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SurvCE 3.0 - GNSS Analysis Point Averaging

In File / Job Settings under the Options tab you can check the box for "Apply GNSS Analysis" the Point Average methods and screen dialogs are completely changed wtihin **Point Average**.

This analysis approach deals with one Point ID at a time, and works if multiple measurements were taken on that Point ID, either as distinct Store Point exercises or as A for Average within Store Points.

The method, however, is designed for a field procedure of distinct single point measurements using Store Point, storing the same Point ID, typically at intervals over a period of time, capturing different satellite configurations. By using this procedure, greater point positional certainty can be obtained through statistical analysis.

The Store Points option of A for average can work similarly if a longer time interval between measurements is used, but the advantage of the individual Store Points approach is that the GNSS rover can be used for other work between returning to the same point to measure it again with the same point ID.

So if you were mixing topo or data gathering work with key point, boundary point measurement, you could measure the key point, do 30 minutes of topo, measure the key point again, do another 30 minutes of topo, and repeat that procedure, accumulating multiple data on the same point ID for the key point, in preparation for "**GNSS Anlaysis Point Averaging**".

If all of your work was "key" point measurement, you could simply sequence from one key point to another, returning to the same points over an extended time period. Then the GNSS Analysis method will calculate the measured points to greater certainty (as reported statistically), with blunder detection and blunder removal.

With GNSS Analysis, extensive testing has shown reliability of between 1 and 2 centimeters with multiple readings, but with statistical standard deviations of as little as 3 millimeters. Blunder detection is accomplished using the Chi Square Variance Test. The parameters and error estimates are hard coded in the preliminary release of this feature, based on thousands of point measurements.

This trial, fixed parameter feature is provided with the caveat that most testing has been conducted with Topcon and Altus GNSS receivers, and for fixed antenna conditions involving low and secure antenna positions.

The parameters for statistical analysis may not apply to your specific condition. These parameters will be converted to user-defined variables with suggested ranges for settings in subsequent releases based on reports from trial usage with a wider range of equipment.

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Preconditions to GNSS Analysis

The following preconditions must be set for GNSS Analysis:

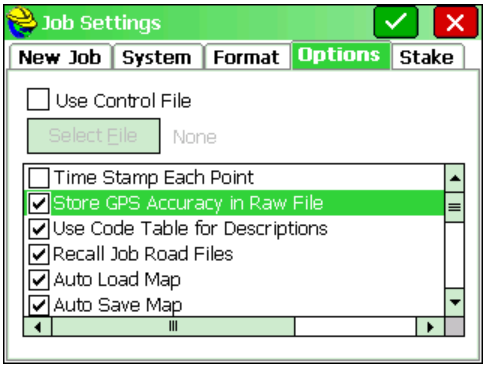
- **Both the CRD file AND the associated RW5 file of the same name must be on the same data directory**

If you just copied a CRD file to a data collector without the associated RW5 file, GNSS Analysis will not work. The companion, same name RW5 file must be present on the same directory. Plus the data in the RW5 has to contain RMS values, DOP values and vector data, stored based on the following two preconditions.

- **File, Job Settings, Options Tab:**

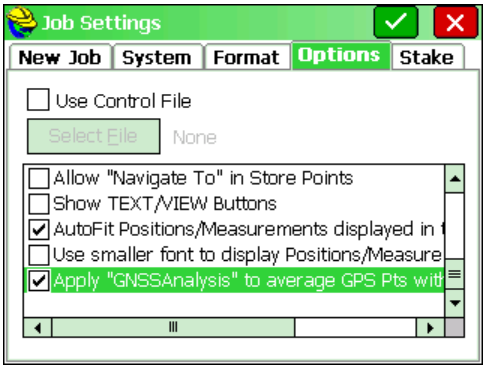
"Store GPS Accuracy in Raw File" checked ON

This stores the HRMS, VRMS, PDOP and other DOP values necessary for the statistical analysis.



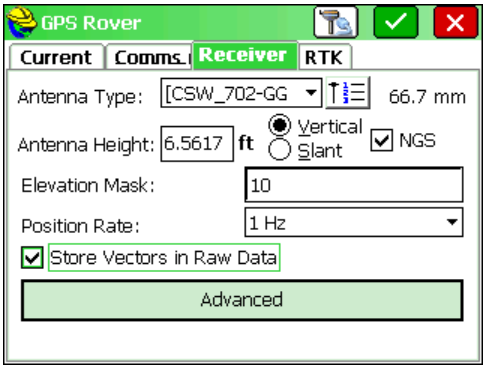
- **File, Job Settings, Options Tab:**
  "Apply GNSSAnalysis to average GPS Pts" checked ON

This activates the GNSS Analysis routine



- **Equip, GPS Rover, Receiver Tab:**
  "Store Vectors in Raw Data" checked On

This stores the base to rover vector data necessary for the least squares calculations used.



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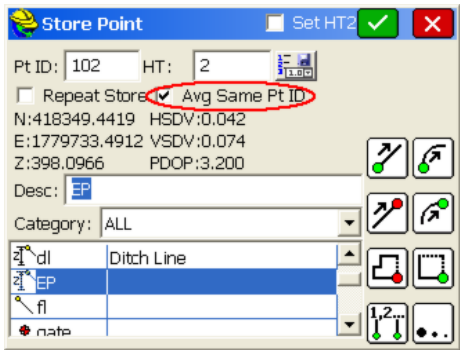
Because it is important to use the same Point ID, and because SurvCE will naturally increment points, it is also useful to turn on Equip / Configure / "Prompt for Heght & Description"

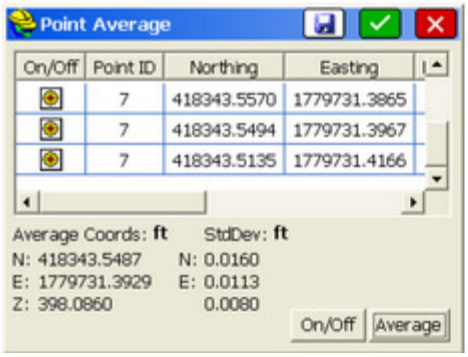
With the Prompt for Height & Description turned on in Survey / Store Points after storing your GPS shot you have an option you can turn on for "Avg Same Point ID" as shown below:

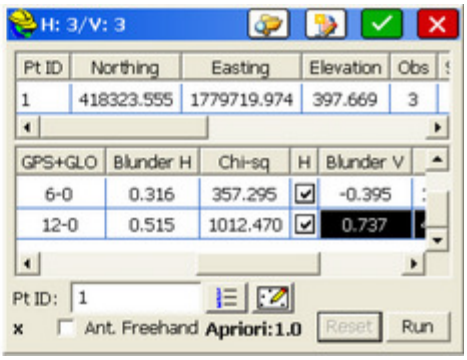
In this mode, if you measure a point for the second time, with the same ID, the program will assume you wish to overwrite it, will avoid the Point Protect screen and will display the duplicated points in a list as shown below: And on the next measurement, after two appear in the list, the auto-increment is disabled and the program will remain on the same Point ID until you enter a new Point ID to measure. In this dialog, the point you choose to store can be averaged, with any individual point turned on or off in the left column. Click the Store Icon to store the point. Otherwise, the last point measured will be stored. This Point Average screen shown below left appears within the command Store Points itself with the option "Avg Same Point ID" on, as above.



The screen shown below appears if GNSS Analysis is on, Store GPS vectors is on and Store GPS Accuracy in Raw File in on. So the Store Points screen itself shows, in effect, the same dialogs as appear in Point Average, whenever "Avg Same Pt ID" is on.

In that sense, the Point Average command is a way to recall measurements and do point averaging later, after you take field measurements. Conducting the averaging by standard and advanced "GNSSAnalysis" methods can occur while in Store Points with "Avg Same Pt ID " on or later by going to Point Average. Observations appear as 0 in upper right of dialog, until the minimum of 3 raw measurements for calculation purposes are obtained. Clicking Enter proceeds to the next measurement, equivalent to tapping the Green Check. So when repeating point IDs and remeasuring points, with Hgt/Description Prompt On, you can take measurements using GNSS Analsysis with Enter for the measurement, Enter for the Hgt/Description Prompt, Enter for the Analysis review. With Hgt/Description Prompt Off in Configuration, each measurement would be 2 Enters.





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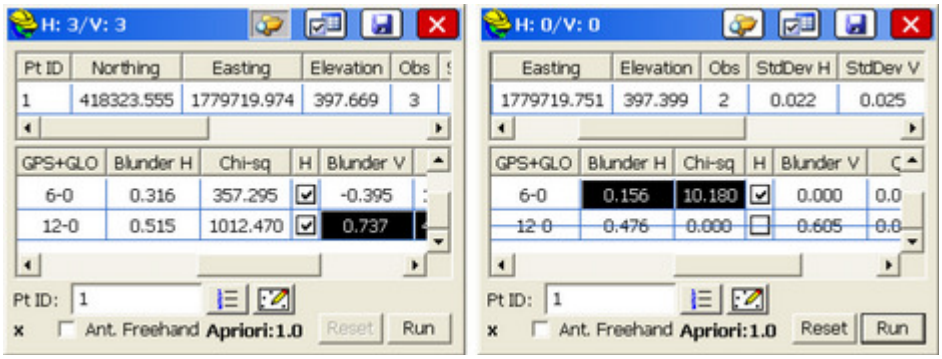
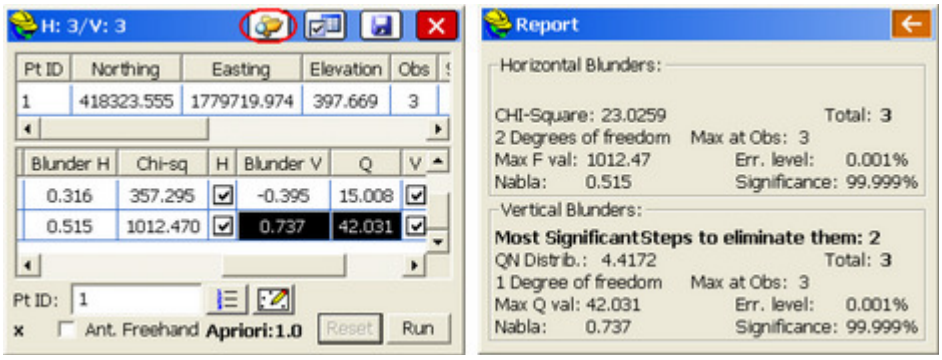
Whether working from within Store Points or within the Cogo Menu, Point Average option, with GNSS Analysis on, AND with both vectors on, leads to analysis options as shown below:



The program defaults to the display above right, by auto-running the blunder removal until H=0 and V=0 in terms of potential blunders. By clicking Reset, the "original" blunder status of all observations can be viewed. This example has only 3 field measurements, and when the 3rd measurement is removed, the remaining two observations pass the statistical analysis parameters. After clicking Reset, you can click Run to allow the program to automatically remove blunders, distinctly in the H and V columns, to obtain the maximum remaining number of measurements that pass the statistical test. With Chi-Square set to approximately 23, the program seeks to get the maximum F test value for the x,y (H) calculation around 10 or less and the maximum Q value for the Z (V) under 1.

If you don't use "Run", you can allow the program to present the highest contributor to errors and then remove these one at a time. In this way, you are rejecting the single observation with the largest contribution to the sum of the squares (standardized residual). Repeat until all observations that qualify for rejection are removed. In the report, the External Reliability is the maximum point deformation, or the maximum effect of a theoretical undetected blunder on the final computed coordinate. The calculations use the covariance information found in the data accuracy estimates of the GNSS receivers. A least squares calculation is used to find the best center point.

Although designed for 5, 10 or more same points readings, here is an example of 3 field measurements and how the blunder detection works when identified and removed manually:



Start by entering the Point ID in the lower left of the dialog to study. Press Enter after selecting the point for the data to appear. The "worst" blunder is identified by highlighting to the left of the H or V column. So in this case, click of the V to the right of the highlight. Prior to doing so, if you click the Report icon (highlighted with red circle), you see the Report at right which shows the high F Value for the horizontal component and also high Q value for the vertical component.

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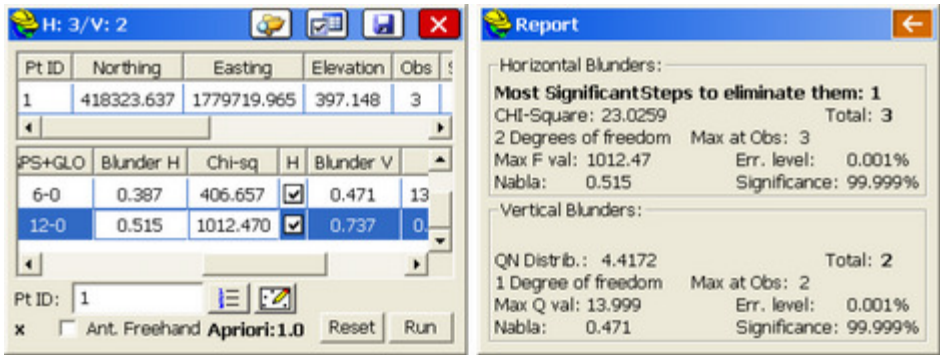
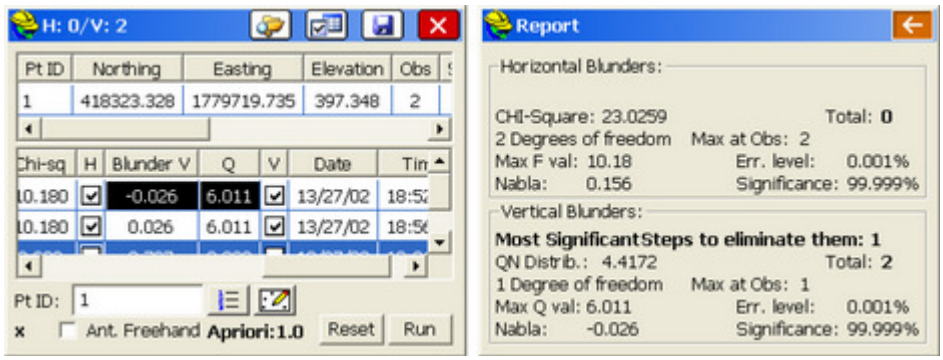
The process of removing blunders will reduce these values to acceptable levels (also accomplished automatically by tapping "Run"). So after removal of the first blunder (V), on the third observation, the next worst blunder appears below, which is the (H) on the same 3rd reading. Note that when one blunder on the same reading is already identified, the next blunder on that reading is identified by reverse coloring (here white, not dark):

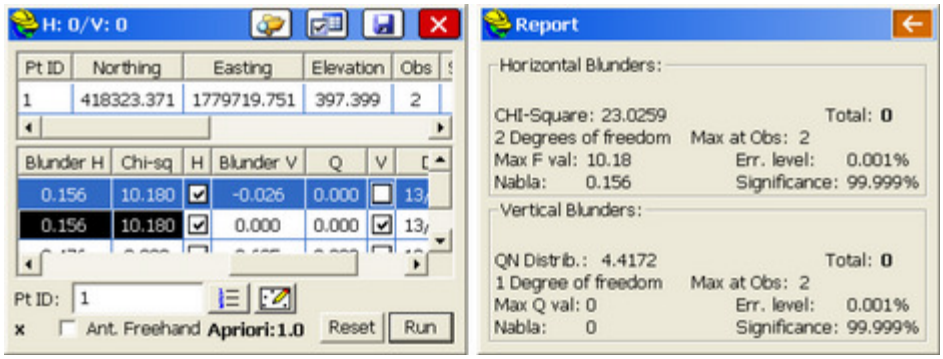


Notice how the Q value came down after removing the first vertical reading.

Next, remove the "reverse highlighted" (H) reading for the third observation, which in effect eliminates that third reading altogether:



With the third observation entirely removed, the horizontal blunders are eliminated (now 0) and max F value is an acceptable 10.18. The vertical Q value is still at 6, and one more blunder has been identified that is "significant" enough that removal is necessary and recommended. This is the vertical reading on the first observation. Remove that to obtain the final result (use of observations 1 and 2 for horizontal, observation 2 only for vertical). Remember, remove to the right of the highlighted item (the H or V):



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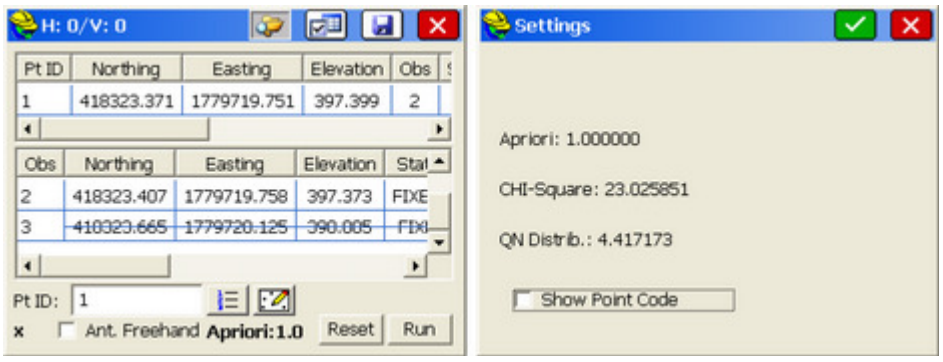
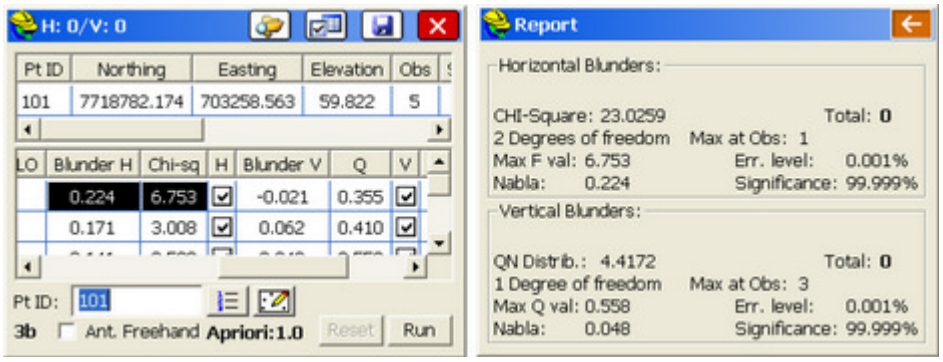
Observation 1 was used for the H only, observation 2 for H and V and observation 3 was not used at all (those observations get a line drawn through as below). This same result is obtained by tapping "Reset". The next "worst" blunder is still highlighted, but there is no reason to continue the process—analysis parameters are satisfied.

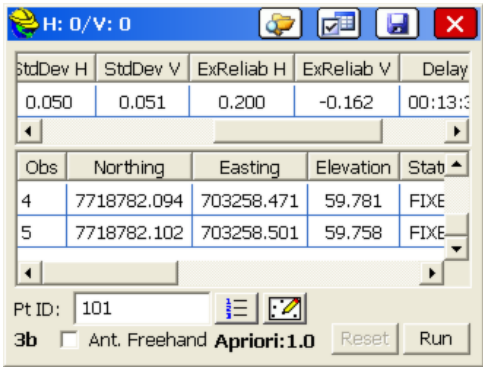


The "X" in the lower left of the screen is a somewhat arbitrary designation category. If 3 or more observations are used and pass the analysis, the quality of the observations are ranked 1 through 4 as follows: 1=city center, 2=rural area, 3a=farm land, 3b=forest, 4=unproductive land. The calculation will "qualify" for one of these designations with sufficient observations. Clicking the Settings button shows the hardcoded Aprior, Chi-Square and QN Distribution values. These values were selected based on extensive testing with a variety of commercial GNSS equipment. The "Antenna Freehand" setting will impact the calculation. If the GNSS antenna is on a fixed tripod, that resets parameters for the least squares calculations in terms of expected errors. If "Antenna Freehand" is clicked on, errors from a potentially moving antenna will be higher.

Here is another example, collected in the field using A for Average within Store Points. Note how all 5 observations are used.



If you scroll the top section to the Right of the statistically averaged point you can view the External Reliability values and data on the duration of the measurement (delay), which in this case was 13 minutes.



Longer delay values are recommended to obtain different satellite constellation configurations.

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