MODERN TECHNOLOGIES USED IN MINES SURVEYING

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ABSTRACT

Today's technology is changing the face of surveying. The goal of any survey is still categorized into two specific areas: collecting spatial data and positioning spatial data. With all this progress, the huge influx of data as well as these new technologies represents a particular challenge for the working methods and equipment used today. The use of laser scanning and the use of unmanned aerial vehicles (UAVs) that create this data, together with software solutions that maintain, display, analyze and manage large amounts of spatially located digital data are necessary. Because spatially located digital data provides a different level of visibility to a business, it becomes highly sought after for a wide variety of users within a mining enterprise. The ability to efficiently manage, maintain, and disseminate this spatial data to the right people at the right time will be critical to the success of an enterprise.

Keywords: UAV, data mobility, mining operation, digital data, mine surveying, laser scanning

INTRODUCTION

The mining sector typically operates in a cyclic fashion with moments of strong expansion followed by inevitable inflexions. It is currently in the throes of a inflection with many owner-operators now looking inwardly in an effort to identify opportunities to improve productivity, while reducing costs. The solution of these ideas is found in innovation and technology.

Possibly, the latest important innovation is the digitization of data, with its interpretation and with its use in the output activity. Different types of sensors are able to assist incredibly exact data. The use of this information becomes a way to the surplus significance over the cycle life of a mine. The mining branch moves into this era of digital information mobility. There is a growing recognition of the main importance of this information as well as the demand to manage, maintain and improve it.

Of critical importance within a mine industry is spatially located digital data. In the operational phase of a mine, the mine project, elaboration project and extraction become a continuous circuit. In order to examine the effectiveness of planning methods in a mine, production evaluation is the basic element to examine both the accuracy of geological models and the accuracy of estimation models, which help to determine and control topographic elements, as well as the efficiency of the exploitation of the ore and metals. The clue to this is the exact positioning of excavations, plus the assessment of geological characteristics, and without this step, progress is impossible to assess properly.

Nowdays's technology is changing the aspect of surveying. The objective of any survey is still categorized into two specific operations: collecting spatial data and positioning spatial data. The massive influx of data as well as these new and modern technologies represents a particular provocation for the existing methods and equipment used by mine surveyors.

The utilization of laser scanning and the utilization of unmanned aerial vehicles that create this data, at once with software solutions that maintain, display, analyze and manage large outputs of spatially located digital data are a necessity.The ability to manage, maintain, and disseminate spatial data to the wise people at the proper time will be great to the success of an mining business.

MATERIAL AND METHODS

To increase productivity, the attention of the mining sector has turned to innovation. Innovation comes in different forms. One such innovation embraced by mining sector is the use of digital data, including data enabled equipment, environmental or operating sensors, and the recognition of the use of laser scanning or point-cloud data. Digital data will be used to support real-time tracking, surveillance, traffic management, environmental monitoring, different automated routines (driverless trucks), and production monitoring and reporting.

Since data from these different sources becomes available to the patron enterprise, the mining sector needs to leverage this digital data to target specific productivity challenges and the ability to leverage digital data across a business is described as data mobility.

Data mobility is a key to unlocking value throughout the life cycle of a business (figure 1). As the mining industry transitions into new era of digital data mobility, there is recognition of the scale of digital data being created and the need to better manage, maintain, and disseminate this information across the entire business to ensure the right information reaches the wise people at the right time. Like an example, iron ore mining, land transport and shipping activities at some mines already generate 3 terabytes of data per minute. A new terminology that has gained mindshare is big data. Big data may determine challenging with strong communications. The idea that big data represent the cloud may not always be relevant.

Figure 1: Data mobility in a mine

The conception of one of the world's largest mining companies anticipates fully automated and remote controls. The company intends to exploit the resonance of spatial 3D information.

Some years ago, spatial data has been captured and stored as islands of data. Throughout the company, numerous business acts (iron ore, copper, etc.) and compartments: survey, geology, environmental, exploration, land management, mineral resource management, planning, head office, etc. produce and consume spatial data.

Spatial data is relevant for many departments. But the same data was not often shared between compartments leading to the existence of duplicated data and big stores of unmanaged data that could not be efficiently utilized for decision making.

The relevant data was not integrated so a holistic view was not utilized to make informed decisions. From a number of compartments the company identified critical data sources, along with:

- high resolution geospatial point cloud data scans using totally electronic stations, laser scanners;
- photo and video data with spatial reference: aerial photography, data of autonomous vehicles, data from regular photos and video, etc.;
- geological data;
- exploration data;
- geographic information systems (survey, topographical, satellite);
- Information about planning in a mine (design, schedules etc.);
- CAD models used;

Spatially referenced documents automated services like real time data import from weather stations, air or dust monitoring stations, conveyor belt sensors, location tracking, etc.; production systems data like drill holes, slope monitoring, etc.

Consumers of spatial data embody include:

-automated machines: mapping, navigation, positioning, etc;

-survey: mapping, volume determinations for mining excavations;

-engineering: design, planning, civil works, services, performance management, etc;

-mining: design, planning, optimization, performance management, maintenance, etc;

-exploration: targeting, planning, resource characterization, etc.;

-resource characterization, reserve estimation, etc;

The operation used in the mining domain cannot afford to exist separated. The scope is to build a GIS (Geographical Information System) platform build on a common architecture that can provide a single system for managing geospatial data, workflows and reports in order as costumers of spatial data can exploit multiple datasets in a common geospatially referenced framework.

A mining activity needs to design and develop an infrastructure prior to its operation and once a mine location becomes operational, the process of design, develop, and extract becomes an integrated loop. This tests both the accuracy of the geological and evaluation models on which the targets are based and the efficiency of the ore and metal recovery departments. Key to this is the accurate positioning of the excavations mined and the geological and evaluation features encountered. Unless this is achieved, it is impossible to gauge the progress made with any accuracy. Additionally, there can be no improvement in the base data used for evaluating the next planning cycle.

Timing is a main part of the control issues on a mine so the operations are continuous, and snap-shots have to be taken to measure planned production against actual outputs. Monitoring the actual extraction volumes versus production target rates has traditionally been measured by mines surveyors at month's end. There is a growing desire by mines industry to measure the volume of extracted material at much shorter intervals, allowing management to better monitor and define the progress of the mine's production rate.

Throughout the Earth, a mine's operation is governed by a significant number of rigorous regulatory requirements and these regulatory requirements vary from region to region, with many requirements directly impacting a raft of mine surveying practices, processes, and workflows. It is imperative the mining operation maintain and manage the mine's survey data, including legacy survey data, in a secure environment throughout the life of the mine. Historical talking, this information has been maintained in hard-copy formats; however, as the mining industry transitions to digital, mechanisms and solutions that manage and maintain this mixed information environment will need to be established. Solutions offering opportunities of secure data management capabilities, including an ability to store all survey data, survey control, survey notes, survey reports, plans of surveys and mine accurate plans will be wanted.

A mining action must design and develop a geo spatial data infrastructure. Once a mine site becomes operational, the design, development and extraction process becomes an integrated part and continues throughout the life of the mine, which is often measured in years or decades. This cycle becomes the focus of a mining operation, with a specific focus on the results obtained throughout the extraction phase. To view the execution, effectiveness and accuracy of planning methods in a mine, it is imperative to determine the mine production. The precision of the geological models and the estimation models on which the objectives are based will be viewed, as well as the competence of the ore and metal recovery compartments. The clue to this problem is given by the exact positioning of the mining excavations and the correct estimation of the geological characteristics occurs in the mines areal. If this condition is not achieved, it is impossible to assess the progress achieved with any precision.

Timing is a fundamental part of control issues in a mine (figure 2). Operations are effective, continuous, so take snapshots to measure planned production versus actual production. Mining surveyors can monitor actual extraction volumes against target production rates using classical but accurate measurement methods. However, there is a growing desire of the mining industry to measure the volume of material extracted at much shorter intervals, allowing managers to better monitor and define the evolution of the rate of production in a mine. Therefore, the ability to accurately monitor this phase is therefore seen as a critical mission, hence denoting the role of the mine surveyor which is an essential one in the success of this phase.

Figure 2. Timing

In the World, the operation of a mine is usually governed by various strict and rigorous regulations, which vary from nation to nation, resulting in a number of different practices, processes and operating procedures, but it is imperative that the mining operation maintain and manage the data of the last mining measurement, including the data of other old mining measurements, in a safe environment throughout the life of the mine. This information has often been kept in analog, printed formats (the classical format). As the mining sector moves into the digital age, solutions will have to be established to manage and maintain these new requirements, the information environment being the one targeted and desired.

In the issue, solutions that provide opportunities for secure data management, data storage capacities for mining measurements, reports, control opportunities for measurements, as accurate as possible mine plans will be necessary.

Due to develop of technology, mine surveying's equipment is changing all the time.

Mine surveying cover different engineering problems, from measurement sciences like: Land Surveying, Geodesy, Photogrammetry, etc. This is especially evident for underground actions, where surveying methods and techniques need to overcome the challenges of this environment. Traditional and historical survey workflows are still evident within mines sector today. However, there is an industry need to promote innovative techniques to measure the underground.

The measurements from mining sector has undergone great changes due to technology accession, including the introduction of electronic distance meters, totally stations, global navigation satellite systems and robotic total stations. In present, point cloud creation technologies are challenging those traditional mine surveying workflows, with surveyors now looking at solutions capable of quickly producing accurate point-cloud data of the mine's inprogress state. Technologies such as unmanned aerial vehicles combined with photogrammetric processes are now used to create point cloud data very quickly.

One of the largest mining companies from the world conducted a study based on unmanned aerial vehicles technology to determine the effects of land subsidence due to underground work carried out in a coal mine. Over a 12 Month period, a number of surveys were conducted over the 300 hectares area. Unmanned aerial vehicles based surveys coupled with digital terrain model potential found within Bentley's PowerCivil were adopted. The research was conducted to confirm theoretical calculations performed during the design period, of possible land subsidence within the immediate area of the underground operations. The results of the unmanned aerial vehicles's survey mixed with a succession of mine plans were used to evaluate damages on agriculture production caused by the subsidence, which was in excess of four meters in studied areas, therefore creating a new lake and large areas of unsuitable land. Validation of theoretical calculations versus actual calculations was established with a little discrepancy identified over the entire area. The unmanned aerial vehicles's survey provided imagery required for photogrammetry workflows culminating in the creation of a point cloud with over 750,000 points and an orthophoto map mosaic of the area. Bentley's PowerCivil was used to create the Digital Terrain Model and perform the different analysis routines, including isopach models, terrain profiling, and cross sectional plan production and reporting. The utilization of unmanned aerial vehicles's technology and the point-cloud generated data, ending in a series of Digital Terrain Models conduct to a moneys saving plus a savings in survey and processing time usually associated with more clasical survey applications.

Laser scanning metods have been slow to make an impression within the mining industry.

The last few years has seen a very different drive with terrestrial laser scanning, airborne laser scanning and mobile laser scanning systems. The increase utilization of this new technology can be traced back to a combination ofelements, which include reduced size and costs of units, better performing and durable hardware suitable for the mining environment. Software sellers are now catching up with the hardware, providing new solutions capable of efficiently working with, managing and maintaining voluminous quantities of point-cloud data. In present, laser scanners are need on a broad range of survey related activities including end-of-month surveys, stockpile volume surveys, mine subsidence surveys, general 3 D topographical surveys: surface and underground surveys, etc

At one mine known as the world's deepest underground gold mine, a decision to perform a laser scan survey provided some important cost savings to the operation.

The final scope of underground survey was to determine the exact location of rock surfaces and associated infrastructure within the haulage line located at one level from mine. The laser scan, resultant point cloud data and 3D model were used to obtain the viability of transporting a new transformer to its substation location, some 600 meters along the haulage line.

Installation delivered to underground site that doesn't fit, as it traverses through the mine, can be both costly, and operational and maintenance access studies are generally considered critical. Time and precision are base considerations for these types of maneuvers, so laser scanning is fast becoming the preferred survey method.

Using a number of Bentley solutions, like Bentley Pointools, MicroStation, Bentley Descartes or Bentley Rail Track, a 3D information model of the rock surfaces and associated infrastructure (pipes, structures, etc) it was developed.

Plus, the 3D design of rail track used to transport the transformer into place was also created. A 3D model of the rail dolly was developed, with the minimum cross section footprint of the transformer. In the final, an animation of the movement along the rail alignment was performed, resulting in a 3D model showing the minimum envelope required to move the transformer.

Bentley Pointools and Bentley Navigator were used to determine where impacts occurred along the haulage line, with either the rock surface or with soft infrastructure assets or hard infrastructure assets. Each identified impact was reviewed in detail to determine what correctional action should be applied previous to the delivery of the transformer.

The scanning of the haulage line with the initial analysis impact to transporting the transformer to the needed location resulted in the identification of a number of key impacts.

The review of the precise and detailed 3D models provided mines control factors with information that allowed them to make well informed decisions, resulting in significant cost savings for the mine. As mines sector continues its concern in increasing productivity, there are a number of more recent survey proposals.

With the use of lightweight and compact laser scanners to the market, the combined benefits of UAVs and laser scanning offers surveyors another option to create point clouds. These combined technologies provide a low cost, quick, and precise choice to map a mine's in-progress state, using the point cloud data to create 3D information models: digital terrain models, etc. An important manufacturer of unmanned aerial vehicles, named Microdrones GmbH, recently announced a solution for the mining industry: the laser microdrone, which is a highly integrated system with various sensors. Riegl, another leading laser scanner constructer also recently released a lightweight scanner named Riegl VUX-1.

So, within the mining sector, different laser scanning techniques have been used to collect and map a mine's in progress state. In present, the mobile laser scanning techniques have been adopted for underground mining applications.

Using a simultaneous localization and a mapping technique named SLAM, which consists of a spinning 2D LiDAR unit and an industrial grade mounted inertial measurement unit, the acquired scan data is processed through a series of steps to produce a dense and accurate geo-referenced 3D point cloud that can be collected quickly, without disrupting mining actions.

In a mine can be made a research using a lightweight handheld laser scanner mounted on a simple spring mechanism that continuously scans, in time when mines surveyors walks through the environment. As the scanner oscillates about the spring, it produces a rotation that converts 2D laser measurements into 3D fields of view.

The technology is called ZEB obtaining a 3D model, conforming to mine's plans. Indifferent of the survey technology adopted, mine surveying still remains the technique and science of precise determining the 3D spatial location of points or features on or below the Globe's surface.

The scope of any survey can be diveded into two specific areas:

- Collecting spatial data
- Positioning spatial data.

Mine surveying specialists are also called upon to analyze and validate spatial data; to manage and maintain spatial data.

Bentley Systems launched Bentley OpenMine Survey, a comprehensive surface and underground survey application for the mining sector.

Bentley OpenMine Survey will give a proven and stable platform available to the mining sector. This solution addresses the survey ensuring all data generated throughout the survey process is automatically incorporated within the broader geospatial requirements and workflows.

Corresponding for both surface and underground operations, Bentley OpenMine Survey offers functionality to address key survey workflows such as: operational surveys check surveys, control surveys, setout surveys, and topographical surveys. The main aspect of survey data management gives a central and clue component, including provisions for: comprehensive auditing capabilities, fusion of survey and spatial data, reporting and dissemenination of survey data, maintenance of spatial data, management and storage of survey data.

MineCycle Survey from Bentley is a new mine survey software used on some mines, an underground and surface mine survey application that accelerates data processing and vizualization to deliver more timely information to planning and operations.

“Bentley is providing the software that will revolutionize the mine survey and planning discipline”.

RESULTS AND DISCUSSIONS

As the mining sector begins the transition to a productivity approach, digital data is set to become influential throughout a mine business enterprise. Spatially located digital data gives another level of visibility to an enterprise. The capability to manage, maintain, and disseminate the spatial data to the wise people at the right time will be a critical factor to the success of a mine business. Spatially located digital data enters an enterprise from different sources. While every mining operation, the mining sector can draw on the collective experience of those owner operators and software traders delivering solutions for present's requirements and tomorrow's needs. A number of recommendations include:

1. **See the vision of your group.** Determine whether your actual systems are capable of supporting and delivering on this vision. Review the impact of increase in digital data may have to your systems. See if these systems can efficiently manage, maintain, and disseminate this data.

2. **Do not forget about data mobility.** Data and information are clue enablers in support of productivity and optimization. Having access to the right information, in the right format, at the right time, provides the fundamentals for informed decision making

3. **Think about spatial enablement.** Typically, spatially located digital data is considered a totally separate application to be handled exclusively by a GIS. However, and as shown, spatially located digital data will be created by many and various sources. The use of an industry-standard database, such as Oracle Spatial or SQL Server Spatial, is recommended.

4. **Obtain your survey solution.** Your organization's survey solution needs to support today's requirements and the survey solution needs to prepare for tomorrow's needs. As the mine surveyor transitions to digital data they will need a survey solution that supports both traditional and future workflows from a variety of survey sensors and vendors. Ensure your survey solution has the capabilities to support transitional workflows and requirements. Ensure your solution seamlessly supports the enterprise wide vision, requiring that all data generated throughout the survey process is automatically incorporated within the broader geospatial requirements and workflows.

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