Accuracy with GNSS
What are you getting?

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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
Series of slides showing:

- Screen shots from collector of different tools/systems cases
- Discuss each one

Select coordinate system:

- Scale factor only
- Select from library
- Key in parameters
- No projection / no datum
- Broadcast RTCM
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
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

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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: 310 bytes
  - 1 min: \((310 \text{ bytes} \times 60) = 18.6 \text{ KB}\)
  - 1 hour: \((18.6 \text{ KB} \times 60) = 1.11 \text{ MB}\)
  - 8 hrs: \((1.11 \text{ MB} \times 8) = 8.93 \text{ MB}\)
  - 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?
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…