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GEOSPATIAL DIVISION

RTK GPS - Improving Your Chances for Success and Potential for Misuse

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What We Will Talk About Today

- Best Practices for Real Time observations
  - RTK Base and Rover
  - RTK Network Solution
- How to improve confidence in a Real Time observation

Life = RTK

- My story will basically be a list of dumbass stuff I did all along the way and how in most cases I lucked out and stayed on course, in spite of myself.

RTK

- We all know it works here…

RTK

- But what about here?

RTK

- Or here?

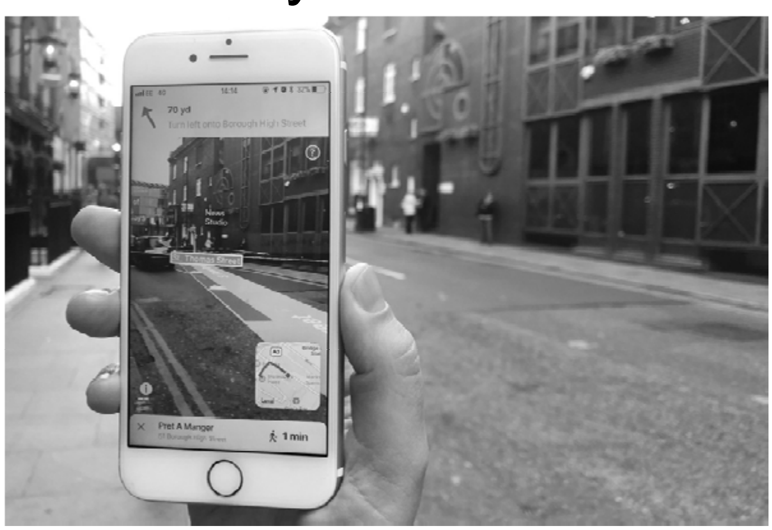
RTK

- Or even here?

RTK

- Opportunity for disaster
  - Multipath
  - Obstructions

What are the various GNSS systems?



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 Classical RTK Survey

- Single reference station
- Dependable, fixed single base point
- Simple, reliable radio communication
- No Internet!
- User control of base!
- More repeatable results

Real-Time Kinematic GNSS Survey Procedures

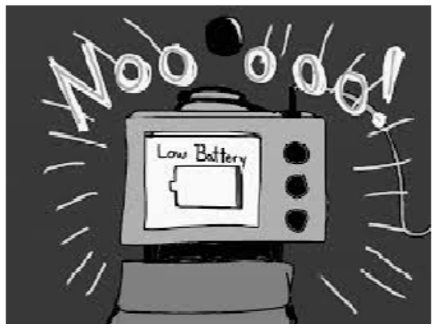
- Key points that apply to all RTK surveys
- Reliable communication between the base and rover is essential.
- When using a conventional base, the broadcast radio antenna should be raised to the maximum height possible.
- Use the appropriate radio antenna
  - 0 db (short) gives a circular pattern signal
  - 5 db (long) gives elongated elliptical signal

Real-Time Kinematic GNSS Survey Procedures

- A fully charged 12-volt battery should be provided.
- Poorly maintained equipment is a source of error and wasted time in any survey.
- All equipment associated with the GNSS survey including tripods, rods, batteries, cables, level vials, optical plummets, etc., shall be kept clean, fully charged, and in good operating order.

Real-Time Kinematic GNSS Survey Procedures

- Dead batteries and shorted cables are notorious for destroying an otherwise well-planned survey mission.



Real-Time Kinematic GNSS Survey Procedures

- Known points must be checked before, during, and after every surveying session.
- Multipath cannot be modelled with the short observation times used for RTK surveys and can induce errors

Real-Time Kinematic GNSS Survey Procedures

- RTK survey should not be performed during geomagnetic storms, passing of weather fronts, or if weather conditions are different at the base and rover.
- Adjust the base and rover circular level vial before every survey and check at regular intervals.

Real-Time Kinematic GNSS Survey Procedures

- When using conventional base-rover RTK, the base must be placed in a location that has unobstructed sky visibility in all directions above a 10-degree elevation angle.
- It is better to establish a new control point in a wide open area than use a known point that is partially obstructed.

Real-Time Kinematic GNSS Survey Procedures

- NGS's published User Guidelines for Single Base Real-Time GNSS Positioning (V 2.1, August 2011)
- Provides recommended best methods and background information intended to allow the user to obtain accurate, consistent three-dimensional positions using Single Base Real-Time GNSS techniques.

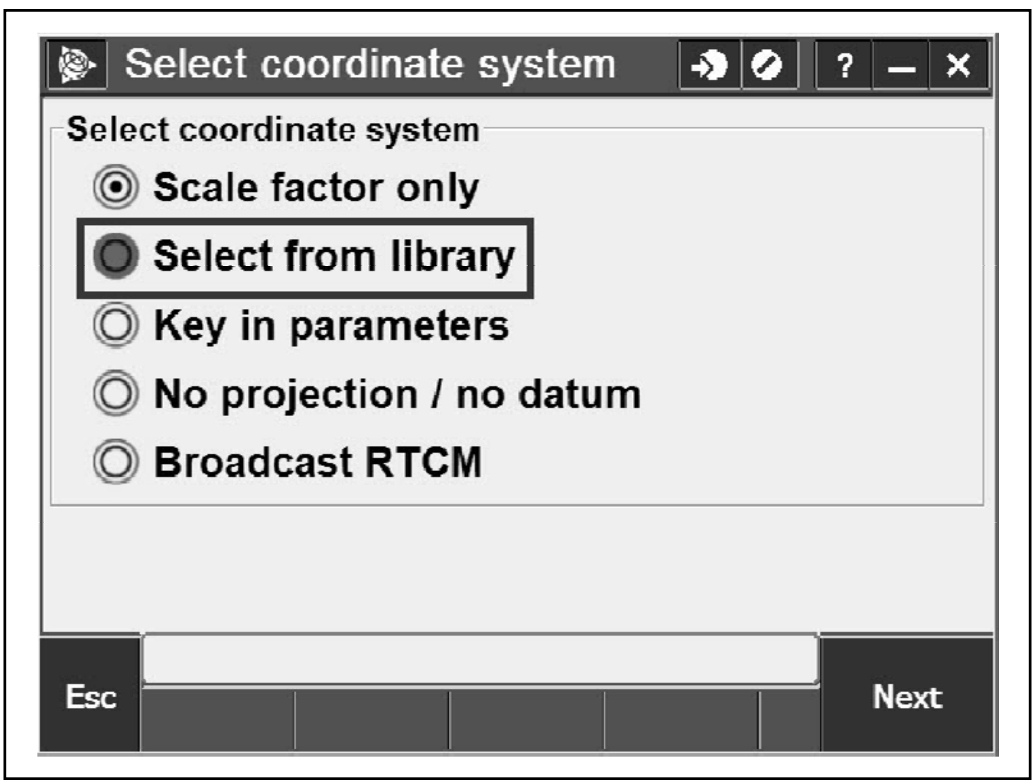
Coordinate Systems

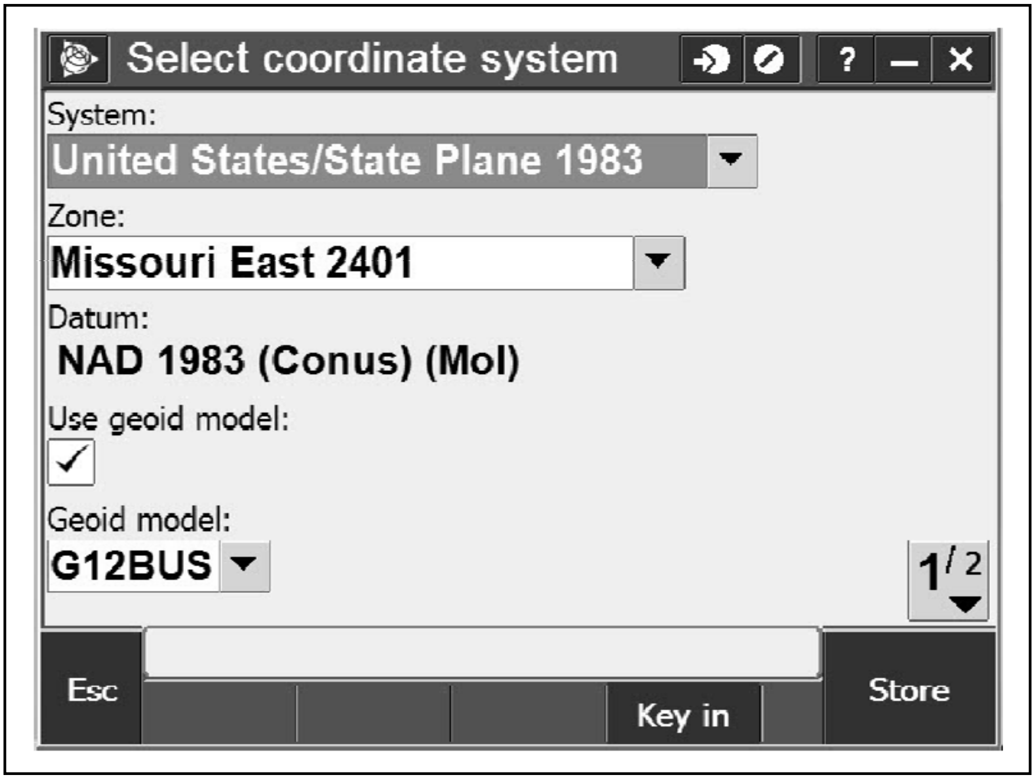
- Does it matter which one you choose?
  - Nothing matters until it does!
  - Everything is significant, but nothing matters…or is it the other way around? That nothing is significant but everything matters?
  - No Projection/No Datum
  - NAD83
  - UTM
  - Scale Factor 1

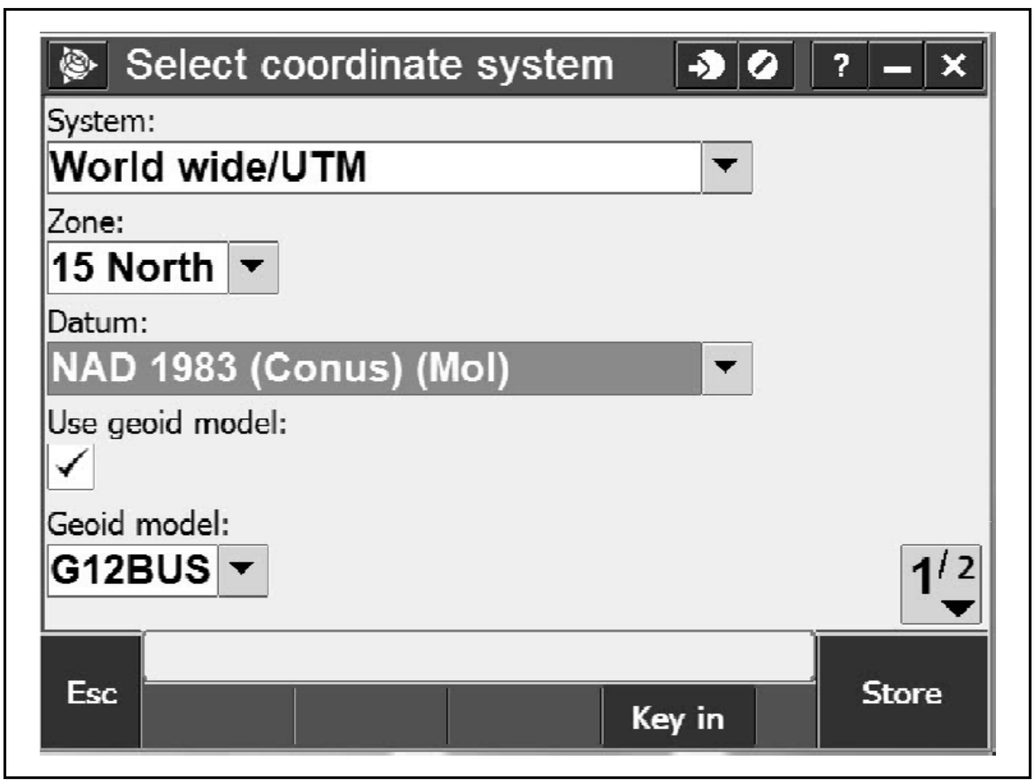

Trimble Access
2:09
kharris.SI
General Survey
Settings
AccessSync
Roads
Tunnels
Land Seismic
Level Me

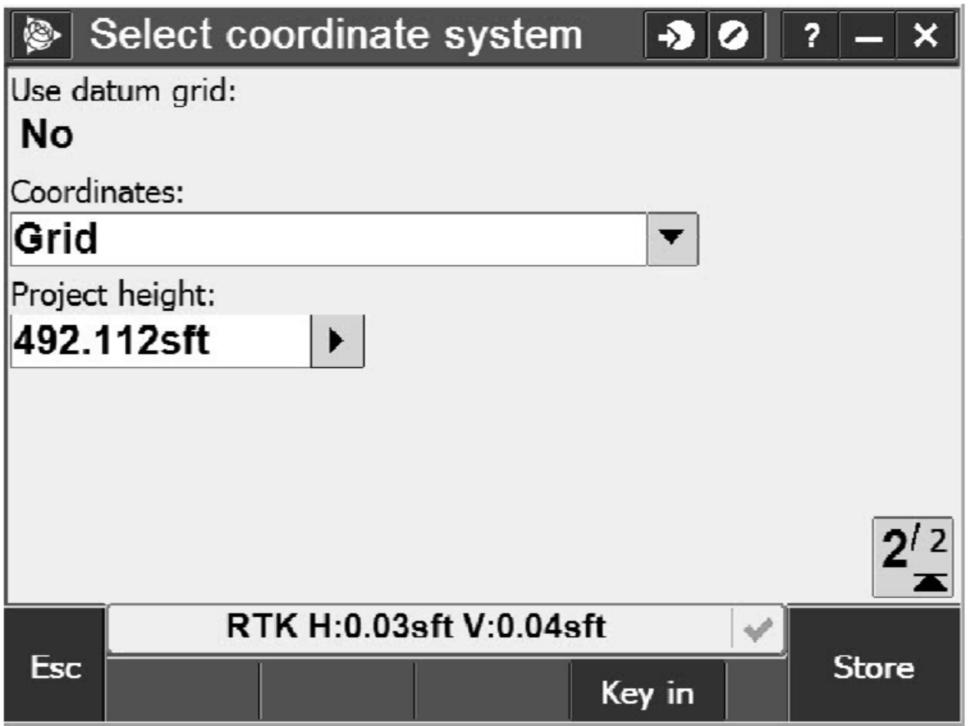

Job: test
Jobs
Key in
Cogo
Measure
Stakeout
Instrument
Map
Menu
Favorites
Switch to
Exit
Enter


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

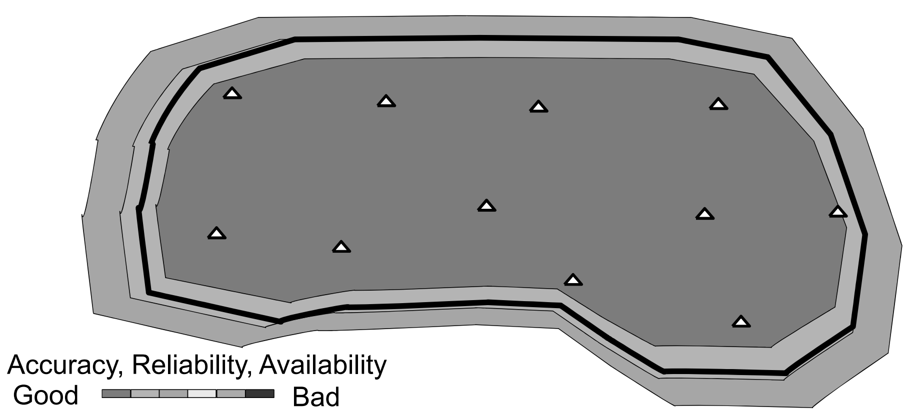

Select coordinate system
Select coordinate system
Scale factor only
Select from library
Key in parameters
No projection / no datum
Broadcast RTCM
Esc
Next


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


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



Reference Station Network (RTN)



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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 you can double the number of GPS systems you have now
- No surveyor required to “watch” the base station
- Consistent known datum and coordinate system

Limitations of a Reference Station Network

- No Internet/Cellular Service, no survey
- Easy at the user end, but…
- Long chain of things that have to happen in the background for it to work
- Most of which, the user has NO control over
  - Wireless provider has tower outages
  - Problems at the base stations or server
    - Rare but it does happen

Datum Used by MoDOT RTN and Trimble VRS Now

- NAD83 2011
- 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)

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
  - Not much in use anymore. More and more wireless providers not supporting Bluetooth Dial Up Networking
  - Better options
- Internal modem in receiver
- Internal modem in data collector

Communication is the Key (2)

- Intuicom RTK Bridge
- WiFi Hotspots
  - Probably most versatile
  - 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 elevations, 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

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

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How to Ensure Accuracy in Real Time Solutions

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

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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

How Much Time Between Observations?

- 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)

How Much Time Between Observations?

- 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 data collectors

- 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 30’ from last initialization
- Change antenna height by 0.98’
- 2nd observation – 30 seconds
- If H & V deltas within 0.08’ & 0.11’, “store as check”
- Time between observations is recommended – but not mandatory

How long should I observe?

- The point of diminishing returns is reached rather quickly in a single session with RTK.
- A more reliable position will be gained with shorter observations under varying circumstances rather than letting it cook for a long RTK observation.

How long should I observe?

- Run 2 sets of 30 second observations at different times.
- If a point is tough to get, record a rapid static observation and post process
- Point is to suggest testing your vectors as opposed to blindly believing the controller or an undefined report.
- It will help you develop a more reliable procedure.

Science Experiment

Science Experiment

- How long do I need to observe a point to get good results?
- How do I know they are good?

Science Experiment

- Set up base and rover at a reasonable distance apart to mimic your normal working conditions.
- Collect a point on the rover for 10 minutes.

Science Experiment

- Note the current average displayed on the screen at 3 seconds, 10 seconds, 20 seconds, 30, seconds, 60 seconds, 120, 180, 240, 300, 360, 420, 480, 540, and 600
- Did the average change over the ten minutes?

Science Experiment

- Was there a point that the average seemed to no longer change?
- This would mark your point of diminishing returns.
- If you are in open skies, you've averaged out all of the variability that can be observed over a short period of time.

Science Experiment

- The only way to improve precision is to return at a much later time, possibly even days apart to vary atmospheric conditions.
- Repeat a few times and you're on your way to becoming an expert on your own system.

Best Practices…one last time!

- The more satellites and the lower the positional dilution of precision (PDOP), the better the results will be.
- Do not try to “force” use of RTK in inappropriate circumstances.
- The more redundancy, the better. Always observe important points multiple times
- Compare individual observations with the average of the results.

Best Practices…one last time!

- Discard any outliers and re-observe the point until all observations fall within an acceptable range.
- Remember that RTK does not work well around tree canopy or tall buildings, and beware of sources of multipath.
- Beware of long initialization times! If initialization takes longer than normal, it may indicate issues with communication or ionospheric/tropospheric interference.

In Summary…

- Takes longer to get to most points than it does to shoot them
- Longer observation is better
- More satellites are usually better
- Redundancy is better than longer observation
- Two 60 second shots than one 180 second shot
- NO single shots on important points
  - Just too many variables…

- **GOOD SURVEYING PRACTICES NEVER GO OUT OF STYLE**

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