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Loader Automation – Proven Technology

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Acronyms

AutoMine® – Sandvik's mine automation system
AutoMine-Lite™ – Sandvik's single loader automation system
CAN – Controller Area Network
Ethernet – Networking technologies for LANs
IP – Internet Protocol
LAN – Local Area Network
LHD – Load, haul, dump machine
VCM – Vehicle Control & Management System
WLAN – Wireless Local Area Network

Introduction

Sandvik started the research of autonomous mining methods already back in the 1980's and the first customer application of automated loaders was commissioned in 2004 in the Codelco El Teniente Pipa Norte mine. In very short time Sandvik has proven that the technologies behind the AutoMine® system really works in the mine environment and today there are AutoMine® and AutoMine-Lite™ systems working in five continents.

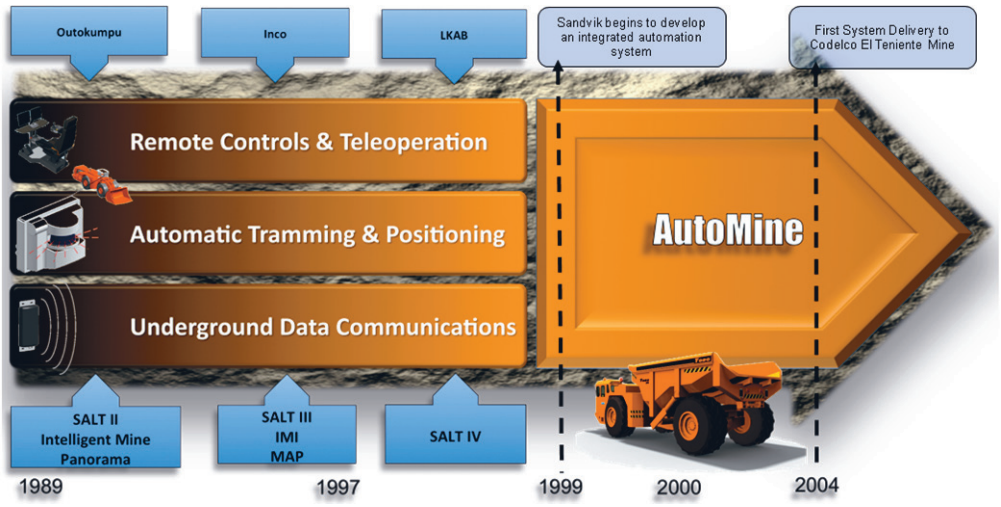

Figure 1. History of Sandvik's Automation Research

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Currently all major loader manufacturers have some automation capabilities available for at least some loader applications. The trend at the moment is to develop semi-autonomous loader automation systems, where most of the cycle is done autonomously but operator still operates part of the cycle via tele-remote controls.

This article focuses on Sandvik's loader automation and especially on the new generation of single loader automation in the offering. In this presentation the system and its development path is described in brief and first customer projects are introduced.

History

The AutoMine® automation system was designed from day one to be able to operate a fleet of automated loaders and trucks. The Test Mine at the Tampere factory in Finland was selected as the place of development of the system and an automated loader was first driven in autonomous mode in the late 90's. The first customer projects were sold very soon after and the first system was commissioned 2004 in Chile El Teniente Pipa Norte Mine. The first integrated loader and truck automation system was following already in 2005 at De Beers Finsch mine in South Africa.

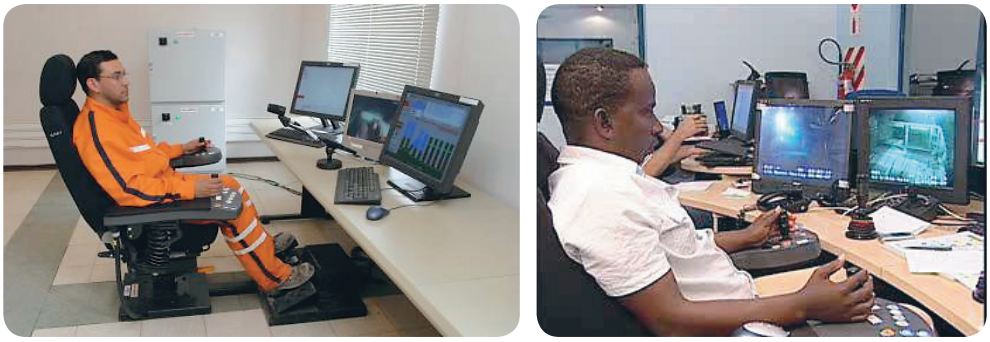

Figure 2. AutoMine® Operators in Pipa Norte and Finsch Mines

In the beginning onboard automation systems were built on top of the standard manual loaders and required different electrical and hydraulic systems which resulted in a very customized machine. However, during the years the onboard automation has been tightly integrated into the machines onboard control system, Vehicle Control & Management (VCM) system. Today the onboard automation package is available as an option for most of Sandvik's larger loaders and trucks. The latest addition to Sandvik's automated loader offering is the 14 ton electric loader, LH514E.

Different communication systems have been utilized over the years and the currently used MineLAN™ communication system has been developed based on the

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Figure 3. Automated LH514E Electric Loader

standard WLAN. For real-time communication needs, some patented technologies have been added on top of standard 802.11g WLAN communication protocols to allow the communication link from the machines to perform seamless hand-overs from access point to another.

All system safety functions are developed by researching the customer needs and according to the EN62061 safety standard to ensure highest level in safety and still allow flexibility to adapt the automation system to the mines environment and automation application. During the development of the technologies different types of safety concepts have been tested and only the best practices are in use in the current systems.

Single Loader Automation

The newest generation of Sandvik's loader automation is called AutoMine-Lite™ and it is designed for single loader automation applications whereby only one loader is operated by the system at a time. The most common application is to replace line-of-sight remote control operations with safer and more effective semi-automated operations.

The technologies behind AutoMine-Lite™ are the same as in AutoMine®, but the design is targeted to provide flexibility and portability. AutoMine® was designed for mass mining applications and AutoMine-Lite™ brings the advantages of the semi-automated loading to the smaller scale mining methods, like sub level open stoping. The new automation system can be divided into four main areas, ergonomically

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Figure 4. AutoMine-Lite™ Operator station

designed operator station, reliable wireless communication system, safety system isolating the production area and the loader equipped with integrated onboard automation package.

The operator station is typically located close to the production area, but the distance is between the operator station and production area is not limited by the system. During operation the operator has all the necessary controls for the loader to be able to tele-operate the loader effectively. In addition to the normal video

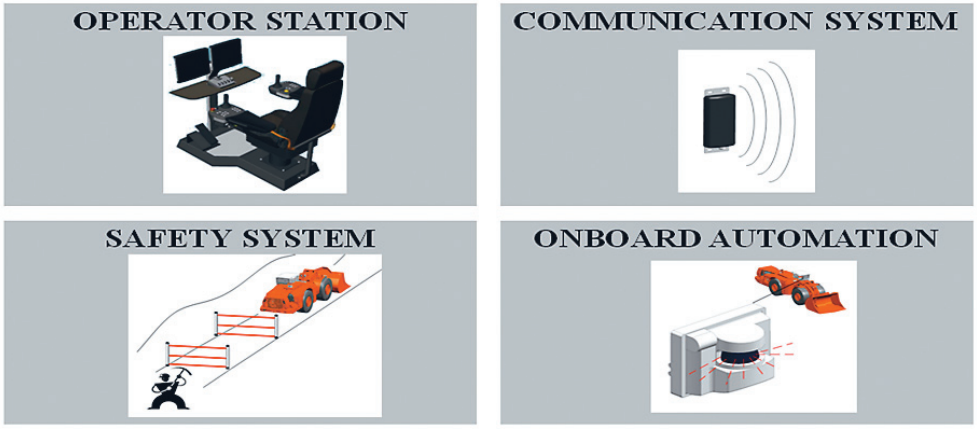

Figure 5. AutoMine-Lite™ Concept

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Figure 6. MineLAN communication system

feedback, the system shows real time alarms and extra visual assistance for the operator. The system also enables the operator to create a production plan and to see real time progress of the execution of the plan. The system performance can be also by followed with the standards reports generated by the system.

The safety of the system is based on the principle to isolate the automated and manual operations from each other with safety rated measures. All accesses to the autonomous area are guarded with Access Barriers which detect any safety breach into or out of the autonomous area. The safety system is an independent system which communicates with operator station and with onboard automation

Figure 7. Automated LH517 Loader

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Figure 8. Servicemen with service tool

system. Isolation of the production area also brings advantages to the production when all secondary activities are planned beforehand, because the whole autonomous area is reserved only for the loading and disturbances to the production are minimized.

The communication system consists of a typical Ethernet-based LAN and WLAN. All communication is IP-based which brings the advantage that the physical locations of the components are invisible to the other system components as long as it is connected to the same logical network. WLAN is developed to be able to respond to the high real time communication needs of tele-operation and also to be able to handle the changing from the access point to another seamlessly as the loader moves in the autonomous area.

The onboard automation is common with AutoMine® systems and consists of wireless communication unit, navigation computer, safety unit, audio/video system and the necessary sensors for navigation. The onboard automation is integrated to the machines CAN-bus based onboard control system, VCM, which is common with all of Sandvik's new generation loaders.

Development of the service tools and other supporting equipment has been also one of the key aspects of the new automation system. The aim was to develop the supporting tools for the system to a level that a mine's own personnel can handle the daily tasks with the system.

Prior to market launch the new automation system went through a demanding field test period in the Inmet Pyhäsalmi Mine in Finland. The first customers are both located in Sweden and projects started during year 2010 to deliver, install and commission the systems.

CASE 1: LKAB Kiruna Mine – towards a more continuous mining process

Luossavaara-Kiirunavaara AB (LKAB) Kiruna iron ore mine is known in the industry to be one of the leading mines in the world when referring to the development of the mining processes and application of automation. LKAB were also one of the first mines to investigate and develop autonomous mining methods already in the

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90's. The mine started to analyze current automation technologies in the market during the year 2009 and during the year 2010 the decision was made to continue technology evaluations with Sandvik's automation offering. The evaluation is to be made with the AutoMine-Lite™ system and with a LH621 loader. The evaluation period is going to last until late 2011.

The mining method is sublevel caving which requires that the automation system needs to be transferred from one production area to another many times per year so there is a need for flexibility and portability from the system. The largest advantage comes from the fact that you can utilize the ventilation time after blasting as the mine has located the control station to a place where the operator can work immediately after the blasting. This means that the ore flow coming is more continuous and the mine can have more effective production hours in a day.

When the mining process is more continuous there is no need for a large buffer reserves in the middle of the process chain. The flow of crude ore is expected to be better with AutoMine-Lite™ system operations when the production break times are smaller and therefore ore flow is more continuous.

CASE 2: Boliden Garpenberg Mine – minimizing the safety risks in open stoping

Boliden Garpenberg mine is Sweden's oldest underground mine still in production and its main products are zinc and silver. The mine evaluated the global automation offering during the year 2009 and early 2010. After a comprehensive evaluation

Figure 9. Automated LH621 LHD

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between different suppliers the mine decided to purchase Sandvik's AutoMine-Lite™ systems and LH517 loaders.

The mining method is open stoping which requires that the automation system needs to be transferred from production area to another frequently, so there is a high need for the flexibility for the system commissioning and re-locating into new area. Initially Boliden plans to have five different mining levels installed for automated production.The largest advantage comes from the fact that you can utilize the same machine for manual and automated production. The mine can use the diesel powered loader in manual operations when working in a safe environment and when working in open stope environment it is very easy to change the production to automated operations.

Until these days the remote loading part of the production was done with line-of-sight radio remote controlled loaders, but the mine wanted to increase the safety and comfort of the operators by moving them out of the production area. In the future most of the production loading shall be done with AutoMine-Lite™ system.

Future of loader automation

As the demand for increased safety and more continuous working methods in the mining business increases, the potential application for loader automation looks bright. The supplier's development focus now begins to change from developing and integrating the base technologies to enhancing system flexibility and improving the user friendliness and maintainability of the automation system.

Currently one of the studied areas is how to bring additional information about the loaders working environment to the operator and the aim is to improve the working efficiency and minimize waste rock dilution during the loading. Sandvik has already taken the first steps with AutoMine-Lite™ system towards these goals and there is constant development ongoing as customer feedback is gathered and as new technologies gain maturity needed for automation systems in mining environments.

Figure 10. Boliden Garpenberg Operator Station