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Effective process monitoring in underground mining

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South Africa is a country rich in mineral wealth, but at the same time is placed as a country that faces formidable challenges in mining its minerals due to the country's unique reef formations, as well as the depths to which many mining operations must go to reach orebodies.

This fact is evident in the number of deep level mining operations such as Goldfields' South Deep mine in Westonaria, as well as low seam operations, such as Anglo Platinum's Bathopele mine in Rustenburg. Although successful, such operations do, however, face very specific challenges.

Safety and productivity are two of the factors that top this list, and one way in which mining companies are addressing these challenges is through the implementation of mechanized mining.

To date, mechanization in challenging mining operations has proved extremely successful. However, effectively monitoring equipment operating in areas that are either difficult or time consuming to reach has prompted machine manufacturers and mining companies to consider ways in which to gather information on 'how' machines are performing underground.

Various monitoring systems that focus on production are currently available to South African mining operations and there has been an uptake of these services. What is very important though, is more effective equipment monitoring, as equipment availability and utilization are key factors in optimal production.

Current equipment monitoring activity is largely ineffective as a result of the challenges mentioned already, combined with poor communication options in underground mining situations. Radio communication and manual monitoring are two of the more frequently used methods, but neither is suitable if an operation is intent on responding quickly to problems.

The answer lies in effective monitoring activities that provide 'real time' information on machine activity underground.

Remote machine monitoring offers tremendous value to mining operations that aim to make the most of their fleets, particularly large fleet operations in challenging environments. Atlas Copco has drawn on its extensive experience in the underground mining industry and over the last two years has worked on developing a remote machine monitoring system to meet customer needs.

Atlas Copco's monitoring system has been designed to focus on machine data and ultimately 'machine health' that plays a key role in mine productivity. Moreover, this is a process that operates in 'real time' allowing for a more proactive response to equipment problems on site.

A remote machine monitoring system offers numerous benefits, with communication flow and the quality of the information collected as the main benefits. An emphasis on 'quality machine information' is important here as quality information, on time, delivered to the right people, offers tremendous value to operations that rely on their equipment to achieve productivity targets.

Concept overview

Central to Atlas Copco's remote machine monitoring system is an underground wireless local area network (WLAN) as the communication bridge.

Other elements include:

- A data collection communication module (DCCM) that is mounted on each machine being monitored.
- The DCCM collects and preprocesses the data before sending it via the WLAN. There are different ways of sending the data depending on the mine's communication infrastructure. These include:
  - A hand-held personal digital assistant (PDA) that can serve as a main data carrier or as a support to a fixed WLAN network
  - A Fixed WLAN network in the entire mine site or parts of the mine site, supported by pick up points
- All data collected is sent to the local back office (LBO), a server situated on site at the mine. From this point, both the customer and Atlas Copco are able to monitor the data and synchronize the information for local business applications. It must be noted that sensitive information can be filtered at this stage to prevent it from going outside the local network
- The LBO data is synchronized to a central back office (CBO) via a web service that backs up the data and feeds the remote monitoring internet portal. The CBO can also work as repository for other business applications and it allows Atlas Copco to supervise the system.

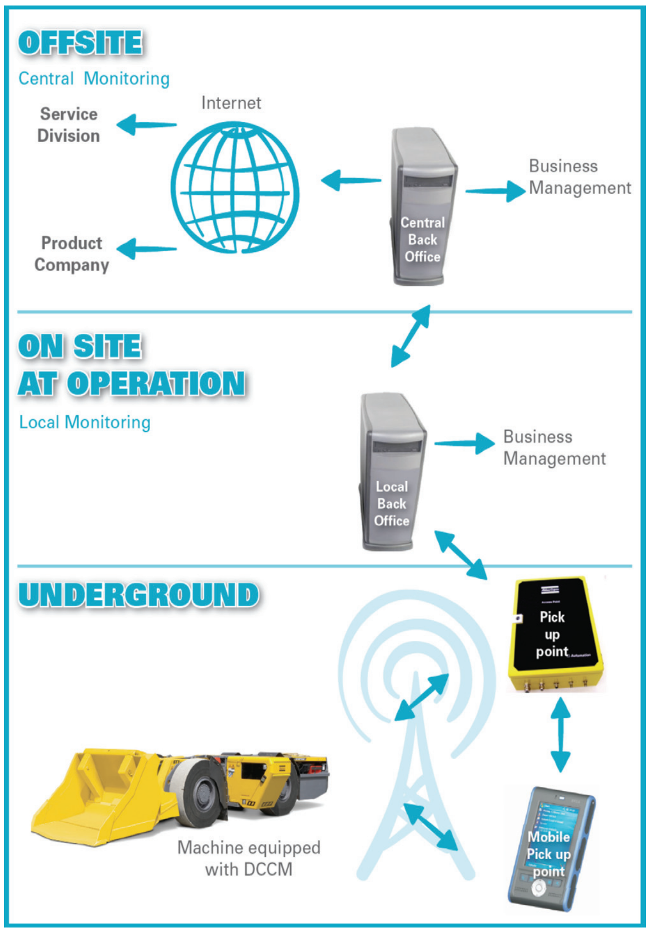

Figure 1. Remote machine monitoring: concept overview

Local back office

The local back office (LBO) is situated on site at the mine and supports the following role in this system:

- Collects data from all equipment fitted with a DCCM (refer to Figure 2 for an example of the information gathered)
- Feeds local mine applications
- Data is uploaded to the central data centre/central back office (CBO) periodically so that regular updates are available
- Can filter sensitive data from data stream.

The Customer and Local Atlas Copco can monitor the data, synchronise it to local business applications and if demanded filter sensitive data from going outside the local network.

Central back office

Data collected at the LBO is synchronized and sent to the central back office (CBO) situated at Atlas Copco via a Web communication service. The CBO is a secure and stable environment that backs up all information regularly to ensure safety of the information gathered. Also referred to as the 'global central data centre or remote monitoring internet portal', the CBO plays the following role in the system:

- Collects data from all equipment utlizing the system. If a mining company has two or more mines utilizing this system, the information will be collected from each mine and stored at the CBO.
- Presents data from all machines using a Web interface

The CBO can also work as repository for other business applications and it allows Atlas Copco to supervise the system. It is user restricted to ensure confidentiality of the communication contained within the system

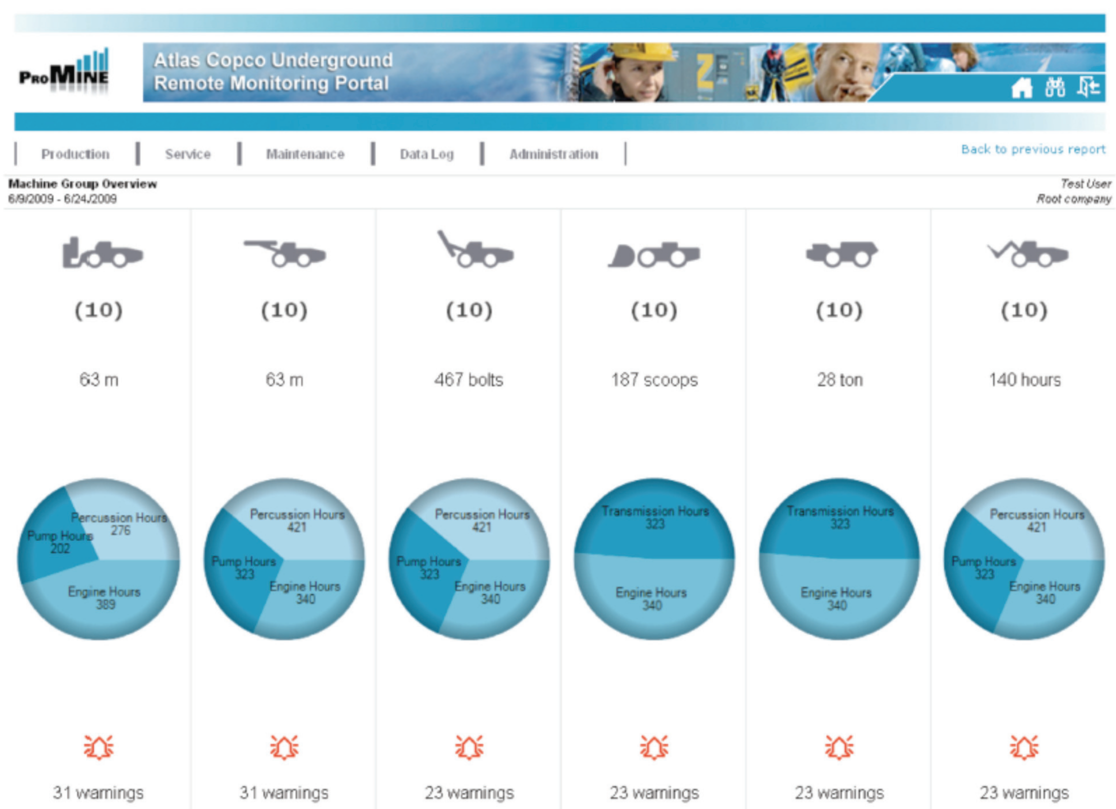

Figure 2. Machine data (used at both local back office and central back office)

Machine data gathered

This aspect of the process yields data that can be used for two main purposes:

Machine maintenance

- Operational hours (refer Figure 3)
- Equipment alarms (refer Figure 4).

Mine operation management

- Machine utilization (refer Figures 5 and 6)
- Machine output (refer Figures 7 and 8).

Whereas machine maintenance and mine operation is the standard information that the system gathers, the system has been designed to cover additional machine data if required. It is also able to work with two-way data communication.

System development and upgrades are based on customer demand.

Communication

Communication underpins the reliability and efficacy of this system. The communication system demonstrates the following characteristics

- It is based on AdHoc WLAN.
- It operates on a dynamic ad-hoc security architecture protocol (DASAP), i.e. data can flow in multiple directions before reaching its destination.
- Over the air (OTA) data protocol is used for transferring machine data and meta data.
- Adding support for a new machine type is done through configuration and does not require a new system release.
- A multi-path WLAN protocol allows the data to flow through different media simultaneously. The benefits of utilizing this approach are:
  - Safety: information should not be able to disappear or become corrupt.
  - Flexibility: works with all kind of WLAN components in any communication infrastructure.

Figure 3. Machine production hours

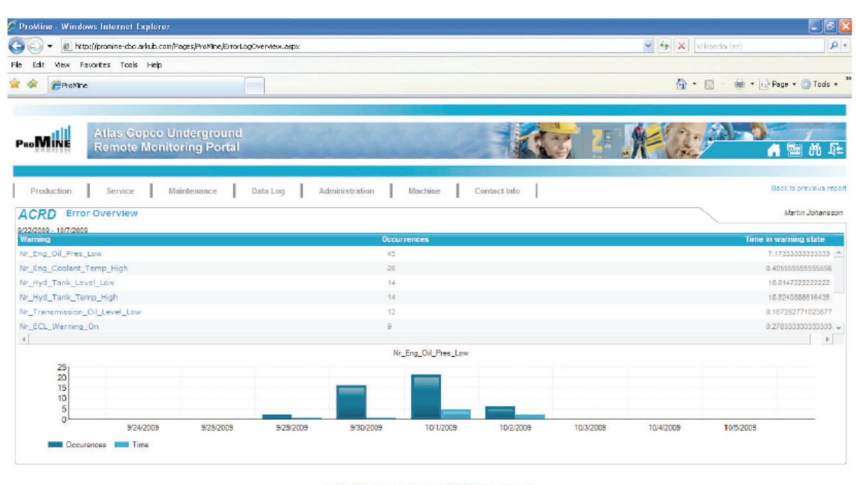

Figure 4. Error overview information (allows for proactive maintenance)

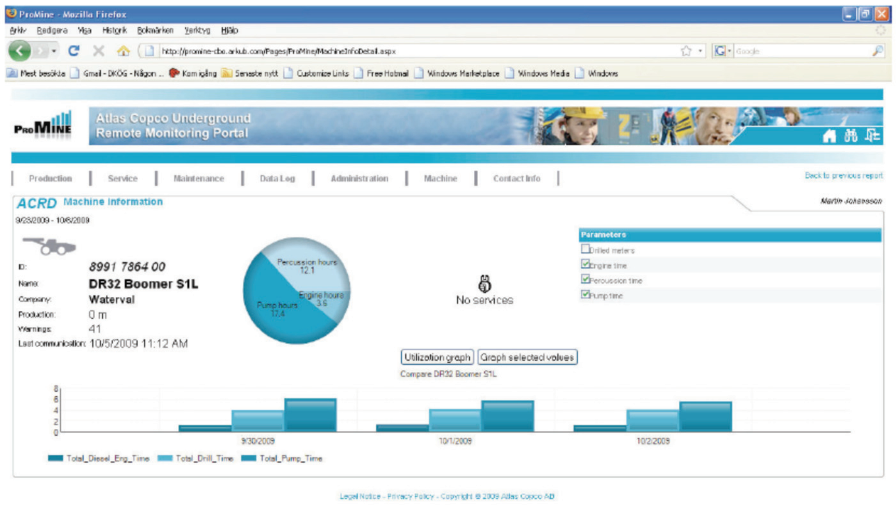

Figure 5. Machine utilization statistics

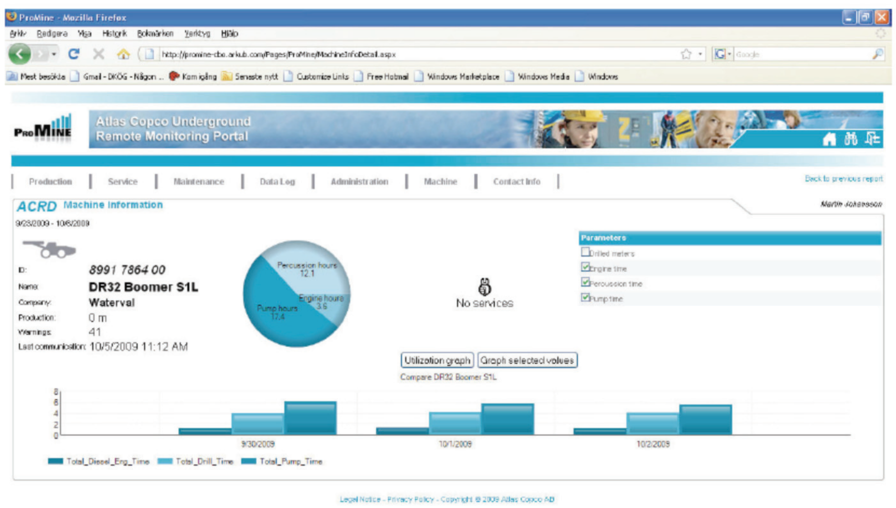

Figure 6. Machine utilization statistics

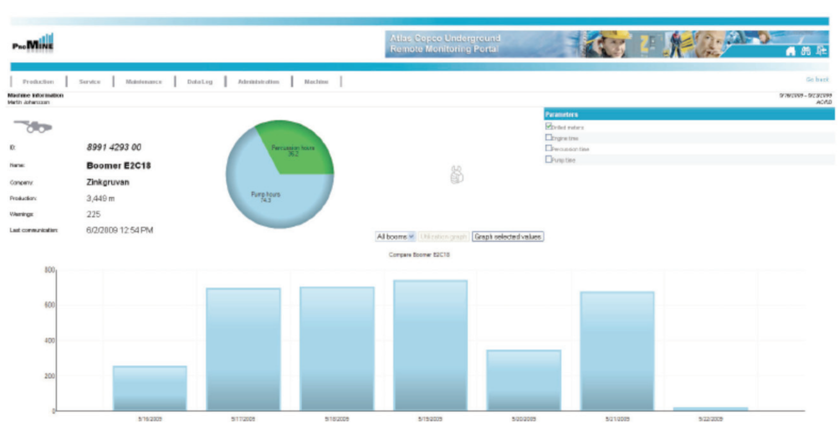

Figure 7. Production statistics (TME)

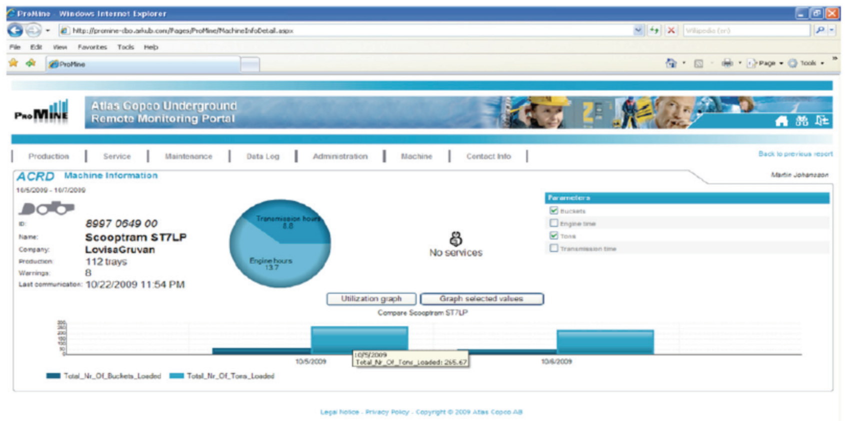

Figure 8. Production statistics (LHD)

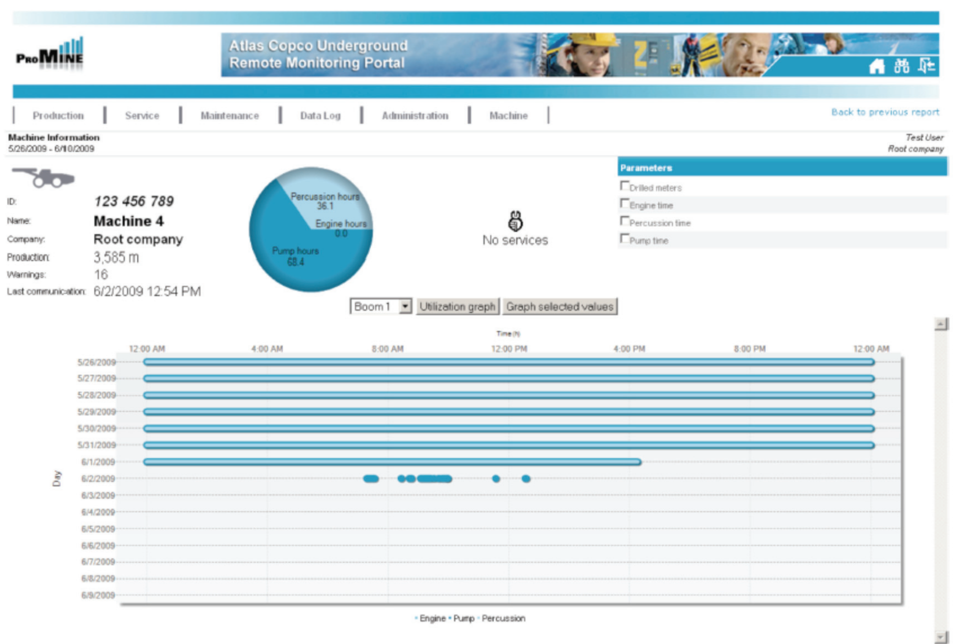

Figure 9. Specific machine information

- Speed: Both the machine computer and the communication protocol are designed to minimize the amount of data flowing between the machine and receiver. The reason for this is to create a fast secure data transfer.

The communication components supporting this system comprise:

- A DCCM that collects and preprocesses the data before sending it via the WLAN. The same unit is suitable for use on all machines, whether the machine uses a direct control system (DCS) or rig control system (RCS).
- The PDA software works with any off-the-shelf PDA supporting a windows mobile platform.
- A WLAN.

Functionality and benefits of remote monitoring

Having addressed the components of the system, we now look at what the system is able to do for the fleet owner in terms of mine processes and machine monitoring. The following information will be gathered and stored:

Fleet information

- No of machines operational on the mine
- The physical location of machines on the mine.

Production information

- Machine/operator utilization charts
- Machine statistics, i.e. standing vs. tramming vs. drilling (refer Figure 9)
- Downtime.

By recording fleet and production information, the fleet owner is able to record production time and machine output. This allows the mine to determine where problems exist so that any problems can be addressed proactively, and in so doing ensure improved production.

Alarms and alerts

- The alarms/alerts functionality allows for the recording of both current and statistical information.
- Current alarms/alerts allow for proactive response to breakdowns/potential breakdowns. Moreover, an early warning system that exists out of the hands of the

Figure 10. Error overview information

operator will ensure that more than one person is able to pick up any problems and react accordingly.

- Statistical alarms/alerts serve the purpose of recording a history on a particular machine. This information can be used for diagnostic purposes, as well as by the OEM in machine development and improvements. (Refer Figure 10.)

Service

After selecting the correct equipment for the task at hand, effective service and maintenance plays an extremely important role in machine availability and productivity. From a machine service perspective, this system allows for:

- Service interval alerts
- Service triggers.

Furthermore, field testing and machine development information is of particular use to the OEM as this enables machine development that is in line with customer requirements and based on solid information.

Product benefits

For the customer

- Higher utilization of machines and increased operational efficiency in that the system 'visualizes' how machines are being used and where room for improvement lies.
- Higher machine availability/uptime with optimized maintenance cycles and more accurate diagnostics. By recording the correct operational hours of different machine components more precise service scheduling is possible.
- The alarms/alerts allow the service organization to be more proactive and solve problems before they occur and also to provide more precise diagnostics for reactive maintenance
- Machine output measurement on RCS machines mean that the OEM is able to provide the customer with key productivity KPIs i.e. drilled metres and loaded tons.

For the OEM

- Service agreements can be structured and enhanced that will prove beneficial to both the OEM and customer. This will be achieved through:
  - Reduced warranty costs (measure and control)
  - Improved performance monitoring of service contracts.
  - Detect equipment degradation prior to failure resulting in increased capacity/uptime (measure and control)
  - Reduced maintenance costs through operational efficiency and improved maintenance scheduling—increased bonuses/reduced penalties.
- Technical data obtained can be utilized effectively for performance and quality improvements on equipment.
- The OEM's ability to measure and control machine/fleet activity is increased.

Conclusion

When a mining operation invests in capital equipment, this should be seen as only the start of a relationship with an OEM. Effective equipment maintenance and upkeep is key in achieving maximum performance from the said equipment. Any underground mining operation would agree that effective maintenance is a challenge.

This being said, it makes sense then that utilizing an effective machine monitoring system that in turn impacts process monitoring, should be seen as a key component in achieving maximum return on investment.

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Education

- Master of Science degree in Industrial Engineering and Management -Master Thesis done at Atlas Copco Parts & Services.

Previous working experience:

- Logistics Controller, SKF Gothenburg Sweden
- Project Leader Aftermarket - New machine development, Orebro Sweden
- Product Manager TME Drill rigs – Aftermarket, Örebro Sweden
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