Modernising excavation management

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Abstract

With cost savings identified as a key decision driver throughout the world in all fields of business there is an incentive for mine and quarry owners, stake-holders and operators to seek productive technology solutions to increase the efficiency of their work.

Recent advances and improvements in the Topcon portfolio bring together the rapid collection of mass data, telematics and machine control and real-time accessible site management tools all focused on making the job as easy and more importantly safe and profitable for all involved.

The paper introduces the key technologies encompassed in modern site management solutions and examines the advantages gained by choosing this as a methodology for cost savings and management in a mining and quarry environment.

Keywords

imaging, mobile mapping, geomatics, mass data, machine control, cloud data management

Introduction

With the ever changing portfolio of technological solutions and the drive to simplify and make technology as ubiquitous and consumable as possible it is difficult to identify any industry where significant technical improvements have not been made in recent years.

In the mining, quarrying and the earth working industry automation is a key drive. The benefits with respect to safety of personnel and efficient resource management are clear. Effective fleet management and optimisation of associated work routines are just the tip of the technological pyramid of solutions that are available to ensure clear and complete digital documentation of the live job site.

Digital project management driving innovation, this trend is reflected in the Architectural Engineering and Construction (AEC) sector and is currently trending under the term BIM (Building Information Modelling). BIM is typically attributed to architectural projects and facilities management but the essence of the BIM process is sound digitally aided project decisions, where clashes and conflicts are identified and fixed before the project even leaves the drawing board. In the mining environment this movement can be encapsulated by a number of digital project management tools. As Evans and Rybka stated in 2012 [1] “the target on every construction site is the highest quality results with the best accuracy, material usage optimisation, and the cost reduction of surveying services. Topcon's solutions are the fastest and most effective available combining powerful machines with the latest control technology and rapid mapping and surveying tools.” This philosophy applies to the mining environment and the key elements of this paper will examine components of the project life cycle and how the latest offerings of technology can fit into the existing systems.

The need for mining survey technology in sub-Saharan Africa (SSA)

SSA as a whole accounts for approximately 13% of the world's human population and 1,7% of Gross World Product (GWP). Although it has abundant natural resources, SSA remains the world's poorest and most underdeveloped region.

In recent years however, SSA’s countries have drawn much attention; now consisting of some of the fastest growing economies in the world. (up to 14%, average 4,7%).

This growth in recent decades can be largely accredited to the closing of large developmental gaps perpetuated by an increase in local political stability. These gaps are large enough to result in regional economic advancements, further enabled by advancing technologies.

The mining sector is no exception: As the home of a large portion of the world’s natural resources – which includes water, oil, coal, land and a multiplicity of commodities – clearly mining is first and foremost a source of mineral commodities that play a vital role for maintaining and improving local standards of living and addressing poverty.
Moreover, the secondary economic opportunities and wealth generated by mining – providing a trained workforce, employment, foreign exchange, dividends, and taxes that pay for hospitals, schools, and public facilities – are substantial [2, 3].

Due to its generally underdeveloped state, the mining potential in Africa remains large as related existing infrastructure is not especially advanced. Increasing political stability is however, steadily enabling foreign investment and increasing development opportunities in the mining sector, providing a chance for Africa to leap-frog other regions in the world.

Taking a closer look at South Africa – Africa's most advanced and richest economy – mining has been the main driving force behind the country’s development. Although it is likely that incremental improvements in technology have driven much of this progress, major contributions have also come from revolutionary developments. Some examples of such developments in mining are the use of the Global Positioning System (GPS) in surface-mine operations, computerised modelling and process control [2].

According to Roubini and Backus [4] “productivity is the cornerstone of economic growth and largely affects our competitive position. It seems that the higher our level of productivity, the more able we are to compete on a global market scale.”

It is clear that businesses in Africa need to grow, but the abundance of capital is low. In other words, keeping impending costs at bay is critical for effective development. Furthermore, it is probable that austerity cost-cutting schemes are not likely to help on their own.

Since productivity and growth are closely linked and cost saving is a key in all fields of business in this region, it is safe to assume that implementing new mining technologies will increase the efficiency of work and safety on the jobsite and enable the way towards increased growth of this sector of SSA business.

**New mining technology solutions: imaging with terrestrial and mobile scanning**

Personnel on the ground at a mine performing daily survey and mapping tasks are labour and cost intensive. In this busy environment the team must be aware of the movements of huge machines, and active face activity whilst trying to complete a high personal concentration activity.

Imaging in the context of this paper describes the creation of three dimensional data utilising the latest in remote measurement technology to collect point clouds and geo-referenced images to describe the job site in a visually compelling and geometrically correct way. The use of mass data collection tools such as terrestrial laser scanners or mobile mappers reduce some of the personnel’s concentration requirement freeing the employee to in turn be more effective and more productive by planning the next part of the job, whilst maintaining high safety standards by immediately enabling the person to achieve more situational awareness by simplifying the task at hand [5].

The combination of terrestrial and mobile lidar offers an effective method for digitally recording the site. Haul roads can be driven with personnel safely in the vehicle cab, and by choosing suitable vantage points the 500 m range of the terrestrial scanner allows staff to record toe, crest and cut bench information accurately far from the active face.

**Technology overview**

Examples of the type of technology that can be combined to achieve this full data collection are the Topcon GLS-1500 and IP-S2 (Fig. 1).

![Fig. 1: The GLS-1500 and IP-S2.](image-url)
The GLS-1500 is a terrestrial pulse based laser scanner capable of high precision millimetre measurement at 30 000 points per second at up to 500 m range. The unit is robust, easily transportable and offers a method for rapidly imaging a site with minimal user interaction. The workflow is similar to a total station and so provides a simple and effective way for the measurement professionals on site to achieve a high quality representation of the topography in significant detail for a fraction of the time required by using conventional methods.

The IP-S2 is a mobile pulse based laser scanning solution. The key advantage being that the site can be driven, with a small sacrifice of point-cloud resolution which in turn is offset by the advantage of a “drive and measure” simplicity to achieve complete site coverage wherever you can drive at typically cm level precision. The system has a maximum sensing swath of 160 m and also collects 360° panoramic images at regular intervals that are aligned to the 3D data. This creates a visually rich deliverable that communicates the site clearly to all data users. Geometrically correct images always communicate in a more effective way than 3D point clouds.

**Fig. 2: Terrestrial scanning (left) supplements the data collection which cannot be driven (right).**

**Advantage**

Terrestrial lidar offers a non-contact solution to record an accurate and complete 3D model of the object in question. Every crack and deformation in a surface can be visualised giving more realistic representations of quantities before even attempting excavation. The non-contact nature of the technique also offers significant benefits in high risk areas. Mines worldwide have made use of this technology and exploited the fact that scanners can be operated in the dark to increase efficiencies in the collection of material at the active face underground. Boliden cites an example from a UK Zinc mine that by using laser scanning, combined with the stope and pillar method, production mining achieves 100% extraction of ore. Dolman [6] reports:

“Once a stope is completely blasted and mucked out the open void is surveyed with a laser scanner. The scan is analysed to know the amount of over-break and under-break to know the dilution and the loss of ore. After the scan is completed and analysed, it is also used to design the best parameter for backfill, such as backfill holes and the bulkhead.”

**Future trend**

Since 2011 there has been significant changes in the value of the point cloud currency in the survey and engineering world. This has been influenced by major CAD software manufacturers increasing their software functionality but awareness has also increased due to the use of laser data in everyday consumer goods such as the Xbox Kinect.

Currently there is a paradigm shift in the way sites are measured and managed in 3D. Whilst the site managers are struggling to adopt or completely understand the advantages of this cutting edge technology, their children are already thinking in 3D. The “WOW” factor in visualisation is normal day-to-day interaction for the future’s mine managers – our children. To address this the software manufacturers are working hard and consequently functionality is constantly improving. Fortunately today’s “gaming” computers are optimised to cope with the demands and usually meet the requirements of the latest in digital data management software.
Continuous representation of reality

We live in an age where data is available instantly and everyone assumes that the same data is current and correct. In the project lifecycle, this instant access to information enables the seamless integration of digital project management processes that require complete, accurate and up to date feedback information from the field.

Combine this data with telematics and a simple method of presenting the information to interested stake-holders (not just the mine manager) and you have a very powerful and complete digital overview of the site. Both in terms of current and rapidly updated site conditions, and real-time monitoring of the machines working on site.

Technology overview

One example software solution for the rapid reporting of site conditions and publishing that data for stake-holder consumption is the Orbit Asset Inventory Management (AIM) software. This GIS database is designed to view, measure, extract, share and publish terabytes of mobile mapping and lidar data such as that collected by the terrestrial and mobile mapping solutions described in this paper.

Once the data is updated in the central database and published, it can be viewed by any informed party using a web-enabled device. Users will see an interface similar to that in Fig. 3.

![Fig. 3: Homberg quarry, Germany.](image)

Another example leveraging the recent advances in machine control and telematics is Topcon’s Sitelink3D. Sitelink3D is the on-site communication solution that provides a data control, machine tracking and reporting system. It provides web based, real-time visualisation and communications including access to job site status, the ability to create new or update job site parameters, and view movement of machines.

Typical business management tools for Sitelink3D includes a suite of equipment planning and reporting tools for all phases of the projects. These operations cover such elements as:

- Creating task areas, assigning machines, specifying production and quantity data, and adding dependencies. Equipment working simultaneously on collaborative tasks can estimate the volume of material moved, calculate differences between planned and actual volumes and send this information in a summarised form to the site manager.

- The information can be communicated in a timely fashion to project and machine dashboards giving at-a-glance information tailored for the user. For example, machine dashboards can display the task, 3D model, offset, activity with active charting of pass counts, position, and production rate. On the project side material, volume, as-built layer, cost code can be displayed with active charting for production rate versus target, progress versus plan, and forecast based on actual versus planned.

Of course traditional monitoring methods can be accommodated in the database. Haul counts and manual topographic survey data can be uploaded from the field to log and can be compared against the estimated data coming in from the machines and then added to automated reports and status dashboards.
Advantage

What does this mean for the project manager and measurement professionals working as part of a bigger team? Current, reliable and complete 3D data from site adds value to the following processes:

- **Control** – processes on site such as variance analysis, production process, stockpiles and material balance can be analysed quantitatively, and managed efficiently.
- **Cost (of failure) reduction** – costly mistakes in design and extraction processes can be spotted early or prevented entirely.
- **Quality** – all shareholders can understand the quality of the work completed, including equipment performance and management when connected to the telematics information.
- **3D** – maps can be impossible to interpret for some end-users. With 3D – what you see is what you get!
- **Insight through visualisation** – people relate to imagery, if it has dimension as well then the end user can perform computations as well.
- **Faster decisions from design and as built visualisations** – achieves incredibly efficient communication of ideas.

Due to the resulting complete site overview, all the measured details are clear in the visually rich combination of point cloud and imagery. The analysis of the site can be communicated easily to all project stake-holders. Utilising the network to disseminate the information efficiently will ensure that this method will become the norm for mine management of the future.

Summary

To summarise, this paper has given an overview of the future of mine management focussing on tools that are available to implement today. Early adopters throughout the world are beginning to embrace this new technology and adapt it to their existing and future work practices. It is clear foremost of the advantages on site for increasing the safety of personnel. By increasing situational awareness and rate of data collection, the benefits to the measurement professionals on site can only lead to cost savings and an improved work environment.

The associated project savings by having complete digital documentation available to all involved in the management of a facility offers additional clear benefits and will avoid costly mistakes in the day-to-day running of the site. A visual overview with picture like quality combined with quantity and quality information communicates to everyone efficiently. Data becomes more accessible to more relevant people ensuring the visibility of on-site processes can be given to all involved.

Most importantly, this is just the beginning of a “new” way of interacting with a complete site of geo-referenced data. However, this “new” way is only new to the current mining professionals. For future mine managers consuming data in this way is already second nature, not an expectation, but a day-to-day activity.

References


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