Future Satellite Signals – An Update

GNSS MODERNIZATION

2006 was an eventful year with regards to satellite launch schedule slips and signal structure discussions. There has also been the release of new GNSS surveying equipment – by both Leica and other manufacturers which can track future satellite signals.

It is almost one year since the last newsletter which focussed on satellite signals (number 35) – this newsletter follows on from this newsletter and gives the latest information with regards to satellites and surveying equipment.

Leica developed a new multi GNSS processing kernel and released the first phase of an ongoing GNSS development program. Phase one incorporated the support of GPS L2C and GLONASS signals. Future phases will incorporate the support of both GPS L5 and Galileo satellite signals.

GPS

THE L2C SIGNAL

On 25 September 2006, GPS IIR-15M (SVN31) was successfully launched from Cape Canaveral, Florida.

This is the second GPS satellite which transmits the L2C signal - a "civil code" on the L2 frequency which is accessible for non-military applications.

Earlier this year, Leica released its latest generation of GNSS System1200 receivers that can track the L2C signal. To see if your receiver can track L2C then look in the CONFIGURE Satellite Settings panel – if the L2C Tracking prompt is visible then the receiver can track L2C. Note, it is not necessary to have a GG receiver to track L2C – the tracking of L2C is possible with both the GLONASS capable receivers (1230GG) and non-GLONASS capable receivers.

Remember that the ability to track the L2C signal does not add any significant benefit to the surveying GNSS user. For this reason Leica does not charge a premium for the ability to track the L2C signal.

Indeed, the current, official recommendation from the US Air Force is that the L2C signal should not be used before it is declared operational - see below:

"... the Air Force emphasized that it would not guarantee the availability or quality of L2C signals until initial operational capability (IOC) - or the broadcast of the signal on at least 21 satellites. ...the new signal is "under development" and "may be used for a variety of test applications prior to IOC. Consequently, until that time availability and quality of the L2C signal may be subject to change without prior notice. Therefore, ..., any use of the L2C signal prior to being declared operational is at the user's own risk.” (Inside GNSS 2006 - http://www.insidegnss.com/issues/one/news_b.php)

The processing algorithms within Leica receivers are designed such that the L2C signal is only used when it would bring benefit to the user – this is the Automatic option for the L2C Tracking setting in the CONFIGURE Satellite Settings panel.

The user can force the sensor to track L2C by choosing the Always Track option – this is not recommended.

More information about the advantages and disadvantages of using the GPS L2C signal can be found in the System1200 newsletter number 35.

THE L5 SIGNAL

A second addition to the GPS signal structure will be a third carrier frequency called L5.

For RTK applications, the availability of three carrier signals will have important advantages for ambiguity resolution and bias estimation such as multipath (Simsky, 2006).

For surveying applications, the main benefits will be an increase in the redundancy of observations. This will result in a slight accuracy improvement and also, ambiguity resolution will become faster and the baseline range will be extended.

The first satellite which will be able to transmit the L5 signal (the first of the GPS Block IIF satellites) is ex-
expected to be launched in 2008 (Leveson, 2006), but note that 6 block IIR satellites (which do not support L5) are still waiting to be launched. These satellites will most likely be launched before the first Block IIF satellite.

**GPS SUMMARY**

An optimistic estimation of the launch for the first IIF satellite, the initial operational capability (IOC) for L2C and L5 and the full operational capability (FOC) is shown below.

IOC can be considered to be the time when the signal will first be of any useable benefit for the GNSS surveyor.

<table>
<thead>
<tr>
<th>Satellite</th>
<th>IOC (12 Satellites)</th>
<th>FOC (24 Satellites)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2C</td>
<td>2005</td>
<td>2015</td>
</tr>
<tr>
<td>L5</td>
<td>2008</td>
<td>2018</td>
</tr>
</tbody>
</table>

Before the IOC is reached the tracking of the new signals will not bring any benefit to the user.

Leica guarantees and has promised that all System1200 GPS receivers can be upgraded at the board level to track the GPS L5 signal and GALILEO signals.

This upgrade will be available well before the time when enough satellites are available such that a user will benefit from the additional signals.

And the upgrade will be fully tested using the real satellite signals. Currently it is not possible for a manufacturer producing receivers capable to track L5 and/or GALILEO signals to test these receivers with real signals.

**GLONASS**

The GLONASS satellite system, which was developed by the Russian Federation, shares many similarities with its US GPS equivalent.

The GLONASS system did reach a fully operational status of 24 satellites in 1995 - however the constellation was not maintained due to a lack of funding which resulted in only 7 operational GLONASS satellites in 2001.

In August 2001, the government approved a program of modernization designed to restore the GLONASS service (Polischuk et al., 2002). The graph below shows the constellation status and deployment schedule (adapted from Dvorkin and Karutin, 2006).

A minimum constellation of 18 GLONASS satellites is scheduled to be available by 2007 and a full constellation in 2009.

At the time of writing two GLONASS-M satellites launched in December 2005 were set as healthy bringing the number of satellites to a useable 15 satellites.

A simple explanation as to why GLONASS can now bring significant benefit to a user is shown below. It can be clearly seen that the white areas when using a GPS only constellation are significantly reduced.

The general lack of GPS satellites to the north of the local zenith results in a relatively weak geometry in this direction.

More benefits of using GLONASS can be found in the recent Leica paper ‘GPS System 1200 – High Performance GNSS Technology for RTK Applications’. This paper has been presented at the ION2006 conference and can be obtained from the Leica download area:

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GALILEO

The European Union successfully launched the first experimental Galileo satellite, the GIOVE A, on 28th December 2005.

This launch is part of the development and validation phase of the Galileo program and does not provide service functionality.

The full constellation of 30 Galileo satellites is scheduled for deployment between 2008 and 2010. Commercial operation is expected to follow the deployment phase in 2011 (Commission of the European Communities, 2006).

Galileo will transmit signals in four frequency bands: E5a, E5b 1164 – 1215 MHz), E6 (1278 MHz) and L1 (1575 MHz).

In newsletter 35, an optimistic guess was made that the approval of the Galileo Signal in Space Interface Control Document (SiS ICD) would take place in the first half of 2006. A year later the SiS ICD is still not finalized and the signal lock (the final definition of the signal structure) is not yet made.

It is still unclear when a locked signal specification will be available.

The committee involved with the signal specification (the Signal Task Force) may modify the L1 signal structure. This is an “interesting” last-minute decision as to whether to change the signal specification – the Signal Task Force are considering a variant of the MBOC (Multiplexed Binary Offset Carrier) for the standard signal on L1 (find out more in Inside GNSS 07/08-2006).

But what does all this “technical-talk” mean for a user considering to buy a Galileo capable receiver today?

It would mean that a GNSS receiver which is currently available and designed to track Galileo has not been designed to handle this change in the signal structure and not benefit from the advantages it could bring – currently available receivers which claim to track Galileo signals will lose the signal power resulting in a 1dB signal strength drop.

REMEMBER...

- A fully operational constellation of GPS satellites transmitting L2C will most likely not happen before 2015
- There is no benefit for surveying applications in tracking the L2C signal. Nevertheless all new GPS1200 receivers support L2C without a surcharge
- Six GPS Block IIR-M satellites will most likely be launched before the first GPS Block IIF which can transmit L5 will be launched
- An initial operational constellation of GPS satellites transmitting L5 will not happen before 2012 – the tracking of L5 before this time will have no benefit for a user
- The Galileo system will further improve the performance and productivity of GNSS receivers for surveying applications. FOC will not happen before 2011
- The uncertainty about the signal structure of the Galileo system makes it difficult for manufacturers to finalize the design of the Application Specific Integrated Circuit (ASIC) chip
- Galileo capable receivers which are already available today may not benefit from the potential changes in the Galileo signal structure
- All GPS1200 receivers are upgradeable to GPS L5 and Galileo

REFERENCES


