

Introduction

Newsletter Vol. 03, No. 3 presented the new features of SKI-Pro v3.0 and highlighted the improved processing performance as well as the new Analysis Tool. This newsletter will give you an insight into the data processing strategies of SKI-Pro v3.0 so that you will understand why SKI-Pro v3.0 is superior over other GPS data processing packages.

The second main topic covered in this newsletter is the Analysis Tool and deals with how to interpret the results. For SKI-Pro v3.0, the residual computation was completely re-designed. The graphical display of residuals allows now to quickly detect poor satellites or to give general statements about the ionospheric conditions.

What are the true benefits of the new kernel?

You might remember newsletter Vol. 01, No. 07, which explains the continuous ambiguity checking method of System 500 RTK. SKI-Pro v3.0 has a new post-processing kernel, which uses the same strategy that is implemented in System 500 RTK, but optimised for post-processing.

Conventional GPS data-processing software packages use the whole duration for one valid ambiguity set. SKI-Pro v3.0 needs at the absolute minimum two timewise independent identical ambiguity sets to declare a baseline as fixed. Typically the ambiguity solution can be confirmed every 30-180 seconds and an overall statistic can be generated which shows the intervals of fixed and not fixed epochs.

Ambiguity Statistics

Total number of ambiguities:	27
Number of fixed ambiguities:	14
Number of independent fixes:	6
Avg. time between independent fixes:	2' 30"

Percentage of fixed epochs (L1):	74%
Percentage of fixed epochs (L2):	74%
Percentage of fixed epochs (overall):	92%

Overall Statistic:

Status	From	To	Duration
Fixed	14/12/2002 10:07:00	14/12/2002 10:13:00	5' 60"
Not fixed	14/12/2002 10:13:00	14/12/2002 10:17:00	4' 00"
Fixed	14/12/2002 10:17:00	14/12/2002 10:36:00	21' 00"
Not fixed	14/12/2002 10:36:00	14/12/2002 10:41:30	3' 30"
Fixed	14/12/2002 10:41:30	14/12/2002 11:37:30	55' 60"

This strategy results in the highest reliability possible for GPS-processing today for static and kinematic baselines, as ambiguities are continually monitored over the entire observation interval.

Ambiguity Statistics

At first sight the new ambiguity statistic might not be so easy to understand, because it is different compared to conventional illustrations of the ambiguity statistics. However the new ambiguity statistics gives you a better indication about reliability and data quality. Honestly, who can an-

swer the following question: Which result is more reliable? A common interval of 1 hour and a ratio between the first best and the second best ambiguity set of 1.5, or a common interval of half an hour and a ratio of 1.8. If you would have the information that the baseline with a duration of 1 hour could have been fixed for only 20 minutes, whereas the baseline with a duration of half an hour could have been fixed over the whole duration, the answer would be simple. The next paragraph describes in detail what some of the parameters in the ambiguity statistics mean.

• Total number of ambiguities

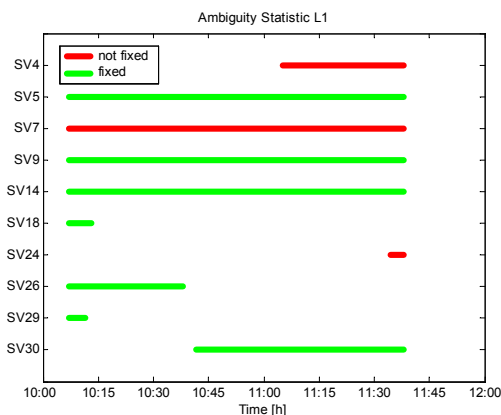
For each satellite and each frequency an integer ambiguity needs to be resolved. Ambiguities which needed to be re-initialised due to a loss of lock will also be counted.

• Number of independent fixes:

Number of times an independent ambiguity search routine has successfully been completed leading to a confirmation of previously calculated ambiguity values.

• Percentage of fixed epochs (L1) and (L2):

If we would look at each satellite individually and check whether the ambiguities of a certain satellite has been fixed or not, we could derive the graphic below.



If we added up all fixed and not fixed intervals we could then derive a ratio between fixed and not fixed areas which would give us the "Percentage of fixed epochs". Note, however, that even if this ratio is not 100%, it will still be quite probable that enough ambiguities are resolved to determine a solution at every epoch (100%) providing there is sufficient redundancy.

• Percentage of fixed epochs (overall):

Percentage of all epochs for which a successful ambiguity resolution has been available. This corresponds to the percentage of epochs for which a fixed solution would be available if the data was calculated in a kinematic mode.

Extended Range

During the development phase of the new processing kernel, numerous benchmark tests have been carried out. One of the tests included a comparison with Trimble Geomatics Office v1.6 on baselines up to 200km under relatively high ionospheric conditions. Apart from the settings “Maximum baseline length to attempt a fixed solution” and “Ephemeris”, the processing default settings have been used in this test. The “Maximum baseline length to attempt a fixed solution” was increased to 250km and instead of broadcast ephemeris, precise ephemeris were used in SKI-Pro v3.0 and TGO v1.6. The final results are summarized in the table below.

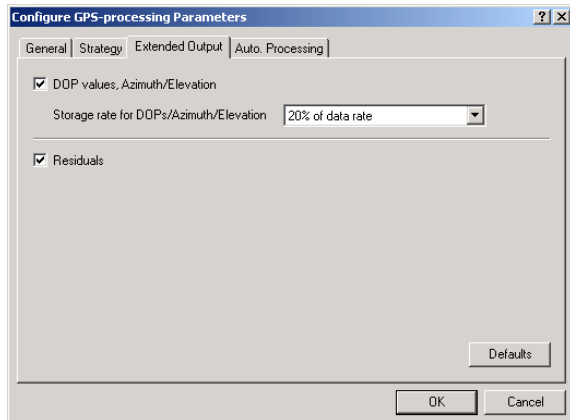
	SKI-Pro v3.0	TGO v1.6
Number of fixed baselines	14	12
Number of not fixed baselines	0	2
Number of wrong fixes	0	4
Processing time	36s	1:11 min

The same data was analysed using SKI-Pro v2.5. SKI-Pro v2.5 fixed all baselines, but showed as well as TGO v1.6 a few wrong fixes. Net result under high ionospheric conditions SKI-Pro v3.0 proved to be much more reliable than SKI-Pro v2.5 and TGO v1.6.

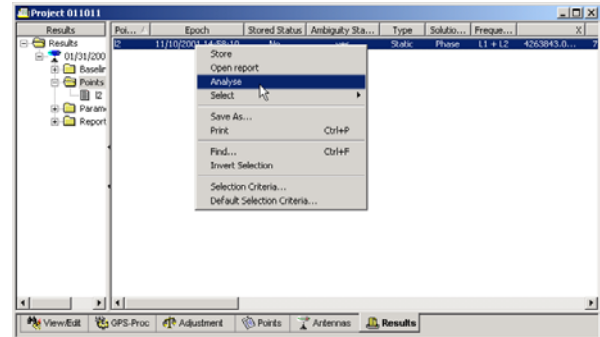
Productivity improvements will be seen with an extended range and higher reliability. In addition, the processing time of SKI-Pro v3.0 was only half of the processing time of TGO v1.6 on the same computer.

GPS-Processing Analysis Tool

The Analysis Tool was designed to easily and quickly get an overview on the results of a processing run. Per default, the DOP values, azimuth information, and the elevation of the used satellites will be available. To display residuals, the check box “Residuals” under “Configure GPS-processing Parameter/Extended Output” has to be ticked.



After processing your data, the Analysis Tool can be invoked by a right mouse click on the point or the baseline of interest.



To launch the Analysis Tool of a kinematic chain, at least one point of the kinematic chain has to be selected. The Analysis Tool can be launched several times for one baseline to enable, for example, GDOP and residuals to be viewed at the same time.

What is a residual?

A simplified description of a residual (GPS) is the following. A residual is the difference between the actual observation and the computed distance between the satellite and the derived GPS-position. Considering a scenario where only 4 satellites are available for a kinematic baseline, the observation redundancy would be zero and therefore all residuals would be zero as well. Meaningful residuals for kinematic baselines can only be computed if there are enough satellites in view to give sufficient redundancy.

Which types of residuals are being displayed for an SPP result?

If an SPP computation is carried out, per default an L1 only free code (Nav) solution will be used. Because there is only one station involved, only undifferenced code observations are used for the processing.

Assuming the result would be an L1 only result, it would not be possible to display L2 or derivatives such as L1 only free (L3) or Geometry free (L4) residuals.

Which types of residuals are being displayed for a baseline result?

If a baseline computation (static or kinematic) is carried out, single, double, and triple difference residuals could be displayed. The frequency type depends again on the frequency which has been actually used.

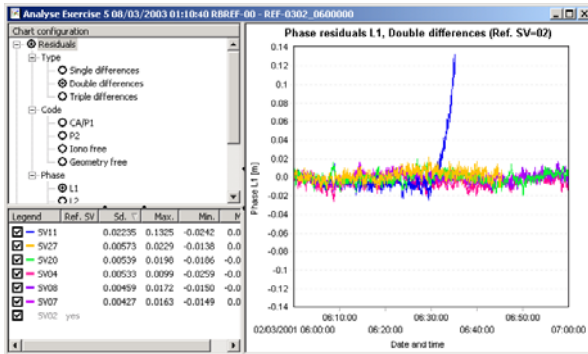
Single, double, or triple difference residuals

Single and double difference residuals are mathematically identical if clock unknowns are estimated and ambiguities are constrained. SKI-Pro v3.0 uses a single difference approach and estimates the receiver clock unknowns. Single difference residuals in SKI-Pro v3.0 therefore differ only slightly from double difference.

It is up to the user to define the reference satellite when computing double difference residuals. Per default the highest satellite is always chosen as reference satellite. A triple difference is the difference between consecutive epochs and allows the detection of cycle slips that have not been repaired.

L1 and L2 residuals

To screen for blunders and poor satellites, it is best to analyse L1 or L2 double difference residuals. As you see below satellite 11 is immediately detected as a poor signal. The reason for these disturbances in this special case is diffraction, as the satellite sets behind a near hill.



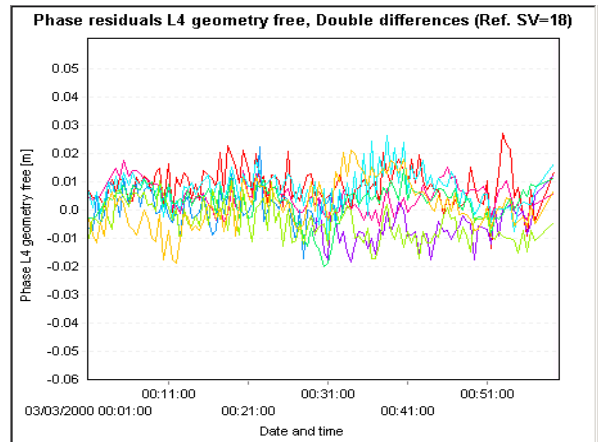
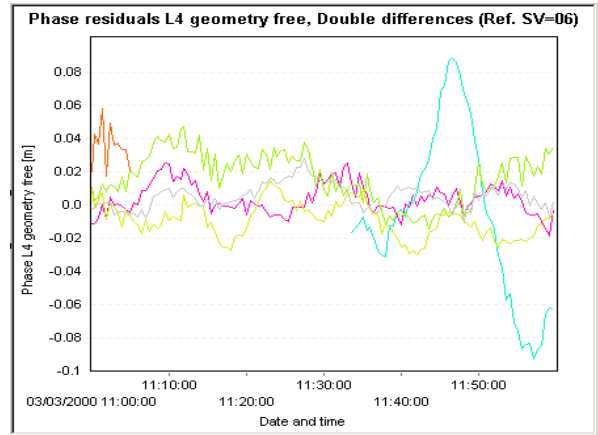
In addition to the graphical display, the bottom left-hand pane allows to sort for the satellite signal with the highest standard deviation or for the satellite with the maximum blunder. Blunder analysis might help in cases where the baseline could not have been fixed in the first processing run. De-selection of poor signals and re-processing the baseline sometimes helps to generate a satisfying result.

Legend	Ref. SV	Sd.	Max.	Min.	Mean
<input checked="" type="checkbox"/>	SV11	0.02235	0.1325	-0.0242	0.0014
<input checked="" type="checkbox"/>	SV27	0.00573	0.0229	-0.0138	0.0023
<input checked="" type="checkbox"/>	SV20	0.00539	0.0198	-0.0186	-0.0003
<input checked="" type="checkbox"/>	SV08	0.00459	0.0172	-0.0150	-0.0002
<input checked="" type="checkbox"/>	SV07	0.00427	0.0163	-0.0149	0.0006
<input checked="" type="checkbox"/>	SV04	0.00533	0.0099	-0.0259	-0.0049
<input checked="" type="checkbox"/>	SV02	yes			

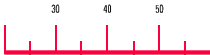
Iono free L3 and Geometry free L4 residuals

If dual frequency data is available, it will always be possible to derive L3 or L4 residuals. L3 residuals are free of ionospheric disturbances. This would mean that the L3 residuals of a baseline observed once during high ionospheric conditions and once measured during quiet ionospheric conditions are similar.

The remaining error source of Geometry free L4 residuals is just the ionospheric amount and parts of the multipath. L4 residuals are perfectly suited to analyse the influence of the ionosphere. The graphic below shows the results of the same baseline measured during high ionospheric conditions (at noon) and during low ionospheric conditions (during night).



At noon the L4 residuals vary from -4 to +4 cm. During night with similar multipath conditions the L4 residuals are within a 2 cm band.



Remember...

- SKI-Pro v3.0 offers the highest reliability possible for GPS-processing today for static and kinematic baselines.
- Single and double difference L1, L2, and L3 residuals are useful to analyse possible blunders, the measurement noise, and the amount of multipath.
- Triple difference residuals can be used to quickly find un-repaired cycle slips.
- Geometry L4 residuals show the ionospheric influence.
- There is no other post-processing package which offers the same reliability and ease of use.