GPS Applications at Optimum Colliery

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Synopsis

Optimum Colliery is an opencast strip mine producing 18Mt of bituminous coal per annum for the export and inland markets as well as for domestic power generation at the Hendrina Power Station. Coal is exposed by four $60m^3$ and four $11m^3$ walking draglines and transported from the open cuts to the processing plants by twelve 130 ton coal haulers. Overburden and interburden areas are drilled by nine 250mm-diameter rotary drill rigs.

Until 1997 all surveying tasks were conducted by electronic total stations requiring accurate control points from which line-of-sight XYZ readings could be taken. In 1997 a GPS system was introduced which consisted of a fixed base station and two rovers. The rovers were able to perform most of the survey tasks assigned to total stations.

In addition, two overburden drills were equipped with blasthole drill navigation systems, which includes the drill monitoring and material (strata) recognitions system. The rest of the drilling fleet will also be equipped with GPS systems.

Blasthole positions are designed in the office based on survey and geological/geophysical information and transmitted via radio link to an industrial PC on the drills. Together with GPS positional data, both the planned and actual drill positions are displayed on an LCD screen. This eliminates the need for surveyed hole positions to be staked before drilling, and for actual hole positions to be surveyed after drilling. As holes are drilled, performance and rock property data transmitted back to the office.

Future applications will include GPS monitoring of dragline positions and pad elevations. GPS receivers on the draglines will utilize the existing base station to calculate and transmit XYZ co-ordinates. Another application will be locating of boreholes in the field prior to the pumping of specified explosive charges into the blastholes. Charging instructions for each blasthole will be loaded into the computer on the explosives truck which will be equipped with a GPS system for hole identification.

Introduction

Optimum Colliery is located in the Witbank Coalfield of the Mpumalanga Province, situated about 30 km south-east of Middelburg and about 20 km north-west of Hendrina.

In 1968 Optimum Colliery was awarded a contract to supply ESKOM's Hendrina Power Station with 6,5 Mton of bituminous coal annually. Originally the mine was planned and designed as a single product, underground mine, which commenced production in 1970. Subsequent planning and economic evaluations proved that an opencast strip mine would be more flexible and profitable. The opencast operations commenced in 1971 with the commissioning of the first large Marion 8000 dragline and continued to expand to include eight draglines in total. Underground operations ceased in 1982.

With the increased demand for coal internationally during the late 1970s and early 1980s, further re-planning converted Optimum into a multi-product mine in 1983, supplying both the Hendrina Power Station and the export market. In the same year the heavy media separation drum plant was commissioned, followed by the commissioning of the cyclone and spiral plants in 1986.

Eikeboom and TNC were incorporated into Optimum Colliery in 1993 and 1995 respectively.

What is GPS?

GPS—the *Global Positioning System*—was developed by the US Department of Defence to provide the various arms of the US Forces with a common, reliable, navigation and positioning aid, regardless of where they were operating in the world. The system consists of a constellation of 24 satellites that orbit the earth at an approximate altitude of 22,000 kilometres. Monitored and maintained by ground stations located around the globe and operated by the US Department of Defence, USDOD, the GPS system cost in excess of US$12 billion to create, and access is available world-wide free of charge.

Put simply, a GPS receiver computes its position by measuring its distance from several different satellites. The distance to each satellite is calculated by measuring how

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long it takes a radio signal from the satellite to reach the receiver, and then multiplying this time by the speed of light. Measuring distances to four satellites at the same time allows a receiver to compute its position.

Why GPS?

GPS technology offers mine operators a number of key advantages that make it a compelling tool in the modern environment.

- Highly Accurate 3D positioning and timing signal.
- 24-hour availability—the GPS constellation is designed to offer 24 hour coverage with four or more satellites visible over the horizon.
- All-weather operation—the radio signals used by the system are not affected by weather conditions.
- Unlimited users—a GPS base station transmitting correction data can be used by an unlimited number of users in the area, so long as they are set up with the correct radio link.
- Line of sight—unlike conventional survey, there is no need for line of sight between the reference point and the rover.
- Dynamic positioning system—GPS receivers work equally well while moving, offering many advantages over beacon-based location systems.
- Free service—there is no charge for using the signals from the GPS constellation.
- Worldwide coverage—receivers will work regardless of their location in the world. This is particularly useful for exploration teams who are free to move around large areas.

Table I

Sources of GPS error

Error type	Cause	Solution
Selective Availability	USDOD deliberately introduces this randomly variable error for security reasons	Differential GPS correction
Ionosphere	Particle ionization changes speed of light	Dual frequency comparisons
Troposphere	Moisture changes speed of light	Mathematical modelling of error
Position Dilution of precision	The relative positions of satelites either cancels errors or reinforces them	Quality control by receivers
Multipath	Reflection of signals increases distance travelled	GPS antenna design, signal filtering
Others	Clock error, receivers, ephemeris	Receiver software

GPS accuracy

The first question on every potential user's mind is 'How accurate is GPS?'. There are actually three main levels of accuracy available to the user, ranging from < 10mm to < 100m, and one must consider the needs of one's application, when choosing what accuracy is required. When discussing the accuracy of GPS, however, one must first briefly look at the sources of errors when calculating the distance to a satellite, as the nature of these errors have shaped the development of GPS technology.

Selective availability

This is by far the largest source of error, and is a randomly variable error introduced into the signal transmitted by the satellite for security reasons, by the USDOD. As the error is variable, it may be zero, or may result in a positional error of as much as 100m. US President, Bill Clinton, recently announced that selective availability would be phased out over the next five years. Thus the error in an autonomous GPS position will decrease dramatically from 15–100m to 10–15m. Most of the remaining 10 to 15m error comes from the following sources.

Ionosphere and troposphere

While the speed of light is a constant in a vacuum, this is not the case when it enters the atmosphere. The errors introduced by ionospheric and tropospheric layers are small enough not to matter except when one gets down to centimetre level accuracy. RTK receivers working to millimetre precision analyse two different frequencies from the satellites to estimate the error and allow for it.

Multipath

Multipath is the term used for the reflection of the satellite signals off surfaces near the GPS antennae. Water, metal roofs, rock faces, etc. are sources of multipath. This error is greatly reduced by good antenna location and installation, special designs of antenna that shield the electronics from all signals below a certain angle, and special receiver software that filters bogus signals from the calculations.

Multipath is important to mines as the environment provides large numbers of surfaces that can reflect signals. However, good installation practice all but eliminates the problem.

Position Dilution of Precision (PDOP)

Position Dilution of Precision is a geometry problem, and one that depends on the positions of the satellites at certain times of the day. Again, receivers are programmed to reduce this problem, and for high precision survey work, software is available that allows the surveyor to predict the PDOP for a time of the day, and to plan work accordingly.

Autonomous Positions

A single receiver operated by itself provides an autonomous position fix. This receiver has no way of correcting the

Table II
Levels of GPS accuracy

Position fix	Horizontal accuracy	Vertical accuracy	Applications
Autonomous	15–100 m	30–200 m	Leisure activities like boating, aviation or hiking
Differential GPS (DGPS)	0.5–5 m	1–10 m	Vehicle tracking, mapping, GIS data collection, exploration
Real-time Kinematic (RTK)	+/- 10 mm	+/- 20 mm	Survey, precise positioning, machine control

inaccuracies that are present in the GPS signals, and so can only fix its position to within 100m. The handheld devices advertised in recreational magazines are of this type, as are the devices used for rough position fixes in the field by exploration scientists.

Differential GPS

To get positions accurate enough for engineering applications, one must have a means of correcting the errors in the calculations of the distances to satellites. This is achieved using a technique called Differential GPS—DGPS—and is the basis for the majority of GPS applications.

The theory is quite simple. Instead of using just one GPS receiver in an area, two are used. One receiver, the *base*, acts as a reference mounted on a known point. The second receiver, the *rover*, is then used to fix positions at the point of application. As the known position of the base can be compared with the position calculated using the satellites, the error can be calculated and used to correct the position of the rover, as long as the rover uses the same satellites as the base for its calculations.

If one establishes a live radio link between the base and the rover, one can then correct the positions in the field to achieve accuracies of 0.5–5m. This solution is good enough for vehicle tracking, and is the technique used by dispatching and MIS software supplied by companies like Wenco from Canada and Modular Mining from the USA.

Post Processing—i.e. processing after the event—is the technique used by mappers and samplers to correct the positions logged by a receiver after the work is done in the field. This eliminates the need for a radio link, and so reduces the cost of the equipment. On returning to the office after a day of data collection, the user runs software that checks the times of the positions logged in the field, and corrects the positions using files recorded for the same times at the base station.

In South Africa, Telkom maintains a network of base stations around the country that are available to the public for post-processing of GPS data. Any user in the country can dial the nearest base station, as long as it is less than 500km away, and use the logged data to correct positions to within 1m.

Real Time Kinematic GPS – (RTK)

A very accurate position can be fixed using receivers that make use of a variety of sophisticated techniques to calculate the distance to satellites to within millimetres. This technique is called Real Time Kinematic GPS–RTK—and results in the most accurate GPS available today. Because an RTK system achieves accuracies better than 10mm, it is the basis for the GPS used by surveyors for measuring and staking out, and by engineers for the development of machine positioning and control systems.

RTK–GPS is far and away the most powerful positioning system available, and it is the technology that will drive the development of applications in mines and quarries for the foreseeable future. Most of the applications discussed in this paper make use of RTK technology.

Note: Although RTK receivers use quite different technology to DGPS receivers, the layout of both systems, i.e. base - radio link - rover, is virtually the same.

Overview of Optimum's GPS system

Having looked at some of the theory of how a GPS system works, it is worthwhile describing the components of Optimum's GPS system before looking at individual applications.

Base Station

Also known as the Reference Station, the base station is the starting point for any mine's GPS system. The GPS base station is designed to operate continuously, 24 hours a day, and to perform two functions, namely

- ➤ Receive data from GPS satellites
- ➤ Transmit GPS data to rovers via radio.

The choice of a base station is most critical when considering GPS, as it affects the flexibility and cost of future GPS applications on the mine. Often a mine selects a base station to give the survey department a GPS tool, only to find a short time later that the base will not accommodate more than one task, and must be replaced to enable vehicle tracking, precise positioning, etc.

RTK & RTCM Signals: The correction information used in DGPS is contained in a format called RTCM-SC104. This format is a subset of the larger RTK signal, and can therefore be received from RTK base station.

At Optimum the base station is installed in a purpose-built brick plinth. This structure is approximately 3m high and is located close to the centre of the mine property. A steel cabinet is built into the plinth. Inside is located the base GPS receiver, the GPS radio receiver, power supplies, etc. The GPS antenna is mounted on the top of the plinth.

Approximately 20m to the side of the plinth is the radio antenna mast. This is a 30m high mast onto which are fitted the GPS radio antenna – for broadcasting the GPS correction data, and the data radio antenna for two-way communications with the drill computers.

GPS radio system

The most critical component in a GPS station is often treated as an afterthought, but is in fact the radio link to the base. The base station broadcasts the correction information once a second, and if an RTK receiver does not receive the signal every second, the position will not be fixed to the correct accuracy. Thus good propagation of the signal throughout the mine's property is vital.

Luckily, radio signal propagation is a well-established field, and the skills and techniques necessary for good radio communications are widely available. Good network planning and system installation can ensure a highly reliable system.

At Optimum, it was decided to locate the GPS base station at the repeater site for the mine's existing radio network. This reduced the number of repeaters at the site. Low loss coaxial cable was used for signal propagation to the antennae, and folded dipole antennae were used to ensure good area saturation with the GPS signal.

Reception of the GPS signal on the site has been excellent. In a few areas where the spoil heaps and excavations combine to create radio shadows, the surveyors have portable repeaters. These are lightweight and easy to use when necessary.

GPS radio antennae on the drills are 20m above ground level and have experienced no reception problems.

Optimum's MIS radio system

The Management Information System's radio system is mentioned here to clearly differentiate it from the GPS radio system. It is sometimes mistakenly assumed that the radio link installed for GPS, a one-way system, can also be used for two-way communications. While this is true in theory, and has been attempted on some sites, in practice the amount of data being transmitted by a GPS radio requires a separate dedicated frequency if reliability is not to be compromised.

It is worthwhile investing in a separate MIS radio link for two reasons; first, because it improves the reliability of the GPS system by not trying to overload it, and second, because it is the most efficient means of getting monitored information to and from the decision makers who need it.

At Optimum the two-way data link has only been installed on two drills. There was quite a bit of trial and error in getting this system to work effectively, but it is now planned to extend this data link to other drills and to the dragline fleet.

RTK versus DGPS

RTK receivers fixing positions to within 10mm are much more complex than DGPS receivers, and also much more expensive. One of the major applications on mines is vehicle tracking for dispatching applications. For this application it is not necessary to fix positions to more than a few metres accuracy, and so the cheaper DGPS receivers can be used. This results in large savings for the mine as the truck fleet is usually the largest fleet on the site. These DGPS receivers can use an RTK base station so long as the base receiver is configured to transmit both RTCM and RTK signals.

Optimum's base station transmits both RTK and RTCM signals, and the applications described in the next section use both of these signals.

GPS rovers

Once a good base station is installed, with a reliable well-designed radio network, there is little limitation to the number or type of applications that can be enhanced with GPS. A large variety of GPS receivers are available, ranging from handheld units for data collection to rugged boxes that pump out y,x,z co-ordinates accurate to <10mm five times a second.

GPS applications at Optimum Colliery

Mine survey - An RTK application

Setting out of geological exploration boreholes

Having received the co-ordinates of the boreholes from the geologist, the surveyor goes into the field, initialises his GPS rover in the near vicinity of a borehole and enters the coordinates into the field logger.

The field logger displays on its screen the position of the surveyor in relation to the required borehole position. The surveyor then walks in the direction of the borehole position displayed on the screen and a line called the 'snail-trail' traces the route being walked by the surveyor. In a very short time the surveyor is able to pin-point the position and install his peg.

The time saving depends on whether there are existing survey control points, type of terrain, line of sight and visibility conditions. This could vary from 0,5 hour where the above conditions are optimal to 3 hours where none of the above conditions are favourable. GPS requires none of these for optimal operation.

Setting out of New Conveyors

Selecting the most ideal route for a proposed conveyor, is another unique application of the GPS system.

- ➤ The starting point of the conveyor is marked off and surveyed by GPS.
- ➤ The next critical point e.g. where the conveyor changes direction, is marked off and surveyed by GPS.
- ➤ The intermediate pegs falling on the line between the starting point and the point where the change of direction occurs, are installed with ease with the aid of the screen, which displays the position of the required line in relation to the position of the surveyor. A theodolite telescope is not needed to accurately line up these pegs.
- ➤ Time saving is minimal if line-of-sight is possible over the length of traverse. If line-of-sight is not possible then time savings of 0,5–1 hour are possible.

Setting out of ground control survey beacons for aerial photography mapping

When it is required to map the surface of certain areas of the mine, ground control is required to fix the aerial photography reference points for mapping by photogrametry. The GPS is used to survey the points in the field, which can be identified on the aerial photos. These coordinates are supplied to the aerial survey company, who in turn supplies the mine with a DTM (Digital Terrain Model) which the mine downloads onto computer. Using software such as Modelmaker, the DTM is used to generate surface contours. These surface contours are then used for rehabilitation designs, drainage patterns, etc. Time taken for setting out is approximately the same as for conventional methods.

Topographic work on coal stockpiles

Coal stockpile volumes are measured, using two different applications of the GPS system:

- ➤ By walking and climbing over an unevenly shaped stockpile and taking readings at strategically selected positions
- ➤ By mounting the GPS receiver on its magnetic base on the roof of an LDV and driving over the even surface of a well-shaped and compacted stockpile.

The field logger is set to take a reading, e.g. every 20 metres, or whatever distance or time interval the surveyor may require. The above readings are recorded in the field logger, which are down-loaded into computer for the volumes to be calculated. Time saving could amount to 50% as compared with conventional methods and the density of spot heights could be doubled or trebled at the same time.

Topographic work on excavations in the opencast pit

Similar to stockpile volume measurements, the GPS is used to measure the top and bottom horizons of excavations in the mining areas.

Typically the No. 2 and 2A coal top and bottom surfaces occur below the surface of the open cut. Spot heights taken close to the highwall would be affected by the limited field of vision in relation to the position of satellites overhead. At this stage use is still made of total stations to a large extent.

Haul road positions, lengths and gradients

When plans and information regarding haul roads and ramps are required in terms of positions, lengths and gradients, this survey is carried out with the GPS. The magnetic base of the receiver is mounted on the roof of the LDV. The field logger is then set to take a reading every 25 metres as the LDV is driven along the route of the haul road or ramp. Having downloaded the recorded data of this survey onto computer, the surveyor is able to produce a plan with all the above information.

Time saving is substantial and could amount to one week in the case of a complete survey of haul roads at Optimum.

Creation of a DTM of levelled spoilpile

Rows of spoilpiles are levelled by dozers. This activity is part of an ongoing rehabilitation process resulting in a post-mining rehabilitation topography.

Approximately every 6 months the rehabilitated topography is mapped by GPS in the following way.

The magnetic base of the GPS receiver is mounted on the roof of the LDV. The field logger is then set to take a reading every 10 metres as the LDV is driven back and forth in lines approximately 10 metres apart, thus creating a grid pattern of 10 metres by 10 metres.

Having downloaded the recorded field data of this survey onto computer, the surveyor creates a DTM of the rehabilitated topography.

This survey contributes continuously to the information required to check ultimate drainage patterns for the E.M.P.R compliance.

Time saving could amount to a number of days on drivable terrain. A large area of 20–30 ha could be completed in one day using GPS.

GPS-based drill Navigation at Optimum—an RTK application

The initial capital application in September 1996 included two Aquila DM5 Systems and two field receivers. This was immediately amended as a result of a radio communication survey to include a base station and five repeater stations. The repeaters were not required solely for the Aquila Systems but were also required for additional survey purposes.

The motivation for the purchase of the Aquila Drill Navigation System was based on the following areas where it was perceived that savings could be made.

Reduced overdrilling

It was assumed that 1 metre of overdrilling per hole could be eliminated based on two features of the Aquila system.

- ➤ After the drill has positioned itself over the hole to be drilled, the on-board computer compares the actual collar elevation with the designated collar elevation and calculates the correct hole depth accordingly.
- ➤ The correct hole depth is displayed on the LCD screen in the operator's cab, where he can monitor the progress of the hole being drilled.

Lower explosive consumption

The motivation assumed that explosives consumption would be reduced once overdrilling was reduced. Blastholes are currently backfilled as a standard practice to minimise coal losses, therefore the assumption that additional explosives would be used was optimistic.

Increased bit life

This claim has not been proven yet. There are many other factors, which can detrimentally affect bit life. Assuming that the mechanical functions of the drill and drill string are sound, then monitoring visually the progression down the stratagraphic column together with read-outs of pull-down pressure, RPM, baling velocity and penetration rate, the operator can prolong bit life by ensuring close to optional drilling practice.

Drill navigation

Due to the requirements of drilling and blasting procedures and standards at mines, in line with legal requirements for marking out drilling positions, many man hours are spent staking out drill patterns for blasthole drills. On some mines up to 50% of a survey department's time is spent staking out blast patterns. At Optimum, the survey department only establishes control pegs for the marking of patterns. Blasters then lay out the individual holes for drills not equipped with drill navigation systems. This could result in patterns that are less than symmetrical.

An important consideration in blasting is the geometry of blasthole patterns. If the blastholes are not positioned or angled correctly for different bench and rock conditions, the explosive energy will not be distributed adequately or evenly. If too much energy is used in an area, there is a substantial cost penalty, and the risk of fly rock increases. If too little energy is used, the ground may not break or only break badly. This can be many times more unprofitable in terms of lower productivities from the draglines than the cost of drilling and blasting.

A GPS-based drill navigation system eliminates the need for benches to be marked with hole positions. Instead the blast pattern is sent, via radio, to an industrial PC on the drill, which is equipped with two GPS receivers. The PC drives an LCD screen with a moving map display to show the drill operator where the drill is in relation to the holes. The drill operator simply moves the drill by monitoring the drill icon towards the next blasthole on the screen, and as the bit gets closer to the collar position, the screen zooms in resulting in a 'cross hairs and bulls eye' effect.

GPS navigation on the two drills at Optimum has helped to improve blasting results by ensuring accurate placement of blastholes. In addition, the whole process of planning and control has been streamlined as follows.

Optimum's blast plans are generated by the Technical Department, using the 'Drill & Blast' module of Mincom's Minescape software. These plans are exported in digital form to a file that is transmitted to the Aquila DM5 system on the drills.

Whenever the drill operator selects the propel function of the drill, the LCD screen displays a map of the area showing him the positions of holes, and indicates holes still to be drilled.

The drill operator simply lines his drill up with the next hole to be drilled, and starts propelling towards it. As the drill approaches the hole, the screen automatically zooms in to give the drill operator a close-up view. A circle represents the bit, and this must be placed on the target circle representing the hole.

The drill operator then levels the drill and starts drilling. Any special instructions for the hole are displayed on the screen. The DM5 system automatically calculates the required hole depth, using the target elevation in the blast plan file. As the hole is drilled, the geology of the hole is displayed on the screen, allowing the operator to see exactly which seam has been reached.

When the hole is finished the planned and actual co-ordinates of the collar are recorded. This data, along with a geological analysis of the hole and productivity statistics, are downloaded daily by the Technical Department via the radio link

Benefits of drill navigation

After nine months in operation, the use of this technology has been verified. Operator acceptance has been excellent, and blast planning and control have been streamlined. Improved blasting performance in the form of achieving design percentage casting in a number of areas has been realised as a result of better placement of blastholes. Most importantly, the system forms the basis for further improvements in the following areas.

- The elimination of geophysical logging—an expensive practice—in identifying the coal contacts.
- Better placement of explosives in relation to hard areas and coal seams.
- Better control over hole placement, allowing the use of inclined holes—too difficult to do without GPS navigation.

An added advantage of having GPS available on the drill is that the co-ordinates of the hole's actual position are logged, so surveyors do not have to stake out or pick up blasthole co-ordinates and collar elevations. This also means that drill monitoring information, which includes strata analysis and blastability indicates, can be located properly for analysis in the office.

The operational experience

The mine has experienced many and varied problems related to the radio repeaters and the base station. These have revolved around damage caused by lightning strikes, power sources, power failures and radio failure. The power supply and power protection problems have been resolved but the problem of a reliable radio has not yet been resolved.

The system has been well accepted by the drill operators. In fact, one could say the system has been too well accepted because it quickly became apparent the operators were relying on the LCD screen to position the drill without paying attention to the area where they were drilling. The dust filtration system on one drill was badly damaged when an operator walked the drill into a 'bump' on the overburden highwall whilst drilling pre-split holes on the interburden horizon.

More serious is the fear that the operator might become disorientated near the highwall crest and tram the drill over the crest. It is also possible that a crest failure could occur before or during drilling operations.

It is obviously vital that the operator and supervisors visually inspect the crest area and this is stressed in our operator training.

The mine has also purchased laser systems for the drills equipped with the Aquila System. The laser is set to pick up a positive or negative change in response to distance and to warn the operator audibly in his cab.

It is apparent from field observation that more accurate drill patterns can be achieved using the Aquila System. The System should also deliver better pre-splits and consequently better control of the front row of the blast. Therefore, there should also be a reduction in the frequency of drilling additional holes to cater for irregular highwalls.

The drill monitoring system provides actual drilling data, which is transmitted to the office via radio. The data is captured in a database (Access 97) on PC. Initially, the software for analysis and comparison of data was not available. This software has been tailored for the mine's requirements and installed recently.

Targeted hole depths are calculated from down-the-hole geophysical logging data for rock and coal interfaces on the pre-split lines. Output reports of target and actual depths have recently become available (Appendix 1).

The strata recognition display screen visually represents the rock type being drilled, building up a stratagraphic column from the collar to bottom of hole. Strata characteristics are derived from measurements of pull-down pressure RPM, penetration rate and rotary torque.

The interpretation of rock types needs to be calibrated with either geological or geophysical data. This facility is in the process of being fine-tuned. Experienced operators will be able to use the strata recognition display to anticipate hard and soft strata as well as the end of the hole.

In similar vein, the mine asked for a comparison of actual and planned hole positions. Here again no off-the-shelf software was available but has now been written and installed.

The supplier claims an accuracy of one hole diameter (250mm) in positioning the drill and field observation shows that this is possible.

It is however not possible to drill inclined holes with the system and the supplier has been asked to address this.

The future

In many regards, the development of precise, rugged, GPS receivers that can be installed on any type of earth-moving equipment is revolutionising the earth-moving industry. Plans, in the form of Digital Terrain Models—DTMs—will simply be transmitted to each machine on the site, and the results of work in the field will be sent back to a central database in real time—just like the feedback on a computerized lathe.

At Optimum, future use of GPS will be to extend the technology to the dragline fleet. At present control over the highwall equipment is compromised by the delays involved in establishing the positions and elevations of the various pieces of equipment. To enable better scheduling of the highwall equipment (drills and draglines in particular), the positions and elevations of all equipment will be monitored in real time. Thus delays to dragline production will be eliminated through better planning and control.

BME, Optimum's explosive supplier, is testing GPS receivers on their HEF delivery trucks. In the near future (the prototype system has already been installed) Optimum's Technical Department will send charging instructions to the HEF Plant. These instructions will be loaded onto onboard computers on the trucks. The truck drivers will use GPS to determine the identity of a hole in the field, and to select the correct charging instruction. In addition the charge loaded will be recorded on a geographical basis.

In 1998 Optimum will be a test site for Trimble's Bench Guide product. This is an extremely robust system fitted to a dozer or shovel. A GPS receiver feeds a processor that compares the dozer's elevation with a stored design DTM, and gives the operator a digital display showing him if he is above or below plan. This level of control can potentially improve productivity, and improve the finished result—e.g. the dragline pad or rehabilitation surface.

In the opencast coal mine of tomorrow, the future is no less exciting. Pre-strip work will be carried out with excavators and dozers equipped with GPS-controlled computers. Drills navigate using GPS, and supply planning engineers with precise positions of coal contacts for the draglines. Dragline operators will excavate to precise depths, in pre-defined sequences, using GPS to facilitate optimal placement of material. Coal loading and hauling equipment is already being tracked with GPS, and dispatched by central computer according to programmes that minimize cost and maximize revenue.

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The Department of Chemical Engineering at the Cape Technikon

The Cape Technikon is a tertiary institution with a proud tradition and distinctive character. Situated on the Zonnebloem campus, the Cape Technikon has a breath-taking view of Table Mountain. The Technikon traces its origin to the Cape Technical College of which the foundation stone was laid in 1920. The establishment of this college followed more than 10 years of representations by the community for the consolidation of the technical courses which were offered at various venues in town. The Science Building, housing the Department of Chemical Engineering, was commenced in 1988.

The Department of Chemical Engineering started in 1978 with only one full-time lecturer. It has now grown to four full-time lecturers, one technician and three technical offices. The department offers qualifications in the form of National Diplomas (ND), Bachelor Degrees B.Tech), Master's Degrees and Doctorates in Technology (D.Tech).

The Department of Chemical Engineering has been involved in research for many years, but the manpower was always a barrier. However, research flared up in 1992 when better facilities allowed students to carry out their in-service training at the Technikon, enabling more industry-related research. A wide variety of research topics are being covered in the Department of Chemical Engineering. Research projects are chosen such that the output is valuable to industry, hence the majority of the projects are sponsored by industry.

The main areas of research include:

- ➤ Environmental Engineering, which focuses amongst others, free cyanide removal from plant effluent using impregnated carbon, heavy metal removal via ion exchange, and an alternative process for free gold, i.e. the coal-gold agglomeration process.
- ➤ Adsorption processes with the emphasis on process adsorption and their interaction with adsorbates such as metal cyanides, organic compounds, inorganic substances, free cyanide, etc. The department continues to contribute to the knowledge of adsorbent-in-pulp systems for the South African minerals industry.
- ➤ Membrane Bioreactors and their applications in the field of minerals processing and chemical engineering.

Industrial involvement includes industries such as Karbochem, Eskom, Kynoch, Sasol, Chamber of Mines, as well as government para-statal bodies such as Mintek, the Foundation for Research Development (FRD), and the Council for Scientific and Industrial Research (CSIR).

The department is heavily involved in activities of the South African Institute of Mining and Metallurgy (SAIMM), and is co-organiser of the Annual Mineral Processing Symposium. ◆

Visit report to the 6th International Symposium on Mining with Backfill*

'Minefill '98'—Brisbane, Australia

14–16 April 1998

The Symposium

Overall attendance was a little disappointing with a total of 160 registered delegates, from the following countries:

- Australia (103 delegates)
- Canada (14 delegates)
- South Africa (10 delegates)
- China (9 delegates)
- USA (6 delegates)
- Germany (3 delegates)
- Sweden (3 delegates)
- Phillipines (2 delegates)
- 1 delegate from each of the following countries: Brazil, Poland, Singapore, Spain, Turkey, New Zealand, Japan and Switzerland.

The lack of attendance of delegates from Russia (CIS), India and Latin America was a cause of concern.

A total of 52 technical papers and 3 Keynote Addresses were delivered during the proceedings, and the overall standard was adequate, but the papers from China were difficult to follow, which was a pity, as the technical content was of relevance and of interest.

The only aspects that were generally poorly covered were operational techniques, problem areas, and real total placed backfill costs.

The Organising Committee, through the Australasian Institute of Mining and Metallurgy, did an excellent overall job, and should be congratulated.

South Africa was well represented, not only in the number of delegates, but also by delivering nine technical papers.

The main conclusion that can be made, based on the Proceedings, is that in the next decade, most backfill development and activity will be centred on paste fills (high density fill, that does not settle in a pipe and does not produce surface bleed water after placement).

Future Minefill Symposia

The Minefill Council, that has informally coordinated and helped to arrange all the previous Symposia was formally constituted, and members had to have the official support of their countries' professional mining body, or government. The confirmed members are as follows:

- Mr Dave Stone representing the SME from the USA
- Dr Jacques Nantel representing the CIM from Canada
- Mr Per-Ivar Anderson representing Sweden
- Dr Güner Gürtunca representing the SAIMM in South Africa
- Dr Martin Bloss representing the AusIMM in Australia
- Prof. Jan Palarski representing Poland.

The current 5 year interval between Minefill Symposia, was agreed to be reduced to 3 years, as a result of the advances being made in the backfill field at present.

The Council, after open discussion with all present, decided as follows:

— Minefill 2001 to be held in the USA

— Minefill 2004 to be held in China. ◆

* *Issued by: Dr A.J.S. Spearing, Senior Manager, Underground Construction Group, MBT International*