AUTONOMOUS LOADING & HAULING TECHNOLOGY AT DE BEERS FINSCHE MINE

Mr Raymond Grobler
Sandvik Mining and Construction

ABSTRACT
De Beers Finsch Mine has already installed and commissioned an autonomous hauling system which is producing on three shifts. This paper will discuss the processes involved in developing and implementing this state of the art transportation system. It will also describe the requirements for such a system and the lessons learnt during implementation and commissioning.

1. FINSCHE MINE OVERVIEW
Finsch Mine is situated approximately 165 kilometres west of Kimberley in the Northern Cape Province of South Africa as shown in Figure 1. The Finsch kimberlite pipe is a vertically sided intrusion into the country rock. Exploitation of the kimberlite pipe commenced in 1964, utilising an open pit mining method. Approximately 120 million tons of kimberlite ore was mined from the open pit. Underground operations commenced during the latter part of 1990. The underground ore body is divided into mining Blocks 1 to 5 as shown in Figure 2. Blocks 1 and 2 were mined out while Block 3 is nearing depletion in 2007. Block 4 is extracted utilising mechanised block caving mining methods. Exploration drilling of the Block 5 resource is in progress already – aimed at improved qualification and quantification of the remaining kimberlite pipe at depth.

Figure 1
BACKGROUND
Sandvik was chosen as the technology partner and systems integrator for De Beers to develop, design, manufacture and commission an ore transportation system (OTS) for Finsch mine. This involved the automation of four Toro 50D dump trucks and six Toro 007 Load Haul dumpers (LHD’s) operating underground in the newly developed Block 4. The LHD’s collect ore in different loading points in the block cave and transport it to the dump trucks from where it is transported by the dump trucks and dumped into a crusher. The project involved the automation of the truck traiming cycle (without operators) utilising laser guidance techniques developed by Sandvik. LHD’s are manually operated during the first phase of the project but are tracked for position underground to ensure that the production plan is followed which is critical for the success of the block cave.

2. INTRODUCTION
De Beers have adopted a formal project management and systems acquisition approach which was followed throughout the project. The main concept of the De Beers Total Project Management (TPM) and system acquisition process as depicted in Figure 3, involves the effective management of time, cost and quality of a complex multi disciplinary system applied throughout the system life cycle. The whole life cycle of the system is taken into account, from determining the needs and requirements, system acquisition, right through to system utilisation whilst always considering the interfaces and interactions with its environment.
3. OTS SYSTEM ACQUISITION PROCESS
Sandvik applied the systems acquisition process defined by De Beers Finsch Mine, with specific reference to the following scope of work:-
- Execute the system acquisition phases of the system life cycle, from concept exploration, up to the final commissioning and support of the system accepting overall system acquisition and performance responsibilities.
- Perform all system engineering necessary to address the entire User Requirement Statements (URS) from high level requirements down to detailed levels.
- OTS engineering design, manufacturing and commissioning project management responsibilities.
- Satisfy all engineering design and development requirements.
- Procure, manufacture and integrate all system elements.
- Commissioning of total system.
- Participate in operational risk assessments (Safety and production related)
- Relevant stakeholder’s engagement.
- OTS system training responsibilities.
- Support the eventual system during utilization and phase-out.

4. OTS SYSTEM
The Ore Transportation System forms a major component of the Ore Management System (OMS) for Block 4. The OMS is an integrated system that will manage the planning, optimal extraction, reconciliation and effective management of the Block 4 ore resource. As a sub-system of the OMS, the OTS is responsible for the optimal transport of ore from production draw points to the underground primary crusher. Figure 4
The system is made up of sub systems with the following functionalities:
(Figure 5)

- **Production Control System**: This system schedules and manages shift production execution for autonomous trucks and manual LHD’s during phase one of the project.

- **Mission Control System**: This system control the production execution by issuing production and drive orders to LHD’s and dump trucks. It also perform traffic control for autonomous trucks, manage truck loading by LHD’s, supervises production resources and monitor the total fleet production, condition and status. It further provides the user interface for supervision and control of the total fleet.

- **Access Control System**: This system consist of various safety gates, warning lights, photocell barriers and sirens in the autonomous truck loop controlled from the control room on surface. The main function of this system is to provide an area for automated machines which is totally isolated from manually operated equipment and personnel.

- **Operator Station**: This is situated in the surface control room from where the fleet is supervised and controlled. The operator station consists of an operator chair, computer systems and video display screens from where machines can be operated tele-remotely.

- **MineLAN**: All communication to and from machines operating in the Block cave is done via the MineLAN communication backbone. The MineLAN consist of various access points located in the tunnels underground and a Fibre optic network backbone running from underground to the surface control room.
Figure 5 – System Architecture

5. **SYSTEM INSTALLATION AND COMMISSIONING**

The system was successfully installed and commissioned at Finsch Mine. The different sub-systems were commissioned first followed by integrated total system testing. This involved the entire ore transportation cycle from loading at the draw points to tipping into the crusher.

Few problems were experienced during commissioning as the complete system was tested and verified in the Sandvik test mine in Finland before being shipped to Finsch for installation on site.

A very important part of the installation and commissioning was to conform to the De Beers underground installation standards and to follow the following process of certification:
Certificate C1 – Construction completeness

The contractor must complete all construction activities before presenting the C1 certificate for approval by the Commissioning Manager. The completion of each individual C1 certificate will allow the applicable module or sub-system to progress to the next phase.

Certificate C2 – Energisation commissioning

This certificate is issued for a complete unit of equipment or product and its associated controls and includes electrical supply, motor control, mechanicals etc. The relevant checks performed will be attached to the C2 certificate.

When safe to do so, all products such as communication system, ACS etc shall be operated individually for short periods under the supervision of the Commissioning manager and in accordance with test procedures.

The C2 certificate shall be signed off to signify completion of an acceptable test run.

Certificate C3 – No load commissioning

During this phase commissioning activities take over from installation and construction activities. It is essential that all construction and installation activities be completed before being accepted for C3 commissioning.

No-load testing involves proving that the integrated OMS operating segment is able to operate in a controllable and stable manner (without receiving ore).

The purpose of this phase is to operate equipment and systems under no load and to certify that the system has been built and is operating as required by product development specifications and design criteria.

Certificate C4 - Product commissioning

The purpose of Product commissioning is to introduce ore feed to the plant, to build up to full production levels and to hand over to the OMS Operating manager.

The OMS Operating manager and his operating staff will be responsible for product commissioning. This commences when all C3 certificates associated with the OMS Operating segment have been issued and approved.
Product commissioning is complete when C4 certificates have been issued by the Commissioning Manager in conjunction with the De Beers OMS project team for all the facilities included in the OMS Commissioning program.

At completion of Product commissioning the De Beers OMS Operating manager will have control of the complete facility. The Commissioning Manager will focus on the clearing of outstanding deficiency list items as per the System Qualification Plan and Verification requirements and generated punch lists.

- Certificate C5 – Completion certificate

This is the final hand over certificate which shall be accepted by the clients operational and maintenance personnel.

- Certificate C6 – Final handover

This certificate will be issued once the maintenance period has expired as per contractual agreement between the main contractor and the client.

6. SYSTEM ACQUISITION REVIEW

- What were the objectives?
  - to meet the requirements in the User Requirement Statement for an Ore Transportation System for Finsch Mine Block 4

- What did we achieve?
  - system is installed and commissioned up to C5
  - system operating 3 shifts per day

- What worked or went well and why?
  - System Engineering / Project Management processes were followed well. Was specified in the beginning that the Systems Engineering process was to be followed. Systems Engineering process was well documented and understood. Consultant was involved up to the end of the concept and exploration phase (C/E) in order to get things going in the right direction and to give training. Project Management was transparent from both sides due to the good relationship and communication.
  - Development of a mature relationship between Sandvik & De Beers. Willingness and acceptance by both parties that there was mutual benefit. The collaboration was then driven by the process put in place to govern the process (e.g. quarterly steering group meetings).
Excellent competencies – mutual participation and attitude. Competent people in the team.

Phases from concept and exploration up to design and development went well. Good continuity.

Formal & informal workshops. Well organised and focussed on value adding (action plans generated etc.).

Mature system installed – no trial and error on site. Research and development done in a test environment before installation & commissioning.

Good commitment from everybody on mine (especially by senior management). Good relationship and continuous communication from project team.

Stakeholder involvement:

- Union representative involved in the project (profiling of roles and selection of operators). It was identified from the start of the project that the union is one of the key stakeholders.
- Communication forums (HR, engineering) internally within Finsch.
- Involvement of 3rd party application providers (e.g. Gemcom at workshop in Finland).
- Involvement of partners and suppliers.
- Risk assessment process with specialist consultants.

Acceptance of system by users. Through good communication to instil pride and commitment to make the system work.

System sold on output based / result driven performance management. Simulation modelling showed benefits over conventional operations.

Remote support (planning and getting links in place). Good communication between Sandvik & De Beers IT and pre-design by Sandvik.

Good definition of requirements and interfaces. Through workshops and good documentation and reviews. Important due to lessons from past experience to ensure clear understanding.

Flexibility to adapt to new technologies and changes/expansions during implementation. Commitment from both parties to look for opportunities to improve.

System expansions were implemented with minimal effect to the schedule. Good communication with stakeholders (especially contractors doing installations).

The schedule was refined throughout the project as experience was gained.

Were able to manage with changes in personnel. Due to good relationship, communication and documentation.

Pre-commissioning deliverables (from OTS project) in place on time. Effective planning and project management.
What can we do better / learn?
- During engineering design phase, engineering drawings should be reviewed and signed off. Allocation of suitable resources (e.g. Clerk of Works and C&I) to participate in reviews.
- Define responsibilities and battery limits clearly in advance – Avoid grey areas
- Communication plan (who talks to who) as part of project plan
- Bill of Materials and Equipment List to be linked to project schedule
- Installations should be performed by specialist contractors
- Resource sharing to be more effectively planned
- Access to areas to be planned in an integrated schedule
- Whole project team to know the total scope and schedule.

7. FUTURE PROJECTS
2006 – OTS expansion to the Undercut level (OTSU Project)
This project caters for the expansion of the OTS, which is applied in the extraction level, to the undercut level for reaching optimal utilisation for the entire Block 4 LHD fleet. Expanding the OTS to cover also the undercut level provides a platform that enables optimising of the ore transportation resources in extraction and undercut levels. This will involve the automation of LHD’s loading in the undercut level.

2006 – Roxon Feeder
This project involves the installation of a hydro-stroke plate feeder for handling ore tipped on the undercut level. The feeder will be fully integrated into the OTS system and will be the first of its kind in South Africa

2007 – Onwards
Further expansion will be done to the OTS system to include Automated LHD’s operating on the extraction level.

8. ACKNOWLEDGEMENTS
The authors are grateful to all their colleagues/partners at Sandvik and Finsch Mine that have contributed to the development of this system solution. Also, the author want to acknowledge the permission given by the partners, Sandvik and Finsch Mine to publish this technical paper.

9. REFERENCES
De Beers Total Project Management System Guidelines for Project Management
Burger D, Oosthuizen J, Cook B, Visagie J – The application of new underground Mining Technology for the Finsch Mine Block 4 Block cave project. MassMin 2004