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Automated underground loader

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Introduction

As a step in the continuous drive to improve personal safety and working environment for the operator, as well as increased productivity, Atlas Copco released the new Scooptram Automation system for the market in 2009. The semi-autonomous system includes tele-remote control, auto tram and auto dump functions for Atlas Copco Scooptram loaders equipped with the Rig Control System (RCS).

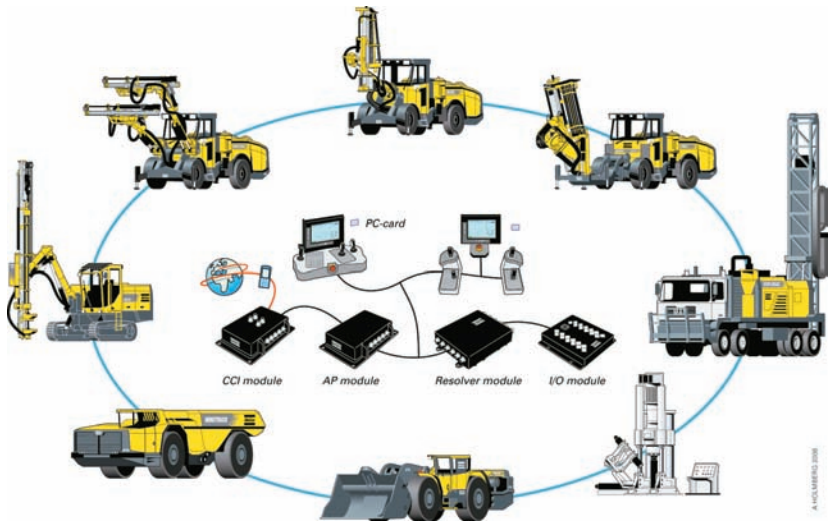
The system was field tested in a real mine application for 12 months. The Scooptram Automation System was tested and mainly used for back fill operations where it proved its safety and productivity benefits.

The Scooptram Automation system is now sold to the first customer. The customer is in a transition period going from open-pit to underground mining. They are looking at the most efficient and economic ways to do business and the Scooptram Automation system is a part of that step.

History

Atlas Copco acquired Wagner 1989, the inventor of rubber tyred loaders with articulated steering, back in 1958. An invention that revolutionized mining all around the world as it led to a fast shift from track bound mining to trackless. This contributed to a huge improvement in underground mining productivity.

2003 Atlas Copco moved the Wagner division from Portland in the United States to Örebro in order to gain efficiency by coordinating engineering and manufacturing processes between drilling equipment, loaders and trucks.



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Since 2003 there has been a large number of product improvements made on the complete range of loaders and trucks, with focus on safety, reliability, ergonomics, serviceability and productivity. Further, new modern products have been added with the additional feature of being automation ready thanks to the introduction of the control system RCS (Rig Control System). RCS is well proven and has been used on drill rigs since 1998.

When it comes to the loaders and trucks there have been a number of steps towards automation for several years including vehicle monitoring systems, load weighing systems and several remote control systems.

In 2005 Atlas Copco released our own line-of-sight radio remote control for Atlas Copco loaders, the Scooptram RRC. The remote control was the first automation product developed for the Atlas Copco loaders. The product has been a success when it comes to user friendliness, durability, cost efficiency and easy to support.

First to be launched was the 14 tonne loader, Scooptram ST14 with RCS, introduced in 2006. This has then been followed by a 7 tonne loader Scooptram ST7 and a 42 tonne truck, Minetruck MT42, all being automation ready with RCS.

Atlas Copco has, for several years, been working on automated functions for repetitive routines. This is to increase the safety and working conditions but also to increase productivity.

2009 Atlas Copco released the Scooptram Automation system, a semi automated system for Atlas Copco RCS loaders. The system was field tested for 12 months in Kemi Chrome mine in northern Finland in 2007/2008. The system integrated with the already existing communication network installation in the mine and was controlled and monitored from a remote operator station 500 meter underground in the office/dining hall area.

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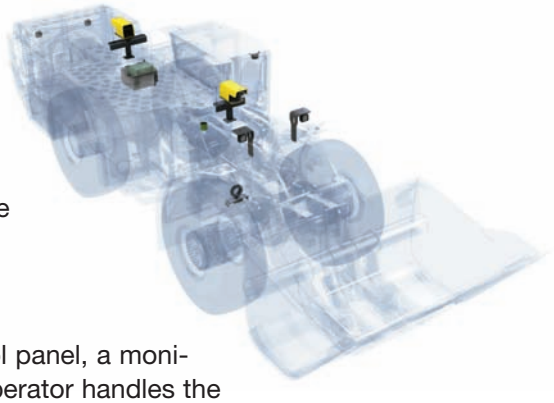
The content of Scooptram Automation

The semi-autonomous system includes tele-remote control, auto tram and auto dump functions for Atlas Copco Scooptram loaders equipped with the Rig Control System (RCS). This makes it possible to avoid human exposure in unsafe areas such as unsupported stopes, or in any other load, haul and dump applications. Scooptram Automation is efficient, reliable and easy to use. The remote operator's station provides the operator with an ergonomic and safe working environment with full control and support of the system.



The vehicle installation

The Scooptram Automation is built with the RCS as a base. Sensors, antennas, cameras and a control unit are added to the RCS for fast and reliable control of the system.

The operator's station

The operator's station includes the control panel, a monitor, server cabinet, desk and chair. The operator handles the vehicle and the system with the control panel and gets visible feedback from on-board cameras and lasers, which is displayed at the operator's desk monitor. Full vehicle data information is displayed along with remote on-line diagnostics.

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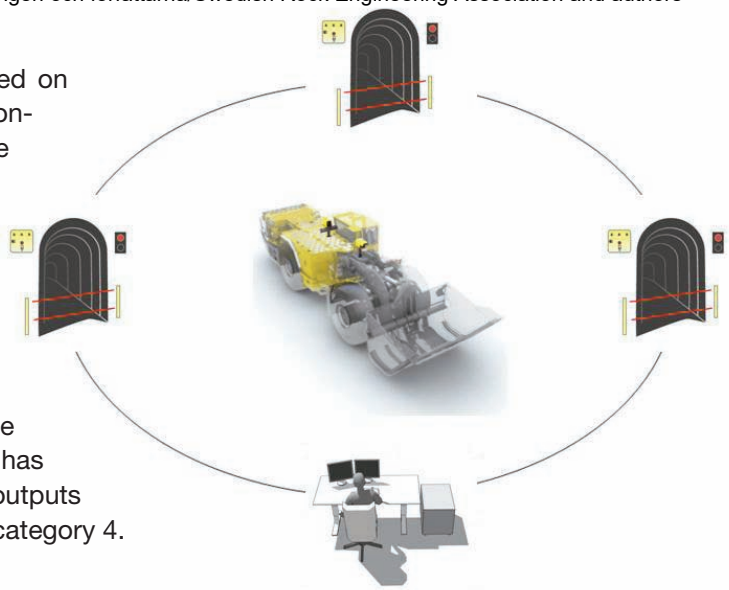
The safety system

The safety system is based on a Programming Logic Control (PLC) and ensures the safety of the mine personnel and the containment of the vehicle within the designated work area. To ensure redundancy the safety system works in parallel with the vehicle's control system. The PLC in the safety system has dual cores and failsafe outputs and is classified in safety category 4.



Options

The above sub systems are the base of the Scooptram Automation system. As an option to this system Atlas Copco include a W-LAN installation including access points, fibre or copper switch and antennas to cover the automated production area if the customer doesn't have this already. Atlas Copco also includes a line-of-site recovery system as an option to recover a vehicle remotely from an unsafe area if the communication link would be lost with the loader.

The product becomes a project

All sold systems will also include a customization and be run as a project for optimal support, productivity and cooperation:

1. Automation audits establishes necessary infrastructure, equipment, training and organization set-up
2. Customization of Atlas Copco automation system
3. Commissioning of automation system
4. Training of operators and maintenance personnel
5. Atlas Copco full service contract during operation
6. Upgrades and additional development and customization of automation system to grow with customer needs.

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The field test

The Kemi Chrome mine, owned by Outokumpu, is located close to the Gulf of Bothnia, about 25 km from the Swedish northern border. The chrome deposit was found in 1959 and a decision to exploit the deposit was made in 1964. The production started in 1968 as an open pit and the underground mine development project started in 1999. Since 2006 all mining has been conducted underground.

The goal

The goal for the field test was to test the Scooptram Automation system as a product in a real mine operation. The field test also included all sub products to the system. The system was mainly used for back fill operations where it proved its safety and productivity benefits.

Conclusions drawn after the field test

A summary of the data collected during the field test and the analysis done afterwards:

Pros

- Increased safety and working condition for the operator
- User friendly system
- Decrease of vehicle wear
- Increased tramming speed of the loader allowing faster cycle times
- System and vehicle maintenance
- Increased availability of the loader
- Data feedback to mine network
- High productivity.

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Cons

- Disadvantage that the safety system blocks a large area for other vehicles.

The ***increase of safety*** and working conditions for the operator is very essential. The operator can by ease operate the loader with full control and performance from an ergonomic work station through out the shift. The operator does not have to be close or near unsafe areas. The operator's station can be installed anywhere as long as it's connected to the LAN or WLAN communication network.

The Scooptram Automation system is designed to be ***user friendly***. The operator can by him self teach a route that he wants the loader to tram, check the recorded route using an offline tool, to make sure that the data collected is valid and correct. Then play back that route to get an optimal safe speed for the route. Vehicle, safety system and the network is monitored by the operator from the operator's station allowing full control of the system.

The ***decrease of vehicle wear*** can be monitored in many ways. The following is one. The ST14, trammed in autonomous mode more then 1400 km during the field test. Thanks to the system's sensors, high tech algorithms and the teach and playback routine the vehicle never went off course hitting a wall or ditch, when tramming in autonomous mode

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An automated loader has big possibilities to ***increase the tramming speed*** allowing faster cycle times. The design of the tunnel profile, the road bed, and the ditches in the mine only allowed manual operators to tram on second or maximum third gear, with a speed of 10–15 km/h. With the automated ST14 we showed that we could tram on forth gear over 20 km/h in the same areas. We discovered that the gravel roads and tires didn't allow for maximum speed all the time, and did some conclusions that the most productive and vehicle friendly speed was around 16 km/h. This gave us fast cycle times and at the same time a good road bed and less ware on the tires.

The ***maintenance*** on the vehicle and the system was, according to service personnel easy to perform. The Scooptram Automation system together with the RCS controls on the ST14 explains the error message in a way so that the operator or technician right away can understand what part of the loader or system that needs to be inspected. The operator will get information from both the system and the vehicle to the operator's station and can immediately take a decision on what needs to be done.

The ***availability of the loader*** was shown in several ways. The operators swapped control of the system after shift changes, in the middle of shifts and continued backfill production even through blasting hours.

Different ***data feedback*** is possible with a vehicle on line connected to a communication network. The ST14, which has a built in load weighing system, was successfully connected to the mine planning system that automatically collected every ton moved to the different back fill stopes. No manual extraction from the loader or system was needed as the system delivered the data automatically. The logs and data collected from the vehicle could be used for other purposes as well.

There was a study done where by Outokumpu compared the ***productivity*** of the Scooptram Automation system with the contractor doing the backfill in parallel. The contractor charge the mine for the back fill operation depending on the distance and tonnage moved. Below there is data showing the numbers of vehicles needed to move the different amounts of ton's each shift.

Contractor doing backfilling:

1 loader and 3 trucks, 4 operators, distance 220 m, hauling capacity 3621 t/shift
1 loader and 2 trucks, 3 operators, distance 450 m, hauling capacity 3174 t/shift
1 loader and 1 truck, 2 operators, distance < 500 m, hauling capacity 1400 to 1800 t/shift

Scooptram Automation doing backfilling:

1 loader, 1 operator, distance 255 m, hauling capacity 1662 t

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The system was “productivity compared” to one manual loader and truck of another brand doing the same job. The conclusion was that productivity and cost efficiency can be gained by adding another automated loader, or even trucks to this or a similar application.

The ***disadvantage*** for this customer was that the area had to be sealed of for other vehicles during the back fill production hours. As the system, and any other similar system on the market, don’t allow any vehicles or personnel in an automated area with self operated vehicles it is still far away for the acceptance of allowing this, even if it would be technically possible. The safety system is designed to customize the customer needs when it comes to what kind of gates and the number of these to seal off the area with. Production areas could of curse be designed for automated loaders but this is rarely the case.

The first customer

Far in the Northwest Territories of Canada the mining company Rio Tinto, Diavik diamond mine inc. (DDMI), delves into the roots of ancient volcanoes beneath the arctic waters of Lac de Gras in search of diamonds. Located 300 kilometres northeast of Yellowknife, the Diavik Diamond Mine exists in a region as remote as it is desolate.

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In 2009 DDMI had their first ST14 included with the Scooptram Automation system delivered. The planned production start was delayed due to the economic situation around the world and was moved from summer 2009 to late spring 2010. Despite this the system was commissioned by the mine during the summer and on the 19th of November the ST14 loader was operated from surface located at the main camp.

DDMI is in a transition from open-pit to underground mining, they are looking at the most efficient and economic ways to do business. When it comes to how they haul ore from their new underground mine to surface, one part of their approach includes using the hi-tech Scooptram Automation system.

During June 2009 the Scooptram Automation system was installed but due to delayed production start, the system was installed in a "test" area. The purpose was that the mine would have the possibility to inspect and operate the system. The system was inspected by safety inspectors, operating managers and other manager involved with the underground mining. The inspection was done in this phase so that, Atlas Copco, had a chance to change or modify the system if needed.

In June 4th the installation of the automation sensors began. The next day the vehicle was calibrated and tested. The underground operator station was moved down to the area on the 7th. On the 15th the entire system including the vehicle, the operator's station, the safety system and the communication installation was tested and commissioned by the Underground Superintendent and the Underground Safety Advisor.

The underground automation test was a success and didn't show any red flags or concerns regarding the system. The project was put on hold due to summer brake and the mine manager gave it a go ahead for the big demo in November presented for Rio Tinto management.

DDMI have made necessary investments in a communication network on site, underground and also a microwave data link connecting the mine site to the city Yellowknife.

The Online Mine

DDMI's vision is to create an 'Online Mine' in order to maximize monitoring and control of key risks and production activities. This can be achieved by:

- Increasing the safety of our workforce through:
  - The use of personnel tracking and safety monitoring systems
  - Removing the need for certain personnel to be underground at all
- Enhancing overall operating capabilities with respect to:
  - Increasing productivity and efficiency
- Being well positioned to take advantage of future changes in technology

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On the 25th of March 2010 DDMI will have their opening ceremonies for the start of the underground operation. DDMI is looking at utilizing the ST14 with Scooptram Automation as a part of the Open Sky project. This project will focus on the top part of ore closest to the surface in the open pit. The Open Sky project is although not the only purpose of the automated loaders. DDMI is also working on a plan to deploy the Scooptram automation systems where blasthole stoping will be used.

The Scooptram Automation system installed in DDMI is more or less the same kind of system setup as the Kemi installation. Some smaller changes have been implemented to customize the product for the customer needs. One operator will be able to operate the loaders from a control room. A safety system will be installed to ensure that no personnel are present in the automated production area. The system will be operated on DDMI's own network system and interact with status and productivity feedback.

Goals and results 2009

DDMI goals June 2009 (phase 1–2)

- Firstly, prove the system would in fact perform as expected in place at DDMI
- Secondly, provide an opportunity to examine the system and determine if any components (Control Room, ST14, Safety System, Network infrastructure) would require modification.

Results

- Having reached the conclusion of Phase 1, it has been demonstrated that the system does work as advertised in DDMI's underground trial location. Also, there have been no immediate flags raised with respect to any major changes required to move forward with the system. Informal feedback from everyone who paid a visit to the automation trial area to observe the work being conducted, or watch a fully operation demonstration of the ST14, was consistently very positive.
- At this point it was stated that the automation trial project was in very good shape with respect to starting Phase 2.

DDMI goals November 2009 (phase 3–4)

- Set up a production area for demonstration
- Install 5 km of fiber optic cables from surface to the underground
- Set up a control room on surface
- Analyze KPI's and data collected

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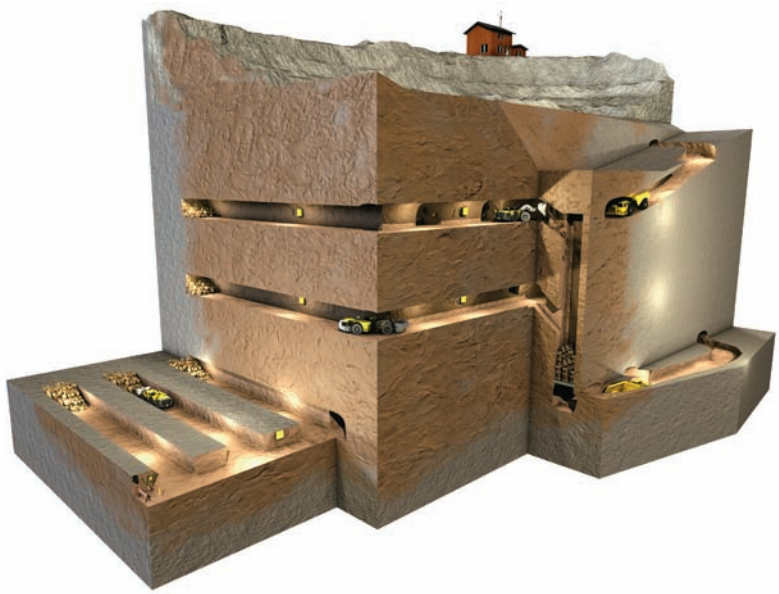
Results

- DDMI have proved that the system is in fact ready as a production tool. DDMI is now ready to leave the “trial and demonstrator” mode.
- The system was operated from surface for several days and was operated of DDMI’s newly certified underground loader operator on the demonstration day during November.
- Data collection from these phases and from the coming production runs will be analysed by DDMI to capture different KPI´s.

The next step

Atlas Copco has now been offering automation systems and integrations for several years. By using self-operating equipment we reduce human exposure in the mining environment and routine or repetitive work. What these automated functions or systems do is depending on the vehicle and application. Our goal will still be the same to increase safety and at the same time increase productivity.

The technology developed on the RCS platform and launched on the ST14 will be available on all new generation loaders and trucks in the future.

To integrate these vehicles will bring huge possibilities on what could be achieved. The productivity and cost benefits of this are unquestionable and will be needed for present and future automation requests for loader and truck applications.
The imagination is the only limit, of what could be automated.

/Oscar Tryggvesson – Product Manager Loader and Truck Automation