GPS Receiver Technology—Present and Future:

The Receiver is at the Heart of any GPS System. Experts tell us what the Future Holds

In GPS machine guidance systems, clearly the performance of the GPS receiver itself has a great bearing upon the effectiveness of the whole system.

So what is the current state of play when it comes to GPS receivers, and what does the future hold?

The Present

Strictly speaking, the term GPS refers to the American system, and one needs to be aware that there is also a Russian satellite network called Glonass. Also, there's a European satellite system mooted, under the name of Galileo.

The back-room boffins are looking for two areas of improvement that are relevant to machine guidance. One is the accuracy that guidance systems can offer; at present it's about 25/30mm. The other is the speed with which receivers 'lock back on' if they 'lose sight' of one or more of the five satellites they need for reliable positioning data to be passed on to the guidance system.

The American GPS system was designed around 24 satellites being in orbit at any one time, 21 being active, and three being spares. At the present time there are 29 American satellites in service. The practical effect of this greater number is that a GPS receiver, at any one time, should have more satellites 'in sight' and therefore be able to lock on to the required minimum of five with a higher degree of reliability.

RTK Gets Systems "Back on the Air' More Quickly

Receivers occasionally 'lose' a satellite, when it drops below the horizon, or is obstructed by trees or buildings. If the total falls below five, they'll notify the operator that the reliability of positioning data is compromised until they 'lock on' again.

Whilst these periods of reduced accuracy are brief, they are a limiting factor in the efficiency of high-precision GPS for machine guidance and therefore present an opportunity for improvement.

Useful advances have recently been made in the speed with which receivers re-acquire satellites, enabling them to resume providing high-accuracy data to the machine guidance system. Real Time Kinematic (RTK) technology has now been put into service by most major manufacturers of GPS receivers.

RTK has reduced from 'a number of minutes' to 'a minute or less' the time frame for re-acquiring centimetre-level accuracy, once lost.

The Russians—Rickety, But Sometimes Helpful

Another approach, so far limited to Topcon for dual frequency, is to offer a receiver capable of reading both American GPS signals and also Russian Glonass signals.

Most manufacturers have opted to avoid this route because they foresee a limited future with the Russians. Shortage of funds restricted the Russians to launching only 14 out of a planned 24 satellites, and those that are still flying are plagued with unreliability—only seven were serviceable at last count.

Nevertheless, in an earthmoving scenario if a receiver 'sees' a couple of Russian satellites at a time when only three or four American GPS satellites are visible (and that can briefly occur) then the machine can keep working, whereas the operator would otherwise have been receiving an 'unreliable data' message in his cab.

This can be an issue in certain very limited circumstances, for instance with a machine working in low latitudes and perhaps deep down an open cut mine, where the expanse of the horizon is curtailed by the wall of the open cut. In those conditions, the machine guidance system needs all the help it can get.

A classic example of this was observed at a mine site in Victoria at the end of October. For certain brief periods, only five GPS satellites were in view, but fortunately five Glonass satellites could make up the numbers.

Critics have been vocal about the dual GPS/Glonass approach, but this was an example that actually occurred and would have involved some costly down-time if a fleet of dozers had been dependant on GPS alone.

The Russians have recently launched three more satellites, so their program is apparently not as dead in the water as many thought.

We keep hearing about short periods of downtime, often around 2pm in the afternoon, from operators of systems that are solely reliant on GPS satellites. Software is available to predict satellite availability and optimum reception periods, so that earthmoving operations can be scheduled either side of these periods of reduced reliability. But prospective users with demanding applications would be well advised to study this point carefully with the proponents of GPS-alone and GPS-Glonass solutions.

The Future

We asked two GPS experts where this technology is headed in the future.

Nick Talbot is Melbourne-based Senior Software Engineer at Trimble, with particular involvement in the recent development of RTK.

Mike Manning is the 'hands on' expert at ABC Lasers, and has been in the thick of their rapid rise to prominence in GPS machine guidance and control.

Nick explains that at present, the GPS satellites broadcast signals on two microwave frequencies, known as L1 and L2. The L1 band carries both military and civil access codes, while the L2 frequency is limited to military use. For our purposes, the military L1 and L2 signals are irrelevant, as the Yanks are never going to give us a look in.

Although commercial GPS is currently designed to provide civil

...the Prospects for Higher Accuracy

access only via the L1 signal, through clever workarounds the civil industry is getting limited value out of L2. These recent developments are known as 'dual frequency' receivers.

This is broadly the situation that currently defines the performance of GPS receivers, and the accuracy they offer.

"The Americans are about to start putting up a series of new satellites that will give us civil access to L2," says Nick. "By 2005 there should be enough of them flying for us to start deriving some benefits. I don't think we'll see a great improvement in accuracy, but we should see an improvement in the speed with which our receivers bounce back and deliver high-accuracy results after they 'lose' a satellite and re-acquire."

"Re-acquisition time should then be in the order of tens of seconds, compared with a minute or so at present."

"We are told that there will be a third civil frequency available in about 2010, and I expect that will cut the re-acquisition time even further, to a matter of a few seconds. I'd also expect positioning accuracy to improve significantly at that time," says Nick.

Mike Manning of ABC Lasers counters by pointing out that with the 'Instant RTK' they are currently offering in the latest generation of receivers, sub-ten second re-acquisition is already a reality. Tests conducted by Ashtech have given five second results, although on a baseline (distance between base station and rover) of less than seven kilometres.

Galileo—Coming or Not?

The dark horse in this situation is the Galileo system proposed by the Europeans. As with the successful Airbus program for manufacturing commercial jet aircraft, the Europeans see benefits in avoiding reliance upon American technology.

Considerable funding has been provided for research, but no definite decision has yet been taken to deploy satellites, which would be for civil rather than military purposes.

The Europeans are talking about a very high degree of accuracy in a system using 24-30 satellites, and there has been much discussion about how costs might be recouped.

Present thinking is that three levels of accuracy may be offered; a 'free to air' level of low accuracy; a mid-range aimed at aircraft and vessels, and a 'full bells and whistles' level. The last two would generate revenue either in the form of royalties paid by manufacturers of receivers, or an annual subscription payable by users direct to Galileo.

An entirely new system to be used instead of existing GPS, or in conjunction with it, would open up a whole raft of opportunities.

Incremental Improvements

Mike Manning of ABC foresees a gradual improvement in accuracy from refinements across a range of components of the existing system. Such things as more accurate predictions of satellite orbits, enhancement of circuitry in receivers, better mathematics generally.

"One thing I'm quite sure about," says Mike. "That is, we will progressively be achieving better and better accuracy."

At present, with GPS offering 25/30mm and robotic total stations (automatic tracking or so-called ATS systems) offering 10mm accuracy, the earthmoving applications for GPS are limited to projects where an accuracy of 25/30mm is acceptable.

But as improvements to GPS accuracy narrow that gap, clearly it will take over from short-range ATS because of its distinct advantage of being able to service a considerable number of machines over a far greater area.

The bottom line is that contractors need to be keeping tabs on GPS because even if it is not sufficiently accurate for all their needs at present, it will become so in the future.

The only component of a present-day system that will need to be replaced in order to get the benefit of this greater accuracy is the GPS receiver itself. And the better-designed robotic systems can, of course, already be optionally guided by GPS.

As we have pointed out in numerous earlier articles, there are considerable advantages currently available to contractors from GPS, apart from simply machine guidance.

Experience shows that it is not just a 'plug and play' technology—personnel from the top to the bottom of an organisation need exposure and hands-on experience, in order to develop the work culture and confidence that will generate maximum productivity.

When will we see One Centimetre Accuracy?

We asked both Nick Talbot of Trimble and Mike Manning of ABC Lasers to look into their crystal balls and tell us when they'd be able to offer a system capable of an accuracy of one centimetre or better.

"Conservatively, my guess is 2012," says Nick.

Mike Manning believes that across-the-board improvements will bring that day closer. "I'm going for five years from now," he forecasts.

Peter Kerville