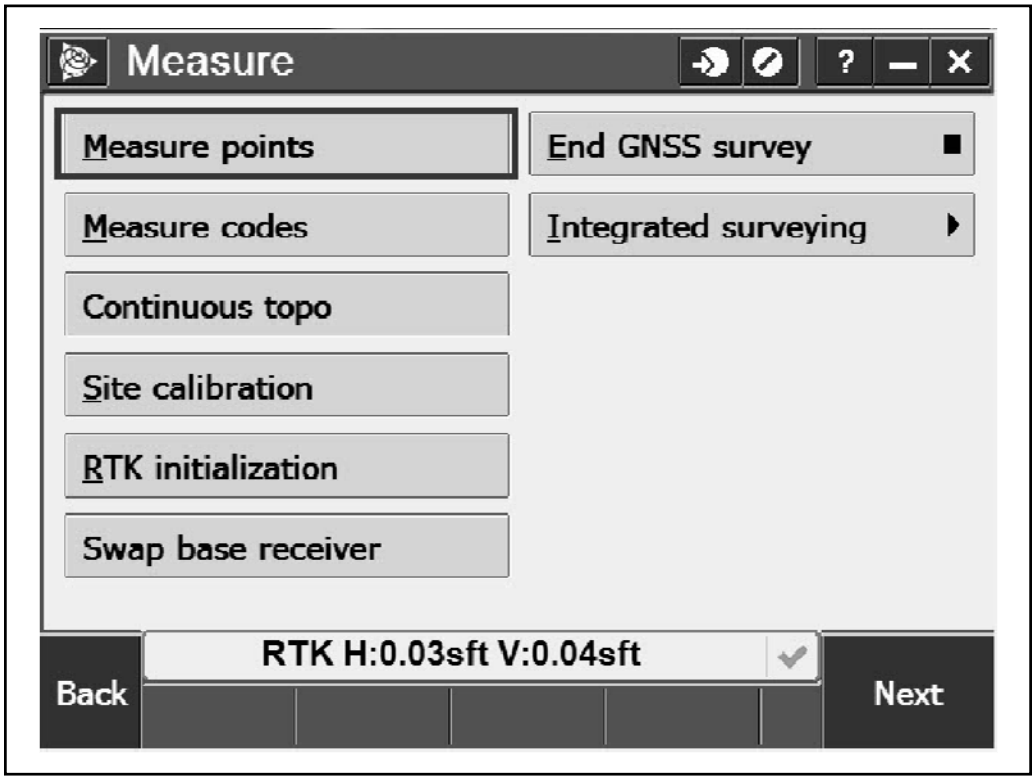
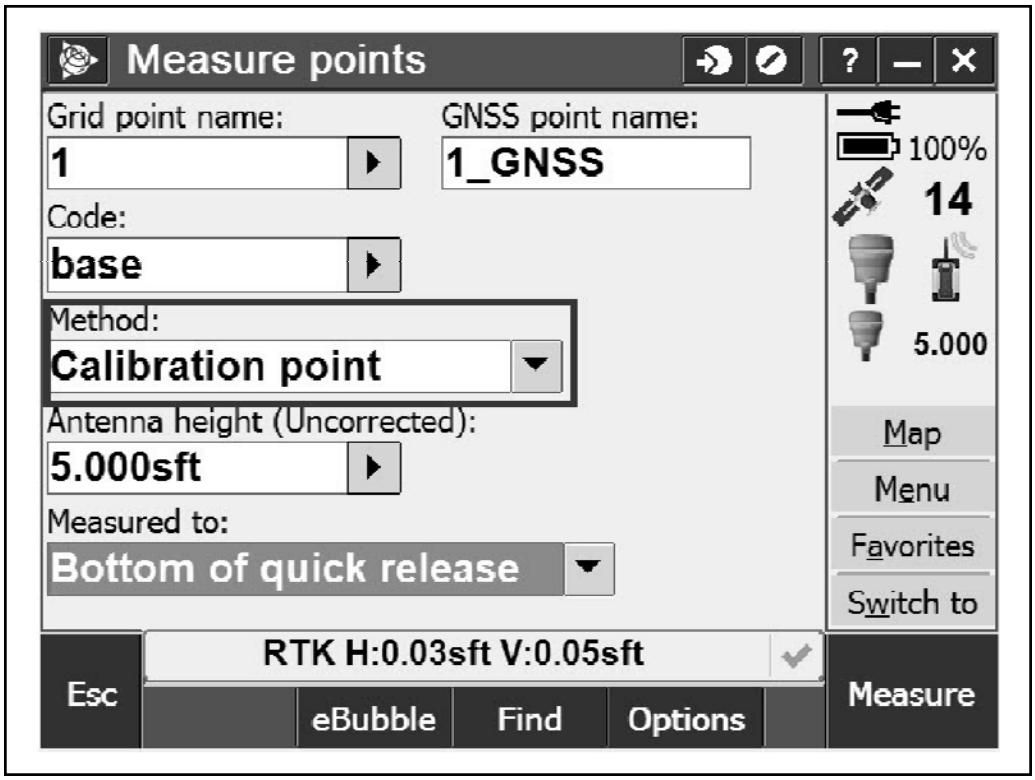
Job: msps
Jobs
Key in
Cogo
Measure
Stakeout
Instrument
100%
14
?
Map
Menu
Favorites
Switch to
RTK H:0.03sft V:0.04sft
Exit
Enter


Measure
Measure points
End GNSS survey
Measure codes
Integrated surveying
Continuous topo
Site calibration
RTK initialization
Swap base receiver
RTK H:0.03sft V:0.04sft
Back
Next


Measure points
Grid point name:
1
GNSS point name:
1_GNSS
Code:
base
Method:
Calibration point
Antenna height (Uncorrected):
5.000sft
Measured to:
Bottom of quick release
100%
14
5.000
Map
Menu
Favorites
Switch to
RTK H:0.03sft V:0.05sft
Esc
eBubble
Find
Options
Measure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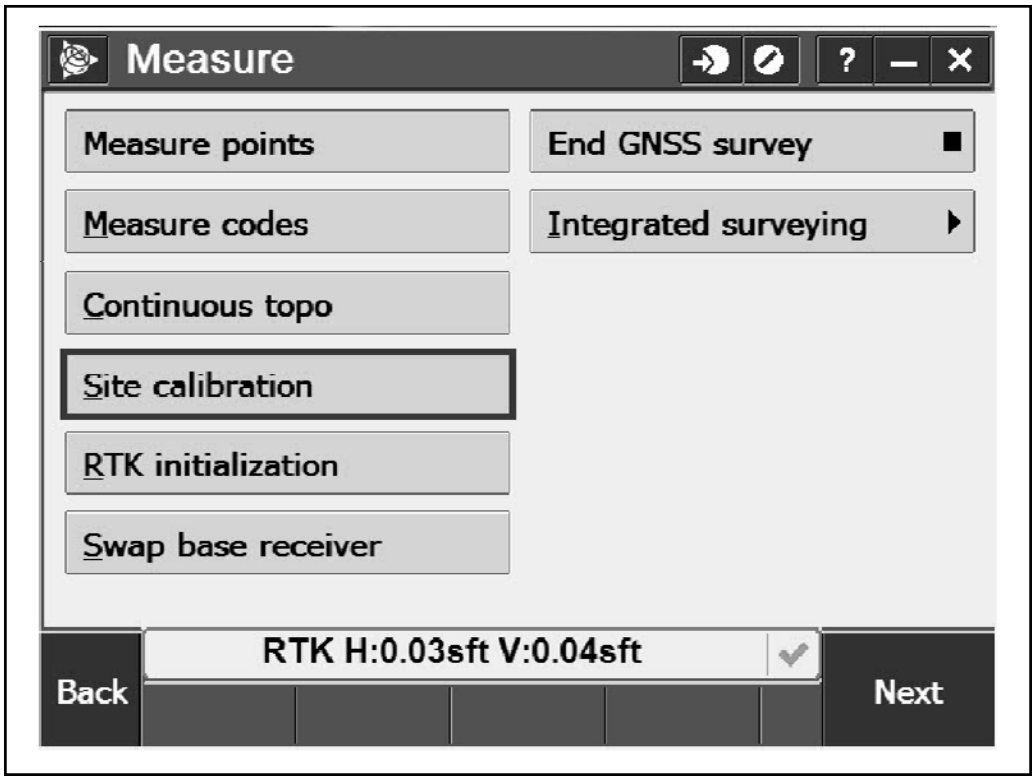
Measure
Measure points
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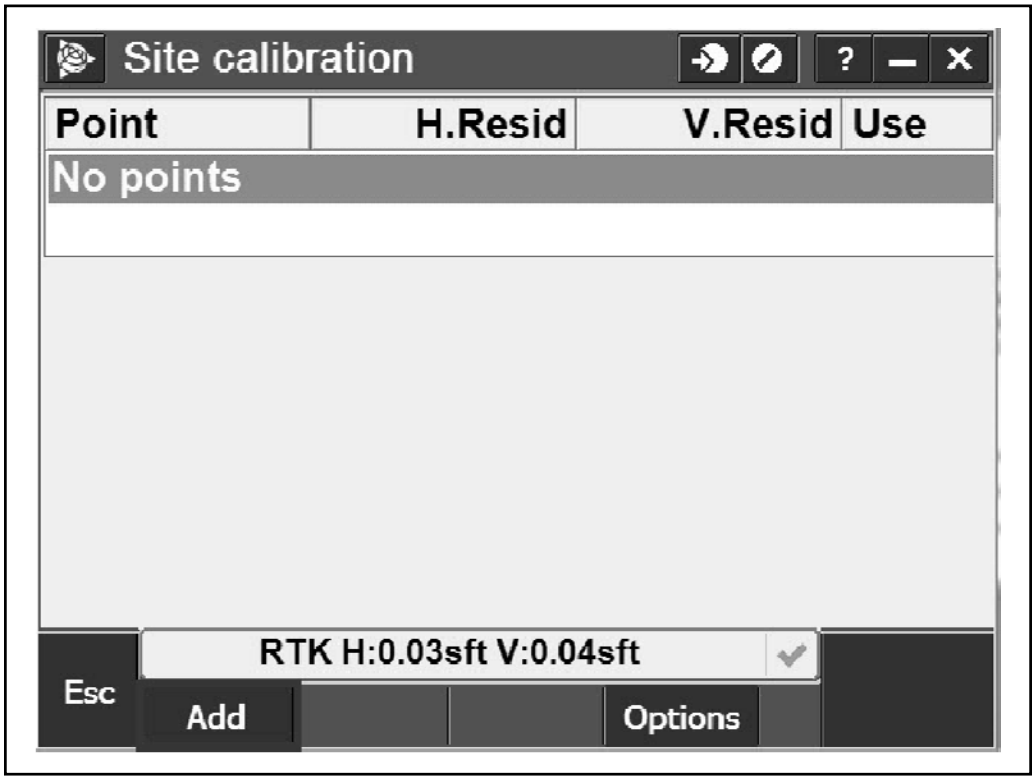
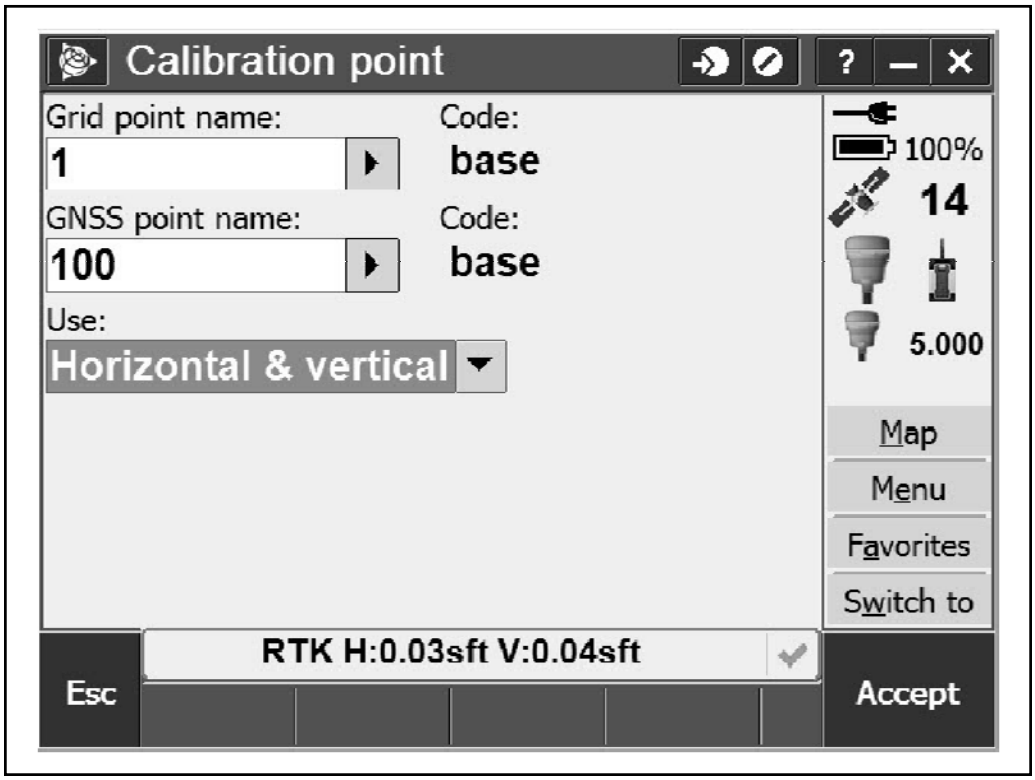
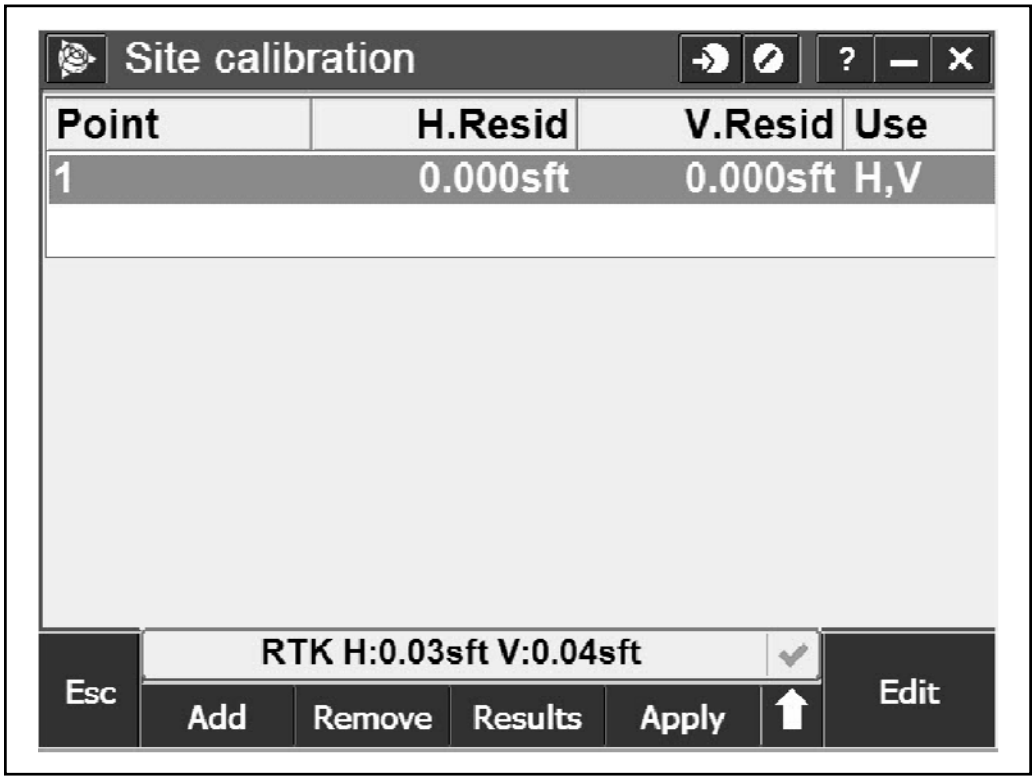
Site calibration
RTK initialization
Swap base receiver
RTK H:0.03sft V:0.04sft
Back
Next


Site calibration
Point
H.Resid
V.Resid
Use
No points
RTK H:0.03sft V:0.04sft
Esc
Add
Options


Calibration point
Grid point name:
1
Code:
base
GNSS point name:
100
Code:
base
Use:
Horizontal & vertical
100%
14
5.000
Map
Menu
Favorites
Switch to
RTK H:0.03sft V:0.04sft
Esc
Accept


Site calibration
Point
H.Resid
V.Resid
Use
1
0.000sft
0.000sft
H,V
RTK H:0.03sft V:0.04sft
Esc
Add
Remove
Results
Apply
Edit

Datum Used by MoDOT RTN

- NAD83 2011
- Old datum NAD83 CORS96 ended 15 October 2015
- Network broadcasts Latitude, Longitude and Ellipsoid heights
  - You choose your coordinate system in your data collector
  - Site Calibration
  - NOT tied to any vertical control (Checks very well with high quality Benchmarks)

Limitations of Classical RTK Survey

- Limited range from single reference station
- Potential gross error in establishing reference station
- Dependency on single reference station
- No integrity monitoring
- Productivity loss
- Security
- Communications
- Power supply

Benefits of a Reference Station Network

- Eliminate the need for local base stations
- Only GPS rover receivers are needed
- Less initial GPS expense because it doubles the number of GPS systems you have now
- No surveyor required to “watch” the base station
- Consistent known datum and coordinate system

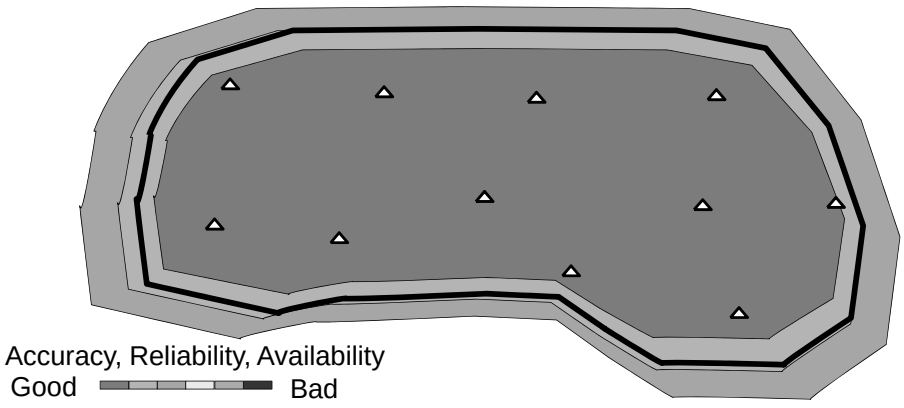
Correction Streams (Mount Points)

- RTCM
  - VRS_RTCM21
  - VRS_RTCM23
  - VRS_RTCM31
  - VRS_CMRplus
  - RTCM3Net_autocell
- VRS
  - VRS_CMRplus
  - VRS_CMRX
  - BOOTHEEL_CMRplus
  - BOOTHEEL_CMRx

What do you see in your data when you choose…

- VRS_CMR?
- VRS_RTCM?
- Any advantage to one or the other?

Reference Station Network (RTN)



RTN Equipment Needed

- Dual frequency GNSS rover receiver
- Data collector
- Communications device to access the internet
- Appropriate accessories

Communication is the Key

- Cell phone…. Bluetooth or old school cable
- Internal modem in receiver
- Internal modem in data collector

Communication is the Key (2)

- Intuicom RTK Bridge
- WiFi Hotspots
  - MiFi devices
  - Phones
  - Other WiFi's
- Without the communication link…VRS is not possible

Choose Your Wireless Provider

- Pick whoever has the best coverage in your area
- Maps are VERY generalized
- Only way to really know which carrier has best coverage is to test it yourself…

How Much Data Does a VRS Connection Use?

- Here is approximately what you could expect using CMR+ with 14 SVs for 8hrs straight:
- 1 sec: 310bytes
- 1 min: (310bytes x 60) = 18.6KB
- 1 hour: (18.6KB x 60) = 1.11MB
- 8 hrs: (1.11MB x 8) = 8.93MB
- 5GB (typical plan amount): 24/7 for 30 days

Best Methods for RTN Users

- Check Equipment, Data Collector Parameters & Site information
- Conditions
- Coordinates
- Communication
- Constraining to passive monuments (a.k.a. Calibrations or Localizations)
- Collection
- Confidence

Check Equipment and Parameters

- Measure the actual height of the antenna reference point (ARP) on the rover pole
- Ensure that all necessary and correct projection parameters are in the data collector
- Ensure that all project data are in the data collector
- Adjust the rover pole bubble before every campaign

Check Equipment (cont)

- Test wireless data communications (cell/CDMA/SIM card/etc.) for Internet connectivity at the project site.
- Make sure the GNSS unit and the communication device batteries are fully charged and that there are backups.
- For orthometric heights, be sure to preload the current geoid model supplied by the NGS

Coordinates

- Know what datum, adjustment and epoch is needed for the coordinate data produced
- Know what datum, adjustment and epoch coordinates are supplied by the RTN
- Grid or Ground?


Job: test
Jobs
Key in
Cogo
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Instrument
Map
Menu
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Switch to
Exit
Enter


Jobs
New job
Map
Open job
Copy between jobs
Properties of job
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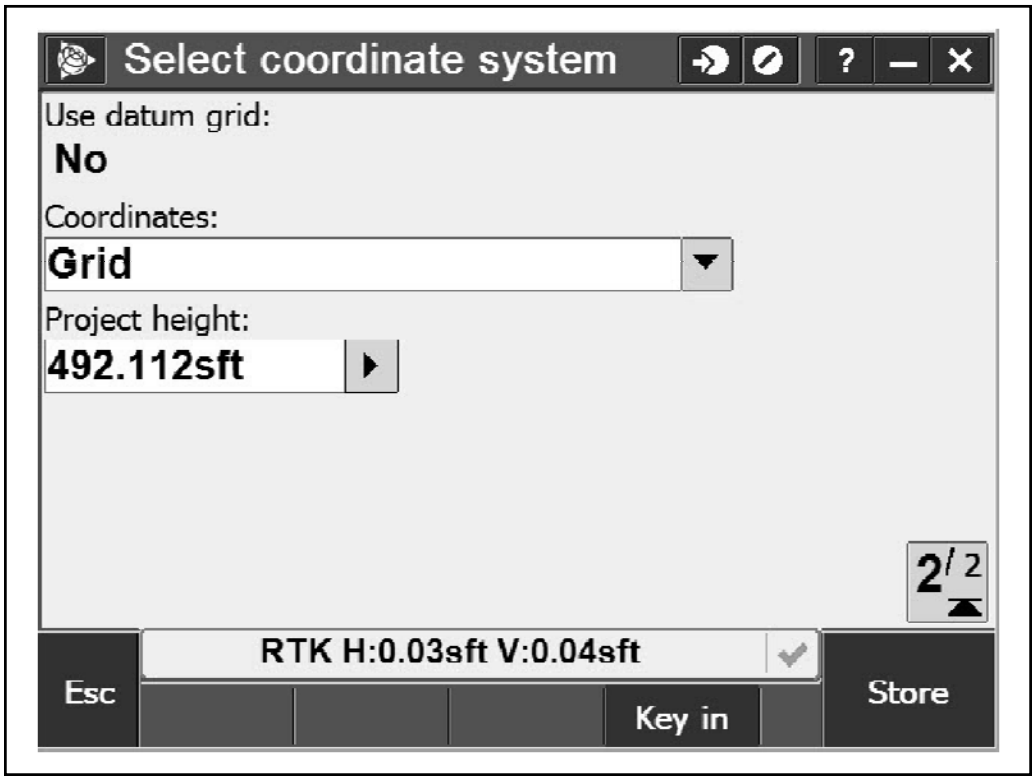
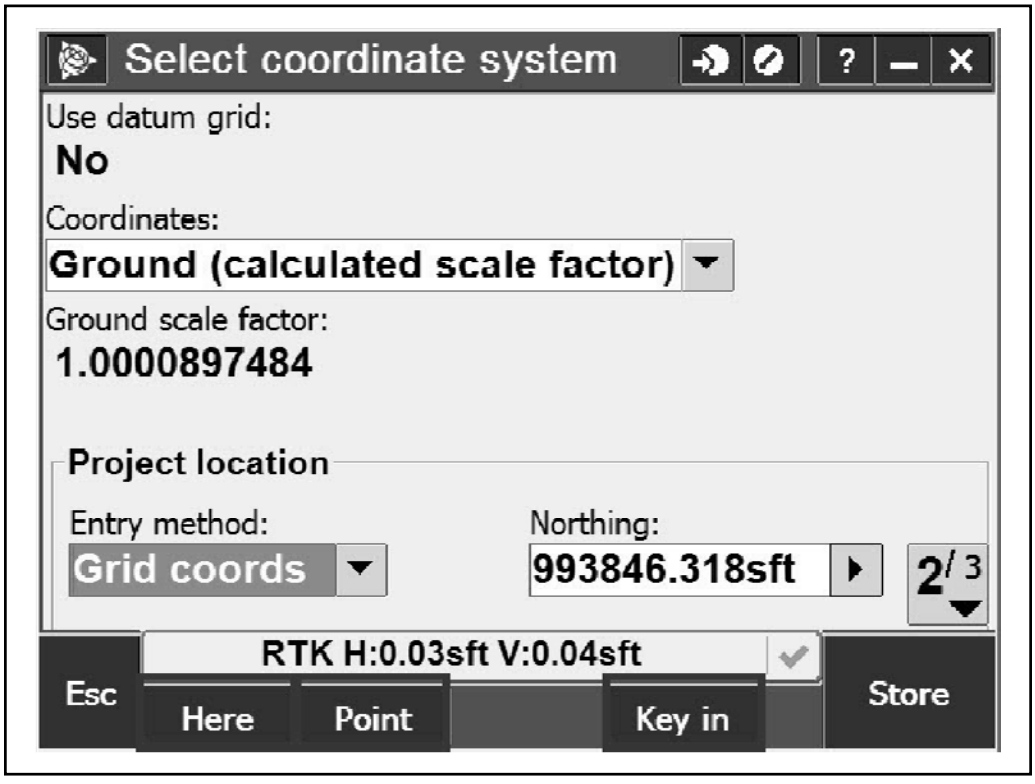
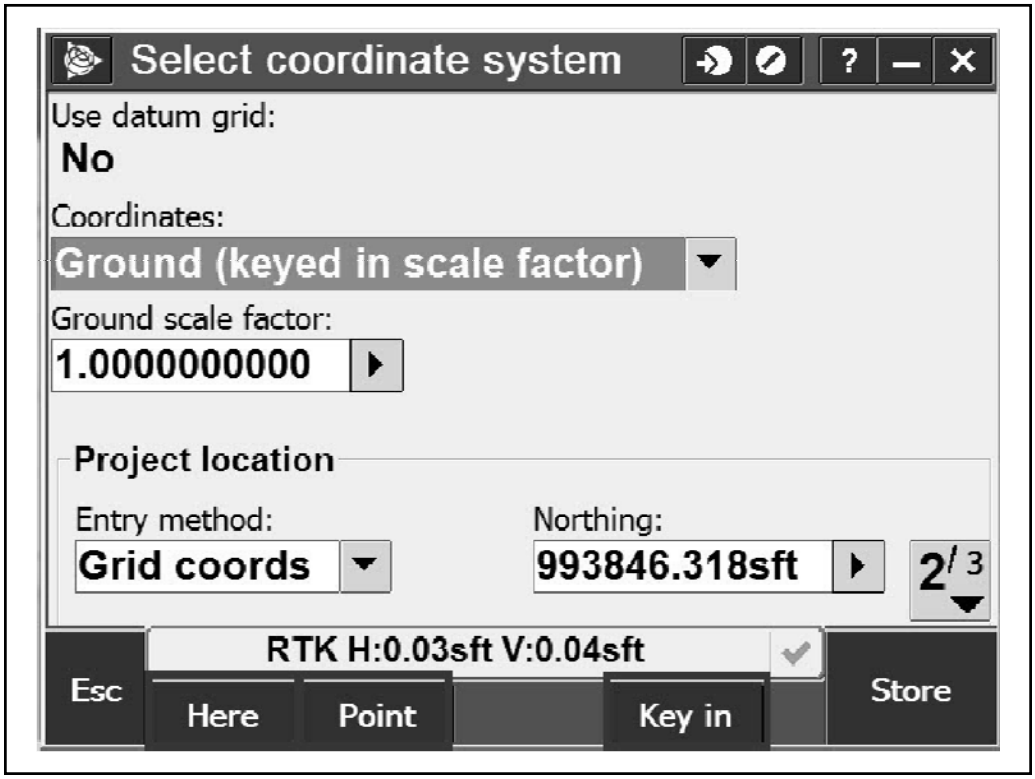
Next


Select coordinate system
Use datum grid:
No
Coordinates:
Grid
Project height:
492.112sft
2/2
RTK H:0.03sft V:0.04sft
Esc
Key in
Store


Select coordinate system
Use datum grid:
No
Coordinates:
Ground (calculated scale factor)
Ground scale factor:
1.0000897484
Project location
Entry method:
Grid coords
Northing:
993846.318sft
2/3
RTK H:0.03sft V:0.04sft
Esc
Here
Point
Key in
Store



Communication

- Robust communication is the key to an effective RTN
- Wireless internet from a variety of sources lets you roam anywhere within an RTN
- Many options
- The GNSS solution at a point of interest should become fixed in a “normal” amount of time and should remain fixed for the duration of the actual data collection

Communication

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Confidence

- Redundancy is the king of RT GNSS positioning
  - Redundancy gives confidence and refines the precision of the data
- Robust wireless Internet connectivity
  - Coordinate accuracy will suffer if
    - Latencies rise above 2 seconds
    - Communication is intermittent during data capture
- Checks on known points
  - Before, During, After
- Obvious Multipath…avoid it

Best Methods for RTN Users - Summary

- Four basic elements to achieve reliability
  - Communication
  - Checks
  - Redundancy
  - Multipath
- Good GNSS gear, good field conditions and good field procedures will yield good Real Time positions

How to Ensure Accuracy in Real Time Solutions

- What is a real time (RTN) shot?
- How can you add redundancy to your work?

An RTK Shot is a Radial Sideshot

- Need to measure it more than once to know for sure that it is right…
- How do we achieve redundancy using RTK?
  - Measure it more than once
  - Measurements separated by time
  - Change in the satellite constellation

Redundancy

- Store raw data at selected locations
  - Submit to OPUS
- If setting two points for control
  - Measuring between them with a total station (or tape) is an excellent check
- You can store more than one observation, and post process and adjust in office software.

How Much Time Between Observations?

- Ideally…four hours
- How big is your budget on the job?
- Studies have shown
  - For precise work where the height component is important, observe for three minutes and then another three minutes
  - A separation of 20 minutes gives a 10-20% improvement in coordinate accuracy
  - 45 minute separation gives a 15-30% improvement over a single epoch solution

If You Do Not Have Time…

- Measure your point
- “Dump” the antenna
- Let it reinitialize
- Measure again
  - Store as same number and look at differences
  - Store as a different number and inverse
- More of a “warm and fuzzy” check than anything…

Or…

- For practical reasons, most users cannot wait four hours between RTN observations due to cost and logistics.
- Record your first point measurement
- Force receiver to lose initialization
  - Raise elevation mask to 90 degrees
  - Change antenna height by 0.3 meters (0.98 feet - Longer than one wavelength of the GPS signal)

Or…

- Change antenna mask back to 10 degrees
- Do a “Known Point” initialization on the point you stored
  - If it does not succeed, the first shot probably wasn’t any good
  - Then measure again after 20 minutes to allow change in constellation

RTN Initialization

For example, on newer Trimble GNSS receivers

- Built in routine for RTN Initialization
  - Resets Satellite Tracking
  - Closes elevation mask to 90°
  - Lose all SVs
  - Reset mask to 10°
  - Regain SVs…Regain initialization
  - Can be added to a hot key
- Can be done manually on any receiver

A Best Practice

- Two “observed control” measurements for ALL SURVEY POINTS
- 1st observation – 60 seconds
- Re-initialize 10 m from last initialization
- Change antenna height by 0.30 m
- 2nd observation – 30 seconds
- If H & V deltas within 0.025 & 0.035 (m), “store as check”
- Time between observations is recommended – but not mandatory

In Summary…

- Takes longer to get to most points than it does to shoot them
- Longer observation is better
- Redundancy is better than longer observation
- I would rather see two 60 second shots than one 180 second shot
- NO single shots on important points
  - Just too many variables…

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