To meet unprecedented demand for minerals and energy resources, open-pit mines are getting deeper and potentially steeper, presenting many challenges that can have an adverse effect on productivity and safety. One challenge is the reduction of ‘sky-view’, which diminishes the availability of satellites used for positional information for mine machinery.

Acceptable real-time kinematic (RTK) GNSS (global navigation satellite system) performance is heavily dependent on a relative unobstructed sky-view, where there are a minimum of five satellites with good geometry available, and on the reliability of the wireless data link used for differential corrections (in this article the more generic term, GPS, will be used to cover all systems).

In a deep mine, high pit walls have a vignette effect on the sky, resulting in ‘satellite masking’. Machinery operating at the bottom of the pit or next to the walls will have a reduced angle from which they can clearly receive signals from the satellites necessary to obtain positioning, which affects availability and accuracy.

This reduced availability and accuracy affects machine control systems (MCS) and fleet management systems (FMS). To optimise productivity and improve safety on site, modern mines rely on the accuracy provided by high-precision GPS machine-control systems for drills, dozers, shovels and draglines, and the efficiency offered by automated truck and shovel optimisation.

Leica Geosystems’ Jigsaw360 fleet management system provides productivity gains through efficient use of equipment and reduced shovel hang time. Along with Leica’s high-precision machine-control systems on loading and auxiliary equipment, the rise in safety systems such as proximity detection, collision avoidance and asset tracking all require high GPS availability for optimum performance. Poor GPS reduces productivity and can affect safety.

INTEGRATING LOCATA
To overcome the issue of obstructed GPS signals, inherent in satellite position technology, Leica has sought to reduce the dependence of its machine-control and fleet-management systems on satellites by incorporating technology developed by Locata Corp. Leica’s Jigsaw360 system has been integrated with Locata’s positioning technology, combined with the use of a GPS-Locata co-located antenna, which Leica developed specifically for mining.

The integration consists of a network of terrestrially-based ‘beacons’ (LocataLites) that transmit positioning signals that augment or replace satellite GPS entirely. These LocataLites form a positioning network called a LocataNet, which can operate in combination with GPS or entirely independent of GPS (for indoor applications). A time-synchronisation technology developed by Locata, called TimeLoc, allows the LocataNet to replicate GPS satellites locally. This invention allows completely autonomous ‘better than nanosecond’ wireless synchronisation, which allows the LocataNet to give the mine high-accuracy RTK survey grade positioning without using any of the reference base stations, differential corrections or data links traditionally needed by RTK GPS. Locata’s technology is the only one in the world that can do this.

In the current system design, the LocataLites transmit their own proprietary signal structure in the 2.4GHz ISM band (licence-free globally). This ensures complete interoperability with GPS, and allows enormous flexibility due to total control over both the signal transmitter and receiver. Further details of the current system design can be found in Barnes et al 2005 (see references), together with positioning results showing RTK-level performance independent of GPS.

Locata, just like GPS, can be used for many different applications. The company is working with a number of global partners on industry specific implementations.

Leica was the first company to recognise the potential of Locata’s emerging technology. In July 2006, the two firms signed a technology co-operation agreement for the distribution and support of Locata technology in open-cut mining for machine automation and mine monitoring.

Leica’s early adoption allowed it to be the first to trial, refine and then develop new mine-specific Locata implementations that are tightly integrated with its machine-automation systems. Leica is the first company to bring Locata technology to open-cut mines.

www.MiningMagazine.com October 2010
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The spatial and frequency diversity of the Locata system will be expanded to allow greater levels of accuracy in the vertical as the pit deepens and changes shape.

**LIGHT VEHICLE INSTALLATION**

During the LocataNet deployment in March, a dynamic test was conducted on the pit floor using a light vehicle (LV) (figure 4). The aim was to confirm the performance of the BGM Locata network against a survey grade RTK system. A GPS/Locata co-located antenna was mounted on the roof of the LV and connected to an integrated Leica/Locata rover system.

**PERFORMANCE RESULTS**

The test trajectory (figure 5) covered an area of about 140m by 120m. Figure 6 shows the difference in 3D-position components between the Locata and Leica System 1200 RTK solutions. The differences between the GPS RTK and Locata positions were 2.4 cm in the horizontal and 6.7 cm in the vertical (RMS 95%). These remarkable results fall well within the positioning requirements of BGM. They are particularly impressive considering they are achieved with only five LocataLites. The better performance in the horizontal, in comparison to the vertical, is due to the relatively shallow pit depth, which imposes considerable constraint on the ‘vertical geometry’ of the Locata solution.

The success of the test highlights some key, unique characteristics of Locata technology, including the ability to leverage the spatial and frequency diversity of the signals transmitted from each LocataLite in the navigation solution. Furthermore, a ‘Stage 2’ deployment of more LocataLites will ensure even greater robustness and greater levels of accuracy in the vertical as the pit deepens and changes shape.

**SUMMARY**

An integrated Leica/Locata system product for fleet management in open-cut mining has been deployed successfully and is operating on a continuous basis at Boddington Gold Mine. A LocataNet, consisting of five LocataLites, provides ranging signals to Locata rovers integrated with Leica’s high-precision machine-control systems on four drills and one shovel. This provides accurate positioning and orientation for the equipment during significant RTK-GPS outages.

Over the coming months, the integrated Leica/Locata system will be expanded to include self-surveying mobile LocataLites, covering two pits and servicing the site’s high-precision equipment of drills, shovels and dozers.

Leica Geosystems’ Locata integrated Jigsaw360 fleet-management system overcomes the hurdle of obstructed satellite GPS coverage. Reliable and complete coverage improves productivity and allows future innovative products to be built on reliable positional information. For example, proximity awareness and collision-avoidance systems significantly increase safety on mine sites, and benefit from complete GPS coverage and availability.

Guaranteed positioning coverage will give more assurance for remote-controlled or autonomous machine control. In another key achievement and a validation of the technology, the US Air Force has awarded a new contract to expand an existing LocataNet system to cover a vast area of New Mexico for the purpose of testing GPS under jamming conditions.

For Hexagon, the owner of Leica Geosystems and the world’s largest supplier of measurement software and hardware, Locata is a fundamental part of its strategy to offer a complete mining solution that covers survey to machine control to fleet management to safety systems, and beyond.

The landscape has changed forever with the advent of the Locata technology and Hexagon will deliver this mining innovation for measurable success as part of its life-of-mine relationship with customers.

References:

More valuable technical information about the Locata Technology is available from a recent Webinar (and the subsequent FAQ follow-up) conducted by a specialist GPS magazine: GPS World Magazine Webinar - LocataNet information: [http://tinyurl.com/87dI8un](http://tinyurl.com/87dI8un)

GPS World Magazine with Locata FAQ's - [http://tinyurl.com/344g469](http://tinyurl.com/344g469)

www.MiningMagazine.com October 2010