System 1200 Newsletter – No. 36

GLONASS

GLOBAL'NAYA NAVIGATSIONNAYA SPUTNIKOVAYA SISTEMA - GLONASS

On 4th April, Leica Geosystems announced yet more additions to the System 1200 family – the GX1230 GG, GRX1230 GG, MNS1230 GG and the ATX1230 GG.

The new 72 channel GG products will allow users to track all currently available GNSS (Global Navigation Satellite Systems) signals – GPS L1 and L2 (including L2C) WAAS, EGNOS and MSAT and most significantly, GLONASS.

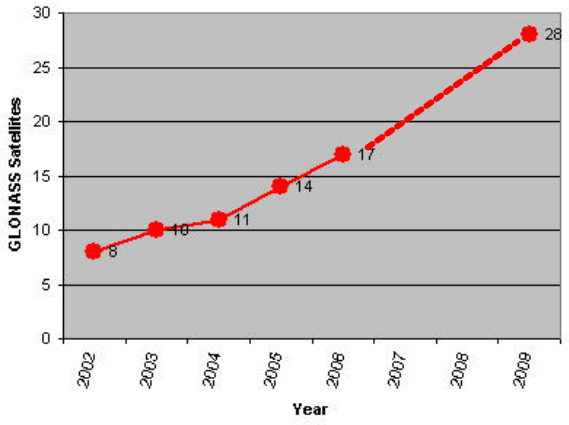
In addition, the new sensors are also future proof – they are designed to support all future GNSS signals – including GPS L5 and Galileo.

This newsletter focuses specifically on the additional GNSS signals which can be tracked by the new GG products and will immediately benefit a System 1200 user today – GLONASS. What are the differences between GPS and GLONASS? What are the benefits? Should a user invest in buying a GLONASS capable GNSS surveying system? These questions will be answered – but maybe the first question to answer is….

WHY NOW?

You may ask, why should Leica only now suddenly support GLONASS – why not before?

The simple answer is that until now, the benefits for a surveyor to use the GLONASS signals were minimal – the graph below shows how many satellites have been available on average over the last 5 years.



It can be clearly seen that only now with a usable constellation of 17 satellites the use of these additional satellite signals makes sense for a surveyor.

Additionally, a press release from Moscow on 7th March this year stated that Russia aims to have a full GLONASS constellation of 28 satellites available by 2009 – and have been given 100% funding to achieve this aim.

Leica has always and will only make technology available to customers when the use of such technology makes sense for the user and has true benefits – hence only now has Leica released the new GNSS products.

SOME BASIC FACTS

It may be interesting to first look at some basic information relating to GLONASS.

The GLONASS system was first conceived and established during the cold war as an answer to the US development of the GPS system and is managed by the Ministry of Defence of the Russian Federation.

A full GLONASS constellation would consist of 24 satellites in 3 orbital planes – 8 satellites per plane. The planes are inclined at 64.8° which is steeper than the orbital planes of GPS (55°) – this is a benefit for users in higher (or lower) latitudes since GLONASS satellites will travel much farther north (or south) than GPS satellites.

GLONASS satellites orbit at an altitude of 19,100km – lower than the GPS orbit of 20,200km. This lower orbit means that the GLONASS satellites make a complete orbit of the earth in 11hours 15mins – compared to 11hours 58mins for a GPS orbit. So a GPS user who is used to almost the same GPS satellite constellation being available from one day to the next (a shift of only 4 minutes) will find that the GLONASS constellation shifts by 1hour 30mins every day.

MORE IS BETTER

Generally speaking, the main advantage of using GLONASS satellite signals in addition to GPS signals is the increased number of available satellite signals.

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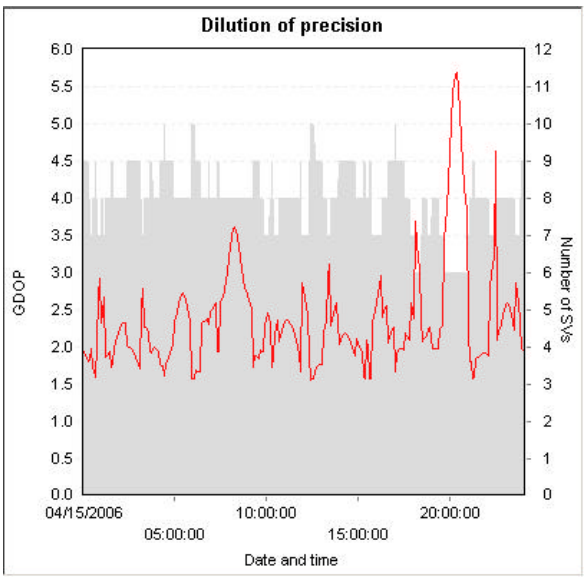
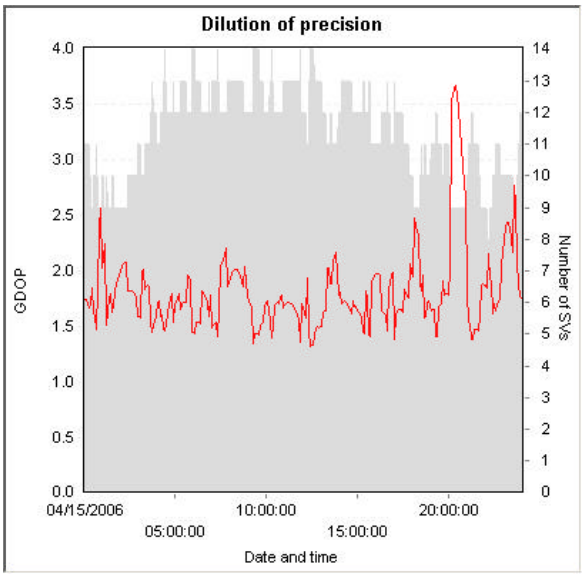
Previously when a surveyor was trying to measure close to obstructions, the “final” GPS signal could be lost, which meant having to move away from the obstruction, wait to re-initialise and then try to measure again. Using the additional GLONASS signals could mean continuing to work in areas where it was previously not possible.

Look at the 24 hour satellite availability plots below (latitude of 47° north).



Using GPS only, the number of available satellites is between 6 and 10 with an average of approximately 7 GPS satellites being visible. The GDOP has an average of approximately 2.3 and peaks at 5.5.



Adding GLONASS satellites increases the number of available satellites from between 8 to 14 with an average of approximately 10 or 11 satellites being visible. Similarly, the GDOP values are reduced.

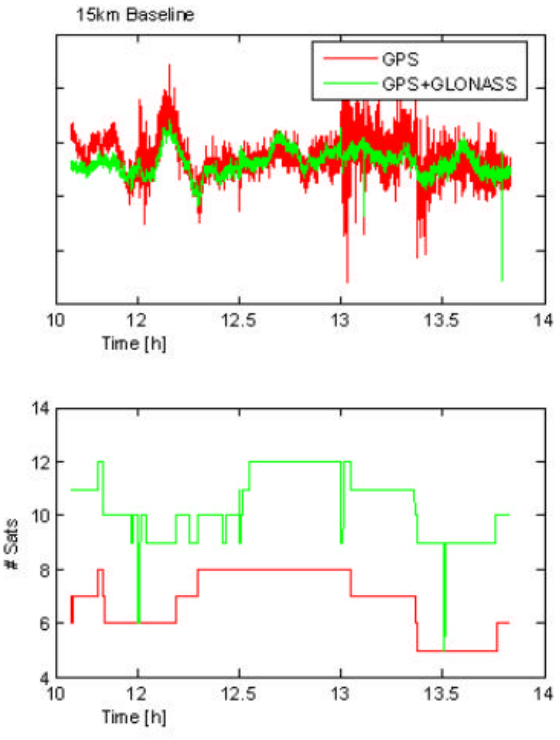
The additional GLONASS satellites can make the difference between continuing to work, or having to try to re-initialise or use other methods to survey the obstructed area…

INCREASED ACCURACY?

Again, with regards to accuracy, the increased number of satellite signals is beneficial for the user. Generally speaking, more satellites signals can help improve the accuracy of measured positions.

The first graph below show the difference on the height component of a fixed position of a GX1230 senor (without GLONASS) compared to a GX1230 GG sensor (with GLONASS) over a 4 hour period. (Remember that the height accuracy is always “weaker” than horizontal accuracy).

The second graph below shows the number of satellites available (which of course directly influences the height accuracy).



BU Surveying
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- when it has to be right

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It can be seen that when using GPS only, as the number of satellite reduces (especially from 13:00 to 13:30) the accuracy of the height position decreases.

When GLONASS is used in addition to GPS then the positional accuracy is generally more stable and can improve accuracy.

Additional Phase Fixed Solutions?

You know the answer now! Again, generally speaking, the more satellites the better, so yes, the time taken to fix and obtain a cm accurate, phase fixed position can be reduced when using GLONASS with GPS.

To quote an "average" improvement is difficult since what are "average" conditions? In Heerbrugg tests were made under the following conditions comparing GPS only performance to GPS and GLONASS:

- Static very long baselines (149km)
- Kinematic test – model train passing constantly passing under obstructions (30m baseline)
- Static under a tree (20km baseline)
- Static under clear sky (2km)

The tests were made such that as soon as a phase fixed solution was achieved then this solution was automatically discarded and the system had to re-initialise.

The percentage values below show how many fixes were made – for example, 50% would mean that 10 fixes were made in period of time when theoretically, 20 could have been made).

The following results were achieved:

Project	GPS (%)	GPS/GLO (%)
Long Baseline	53.31	61.76
Kinematic	55.89	90.49
Tree	72.73	100
Static	97.06	99.22

Clearly, the use of GLONASS in addition to GPS increased the number of fixes which were possible – again, increased productivity for a user.

On average, it can be said that the number of fixes for the GX1230 GG (GPS/GLONASS) sensor was 15% higher than that of the GX1230 (GPS only) sensor.

Some Technical Information

For those who are interested, the following "more technical" information may be of use. Of course, all this happens in the "background" of the GG sensors – nothing for the user to worry about!

Clocks

The caesium clocks within all GPS satellites are highly stable (losing only 1 second in 1 million years). Similarly, the clocks within all GLONASS satellites are also highly stable to a similar level.

The time reference of the GPS system is GPS-time whereas the time reference of GLONASS is based on UTC (SU) – the offset between the 2 time systems is known to a certain accuracy, but not accurately enough for survey applications – it can be said there is a "clock offset" between the 2 systems.

This clock offset must be solved for when using a combined GPS and GLONASS sensor - therefore at least 2 GLONASS satellites are needed to contribute to the positional solution – one to solve the clock offset and then the additional GLONASS satellites are used to contribute to the positional solution.

This again shows why it is only now Leica has released the GG sensors. Refer back to the graph on the first page to see that only now there are sufficient GLONASS satellites available such that typically, 3-4 GLONASS satellites will be available to be used.

CDMA and FDMA

As may already be known, the GPS system is based on Code Divisional Multiple Access (CDMA) techniques. This basically means that all GPS signals from the different satellites are based on the same frequencies and the individual satellites are recognised by different "code signals" (signals unique to each satellite).

GLONASS signals however are based on Frequency Divisional Multiple Access (FDMA) techniques. This means that all GLONASS satellites transmit the same "code signals" but the individual satellites transmit on different frequencies.

The fact that the wavelengths of the GLONASS satellites are different means that using these signals is technically more difficult than GPS. Whenever it is needed to form linear combina-

tions between satellites – for example to reduce atmospheric delays – then additional biases have to be solved for… A future newsletter will go deeper into the complexities of the GLONASS system...

SUMMARY

With 17 GLONASS satellites available today, and commitment from the Russian government to have a full constellation of satellites by 2009, now is the time to be investing in GNSS sensors.

The main benefit for a surveyor using a combined GPS/GLONASS sensor is the additional number of satellite signals which are available - additional satellite signals can lead to higher accuracies and an increased number of phase fixed positions – all leading to increased productivity.

Please contact your local Selling Unit or local Leica dealer if there are specific topics you would like covered in these newsletters.

We welcome all suggestions for TPS1200, GPS1200, LGO, TPS400, TPS800, accessories or specific applications. We look forward to receive your idea.