What checks/redundancy do we need in GNSS today?

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I wish I had an exact answer but I don't.

In traverse I always thought we had

(1) Repetition – as in turning extra angles and averaging

(2) Repetition/Simple Redundancy – like measuring distance on a backsight so you can compare 1 to 2 vs. 2 to 1 (in vertical too)

(3) Geometric Redundancy – closure, cross ties, resection, angles to towers, etc.

(4) Extra control – this is way easier today thanks to GPS

In GPS (post processed or RTK) - vectors base to rover

(1) Repetition – multiple epochs – in RTK it could be 2 and in post processed could be hours of epochs

(2) Redundancy

(a) re-occupation – do we need to change where the other end of the vector is from?

(b) Multiple bases for a single occupation – this is very OPUS-like but does not enforce long occupations (does not check setup!)

What kind of bases can we have in GPS?

(1) Field base(s) – the good old days – if RTK could communicate with rover(s) via radio or cell

(2) Permanent base stations – if post process download Rinex (or send your data to an Internet site a la OPUS)

- **If you RTK you would communicate via cell and universally accepted format like RTCM.**
- **Usually connect to closest permanent base station**

What kind of bases can we have in GPS?

(continued)

(3) Virtual Reference Station (VRS) – can be Rinex if post processed (but for some weird reason not available in Vermont???) or is accessed real time via cell and RTCM similar to a permanent base station (this works in Vermont – yeah!)

- Software estimates what base station data on a job site would look like using the permanent base stations surrounding where you are surveying

Why does Ray love VRS?

(1) It works really good! Probably don't need to see the rest.

(2) You have minimized distance from base to rover which makes GPS work better (same atmosphere)

(3) There are no satellite obstructions (It is virtual)!

(4) The data has been checked from multiple base stations

(5) The data can have systematic errors removed as it has been processed by studying vectors between base stations

(6) You don't have to decide which base station to use!

VRS

I realize the concept of a virtual control point goes against our conservative surveying approaches.

BUT IT IS A CONTROL POINT THAT WAS GENERATED FROM SURROUNDING CONTROL POINTS!!!!

If you feel rover points need to be measured from two bases/known points.

(1) Measure all points once from VRS base 1.

Disconnect move to other side of survey.

(2) Measure all points again from VRS base 2.

In post processed mode you download two VRS stations with two different time intervals.

In RTK mode disconnect and moving over will force the VRS when started up the second time to be at a second control position.

If you don’t like all Virtual Control????

Make the first occupations VRS, make the second set from a permanent base.

If doing an adjustment I would hold the VRS vectors tighter in error estimate as shorter vectors/base closer to job site.

Are we having fun yet?????

Just because Ray always does it do we really need a least squares adjustment of vectors?

Definitely not in a world without rules, but lets treat ALTA absolutely, the only way to satisfy positional tolerance in ALTA is via least squares as it uses error ellipses.

Note in my real time 2 VRS control station example the biggest residuals were .008 meters horizontally and .003 meters vertically (I love fixed height bipods). The amount of "adjustment" was quite insignificant so one could argue for coordinate production the least squares is unneccesary.

But ALTA says error ellipse!!!

Can you generate error ellipses if all vectors are from one base station?

Yes welcome to mathematics.

BUT if all vectors are from one base station are those legitimate error ellipses?

Needless to say due to the VT base stations it is "easy" to use multiple base stations.

The biggy! Can we treat a single occupation with multiple epochs as a legitimate "redundant" position?

If you trust your setup ability, and you trust the indicators of your GPS software (fix/float, PDOP, horz. quality, vertical quality, etc.), you can have great certainty in the quality of a one setup occupation. The GPS vendors have poured millions of research dollars into ensuring this.

Note the above paragraph is identical to OPUS processing (a single setup with lots of epochs).

Ray's beef with the current thought process.

We have been convinced "lots" of data is good.

But if you have good data, an RTK solution from 2 epochs (where you know the solution is fixed and the horizontal/vertical quality is decent) can produce the same statistical coordinates as a 4 hour OPUS solution!!!!

In other words GPS gets a decent answer (in the open) or has a lousy solution (in the woods). The amount of occupation time does not change the solution significantly.

Ray's suggestion if post processing and points are close to each other

Use Post Processed Kinematic not Static

Post Processed uses the data between point (just like RTK) where static does not – keeping lock on satellites makes occupations on points shorter!

But Post Processed Kinematic usually requires use of data collector as entry of a point id tells processing when you are on a point as opposed to moving between points.

Suggestion

Use the best of both worlds.

If a corner is not GPS'able set two nails nearby in open and GPS them.

One angle and distance in and you have good coordinates on the corner. If not a long shot don't tell anyone grid distance = ground distance.

Construction surveying

Localize, localize, localize!

We are still in the era where “permanent” monuments with coordinates will be on the site.

Localizing allows one to use GPS in any assumed coordinate system that exists.

1D 1 point – no check but go to other points and see if it fits

- **2 points – never use as too linear**
- **3 points – perfect fit**
- **4 points - redundant**

Construction surveying

2-D localizing

1 point – very dangerous as no rotation but could use in a grid coor. to grid coor. shift as both are grid north

2 point – will scale exactly unless you say use scale of 1.00

3 point – redundant will get residuals