

INTEGRATION OF TRACKING INTO HORIZONTAL UNDERGROUND TRANSPORTATION SYSTEM

By

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DEDICATION

I dedicate this to all those men and women who preach the message that it is not your birthplace, race, background or natural abilities that determine your destiny. It is your vision, passion, resolve, discipline and perseverance that determine your destiny.

ABSTRACT

The world, especially the business world, has changed from consisting of different countries and markets to one global market. This can be attributed to better transportation, communication and information systems.

This new development has changed the rules of the business game. No more do companies compete with local players only but increasingly with foreign based entities. Many experts argue that top companies in the world today are those that have embraced new technologies to improve their entire operations. New information technology allows them to integrate their operations upstream with their suppliers, downstream with their clients as well as in-house to improve their efficiencies. This includes mining companies who have to introduce new information, communication and transportation systems to compete with their global counterparts.

This study investigates the operation of South African underground mines operation. This is done with a focus on the integration of tracking technology into the horizontal transportation system. The objective is to improve productivity due to better process control. In order to achieve this objective the entire operational process had to be divided into key elements that had to be investigated. The following key elements were identified and investigated:

- Information and communication strategy
- Organisation structure
- Departmental integration
- Organisational processes
- Management information
- Information management
- Management information system
- Solution selection criteria
- Causes of low productivity
- Problems with logistics system
- Technology implementation methods

- Outsourcing
- Reasons for technology failure
- Future challenges facing industry

The investigation was done in four phases. The first phase provided a framework for a literature study. The second phase comprised a literature study that would set the foundation for the empirical study. The third phase consisted of the empirical study, research methodology and data gathering. The fourth and final phase consisted of data grouping and analysis, conclusions and recommendations. Among the conclusions drawn, the following stand out: There is a general problem in the industry that can be attributed to logistics. There is also a problem of information quality and information flow among the different departments that lead to poor integration. Another problem that was highlighted is the non-involvement of end-users in technology selection and implementation. In terms of future challenges facing the industry, poor education levels, productivity and commodity prices were identified. In terms of solutions for the future, integrating technology, with the involvement of end users, were mentioned. All these findings were uniform across the different mining houses, which show the similarity of the industry culture.

Key terms: RFID, real-time, information, integration, productivity improvement

OPSOMMING

Die wêreld, veral die besigheidswêreld, het verander van verskillende lande en markte, na een, groot, globale mark. Dit kan toegeskryf word aan beter vervoer, kommunikasie en inligtingstelsels.

Met die nuwe ontwikkeling het die besigheidspel se reëls verander. Daar word nou nie slegs met plaaslike besigheidsmeeding nie, maar die oorsese mark word ook betrek. Baie deskundiges reken dat die beste maatskappye in die wêreld dié is wat die nuutste tegnologie deel van hul besigheidstruktuur gemaak het. Die nuwe inligtingstegnologie stel hul in staat om van die verskaffers tot die kliënte en intern te verbeter na gelang van hul behoeftes. Dit sluit mynmaatskappye in met wie hul met nuwe inligting-, kommunikasie- en vervoerstelsels moet meeding in hul globale veld.

Die studie ondersoek die wyse waarop Suid-Afrikaanse ondergrondse myne te werk gaan. Die kollig word geplaas op die integrasie van opsporingstegnologie in die horisontale vervoerstelsel. Die doel is om produksie te verbeter met beter beheer van die proses. Om in hierdie doel te slaag, moet dit in sleutelbeginsels verdeel en ondersoek word.

Die volgende sleutelbeginsels is gestel en ondersoek:

- Inligting- en kommunikasiestrategie
- Organisasiestruktuur
- Departementele vervolmaking
- Organisasieproses
- Bestuursinligting
- Inligtingsbestuur
- Bestuursinligtingstelsels
- Oplossingskeuses maatstawwe
- Oorsake van lae produksie
- Probleme van die logistieke stelsel

- Tegnologie toepassingsmetodes
- Uitkontraktering
- Redes vir mislukte tegnologie
- Toekomstige uitdagings gerig op die industrie

Die ondersoek is in vier fases gedoen. Die eerste fase was die raamwerk van die studie. Die tweede fase was die literatuurstudie wat die fondament gelê het vir die empiriese studie. Die derde fase het bestaan uit die empiriese studie, navorsingsmetodologie en data-insameling. Die vierde en laaste fase het bestaan uit datagroepering en -analise, gevolgtrekkings en aanbevelings. Die gevolgtrekkings was dat daar 'n algemene probleem is in die industrie wat toegeskryf kan word aan die logistiek. Daar is ook 'n probleem met die kwaliteit inligting en inligtingsvloei tussen die verskillende departemente wat lei tot swak integrasie.

Nog 'n probleem wat uitgelig is, is die onbetrokkenheid van die eindverbruikers in die tegnologiestelsel, en in die keuse en implementering daarvan. Die volgende uitdagings vir die industrie is geïdentifiseer: lae geskoolde arbeid, produktiwiteit en metaalpryse. In terme van toekomstige oplossings is integrerende tegnologie en betrokkenheid van eindverbruikers geïdentifiseer. Die bevindinge strek oor al die mynhuise wat 'n bewys is dat dit 'n industrieprobleem is.

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LIST OF ABBREVIATIONS

| | |
|------|--------------------------------|
| EHF | Extremely High Frequency |
| HF | High Frequency |
| IC | Integrated Circuit |
| LF | Low Frequency |
| MCS | Management Control System |
| MES | Manufacturing Execution System |
| MIS | Management Information System |
| MM | Materials Management |
| MO | Mine Overseer |
| PGM | Platinum Group Metals |
| RFID | Radio Frequency Identification |
| RS | Read Station |
| RTLS | Real Time Location System |
| SHF | Super High Frequency |
| U/G | Underground |
| UHF | Ultra High Frequency |
| VHF | Very High Frequency |
| VLF | Very Low Frequency |
| WiFi | Wireless Interface |
| UPS | Uninterruptible Power Supply |

CHAPTER 1

NATURE AND SCOPE OF THE STUDY

1.1 INTRODUCTION

“The greatest contribution information makes to organisations is as a resource to improve the performance of organisations and the individuals that work within them. Organisational performance can be improved by utilising information resources to help deliver better-quality products or services more profitably. Individual performance can be improved by providing employees with more relevant, timely information to support their decisions.”

(Chaffey & Wood, 2005:10)

For the last hundred years the South African narrow reef mining industry has battled to control working costs in a labour-intensive industry. The industry has been stuck in a time warp with relatively little change in the mining process during the last century (Pickering, 2008:2).

The mining environment on the other hand is described in exactly the opposite terms. Mining is a dynamic operation with a continuous stream of timely information needed to monitor trends, which indicate a change in risk status. Operators are also expecting to have access to all the information they would like in real time (Mallet, Einecke & Glynn, 2007:1). Mining consists of distinct processes that need an uninterrupted flow of information between the processes (Hung, Gerhart, Pix & Hackwood, 2001:1).

From the above statements, one can conclude that the mining industry falls into traditional organisations, if not ancient, due to the little changes during the last century. Traditional organisations have been separated into departments such as Marketing, Sales, Procurement, Production and Service. Even the Information Technology (IT) systems and applications supporting these functional

departments were built around them (Johanesson, 2007:2). The result of this structure is a stove-pipe relation between the functions and the applications where every function in the company is supported by its own system or application with little communication.

The biggest challenge has been to find and adapt thinking and systems from the more traditional labour-intensive planning to a capital-intensive planning approach (Croll, 2004:17). Improving old processes by simply applying information technology, ignoring organisational infrastructure and deficiencies will not result in any real improvement in performance (Luftman, Lewis & Oldach, 2003:12). When this happens, executives fail to get the information that they need in a timely manner and the result is lost opportunities or problems not being solved in time. Information is the most important resource outside of the intellect of the executive or decision maker (Wetherbe, 2004:1).

Information technologies in mining will have a significant impact on mining operations in the forthcoming decades, giving mine managers and staff much greater understanding of and control over mining processes (Rand Org Editorial, 2006:34). What is required, is the development of the appropriate technology and the integration of that technology into an improved system (Pickering, 2008:1).

Based on the above expert opinion, one can conclude that what is needed is a system that will lead to integration and information sharing that will link previously separate operations departments and processes around the mine through integrating real-time information.

1.2 BACKGROUND

Any continuous operation requires real time, reliable data about the state of operation for any real-time synchronisation of various inputs. Real-time synchronisation of complex operations can only be achieved in large scale mining

by using technology systems (Bizos, 2007:121). Due to the isolation of the different departments it is logical that real-time, reliable data that integrates the different departments is not possible.

The following applications are examples of the solution to this problem. An Enterprise Resource Planning (ERP) system is, in essence, an integrative mechanism connecting diverse departments through a shared database and compatible software module (Hammer & Stanton, 1999:108). A workflow system automates tasks that were previously done manually. The result of this automation of business processes across teams' functional departments and supplies result in the decrease of cycle times and costs and eliminate duplication of effort (Leon-Zhao, 2007:1).

The introduction and diffusion of IT in the mining industry has been slower than in other sectors such as petroleum and chemicals industries in part, because the mining environment presents unique and formidable challenges (Rand Org Editorial, 2006:5).

On the other hand, there has been a strong decline in the profitability of mines due to a decline in the labour productivity, which constitutes 50% of total production costs and the declining price of commodities. Due to these realities time pressure compels them to look at ways to increase productivity and profitability on all fronts (Smit & Pistorius, 1998:4). Scoble and Daneshmend (1999:19) suggest that technology should be employed to plan, design and operate differently, to be better informed and intelligent in decision making, more efficient in operation, and safer and more responsible to society.

1.3 PROBLEM STATEMENT

The changes observed in mining technology have been about the improvement of existing technologies using current conventional methods which result in incremental and marginal improvements; for example, the replacement of hand drills with drills that are supported by a hydraulic leg. Secondly, those improvements were done in isolation, without taking cognisance of their impact on the whole system. For example, the improvement of blasting techniques will affect the removal of ore, but the latter is not optimised (Pickering, 2008:1). What is needed is an integrated information system that will allow mines to make improvements across the entire site-in operations, maintenance, safety and mine management (Edwards, 2008:2). After studying the mining value chain, logistics were identified as the process that should be integrated into the mining operation for the reason stated below:

Optimisation of an underground mining system must take into account the efficiency of the transport operations moving ore, waste and backfill within this infrastructure framework (Brazil, Lee, Rubenstein, Thomas, Weng & Wormald, 2001:2).

The focus of this study is to understand the mining operations process and the value chain, so as to implement a technology that will integrate the horizontal inbound and outbound logistics functions to improve productivity.

1.4 OBJECTIVES

The objectives can be divided into primary and secondary objectives. The primary focus will be on achieving the primary goals. Moreover, the secondary objectives also have to be realised.

1.4.1 Primary objectives

The primary objective is to provide a **framework for the integration of technology** in underground horizontal transport that would result in:

- Better quality information
- Reduced lost blasts due to material shortages
- Better tracking of assets

1.4.2 Secondary objectives

The secondary objectives are:

- **Outsourcing:** Companies do not always have the necessary expertise to implement some projects or carry out some tasks. Companies must focus on core competencies to deliver value to their shareholders. The company can then outsource some of the functions. The study investigates the different options of approaching outsourcing to enhance the logistical arena.
- **Cost-benefit:** The study investigates the major costs associated with the implementation of Information Technology as well as the expected returns from the technology implementation and how to manage this.
- **Criteria for solution/Vendor selection:** For any large organisation, like a mining group, it is very important to have a procedure of appointing vendors. This is to ensure that the right procedures were followed in choosing the technology and to ensure that the vendor will deliver as expected. Furthermore, it is to reduce the risk factor associated with the technology and the vendor. To ensure that this was done, proper vendor evaluation criteria will be used to guide the company decision makers.

1.5 CONSTRAINTS

The scope of the study considers the implementation of integrating technology in underground horizontal transport in South African hard rock mines. Due to the peculiar nature of these mines in South Africa, in terms of labour intensity, depth and education levels as compared to countries such as Canada, Australia and Sweden, it might have to be adapted for usage within other countries.

Integrating technology for the purposes of this study would be a technology that is not limited to any one department or function, but links up and communicates with the entire operations process.

The literature study concentrated on material found readily available in South Africa in the public domain and the Internet until December 2008.

1.6 METHODOLOGY AND LAYOUT

The approach taken to achieve the objective of this dissertation is as follows:

1.6.1 Literature review

Information was acquired from both primary and secondary sources. The primary focus was to research and document available research on the topic that was investigated.

1.6.1.1 Management information

Although there is general agreement about what management information entails, it was still important to get a general agreement of what it entails for the purpose of this study. Different aspects of information and the importance and requirements of a good Management Information System (MIS) were investigated.

1.6.1.2 Evaluation criteria for technology solutions

Due to the evolution and revolution in the technology field, requirements of client expectations have increased. To get the best technology, specifically for the mining industry, a literature study was done to acquire the most suitable Information Technology solution.

1.6.1.3 Change management considerations

The deployment of a technology system requires changes to people, technology and processes. To reduce the negative impact and improve successful implementation, some change management models were discussed.

1.6.1.4 Outsourcing

The practice of transferring a certain part of operations to an outside company was investigated. For a new technology, this is important, as new functionality is required and systems have to be updated to ensure that current business and process conditions are accurately reflected. The company might also not have the capabilities for in-house development.

1.6.2 Empirical study

In order to test the findings of the literature study an empirical study was conducted. The literature study included the collection of data from published reports, journal articles, other printed material and interviews with subject experts, operations personnel and suppliers.

Based on this, a framework was developed to guide companies in their approach when considering Information Technology (Tracking Technology). To test the framework, a questionnaire was sent to the heads of the different departments. Their responses provided the basis to improve the framework and develop a model that is presented as part of the solution.

1.6.3 Analysis of data

Data collected during previous phases were used to create a better understanding of the Information Management Technology system environment and to identify the current shortcomings of the mine's logistics system. The analysis phase was also used to further refine the original framework that was proposed and formed the basis for the recommendations and conclusions of this study.

1.6.4 Recommendations and conclusions

Once the analysis was completed a set of recommendations for implementing Information Technology was explored. This included a suggested framework as well as possible impacts on the organisation. A conclusion was then reached that the updated implementation framework and the proposed model would provide guidance to other underground hard rock mining companies wanting to implement Radio Frequency Identity technology.

1.7 RESEARCH DESIGN

Due to the exploratory nature of the study, there will not be any hypothesis formulation. The study's emphasis will be discovering best practices in the usage of RFID technology to improve underground mining logistics, from a business perspective rather than on confirmation of prior research.

1.8 QUESTIONNAIRE DESIGN

The questionnaire was formulated according to the model established during the literature study. Historical logistics and production information were accessed from the mining information system.

1.9 DIVISION OF CHAPTERS

The study is divided into four chapters.

Chapter 1 indicates the scope of the study and methods used. It includes the introduction, problem definition, objectives, description of the technology and methodology as well as the scope of the study.

Chapter 2 consists of the literature study involving the chosen topic, namely Integrative Information Technology.

Chapter 3 consists of the research methodology that was followed to do an empirical study as well as the empirical study per se.

Chapter 4 focuses on the results analysis, interpretation, conclusions and recommendations.

1.10 SUMMARY

An organisation should be seen as a system with a clear set of objectives. In order to achieve these objectives, there need to be proper coordination and integration among the different components.

When applying this analogy to a mine, the objective is to mine safely and profitably. The different components that need to be managed to achieve this objective are the different resources, human, financial, physical immovable assets, machinery and consumables. All these assets are allocated to the different functional departments that have to utilise them in line with the set

objectives. Without proper communication there will not be proper coordination and integration. Proper communication can only occur if accurate information is available in time to enable coordination. Without quality information the result will be failure to reach the set objectives.

The task of information management is to ensure that accurate, updated information is received by those who need it. This task is normally facilitated through the usage of manual methods or technology.

From the information available, there seems to be a problem for the mines to achieve their intended objectives. More specifically, there seems to be a problem with the integration of the logistics function into the mining process, resulting in bottlenecks that hamper productivity.

Chapter two will focus on identifying these problems, through a literature review as well as possible solutions.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

“The economy is changing structure from being organised around the flow of things and the flow of money; it is becoming organised around the flow of information.” (Carmichael, 1998:1)

The introduction of new technology into mining operations is seen as a strategic necessity by mining companies in order to improve safety and to improve operational effectiveness (Macfarlane, 2004:1). The same view is held by Umar (2003:1) who says that the modern day mining industry has become less physical and more cognitive as manual labour is replaced by machines. To support these views, Cramer (in Schlage, 2003:1) states that one needs only to look at South Africa’s gold mining industry for an example of an industry that has not innovated fast enough to meet the falling real prices. Cramer also states that the industry cost structures are heavily weighted to the mining operations with a heavy reliance upon a large number of unskilled men who travel daily to the stopes to drill and blast and move the ore to shaft system. Operations can be typically 65-75%, concentration 8%, smelting 10% and refining 10% (Schlage, 2003:6). The recommendation is that individual companies must make the capital investments required for future competitiveness. To show the importance of this matter, this issue was taken up by the Department of Minerals and Energy through the Chief Inspector of Mines. When asked by the Chief Inspector of Mines to identify the technologies critical to resolving the major productivity bottlenecks, industry representatives identified a consistent set of priority areas:

1. Information and communications technologies for process optimisation
2. Remote control and automation
3. Operations and management
4. Unit operations capabilities (Hermanus, 2003:7)

This research was done from the following paradigm: In this chapter, a literature study is done regarding the importance of management information for decisions that will lead to the integration of the different value adding activities as required for planning, executing and controlling operations. Following this, the current Management Information System that provides the needed quality management information was explored, as well as what quality information entails. This information was used to integrate technology that will improve the underground logistics system for better productivity, reduced cycle time of material cars and better tramming. The technology that would be most suitable for the tracking of assets on a mine, surface and an underground environment, was identified.

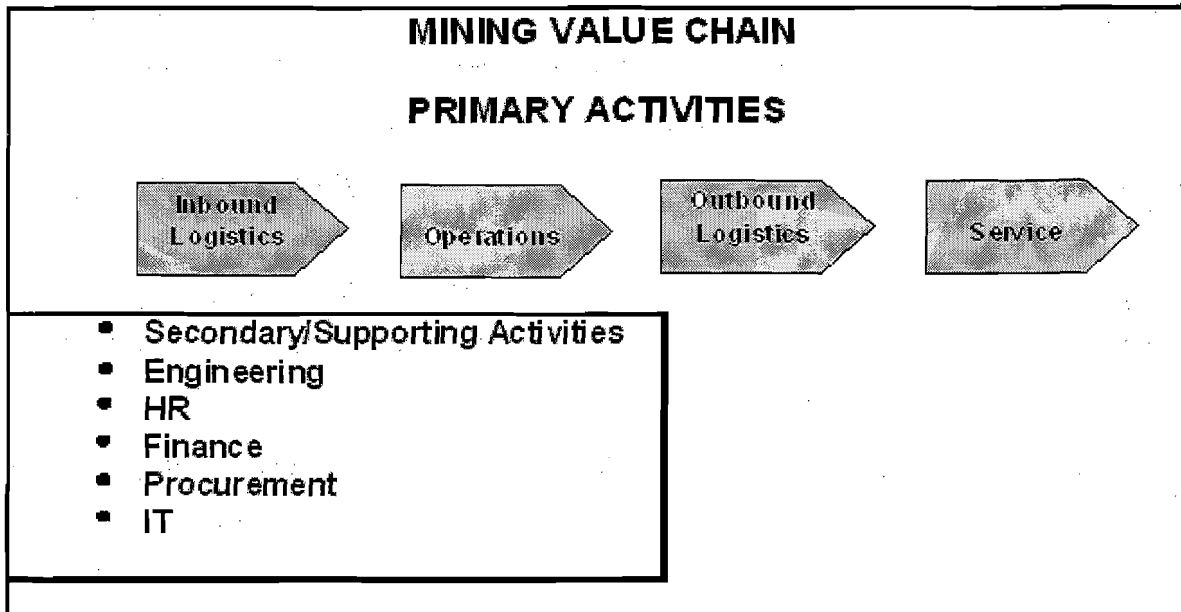
This particular technology was then researched in terms of its history, shortcomings, benefits and its successful application in other industries. According to experts, a value chain analysis helps in identifying key value adding processes that could be made more effective using information technology (Pant & Ravichandran, 2001:2). Therefore, the first step to be taken for productivity and process improvement is the understanding of the business as well as its value chain.

2.2 VALUE CHAIN

The value chain describes the full range of activities which are required to bring a product from conception through the different phases of production, involving physical transformation, delivery to final consumers and final disposal after use (Kaplinsky & Morris, 2001:8). Value chain analysis is undertaken in order to understand the behaviour of costs and the sources of differentiation (Elloumi, 2004:112). Organisations can achieve a competitive advantage by managing the value chain better than others in the industry and that highlights the importance of the value chain. Figure 2.1 is a representation of the Mining Operations value chain which shows the relationship and interdependencies that exist among the different tasks. The value chain is very important for the research, because it

guides us in understanding the process, the interdependencies as well as the costs associated with each activity.

FIGURE 2.1: THE MINING VALUE CHAIN



Source: (Fourie & Van Niekerk, 2001:1)

Primary activities relate directly to the value created in a product or service while support activities make it possible for the primary activities to exist and remain coordinated. Information technology is one of the major support activities since every activity creates and uses information (Pant & Hsu, 1999:5).

Each activity may affect how other activities are performed suggesting that information resources are not applied in isolation (Wiley, 2003:29). The use of IT within each of the activities enhances the value creating potential of the organisation (Tallon, Kraemer & Gurbaxani, 2001:6).

From what have been said by the different authors thus far, information supports and coordinates the different functions across the value chain. Information technology can improve coordination, support and integrate the different activities.

The primary objective of any mining plan according to mining experts should be the effective integration of all the activities involved in the overall mining process that will meet predetermined targets with regard to health, safety, environment, productivity and unit cost criteria (Fourie & Van Niekerk, 2001:2).

Inbound and outbound logistics, as indicated in Figure 2.1, are positioned on either side of operations. This shows the strategic importance of these activities. The reason for choosing logistics is further explained by the following sections.

2.3 MINE LOGISTICS

The importance of the logistics system is summarised by Pudhota and Chang (2001:9) when they say that, "In today's business environment good logistics management often determines the success of a business." From this statement one can assume that a successful mining business also depends on a good logistics system. Optimisation of an underground mining system must take into account the efficiency of the transport operations moving ore, waste and backfill within this infrastructure framework (Brazil *et al.*, 2001:2). Petit (2004:1) also mentions the importance of ensuring that logistics are fully integrated and supportive of the production process. Mining operations are characterised by fluctuations as a result of three reasons, namely, interdependency between the chain resources and the impact on production, variability in the system and its impact on production and the non-physical elements such as assumptions (Arnesen & Van der Westhuizen, 2003:2). A report by the Safety in Mines Research Advisory Committee also identified failure of ensuring the timely supply of materials to the stope face as one of the factors affecting safety (Van der Merwe, Wojno & Toper, 2001:3). It is thus very clear that the logistics function in an underground mine is very critical to productivity and safety.

Information technology can be used to reduce costs, improve productivity, re-engineer key business processes and improve corporate planning (Tallon *et al.*,

2001:2). This can be done by moving information from a narrow focus across the activities in the value chain (Wiley, 2003:30).

One of the technologies that could be used to provide the much needed real time information is the integration of tracking technology into the MIS by tracking inbound and outbound logistics. The benefits of better decision making facilitated by fully integrated technologies will be realised soon if the mine's strategic plans of the price of any key element or commodity in the complex mining process should change unexpectedly or significantly (Le Pastrier, 2000:1).

The first component that needs to be discussed is the impact of information management on the logistics process. This was done on the basis that the logistics process requires real-time information for optimum effectiveness and efficiency, as the different authors have alluded.

2.4 THE IMPACT OF INFORMATION

2.4.1 Information management

Information management is a means by which a centre maximises the efficiency with which it plans, collects, processes, controls, disseminates and uses information and through which it ensures the value of that information is identified and exploited to the fullest extent (Wangler & Jayaweera, 1999:5).

2.4.2 Management information

Management information is information that is used to support decision making by managers (Hawley, 2008:1). Information is what is used in the act of being informed whilst management is the planning, organising, directing and controlling the operation (Business Encyclopaedia, 2008:1).

Information can be differentiated into levels on the basis of its contribution to effective decision making (Harsh, 2004:3).

- **Level 1** is descriptive information that simply describes the “what is” condition.
- **Level 2** is diagnostic information that tells us “what is” and “what ought to be”.
- **Level 3** is predictive information that predicts the future and assists in planning to reduce risk formulated plans.
- **Level 4** is prescriptive information that enables employees to test or simulate the different system interactions.

The information that is required from the envisaged MIS is one that provides prescriptive information that will be provided by the integration of RFID into the system. The focus is then on the quality of information that is used by management, namely, management information, to plan and control operations, with specific reference to inbound-outbound logistics information.

2.4.3 Management Information System

2.4.3.1 Definition

The Business Encyclopaedia (2008:1) defines Management Information System (MIS) as a computer-based or manual system that transforms data into information useful in the support of decision making. MIS performs three functions:

- It generates reports
- Answers “what if” questions
- Supports decision making

The different functions of the MIS are essential for supporting or guiding management decision making. The quality of the three functions, in terms of the

information quality output, can be used to determine the effectiveness and efficiency of the system.

2.4.3.2 Information requirements

Any continuous operation requires real time, reliable data about the state of operation for any real-time synchronisation of various inputs. Real-time synchronisation of complex operations can only be achieved in large scale mining by using technology systems (Bizos, 2007:121).

The purpose of any effective MIS is to provide quality information that will enable management to perform the three functions already mentioned. Failure to get executives the information they need in a time speedily manner can result in lost opportunities or in a problem not being solved in time. Wetherbe (2004:1) and Chaffey and Wood (2005:511) identified the following information quality attributes:

- Relevance – must support a decision
- Presentation – must be presented in a form that makes it easily understandable
- Timeliness – needs to be up to date
- Accessibility/Availability – must be available to those who use it

These attributes are very important for management to make the right decisions in terms of planning, executing and controlling. This is more so in a mining environment. Mining is a dynamic operation with a continuous stream of timely information needed to monitor trends which indicate a change in risk status. Mine operators are also expecting to have access to all the information they would like in real time (Mallet *et al.*, 2007:1).

Throughout the mining supply chain there is a need to streamline operations and improve internal processes. Mining companies benefit from improved efficiencies

in production due to faster and more accurate automated exchanges of information which help enable better planning and management (Cisco, 2006:1).

2.4.3.3 Current mining MIS

As already mentioned, traditional organisations were separated into departments such as Marketing, Sales, Procurement, Human Resources, Finance and Information Technology systems. Although a high number of specialised information technology applications exist, some are partially integrated across activities and many are not. Much of the production planning information collection, analysis and reporting on the mines occur by spreadsheet and site (SAP, 1999:7). This resulted in the creation of functional “islands of automation” with limited communication (Johanessen, 2007:2).

Improving old processes by simply applying information technology, ignoring organisational infrastructure and performance deficiencies (Luftman *et al.*, 2003:12). For example, there are emergencies, delays and the timely forwarding of changed information. The high dynamics of the wider environment poses a strong problem for existing information systems which are based on analytical improvement of business figures such as minimisation of lead times, idle times or capital commitment for controlling logistics (Sackman, Eymann & Muller, 2002:3). What is required is a flat structure that is process focused and not function focused.

Data collection that could be used to integrate the different departments is very problematic on the mines. Production information may be collected at several points at different times for different purposes and according to different standards. Information integrity across the mining operation is poor and aggregated performance metrics, financial and physical, is difficult to reconcile (SAP, 1999:9). The result is poor quality management information that affects management decisions.

This is contrary to what Chase, Jacobs and Aquilano (2006:391) suggest should be done. They suggest that information should be collected and captured in the company's online information system only once at the source where it was created. This non integration that leads to a lack of quality information can be attributed to the different systems that are not integrated. Information naturally has a role both in linking the elements of the value chain and adding value or reducing costs (Chaffey & Wood, 2005:305). In order to integrate the different functional departments an ERP system should be used.

A comparison of mining to manufacturing raises important differences. In a manufacturing environment, a fully integrated system is used that integrates the areas of design, testing fabrication, assembly, inspection and material handling with manufacturing planning and scheduling to lower costs and improve productivity (Chase *et al.*, 2006:772).

The conclusion that one can draw from this comparison is that technology is available to integrate the different activities. More important is the proof that integration is possible, as manufacturing has shown. The challenge is whether the mining industry is ready to capitalise on the benefits that information technology brings.

2.4.3.4 Benefits of integrated information systems

For the shareholder the integration of the mine via a Mine Area Network translates into one benefit-greater production. Production is driven by information because information allows managers to do more with less. Mine Area Networks translate into increased production at lower costs because they deliver to management all the benefits system integration have given to modern factories, namely increased efficiencies (Bizos, 2007:12).

Mine Area Network will provide to both miners and management information in real time that previously were not there – real-time accurate production information (Bizos, 2007:13).

2.4.3.5 Envisaged mining MIS

Throughout the mining supply chain there is a need to streamline operations and improve internal processes. Mining companies benefit from improved efficiencies in production because of faster, more accurate automated exchanges of information which help enable better planning and management (Cisco, 2006:1).

To provide the required quality information, the Enterprise Resource Planning (ERP) system must integrate with the existing system (Chaffey & Wood, 2005:64). An ERP system is, in essence, an integrative mechanism connecting diverse departments through a shared database and compatible software module. It is impossible to get the full benefits of an ERP system without having an integrated process (Hammer & Stanton, 1999:108). The operational requirement of IT in the organisational environment is to link the different departments for real-time information flow and total visibility across the supply chain (Waller & Howard, 2008:1). Application integration is required to connect front office systems with back office systems. Timeliness is to a great extent dependent on having the correct infrastructure and information architecture in place. The right systems enable access to real-time information (Chaffey & Wood, 2005:548). With access to real-time information timely decisions can be taken that will improve productivity and save costs.

This real-time information could be used to improve the efficiencies of one of the most important elements of the mining value chain, namely logistics. As an example:

To achieve the objective of:

- being a low cost producer and a
- sustainable ROI of 15%

a mining company will have to do the following:

- understand and manage controllable costs
- manage mining cycle time

- establish supply chain integration (Mottola & Payton, 2001:10).

As already indicated, the focus in this study will be on the third point namely the integration of the mine logistics system by providing real-time information across the organisation to achieve integration. To achieve this objective, an investigation of technologies that could be used to provide real-time information was done.

A comparison of the different technologies that could be used to provide the necessary real-time information to integrate the logistics task into the mining process value chain was done. Although not much is known about the technology requirements to be used, it will have to be a wireless technology since wireless can be used on the move and logistics is about moving items and assets. Wireless technologies provide a powerful platform for the development of a vast array of strategic applications in the value chain (Barnes, 2002:941).

2.5 TECHNOLOGY OVERVIEW

One of the possible technologies that were researched is location awareness technology. Advances in network location technologies have opened many opportunities for location awareness applications (Barnes, 2002:941).

2.5.1 Real-time technologies

Jordan, Soriano, Graullera and Martin (2001:172) compared the different technologies that could be used for real-time information and revealed the following:

- Micro Wave technology produces cancer related health problems and is heavily affected by water vapour.
- Infra Red (IR) requires line of sight and cannot go through opaque surfaces or objects. Global Navigation Satellite Systems have an

accuracy problem of between 10-15 metres, which is very high for this purpose. Bluetooth was discarded because of high costs.

- Radio Frequency Identification (RFID) on the other hand was found to be very robust, accurate and poses no health problems.

All the technologies were found to be compatible with other systems, which is a requirement for any technology that has to provide real-time information across the organisation. The focus is now on RFID, which is a tracking technology that has to be compared with other tracking technologies. The purpose of the comparison is to look at the different available technologies. The primary purpose is to select the technology that would be most appropriate for the objective of this study.

2.5.2 Tracking technologies

There are different types of tracking technologies, each suited for a particular situation or purpose. Current technologies used to create location-based systems include (Gibson & Bonsor, 2006:1):

- Geographic Information Systems (GIS) that can capture, store and report geographic information. It is suitable for large-scale location tracking systems.
- Global Positioning System (GPS) – A constellation of 27 earth orbiting satellites. GPS is ideal for outdoor positioning such as surveying, farming, transportation and tracking over large areas. But GPS would not be suitable for tracking items in a warehouse or indoor tracking. It is not practical or cost effective. The accuracy of the GPS is also not sufficient for such a small scale.
- Radio Frequency Identification (RFID) works on the same principle as bar codes. It uses tags and readers that transmit information via a predetermined radio frequency to identify and track products. The reader is connected to a large network that will send information to the user. The difference and advantage of RFID is that it eliminates the need for line-of-sight (Gibson & Bonsor, 2006:1). Bar codes are prone to wearing out and

fading. RFID technology enables much greater accuracy in tracing and tracking, even in harsh environments since they do not wear out and do not require line-of-sight to function (Schell, 2003:2).

- Wireless local area network. These network devices pass radio waves and provide users with a network with a range of between 21.3 and 91.4 metres.

Gibson and Bonsor (2006:1) and Franz (2008:3) identified the following significant benefits of RFID over other tracking technology:

- Line-of-sight is not required
- Durability
- Range
- Data volume
- Multiple read speed
- Read Write update

Supply and delivery are key advantages of tagging products, simply because of the inherent features RFID offer over bar-coding. The results of the comparison among the different technologies show that RFID would be the best technology for the mining environment.

2.6 RADIO FREQUENCY IDENTIFICATION (RFID)

2.6.1 Overview

According to Franz (2008:1), RFID is the method for reading physical tags on single products, cases, pallets or re-usable containers that emit signals to be picked up by reader devices. These tags must be supported by a sophisticated architecture that enables collection and distribution of location based information in near real time.

RFID systems transfer information and energy between a reader and transponders by means of electromagnetic waves (radio waves) at a particular operating frequency, and those transponders will collect energy at this operating frequency and use the frequency for powering up their circuits. The reader will also have a receiver for detecting this very weak return signal from the transponder so as to receive the data from the transponder. The information between the reader and the transponders is transferred using radio waves by modulating the waves with the information to be transferred (Marsh, 2008:1).

RFID is a combination of radio broadcast and digital coding technology. The digital data is encoded on a microchip and RFID uses radio waves to capture the digital data encoded in the microchip without any direct contact with the microchip (RFID Institute of South Africa, 2008:1).

RFID is a generic term used to describe a system that transmits the identity (in the form of a unique serial number) of any object, wirelessly using radio-waves. RFID is a form of Auto-id, relying on storing and remotely retrieving data using devices called RFID tags, RF Tags or RF transponders. There also Passive tags, which are powered by readers when in range and Active tags which have their own internal power source and generate radio frequency for data transfer, and Semi Passive Tags, that have internal power but do not generate Radio Frequency like active RFID (McMurray, 1997:1).

From the above definitions, there is agreement that RFID is about the transmittance of radio waves by a tag which assigns a unique identity to the tagged item which shows the position of the tagged item. Some authors argue that RFID should be regarded as a proven technology due to its usage over the years. For better understanding of RFID the next section investigates the different components that make up a RFID system as well as the operation thereof.

2.6.2 Components and operation of RFID system

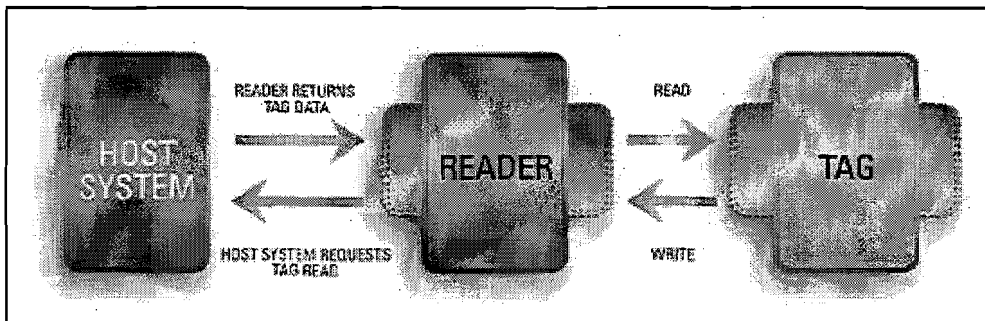
A basic RFID system consists of three components as seen in figure 2.2:

- Programmable tag for storing data
- An antenna to facilitate the reading
- A reader that encodes/decodes the data in the tag's integrated circuitry

The basic physics of RFID are:

- RFID readers, which is a radio that picks up signals
- Produces signals to antenna that sends them out
- The Tag responds to the signal of the tuned into frequency
- The reader is connected to the host system that presents incoming information as usable information to the users on their computers (Patni, 2004:7).

FIGURE 2.2: BASIC COMPONENTS



Source: RFID Institute of South Africa (2008:1)

For more information on this topic, visit the following websites

www.satoamerica.com; www.accenture.com and www.kics.or.kr

2.6.3 Functionality of RFID

The functionality of any technology can be looked at from two perspectives. It could be looked at in terms of its core functionality or in terms of its support function (McClellan, 1997:120). In the same manner, RFID will be discussed in terms of these two functions.

2.6.3.1 Core functions

Core functions of the RFID are functions that a system must have that will provide maximum value to the business.

The following RFID core functions were identified:

- **Integration of systems** – integrates the different departments, for example, Human Resources, Finance, Logistics, Mining and Finance
- **Data collection** – collects all inbound and outbound logistics data and turns it into usable information
- **Asset tracking** – shows the position of all tagged assets
- **Exception management** – detects and immediately reports any incident that affects planned process flow
- **Improved production planning** – by having a better controlled logistics system
- **Better production planning** – which depends on material supply will be done
- **Material movement management** – the movement of material will be better managed and scheduled
- **Better utilisation of supply resources** – a stable cycle time will result in better planning of surface store resources such as personnel and forklifts
- **Better scheduling** – surface store personnel will be able to plan and schedule supply, loading and transportation of material cars
- **Better processing planning** – a stable supply of mined ore will result in better planning from the metallurgical plant that will result in lower processing costs and maintenance scheduling

2.6.3.2 Support functions

Support functions are those functions that support the core functions and make them operate easily:

- **Improves information quality** – by eliminating manual data collection

- **Identifies problem areas** – by highlighting system bottlenecks
- **Improves asset planning** – by providing detailed data of usage
- **Improves labour efficiencies** – by providing actual operational reports
- **Infrastructure maintenance** – highlights problem areas in track condition by showing locomotive movements
- **Warehouse management** – by having an efficient and consistent cycle time; better planning for inventory will be achieved
- **Maintenance planning** – proper asset utilisation reports will result in better maintenance planning
- **Supplier management** – a stable supply system will result in better planning from suppliers which will result in lower costs
- **Asset planning** – a stable logistics support will result in better planning of equipment needed, number of locomotives
- **Asset replacement** – by having usage reports, replacement planning periods can be better planned, for example, Loco battery replacement
- **Maintenance management** – by having quality reports one can ensure and avoid any deviations from supplier suggested maintenance which affects warranties.
- **Crime prevention** – accurate tracing of explosives will result in reduction or elimination of explosives being stolen, which is currently a big issue.

The real value of RFID is the ability of the organisation to leverage data collected to become more efficient and agile (Patni, 2007:15). If all these functionalities or some of them are realised, then the companies should be able to realise benefits. These benefits must then be quantified in the form of a business case to determine the actual returns on the investments.

Bottani and Rizzi (2008:549) argue that the main reason for RFID diffusion is the capability of the tags to provide more information about products than traditional bar codes. Main benefits of RFID that were identified are:

- Availability of real-time information
- Increased inventory visibility

- Reduction of labour
- Better control of supply chain
- Reduced pilfering
- Better tracking of material, labour efficiency (reduced labour) and improved fulfilment that can be gained from the integrated production cycle (Simchi-Levi, 2005:3).

RFID revolutionises the data collection process making it faster and easier to have real-time quality data with a great reduction in the manual entry required by legacy technologies (SAP, 1999:9). RFID technology provides a complete solution that supports process optimisation and supports decision making. The resulting availability of real-time information facilitates productive coordination and collaboration of different manufacturing resources and timely implementation of enterprise systems (Buyurgan, 2004:3). RFID allows a fast, error free and cost efficient flow of goods to ensure that the products end up *where* they are supposed to be, and *when* they are supposed to be there with a hundred percent visibility across the supply chain. RFID can be used more upstream in the supply channel to observe work-in-process (Buyurgan, 2004:3).

2.6.4 Successful applications of RFID

Wal-Mart and the US Department of Defence have focussed attention on RFID technology's impact on improving efficiencies within the supply chain. RFID has been used in sporting events, to provide accurate race times, patient tracking to provide real-time location of patients and assets as well as Fast Moving Consumer Goods by companies such as Wal-Mart as areas in which RFID is used (Brazil *et al.*, 2001:12).

Bottani and Rizzi (2008:7) predict that RFID will be by far the fastest growing segment of the smart label market this year with an estimated growth of 180%, from 10 million labels that were sold in 2002. They also state that RFID tools have assumed an important role in supporting logistics and SCM processes

because of their ability to identify, categorise and manage the flow of goods and information throughout the supply chain.

2.6.5 Limitations of RFID

As much as the benefits were mentioned there are also some challenges linked to both the performance as well as the implementation of RFID. The following RFID limitations were identified by different authors:

- Bottani and Rizzi (2008:7) argue that the main limitation of RFID is cost. They say that the critics argue that investment in tags and readers as well as in the related informatics infrastructure are still not profitable.
- According to Sarangan, Devarapalli & Radhakrishnan (2008:7), one of the biggest challenges facing tag reading protocols is to read tags effectively and efficiently when the tags are mobile and are passing through the readers' range as in the case of assembly lines. The challenges, they argue, arise out of the fact that in a mobile setting the reader has a limited time to complete the reading process.
- Marsh (2008:4) identified the following problems with RFID Technology: Firstly, long distances travelled from the source for data transfer. When this happens, the frequency can be reused for another communications path between a different reader and transponder. Interference then occurs between different systems because of the lowered frequency. Secondly, the occurrence of scattering affects RFID. This occurs when there is energy reduction that, he says, is caused by the sources of energy, namely antennas. He says because they direct energy in specific directions as this energy hits a hard object, it scatters and it is difficult to get energy separation from one RFID system to another just with antenna radiation patterns. Lastly, he states that the radio spectrum is not an unlimited resource and the technology needs to adapt to the available resource which is being exploited by more and more users.
- Environmental conditions and materials near RFID systems can affect RF field parameters like reflectivity/refractivity, absorptive and dielectric properties (detuning). Hence, tag performance is dependent upon

materials near the tag, and environmental conditions like temperature, humidity and other factors. Different frequency ranges experience different degrees of effect due to the above material (Bukkapatnam, 2005:12).

- One of the biggest challenges facing RFID is the lack of standards. Common international standards for tag scanning do not exist. There has to be a reduction in the cost of tags to make RFID economically viable. One example is the reliability of tags, which according to most analysts, function at an 80% success rate. Antennas sometimes separate from their tags and even when the tags stay intact, tag readers are not always reliable. There are also problems reading tags through metal or liquids and interference from nylon conveyor belts (Simchi-Levi, 2005:13).
- Liquids tend to absorb the radio signals emitted by the tags – the labelling of liquids would be ineffective. The signals are reflected and altered by metals (Vetschera, Hallwirth & Kogelnig, 2004:7).
- Very importantly, countries and companies have not decided on common standards regarding RFID technology. Decisions have to be made regarding Megahertz frequency for RFID equipment, but also an agreement for a common protocol; the language the reader speaks and understands has not been reached yet (Vetschera *et al.*, 2004:13).

Schneider (2004:3) identified the following factors as obstacles to the implementation of RFID: Lack of standardisation, high cost of intermediaries, slow technology development and deployment risks as well as the elimination of unskilled labour are all factors currently preventing the adoption of new RFID technologies.

Challenges and implications of adopting RFID is still financially, technically and operationally not feasible for many businesses, especially those supply, manufacturing and logistics processes that are not standardised (Asit & Mandiwalla, 2003:15). Other challenges are training, standards, security, organisational readiness, and accuracy and implementation challenges (Asit & Mandiwalla, 2003:54).

Lastly, firms with unpredictable equipment, unreliable manufacturing processes, long supplier lead-times and facilities with long and variable flow times have little to gain from RFID. It is important to note that RFID is not a cure for bad business practices; it may even exacerbate the problem (Vetschera *et al.*, 2004:13).

The following shortcomings of RFID were identified: There is a 38% gap in the ability of RFID to track and identify physical objects. Major problems in the tag are storing enough energy with the RFID tag due to its small size and the low cost manufacturing targets of the tag. There is a 40% gap on instant access to information on physical objects due to network infrastructure and Networking Technologies Subsystems. Security issues and bandwidth congestion in the network are the major problem sighted. There is not enough information on the intelligence of items to negotiate with other objects and perform required action. Performance was found to be low on proper security and authorisation to access information. It was actually the least performing requirement (Bukkapatnam, 2005:25). Feasibility to scale the technology to all the required parts was less than average. The primary challenges of successfully implementing RFID are cost factors, consumer privacy concerns and security factors (Bukkapatnam, 2005:12).

According to Bukkapatnam (2005:5), the following are the parameters that must be considered when selecting tags: Lower frequencies Passive tags are not capable of transmitting their data further than a few feet due to power limitations. Also, Passive tags may not be placed on metal objects because metal significantly reduces the flux of magnetic field. As a result, RFID tags do not receive the minimum power to start functioning. To counter this, special construction techniques have been developed to install RFID tags into metal items such as tools and gas bottles (RFID UK Editorial, 2004:4).

As promising as the technology seems, it is yet to overcome significant obstacles before a full-scale implementation can be realised (Bukkapatnam, 2005:27).

Despite these identified problems, RFID is still being implemented. The next section will look at how RFID problems are tackled.

2.6.6 Solution to RFID problems

The RFID Institute holds a different opinion regarding the shortcomings of RFID. They argue that with sufficient planning RFID can work very well.

RFID accuracy problems are usually due to physical causes. Their solution consists of applying sound design criteria to the system; for example, the following should be carefully looked at: Position of antennas connected to the readers, areas where tags are going to be passing by, system characteristics of the materials of the environment where the RFID is going to be embedded into, power constraints and operating frequency are all factors that must be carefully selected. Experience and an iterative approach should be applied (RFID UK Editorial, 2008:1).

It is important to understand that there are physical and logistical differences between a mining production section and a manufacturing company. For example, in mining, the physical environment presents certain boundaries and the physical environment presents certain boundaries, and safety risks that are not found in a manufacturing plant (Claasen & Visser, 2004:56). The following RFID applications for mining were also identified by different authors in the mining industry (McMurray, 1997:1).

2.6.7 Mining applications

In response to the above concern, it seems as if RFID is already being used successfully in underground mines. Stobie mine used RFID and reported benefits by getting the required ore-related information that could be used for better decision making. For example, knowing the head grade allows the mining company to more accurately forecast production (Fiscor, 2008:1). The mine senior geological technologist, Mark Palkowitz, said that the value that the

system provides is the ability to understand the dynamics of the excavation process, because RFID readers tell the mine what ore is moving where (Fiscor, 2007:10). It also tells the mine the average ore in the rail cars; and it tells the concentrator what to expect. Werniuk (2008:24) says the benefits of the system are summarised as follows: that this system will allow the management to better understand this process and make more timely decisions in this regard.

Tracking technology can also be used in the mining industry to improve the following aspects of operations (McMurray, 1997:1):

1. *Tracking of assets*

The use of RFID Technology can have a significant impact on:

- Logistics efficiencies
- Productivity
- Trammings operations

2. *Tracking of personnel*

3. *Scheduling of activities*

Many attempts have been made in recent years to introduce new technologies into mining operations in Southern Africa with noteworthy success as well as disappointing failures (Macfarlane, 2004:01). In the next section the factors that have to be considered in order to ensure successful RFID implementation that will result in better profitability for the organisation, will be discussed.

2.7 INFORMATION COMMUNICATION TECHNOLOGY STRATEGY

A successful information technology plan must be linked to the business direction of the organisation (Mottola & Payton, 2001:1). In terms of strategy, the company must ask whether technology is a strategic thrust for the company, meaning whether the technology is addressing issues that are likely to impact on the industry of the future. Issues concerning health and safety, legislation and

business objectives in terms of profitability are examples of strategic importance (Macfarlane, 2004:5).

Technology strategy serves as the basis for fundamental business strategy decisions. It helps answer questions such as:

- Which distinctive technological competences are necessary to establish and maintain competitive advantage?
- Which technologies should be used to implement core product design concepts and how should these technologies be embodied in products?
- What should be the investment level in technology development?
- How should various technologies be sourced – internally or externally?
- When and how should new technologies be introduced to the market?
- How should technology and innovation be organised and managed? (Burgelman, Christensen & Wheelright, 2004:142).

Since strategy is the organisation's competitive plan, it is very important to have all other business components aligned to the strategy to ensure successful implementation. The business plan is also based on the strategy. The next section will focus on how business decisions regarding technology implementation are taken.

2.8 BUSINESS DECISIONS

2.8.1 Business requirements

The first point to be considered when looking at information technology is that incumbent solutions meet business requirements regarding infrastructure, integration and comply with industry standards. Furthermore, seek guidance from industry peers for anything that is unclear (Group Editorial, 2007:56).

According to the RFID Institute of South Africa (2008:1), the following criteria should be used to evaluate RFID systems and ensure that the right system is purchased:

1. Application requirements
2. Tracking requirements
3. Frequency
4. Functionality
5. Environmental conditions
6. Form factor-size and shape of the tag
7. Standard compliance EPC/ISO

Reader Selection Guide:

1. Application requirement
2. Frequency range
3. Read Write range
4. Functionality of tag
5. Standard EPC/ISO Air interface

Middleware/Savant Selection:

Collect raw data and convert it into information that can be understood.

1. Collect data
2. Filter out replicating
3. Smoothen out data set

Software Requirements:

1. Able to recognise each reader and gather data from it
2. Able to perform aggregation activities like counting, rate
3. Filter gathered data
4. Convert data into a predefined repository
5. Communicate with other external ERP systems to enable decision making
6. Allow web users to log on and view various statistics related to current status of gathered data

7. Should be configurable

The basic operation of the system is to gather data of identified and tagged objects through the readers. This data is then converted into information by the middleware. The middleware then transfers this information to computers where the software presents the acquired data as meaningful information. The reason for the conversion is that only meaningful information can be used to provide the required benefits. These benefits can then be compared to the investment that was made to acquire them to calculate the return on investment.

2.8.2 Return on investment

The use of appropriate project evaluation techniques is more important in the mining industry than other industries as a result of the industry's risks. A Canadian Minerals Economics survey ranked ore grade as the highest grade, followed by factors in the macro environment and price as the third (Topal, 2008:1). The importance of these risks is clearly illustrated in the formulas that are used to calculate return on investment.

According to Franz (2008:17), payback or return on investment (ROI) in Information Technology is measured using the following criteria:

- Time savings for location and tracking of material
- Providing a safer work environment because manual intervention is reduced and/or eliminated
- Reduced on hand inventory
- Reduced human error
- More accurate inventory
- Hands-free material movement
- Real-time information
- Tracking work in progress
- Reduced production time

Critics argue that optimistic assumptions will not be realised (Bottani & Rizzi, 2008:549). They also emphasise the high capital investment required for an RFID application. They considered it too expensive and unlikely to pay off.

There are three methods that could be used to calculate return on investment in the mining industry, which are the: Discounted Cash Flow method, Monte Carlo Simulation and the decision tree analysis (Topal, 2008:64). The Discounted Cash Flow method is the one that is mostly used, in 75% of cases (Topal, 2008:73).

Two issues stand out in business decisions. Firstly, there is a group that sees RFID as a cost saving technology whilst others see it as a productivity improvement technology. Secondly, there is a clear difference in approach to the calculation of ROI by the different authors. Some focus more on indirect savings like improvement on efficiencies whilst others look at Discounted Cash Flows. Since the accepted method for the mining industry seems to be the Discounted Cash Flow method, which seems to be working, it would be advisable to keep to it. RFID is not an innovation to make money, but to save money (Schlage, 2003:12). With the business case in favour of implementation the next step would be to investigate the implementation phase.

2.9 METHODOLOGY USED IN IMPLEMENTATION OF RFID

Macfarlane (2004:7) identified the following technology implementation failures in South African mines:

- Resistance to change
- Unnecessary complex technology
- Poor ergonomics
- A Hawthorne effect due to heavy management thrust out of balance with worker resistance to change
- A fear that the technology will, when coupled with mechanisation, lead to job losses

From the lessons learnt, Macfarlane (2004:7) recommends the following, that:

- Firstly, technology introduced must be appropriate to the level of development of work system
- Secondly, there must be clear objectives identifiable on the bottom line
- Thirdly, the technology must form part of a common vision to all
- Fourthly, the workforce who will be using the technology must be involved all the way
- Lastly, he warns about off the shelf technology that may not be mine worthy in South African conditions: time must be allowed to establish mine worthiness through redesign.

Two other implementation models were also identified, as summarised in table 2.1. From the different approaches advocated for implementation, it is clear that implementation is more an art than a science. To understand and deal with human problems or reactions associated with technology implementation, change management forms an important part of this study.

TABLE 2.1: IMPLEMENTATION MODELS

| | |
|--|---|
| <p>Mottola and Payton Framework:</p> <ol style="list-style-type: none">1. Develop a business case.2. Follow a phased approach for installing and integrating the new technology and for business procedures and organisational structures.3. Have a transition plan ensuring timing and sequence of events is used in the removal of existing systems and the implementation of new systems.4. Risk management. Ensure that assumptions and constraints that may impact the project have been identified and that an adequate plan is put in place.5. A communication plan needs to be in place to identify needs and change in scope.6. The conversion migration plan which identifies the order in which information must be moved from the old system to the new system and establishing a strategy for acquiring the information required by the new system that is not being captured.7. The key factors for successful implementation are senior management leadership, development of business case and effective change management. | <p>The RFID Institute methodology:</p> <ol style="list-style-type: none">1. Evaluate business case.2. Develop clear project plan.3. Master the physics of RFID.4. Plan for extensive remote maintenance.5. Carefully manage your networks capacity.6. Be aware of RFID risks.7. Keep process and technical design flexible.8. Take effective security measures.9. Consider primary issue.10. Evaluate strategic implications. |
|--|---|

Source: Adapted from Mottola and Payton (2001:100) and RFID Institute of South Africa (2008)

2.10 CHANGE MANAGEMENT

The implementation of RFID technology is going to change the way things are done in the underground mining environment. When a technology changes the way a business objective is met significantly, it is said to be disruptive. The following five elements are disrupted namely: people, processes, applications, technologies and the partner's relationship (Sandhya & Sunil, 2004:5). Change management is an approach to managing changes to organisational processes, structural, technical, staff and culture change within an organisation (Chaffey & Wood, 2005:384).

An effective Information Technology design is not sufficient for organisational performance unless the technology is used. Therefore, the appropriate use of an effectively designed technology is also a necessary condition for improved organisational performance (Soh & Markus, 2000:30). Scoble and Daneshmend (1999:1) argue that the magnitude of the mining environment and cultural resistance to change should not be underestimated. Success is only likely with a significant change in the South African mining culture to assimilate more technological dependence. Organisational culture has a significant impact upon the successful implementation of an IT System (Chatfield, 2001:1). Resistance to change is an infamous characteristic of the mining industry, especially at the grassroots level (Smit & Pistorius, 1998:1). Sustainable technology change is often difficult in mines because of organisational and institutional factors (Willis, Dixon & Pooley, 2004:118). To overcome this problem, all employees will have to be convinced about the need for change. This change will enhance the successful implementation of RFID implementation and these fears will have to be addressed through change management.

Three change management models were identified. The purpose is to find the one most suitable for purposes and implementation of RFID on a mine.

Coetsee (2005:3) explains change management as moving between the present state to a desired end state. To get to the desired end state requires action from

both the team and management, as the single most important threat to successful change is the resistance to change that consists of both external and internal forces. These forces slow down and impede the change. To reduce the resistance to change, the stakeholders need to be taken through a series of planned interventions to address their fears and concerns. The following models were accessed from the CIPD website (2004).

2.10.1 Beer's model

This model indicates that change can still be successfully achieved by a uniform process that consists of six steps. This model sees 'task alignment' as the focal point of change. Thus employees' roles, responsibilities and relationships are examined and changed to embed new ways of thinking, attitudes and behaving.

The six steps of the process are:

- Jointly diagnose the requirements so that a commitment to change is achieved.
- Develop a shared vision so that all activities and thoughts are aligned.
- Create an environment that results in consensus and commitment to the shared vision.
- Educate all stakeholders and market the change.
- Create formal policies so that the change can be embedded.
- Monitor the impact and change the policies if required.

The Beer model puts more emphasis on the technical aspects of the implementation. It also appears to be neglecting the peculiar nature of different industries as well as the differences that exists among different occupational categories to change. This approach does not seem to address these differences that are very important in the mining industry.

2.10.2 Shaw's model

This model sees change as a complex and evolutionary process. The initial assumption is that the environment of an organisation is not in equilibrium. Thus, change cannot be achieved by following a set of fixed steps, and the starting point is not static and cannot be used as the basis for change. The advice is that the forces for change are already part of the system and will emerge as the system adapts to its environment (CIPD, 2004).

2.10.3 Coetsee's model

Coetsee (2005:23) suggests that successful change is based on adopting the following ten principles when addressing the change:

- **Establish what the results of the change process should be:** This involves creating a vision and involving all stakeholders so that they understand the end deliverable/s that would result from the change.
- **Clarify the need for change:** This involves educating the stakeholders about how they would benefit from the change and why the change is necessary.
- **Involve and obtain the commitment of all stakeholders in the planning and execution of the change process:** By involving all stakeholders they would feel a sense of belonging and it would result in their commitment and alignment with the objectives of the change.
- **Diagnose present functioning:** This helps people understand the underlying causes why the change is required and so that they do not feel threatened as a result.
- **Develop a results-oriented rather than an activities-orientated strategy for change.**

- **Assure that enabling structures are all aligned:** This ensures that the change is seen as meaningful.
- **Pay special attention to the organisational culture and climate:** All projects and change cannot be carried out at the same pace. Once the culture and climate is determined a plan can be made to fit in with the current conditions.
- **Create a change adept learning organisation.**
- **Build in reliable feedback mechanisms to monitor, manage and eventually evaluate the change process:** By measuring the process, the impact on the organisation can be determined and managed accordingly

Due to the dynamic nature and unique mining culture of resistance to change, the Coetsee model will be the appropriate one. The reason for choosing this model is the emphasis that he places on organisational culture and climate.

2.11 CONCLUSION

From the literature review, the following conclusions can be made:

The South African mining industry is experiencing productivity challenges. To overcome these challenges the presently isolated functional departments have to be integrated into a process. The only way that integration can be achieved is through Information Technology. RFID seems to be the technology most suitable for the required application. Despite its identified shortcomings, the biggest challenge facing the implementation is mining culture. The best method of implementation would be through out-tasking, the partial outsourcing of a solution that ensures control over the process.

2.12 SUMMARY

The first part of this chapter investigated the problems facing the South African underground mining industry. After identifying the problem of a lack of integration among the different value chain activities, logistics was identified as the most important activity to integrate. After concluding that real-time information was needed to integrate the different activities, possible solutions were discussed. The next part investigated possible solutions to integrate the activities. Tracking technology, RFID, was identified as the most suitable technology for the underground environment. A business case was done to look at the possible integration of RFID into the horizontal mine transport. Factors such as vendor selection, outsourcing and change management were all considered to ensure successful integration of RFID with the objective of improving productivity. Chapter 3 comprises the empirical study.

CHAPTER 3

EMPIRICAL STUDY

3.1 INTRODUCTION AND METHODOLOGY

The objectives of the previous chapters were primarily targeted at a literature study of mine logistics and tracking technology (RFID). The purpose of the empirical study is to align the primary and secondary objectives of the study as discussed in Chapter 1.

South Africa's position as the leading supplier of platinum and former top supplier of gold has led to substantial literature on mining coming from the South African Mining and Metallurgy (SAIMM) organisation. This assisted in terms of having a representative part of the literature study originating from South Africa. It is the peculiar nature of the South African mining environment, physical and cultural, that must be used to contextualise the study and to realise the objectives of this study. The objectives are to:

- Provide a framework for the implementation of RFID
- Provide a cost-benefit analysis of RFID
- Develop a criteria for the solution of RFID
- Consider the impact of change management on the RFID project implementation
- Consider outsourcing as a means to support any RFID implementation

The empirical study was also used to:

- Align primary and secondary objectives as explained in Chapter 1
- Refine the framework as well as develop a suggested model that can be adopted by other mines when considering the implementation of RFID technology

In order to achieve the stated objectives, a representative sample had to be chosen to determine whether the perceived problem was limited to some areas or mining houses or whether it was a general industry problem. To satisfy this requirement, five mining houses were identified for the sampling population.

The next goal of the population sample was to get a representative sample in terms of race and gender due to the imbalances that still exist between males and females and black and white. After ensuring that all sub-groups were included in the sample population, a questionnaire was designed that would provide the information needed to realise the stated objectives.

3.2. STRUCTURE OF QUESTIONNAIRE

The questionnaire was designed to test the perceptions of the respondents regarding the components of the framework for integration of RFID into the mining logistics system.

3.2.1 Questionnaire sections

The questionnaire was divided into different sections. These sections were more a result of the type of response required than a reflection of the content. It started with a section requiring a Yes/No answer followed by a sliding scale response. The last section required a written response since it involved suggestions. In terms of content the questionnaire can be divided into two sections.

3.2.1.1 Section A

Section A of the questionnaire focussed on the understanding, by the mining personnel, of the importance or impact of an inbound and outbound logistics system on productivity.

3.2.1.2 Section B

The second part of the questionnaire focussed on the respondents' opinions regarding factors that affect the logistics process. These factors include departmental integration, management information, systems and their impact on process flow. The aim of the question is to find out whether tracking technology would reduce the problems and improve integration of all the functional departments that are affecting logistics and, consequently, productivity.

3.3 BASIS OF DESIGN

The questionnaire was designed using the following methodology:

- The objectives of the study were established and used to define the research objectives of the study.
- The kind of questions needed to be asked to obtain the information necessary to answer the research objectives of the study, were determined.
- Information needed to realise the research objectives, was established.
- Objectives were converted into the information needed from questionnaires.
- Questions were developed to get the necessary information needed to get to the research objectives.
- Questions were sorted from general-type questions to more specific-type questions.
- Questionnaires were designed on a basis of a four-point Likert scale. Respondents had to indicate their degree of agreement or disagreement.

3.4 GATHERING OF DATA

3.4.1 Research process

The approach that was followed was to rather do an industry-wide study rather than an in-depth analysis of a single mine. The reason behind this approach is that the aim of the research was to find out the existence of a problem and how widespread the problem was rather than solve a specific mine's problems. By covering a wider area, mines in the same areas, due to the same ground, grades and systems, would have similar mining methods and problems.

3.4.2 Data collection

In line with the approach of covering as many mining houses as possible, each mining house was sent a total of ten questionnaires stratified to cover all the departments, races and genders.

The empirical study was done using both electronic surveys using e-mail and hard copies delivered by hand. A total of twenty eight responses were received from a total of 50 sent out.

3.4.3 Data analysis

Analysis was done on the data received from the valid responses. The following section will cover these responses in more detail.

To ensure the effective implementation of the proposed RFID technology on the two process areas identified (namely inbound and outbound logistics), it was fundamentally important to have a clear understanding of the As-Is process flows as well as an appreciation of the end users' requirements. These two elements form the cornerstones on which the design of the ultimate solution is built.

3.5 INBOUND LOGISTICS

3.5.1 Work process analysis

The objective of the study, with respect to inbound logistics, was to clearly understand the As-Is inbound logistics process and to include the changes to the abovementioned process as a result of the application of RFID technology to the process.

In order to understand and map the inbound logistics As-Is processes, many focus interviews and process mapping workshops were held with Production Management, Mine Overseers, Mine Logistics personnel, Shaft and Central Stores personnel as well as various individuals from the Human Resources department on the mine.

Once the required information was gathered, a high-level process flow was mapped and shared with the abovementioned stakeholders, who reviewed, corrected and approved the processes as and when required.

The inbound logistics process mapped the flow of stock items and explosives from the shaft stores to the underground delivery points. The process flow also included the return of the material cars to the surface as turnaround times on cars appeared to be a significant challenge.

The questionnaires were divided into categories. Each category's questions/statements would be used to validate and improve a certain part of the framework or test the benefits and concerns surrounding RFID implementation. The first part focussed on the current workings of the system, with its shortcomings, whilst the second part looked at the opportunities to use RFID to improve the current system.

The following categories were investigated:

- Current management structure
- Information flow
- Information quality
- Integration among departments
- Material car movement
- Change management
- Solution support
- Pilot site
- Business case

The reason for the division into different categories was to create a common understanding and minimise misunderstanding.

3.5.2 Current management structure

Current management structure refers to the different functional departments and its relationship to each other. It also gives an indication of the decision making levels.

3.5.3 Information flow

This is to clearly understand how and where information is created and the path that it follows. It also informs about who has access.

3.5.4 Information quality

Information quality refers to the gathering of data, methods and systems used for the manipulation distribution, relevance, presentation and usage of information within the structure.

3.5.5 Integration among departments

The goal was to clearly understand how logistics information, be it material car order, breakdown or blocked ore-passes, is communicated when and how.

3.5.6 Material car movement

Material car movement clearly delineates the path that cars travel from stores to underground and back.

3.5.7 Change management

Change management investigates the reaction of people to a changing situation, their fears and aspirations, their receptivity to technology and the management of all those factors.

3.5.8 Solution support

This looks at how the company has treated any new ways or technologies after implementing them. Was there an acceptance and support for the new way of doing things or did staff revert back to the old ones?

3.5.9 Pilot site

A pilot site is a site where the envisaged implementation is going to be tested and adapted if possible. If successful, it would then be spread to other sites.

3.5.10 Business case

The business case is the comparison between the total costs incurred and the total extra benefits that will accrue should the project be implemented. The benefits must be more than the costs for the project to be approved.

3.6 RESULTS OVERVIEW

Some questionnaires were filled in electronically and sent back. Others were filled in personally by the researcher in an interview format, especially with services departments who did not understand the operations' complete process. This task was made easier by understanding the business as well as information that was freely available for all stakeholders on the shaft.

The M/O's and Section Managers were interviewed just to get their views on the shortcomings of the current system and to improve the questionnaires. Quantitative information was available on the system where it is captured daily.

The services departments, store personnel, Engineering, Finance and Human Resources were also interviewed so that one could get another view that is focussed on efficient supply rather than efficient reception of material.

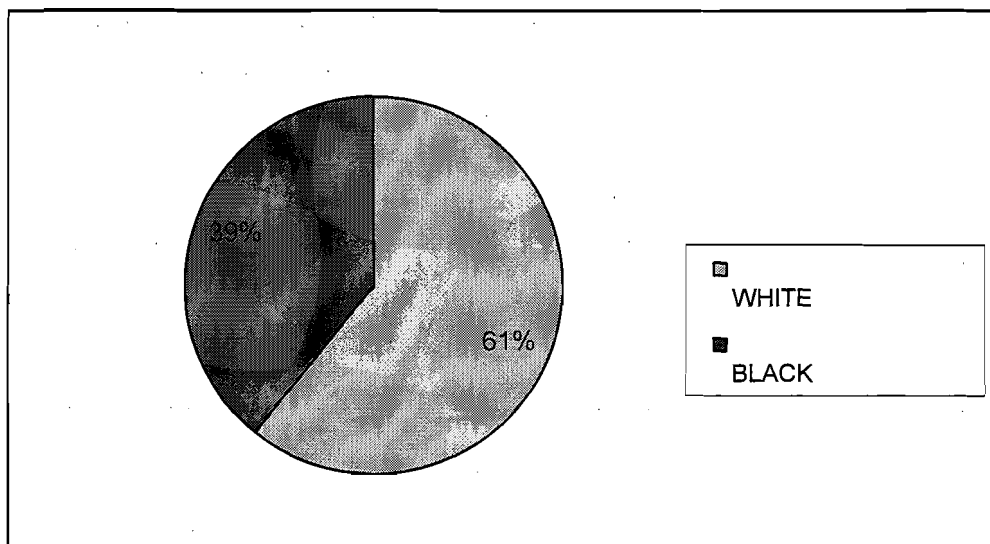
As would be expected, the most responses, twenty eight, were hard copy questionnaires that were distributed personally. These responses on the questionnaires were also the most complete, because the researcher was able to follow up on any unanswered questions, due to non-understanding. For the electronic responses, all queries were either done electronically or telephonically. All received responses were collected for analysis. The following section will deal with the analysis of the responses received.

3.7 RESULTS ANALYSIS INTERPRETATION, CONCLUSIONS AND RECOMMENDATIONS

3.7.1 Demographic information

The responses that were received were divided into different descriptive categories. These categories are race, gender, educational level, occupation grading and mining houses. The objective of the graphs is descriptive so as to give an indication of the respondents' profile. Demographic information is covered from graph 3.1 to 3.4. The population sample consisted of both black and white respondents. Their percentages are indicated in Graph 3.1.

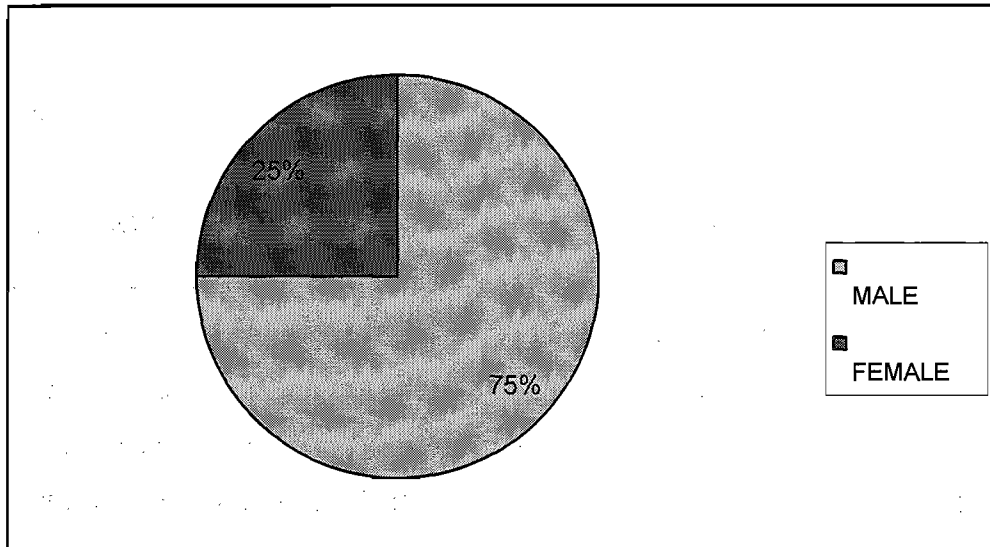
Graph 3.1: Race of respondents



It is very clear from the percentage split that white respondents are in the majority at 61% whilst blacks are at 39%. This discrepancy can be attributed to the mines' history where job reservation led to the imbalance. This situation is more pronounced at the higher level at which the survey was done whereas at a lower level the opposite would have been true.

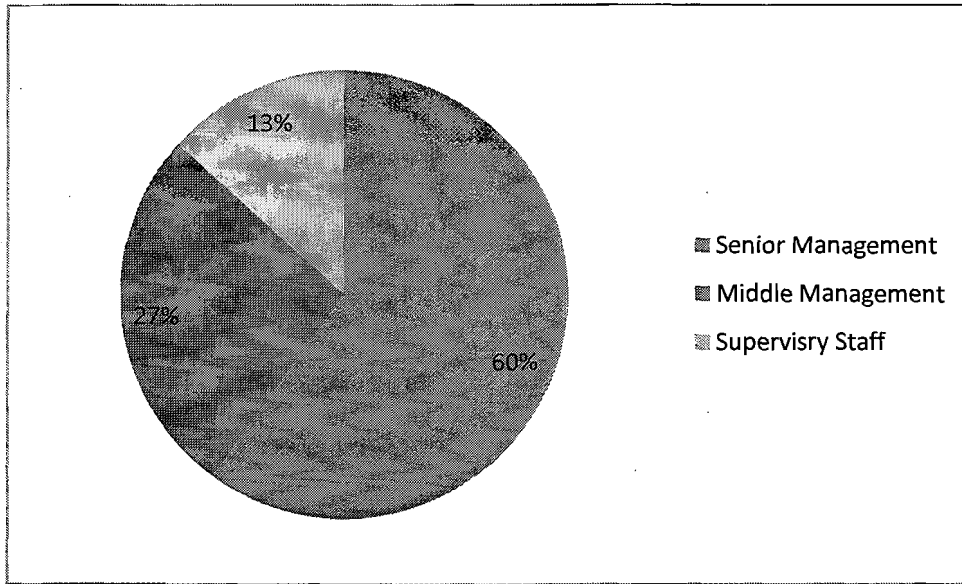
The population sample consisted of male and female respondents. These percentages are indicated in Graph 3.2.

Graph 3.2: Gender of respondents



Again due to historical reasons the mining population is heavily skewed in favour of males, with a 75 percentage. Although there have been some changes with regard to female employment most of the respondents are from the services departments, like Human Resources, Survey, Finance and Planning. The mining department is still dominated by males, especially white males.

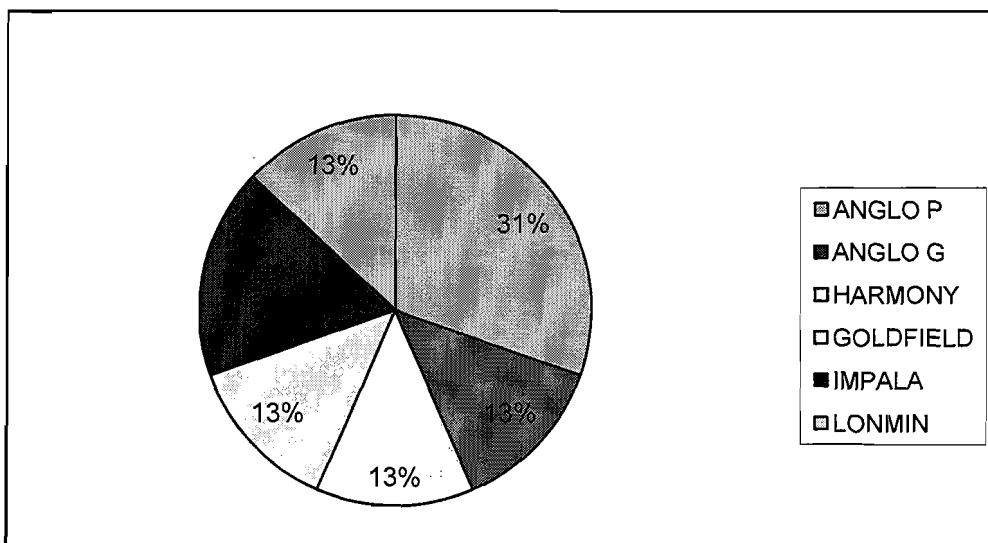
Graph 3.3: Management level



The focus of the survey was more on the management level due to their understanding of technology usage and systems implementation; it is for this reason that senior management constitutes the greatest percentage of respondents, which is 60%.

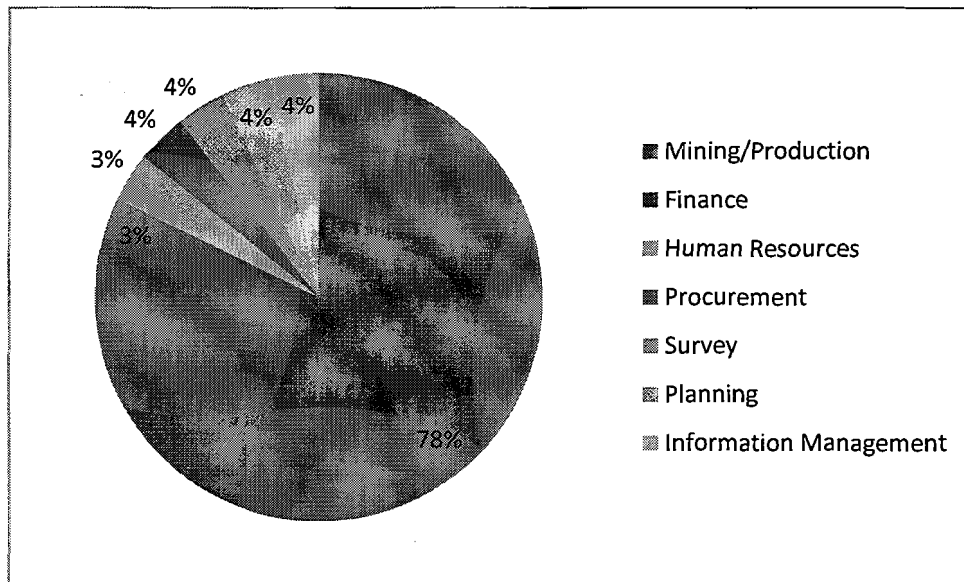
In order to find out that the logistics problem was a general phenomenon across the industry, different mining houses were surveyed. Since Anglo Platinum is the largest mining house, the percentage of response from it is also the largest at 31%. This is shown in graph 3.4.

Graph 3.4: Respondents according to mining house



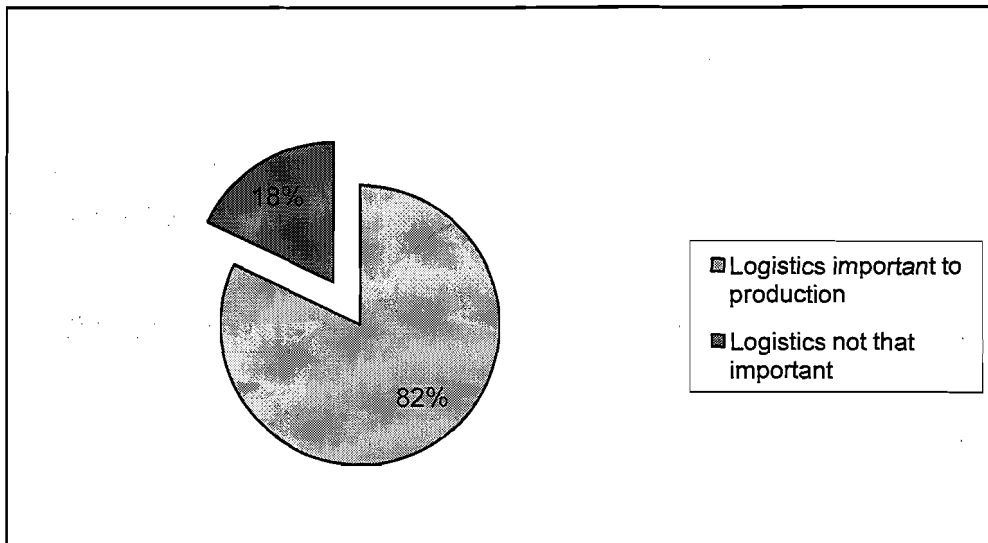
The population sample was taken from as many departments as possible so as to get an understanding of the different views held by the different departments. Below is a breakdown of the different departments. Mining respondents form the biggest group at 78% since they are the ones who are involved and are affected by all the other departments, especially the logistics department.

Graph 3.5: Division according to functional department



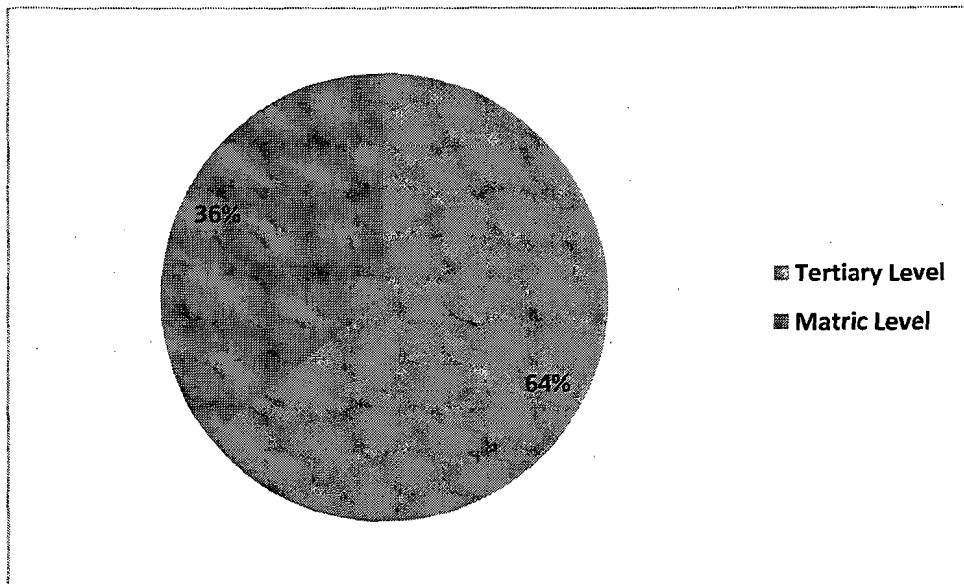
From the total responses received, regarding the importance of logistics to Production, 82% said it was critical to Production whilst only 18% said it is not as important. These responses were all from non-production personnel. This is a very clear indication of the division and different outlook that exist between Production and services departments. It also shows that some people in the services departments are not aware, or do not realise their departments' role in the value chain.

Graph 3.6: Importance of logistics to production



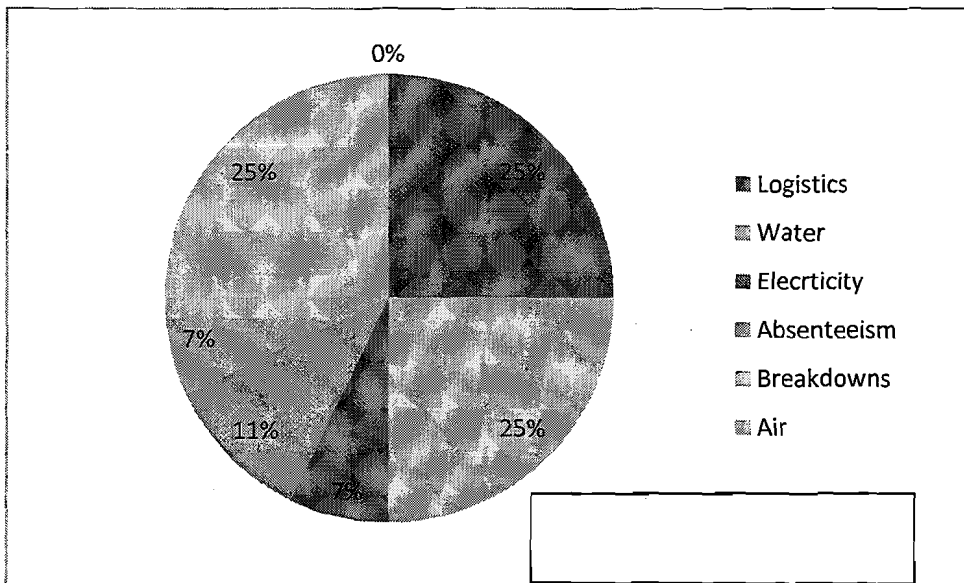
The education level of the respondents was heavily skewed in favour of tertiary level education owing to the focus on senior and middle management levels. People at this level are most likely to be from tertiary institutions due to the position requirements. That explains why there are more tertiary level respondents at 64% and grade 12 level respondents at 36%.

Graph 3.7: Education level



3.8 LOST BLAST BREAKDOWN

Graph 3.8: Reasons for lost blast

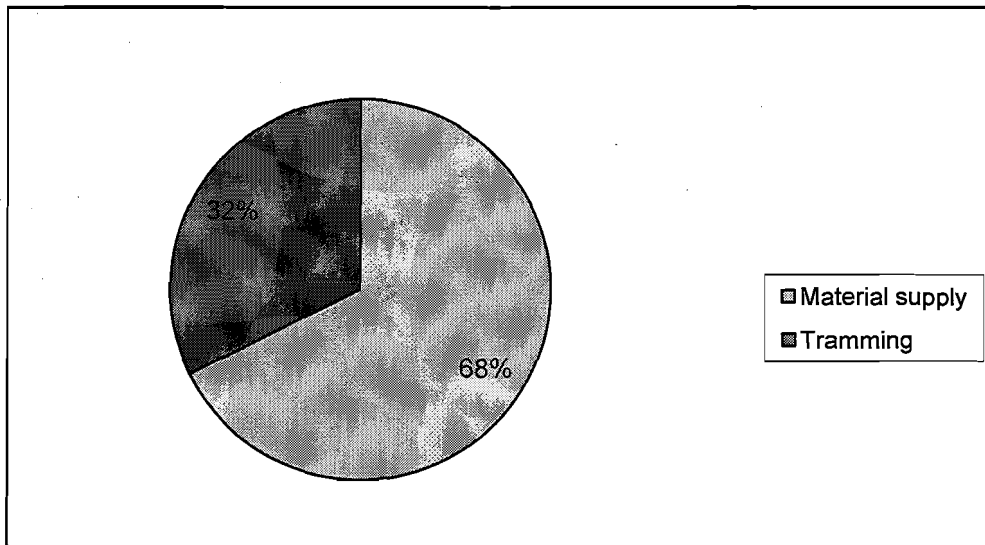


This graph is a clear indication of the importance of logistics to the production process.

3.9 LOGISTICS LOST BLAST BREAKDOWN

Out of the total lost blasts attributed to logistics by the respondents, 68% is linked to material supply whereas only 32% is linked to tramming, as shown in Graph 3.9. Looked at differently, one can say that material supply is responsible for double the number of lost blasts attributed to tramming. This also means that the focus is more on material supply problems.

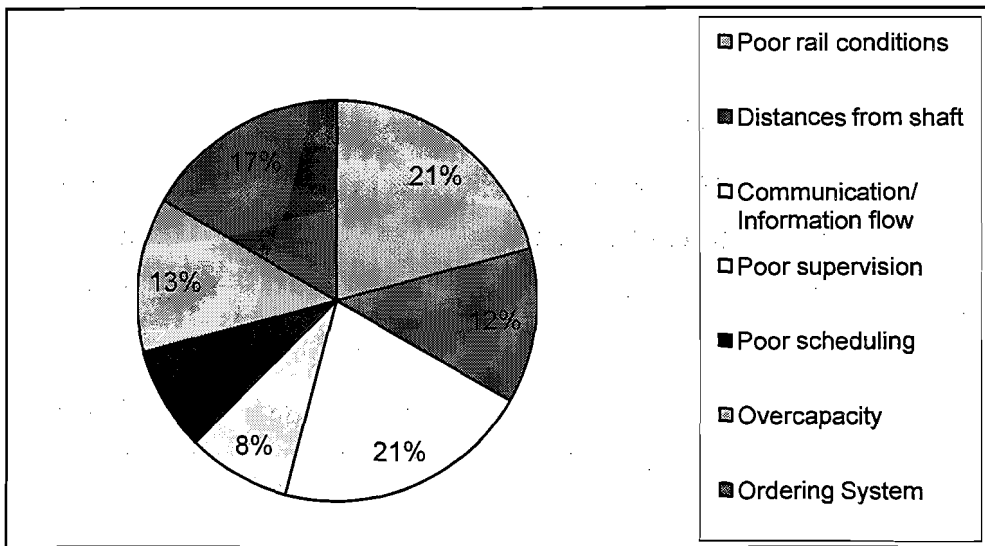
Graph 3.9: Logistics lost blast breakdown



3.10 REASONS FOR LOGISTICS INEFFICIENCIES

Poor rail conditions top the list of logistics inefficiencies at 21%, followed by the delays in the ordering system at 17%, and tramming distances and poor scheduling at 13% and 12% respectively.

Graph 3.10: Reasons for logistics inefficiencies



In response to a question regarding the cause of poor logistics efficiencies, the following responses as set out in Graph 3.10 were received. The ordering system, scheduling and communication, which are all linked to the information system, account for 46% of the causes of logistics inefficiencies. Upon further probe into this matter it was revealed that due to the manual ordering system that is captured by the materials clerk at the ordering department, there is often a delay before capturing. This is worsened by the fact that there is no indication or a way of tracking if capturing was done. The second delay related to this is the signing off of over-expenditure which only the ordering department has access to.

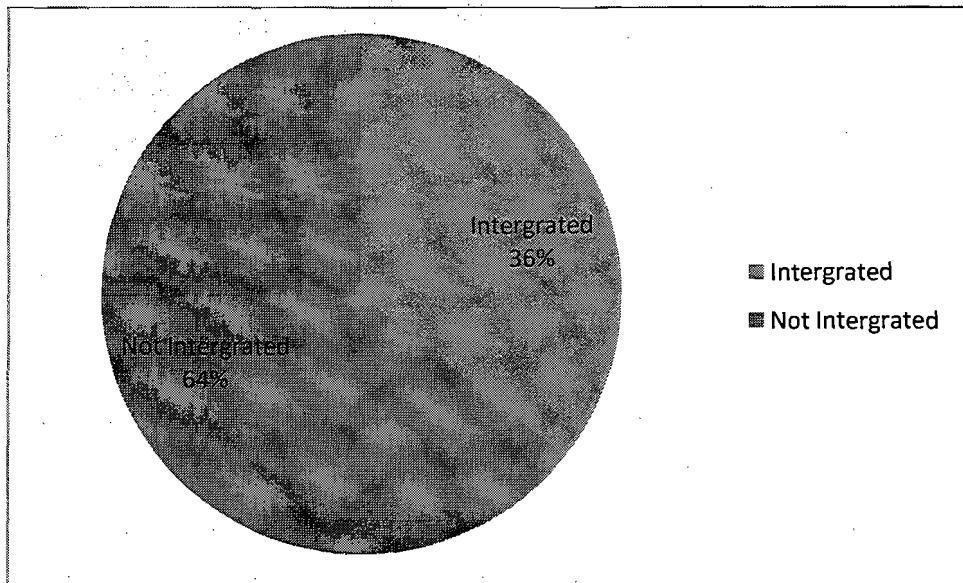
3.11 DEPARTMENTAL INTEGRATION

In response to the question about the integration of the different functional departments, 64% said there is no integration whilst 36% said there is, as indicated in Graph 3.11.

The reason mostly cited by those who said there was no integration was the lack of communication that existed among the departments. There is also a perception that the departments are not treated equally in terms of importance and remuneration. Those who said there was integration were mostly from the services departments like Planning, Human Resources and Survey, which do not

receive any material underground. Their response is more related to exchanges on surface.

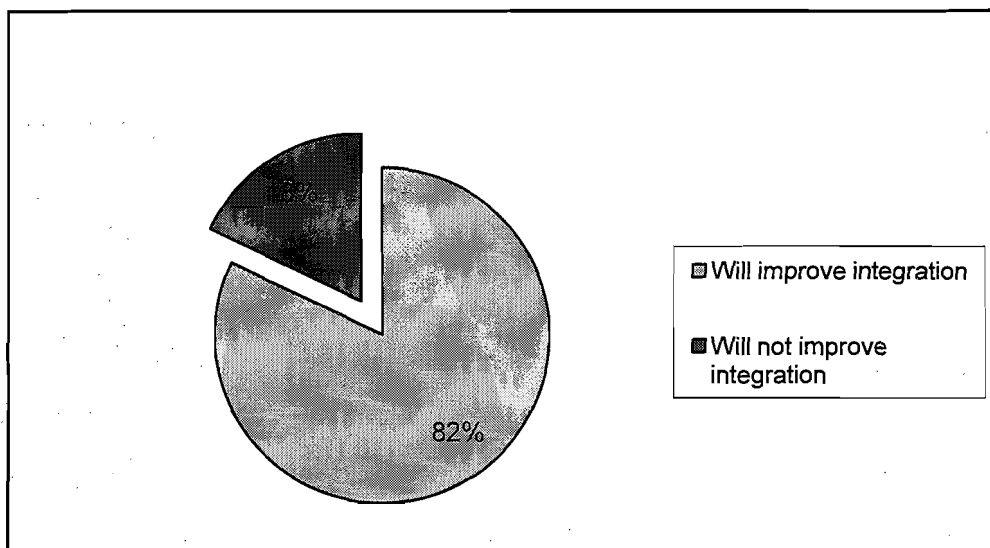
Graph 3.11: Departmental integration



3.12 TRACKING TECHNOLOGY INTEGRATION

A follow-up question was then posed to find out whether the respondents think tracking technology can lead to integration. An overwhelming majority of respondents, 82%, said yes whilst 18% said no. This is shown in Graph 3.12 below. Most of those who said tracking technology would not have any significant impact do not receive material underground and are not affected by tramming operations. This confirms that there is a lack of understanding of the production process from the other departments.

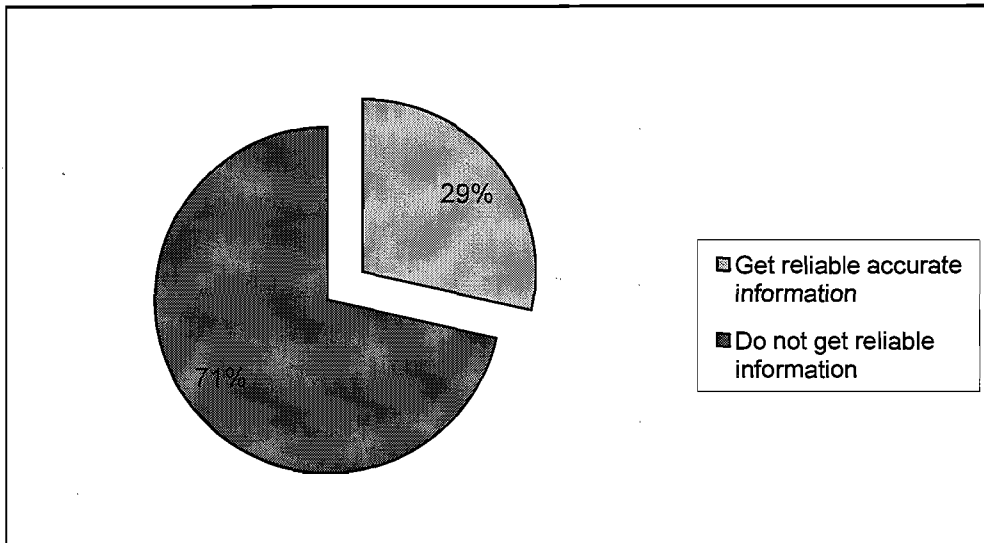
Graph 3.12: Tracking technology integration



3.13 INFORMATION QUALITY

Responding to the question of whether the current system provides them with reliable, accurate and timely information, 71% of the respondents said No compared to 21% who said yes. The results are shown in Graph 3.13. When further probing was done with regard to the type of information referred to, even those who said the information was accurate started distinguishing between the different types of information. For example, the fact that some incentives were tied to information like tons trammed served as a motive to overbook tons trammed. Since there is no integration between what gets booked and what goes to the mills one cannot pick up the discrepancy. This can only be established when reconciling the figures at the end of the measuring month. Still one will not be able to pinpoint the culprit.

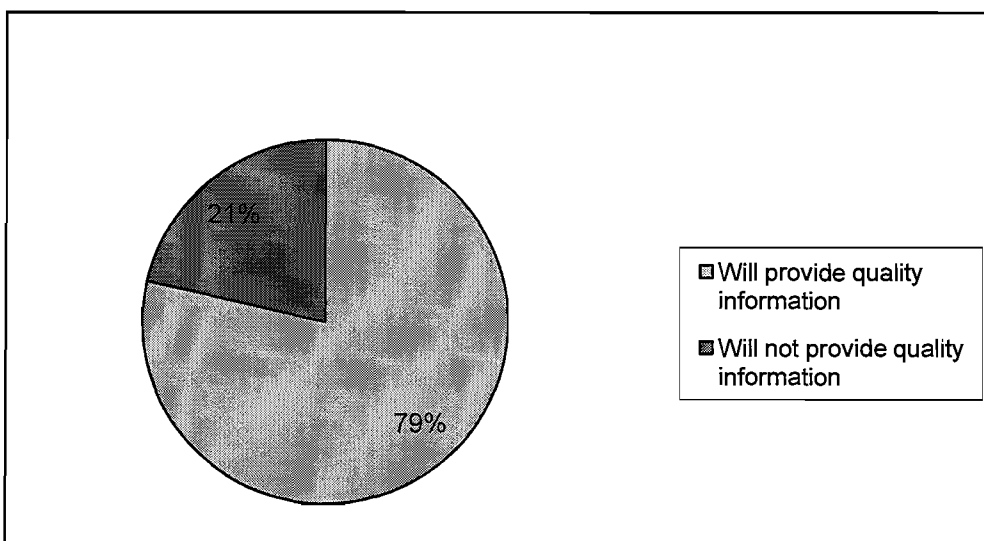
Graph 3.13: Reliable, accurate information



3.14 TRACKING TECHNOLOGY IMPROVING INFORMATION QUALITY

In response to a follow-up question that asked whether they thought tracking technology could improve the quality of information, the response was as follows: The majority, 79%, said yes, against 21% that said it would not, as indicated in Graph 3.14. When asking this question to services departments, respondents, after explaining the logistics process, tended to agree there would be an improvement. This again goes to show that understanding of the process definitely has an impact on the responses given.

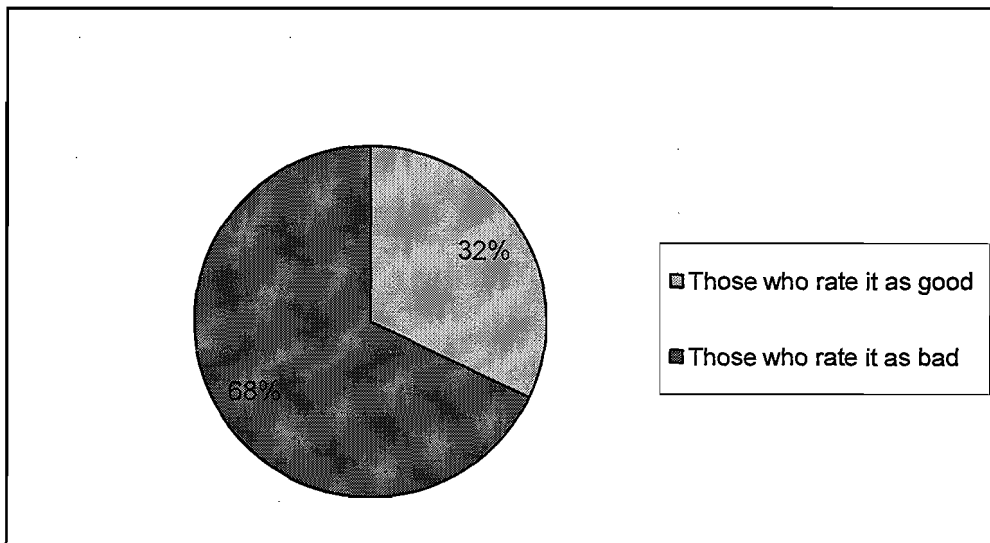
Graph 3.14: Tracking technology improving information quality



3.15 VENDOR SOLUTION CRITERIA

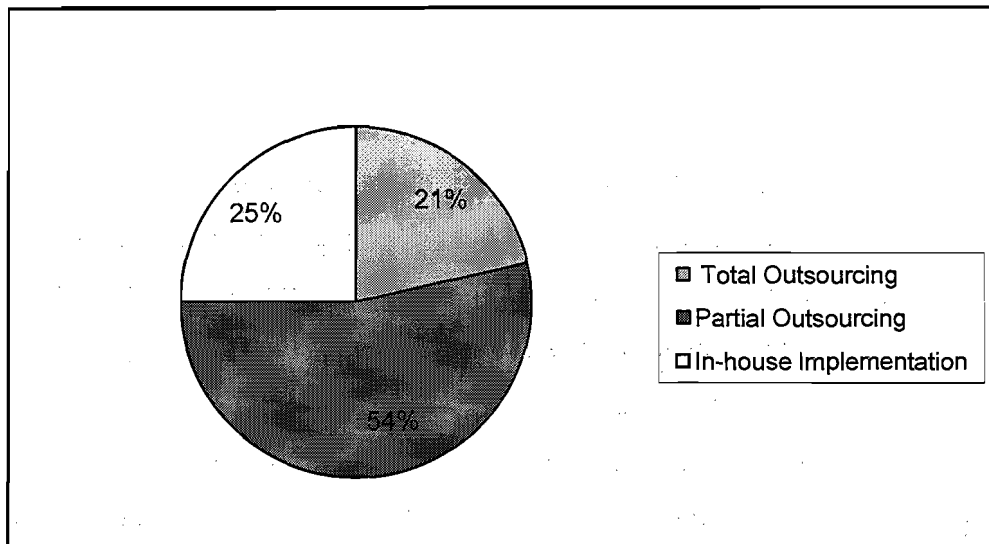
With regard to the criteria that are used to select a vendor or choose a solution, the response indicated 68% rated the criteria as bad, against 32% who rated it as good. Graph 3.15 shows the results. The reason mostly stated is the non-involvement of the end-user during the process. Most of the technological procurement on the mines is capital investments. That means decisions are taken at corporate level and not at operation or mining level. The reasons for this are mostly to standardise and to get volume discounts. Unfortunately, this leads to the problem of excluding the end-user. This could be one of the reasons for technology failure.

Graph 3.15: Rating of solution criteria



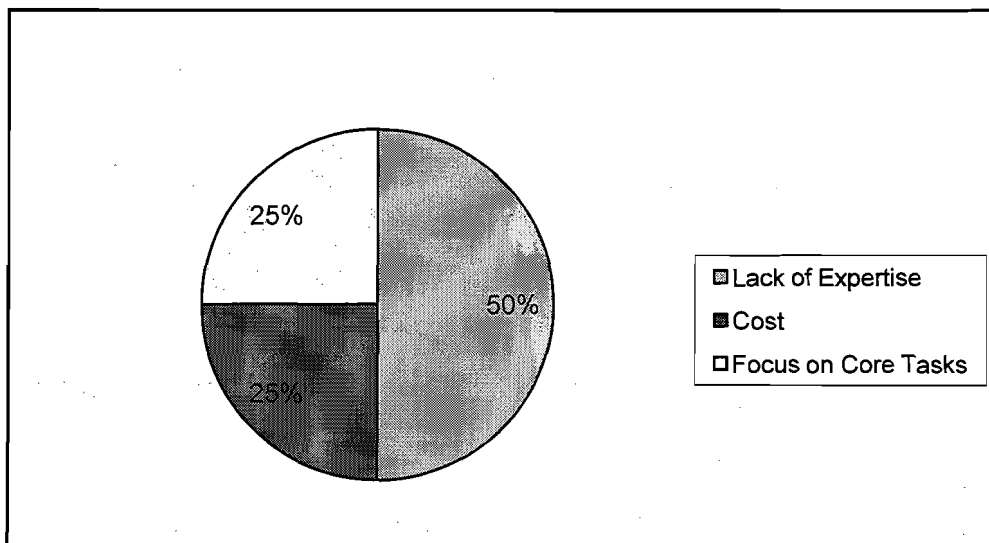
The technology implementation choice response was as follows: 54% chose partial outsourcing whilst 21% chose total outsourcing, and 25% chose in-house implementation, as shown in Graph 3.16.

Graph 3.16: Implementation choice



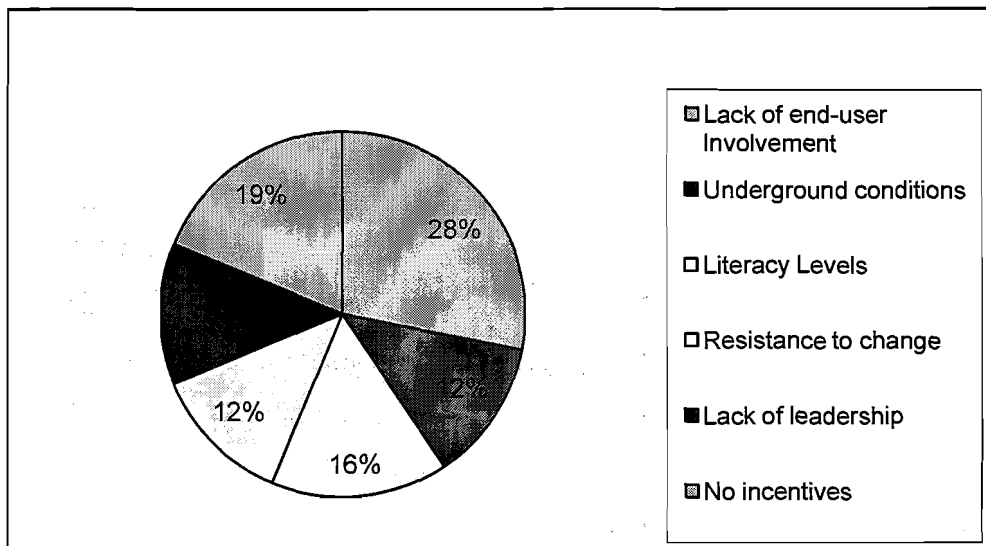
In response to a question regarding the reasons for outsourcing, 50% mentioned a lack of expertise as the reason for outsourcing whilst the other 50% is shared equally between cost and focus on core tasks.

Graph 3.17: Reasons for outsourcing



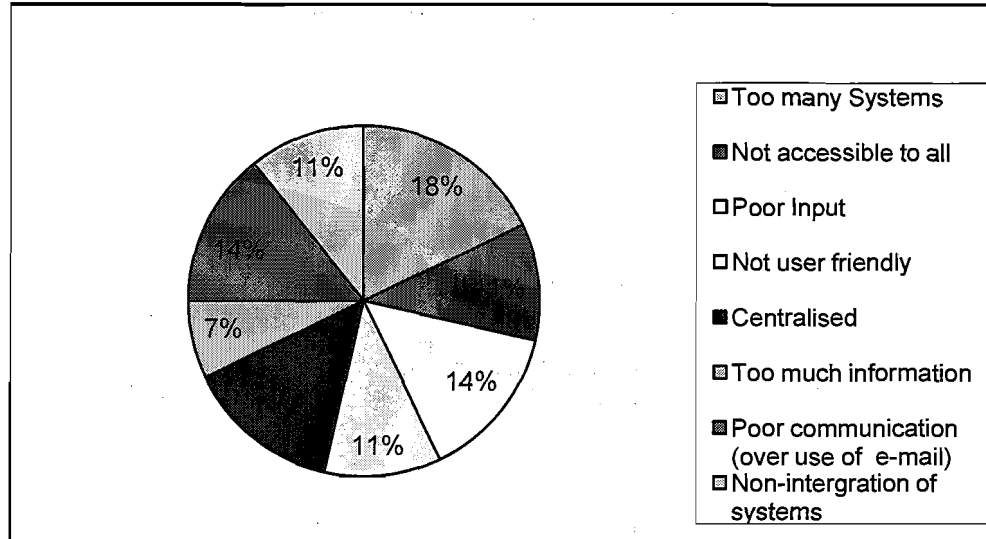
The responses for the reasons for technology failure implementation are set out in Graph 3.18. A lack of end-user involvement is the leading factor followed by underground conditions and literacy levels at 19% and 16% respectively.

Graph 3.18: Reasons for technology failure



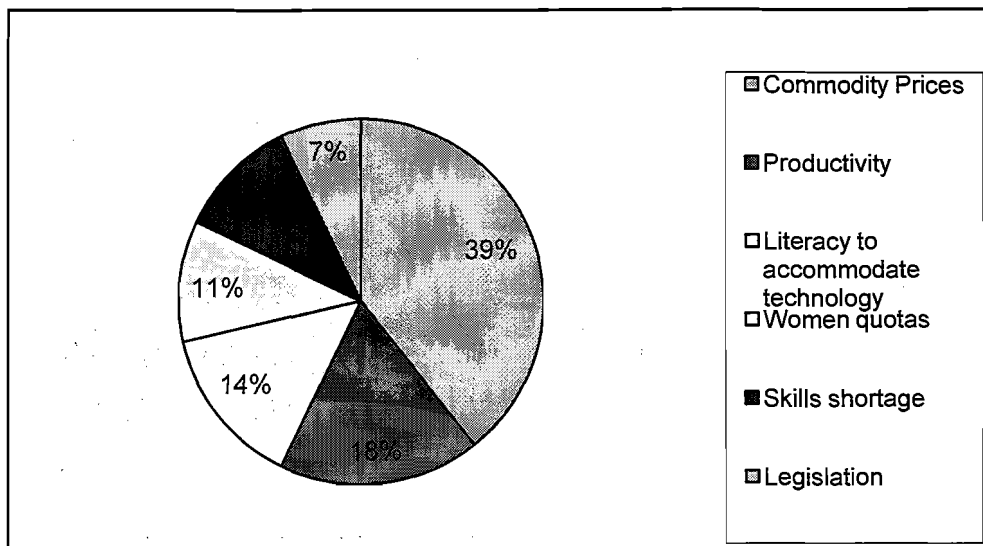
In terms of the problems associated with the Management Information System, too many systems at 18% leads, followed by centralisation at 14%, accessibility at 11% and user friendliness at 11%. Other results are shown in Graph 3.19.

Graph 3.19: Management Information System problems



In terms of future challenges facing the mining industry the responses indicated that the biggest challenge faced by the industry is the commodity prices at 39%. This is followed by skills shortage at 14%, literacy at 11% and women targets as required by law. The full breakdown is shown in Graph 3.20.

Graph 3.20: Challenges facing the mining industry



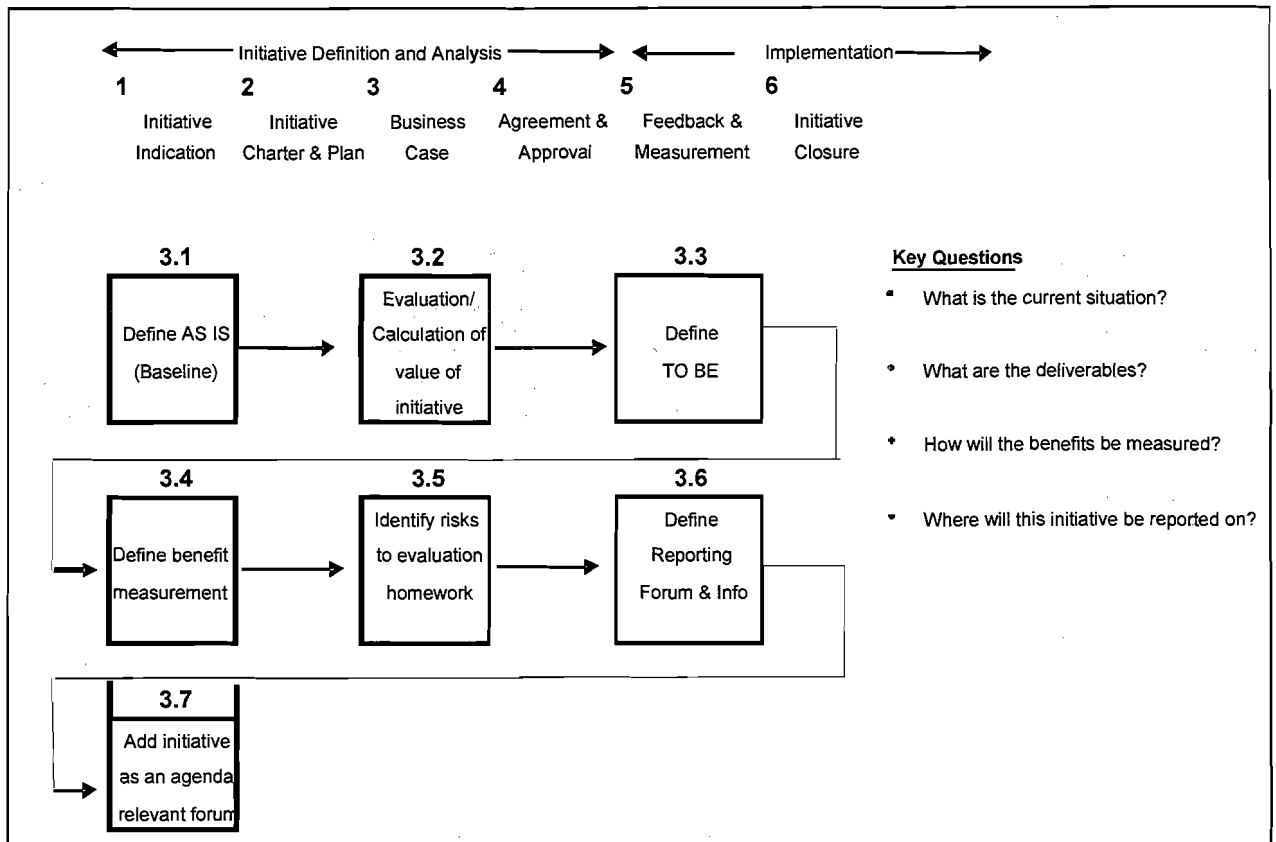
3.16 BENEFITS CASE OVERVIEW

In line with the proposed Benefits Analysis in the literature study, the following analyses were done. Improved productivity is anticipated to arise from a reduction in “Lost blasts” attributable to:

- Reduced incidences of excessive or preventing work cycles
- Timely delivery of essential materials and equipment
- Improved rolling stock utilization

For the purpose of this study, no financial value was attached to the improved safety performance resulting from the application of the technology. This does not mean that the benefits are to be ignored in deciding to apply or disregard the application of RFID on the shaft. The development of the business case was therefore based on the expected improvement in productivity, but a recent reconfiguration of the mining layout for Shaft, together with an emphasis to reduce the operating rolling stock, makes any attempt to assign a value to reduction in rolling stock to the application of RFID technology impractical. The focus was thus transferred to assigning a value to reduction in lost blasts due to incidences of excessive ore and material and equipment shortages. A generic business case methodology was followed, as represented below:

Figure 3.1: Generic business case methodology (A)



In development of the business case, data was provided by the Shaft Planner summarizing the capture of “lost blast” data over the previous year. The actual bookings were considered and found to not reflect root cause analysis but rather subjective reasons for non performance. An exhaustive exercise was conducted which eventually grouped the sum totals of various sets of bookings into root causes. An assumption was made of the possible impact that the application of RFID technology could have in reducing these statistics of lots blasts and factored with the estimated value of a lost blast for the Shaft at a value of the application. When presented back to the Shaft management, all assumptions were accepted with the exception of those relating to improvements anticipated from reduced incidences where poor supervision and discipline resulted in lost blasts. The resultant value of the application of the technology can thus be regarded as extremely conservative and robust.

Figure 3.2: Generic business case methodology (B)

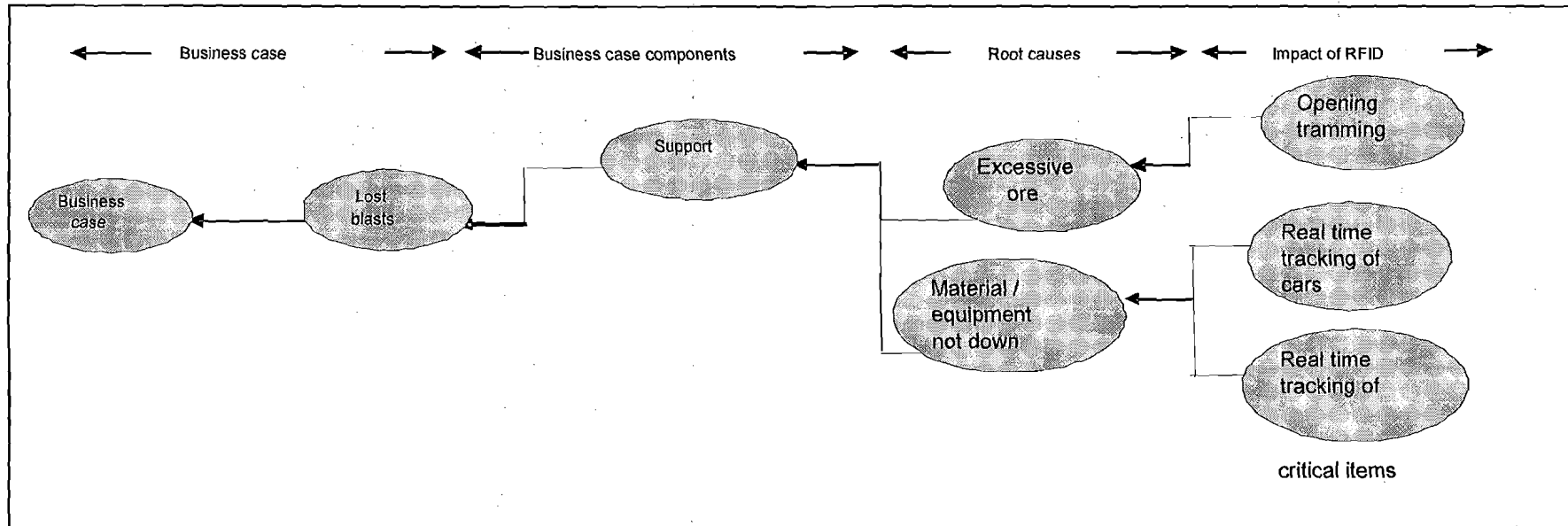


Table 3.1: Input data

| Evaluation Input Data | |
|--|---------------------|
| Face length (m) | 28.00 |
| Face width (m) | 1.50 |
| Face advance (m) | 1.10 |
| m ³ | 46.20 |
| Tons / m ³ | 4.17 |
| Tons / blast | 192.65 |
| Stope Grade | 4.63 |
| Platinum Factor | 0.5975 |
| Platinum Grams / ton | 2.77 |
| g / blast | 532.96 |
| Gram / ounce | 31.102 |
| Ounces / blast | 17.14 |
| Recovery rate | 0.80 |
| Lost ounces | 13.71 |
| Basket price / Pt oz | R 13,852.00 |
| Gross Contribution / lost blast | R 189,893.00 |
| Variable cost per Ton | 69.85 |
| Variable cost per lost blast | 13,456.88 |
| Nett Contribution / lost blast | R 176,437.05 |
| Recovered tons | 73,097 |
| grams | 202,217 |
| Ounces | 6,502 |
| Recovered blasts | 379 |
| Nett recovered contribution | R 66,943,927 |

Table 3.2: Potential lost blast reductions

| # | Reason | # of Blasts | % of Total Lost Blasts | Equivalent Tons | Lost Net. Revenue |
|---|--------------|-------------|------------------------|-----------------|---------------------|
| 2 | Inbound | 166 | 5.8% | 31,929 | R 29,241,008 |
| 3 | Outbound | 214 | 7.4% | 41,168 | R 37,702,918 |
| | Total | 380 | 13.2% | 84,200 | R 66,943,927 |

Potential Lost Blast reductions resulting from better discipline and supervision of labour have been intentionally discounted although some improvements are anticipated.

Table 3.3: Financial analysis

| Cost | | | |
|---------------------------|---------------------|---------------------|----------------------|
| | Consulting Fees | Technology Cost | Total Cost |
| Pilot Rollout | R 9,000,000 | R 30,600,000 | R 39,600,000 |
| Annual Maintenance | R 1,000,000 | R 1,800,000 | R 2,800,000 |
| Benefit | | | |
| | Low Case | Middle Case | High Case |
| People | | | |
| Inbound | R 23,392,807 | R 29,241,008 | R 35,089,210 |
| Outbound | R 31,419,098 | R 37,702,918 | R 43,986,738 |
| Tramming Utilisation | R 2,684,380 | R 3,355,476 | R 4,026,571 |
| Total | R 57,496,286 | R 70,299,402 | R 83,102,519 |
| ROI | | | |
| | Low Case | Middle Case | High Case |
| ROI - Year 1 | 145% | 178% | 210% |
| ROI - Year 2 | 271% | 332% | 392% |
| ROI - Year 3 | 382% | 467% | 552% |
| Pay-Back Period | 19 months | 12 months | 8.5 months |
| Net Present Value: | 11.5% | 5 Years | R 124,789,028 |

Table 3.4: Financial findings, conclusions and recommendations

| Section | Findings | Conclusions | Recommendation |
|---|--|--|---|
| Analysis High Level Financial Findings | | | |
| Benefits Case | <p>Project is feasible both technically and financially</p> <p>The project has a Net Present Value of R124m calculated over five years at 11%</p> <p>The project will require a capital expenditure of R42m, excluding financials</p> <p>The project will have substantial safety benefits</p> <p>The project approach is holistic and only purchasing certain functionality would be costly due to the common infrastructure requirements</p> <p>The benefits of the enhanced management information is understated</p> | <p>The project is feasible and viable and will contribute to safer working environment</p> | <p>Full installation of all facets of the design in accordance with the Blueprint</p> |

3.17 SUMMARY

This chapter analysed the data collected via the survey that was sent out to various participants from various mining houses and departments. The information was analysed and the following important issues were identified:

- Logistics is critical to production across the industry, according to 82% of respondents, as shown in Graph 3.5.
- Integration of departments is important for productivity improvement, according to 82% of respondents, as shown in Graph 3.10.
- Functional departments on the mine are not integrated, as shown in Graph 3.10.
- Management information is of poor quality due to manual data collection, as shown in Graph 3.6.
- Information technology can improve information quality, according to 82% of respondents, as shown in Graph 3.11.
- Management information systems are not fully integrated, as shown in Graph 3.17.
- End-users are not involved in the solution selection, as shown in Graph 3.7.
- Change management principles are not utilised to address the change resulting from technology implementation, as shown in Graph 3.17.
- Most respondents prefer partial outsourcing, due to a lack of skills, as shown in Graph 3.16.
- Poor literacy levels lead to poor technology acceptance and implementation, as shown in Graph 3.17.
- Commodity prices, productivity and literacy, to enable technology implementation are future challenges of the mining industry, as shown in Graph 3.19.
- There is very poor understanding of the mining process in the support departments as shown in the different responses given by the support services compared to the production departments.

CHAPTER 4

CONCLUSION AND RECOMMENDATIONS

4.1 INTRODUCTION

This chapter will take the information from the previous chapters in this study and combine it to develop a conceptual framework for the implementation of tracking technology into underground horizontal transportation/logistics. The chapter will start by discussing the framework and conclude with a summary of the study as well as recommendations for further study.

4.1.1 Conceptual framework and considerations

The framework that was developed can be seen as a framework not only for tracking technology but for general technological implementations. The considerations pertain to the specific objective of this study namely the development of a conceptual framework for the integration of tracking technology. The main components will be discussed in this section as well as the considerations to the framework.

4.1.2 Framework components and considerations

It is important to understand that data gathering has always been done manually on the mines. Therefore, it should be expected that any revolutionary change from this method would result in the disruption of the old ways of doing things. It is also important to remember that incentives are tied to the information generated. This situation often leads people to reject any thing that appears to be working against their self-interest. Lastly, and more importantly, it should be remembered that management planning and decision making is based on this information.

The following framework components were identified and analysed:

- Information and communication strategy
- Departmental integration
- Management information
- Management Information System
- Vendor solution criteria
- Technology implementation alternatives
- Change management considerations

4.2 CURRENT FRAMEWORK OVERVIEW

4.2.1 Respondents' overview

The respondents covered all the different departments on the mine. The reason for this was simply to try and get information from the whole mine and since there was no integration it could only be obtained from someone in that department. Three people from each department at different levels were interviewed. The aim was to see if there would be any similarities or differences within the same department, but different occupation and level. Another variable investigated was education level, with the purpose of looking at any relationship between education level and receptivity to technology or change.

4.2.2 RFID implementation

Eighty percent think RFID will have a positive impact on the logistics process and on the operations.

The functionality most wanted by senior personnel was data collection. The reason for this, they say, is because of the huge disparities and even fraud of overstating tons trammed that will only be picked up at the end of the measuring month during reconciliation. The lower level logistic respondents and shift overseers are the ones who focussed on other functionalities. Upon further

investigation it was found that these two groups are the ones who generate tramming information manually. So any replacement of the manual system by technology would mean wrestling control over any manipulation power that they had over this function. For the low level employees this could also declare them redundant.

In terms of technology implementation, all respondents agreed that it was more a functional rather than a process decision. For example, anything related to the engineering field would be decided upon and implemented in that department and the same for mining, Finance, HR and others. This is despite the implementation having an impact on the other departments or processes; everything related to the technology, whether it is costs, performance, support, pay-back and more. This proved two things; namely, the lack of change management as well as the functional focus rather than the process focus of the operations.

4.2.3 Governance approach

According to the respondents, the strategies are taken at corporate level. However, the problem comes with implementation. There is a gap between the group wide strategy formulation and shaft level implementation. This gap is caused by a lack of integration between the corporate office and shaft personnel. They are also never involved in the strategy formulation process. This problem raises the issue of taking ownership. When the shaft people take no ownership, the technology is utilised only whilst the implementing team is present. After their departure the shaft people revert to their old ways of doing things.

4.2.4 RFID team dynamics

From the responses received accountability is often limited to the functional department implementing the technology. Alternatively, it is limited to the group that has been identified to implement the technology by the corporate office.

4.2.5 Methodology

Due to the impact that RFID implementation is going to have across the various functions, it is important to ensure that important stakeholders are adequately consulted. Every stakeholder who is going to be affected by the implementation has to be involved and properly informed about how business requirements are going to be met both from a business and technical perspective. It must also be determined how evaluation is done and by whom.

According to the responses received, only middle to senior personnel appeared to know about the Procurement and Standards committee solution selection criteria. But even they did not really understand the criteria for things such as technology, which is different from consumables.

None of the respondents could identify the full criteria for vendor solution and the weightings allocated for the different criteria. Most importantly, they did not know if there were any criteria for the composition of the standards committee to avoid any bias towards a specific discipline.

4.2.6 Change management

According to experts, any change has to be managed. The more disruptive the technology the higher the impact of the change and the more change management is needed.

Close to 90% of the respondents say the biggest problem with change management is that it is either not implemented at all or the change agent, being an outsider, is not given sufficient powers. They also cited a lack of leadership from management as another hindrance to successful implementation. Anything that is perceived to be blocking production short term is not given sufficient effort even if it was going to improve production in the long term.

Due to this attitude there is almost no

- Feedback on progress

- Communication

An issue that is definitely dealt with is the effect the new technology is going to have on jobs. Even this is more as a response to the union's concerns regarding technology and mechanisation.

4.2.7 Support

For a technology to add value it must operate as required and be available at all times so as to ensure a smooth running of the process. For this to happen, the installation must be up to standard, the components functional and for any breakdowns there must be support and maintenance. This could be either in-house or from outside, by the supplier preferably.

Due to the specialist nature of some technologies and the shortage of highly skilled engineering personnel on projects such as RFID implementation, almost all respondents agreed that the suppliers provide the back-up support.

4.2.8 Initial testing

Due to the impact that the technology would have on the mine information system and operations, it must be ensured that it functions well. To do this properly, tests must be done before implementation so that any problems that might arise can be rectified without any effect to the operations. This will also improve the system because of the integration of the lessons learnt into the system.

According to respondents depending on the lessons learnt, some technologies or systems just do not allow any modifications to one component without redesigning the whole system. But for technologies where that is possible and which will not have any major impact on operations, that is allowed. However, this is after a proper risk assessment covering the modification and its impact is done.

4.3 RECOMMENDATIONS

To improve the inbound-outbound logistics efficiencies it is recommended that an integrative technology RFID be integrated into the logistics process. Based on the preceding analysis it is recommended that the implementation is done on a pilot stage to mitigate the risks of all out implementation whilst standing the chance to benefit from successful implementation.

4.4 REFINED RFID IMPLEMENTATION FRAMEWORK

A couple of factors that affect the effective implementation of RFID were identified during the analysis of the implementation framework. Some of these factors were found to have shortcomings that will affect the implementation which, if they can be improved, will enhance the implementation. The following section will look at each of these factors and make recommendations on their improvement.

4.4.1 Examine ICT strategy

From responses received it is felt that the ICT strategy is formulated without any input from the end users on the shaft. The implication of this is that there is no sense of ownership on the side of the users resulting in no commitment from them to use the technology and make it work.

Another point that emanated from the interviews is that the strategy is based on information that is supposed to be rather than actual information. For example, the information on the system might indicate that an engineer will be able to assist with the implementation whilst the shaft manager has already assigned him to do something else. The recommendation in this regard is to involve the shaft personnel from the onset so that they can contribute to the design and make provision for the implementation.

4.4.2 Evaluation criteria vendors

The responses indicated that there is very little, if any, understanding regarding this component. According to the respondents, vendor selection is very biased towards the functional department that will be using the technology and the central based Standards Committee. The view is that since technology will have an impact on other departments they should also be involved to make an input in the following areas:

- **Integration with other systems:** More emphasis should be placed on this factor since promised and actual integration did not materialise in the past.
- **Existing systems:** A careful analysis of the resources and disruption during the integration of the new and existing systems and the training is required.
- **Future needs:** Decisions should be taken in light of long term and not short-term planning to ensure return on invested capital.
- **Infrastructure requirements:** Some products require high initial investments to accommodate the new technology, like the laying of special cables. All these factors must be carefully evaluated.
- **Application modification:** Most systems are standard made and not custom made. This point should be considered and factored in when acquiring new technology. The vendor should have a clear understanding of what the end product should look like and, if possible, do the actual modification.
- **Ease of use:** Due to the mining industry culture and education levels, ease of use should be high on the list if the technology is to be accepted and used.

4.4.3 Risk management

Scope creep has been identified as one of the major risks. To minimise this risk, different scenarios should be looked at with an indication of the cost implications of each and the probability of that happening. By carefully looking at each scenario, proper budgeting can be done and included in the business case.

There should be systems in place to safeguard the information during the transition from the old to the new system. There should be back-up during the interim phase to ensure that there is no point at which both systems will not provide the required information.

4.4.4 Evaluation of current outsourcing strategy

The current outsourcing strategy is based on 100% outsourcing. This opens the company to two risks. Firstly, the company could be held to ransom by the outsourced company. Secondly, should the contracting company experience any problems like a strike or liquidation the system would come to a virtual stop. To avoid this problem, part of the support crew should be company employees.

4.4.5 Process and structure

Any disruptive technology is bound to have implications for the organisation structure. The organisation structure will have to be changed to fit the new technology strategy. When this happens, roles and functions change which has to be complemented by rules, policies and remuneration. According to the respondents, this was not the case in the past. This needs to be addressed in the refined framework.

4.4.6 Explanation of RFID implementation model

The previous sections 4.8 and 5.2 looked at each of the elements in isolation. This section is going to integrate the different steps to present the process to be followed when implementing RFID.

1. The **first step** should be the ICT strategy. This should be based on the identified factors that will affect the industry in future. For example, technological and legislative forces affect the choice of strategy to be followed. These should then be communicated to the shaft level and integrate the input received.
2. The **second step** is to look at the available technology to get a competitive advantage in response to the above factors. Also included should be a thorough and honest assessment of the identified factors that must be satisfied to implement the technology.
3. The **third step** is a parallel investigation into the best possible way to implement the technology. This involves discussions among the corporate, technology suppliers and shaft level representatives.
4. The **fourth step** will be focussed around human issues and change management. The following factors are dealt with at this level: identification of the project champions, expected impact of technology on structure and processes, training needs, feedback sessions, criteria for evaluating progress and incentives for both the implementation and usage of the new technology.
5. When this is completed the **fifth step** is the identification of a site for the pilot project. The site is then prepared and staffed as per agreement.
6. **Finally**, the pilot project kicks off with a high profile communication action plan to get everybody focussed. Progress is monitored and lessons learnt are documented for further improvement.

4.5 FURTHER FACTORS TO CONSIDER

This dissertation investigated the framework for the integration of RFID into the horizontal transportation system. However, the horizontal transportation is linked and dependent on the vertical as well as the conveyor belt transportation. That means any optimisation on the horizontal transportation alone will transfer the bottleneck to the next transport system.

For further research, I suggest that the complete integration of the three systems including the processing plant capacity should be investigated.

4.6 IMPROVING EMPIRICAL STUDY

To improve the empirical study, it is suggested that the questionnaires be sent to more mines so as to look at the specifics of each shaft. For example, some mines only use decline shafts and not vertical shafts, which has a bearing on the most important shaft resource time.

Also different shafts experience different underground conditions. Some mines are classified as hot and others as cold due to the temperatures experienced underground. Mines also differ in terms of the amount of water. All these factors could have an effect on the performance of the technology and need to be investigated. If this is not done, the transfer of the technology from one successful pilot site to the next could be compromised.

4.7 CONCLUSION

From the analysis done, it is very clear that the current framework for the implementation of information technology (RFID), proper consultation and involvement is not done in terms of the need to change and vendor selection.

The empirical and literature study highlighted the following:

- There is general agreement about what RFID entails.
- The change to information technology is not a choice anymore.
- Technology is becoming cheaper and more available.
- RFID technology despite its problems is being used effectively to improve operations.
- Contrary to popular belief that technology cannot be applied on the mine, with the right precautionary measures it can be successfully applied.
- The implementation of technology on the mine is not a transparent and consultative process. That leaves a gap between the corporate office, the functional departments and the shaft.
- A model for the implementation of information technology does not exist. The proposed model could be used as a base. The responses received can then be used for the further improvement and implementation of a future model. This is very important due to the rapid change of technology.
- Most importantly, the business case showed that the benefits that would accrue from the implementation of tracking technology far outweigh the costs and risks.

The study has also identified areas that would make implementation of Information Technology (RFID) easier and more beneficial in future. The model addresses all the objectives that were identified for this study. However, there are still many areas that have to be explored to further improve the framework:

- They include the organisation structure and processes
- Getting a reputable vendor as a strategic partner in the role out of RFID
- Creating a performance management criteria for new technology

REFERENCE LIST

ABERDEEN GROUP EDITORIAL. 2005. Solution selection criteria: total telecom cost management. TTCM solution selection report. [Web:] http://www.controlpointssolutions.com/download_docs/Aberdeen_TTCM.Solution_Selection_2005.pdf Date of access: 17 Jul. 2008.

ARNESEN, M. & VAN DER WESTHUIZEN, W.A. 2003. Knowledge In – Money Out: redefining mining planning and scheduling standards to improve and stabilize business performance. [Web:] <http://saimm.co.za/events0305apcom/downloads/151-158%20arnesen.pdf> Date of access: 3 Jul. 2008.

ASIT, Z. & MANDIWALLA, M. 2003. Integrating the supply chain with RFID: a technical and business analysis. [Web:] http://cclab.mis.ccu.edu.tw/RFID/meeting_files Date of access: 3 Jul. 2008.

BARNES, J.S. 2002. Unwired business: wireless applications in the firm's value chain. [Web:] <http://www.pacis-net.org/file/2002/035.pdf> Date of access: 3 Jul. 2008.

BIZOS, A.J. 2007. The network control revolution in underground rock breaking. [Web:] <http://www.detnet.com/detnet/value/AEL&%20white%20paper%204-%20network%20control%20revolution%20in%20%20underground%20rock%20breaking.pdf> Date of access: 3 Jul. 2008.

BOTTANI, E. & RIZZI, A. 2008. Economic assessment of the impact of RFID technology and EPC system on the fast moving consumer goods supply chain. *International journal of production economics*, 112(2):548-569, April. [Available: Academic Search Premier.] Date of access: 17 Jul. 2008.

BRAZIL, M., LEE, D.H., RUBENSTEIN, J.H., THOMAS, D.A., WENG, J.F. & WORMALD, N.C. 2001. A network model to optimise cost in underground mine design. [Available: Academic Search Premier.] Date of access: 17 Jul. 2008.

BUKKAPATNAM, S. 2005. Sensor RFID networks and complex manufacturing system monitoring: laboratory for RFID. [Web:] <http://www.okstate.edu/ceat> Date of access: 3 Jul. 2008.

BURGELMAN, R.A., CHRISTENSEN, C.M. & WHEELRIGHT, S.C. 2004. Strategic management of technology and innovation. 4th ed. Boston, Mass.: McGraw-Hill.

BUSINESS ENCYCLOPEDIA (Home page). 2008. [Web:] <http://www.inc.com/encyclopedia/management-information-systems-MIS.html> Date of access: 3 Jul. 2008.

BUYURGAN, N. 2004. Real-time manufacturing system control with RFID technology. [Available: Academic Search Premier.] www.oretrak.co.za Date of access: 17 Jul. 2008

CARMICHAEL, D. 1998. T801 MSc in manufacturing: management and technology. [Web:] <http://www.mysupplychain.co.uk/Msc/T801.pdf> Date of access: 19 Jul. 2008.

CHAFFEY, D. & WOOD, S. 2005. Business information management: improving performance using information systems. Essex, U.K.: Prentice-Hall.

CHASE, R.B., JACOBS, F.R. & AQUILANO, N.A. 2006. Operations management for competitive advantage. 11th ed. New York: McGraw-Hill.

CHATFIELD, C. 2001. Organisational Influences on the successful implementation of an ERP System. [Web:] Date of access: 19 Jul. 2008.

CIPD. 2004. Change management. [Web:] www.cipd.co.uk/subjects/corpstrtg/chngemmt/chngmgmt.htm?IssrchRes=1&scersion=printable Date of access: 15 Jun. 2008.

CISCO. 2006. Going underground. [Web:]

<http://www.cisco.com/web/strategy/docs/manufacturingmining-industry.pdf> Date of access: 3 Jul. 2008.

CLAASEN, S.J. & VISSER, R.T. 2004. An operational model for a coal mining production unit. *South African journal of industrial engineering*, 15(1):53-65.

[Available: Academic Search Premier.] Date of access: 17 Jul. 2008.

COETSEE, L.D. 2005. Change management (MPTP813 ET0). Potchefstroom: North-West University (study guide).

CROLL, A.M. 2004. Mechanisation: an Anglo Platinum perspective. [Web:]

http://www.basemetals.org/Pt2004/Papers/125_Croll.pdf Date of access: 3 Jul. 2008.

DEPARTMENT OF MINERALS AND ENERGY **see** SOUTH AFRICA.

EDWARDS, K. 2008. Improving productivity through technology. [Web:]

http://www.cat.com/cda/files/951286/7/Viewpoint_2008_issue3.pdf Date of access: 3 Jul. 2008.

ELLOUMI, F. 2004. Value chain analysis: a strategic approach to online learning. [Web:] [http://www.freidok.uni-](http://www.freidok.uni-freiburg.de/freidok/volltexte/2004/138/pdf/TPOL_book.pdf#page=93)

[freiburg.de/freidok/volltexte/2004/138/pdf/TPOL_book.pdf#page=93](http://www.freidok.uni-freiburg.de/freidok/volltexte/2004/138/pdf/TPOL_book.pdf#page=93) Date of access: 3 Jul. 2008.

FISCOR, S. 2007. Vale Inco tracks ore with RFID Tags. *Engineering and mining journal*, 52(3):10. [Available: Academic Search Premier.] Date of access: 17 Jul. 2008.

FOURIE, G.A. & VAN NIEKERK, D.J. 2001. Guidelines for the integrated planning and design of underground coal mines. [Web:]

<http://researchspace.csir.co.za/dspace/handle/10204/1523> Date of access: 3 Jul. 2008.

FRANZ, J.W. 2008. What is RFID? *Metal producing & processing*, January/February: 22.

GIBSON, G. & BONSOR, K. 2006. How staff work: reinventing the bar code. [Web:] www.howstuffworks.com/search.php?termsrfid&=9/&=21 Date of access: 19 Jul. 2008.

HAMMER, M. & STANTON, S. 1999. How process enterprise really work. *Harvard business review*, 77(6), Nov-Dec, starting page 108 ISSN 00178012. [Web:] <http://www.ida.liu.se/~TDE136/documents/hammer-stanton.doc> Date of access: 3 Jul. 2008.

HARSH, S.B. 2004. Management information systems. [Web:] http://departments.agri.huji.ac.il/economics/gelb-manag_4.pdf Date of access: 3 Jul. 2008.

HAWLEY, D. 2008. Management information. [Web:] <http://www.davehawley.com/ITIC/v2pre3/pages/managementinformation.html> Date of access: 3 Jul. 2008.

HERMANUS, M. 2003. The South African mining industry: sustainable development requires new integrated systems of governance. [Web:] <http://www.saimm.co.za/events/0310smci/downloads/001-hermanus.p> Date of access: 3 Jul. 2008.

HUNG, J., GERHART, D., PIX, A. & HACKWOOD, J. 2001. Technology applications and impact on business operations. *International journal of production economics* (Editorial), Ec.112(2008): 507-509. [Available: Academic Search Premier.] Date of access: 17 Jul. 2008.

JOHANESSON, P. 2007. Application and process integration: concepts, issues and research directions. [Web:] http://is.dsv.su.se/dubsfiles_folder/33.pdf Date of access: 3 Jul. 2008.

JORDAN, J.G., SORIANO, F., GRAULLERA, D. & MARTIN, G. 2001. Comparison of different technologies for EFC and other ITS applications. [Web:] <http://robotica.uv.es/pub/Roadpricing/09comparison.pdf> Date of access: 3 Jul. 2008.

KAPLINSKI, R. & MORRIS, M. 2001. A handbook for value chain research. [Web:] <http://www.inti.gov.ar/cadenasdevalor/manualpar.investigacion.pdf> Date of access: 3 Jul. 2008.

LEON-ZHAO, J. 2007. Knowledge management and organisational learning in workflow systems. [Web:] <http://chord.nce.ufrj.br/cursos/scti2004/documentos/ais98-icm.pdf> Date of access: 3 Jul. 2008.

LE PASTRIER, R. 2000. SA instrumentation and control. [Web:] <http://www.instrumentation.co.za/news.aspx?pkNewsId=301> Date of access: 19 Jul. 2008.

LUFTMAN, J.N., LEWIS, P.R. & OLDACH, S.H. 2003. Transforming the enterprise. [Web:] <http://www.research.ibm.com/journal/sj/321/luftman.pdf> Date of access: 3 Jul. 2008.

MACFARLANE, A.S. 2004. The implementation of new technology in Southern African mines: pain or panacea. [Web:] <http://www.saimm.co.za/Publications/downloads/v101n03p115.pdf> Date of access: 3 Jul. 2008.

MALLET, C., EINECKE, G. & GLYNN, P. 2007. Mine communication and information for real-time risk analysis. [Web:] <http://www.australiancoal.csiro.au/dfs/mallet.solutions.pdf> Date of access: 3 Jul. 2008.

MARSH, M. 2008. RFID interference: RFID spectrum. [Web:] www.trolleyscan.co.za Date of access: 3 Jul. 2008.

McCLELLAN, M. 1997. The collaborative effect: intelligent enterprises. [Web:] <http://www.intelligenteai.com/showarticle.jhtm//articleID=50500796> Date of access: 17 Jul. 2008.

MCMURRAY, J. 1997. Miners strike gold with RFID. [Web:] http://www.rftags.co.za/rfid/types_of_rfidtags.php Date of access: 3 Jul. 2008.

MOTTOLA, I. & PAYTON, R. 2001. Information technology for mining: a strategic approach. [Available: Academic Search Premier.] http://www.hatch.com.br/Consulting/Knowledge_Base/Articles/Information%20Technology%20for%20Mining%20_20%A%20Strategic%20Approach.pdf Date of access: 17 Jul. 2008.

PANT, S. & RAVICHANDRAN, T. 2001. A framework for information systems planning for e-business. [Web:] <http://w3.msi.vxu.se/~per/VC743/LM/p85.pdf> Date of access: 19 Jul. 2008.

PANT, S. & HSU, C. 1999. Strategic information systems planning: a review. [Web:] <http://viu.eng.rpi.edu/publications/paper.pdf> Date of access: 12 Oct. 2008.

PATNI, M. 2004. Investments in RFID: a real options approach. [Web:] http://www.patni.com/resource-center/collateral/RFID/tp_RFID-Real-options-approach.pdf Date of access: 17 Jul. 2008.

PICKERING, R.G.D. 2008. Has the South African narrow reef mining industry learnt how to change? [Web:]

http://www.saimm.co.za/Publications/downloads/v107n09p_557.pdf Date of access: 3 Jul. 2008.

PUDHOTA, L. & CHANG, E. 2001. Services management in component based collaborative workflow processes. [Web:]

<http://espace.lis.curtin.edu.au/archive/00001350/01/1400> Date of access: 3 Jul. 2008.

RAND ORG EDITORIAL. 2006. Critical technologies for process optimisation.

[Web:] <http://www.rand.org/pubs/monograph-reports/MR1324/MRI1324.ch4.pdf>
Date of access: 3 Jul. 2008.

RFID INSTITUTE OF SOUTH AFRICA. 2008. Implementation of RFID. [Web:]

www.rfidtec.co.za Date of access: 3 Jul. 2008.

RFID UK EDITORIAL. 2008. Real-time manufacturing control with RFID

Technology. [Web:]

www.umoncton.ca/cie/conferences/35thconf/are35proceeding/pdf/502.pdf Date of access: 19 Jul. 2008.

RFID UK EDITORIAL. 2004. Technology applications and impact on business operations. *International journal of production economics*, 112:507-509.

SACKMAN, S., EYMANN, T. & MULLER, G. 2002. Real-time controlled mobile information systems in health care applications. [Web:]

<http://www.mocomed.org/workshop2002/beitraege/Sackman.pdf> Date of access: 17 Jul. 2008.

SAP. 1999. The SAP Mining Solution White Paper. [Web:]

http://www.com/industries/mining/pdf/SAP_Mining_solution.pdf Date of access: 19 Jul. 2008.

SANDHYA, S. & SUNIL, A. 2004. Is RFID a disruptive technology? [Web:] http://cnscenter.future.co.kr/resource/hot-topic/wpan/tp_Is_RFID_Disruptive_Tech.pdf Date of access: 17 Jul. 2008.

SARANGAN, V., DEVARAPALLI, M.R. & RADHAKRISHNAN, M.R.S. 2008. A framework for fast RFID tag reading in static and mobile environments. [Available: Academic Search Premier.] <http://www.elsevier.com/locate/comnet> Date of access: 17 Jul. 2008.

SCHELL, H. 2003. Future trends in mobile commerce: service offerings, technological advances and security challenges. [Web:] <http://dev.nil.unb.ca/Texts/PST/pdf/grami.pdf> Date of access: 21 Jul. 2008.

SCHLAGE, M. 2003. The history of RFID technology: RFID data capturing technologies taking over from bar codes. [Web:] <http://www.rfidjournal.com:80/article/1338/-Y1> Date of access: 17 Jul. 2008.

SCHNEIDER, M. 2004. Radio frequency identification (RFID) technology and its applications in the commercial construction industry. [Web:] <http://e-pub.uni-weirnar.de/volltexte/2004/1159> Date of access: 19 Jul. 2008.

SCOBLE, M. & DANESHMEND, L. 1999. Mine of the year 2020: technology and human resources. *The Australian coal review*, April.

SIMCHI-LEVI, D. 2005. Impact of RFID on supply chain efficiency. [Available: Academic Search Premier.] http://supplychain.mit.edu/securedocs/case-studies/rfid_ch_vlauechain_dsl_final.pdf Date of access: 17 Jul. 2008.

SMIT, F.C. & PISTORIUS, C.W. 1998. Implications of the dominant design in electronic initiation systems in the South African mining industry. [Web:] <http://researchspace.csir.co.za/dspace/handle/10204/1482> Date of access: 3 Jul. 2008.

SOH, S. & MARKUS, L. 2000. How IT created business value: a process theory synthesis. [Web:]

<http://www.bus.ucf.edu/lsaunders/ism7939/soh%20Markus%20ICIS%20process%20theory.pdf> Date of access: 3 Jul. 2008.

SOUTH AFRICA. Department of Minerals and Energy. 2008. [Web:]

<http://saimm.co.za/events/0310smci/downloads/001-Hermanus.pdf> Date of access: 19 Jul. 2008.

TALLON, P.P., KRAEMER, K.C. & GURBAXANI, V. 2001. Executives' perspectives on IT: unravelling the link between business strategy, management practices and IT business value. [Web:]

<http://www.cito.uci.edu/publications/pdf/itr/itr-147pdf> Date of access: 3 Jul. 2008.

TOPAL, E. 2008. Evaluation of a mining project using Discounted Cash Flow analysis, Decision Tree Analysis, Monte Carlo Simulation and Real Options.

International journal of mining and mineral engineering, 1(1):11-13. [Web:]

<http://www.inderscience.com/storage/f121246958711103.pdf> Date of access: 13 Nov. 2008.

UMAR, K. 2003. Service delivery strategy for mining systems. [Web:]

<http://www.saimm.co.za/events,03050pcom/downloads/043-048%20Kumar.pdf>
Date of access: 19 Jul. 2008.

VAN DER MERWE, J.N., WOJNO, L. & TOPER, A.Z. 2001. Planning for value in the mining value chain: implementation of state of the art mining knowledge and technologies in design. [Web:]

<http://researchspace/dspace/hanelle/10204/186> Date of access: 3 Jul. 2008.

VETSCHERA, R., HALLWIRTH, V. & KOGELNIG, A. 2004. Impact of RFID on supply chain management: advanced topics in organisations (SE). [Web:]

http://gerda.univie.ac.at/orgplan/lehre/WS_04_05/AT_SE/AT_SERV/downloads/rfid_scm.PDF Date of access: 3 Jul. 2008.

WALLER, B. & HOWARD, M. 2008. The future of IT: developing real-time information. [Web:]

<http://www.3daycar.com/mainframe/sponsors/conference/jul01conf/future.IT.pdf>

Date of access: 10 Oct. 2008.

WANGLER, B. & JAYAWEERA, P. 1999. Information management : scope, definition, challenges and issues. DRTC workshop on information management, 6-8 January 1999. [Available: Academic Search Premier.] Date of access: 17 Jul. 2008.

WERNIUK, J. 2008. Using RFID to track ore and save costs at Stobie Mine. *Canadian mining journal*, 2008-01129. [Available: Academic Search Premier.] Date of access: 17 Jul. 2008.

WETHERBE, J.C. 2004. Executive information requirements: getting it right. [Web:] <http://www.h12.bgu.ac.il/users/2822/design/wetherbe-requirements.pdf> Date of access: 3 Jul. 2008.

WILEY, M. 2003. Strategic use of information resources. [Web:] http://media.wiley.com/product_data/excerpt/46/04713464/0471346446-1.pdf Date of access: 3 Jul. 2008.

WILLIS, R.P.H., DIXON, J.R. & POOLEY, A.D. 2004. A framework for the introduction of mechanised mining. [Web:] http://www.basemetals.org/Pt2004/Papers/117_Willis.pdf Date of access: 19 Jul. 2008.

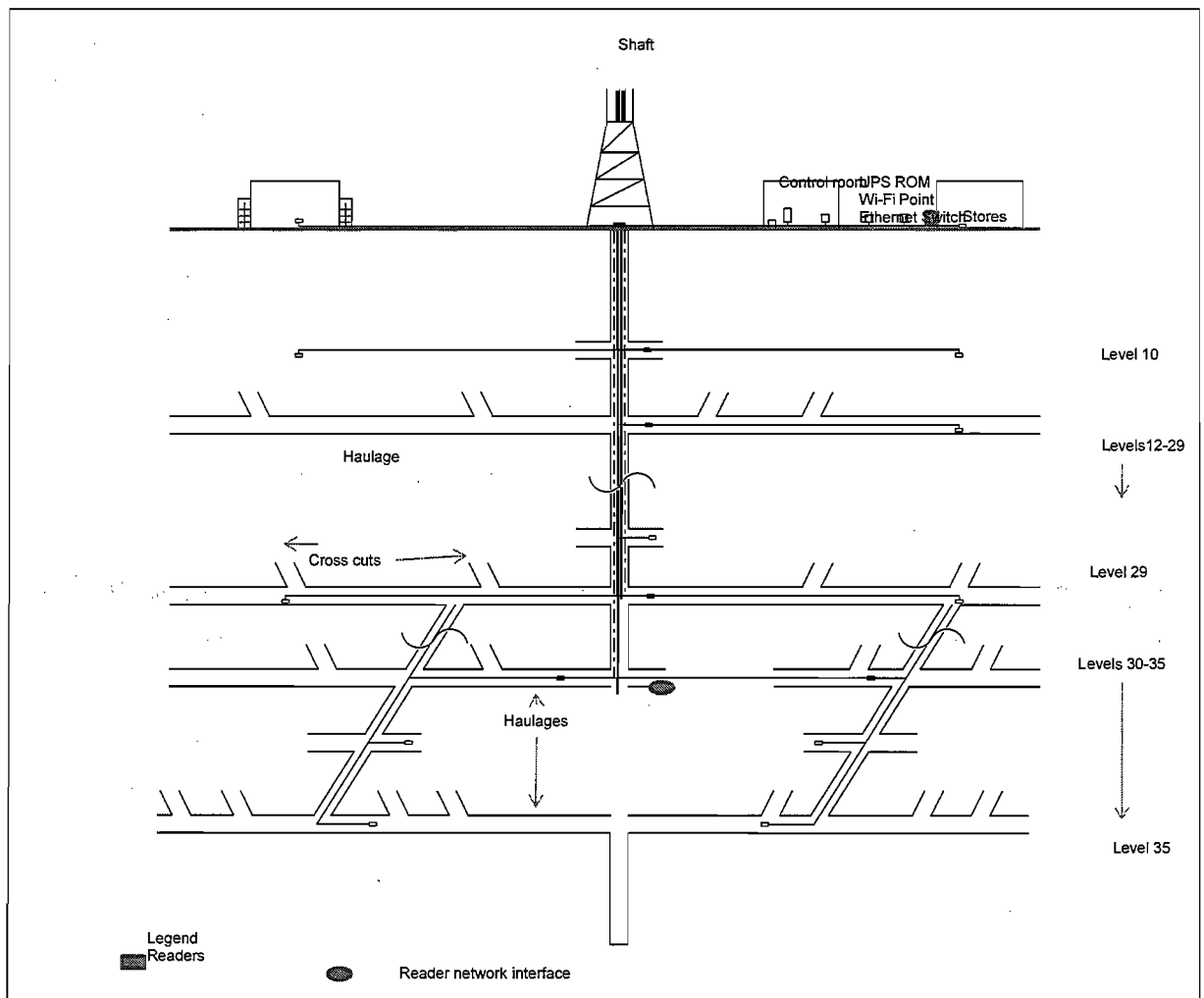
APPENDIX A: MINE LAYOUT THAT SHOWS THE MOVEMENT OF CARS

Functionalities

A.1 Mine Layout

The mine layout is made up of the surface area Upper levels 18-25 Lower Levels 29-33 and sections north and south with an average of 20 cross cuts per level. Not all cross cuts are active. It is required that certain items are tracked throughout the mine areas being:

- Surface entry/ exit gates
- Surface stores
- Underground levels haulage 18-25 north/south; and
- Underground levels Cross Cuts (active only) 18-33 North/South



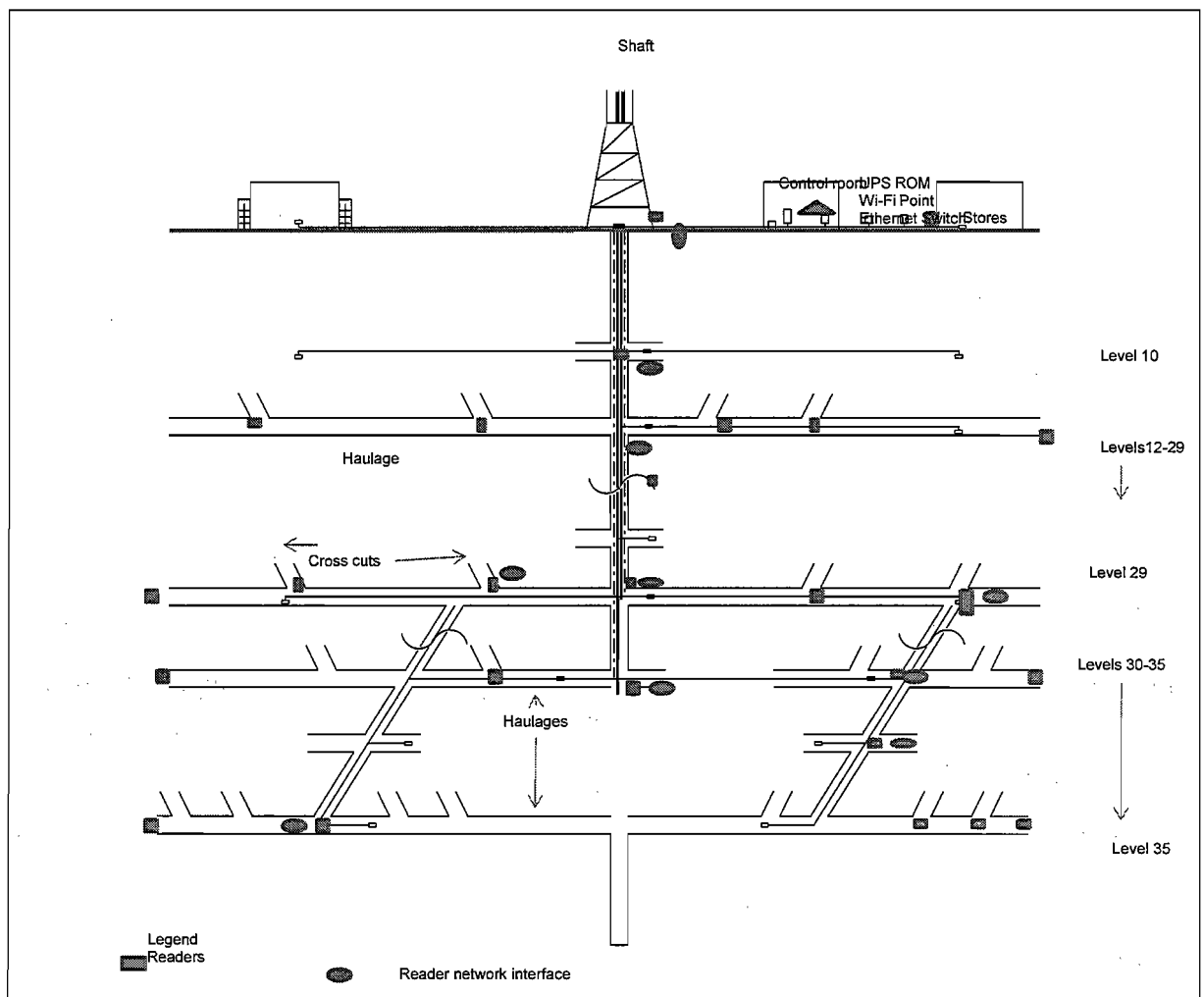
A.2 System architecture

The system architecture comprises of a common “host” system with its network infrastructure responsible for data collection, storage monitoring and system interfacing. Then there are the various Outbound Logistics.

The surface and underground system RFID readers and WiFi points are all networked to the RFID server.

The Middleware filters and buffers the raw data before storing all tag read data on the SQL Database. The RFID server then transfers all data to the SCADA system for event logging, user information, reporting and scheduling functions.

System Architecture



A.2.1 Common System backbone

For any of the RFID applications to operate as per the defined user requirements there are certain components that are essential and will have to be in place, namely;

- SCADA System
- RFID Server
- Local Area Network-Industrial Ethernet (Surface)
- Local Area Network- Industrial Ethernet (Underground Levels) and
- UPS- Power Distribution

Further to this, certain RTLS active read station are required throughout the areas located at strategic common points whereby tagged items from each of the applications will be read, namely:

- Cage Levels – active readers
- Haulage – active readers; and
- Cross Cut – active readers

A.2.2 Inbound Logistics

This system must provide a reader infrastructure that will track all critical materials, explosives, winches, pumps, material and explosive cars throughout the surface stores and underground levels up to within an active cross cut.

A.2.3 Outbound Logistics

This system must provide a reader infrastructure that will:

- Track raw materials (Ore) from a panel through to the main silos by tagging all loco's and hoppers; and
- Track all the returning empty material cars

A.3 RFID Components

A.4 Management Information System

A.4.1 RFID Server-Host

The Host system receives processed and normalised data-sent from the tag-through the reader and the RFID middleware software. The host application reports to a SCADA system. The SCADA system will interface to all users and existing systems for the purpose of providing Reports and Scheduling.

A.4.2 RFID server Middleware

RFID middleware is software that bridges hardware and enterprise applications. It is the primary means of data gathering for any RFID deployment. This data is held in a database where full details of a tags life are kept. From time to time this data is transferred to an archive table.

The major functions of middleware are:

- Device Management
- Automatic Health Check
- Event Management
- Data Filtering; and
- Application Interface

Device Management

Middleware must enable the administrator to centrally manage all the different types of readers, via an easy to use interface. Due to the large number of readers it is essential to be able to monitor of the readers to make sure they are performing optimally.

Health Check

The system automatically checks that each reader is operating as per defined parameter and that there are no technical errors. It also monitors reads made by a reader and is able to detect when readers have not passed any data to the RFID server for a period of time.

Event Management

The system can detect tags being read at a certain point or out of predetermined sequence.

Data Filtering

One of the enemies of the RFID environment is an excess of unwanted data. The job of the middleware is to filter out unwanted data and therefore be able to present enterprise applications with clean meaningful data. Excess reads have to be ignored or the database will be bombarded with duplicate data.

Application interface

After collecting raw RFID data from the readers and filtering out duplicate data, Middleware can then pass data to various applications at certain read points. Parameters can be established so that information coming at certain times from certain readers can be sent to other host applications. This can be just the tag ID and the time of reading or other data held on the tag or within the database.

3.5 RFID Tags

The function of the RFID tag is to receive a signal, power up an onboard chip with data embedded on it, and broadcast that information. The three components of a

tag –chip, antenna and substrate- help it receive and respond to RF queries from an RFID reader.

A.6 RFID READERS

Readers/Interrogators are classified as read only interrogators and read/write interrogators.

A.6.1 Reader Types

A.6.1.1 Handheld RFID Interrogators

Is handheld and the reader, antenna and application software are all parts of a single device. Information exchanged with the tag in the reader can be directly stored and then transferred to the SCADA system. This capability requires that interrogator's antenna be close to the RFID tag to read it. The read range of a handheld interrogator is less than that of a fixed mount because the size of the antenna makes the device less efficient.

A.6.1.2 Vehicle mount RFID interrogator (Loco)

A mobile interrogator is placed on the Locos. Unlike a handheld interrogator the mobile interrogator cover a reading range of up to 100 metres.

However, one of the major challenges that a vehicle mount RFID interrogator faces is its use in a metal environment. Metals can detune the reader and antenna, causing a drain on RF energy. Therefore it is important to set up the RFID system in such a way that reader antennas are positioned away from metals. The entire RFID system should also be able to handle harsh mobile environments such as vibrations, heat and moisture.

A.6.1.3 Fixed mount RFID interrogator

A fixed mount interrogator is placed at locations where items must pass through, such as entry and exit points, stores or at any designated strategic position required for tracking. The advantage of a fixed interrogator is its ability to scan items automatically.

A.6.2 Functionality of readers

The functions of the readers vary, depending on the application it is used in. Here are some of the common uses of the readers:

- Energising the tag for communication purposes

- Defining the operating frequency at which the tag and the interrogator communicate with each other
- Reading data from the tag
- Write data to a writable tag
- Communicating with the host computer through a serial or Ethernet connection

3.7 Network

An industrial Ethernet network will be provided on the surface and via a Fibre Optic switch to an underground switch. From the switch a network hub will be provided for on each level. Ethernet switches allow the system to send and receive information at the same time (Full Duplex Mode). It also allows each port to have dedicated bandwidth instead of a shared bandwidth. This makes a big difference since the RFID system will be transferring large volumes of raw data.

A.8 UPS Power (Uninterrupted Power Supply)

A UPS is a device that provides electrical power with a constant regulated voltage output when the main supply of electrical power is interrupted. The Ups will feed and maintain all RFID Readers, system Servers, Computers, related network equipment that can shut down or lose data during power interruptions.

A.9 Hardware Grounding

Grounding is critical for the operation of the reader. Electrical grounding is important because it provides a reference voltage level, called zero potential or ground level. An effective electrical ground connection:

- Minimises the possibility of interference
- Reduces the risk of equipment damage due to systems components;
- Helps protect personnel who service and repair electrical, electronic and computer systems

APPENDIX B: QUESTIONNAIRE

Mine: Occupation: Grading:
.....

Gender: Education:
Race:.....(Only for statistical purposes)

Section A: Please answer Yes/No to the following questions by ticking in the appropriate box.

1. Do you have a logistics problem?

Yes No

2. Does your logistics system operate efficiently in terms of: (a) Material Supply?

Yes No

(b) Trammig of ore?

Yes No

3. Are the different functional departments (Human Resources, Mining, Finance, Procurement, Information Technology) integrated (does the one have access to the other's information)?

Yes No

4. Do you think an improvement in logistics will improve productivity?

Yes No

5. Does logistics (a) material supply affect productivity?

Yes No

(b) trammig of ore affect productivity?

Yes No

6. When you increase / decrease your production plan do you do the same with:

(a) Logistics personnel?

Yes No

(b) Vehicles?

Yes No

7. Do you use a manual system to (a) book material?

Yes No

(b) Book trammed ore (tons)?

Yes No

8. Does the system used in (7) provide you with (a) accurate information?

Yes No

(b) Reliable information?

Yes No

(c) Timeous information?

Yes No

9. Do the different functional departments get accurate, reliable information?

Yes No

10. Do the different departments understand the impact of their department on other departments?

Yes No

11. Does Senior Management encourage cooperation among the different departments?

Yes No

12. Does the incentive system encourage cooperation among the different departments?

Yes No

14. Does your current information technology enable process thinking/departmental integration?

Yes No

15. Do you think tracking technology will improve your logistics process?

Yes No

16. Do you think tracking technology will improve your logistics process?

Yes No

17. Do you think tracking technology will lead to better integration of the logistics process?

Yes No

18. Do you think tracking technology will lead to better integration of the different departments?

Yes No

19. Do you think integrated departments will lead to improved productivity?

Yes No

20. Do you think tracking technology providing quality information will lead to:

(a) better management planning

Yes No

(b) better execution

Yes No

(c) better control

Yes No

Section B: Sliding Scale

Please answer the questions by ticking the response that most closely describes your opinion.

1. What percentage of your lost blasts can you attribute to:

| | | | | |
|----|----|----|----|-----|
| 20 | 40 | 60 | 80 | 100 |
|----|----|----|----|-----|

(a) Material supply?

(b) Tramming of ore/ waste

| | | | | |
|----|----|----|----|-----|
| 20 | 40 | 60 | 80 | 100 |
|----|----|----|----|-----|

2. What impact, in percentage, does logistics have on productivity in terms of:

(a) Material supply

| | | | | |
|----|----|----|----|-----|
| 20 | 40 | 60 | 80 | 100 |
|----|----|----|----|-----|

(b) Tramming

| | | | | |
|----|----|----|----|-----|
| 20 | 40 | 60 | 80 | 100 |
|----|----|----|----|-----|

3. How would you rate the acceptance of new technology on the mines among

Senior management

Middle management

Lower level workers

| | | | | |
|------|---------------|---------|---------------|------|
| Poor | Below average | Average | Above average | Good |
| Poor | Below average | Average | Above average | Good |
| Poor | Below average | Average | Above average | Good |

4. How do you rate the current stakeholder involvement when new technology is considered?

| | | | | |
|------|---------------|---------|---------------|------|
| Poor | Below average | Average | Above average | Good |
|------|---------------|---------|---------------|------|

5. How would you rate the current vendor/solution selection criteria in terms of its effectiveness?

| | | | | |
|------|---------------|---------|---------------|------|
| Poor | Below average | Average | Above average | Good |
|------|---------------|---------|---------------|------|

6. Do you think the input from end users at all levels is seriously considered/ implemented?

| | | | | |
|------|---------------|---------|---------------|------|
| Poor | Below average | Average | Above average | Good |
|------|---------------|---------|---------------|------|

7. How would you rate the current success rate of technology implementation on the mines in percentage?

| | | | | |
|----|----|----|----|-----|
| 20 | 40 | 60 | 80 | 100 |
|----|----|----|----|-----|

8. What type of implementation do you think leads to success?

| | |
|----------------------|--|
| In-house | |
| Partial outsourcing | |
| Complete outsourcing | |

Section C: Written responses

1. What do you think is the biggest problem with logistics?

(a) Material supply?

.....

(b) Trammimg?

.....

2. What (if any) do you think is the biggest problem(s) with the current organisation structure?

.....

3. What do you think needs to be done to improve/ rectify problems identified in 2?

.....

4. What is the biggest problem with your current Management Information System?

.....

5. What do you think needs to be done to rectify this problem?

.....

6. What can management do to encourage cooperation among the different departments?

.....

7. What do you think needs to be done to improve technology implementation on the mines?

.....

8. What do you think needs to be done to improve the vendor solution selection?

.....

9. What are the challenges facing the mining industry?

.....
.....

10. What problems do you experience with:

(a) Total outsourcing.....

(b) Partial outsourcing.....

(c) In-house implementation

Thank you very much, your assistance is highly appreciated.

APPENDIX C: THE MINING HOUSES THAT WERE SURVEYED

1. Anglo Platinum
2. Impala Platinum
3. Goldfields Mining Company
4. Harmony Gold
5. AngloGold Ashanti

APPENDIX D: RESPONSES RECEIVED FROM QUESTIONNAIRE

| STATISTICS | |
|---------------------------------|----|
| A. DEMOGRAPHICS | |
| A.1 RACE: | |
| White | 17 |
| Black | 11 |
| A.2 Gender | |
| Male | 21 |
| Female | 7 |
| A.3 Mining House | |
| Anglo Platinum | 10 |
| Anglo Gold | 3 |
| Harmony | 3 |
| Goldfields | 4 |
| Lonmin | 3 |
| Impala | 4 |
| A.4 Management Level | |
| Senior | 18 |
| Middle | 8 |
| Supervisory | 4 |
| B.1 Logistics Importance | |
| Critical | 23 |
| Not important | 5 |

B.2 Total Lost Blast breakdown

| | |
|-------------|---|
| Logistics | 7 |
| Water | 7 |
| Electricity | 2 |
| Absenteeism | 3 |
| Breakdowns | 2 |
| Air | 7 |

B.3 Logistics Lost Blast breakdown

| | |
|-----------------|----|
| Material supply | 23 |
| Tramming | 11 |

C. Departmental Integration

| | |
|----------------|----|
| Integrated | 10 |
| Not Integrated | 18 |

Will technology improve technology?

| | |
|-----|----|
| Yes | 23 |
| No | 5 |

D Management Information**D.1 Management Information System Problems**

| | |
|-----------------------|---|
| Too many systems | 5 |
| Not accessible to all | 3 |
| Poor input | 4 |
| Not user friendly | 3 |
| Too centralised | 4 |
| Too much information | 2 |
| Poor communication | 4 |
| Non-integration | 3 |

D.2 Information quality

Do Departments get accurate, reliable information

| | |
|-----|----|
| Yes | 8 |
| No | 20 |

D.3 Will tracking technology improve the quality of information?

| | |
|-----|----|
| Yes | 22 |
| No | 6 |

E. Reasons for Technology failure in mines

| | |
|------------------------------|---|
| Lack of end user involvement | 9 |
| Underground conditions | 4 |
| Literacy levels | 5 |
| Resistance to change | 4 |
| Lack of leadership | 4 |
| No incentives | 6 |

F. Outsourcing

F.1 Reasons for outsourcing

| | |
|-------------------------|----|
| Lack of expertise | 14 |
| Costs | 7 |
| Focus on core functions | 7 |

F.2 Preferred Method of outsourcing

| | |
|-------------------------|----|
| Total outsourcing | 6 |
| Partial outsourcing | 15 |
| In-house implementation | 7 |

G. Vendor/solution criteria

| | | |
|--------------------------|------|----|
| Rating of current system | Good | 9 |
| | Bad | 19 |

H. Challenges facing mining industry

| | |
|---------------------------------|----|
| Commodity prices | 11 |
| Productivity | 5 |
| Women quotas | 3 |
| Education levels-for technology | 4 |
| Skills shortage | 3 |
| Legislation | 2 |

