DEVELOPMENTS IN GNSS, POSSIBILITIES FOR HYDROGRAPHY

GNSS: Hydrographic Perspectives (Part 2)

Hydro International Interviews Gary Chisholm, Trimble, Paul Cross, UCL, Owen Goodman, Fugro and Peter Grognard, Septentrio

 When Hydro International interviewed a group of experts on developments in GNSS as related to the hydrographic profession, they responded with such enthusiasm that that we were forced by lack of space to publish the interview in two parts. Part 1, which concentrated on the new opportunities offered the surveyor by horizontal and vertical accuracy and the need for differential solutions, appeared in our October issue. We now present the second part of the interview.

Can you briefly explain the possibilities/advantages of the many signals for carrier-phase solutions?

Chisholm: Simulations of various signal structures and satellite constellations have shown that instant-aneous centimetre-level positioning should be possible with three-frequency signal configurations. Currently, RTK systems operating range are around 30km from a single base station. Baseline lengths of 70km or more from a single base station will be possible with three frequencies and improved satellite geometry. Users of virtual reference station systems (VRS) will experience much faster initialisation times.

Cross: The detailed structures of the many signals that will be available once Galileo and modernised GPS are fully operational would need a whole, and rather long, technical paper to describe. Each signal has been specially designed to deliver range measurements with specific characteristics. Rather like in the initial design of GPS, many are designed for both fast acquisition and high precision; i.e. they carry two codes, one short and another long. Perhaps the first point to mention is that the new signals will be harder to jam and less susceptible to interference. This is due to their increased power, longer code sequences and larger bandwidth. Also, the fact that there are more of them will mean that there is a greater chance that at least one will be free of interference, at least, when this is unintentional.

Another important feature of the signals is that they will allow both code and phase measurements to be made with a much higher resolution; this for a number of reasons, including the faster chipping rate of some codes. In fact, it is predicted that on some signals, code measurements will be possible with resolution of little more than a centimetre. Also the measurements will be less susceptible to multipath, except from very close reflectors or, more correctly, from reflectors causing only a small additional path length. This, combined with the ability to use multiple frequencies, will mean that except in the most extreme conditions ionospheric error will no longer be an issue. There will be a massive improvement, of several orders of magnitude, in the ability of GNSS to resolve ambiguities in a single epoch over short distances.

Possibly of less importance to hydrographic surveyors, who generally work in conditions of clear skies, is the fact that the new signals will have increased penetration, so enabling the use of GNSS in densely forested areas and inside some buildings. This is largely due to increased power and longer codes. Also, the pilot signals, those without a data message, will allow longer integration times, so enabling high-precision phase meas-urements on weak signals. It is also worth mentioning that the shorter codes can be used for faster acquisition after turning on a receiver or losing lock on a satellite after passing an obstruction.

Goodman: Faster ambiguity resolution for longer baselines where ionospheric effects are greater and greater redundancy. The new signals will be stronger and have improved availability. Non-RTK solutions like the Fugro Starfix-HP and XP global solutions will converge to achieve optimum accuracy faster.

Grognard: A larger number of satellites and frequencies shall increase the redundancy of information available for the ambiguity resolution, thus improving the performance of ambiguity fixing. Some of the new signals, such as E5AltBOC, have extremely low code multipath noise, which shall also help with ambiguity resolution when these signals are used. Ambiguity resolution with three and more frequencies shall be helped by triple-frequency relationships between ambiguities (for more details see a paper by A. Simsky â€˜Threeâ€™s the charmâ€™ in the July/August issue of InsideGNSS, p 38-41). Availability of multiple frequencies allows for pre-processing cycle slip detection/removal techniques based on the monitoring of inter-frequency jumps. On top of that, multi-frequency phase processing is simply more robust to interference, which may affect one band but not the others.

Which combinations of signals are optimal for future hydrographic purposes? Will different combinations be applied to different survey projects?
Chisholm: Size and power consumption are typically not driving factors in hydrographic survey products compared to, say, GIS or mobile phone-based products where compromises need to be made on which signals to track. More is generally better for high-precision work.

Cross: I think this is very much a 'wait and see' issue. There will, in fact, be ten open service (free) signals once Galileo and modernised GPS are available: four on modernised GPS and six on Galileo. And there will be even more if we consider Glonass as well. It is unlikely that anyone will build a receiver that uses all of these, and many different subsets are pos-sible. I suspect that there will indeed be different combinations for different applications. Just like today we have single and dual-frequency, and phase and code combinations, but there will be many more. Certainly for the very high-accuracy applications I expect to see all three frequencies of each system being used. There is going to be lot of competition to come up with the very best combinations, and I doubt we will know how things are really going to pan out until some of these signals are available. Itâ€™s perhaps worth pointing out that today we have only one GPS satellite with an L2C signal, no L5 signals and no publicly available Galileo signals!

Goodman: Actually, the increased number of satellites available, spread across the sky, using all GNSS systems, is likely to be more important than the increase in signals (frequencies) per satellite, particularly to speed up ambiguity resolution for long-range RTK methods etc. Additional signals, at different frequencies, will help to eliminate ionospheric effects on long baselines.

Grognard: According to available research, the combination of L1/L5 can be considered as a good choice for dual-frequency Galileo/GPS receivers of the future after full deployment of GPS L5. For the transitional period, GPS L2(P)/L2C shall still be used as a second GPS frequency, hence a triple-frequency L1/L5/L2 receiver is a most likely candidate for the near future. Multi-frequency receivers shall also be used, especially for research projects, but it is not clear at this point to what extent the gain in performance due to the use of multiple frequencies will justify the increase in complexity and cost.

Can we expect to use a single GNSS receiver, and will all differential and ephemeris messages be collated somehow?
Chisholm: Regional differential correction services may be offered as part of the Galileo and modernised GPS civil services. The 50bit per second navigation data stream used for GPS today will be supplanted by higher-speed downlinks with more flexible message structures. Wireless internet services have already gained wide acceptance in populated areas. The internet will continue to have an important role to play in high-precision correction service delivery.

Cross: This is really a question for the receiver manufacturers, but I would be very surprised if the answers to both questions are not 'yes'.

Goodman: GNSS receivers that can handle augmentation data for both GPS and Glonass are available today. Integrated GPS/Glonass/Galileo receivers will be available as soon as Galileo is operationally available. Collating ephemeris and other messages may take a bit longer, but is achievable.

Grognard: We are currently observing wide diversification of differential correction services. Most of the global-scale differential services use signals either in L1 frequency band (such as WAAS or EGNOS) or in adjacent microwave frequency bands, such as Omnistar. The receivers capable of these services are fully integrated devices, even though the differential corrections are still coming via separate communication channels transparently for a user. Most local differential services still use traditional means of delivery via direct radio links or TCP/IP. In the future, navigation messages shall be delivered together with local differential corrections within the framework of so-called 'assisted GNSS' technology.

What advances in GNSS hardware do you foresee over the coming ten years?
Chisholm: Trimble is continually investing in R&D to make receivers even more suitable for the users. We see the receivers becoming smaller, requiring less power and being able to be used for a variety of tasks, ranging from onboard a vessel to use by the surveyor for measuring land reclamation or coastline features.

Cross: This is another best left to the representatives from the manufacturers to answer.

Goodman: Enhanced multipath reduction, further miniaturisation and integration with MEMS devices. Perhaps some of the less sophisticated anti-jamming technology used today by the military may become available in certain civilian receivers.

Grognard: As mentioned earlier (Ed: Question 1, Part 1), GNSS hardware will become more potent: smaller, with lower power consumption and more onboard CPU and storage capacity etc.

Given that the commercial sector has proven to be capable of providing accurate GNSS augmentation services globally and reliably for some years now, do you believe there is a role for government in providing GNSS augmentation services, and if so, why?

Chisholm: The government sector has already provided DGPS beacon systems. They were reliable, well planned and solved a real need. Today the USA Coast Guard is studying the next generation of beacon technology. Virtual Reference Station services have been installed and operated by governments around the world such as in UK, Germany, Sweden, Australia etc. They are cost-effective to use and ensure use of a common datum.

Cross: I believe there is a role for both commercial and government-funded (free to the user) services. GNSS is fast becoming a ubiquitous service with an ever-increasing number of applications. It is also a catalyst for a massive number of income-generating activities and public-good services. Augmentation costs little in comparison with the setting up and running costs of a GNSS, and for governments not to fund this is to effectively deny high-performance GNSS to the majority of their citizens, who have paid for the systems through their taxes. Applications of such navigation for blind pedestrians and future automatic, personal transport systems will need GNSS to be augmented in order to provide the required accuracy and integrity. I believe that there will also be a class of professional users, including some hydrographic surveyors, who will need more from the GNSS, especially in terms of quality control and its relationship to survey specifications, and I see these as still relying on commercial services. It could be that a kind of hybrid will arise whereby governments provide the physical side of the augmentation, i.e. they operate base stations and provide data, and commercial organisations add value to the data and sell services. Certainly this is a model that I would like to see develop.

Goodman: No! The private sector has led the way in developing, implementing and operating GNSS augmentation systems since GPS was launched. The accuracy, global coverage and success of commercial GPS augmentation services largely contributed to the ending of GPS Selective Availability by making it redundant, and have influenced the design of the planned Galileo system. Commercial companies have also developed GNSS integrity monitoring systems that meet the extremely high demands of the offshore oil & gas sector.

In a free marketplace there is absolutely no reason why government agencies should spend quite literally billions of dollars of taxpayersâ€™ money providing GNSS augmenting services which the commercial sector have proven themselves quite capable of delivering at a fraction of the cost.

Grognard: While this is not Septentrio's area of expertise, I personally believe that government should be very cautious when influencing a competitive market in which European industry has proved itself very successful worldwide. Industry in Europe has acquired world-class expertise in this domain and contributes significantly to the success of European GNSS industry. Therefore any such initiative must be pondered very carefully and should not upset a healthy industrial sector.

Galileo is being promoted as a civil (non-military) system in the sense that this should offer the user a better guarantee of availability than GPS currently provides. Do you believe that Galileo will offer the civilian user any

protection against interference or interruption of their positioning/navigation capability in times and areas of war or civil conflict?

Chisholm: Denial of accuracy is usually very localised and practised in areas of intense conflict. The Safety of Life services from all GNSS systems should be guaranteed against any military jamming.

Cross: GNSS signals are very weak, typical power output being equivalent to a domestic light bulb, and in prin-ciple all satellite navigation systems can be jammed or services withdrawn. I do not believe that civilian users will be protected against either of these during a major conflict, but perhaps in such situations the last thing on peoples' minds will be the carrying out of hydrographic surveys. Of some concern is the fact that Galileo signals have been deliberately separated from the new GPS military codes. It is hard to imagine any other reason for this than to enable the jamming, or denial by other means, of satellite navigation, both GPS and Galileo, without affecting the ability to use GPS to support US military objectives. I believe that a more serious threat than that from war is from terrorists, hackers - especially when satellite navigation is used for applications such as road-user charging - and completely unpredictable failures of the type that many believe to be so unlikely as to be impossible. I say this even though the new signals will be a little harder to jam than the existing ones. It follows that I strongly believe that some kind of back-up system should be maintained so that a capability, albeit significantly reduced, for safe navigation can be maintained when GNSS is, temporally, unavailable. For offshore applications eLORAN (Enhanced LORAN) is the obvious choice for this.

Goodman: Unfortunately, if the US, or any other country for that matter, decides to deny civilian users access to GNSS in times of a security crisis by jamming the signals, they will most likely jam all GNSS signals. While Galileo may have been instigated as a civilian system, the reality is that a user of Galileo will be no better protected from jamming or other signal interference than a GPS user.

Grognard: Galileo and GPS are governed by the same Laws of Nature. Weak GNSS signals are by default vulnerable to interference and this will also be the case with Galileo. However, the combination of several GNSS signals and the coupling with non-GNSS sensors in one receiver will make the positioning/navigation capability very robust, even in times of war or civil conflict.
