System 1200 Newsletter – No. 35

Future Satellite Signals

GNSS Modernization

Two years ago a newsletter about the new civil code on L2 (L2C) signal discussed the benefits of the use of this signal for a surveyor and also provided a launch schedule of IIR-M satellites that support the L2C signal.

It is now a suitable time to give an update on both L2C and on the GNSS modernisation program in general – and again look at the true benefits for a surveyor with regards to new satellite signals. Maybe a question to bear in mind when reading this newsletter is the following…

When is the optimum time to invest in a GPS surveying sensor that could track future satellite signals – when these signals will not be of any practical or beneficial use for many years to come?

A Little Repetition: GPS - L2C

Only until recently, all GPS satellites (block II, block IIA and block IIR) transmitted the civil code (C/A) carried on L1 and the two precision P(Y)-codes carried on L1 and L2.

Today most dual frequency surveying GPS receivers track the C/A code, the corresponding L1 phase carrier, the encrypted P-code on L2 by utilizing code aiding technologies and the L2 phase carrier.

On 26th September 2005, the first block IIR-M satellite (PRN 17) was launched. In addition to the signals described above the IIR-M generation supports the military M-code and a civil code on L2 (L2C). The M-code is encrypted and restricted to the US department of defence. The civil code is accessible for non-military applications.

All Leica System 1200 GPS sensors are designed to support the second civil frequency. An upgrade will be necessary to accommodate L2C.

Advantages of L2C

Today, all civil dual-frequency receivers use codeless or semi-codeless techniques to measure L2 without knowledge of the encrypted (P)Y-code. The knowledge of the L2C code sequence makes tracking the L2 signal easier. This is simply an advantage for GPS manufacturers, but "invisible" to the user.

From a surveyor's point of view, there is no advantage to use a GPS survey sensor which can track L2C.

The only conceivable benefit for surveying would be a marginally stronger signal on L2.

In general, above a 10° elevation angle there is no difference in the number of observations between L2C and L2 P-code. It could be that extremely weak L2 signals could sometimes be tracked with the aid of L2C when it would otherwise not be possible.

In fact, such weak signals would deteriorate the position solution instead of supporting it. Due to a higher chipping rate of the L2 P-code, the code accuracy of L2 P-code is slightly better than the L2C-code. Furthermore, it is not yet clear whether in the future, L2 P-code will still be the first choice for positioning even though L2C would be available.

Currently there is one satellite (PRN 17) broadcasting L2C, but this satellite is still defined as unhealthy. It is expected that the satellite will be operational from February 2006 onwards.

Launch Schedule for L2C

Even though L2C will not bring benefit to the surveying user, there are advantages for manufacturers to directly track the L2 code without code aiding technologies.

A constellation of at least 24 satellites supporting L2C will be necessary to make codeless or semi-codeless tracking techniques obsolete for dual frequency RTK.

With an average of currently 2-3 launches per year it will take at least 8 years to achieve full operating constellation (FOC) for L2C.

Table 1 shows a list of the GPS launches within the last 5 years.

Date	PRN
Jan 2001	IIR-7 PRN18
Jan 2003	IIR-8 PRN16
Mar-2003	IIR-9 PRN21
Dec-2003	IIR-10 PRN22
Mar-2004	IIR-11-PRN19

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Jun-2004	IIR-12 PRN23
Nov-2004	IIR-13 PRN02
Sept-2005	IIR-M1 PRN17

Table 1: Block IIR, IIR-M launches (US NAVAL OBSERVATORY, 2005)

This launch schedule indicates that the current modernization strategy seems to maintain a constellation of 29 satellites rather than actively modernize the space segment. Due to the long life-time of the satellites (18 satellites are past their design life time target) it is not to be expected that modernisation will accelerate.

Seven block IIR satellites supporting L2C, are waiting to be launched and will most likely be launched within the next 3-4 years – this is most likely before the first IIF satellites - that support L5 signals - will be launched….

GPS – L5

The L5 signal (1176.45 MHz) will be available on GPS Block IIF satellites. L5 will provide benefits beyond the capabilities of the current GPS constellation, even after the planned second civil frequency (L2C) becomes available.

The benefits of the use of the L5 signal are mainly in the area of precise navigation operations (sub-metre accuracy) and to some extent also for surveying applications.

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.

Currently there is no accurate launch plan for IIF satellites. As already mentioned, it is very likely that the 7 remaining IIR-M satellites will be launched before the first IIF satellite will be launched.

Therefore the first satellite that broadcasts L5 will most likely not be in space before 2008.

To benefit from the third frequency for surveying applications a constellation of more than 12 satellites must be available.

It is almost certain that an initial operating constellation (IOC) of 12 L5 satellites will not happen before the end of the decade.

Leica GPS sensors of the 1200 series are flexibly designed and an upgrade plan will be available.

Table 2 gives an overview of the signal availability for existing and upcoming GPS satellite generations.

Signal	II, IIA, IIR	IIR-M	IIF
L1 C/A	Yes	Yes	Yes
L1 P/Y	Yes	Yes	Yes
L2C	-	Yes	Yes
L2 P/Y	Yes	Yes	Yes
L5	-		Yes

Table 2: New signal availability. Source: Fontana (2001)

GALILEO

Galileo will be a European global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control and will be inter-operable with GPS and GLONASS (European Space Agency (ESA), 2005).

It is planned that users will be informed within seconds of a failure of any satellite - this will make it suitable for applications where safety is crucial, such as running trains, guiding cars and landing aircraft. The integrity monitoring will be the most significant advantage over GPS.

The current schedule of Galileo is to be operational at the end of the decade. This schedule seems to be very optimistic due to the fact that until now no consortium has been awarded for the deployment phase. This increases the likelihood that FOC will not be in this decade.

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

The Galileo Signal in Space Interface Control Document (SiS ICD) is still not finalised - it is unclear when a locked signal specification will be available. The Task Force assigned to define the signal structure may want to modify the L1 signal structure, but ESA may want to push ahead with the current signal structure. A final agreement is not expected for at least 5 to 6 months.

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The uncertainty about the signal structure makes it difficult to finalize Application Specific Integrated Circuit (ASIC) chip designs.

Other GPS manufacturers may claim that they have come up with a way to track any Pseudorandom Noise (PRN) code. This is however unlikely since (for example) the E6 will have a commercial encryption scheme for the spreading codes that are currently still classified. It does not matter how generic the channels are, without having the encryption implemented on the chip, the probability of it working is very low. The E6 encryption algorithms are still not publicly available.

It is worthwhile to note that Leica is part of the ARTUS (Advanced Receiver Terminal for User Services) consortium to jointly develop a receiver for the Galileo test-beds. Being part of this consortium allows Leica access to confidential Galileo documents which some other GPS manufacturers in the surveying industry may not have.

Other survey GPS manufacturers may have recently claimed to be able to track Galileo signals, but any concrete results or proof of this (even using simulated signals) is not yet available.

REMEMBER…

- On average 2-3 GPS satellites are launched per year and a fully operational constellation for L2C is very unlikely to be available before 2012
- There is no benefit for surveying applications of tracking the L2C signal. Advantages are mainly for navigation applications
- The third GPS frequency L5 will bring true benefit with regards to ambiguity resolution. However seven IIR-M satellites will most likely be launched before the first IIF (with L5) will be launched
- An initial operating constellation of L5 capable satellites will not be present before the end of the decade
- The Galileo system will further improve the performance and productivity of GNSS receivers for surveying applications. A fully operational constellation will not happen before the end of the decade
- Leica is part of the ARTUS consortium and at the forefront of Galileo developments

REFERENCES

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