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THE FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT
DEPARTMENT OF QUALITY AND OPERATIONS MANAGEMENT

TITLE: AN ASSESSMENT OF FACTORS INFLUENCING SUCCESSFUL IMPLEMENTATION OF ERP IN A MINING INDUSTRY

(An investigation into the possibility of integrating Oracle ERP system with the Lean Six Sigma philosophy in a mining operation, using them in collaboration with industry 4.0)

Master of Technology: Operations Management
MANTI SILASE
201012080

Supervisor: Dr. Pule Kholopane

THE UNIVERSITY OF JOHANNESBURG
OCTOBER 2018
ABSTRACT

While the importance of Enterprise Resource Planning (ERP) systems is known to mining organisations, these organisations are still distrustful of these systems because of the high risk and cost associated with them. The objective of the study is to evaluate the key factors that affect ERP system implementation in two dimensions, project success and business success. The study aims to help organisations adapt to the danger challenge they are facing, recognise the failures experienced previously, comprehend the gaps to be fulfilled for successful implementation. Also distinguish factors that impact strongly on the success of ERP implementation and the possibility of its integration with other continuous improvement principles such as Lean Six Sigma (LSS).

In this project, it is proposed that despite the fact that they appear to vary, they may be mutually supportive, and the likelihood of their integration is researched. Also the role of Industry 4.0 in mining industry is discussed.

Descriptive and exploratory techniques are adopted in this study to identify critical factors that influence successful ERP implementation in a mining industry. Using this analysis, speculations are hypothesised. To uncover the perceptions on and advantages of ERP and LSS integration, a survey questionnaire is drawn up and administered, with questions derived from the literature. Thereafter, these questions are discussed with a project manager and ERP expert with experience in heading ERP implementation projects in mining organisations.

On the basis of the research findings, the study proposes that it is essential that the factors that influence the success of ERP implementation in a mine are recognised and understood.

The study contributes to the research on the successful implementation of the ERP system in the mines and continuous business process improvement. It adds to the discussion on prototypic key factors that compel both the project and business success dimensions of an organisation.

Keywords: ERP system, critical success factors, successful implementation, information system (IS), Lean Six Sigma principle.

Paper type: Conceptual
AN ASSESSMENT OF FACTORS INFLUENCING SUCCESSFUL IMPLEMENTATION OF ERP IN A MINING INDUSTRY
(An investigation into the possibility of integrating Oracle ERP system with Lean Six Sigma philosophy in a mining operation, using them in collaboration with industry 4.0)

By

Manti Silase

Dissertation submitted to the Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa in partial fulfilment of the requirements for the Degree of Master of Technology in Operations Management 2018
PREFACE

Despite the fact that the ERP system is developing and becoming more predominant, these systems are still relatively unfamiliar to mining business. Successful ERP implementation provides important benefits to organisations, so this issue is constantly viewed as top priority in the research area related to ERP. The Lean Six Sigma approach is considered vital for the improvement of business operational procedures. Although several factors should be considered for effective implementation, yet most mining firms have no idea what factors ought to be prioritised. Along these lines, the primary objective of this research is to help these organisations better comprehend the critical factors that should be considered to guarantee the success of ERP systems. It also considers whether the successful integration of the ERP system with Lean Six Sigma functionalities is useful for achieving the objective.

The lean production concept has its origin in the automotive industry and is broadly used in the manufacturing sector. What makes its applicability in mining difficult is the dynamic nature of mining operations, which brings a high level of uncertainty to different unit operations. To lessen the wastage of efforts, organisations need to remove instability and anticipate the process behaviour as accurately as possible. Moreover, to implement the lean approach in an organisation, the entire chain should be considered, starting from mining exploration and continuing through mine planning, drilling operations, and blasting to loading and transportation, ore dressing reclamation and so on. To be lean in mining is not just subject to production systems that comprise equipment and machines but also relies on quality and reliability of information flow, which progressively produce action plans. Reliability and maintenance readiness also have a real impact on the level of waste being created in the process.

In fact, lean production has its origin in (leans toward) Just In Time (JIT), Total Quality Management (TQM) and Total Production Maintenance (TPM). The common factor of every one of these theories is the human in the process. To enhance any process one needs to quantify the current status so that any adjustment in the status can be recorded.

The most successful industrial development is where the concept of Industry 4.0 is introduced. Since Industry 4.0 commenced several years ago, many organisations have been successful and experienced incremented levels of competitiveness. The application of robotics and automation in collaboration with Cyber-Physical systems, has changed the way they do business.
ACKNOWLEDGEMENTS

First and foremost, I thank God, my provider of strength, courage and wisdom for giving me the ability to undertake this project and carry out this study.

I am proud also to express my deepest appreciation to my supervisor Dr. Pule Kholopane, who has always been supportive in aiding me to produce my best throughout this study and in the Master’s Degree programme as a whole. His valuable thoughtful comments, advice, guidance and positive criticism helped me to remain motivated and focused on the effective completion of this study.

I would also like to thank Ms Khathu Mushavhanamadi, who gave me advice on some of the significant aspects of this work.

I am really grateful to these people.

Additionally, I would like to thank my friends, who have been with me at all times and also made me happy. Finally, a big thank you goes to my family, which has always very supportive of me materially and morally throughout my life.
DECLARATIONS

I, Manti Silase, declare that:

- This work has not been previously accepted for any Master of Technology (MTECH) and is not being concurrently submitted in candidature for any Master of Technology/Master’s degree.

- This dissertation is being submitted in partial fulfilment of the requirements for the Master of Technology of Operations Management.

- This dissertation is the result of my own independent work and experience, except where otherwise stated. Other sources are acknowledged by complete referencing.

..........................................................
Signature
..........................................................
Date
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SECTION 1: INTRODUCTION

1.1 BACKGROUND

Enterprise Resource Planning (ERP) software is one of the quickest developing markets in the software industry. ERP systems are used to manage data over a whole organisation—across multiple departments such as finance, sales and distribution, manufacturing and customer relations management, using an incorporated software application. ERP facilitates the data flow between business functions within an organisation and oversees organisations with outside partners. It can also be used to control various business exercises, such as stock control, order tracking, customer service and human resources (see Figure 1.1). Other distinctive descriptions of ERP are found in Everdingen van et al. (2000), who refer to it as a business-transformation process in: better decision making and performance, enhanced procedures and improved performance, which are the core objectives of most organisations. ERP allows organisations to be ahead of their competitors. It is currently employed in organisations of different kinds and sizes to oversee practices, lessen cost and provide managers with visibility. An investigation conducted by the Aberdeen Group (2000), a market research firm, however, found that organisations ought to distinguish ERP solutions that can be implemented speedily and less expensively, to guarantee a quick return. Chosen solutions that do not meet these criteria may bring about more damage than benefit, particularly with respect to rising potential interruptions. To prevent this, organisations may need to incorporate different standards into the system to improve business process. One such set of standards is Lean Six Sigma (LSS).

Figure 1.1: Typical ERP modules. (Source: Adapted from Wikipedia: The free encyclopedia, (2000), modified 2014)

CRM: Customer Relationship Management
SRM: Supplier Relationship Management
PLM: Product Life-cycle Management
SCM: Supply Chain Management
Lean standards, systematic method for elimination of waste, have been altering the manufacturing industry since they began with the Toyota Production System (TPS). These standards have functioned in nearly all types of manufacturing organisations in recent years and have begun to be used in different industries, including the mining industry. There are two reasons that the mining industry ought to embrace lean principles in its business practice. The first is the diminishing profitability brought about by the increasing cost weights in relation to the social and ecological requirements of sustainable improvement (Humphreys, 2001), which should be compensated for by lessening production cost. Management innovation (e.g. using the lean principles) that has a good reputation for decreasing cost ought to be incorporated into the current management of the mining industry (Klippel et al., 2008).

The second reason is that, like automotive enterprises, mining enterprises (Collard et al., 2007) depend on:

- Effective business forms
- Efficiency inside the value stream
- A broad inventory network (supply chain)

Additionally, both the automotive and mining segments do their outmost to expand operational proficiency and both have to concentrate on wellbeing of their customers.

As the automotive industry has employed these principles successfully, the similarities in these abovementioned factors that these industries depend on indicate that lean principles may be applied effectively in the mining industry.

Numerous organisations in different enterprises have implemented a portion of the standards of lean in an attempt to imitate Toyota’s success; however, only a few have matched the dramatic improvements accomplished by Toyota. The reason for this is that many organisations have incorporated lean tools, but lack an understanding of what makes them interact within a system (Liker, 2004). The lean principles involve not simply adjusting the tool, but rather establishing how to change the entire organisational culture to a genuine culture of continuous improvement. As opposed to the development approach, which focuses on a quick development or change, the lean principles involve a continuous improvement approach that stresses little yet steady enhancements.

In applying the principles to the mining industry, one ought to appreciate that the lean principles make up an operational philosophy in a unique setting (e.g. the automotive industry) with specific qualities, needs and attributes. Mining work takes place in a dynamic, unverifiable, unpredictable and hazardous environment. Dunstan et al. (2006) present contrasts between the resource and mineral processing industry and the car industry; some differences that are related to the mining industry are presented in Table 1.1.
Table 1.1: Comparison of the mining industry and automotive industry

<table>
<thead>
<tr>
<th>Mining Industry</th>
<th>Automotive Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physically challenging environment</td>
<td>Ambient environment</td>
</tr>
<tr>
<td>Geographically spread output teams</td>
<td>Compact plants</td>
</tr>
<tr>
<td>Inherently raw materials</td>
<td>Controlled raw materials</td>
</tr>
<tr>
<td>Remote locations</td>
<td>Large centres</td>
</tr>
<tr>
<td>Inherently variable environment</td>
<td>Stable work environment</td>
</tr>
</tbody>
</table>

Source: Dunstan et al. (2006)

1.1.1. Oracle System

Among numerous systems of this kind emerging in today’s business world, we have Oracle ERP system. The world’s most successful mining companies rely on Oracle technology and applications to get the comprehensive business intelligence they need to improve their processes and maximize profitability. Natural resources companies across South Africa face enormous operational challenges and new economic realities, many of these companies are seeking advanced ways to streamline production and increase operational efficiency. One of the biggest challenges these companies face is reconciling disparate systems including process monitoring and control, sensors and activators and enterprise resource planning. However, Oracle offers natural resources companies an integrated view of the metals and mining process for timely decision-making and improved efficiency of the production process. Furthermore, it helps these companies with;

- Bridging between their enterprise resource planning and plant floor systems.
- Monitoring production performance in real-time, irrespective of the source.
- Running lean, six sigma and compliance initiatives.
- Comparing sites, plants, production lines, equipment and product lines.
- Optimizing operations to improve safety, reliability and productivity.
- Increasing operational effectiveness and efficiency through intelligent operations.
- Managing operations execution.

1.1.1.1. Why Oracle

- Mining companies require comprehensive functionality to address their unique business and operational challenges
- Mining organizations face significant challenges in human resource management as a result of location and work demands
- Equipment maintenance is generally managed at mining sites, but can draw on resources that are thousands of miles away
- Procurement needs vary—involving everything from housing requirements to conveyor belts and hydraulic filter spares—and inventory shortages can spell shutdown
• Complex, globally diverse mining companies need IT system that can drill down into detail and roll up to show consolidated financial information.

1.1.1.2. Oracle In the Mining Industry

• Oracle offers the most complete suite of standards-based tools for integrating and leveraging legacy systems

• Oracle delivers best-in-class financial management and strategic planning tools with unique capital asset modelling for global, diverse organizations

• Oracle delivers best-in-class strategic planning for acquisitions and life-of-mine planning

• Only Oracle’s strategic planning solution is capable of planning from extraction, blending, processing, and distribution

• Oracle delivers a world-class multimodal transportation planning and execution solution

• Only Oracle offers an integrated asset lifecycle management suite linked to production planning and real-time analytics

• Oracle is the only enterprise software provider with a complete set of holistic planning and optimization tools and a complete, open, integrated technology stack from applications to disk.

1.2 THEORETICAL FRAMEWORK

1.2.1 Enterprise Resource Planning (ERP) System

The importance of ERP implementation success may differ across individuals and circumstances. Studies that have investigated the diverse phases of the ERP implementation life cycle have found that the impacts of success factors can be brief because of the change in their relative significance with the move from one phase of implementation to the next (Somers and Nelson, 2004). Studies may also differ in how they measure success. Many studies use objective organisational measures, for example, organisation cost or profit figures, as items for estimating Information System (IS) success (Poston, 2001). Owing to the difficulty of acquiring these kinds of data, however, numerous researchers use self-reported subjective IS success measures. Prominent success measures that are used for studies that focus on innovation and technology acknowledgment by end user are ‘user satisfaction’ and ‘intention to use information system’ (Bradford and Florin, 2003). Markus and Tanis (2000) specify two dimensions in which the success of ERP system implementation can be measured: project success measurement (i.e. meeting project due dates, spending plans and expected performance) and the business success dimension (i.e. business advancements, such as inventory diminishment, cycle time decrease and lessening of marketing time).
In this study, the relationship between identified success factors and the two dimensions recommended by Markus and Tanis (2000) is analysed. The structure recommended in this research attempts to add to the previous studies focus on the factors view of ERP implementation success through two viewpoints.

To start with the study reflects on ERP implementation from the viewpoint of mine organisation practices. The literature on ERP suggests that implementation needs to suit the size and encounters of an organisation, as viewed by Malie et al. (2008) and Aiken (2002). However, the categorisation of organisations is not tracked by official state agencies on the grounds that there is no precise and exact information accessible regarding the number of organisations that fall into every class of the four categories (micro, small, medium and macro). Ntsika (1999) categorises organisations by headcount. An effort was made to address the complex adaptation process required for effective implementation of the ERP system by including factors that relate to both or one of the dimensions; for example, organisational fit, technical fit and business process re-engineering, which are examined briefly in the next section. This structure draws on future research recommendations presented in the last section of this study concerning factors that might reflect diverse implementation environments for such systems.

Second, the study looks at ERP implementation from the viewpoint of the dimensions project success and business success in a mining organisation, as specified beforehand and tests proposed success factors against each dimension. It is not clear from the literature which factors may affect these success dimensions in this sort of industry. There are likewise no observational proofs about the possible role that either of the success measures may have in an incorporated model.

An extensive review of the related literature was conducted to identify critical success factors for ERP implementation. This task was eased by some of the past studies that had been conducted (e.g. Somers and Nelson, 2004, Nah et al., 2001). From these studies, 14 related factors were at first distinguished. Post the review of the literature, using the study by Kamhawi (2007) these factors were narrowed down to ten. The main concern was to incorporate the factors that could be more persuasive to mining firms and to avoid including superfluous comparable factors. The list of the 10 critical success factors was refined to 8 factors that were considered to be more influential. These are discussed later in the second section of this study.

1.2.2 Lean Six Sigma (LSS)

Lean thinking within a business is about looking at all processes as opportunities for cost reduction and customer service improvement whereas Six Sigma is a statistical problem-solving methodology and a management philosophy that dictates that business and process decisions should be based on data. Its fundamental goal is to reduce operational variance by improving the overall quality and performance levels of business processes. Even though lean thinking provides the companies to eliminate
waste from their business processes, it falls short of increasing quality of the products and services because of focusing more on speed of the business processes. Womack and Jones (2003) propose five lean principles. These are outlined below.

1.2.2.1 Identify customer and specific value

The essence of this principle is to distinguish the specific value of the end customer in terms of the most vital features of the market offering. The complexity of this principle is that there may be slightly opposing views regarding this value within various market sections. The inability to identify the value of the end customer precisely may bring about profoundly wasteful operations that do not completely convey the desired value and, as a consequence, undertake non-value-adding activities. In terms of this principle all non-value-adding activities can be targeted for exclusion.

1.2.2.2 Identify and map the value stream

The value stream is the entire set of activities across all parts of the organisation required in jointly conveying the product or service. This embodies the end-to-end process that conveys the value to the customer. Non-value-adding activities ought to be modified or eradicated from the process.

1.2.2.3 Create flow by eliminating waste

Flow is created by outlining the process and establishing capacities that empower constant development throughout the procedure with no disruption, deviation or waiting, by eradicating waste.

1.2.2.4 Pull

Pull implies meeting customers’ rates of demand without overproduction. No action is taken unless the result of the action is required downstream.

1.2.2.5 Pursue perfection

The eradication of non-value-adding factors (waste) is a procedure of continuous improvement. It is a steady striving to enhance value specification, challenge the steps in the value stream and increase the speed in the flow so that hidden waste can be identified and eliminated.

The basic beginning stage of lean thinking is value. Value must be characterised by a definitive client (Kulasooriya, 2010). It starts with a concise attempt to define value accurately in terms of a particular product with particular capacities offered at a particular time at a particular cost through a dialogue with explicit clients. Value is created by the producer, and, from the client’s point of view, this is the reason a producer exists (Womack and Jones, 2003). Everything that does not add value to the product is waste that the client is not willing to pay for. Waste ought to be eliminated to create value flow. The lean principle initially distinguished seven sorts of waste, which are known by the acronym WORMPIT: Waiting, Over Production, Repair, Motion, Processing (over), Inventory and Transportation.
Later, another kind of waste – 'Human Talent' – was added. Waste is now known as 7 + 1 waste.

1.2.2.5.1. Lean’s 8 wastes in Mining Industry

**Waiting**
Inappropriate conditions/working environment, e.g. lack of ventilation for dust and gases removal (Klippel et al. 2008a), due to unavailability of machines and spare parts (Chlebus et al. 2015), equipment breakdowns and plant downtime (Dunstan et al. 2006; Oware et al. 2015), maintenance downtime and unscheduled shutdowns (Indrawati and Ridwansyah 2015), equipment failures (Dunstan et al. 2006).

**Overproduction**
(Flynn and Vlok 2015), due to mining capacity to outstrip ore processing, continuous production with push system (Dunstan et al. 2006; Chlebus et al. 2015)

**Defects (repairs)**
Rework/repair (Dunstan et al. 2006; Oware et al. 2015), quality of raw materials (Indrawati and Ridwansyah 2015), equipment failures (e.g. fluid leaks) (Dunstan et al. 2006), physical material waste (Flynn and Vlok 2015)

**Un-necessary Movement (motion)**
Inefficient location of instruments (Dunstan et al. 2006; Klippel et al. 2008a), transport material unavailability, non-compliance of workers (Indrawati and Ridwansyah 2015), walking of operators (Flynn and Vlok 2015).

**Over/ incorrect processing**
Performance of tasks by one employee instead of parallel operations, auxiliary equipment preparation (e.g. drill sharpening, cleaning operations), process method (e.g. dry drilling taking more time for processing compared to wet drilling) (Klippel et al. 2008a), incorrect processing due to equipment breakdowns or failure (Oware et al. 2015), inefficient use of materials (Indrawati and Ridwansyah 2015), over processing to better grade ore than the customer willing to pay (Dunstan et al. 2006).

**Excess inventory**
High inventory of spare parts (Chlebus et al. 2015; Flynn and Vlok 2015), inefficient inventory management (stockpiles/ shortages) (Dunstan et al. 2006)

**Unnecessary transport and conveyance**
Inefficient layout for transportation (Garza-Reyes et al. 2016), stockpile material transportation (Indrawati and Ridwansyah 2015), inefficient movement of extracted ore until it reaches final destination (Dunstan et al. 2006), long distances (Flynn and Vlok 2015).

**People**
Unskilled labour (Indrawati and Ridwansyah 2015; Oware et al. 2015), inefficient shift schedule (Indrawati and Ridwansyah 2015), absenteeism (Dunstan et al. 2006),
incorrect assignment of people to tasks (Klippel et al. 2008a), improper communication (Castillo et al. 2015; Flynn and Vlok 2015)

Lean standards are set out in a structure known as The Lean Temple, (See Figure 1.2)

![Figure 1.2: The Lean Temple (Source: Knowledge Management and Transfer, 2009)](image)

The temple (otherwise called House of Toyota) foundation comprises three blocks. In the first block is TPM (Total Productive Maintenance) and QCO (Quick Change Over). The aim of TPM relates to an equipment-breakdown-free state, where operators perform routine maintenance and a maintainer is in charge of scheduled maintenance. QCO’s aim is to shorten production downtime during operational change or planned maintenance. The second block is standardisation, which concentrates on procedure/standard improvement. The third block is the 5S (i.e. sort, set in order, shine, standardize, sustain) and a web program-based software application, which mainly focuses on working environment assurance, organisational wellbeing and productivity. “There can be no kaizen [an approach to creating continuous improvement] where there is no standard” (Taiichi Ohno, cited by Sehested & Sonnenberg, 2011). The temple has two pillars: the first is Just in Time (JIT), which is the philosophy of processing or transporting the right part, at the right amount and quality, to the right place at the right time. The second pillar is Jidoka or automation with a human touch. On the rooftop is the core of Kaizen or continuous improvement. In the heart of the temple is regard for people, which implies that workers are the centre of the action.
1.3 PROBLEM STATEMENT

ERP has had a difficult beginning, with a few ERP project failures and a great scarcity of skilled and experienced workers. An ERP system is extremely costly to implement and, thus, it is exceptionally costly to fix the changes it makes to the organisation (Mabert et al. 2003). Using the ERP life cycle structure to break down the system’s implementation, 10 critical factors were distinguished and 3 implementation problems are summarised here: (1) poor consultant effectiveness, (2) uncertain project management viability and (3) low quality of business process re-designing. Unfortunately, it is evident in the current literature that the implementation failure gap remains uncertain, which leads to a requirement for research such as the current study.

Numerous organisations that are considering embracing an ERP system are worried about failure of the project. Many mining firms are aware of how useful ERP systems are, but are hesitant to embrace these systems because of the high cost and risk (Davenport, 2000). A study conducted by the Gartner Group, the world's leading information technology research firm, demonstrated that 75% of all ERP projects fail (Warren, 2016). This has affected the decision to use an ERP system in numerous mining firms. This study therefore attempts to lessen the chances of failure through assessing the key factors that affect ERP project success in mining firms. The intention of the study is to help companies cope with the failure threat challenge, recognise past failures and understand the gaps to be filled for effective ERP implementation, and distinguish and understand the factors that affect the success of ERP implementation (cf. Umble, 2000). Likewise, the study aims to ensure positive ERP implementation by providing elements connected with the success of ERP system in the mining business. Moreover, the study presents proposals to South African mining organisations regarding which implementation success factors to consider when embracing ERP to achieve global competitive advantage.

It is vital to monitor practices while business is being conducted and every concern ought to be dealt with to prevent the degrading the work process. Along these lines, Japanese business managers have produced some of the continuous improvement systems used today, such as Six Sigma and lean thinking. Their need for continuous improvement is driven by the need for productivity in today's global business world which is a standout amongst the most imperative issues that the majority of the organizations ought to think about. The lean manufacturing approach focuses on the elimination of waste and the Six Sigma system for business excellence permits top managers to modernise their business practices while expanding the quality of business procedures, products and services, to intensify profitability. This enables organisations to become profitable in a competitive business environment. Girenes (2006) argues that there are insufficiencies inside these individual techniques. He suggests that while lean concentrates on eliminating flaws from the business processes, it does not take the quality aspects of the organisations into consideration. Six Sigma presents a cure for these defects. The study examines factors that have an
impact on the successful implementation of ERP in the mining industry, explores and clarifies in detail the approach of coordinating ERP system functionalities with LSS rationality and provides reasons regarding the advantage to a mining business of using them in collaboration with Industry 4.0.

1.4 PURPOSE OF RESEARCH

Being lean in mining is not just subject to a mine production system that comprises hardware and machines. It additionally relies on the quality and dependability of information flow in producing a continuous operation plan, which can be functionalised by an ERP system. The purpose of this study is to investigate factors that affect ERP implementation project success and research the possibility of integrating the ERP system with the LSS philosophy and the advantages of this integration for the mining business. The study examines ERP implementation failure with the aims of recognising key factors for success, lessening the level of threat for mining firms that are considering this system, decreasing the likelihood of failure and enhancing the system for improved business excellence. It also highlights the issues connected with the implementation of lean standards in the mining industry.

1.5 RESEARCH QUESTIONS

1.5.1 Primary Research Questions

The study seeks to answer the following primary research question.

- Is there a possibility of coordinating the ERP system and LSS strategy for enhanced business process, in collaboration with the principles of the immerging industry 4.0?

1.5.2 Secondary Research Questions

This study answers questions that arise around the issue of the successful implementation of ERP and its integration with LSS strategy. To establish what factors are critical to project success relies on responding to three questions:

- Why do ERP projects fail?
- What are the basic factors that affect the effective implementation of ERP in a mining firm?
- What are the variables that prompt successful project management?
- What elements point to an effective ERP implementation project?
- What factors promote reliably successful implementation projects? (Davies, 2002)
- What are the benefits of ERP, LSS and Industry 4.0 coordination for a mining organisations?

In addition, open-ended question to be addressed is:

- What are the components that promote effective implementation of LSS?
1.6 HYPOTHESES

The following arguments are proposed on the basis of past studies and the recommended research model:

**A1:** Technical fit of the retained system with the new ERP system will impact heavily on ERP implementation success.

**A2:** Organisational fit between the ERP system firmly fixed reference process model and the organisation's specific context will have a heavy impact on ERP implementation success.

**A3:** The level of business process reengineering to best practices of an ERP system will impact heavily on ERP implementation success.

**A4:** Top management support for the ERP system will impact heavily on ERP implementation success.

**A5:** Project planning to best practices of an ERP system will have a heavy impact on ERP implementation success.

**A6:** User participation/involvement and training due to the perception of the convenience of the ERP system will have a heavy impact ERP implementation success. The level of training workers regarding an ERP system will make it simple for them to utilise the system along these lines, increasing their involvement.

**A7:** Organisational resistance to an ERP system will have a heavy impact on ERP implementation success.

**A8:** Effective communication within the project members, the entire organisation and service provider will impact heavily on ERP implementation success.

**A9:** ERP project success will impact moderately on the relationship between ERP critical success factors and ERP implementation business success.

It is not clear which critical success factor impacts distinctively on either of the two dimensions of success, project and business, in the mining organisation since the theories do not indicate which dimension is focused on. Independent factors therefore are tried separately on each dimension.

1.7 SIGNIFICANCE OF THE RESEARCH

This exploration has implications for mining firms and project managers in that it demonstrates the factors that are perceived to be strongly influential on ERP system implementation in both the project and business success dimensions. It also highlights the essential benefits of ERP integration with the LSS strategy. The concern for uncovering the benefits of an ERP implementation stems from the fact that ERP failures are generally related to the deployment of ERP rather than to the system itself. If project managers embrace the critical success factors of both project management and ERP implementation, then the organisation can profit from what ERP can offer.
and there is a high level of threat to embrace this system. The justification for using an ERP system is that it can replace the organisation’s legacy system with one incorporated system that reduces operational expenses, while the LSS standards help the organisation to achieve business excellence through the elimination of waste, which enhances the output quality of its procedures and streamlines its business processes.

The implementation of an ERP system does not just empower organisations to resolve their business needs but permits them to add on different functionalities that it has built in for more effective integration. For instance, various countries have diverse laws and approaches and the ERP system can help them to keep principles and controls set according to the nations they operate in as a built-in functionality of the system. It can also enable them to satisfy their administrative obligations and enhance their business procedures and economy both in South Africa and around the world.

This review contributes to the growing body of literature on factors that affect the effective implementation of ERP systems in the mining business, the improvement of continuous business processes and prototypical key factors that are influential in both the project and business success dimensions.

1.8 ASSUMPTIONS

Integration of the functionalities of ERP as information management system and LSS as a business improvement strategy is potentially an extremely useful initiative for mining organisations. ERP systems provide software programs to organisations for managing their data systems while the LSS strategy helps organisations to accomplish business success by eradicating waste from their organisations, enhancing the quality of the outputs of their procedures and streamlining their business processes.

While different factors are significant predictors of ERP implementation success, they are not all perceived to be influential. Not all factors that are perceived to be influential in the mining business would be so in another industry (e.g. manufacturing) or across all mining industries (e.g. copper, coal, platinum and so forth) nor would they be compelling in both the project success and business success dimension at the same time.

1.9 LIMITATIONS

The study has a number of limitations. The first restriction of this study is the sample size owing to the nature of the small population the research was conducted in. Secondly, there could be concerns over the authenticity of information gathered through questionnaires. To counter this, an interview approach was used to support the results from the survey and to provide stronger ground for proclaiming any of the factors influential. The questionnaire is an information-gathering instrument; however, it is constrained by the fact that, while the factors are ranked by relevance, when descriptive analysis is conducted this data is presented in numerical form, relating each factor with each other based on their frequencies and overall mean. So to
research the genuine causes behind the importance of these factors, secondary analysis was conducted that involved interviews so that the significance and causes of the factors could be verified. Thirdly, the study was initially planned to be a comparative study of the mining industries in South Africa and Zambia. However, obtaining travelling funds to the sites to extract real-time reliable information for strong ground analysis was a restraining challenge for the researcher. For this reason, the scope of the study was limited to various mines in South Africa.

Research has sometimes demonstrated mixed results when applied practically. To clarify this further, it can be challenging to analyse data from literature on technologies that are applied practically. However, this did not constrain the scope of this study, as the survey and interviews were conducted to support the study’s arguments.

1.10 DELIMITATIONS

The initial aim was for the study to be a comparative investigation of the South African and Zambian mining industries. This was driven by the recent successful implementation of the ERP system in Mopani Copper Mine in Zambia. However, this proved to be an extremely wide scope in relation to obtaining data on the Zambian mining organisations. Consequently, the scope of the study was reduced to mines in South Africa.
1.11 ORGANISATION OF THE RESEARCH

INTRODUCTION

SECTION 2: LITERATURE REVIEW
- ERP
- LEAN SIX SIGMA

SECTION 3: RESEARCH METHODOLOGY
- Quantitative research
- Structured face-to-face interviews
- Questionnaires

SECTION 4: DATA ANALYSIS
- Perspective about ERP implementation success factors by the experienced manager who lead ERP system implementation project and end users in the mining company

SECTION 5: DISCUSSION
- Relationship between ERP and LSS in relation to mining company
- Possibility of ERP and LSS integration with mining functionalities

CONCLUSION
SECTION 2: LITERATURE STUDY

2.1. INTRODUCTION

In this section the literature is extensively reviewed to analyse critical success factors for ERP system implementation, critical questions to ask before choosing an ERP solution and how to utilise technology to support the lean enterprise. The work done in this study is organised in the ascending order (i.e from older years to the most recent). Glatthorn and Randy (2005) states, "This is an effective approach to compose a literature review that builds a picture for reader to know where the issue stands as of current, where it began and how this study will contribute to it.

2.2. REVIEW OF LITERATURE

2.2.1. Enterprise Resource Planning project failures

ERP Projects are tedious and include a great deal of complexity during implementation. Research conducted previously has demonstrated many instances of failure in the implementation of ERP systems. Authors who have dealt with the comparable studies express that the implementation of ERP systems solves the fragmentation of information in organizations, and the entire flow of data is coordinated in the process. Irrespective of the implementation of ERP systems benefits, the failure rate is very high and it was reported that 40% of ERP implementations failed to meet its objective in a survey conducted in 117 organisations. ERP package cannot be installed like an operating system on a computer because it is a semi-finished product that requires customization and configuration. Different researchers have confirmed that organisations which regarded ERP as an off-the-shelf product have estimated that no less than 90% of ERP projects have been late or over the evaluated budget. ERP project are complex because of the level of business integration that is involved. Organizations that have not embraced the proper approach in the implementation of ERP project have experienced real challenges. This variable has added to the failure of these projects. Among different factors there is business process re-engineering (BPR). Organisations need to re-design their core business processes against the supporting business processes of the ERP package. As indicated by Markus and Tanis (2000) configuration is about mapping the functionality of an ERP package to the business procedures of an organisation. Unfortunately, 70% of BPR projects come up short as per Greasley and Barlow (1998). BPR without correct planning can prompt to the general failure of ERP projects.

ERP failures cannot be characterized in one concluding statement that this component is the reason for failure. The failure relies on upon numerous points of view and many factors and along these lines this study plans to investigate those factors that if excluded from ERP project implementations, then the entire or part of the project can be a failure. This can be utilized as a guide for mining organisations considering embracing and enhancing ERP, Markus et al (2000). It is an extremely complex issue since it simply relies on upon various points of view from various partners. Markus and Tanis (2000) expressed that ERP failure is assessed at many levels, for instance completing the project on time will be seen by the project manager as the entire project being effective but that is a bit much from the partners' viewpoint. For instance the
organisation who implement ERP to accomplish better performance still was not able to accomplish that even after the implementation, so from the organisations viewpoint it is a failure.

ERP system inability to manage the essential activities, considerably more business related, will not bring about significant benefits for the entire business. Cesare de (Tomi et al 2004) expressed that a standard ERP package cannot be viewed as a genuine enterprise system for mining organization. It can be perceived to lack functionality to fit the mining requirements since none of the mining organizations they studied utilized ERP modules as a part of production, production planning, outbound logistics, sales or the business primary activities. This matches Laurindo and Mesquita (2000) statement that ERP implementations involve only administrative modules and non-productive ones. Cesare de Tomi et al (2004) observed that ERP system fit extremely well with the supporting activities such as finance, supplies, maintenance and material – mostly non-productive – and HR.

In year 2009, attempts were still being made to fill the gap, as per Mao and Pan (2009) who attempted to fill the similar gap in ERP implementation. Among the ideas highlighted, it was concluded that brainstorming can be exceptionally effective in ERP Implementation to advance user participation. This shows that there is a solid need to investigate the key factors affecting ERP project failures that different organisations can use as a guide during ERP project implementation, which this study aims to investigate. Despite the efforts made by different authors to settle the missing gap and the attempts made by different researchers as discussed earlier, there is a clear justification for this study to be conducted to attempt to determine the missing gap and enhance the existing ERP system in the mining business.

This issue of ERP project failures is an extremely questionable subject in literature that has turned into a key area of interest for many researchers who have done a great deal of work in this field:

"By implementing ERP system we've been able to create a shared service center for our finance and HR functions, establishing consistent, high business process and reducing operational costs" (Yurik Shekhovstov, 2011). This supports exploration of an ERP implementation using a package and that ERP could significantly affect an organisation's knowledge creating capacities. It likewise supports that managers ought to apply ERP in a sensitive and judicious way, as opposed to be driven by its capabilities.

An investigation of organisations completed on effective upgrade of an ERP system proposed a reasonable structure of ERP implementation process and expressed six critical factors for success: (1) clear objective statement, (2) good communication and coordination with implementation partners, (3) intensive management of customization, (4) planning for system requirements, (5) role re-definition amongst business and IT divisions, (6) total involvement of the entire workforce. These give general guidelines to ERP implementation. This is the issue and gap between previous work and existing failures that there seems to be no single point of view from which an individual i.e. project manager or an organisation can benefit from to avoid failure.
Success from each point of view is impossible; in this way, success must be achieved through individual viewpoints all together for general success.

From a South African perspective on failure of ERP, project failures continue happening in spite of research that began over 10 years back on the critical success factors of ERP implementation and which has been repeated several times since then. The fundamental drivers and objectives are business-related and majorly affect people, procedures and culture. "Some imperative non-technical aspects of ERP projects were recognized early on large, complex projects, including large groups of people and different resources, cooperating under time weight and facing numerous unexpected developments.", Alleman and Krigsman (2012).

2.2.2. ERP in a Mining industry

Mining is part of Process industry that includes about half of the manufacturers around the world. It is a huge capital intensive enterprise, with heavy hardware and huge plants. To accomplish the best return on assets, considering it's a capital intensive business, mine equipment and plants typically run 24 hours a day, 7 days a week. Along these lines, the fundamental focus for any ERP in this industry ought to be keeping the sizeable hardware and plants running, through effective capacity and maintenance management. Consequently, avoiding idle time by employing accurate production schedules, and maintaining a strategic distance from unforeseen breakdowns by planning preventive and predictive maintenance undertakings, are vital aspects for the business performance.

ERP system for the mining business is intended to supplement and upgrade operation effectiveness, optimize cost management and enhance customer relations and service, Paulo (2004). It likewise offers the accompanying;

- Easy integration with computerized maintenance management systems (CMMS)
- Permits full capacity to enhance quality control through tracking and substitution of any unreliable materials. It caters for tracking of materials through their receipt, producer, assembly, inspection, stocking and distribution, while keeping up quality guarantee certification and tracking expiry dates. It also manages item reviews productively and successfully through all transactions
- Enables the reduction of inventories and enhanced capacity utilization
- Addresses the nature of the business through the providing up-to-date, real-time data in regards to the estimation of all benefits inside the organisation. It does this by keeping a record of deterioration and current resource values.
- Facilitates consistence with local and global environmental and safety regulations
2.2.2.1. Mining Industry (ERP and CMMS) Features and Functions

This learning base incorporates enterprise resource planning (ERP) and computerized maintenance management system (CMMS) modules designed for the ordinary requirements of organizations in the mining business, Technology Evaluation Centre (2013). They incorporate vital criteria for financials solutions and human resources (HR). It also has additional process workflow, quality management, field service. Furthermore, other criteria, such as, maintenance management, manufacturing management, stock management, sales management, buying management, project management and product innovation.

2.2.3. Benefits of ERP system in a mining industry

In 2007, Aberdeen Group conducted a survey on the reasons behind implementing ERP system. On the basis of the responses of 1,400 manufactures, the following statistics were found;

- availability of low-cost alternatives that minimize risk: 41%
- pressure from clients or suppliers for data and coordinated effort: 40%
- explosive development: 33%
- growth beyond a predefined limit: 29%
- regulatory consistence requirements: 25%
- disastrous event that demonstrated ERP is essential to operate effectively: 18%
- mandates from the parent organization: 11%

In many mining organizations, each department/unit has its own particular manner of measuring outputs, which regularly is incompatible with legal or shareholder requirements, Satenstein (2008). An enterprise resource planning (ERP) system permits every division to utilize its own particular reporting measures. The ERP software transforms information bi-directionally to the standard (legitimate) business reporting. However, it is this utilization of different strategies by departments that causes confusion within the mining organisation.

If every department had its own particular business system (as was the case before economical computing), the issues would show themselves as: numerous inconsistent product measures, lack of timely information exchange, difficulty incorporating spreadsheets with computer systems, trouble converting data from one measure to another, problem with audit capacity, and poor capacity to respond to business or government requests, Satenstein (2008). To avoid these problems and to have the capacity to perform financial month-end within days, there must be some constant system that each group utilizes where the yield at each mine is converted to a standard measure. A modern ERP system meets these business needs, and gives various benefits as well.

Satenstein states that the main advantage of any ERP system is that it is a comprehensive, real-time system. Some business parameters are fixed, while others,
such as, currency conversion are date stamped. An ERP system has all the transactions customized for continuous updates. An invoice, payment, mineral shipment, or purchase shows up immediately on the balance sheet. Each division can make use of the organization's up-to-date information.

2.3. LEAN SIX SIGMA (LSS)

"Lean is a theory that is focused around shortening the course of events between the client request and the conveyance of the service by eliminating waste." (Shaffie and Shahbazi, 2012) According to Sunder (2013), "lean thinking increases production efficiency by reliably and thoroughly eradicating waste". Similarly, Girenes (2006) demonstrated that lean management is a consequence of that investigation: How could client request be responded to in the shortest time by utilizing least resources and giving the least expensive and defect-free process. Likewise, she added that it is additionally a response to the question: How could an organization's potential benefits all be used by utilizing all manufacturing and avoiding waste. Nauhria et al (2009) characterized lean manufacturing as "recognizable proof and elimination/minimizing of a wide range of manufacturing wastes" as well. They underlined that lean manufacturing "synchronizes production levels to actual client demand". Sheldon (2005) drew people’s attention to that point: "Lean thinking within a business is about looking at all processes as opportunities for cost reduction and client service improvement". As indicated by him, "without lean, proficient supply chain management cannot exist".

Launching a business which is based on brilliant idea does not ensure accomplishment. Business procedures ought to be monitored while leading the business and each problem ought to be attempted to be avoided before they degrade its work process. In that case, some continuous improvement strategies, such as, six sigma and lean thinking have been developed by Japanese business managers. The motivation behind why they have been required is on account of efficiency in today's worldwide business world is a standout amongst the most critical issues which the majority of the organizations ought to consider. Lean manufacturing approach concentrated on eliminating waste and Six Sigma methodology for business excellence permit top managers to streamline the business processes while increasing the quality of business procedures, products or services, which thus increase the efficiency. Along these lines, organizations get to be distinctly profitable in a competitive business environment. Nonetheless, there are inadequacies inside every individual strategy as indicated by Girenes (2006). Girenes (2006) expressed that while lean concentrates on removing defects from the business process, quality aspect of those organizations are not commensurately considered. By then, six sigma remedies that deficiency.
2.3.1. Lean Six Sigma in a mining industry

Product and customer have exceptional qualities in the mining business. Therefore firstly, to apply the lean principle in the business requires comprehension of value based its customer demands (Laurindo et al, 2004). Products got from mining industry are standard products that have very well defined specifications and requirements. Market is the determinant of quality and cost and there is no diversity between enterprises. Transactions occurs in stock market without direct contact between mining industry as product supplier and the buyer. In a more extensive view, mining industry has indirect customer (stakeholders) who passively and actively contribute in the role of business. The significant interest of their customers is the quality behind the product (i.e economic success of society, human well-being, environment, etc) not the product. International Council on Mining and Metal (ICMM) in its vision has articulated these necessities as the current value of mining industry. "Respected mining and metals industry that is broadly recognized as fundamental for society and as a key contributor to sustainable development" (ICMM, 2009).

The second step in lean application is characterizing waste and its counter measure. The 7+1 waste in the mining is described as follows;

1. **Wait**

The major cause waste in mining is the waiting period in the blasting. Because the activities in the mining organisation are subject to each other, all activities have to stop during this period. Another waiting waste is idle time of mobile equipment. Its utilization in underground mining is low due to trade-off between use of mining face, work force and mobile equipment.

2. **Over Production**

This is not an issue in the mining business because of the stability in its market, unlike automotive industry. Despite the volume of the product, the market can always absorb.

3. **Rework**

Repair/rework in mining is not just due to imperfect work but also because of the nature. The risk involving repair/rework is high because of potential accidents and cost related. Dynamic unstable environment introduce consistent probability for rework and that cannot be avoided.

4. **Motion**

This is the movement of equipment or people that adds on value. This sort of waste in mining is identified with how the work is done. At present, the new operators are trained casually by mentoring the system. Due to the change between experienced operators and trainees, a standardized method is not acquired, thus the certification system is not applicable.

5. **Over Processing**

The work performed on a product that adds no value is a waste. In mining the most visible over processing waste is the dimension of the tunnel. It is basic to observe that
the dimension of a tunnel is surpassing required dimension. This is not created by unstable rock only rather over work in facing work as well.

6. **Inventory**

Pointless raw material, work-in-process (WIP), completed merchandise and excess operating supplies add no value and are wastes. *This* kind of waste is hard to resist in mining. Especially higher cost of downtime compares to cost of inventory, make it ordinary to trust that inventory is certain. (Laurindo et al, 2004).

7. **Transportation**

This sort of waste manages the decision of method of transportation, type of material transported, pick-up location and equipment sizing.

8. **Human Talent**

Underutilization of human resources is in terms of working hours, capacity and capability is a waste.

It ought to be comprehended that lean principle, in its unique setting, is a working philosophy that has specific qualities, needs and attributes. This ought to be taken into consideration in applying it in a mining industry.

2.3.2. Benefits of Lean Six Sigma in a mining industry

Throughout the years, Six Sigma and Lean have worked their approach to wind up distinctly the preferred instruments for business improvement. While their foundations started in manufacturing, numerous different enterprises are additionally recognizing its rewards. The mining business is the same. Faced with rising operations cost and huge demand for resources, more mining organizations are currently considering how to eliminate waste and enhance processes. The rewards of Six Sigma are not just restricted to more proficient operations. Ultimately, organizations are recognising direct enhancements in their primary concern.

Fresnillo, the world's biggest essential silver producer and Mexico's second biggest gold producer credits the implementation of Six Sigma with helping it accomplish record silver and gold production during the last quarter of 2010.

"Our newest gold mine, Soledad-Dipolos, was an essential factor in this excellent performance, and in addition productivity measures at our mines and the implementation of the six sigma management tool enhancements," CEO Jamie Lomelin said.

The 2010 Sustainable Development report from New Zealand Aluminium Smelters Limited, which possesses the main aluminium smelter in the nation, estimates they made savings of NZ$18.7 million during the year as a consequence of its Lean Six Sigma initiatives.

While a few organisations are setting aside time for the consequences of business improvement measures to be fruitful, Newmont Ghana has anticipated savings of up to $3 million – just a while after Lean belt training was given.
Different initiative to yield from business improvement programs like Six Sigma and Lean incorporate minimised shutdowns, increased production and expanding opportunities to hit annual plans. Plainly, there are plenty of different opportunities for mining organizations to benefit from Lean and Six Sigma. In any case, their implementation will not generally yield prompt outcomes. The vital fact to recollect when setting up these business improvement procedures is that they do not come overnight and effective implementation requires the support of the entire organisation.

"Six Sigma is an exceptionally major change in the way that we structure our work, actively engaging, actively involving and actively communicating with our people." Rio Tinto's CEO Sam Walsh expressed, (2008)

2.3.3. Integration of ERP system and Lean Six Sigma

Despite the fact that these standards are valuable for the organizations independently in order to accomplish the business excellence, both ERP Systems and Lean Six Sigma Methodologies have inadequacies in themselves. All things considered, it appears that they could supplement each other. There may be a few issues/challenges in this adoption process mentioned before. By then, they may be solved through Lean Six Sigma Methodologies and the organization's implementation procedure may be streamlined. In that case, Kimberling (2012) demonstrated that in spite of the fact that the organizations which have six sigma teams adopt lean standards, they cannot use their ERP system appropriately on account of not having the capacity to convey quantifiable business value. They simply invest their time and money to their ERP systems. In this circumstance, Lean Six Sigma tools may be useful for the organization staffs responsible in order to measure the business value of an ERP system and its shortcomings' effects to the implementation procedure.

Then again, an ERP system may be a capable repository that could give a stage to a Lean Six Sigma team for monitoring their state of affairs. On the other hand, they could likewise access historical information that could permit them and top managers to compare after-implementation circumstance and before-implementation circumstance. Along these lines, "how much could the Lean Six Sigma project enhance the business?" could be measured both subjectively and quantitative.

"A well implemented ERP system is the establishment on which an effective Lean Six Sigma program can be assembled." (Nauhria et al (2009). They further indicated that ERP facilitates detailed information about efficiency, quality and yields, which can be correlated with different parameters, such as, inventory level, margins, expenses and process conditions". "Lean Six Sigma is a philosophy that maximizes stakeholder’s value by accomplishing quickest rate of improvement in consumer satisfaction, cost, quality, process speed, and invested capital".
2.4. CRITICAL SUCCESS FACTORS

The concern of this study is to incorporate the factors that could be more influential to the mining business. To avoid the unnecessary similar factors, the last refined list that included 8 factors distinguished by Somers and Nelson, 2004 is utilized and discussed below.

2.4.1. Technical fit

ERP is an extensive software package which coordinates the total scope of business procedures and capacities presenting an interconnected perspective of business from a single information technology architecture. Many firms have old stand-alone applications which do not enable them to communicate with each other within the organisation or with outside clients and suppliers with large systems that ease the enterprise-wide integration. Accordingly ERP system supported in this corporate computing shift. In this case a technical fit is a fundamental element for incorporating the old system existing in the organisation with the ERP system/technologies. Bradford and Florin (2004) in their study of the effect of this factor as an innovative characteristic found a confirmation that it impacts ERP success.

2.4.2. Organisational fit

It could be characterized as an agreement between the organisational artefacts of ERP (i.e physical objects, informational objects or conceptual artefacts) and it's context. The variety in interests between the organisation embracing the ERP system and the system vendor who generic solution relevant to broad market creates "organisational misfit", Kumhawi (2007). Infusing the culture of an organisation in the organisational artefacts yields development in culture, May and Taylor (2003). Therefore the agreement between these artefacts and the context yields culture development in an organisation. A culture with shared values and common aim is conductive to achievement since it emphasises quality and empowers the eagerness to acknowledge new technology. It would significantly help in implementation efforts. Organisation ought to have a solid corporate character that is open to change, (Kuang et al (2001). The innovative open organisational culture will facilitate the user participation throughout the entire implementation process. Then again, an organisational culture that is not supportive of organisational learning and data sharing will demoralise workers from discussing the possibility of failure of new systems implementation.

2.4.3. Business Process Re-engineering (BPR)

This is related with the alignment between business processes and the ERP business model and related best practices. This process will permit the improvement of the software functionality as indicated by the present and future organisation needs. Managers need to decide if they do business re-engineering before, during or after implementation. Vendors dependably suggested keeping the ERP package unique ("as is") for optimal development of good effect of the package and to avoid the technical complexity of customizing the package and the future technical problems in introducing the product and updates, especially in phased implementations of these system. Preserving the original ERP software usually come on the expense of difficult
reengineering process, especially in basic and thorough ERP implementation strategies. Therefore, organisations that have better abilities in reengineering their business processes will most likely experience smoother implementation of ERP systems.

2.4.4. Top Management Support

Sustained management commitment, both at top and middle level during the implementation, in terms of their own involvement and the willingness to designate important organisational resources (Holland et al. 2000). Management support is critical for accomplishing project objectives and targets and aligning these with key business objectives (Sumner 2000). This is the element that always cited as the most important success factor in IS implementation projects. Many studies gave confirm that show of how top management support is required during project implementation and how remained critical for developing and understanding the benefits of the system, (Kanhawi, 2007).

2.4.5. Project Planning

Quickly planned projects may save time and money in the beginning, but in the end the results will be poor, more expensive and time consuming. Adjustments and corrections will become necessary in order to make the software operate properly. ERP implementations are complicated and risky projects. They require large scale business process engineering, complex arrangements to adapt with any existing or future software of the core ERP technology and good management for different contributions from the functional departments, consultants, business partners and vendor involved in the project. All these requirements and more magnify the project management challenges for such undertaking, making them implementation failure-prone (Sadoe et al., 2001). Project planning which refers to the extent to which timetables, milestones, workforce, equipment and budgets are specified becomes crucial in this type of complicated project environments. This factor entails the following;

2.4.5.1. Project manager selection

In order to guarantee that project objectives will be met, project manager selection is vital. The person ought to have the right skills and experience to permit them to be effective; this is essential to having a successful implementation of ERP system.

2.4.5.2. Adequate project team organization

A project group ought to consolidate all capabilities and skills that are expected to be significant during the project. This may imply that the project team is formed by individuals with different educational foundations, abilities and professional experience. ERP projects commonly require some combination of business, information technology, vendor, and consulting support. The structure of the project team has a strong effect in the implementation procedure. Two critical factors are the integration of third party consultant within the team and the retention within the organisation of the relevant ERP knowledge.
2.4.6. User participation and Training

User participation refers to the conduct and activities that users perform in the system implementation process. User involvement refers to a mental condition of an individual, and is defined as the significance and personal relevance of a system to a user (Kanhawi, 2007). User involvement and participation will result in a superior fit of user requirements achieving better system quality, use and acceptance. The degree to which ERP system is perceived to be free from physical and mental effort is said to be ease of use which improves the confidence of the end user partake in the system implementation and has impact on the intensions to use ERP systems, (Amoako-Gympah, 2005; Calisir, 2004).

The training plan ought to contemplate both technical staff and end-users, and its scope will rely on upon the kind of implementation approach chosen. A few organisations utilize an in-house training approach while others favour utilizing training specialists. This is a critical part for effective teamwork. It establishes a cohesive team that has common objectives and has the ability to avoid unnecessary problems that may emerge during the lifecycle. Effective training involve the business knowledge training, requirement training, process techniques orientation objective setting and quality training, programming convention and speciality areas that are instrument to project success, (TEC., 2007). Lack of user training has been referred to as the principle reason behind ERP implementation failures (Somers and Nelson, 2004). Training is essential for complex system, such as, ERP, particularly with large scale changes in jobs’ skills, contents and computerization. These systems do not endure errors hence the significance of training in these systems. Employees ought to know about how their mistakes may influence what other users are doing in various areas of the entire system. Past studies found that training reduces level of resistance, increases ease of use and user involvement, which enhances success potential outcomes of information systems’ use, (Bradford and Florin, 2003).

2.4.7. Organisational resistance

ERP systems generally present substantial scale changes that can bring about resistance, which may diminish the expected benefits of the system thus. Somers and Nelson, (2004) made a substantial progress in understanding how resistance influence IS success particularly from process perspective. Effective organisational change management diminishes the level of resistance since its approach tries to ensure the acceptance and readiness of the new system allowing organisation to get the benefits of its utilization. A successful organisational change approach depends in a proper incorporation of individuals, process and technology.

2.4.8. Effective communication

Communication ought to be of two sorts: "inwards" the project team and "outwards" to the entire organisation. This implies sharing data between the project team as well as communicating to the entire organisation the outcomes and the objectives in every implementation stage. The communication effort ought to be done in a regular basis during the implementation phase. Frequent and open communication is vital for effective project implementation. This incorporates both internal communication
among the project colleagues and outside communication between the service
provider team. Communication techniques ought to use different structures, each with
a unique method for uncovering potential gaps in understanding. These incorporates
team meeting, face-to-face meeting, email, telephone communication and instant
messenger and video/text conferencing.

The effective communication can make the new system penetrate into the
organisation. It should also achieve all levels in the organization, from upper managers
to base managers; they ought to know what they could expect in the business process
change. They need to change their responsibility and roles as indicated by the new
requirements of ERP systems. Communication effectivity would improve their
readiness to change and result in the increase speed of business process
reengineering. Sandra Borden, deputy project manager for Coast Guard Vessel Traffic
Services acquisition once said, "Technology is not the issue. It's the people".

2.5. ADDITIONAL ISSUES TO CONSIDER WHEN IMPLEMENTING ERP
SYSTEM

Despite the fact that this section provides a deeper diagnose of the critical factors
influencing the success of the system implementation, there are various issues to be
considered for enhanced profitability, such as asking the right ERP questions and
establishing how technology aids in supporting lean implementation.

2.5.1 Critical questions to ask before choosing ERP solution

When considering ERP system implementation, the selection of an ERP vendor is one
of the significant factors to put as a top priority. There are issues to be considered
when choosing partner to provide the principal business operational system. ERP
structure is much of the time the mainstay of the business, as it handles everything
from plant administration to invoicing. Accordingly, choosing and actualizing ERP
system is a remarkable and a huge venture for any organization. The framework
selected will decide how well the business can work and create benefits. Therefore, a
thorough research on potential ERP vendors will be fundamental before making the
final selection.

Based on various mining industry and companies’ needs, conducting a thorough
research will help generate the list of prospective vendors to which the right ERP
questions are to be asked.

2.5.1.1. How is the proposed solution a sustenance for business process style?

There is a software that works, and there is a software that works for a business. It is
important to note this distinction to ensure that the system is not only functional, but
that it also aligns with the needs and culture of the organisation. There are many
“styles” of mining, from searching for minerals to actual recovery of minerals from the
earth (e.g. aqueous extraction, placer mining, hydrau-licking, solution mining, etc.).
Additionally, mining organisations utilise various processes (e.g., prospecting,
exploration, development, exploitation, etc.), across multiple organisations. Each combination of mining style process has a completely unique set of requirements.

In this instance, it is imperative to purchase a system that addresses these processes in the core of its product offering. In order to find the right system for the business needs, a vendor who will take the time to learn about the business must also be established, (Deakins, 2009). Very often, sales representatives will immediately want to show a demo without first taking the time to learn about the unique business processes. This can become problematic down the road if the system is found to lack certain functionality required. No two businesses are identical and each will vary in the way they operate. Therefore, a vendor who comprehends this and doesn’t lack any distinguishing attributes when selling software, is needed. The solution chosen to run the business must support the style of mining and business model. The system ought to have a vital usefulness to aid in effortlessly and viably managing the costs relative to the job, setting up to undertake the activities, and the actual production. It should also be establish if the system support employed strategic initiatives such as, lean manufacturing, improved quality, et cetera. Moreover, it is crucial for the vendor to demonstrate its capabilities to aid the organisation lower operating expenses and increment profits?

2.5.1.2. Can the solution be easily modified to meet the business’s specific processes?

No ERP solution comes out of the box and impeccably addresses every organisation’s needs. While one that has been particularly developed for manufacturers and comes delivered with built-in “best practices” may address the majority of the requirements, there still are processes that are unique to an organisation, (Deakins, 2009). Many ERP packages still run on old technology, with rigid platforms and architectures that cannot be easily customized without cumbersome tools or costly source code changes. This, of course, diminishes the value of the ERP system. The solution should have embedded tools that are easy to use (for the end user, not developer) for modifying or broadening the value of the system.

Customised software is a product customised mainly for a specific organisation, bringing about exclusiveness to it. Configurable software, then again, is intended to handle an extensive variety of necessities appropriate right out of the package, deprived of modifications to the essential programming code. An enduring utilization of a system will subject to these distinctions. This product can be difficult to maintain due to the fact that, modifying vendor’s base system, is predominantly “getting off the ship.” (Deakins, 2009). None of the vendor’s various customers have the indistinguishable systems. Thus, at whatever point the vendor publishes the new versions and updates, organisation’s system will individually require extra testing and revamping to roll out the improvements compatible with its program and keep its pontoon running parallel to the vendor’s ship, (Deakins, 2009).

A few vendors like this prearrangement since it gives them a steady stream of returns, ideal from consumer’s pocket. Then, when the system diverges adequately a long way from the primary system to make IT support unbenefficial for the vendor, they may quit supporting the customised program entirely. Thus, deserting the firm to either sustain
the software itself, outsource an IT team to bolster it, or purchase another software solution.

The organisation remains on the ship provided the configurable ERP software. With the capability to symbolise fields within the system, such as naming customs or rating structures, without any alterations to the product/software code. The system fits the necessities, but it’s also a similar software being utilised by a greater part of the vendor’s customers. Therefore, the vendor can issue frequent software updates, which are easy to manage.

Determining whether a software system needs to be tailored will help in identifying costs related to customisation and comprehend how much support will be required to maintain the system currently and at a later on.

2.5.1.3. Can the software coordinate all the business processes in a single system?
Managing a business can be problematical if alternate software systems are utilised to handle each of its processes. It makes it challenging to access data which is in a lower level of a hierarchically structured database or old transactions in real time. It’s difficult to update systems. And numerous vendors must be managed and adjust to varying system formats and structures.

Genuinely coordinated ERP software, in any case, flawlessly connects all the business processes in a single system. A portion of the advantages of an incorporated ERP package include, (Deakins, 2009):

- Abridged research and reporting. The task of viable control of information is eased by having all the data in one place. Consequently, yielding an effective creation reports.

- Single-system updates. Where two systems are coupled, there are typically custom projects, or extensions, designed to convey data between them. If one of the vendors updates one system, the need to update the bridge as well emerges, to prevent system conflicts and data errors. But with a solitary integrated system, this tedious process and the IT support essential to manage updates for various systems can be avoided.

- Enhanced vendor administration. Single system utilization implies no worry about monitoring which vendor to call when the production system has a problem. Also diminishing the possibility of getting stuck in between vendor blame dispensing from system conflicts. With one system, there’s one vendor, one company to approach when queries radiates.

- Simplified training. One system likewise implies one regular “appearance and feel” throughout the application. Working with a solitary strategy structure makes system navigation easy, and it propels the training process.
Discussion on the possibility of an ERP system requiring an additional systems or IT support early in the software search, will better prepare the organisation to manage any related time, personnel, and budgetary demands.

2.5.1.4. Does the solution provide functionality for the broader organization?

The solution should support the “extended enterprise.” Some solutions only provide functionality for specific areas of a business (e.g., customer relationship management, financials, production). A solution that provides functionality for the organization as a whole must be sought. A comprehensive, integrated solution minimizes or eliminates the need for isolated applications, spreadsheets, and “work arounds.” More importantly, if the solution is built on a common database, entered data flows through the system from one step to another, streamlining processes and providing enhanced customer, operational, and financial visibility across the organisation.

2.5.1.4.1. How does the system support the “extended enterprise”?

A mining operation doesn’t exist as an independent domain; it has suppliers and customers that require direct access to data from the organisation. And, of course, that data connection must be both reliable and highly secure. For a definitive flexibility, the system ought to have the capacity to expose any transaction to a customer or supplier – without any programming, and without installing software at a trading partner. Additionally, the interface to the system ought to be intuitive enough that suppliers and customers will not need training to use it effectively.

Some uses of this system include:

- **Problem Reports** – also called Corrective Action Requests. Once the supplier is notified (e.g., with an automatically generated email), they ought to have the capacity to sign on to the system and follow the endorsed problem-solving approach.

- **Lean Replenishment** – as opposed to calculate orders based on forecasts and holding “just-in-case” inventory at both the supplier and customer, the software should support electronic kanban or pulls. An alert can be sent to the supplier as the mining operations consume material in the production process.

- **Quality Management** – Can the details of the suppliers’ quality plans be accessible in an electronic format? Some mining organisations find it useful to allow customers to view their quality checks, restorative activities (corrective actions), et cetera.

These applications ought to be accessible by means of a simple web browser, without the need to assemble a separate “portal” for company accomplices. This not only simplifies access, it significantly accelerates deployment schedules – from weeks or months to just minutes, (Deakins, 2009).
With a web-based system, adding a new vendor to a list of accomplices/partners takes just minutes, and the partner can access the system as soon as they are provided with the authorisations.

2.5.1.5. What performance management and reporting tools are delivered as part of the solution?

A principal concept of ERP solutions is that they should simplify the process of taking raw data and turning it into useful information. A good solution should provide embedded and subordinate tools that are easy to use and can pull together data from across the organization. From operational reporting, to tracking key performance information, to supporting advanced performance analysis, the included tools should support real-time decision making, optimally managing operations and strategic planning.

Next, as the vendor is going to be providing the ERP solution, there are a couple of operational and contractual aspects that would need to be discussed and get assurances on. So the following set of questions should be:

2.5.1.5.1 What assurances does the vendor provide in the area of pricing protection?

ERP solutions are customarily sold on a subscription basis over a term, (e.g., as per user, per month basis for 36 months). The license model simplifies licensing software, as there are no large up-front license fees, and typically most everything is included in the fee (i.e., software, hardware, support, training resources, and on-going system maintenance). However, one item that regularly goes disregarded is pricing protection. Be sure to address what the subscription fees could be at the time of renewal. A good vendor will cap any potential increase for a subsequent term. This guarantees there won’t be an intense cost increment at the renewal. It is imperative to establish if the vendor’s price is guaranteed. A guaranteed price put into consideration the intricacy of the project, preceding the agreeable license arrangement signing. A smooth rate for the system, implementation, training, data transfiguration, and support is also received. If the vendor acknowledges, along the way through the implementation, that the data transfiguration is considerably more complex than initially figured, the organisation will not incur additional cost in such manner.

The preference is an open-ended valuing structure. For this situation, the price is large in view of the cost of the system and the clients’ quantity, in addition to estimated cost for data transfiguration, implementation, training, and any required customization or additional items. This could leave the original price disposed to inflammation if, data transfiguration process gets complex, or other implementation hiccups are encountered, and the project completion stretches, (Deakins, 2009).

Establishment of whether a vendor’s price is guaranteed will aid in making a thorough comparison when settling on software decision. It also encourages a better comprehension of the concrete costs identified with licensing and sustaining a new ERP system.
2.5.1.5.2 What assurances does the vendor provide in the area of business continuity?

As the vendor is going to be “facilitating and managing” the implemented ERP solution, it would be vital to acquire assurances that the system is up and running when it’s required to. The initial step is understanding from where the system is being hosted. Is it from a credible data centre or out of a closet at the vendor’s office? A brisk approach to validate this is to inquire about their data centre, including the security and confidentiality policies, their 3rd party compliance, and the availability commitment (sometimes known as their “Service Level Commitment.”). Next, inquire about their data reinforcement approaches, system redundancies, and sustenance level measurements. Data would need to be backed up and stored online in multiple locations (ideally different geographic locations). The system ought to have redundancies inherent, so if one part of the system fails, the services will continue on consistently.

2.5.1.6. Will employees’ training be provided on how to proficiently use the software?

Similarly as with any new system or process there will be an information absorption that users will have to manage. There’s no maintaining a strategic deviation from this reality because every employee varies in how effortlessly they can become accustomed to new technology. Most vendors will provide training documentation and recordings enlightening how to appropriately use their software; however, this should be used in conjunction with hands on training. No matter how user-friendly a system may be, there isn’t a replacement for the value of hands-on vendor conducted training. Training videos and documentation may help employees get a feel for the system, but having a person training the team on new processes and explaining how different parts of the ERP are connected is instrumental to their comprehension of the overall system. Ensure that the vendor properly trains the staff on the system either in-person or remotely via webcast.

2.5.1.7. How many customers are on the latest release of the software and when was the latest release?

Most analysts estimate that fewer than 50% of enterprises are within two releases of the current version of their enterprise software packages. Thus the next significant inquiry would be; “How many of your enterprise systems are on the latest version of the software?”

This is exclusively important because the customary strategy for delivering software is full with waste and delays. Producers of on-site solutions provide software updates every six months or so, at best. Customers then evaluate whether the improvements are meaningful to them and whether the updates will conflict with any customizations they have done. After the planning, hardware upgrades, operating systems reinforcements, migration, testing, retraining and bug-fixing, more time has passed and the customer wonders whether it was worth the work and the disruption to their business. The end result is that most enterprises are two to five years behind the current state of technology, putting them at a disadvantage at a time where the industry
is demanding they be more responsive. Meanwhile, the vendor has to support multiple versions out in the field, multiple databases, operating systems and hardware types. It is a nightmare that slows the innovation process and adds waste and cost to the whole process.

2.5.1.8. Do you have customers like me in my industry?

Since the purpose assurance have been covered, determine whether vendor has overseen relative circumstances with other mining customers. Given the vendor is or has managed comparable businesses, it’ll be anything but difficult to comprehend industry subtle elements that the organisation may have underestimated, however various vendors may disregard.

Reaching references in the comparative industry is moreover a respectable opportunity to differentiate similarities in points of complications with an industry associate. One can discover how a system settles complexities. In what manner has there been an improvement for the company?

In respect to the requests on what it resembles to work with the vendor in like manner, some other moral inquiries to be asked would include:

- How the software implementation process is? If a software vendor characterise and adhere to the process and guarantee customer satisfaction consistently?
- On normal basis, to what extend is the response time for support calls? At what rate are the updates of the software occurring?

These inquiries won’t only demonstrate the vendor’s system capabilities for the industry, but it also will uncover the vendors’ customers’ satisfaction, which can aid in anticipating satisfaction level with the vendor.

2.5.1.9. What is the vendor’s reputation? Do they have a long standing, transparent history?

Finally, trust and transparency are significant in any relationship, perhaps more so with ERP as the vendor is facilitating and managing the customer’s software. Therefore, thoroughness is vital. To what extend has the vendor been around? How much quantity of customers do they have? Do they have a background marked by serving in the comparable business? Is it accurate to say they are stable and profitable? It actually facilitates the task if the company reports its monetary data openly and the data is promptly accessible.

2.5.1.10. Will the vendor provide continuous assistance after go-live?

What unfurls post go-live is as fundamental as the implementation process. Preparation on a system can be provided for weeks and still not be completely agreeable. That is to more prominent degree a demonstration to the fact that ERP software is incredibly vigorous and to learn the unpredictable subtle elements of any given system is a troublesome errand for anyone. Inquiries will emerge that were not canvassed in the underlying preparation and a firm needs a vendor who is aware of
this and is opportune in managing these circumstances. A viable practice some vendors take after is having the individual who conducted preparation and implemented the system be accessible for inquiries in the weeks post go-live date. Since this individual already has a working association with the employees and comprehends the business from their time on premises, they will be the ones most suitable for any additional inquiries that emerges.

2.5.1.11. How does the organisation get its data back at the end of the relationship?

Parting way is often difficult to do. If the decision to cut ties with ERP vendor is made, it may be essential to do so as smoothly as possible. Some vendors charge termination fees, some use a document format that’s impossible to extract data from, and others simply make life difficult. Investigating the vendor’s contract terms regarding termination may be intensively vital in this instance, to be familiar in advance what to expect if the organisation decides against re-establishing for another term. In addition, the company would need its data back without any hassles and astonishment charges. The policy of data possession, the process toward reacquiring data, as well as any associated costs must be investigated.

2.6 HOW TO UTILIZE TECHNOLOGY FOR THE SUSTENANCE OF LEAN ENTERPRISE

The present aggressive nature of business expects organisations to take a stab uniqueness through augmenting their incentive to customers. This channels the endeavours to eliminate non-value adding undertakings and variability, increment immovability and responsiveness while maintaining predominant quality. All the initiatives that can yield cost-adequacy. Subsequently develops the necessity for organisations to gadget lean initiatives. Since visual and manual executes cannot keep the pace in today’s dynamic fast-paced global mining environment, there is a rapid development in the accord that technology is fundamental for effective lean initiatives. And a well employed enterprise resource planning (ERP) system offers such groundwork, (Strothmann, 2008).

ERP system coupled with lean initiatives can yield a tremendous improvement of a mining operation. Lean Six Sigma tied with ERP system can ease the task of evaluating the performance through relentless measures for success to continuously enhance processes to convey the most noteworthy incentive (value) to customers.

Embracing lean philosophy requires a noteworthy change to the organisational structure set up, integrating information definitively to propel operations, lessen cost and waste. Organisation’s readiness to embrace this nature of progress is reinforced by using technology which encourages the overall lean strategy. These reinforcements incorporate establishing reliably high enterprise-wide levels of performance, how to convey value and increasing revenue through lean enterprise, (Strothmann, 2008). World-class organizations are migrating from individual based approaches to processes upheld by a technology that endures and outpaces the individual.
Implementing an integrated business software platform to regulate lean processes creates a standard change. This establishes a lean culture, rather than storehouses of lean aptitude. Thus becoming rooted in customary strategies of getting things done. Setting up business processes that are constantly evaluated and enhanced and by utilising consolidated enterprise data to perform business-cycle exploration, can disseminate continuous improvement across the enterprise and measure the effect of activities on margins more reliably and accurately. This empowers the establishment of customary work processes, continuous real-time information sharing, application integration and data integrity to meet demands, real-time order management, proactive exception management, business intelligence and analytics, and numerous various capabilities that are vital to the success of any Lean and Six Sigma initiative, (Strothmann, 2008). Employing the correct technology foundation significantly impacts on the ability to spread Lean principles to achieve the performance enhancements such as;

- Improved business comprehension and efficiency by delivering real-time, customized measurements tied directly to corporate objectives.
- Access to information such as business statistics and key performance measurements presented with regards to business responsibilities.
- Assurance on compliance and predictability of business performance.
- Enabling more profound budgetary comprehension across the enterprise and constrict control of finances.
- Automated budgetary and managerial accounting and financial supply chain management.
- Thorough support for budgetary reporting and corporate-governance commands.

After the lean culture being established throughout the enterprise and successful practices with fast and predictable responses implemented, it’s an ideal opportunity to broaden the standpoint. All things considered, it is vital to address downstream distribution as part of lean initiative, to improve response times and reduce work in progress. Thus an inquiry would need to be made on how supply chain can be controlled to increase value for your customers?

Top-performing mining companies are delivering greater value by using technology to accomplish the following process improvements:

- Automated and integrated mining processes with other core business processes to reduce waste and reduce cycle times.
- Shared real-time data and information across the company.
- Extended lean replenishment principles to the distribution network.
• Increased demand visibility
• Improve days’ sales outstanding by introducing innovative, vendor managed inventory programs with customers
• Increased customer satisfaction by significantly improving the responsiveness of the entire value chain

Organizations can amplify these benefits by broadening Lean and Six Sigma practices to the enterprise as a major aspect of a conjoint technology platform. By merging a Lean philosophy and new technology will enable the capacity to design new streamlined operations quickly, both within and beyond the organisation to achieve an incremented level of flexibility and customer responsiveness. Broadening Lean standards throughout the enterprise and the supply chain guarantees a streamlined value chain and an established business-cycle explorations to continually enhance processes.

Technology solutions empower world class organizations to prevail over contenders by enabling co-operative business processes intended to quickly detect and respond to changes in market requirements. To counterpart this, specialized software solutions provide an essential influence to enhance efficiency and drive cultural change throughout the enterprise and production network.

Lean is not generally about cost reserves. Eventually, the benefit of lean post waste elimination, processes streamlining, and increasing customer satisfaction is in setting up a groundwork to support profitable growth. Every business that embarks on a Lean initiative ought to have a strategy on how to use its authorized capacity and working capital. Alternative to using that capacity to build products that will sit in inventory, awaiting an order, world-class companies use their dexterity as a substance for development.

By using an experience with process improvements, new product offerings can be introduced with proficient, profitable, lean practices right from the earliest point. Innovative lean pioneers also discover approaches to deliver new high-margin, value-added services to customers, such as speedy delivery programs that can call for superior cost. Having the correct technology foundation will aid in being a step ahead of rapidly alternating market conditions, competitors, and fluctuates in customer demand. The current dynamic markets require enterprises to adjust and revolutionise at a matching fast pace. The technology platforms that support innovation and flexibility deliver a competitive advantage.

The correct technology platform that facilitates rapid deployment of innovative business processes drives value for an enterprise in the following ways, (Strothmann, 2008):

• Simplifies, automates, and incorporates complex business processes.
• Facilitates and ensures conjunction operation between applications and systems.
• Provides significant intelligence and supports rapid response to spontaneous proceedings.
• Supports the intricacy of the global business.
• Increases the productivity of the organization by documenting and enforcing standardized work and procedures across the enterprise.
• Supports collaborative processes while providing the highest level of data security for sensitive information.

2.6.1 How are lean principles supported in the system?

First challenge: “enterprise” software systems are generally considered to be counter to lean principles. The standard approach to software when implementing a lean program is to allow individual departments or functions to select the application that best meets their individual needs. This department empowerment is core to any lean program.

However, many companies embracing lean principles still choose to implement enterprise solutions simply because the advantages offered by a system that navigates multiple departments are too big to be left behind, provided they are genuine. The more imperative issue for mining organisations whether the system aids to eliminate waste from the entire system both internally and all over the production network. Once the value streams are optimized, it should be established with certainty how the system supports lean implementation. Are pull systems part of the core solution? Are transactions proofed for mistake from the beginning? Is production smoothing available? And are these functions reinforced across the production network, with customers and suppliers?

2.7 FOURTH INDUSTRIAL REVOLUTION (INDUSTRY 4.0) AND ERP IN MINING

Throughout a decade to come, Industry 4.0 will develop to conform to the specifications of the products produced for a definite purpose, at a reasonable price. These will range from mobile devices to automobiles to sheet metal manufacturing. It will consequently grant mining organisations and organisations in other sectors access to a mass production processes with tremendously high levels of flexibility that can be swiftly adapted to meet the rapid market changing requirements.

Among other requirements of the cutting edge world, is a considerable measure of commodities, which consequently yields a crisis as a result of incremented levels of raw materials demand, (Honrubia, 2017). With an attempt to aid mining companies to have more secure and quickened mining operations, mining technologies are currently being developed. These developments also emanates from the fact that the African mining industry is under pressure due to doubled up domestic economic conditions against the global low turn mining cycle. The industry is currently on the fourth revolution, also known as “Industry 4.0” and to bring about the momentum in mining innovation, the mind-set has to be changed towards innovation in mining industry.
Sharing information between the production floors and business systems aids organisations to acquire very innovative levels of efficiency. ERP systems as an information flow managing tool, contain information relative to customer demands. Thus, there high substantial anticipations on the efficiency brought about integrating it with digitisation and the benefits of such integration. It goes without a saying that lean processes are imperative for any organisation currently than ever. Therefore integrating the two could yield incremented, operational efficiency, responsiveness to customized and changing market requirements and enable flexibility in the organisation, (Lavi, 2017). Moreover, real-time information exchange between the business layer and the production layer could aid increment overall equipment efficiency (OEE), provide management with greater visibility for improved decision-making and reduce cycle times. There are various way in which ERP systems can be integrated with industry 4.0 based principles which consequently bring people, process and equipment together. Among others are the following;

- Demand changes recorded in the ERP system can be fed to production schedules to ensure that quantities of products are accurately aligned with demand for leaner and more efficient production.
- Integration of ERP and production data for more precise demand forecasts can reduce inventories and avoid over production.
- ERP schedules can be more realistic by incorporating swift production times based on the latest improvements on the production floor. E.g. sensors on containers or trucks deliver real-time insights to products across the supply chain, defective equipment can be reported to adjust delivery times.
- This integration can enable organisation to deliver demands to customers at the agreed time. Leading to customer trust in company’s competence.
- Any new production processes that require production time and expenses are to be shared immediately with enterprise systems so as to update delivery information with immediate effect. Also, a product changes requested by the customer have to be transferred to production system promptly to avoid uncertainties in fulfilling the demands.
- Integrating predictive maintenance data with ERP systems to optimize workflow scheduling can help operations minimize the impact of equipment unavailability by dynamically adjusting the production run. If defective material is detected, it can be removed and returned to the supplier. Eliminating waste due to defective raw material and reduced recalls aid organisations to improve profitability.

2.7.1 Progress from first to fourth industrial revolutions in mining

The main development in mining began from automation through utilisation of water powered bore (hydraulic drills), and steam controlled engines, (Figure 2.1). The second revolution began with the large scale production and assembly lines alongside electricity, making progressive equipment accessible to miners with an aid of electricity. The third upheaval begins with a shift to utilisation of computers and automation, offering approach to various mining robots to perform hazardous minerals
diggings and furthermore lift heavy materials. And ultimately, is the fourth revolution or “Industry 4.0”, which is the current industry mining is in.

Figure 2.1: From 1st to 4th industrial revolution in mining (Source: 4 mining innovations for the industry, 2017)

Industry 4.0 necessitates digital physical systems, which is a form of automation where the communication between the cyber system and other parallel systems is enabled and also the utilisation of industrial “Internet of Things (IoT)” by humans. There are various innovations/techniques involved, such as robotics, enhanced 3D-imaging engineering and cloud computing.

2.7.2 Industry 4.0 in the mining sector

The mining industry is in an extremely tight space. When commodity prices were high it was largely a matter of trying to get product out of the ground as quickly as possible. Now they have had to shift their focus to improving the productivity of existing operations. However, and despite the alternating growth and declination of the economy, cycle of mining has been consistent for a long time, productivity has not improved, (Carter, 2017).

Frequent breakdowns result from the pressure and strain put on the mining equipment. Digital technologies are capacitated to unlock enhanced approaches of managing this variability through the large-scale adoption of cutting edge technologies. The embedding of sensors in machinery to collect data and empower interchanges between machines is progressively affordable and accessible. Mining organisations now produce huge measures of data, and extracting relevant data about machinery, processes and ore bodies are now of more important than ever before.

Complex mining errands such as geo-modelling, day-to-day scheduling and predictive maintenance are progressively handled by smart analytics software packages, while smartphones and other handheld devices have transformed the manner in which workers interact, both with each other and with machines. For incremented safety outcomes, work garments can incorporate sensors that transmit employee locations
and trigger warnings about hazardous situations. Advances in automation and sensor technology are additionally now making guided equipment significantly more affordable and compelling. Utilisation of tele-remote, assisted control and fully autonomous equipment is becoming progressively broadened in the mining industry. These technologies will facilitate a fundamental shift in the way of mining, (Carter, 2017). Reduced variability in decision-making and more centralised automated operations that reduce variability in execution will emerge.

Through a superior comprehension of the precise resources that are in the ground and where, and integrating geological information into one inclusive database enables operators to optimise drill and blasting operations, creates better mine plans and helps avoid resource quality issues. According to Carter, 2017, deploying remote-controlled machinery such as underground vehicles with laser scanning technologies can cause a step change in productivity, and the 3D modelling data provided by these robots can inform engineers in remote locations and avoid the dangers of sending geologists to just-blasted mine faces.

Real-time data and better analysis tools such as ERP system also make conceivable improved scheduling and processing decisions, while fitting smart sensors to equipment facilitates the prediction of failure of components. But possibly the greatest advantages of real-time data is knowing the state and location of every piece of equipment at any time, making possible sophisticated decision-making in real time that takes into account the whole operation and not just restricted operational storehouses.

A great part of the value creation in mining has already shifted from how well companies move material to how well they gather and act on information to move material more efficiently. But much remains to be done. In the fullness of time, mining will evolve towards an industry where knowledge will be used to solve indistinguishable problems of today through different means. Mining companies that recognise this and adopt new technologies and ways of thinking now will be prepared for tomorrow.

Industry 4.0 is broadening quickly globally in various consumer industries as well as some extractive branches. Establishing team of talpa-solutions, a German based technology start-up which implements an online asset management platform for mining companies as well as Original Equipment Manufacturers (OEM’s) provides a its perspective on the issue from within the developer lab. DMT, worldwide engineering and consulting group, passes their remarks on how such solutions can be implemented in mining.

2.7.2.1 Opportunities remain unused

Mining tools and equipment are complex and expensive. Standard load-haul-dump (LHD) equipment used for material haulage in underground mining is approximately 70% more expensive than a lorry with the same capacity used for civil purposes. Very often the equipment is parked due to missing spare parts, sudden failures or simply because there is no ore to load due to insufficiently scheduled processes.
The founders of talpa-solutions have noticed that the equipment of several OEMs, is already supplied with a broad variety of over 100 sensors allowing to read various parameters. However, the readings from only about 5% of the sensors are taken into consideration while monitoring the state of the machines. Even less information was used to predict the need for maintenance and repair. When asked about the reason for this, most of the OEMs’ representatives have pointed out that the absence of a solid system for data collection, structuring, and analysis. So far, data acquisition and communication between OEM and mines happens sporadically and time-intensively by e-mail and/or USB-stick.

Further investigations, have revealed that the mines hardly utilize any of the information potentially accessible from the existing sensors. Rather than receiving this information online and analysing the data to optimize the production process and reduce unnecessary standby times and costly downtimes, employees are to manually measure, for example, the volumes transported or the cycle time from face to breaker. DMT has been pointing out the importance and possibilities of the effective use of Industry 4.0 solutions in its studies made for various companies worldwide. This concerns all mining processes, from inventory management for OPEX optimization to total production quality control, based on online monitoring of the ore grades further giving the command to automated production and haulage solutions.

![Diagram](Image)

*Figure 2.2: Software conception of asset analytics. (Source: Industry 4.0 in mining – opportunities and challenges, 2016)*
1. Complex made simple

Integration of assets in complex operating processes.

Currently, common practice entails lengthy handwritten or, spreadsheet based failure records and maintenance schedules, in the most ideal situation. Unplanned equipment relocations are based on subjective decisions by the shift supervisor with limited overview of the effect on the entire process chain. To allow operating staff a reliable and fast reaction to the changing conditions and to minimize downtimes of the machines, a constant and automated data transfer, well-structured data preparation, and condition analysis, enabled by an organized communication infrastructure, have to be provided.

Companies operating in the “Internet of things” (IoT) section develop solutions that capture and expand data from various interconnected machines included in an operation. The condensed and meaningful data is displayed to the user allowing them making further decisions.

Being a cutting edge technology in automotive and some other industries, Industry 4.0 is quite new in mining. Several success stories from across the world though show that the industry matures. What is missing though is unified vendor independent platform concept available for any client with low investment possibilities (significantly Small and Medium Enterprises, SMEs).
2.7.2.2 Cooperation is the key word

DMT experience in setting up condition monitoring systems for mining equipment suppliers, such as CAT, in addition to a number of refineries, power and processing plants demonstrates the imperativeness of the continuous dialogue between the project owner and the solution developer, which should not only end with placing the order, but to go far post this until the common goal is achieved. Such a collaborative dialogue helps the developer to understand customers’ specific requirements and every user’s individual story and role within the project. Swift adjustments made to the solution in the development process enable an appropriate functional set of applications that generate a certain added value. Incremental application releases guarantee quick wins without losing the big picture.

Procurement and technical departments of mining companies or OEMs tend to be completely secluded and often do not comprehend the necessities of each other. This has been one of the reasons why Industry 4.0, usually following the swift development principle, has been constrained from working in fixed price contracts traditionally awarded by mining companies. Furthermore, this creates approachable environment for small and flexible start-ups that come to decisions faster than, IT departments of big manufacturers often struggling with tedious decision-making processes.

2.7.2.3 What to expect

Uniqueness in the realm of new enterprises, talpa-solutions is starting to get positive calls, both from potential customers and investors, intending to bring Industry 4.0 into yet unexplored industry sectors. The primary errand of talpa-solutions as desired by pilot customers is to develop a vendor independent platform for real-time analysis of big data. Integrated features are a user-friendly interface which allows personnel with user or role-specific access authorization to receive the required information and improve their performance. Following the request for “no-advanced science solutions”, the interface must be spontaneous to use and requiring minimum training.

OEM perceives that the significant benefits of IoT concepts are concentrated in the area of Equipment Relationship Management (ERM). An integrated after-sales system allows OEMs to collect information about the current condition of equipment, such as wear and tear, from multiple devices and proactively contact the responsible mine personnel. Beside the improvement of the lifetime of the assets, this approach will intensify and improve the relationship between OEM and the mine. In addition, in the event of downtime, a faster and more accurate analysis can be performed remotely. This supports the OEM in reducing cost-intensive long-term downtimes as well as preventive on-site visits. By retrieving all relevant information from one source, service engineers can be informed about the existing damage, required tools and supplies in a timely manner. The OEM can also utilize status information about distributed assets. Based on the information of how equipment is being used, important insights for research and development as well as the sales process can be made.

Direct value adding measures for the customer:

- Calibrating a mine plan compliance with actual asset/fleet performance
- Improvement by means of KPIs such as technical availability, asset utilization, maintenance metrics (MTTR, MTBF) and process related criteria
- Correlation of root cause analysis, trends & event.
- Detection of exceptional conditions & irregularities through selective data blending
- Reduction of overall costs of information, communication & collaboration

In a nutshell, the following challenges are observed in spreading Industry 4.0 in the mining sector:

- Creating interfaces that are easily understood by various levels of users
- Getting mining companies involved in the development process
- Flexible financing instruments based on the expected cost reduction rather than fixed capital expenditure.

Digital innovation could be a breakthrough provider for the focus of the miners on improving productivity, which emerges from the declination of the profits. Many mines are developing, consequently, the extraction of lower ore grades, longer pull distances from the mine face, mineral body replacement rate are declining and to develop new mines is increasing. Over and above, global mining operations are 28% less productive now in comparison to a decade ago, and that is post the adjustment for the ore grades, (Durrant-Whyte et al, 2015)

The industry has shifted its focus to improving productivity by increasing the efficiency of the existing assets. Regardless of the industry’s economic expansion and contraction, the nature of mining has remained the same for quite a long time. Accomplishment of a revolution on productivity performance strains on re-evaluating how mining functions. Currently there is a tremendously high possibility of industry achieving such breakthrough through digital and technology innovations that could bring about transformation into the key aspects of mining. A sufficient number of digital technologies have long been in progress and are now accessible and affordable enough to become operational at scale across the mining industry. Their applications incorporate building a more comprehensive understanding of the resource base, optimizing material and equipment flow, improving anticipation of failures, increasing mechanization through automation, and monitoring performance in real time. These opportunities individually has genuine potential. Collectively they represent a principal shift in both potential safety outcomes and how value can be captured in the mining sector.

2.7.3 Is the organisation’s ERP system compatible to Industry 4.0?

It goes with certainty that industry 4.0 offers businesses an opportunity to innovate. Global competition and rapid changing market demands have put the sector under considerable pressure. However, organisations which managed to implements industry 4.0 based principles successfully to date, this has enabled them to incorporate more high-value production related services into their business models. This includes knowledge-intensive activities such as research and development, technological
innovation and product design. Additionally, given the need to be competitive in global markets, companies have made a greater push to upgrade their operational capabilities to enhance the vibrancy of the ecosystem. In line with the trend towards related high-value services, mining companies need to begin assessing whether their current systems are compatible with the future of the industry. Here is where Industry 4.0 and the opportunities for innovation it provides mining organisations in South Africa, is anticipated with expectancy. There’s no doubt that Industry 4.0 will have an impact on the mining industry. Over 50% of the mining firms worldwide agree that this fourth Industrial Revolution will have a significant impact on the sector, Archer, 2016). Lack of digital culture and training are found to be a crucial challenge when embracing Industry 4.0.

2.7.3.1 New connections between machines, production processes and systems

Primary requirement for Industry 4.0 is a future of swift and affordable operation powered by technology enablers such as the Internet of Things (IoT), 3D printing, cloud computing, mobile devices and big data. This gel harmoniously together with the production world and networking in a connected environment. Therein enterprise resource planning (ERP) will become increasingly central to production. The ERP system will become the backbone of the network; connecting smart machines, logistics systems, production facilities, sensors and devices as products and machines communicate with each other and exchange commands as products move the production line. In preparation for Industry 4.0, ERP vendors are breaking off the pre-built interfaces and formulas to develop highly connected systems that conduct operations at the production line level, whilst giving business decision makers the real-time data they require. One aspect of this is the manner by which Industry 4.0 compatible with ERP system will completely coordinate with manufacturing execution systems (MES). Subsequently, it will be conceivable to track and record the transformation of raw materials through to finished goods. It is exceptionally imperative for industrialists to address whether their current ERP environment can engage this level of system integration as they embark on their journey towards Industry 4.0.

According to Archer, 2016, the following are five inquiries, which each industrialist ought to get some information about their ERP system arranged by planning for Industry 4.0.

Question 1: Is the organisation’s ERP system adaptable?

Industry 4.0 is an adventure, not an irregular undertaking. Industrialists will therefore benefit most from ERP software that has adaptable deployment options. This will enable them to adjust to new business and service opportunities, new processes, workflows, data networks and decentralised locations, all progressively as their business grows in an inter-connected world. Whether the ERP solution is facilitated in the company’s own data centre, in the cloud, as a managed service, on-premises, or a combination thereof, it ought to be conceivable to effectively switch procedures and adjust to better approaches for working, to keep up business agility.
Question 2: Is the company’s execution system compatible with its ERP system, and able to adapt to multiple locations?

The best cutting edge ERP solutions can integrate with an execution system effectively. This is imperative since it takes into consideration real-time data trade. For developing manufacturers, their execution system ought to have the capacity to adapt to individual facilities, but also with the centralised management of multiple production sites. This will provide the freedom required to integrate production lines with higher-level business processes, step-by-step, according to their strategic plans, without compromising on the end result.

Question 3: Is the company’s ERP software capable of central data management?

In preparation for Industry 4.0, ERP software should meet three key criteria. Firstly, it should offer organisations a segmental platform, in a service-oriented architecture’s view. Along these lines business processes can be effectively customised without changing the software code, securing the way for future technological developments or release updates. Secondly, ERP software should allow for central master data management. Last but not least, it should offer real-time data processing, enabling all stakeholders in the business to have access to the latest and most accurate data in real-time.

These three requirements form a powerful combination when it comes to accurate business decision-making. It enables all parties to view the same information about projects, customers, raw materials or locations, helping manufacturers to improve their customer experience and speed to market.

Question 4: Does your ERP system facilitate mobility and social collaboration?

Whilst data sharing is becoming synonymous with Industry 4.0, this will also enable fluid cooperation across departments, from the shop floor to the top floor. As part of this flexible communication, user-friendly access to ERP information via tablets and smartphones will become essential for manufacturers. ERP solutions that feature intuitive dashboards and comfortably suit all screen sizes, will be key to businesses embracing the Industry 4.0 ethos of updating and sharing information in the mobile-working world. These solutions should also have the necessary mobile infrastructure in place to ensure real-time data synchronisation.

Collaboration is increasingly important and next generation ERP solutions are integrating social capabilities to help external partners, suppliers and customers become part of the business process. Embedded in the ERP system, information from these informal discussions is stored centrally in context with ERP data, instead of being buried in third-party systems.

Question 5: Are you ready to benefit from the powerful analytics and business intelligence associated with Industry 4.0?

Powerful planning and management functions in next generation ERP systems can ensure that the benefits of intelligent manufacturing have an impact on all relevant areas of the company. Within the Industry 4.0 world, sophisticated analysis tools will,
for example, help to verify the planning, execution and evaluation of new business models; testing what will work, allowing business leaders to make informed decisions, and helping them to adapt to market or customer demands.

It is clear that for manufacturers, growth in an Industry 4.0 environment will be intrinsically linked to a business's ERP system. Those with next generation ERP solutions in place will be in a better position to meet the fast-paced and connected requirements of Industry 4.0. Certainly, the boundaries between production and management should diminish. Additionally, ERP and MES systems must form an integrated unit if businesses are to realise the growth opportunities presented by this new age of intelligent manufacturing. Taking a critical look at the existing IT environment in your business is the first step towards understanding how prepared - or unprepared - you are for Industry 4.0.

2.8 LEAN AUTOMATION ENABLED BY INDUSTRY 4.0 TECHNOLOGIES

In the early 90’s, Lean Production principles made a broad appearance and are widely adopted by various industries since then. Lean Production philosophy emphasises the severe integration of humans in the production process, a continuous improvement and focus on value adding activities by avoiding of waste. Its simplicity and up to 25% incremented productivity are some reasons why Lean Production has become a current state of production systems (Gröbner, 2007).

Today’s business world, is faced with a new prototype known as Industry 4.0, which primarily seems to be a renaissance of the Continental Idea Management (CIM) which emerged 85 years ago and it entails collection of ides from employees across the organisation. Industry 4.0 is a network approach where components and machines are becoming smart and a part of a standardized network based on the well proven internet standards. By strict standardization these objects can be connected to set up larger systems. To ease engineering and set up, the computer systems that are capable to automatically recognize the presence of the new peripheral hardware devices, locate necessary support software and configure device interface may be developed. Furthermore, looking deeper into the Industry 4.0 vision, parallels to Lean Production can be identified, (Kolberg & Zuhlke, 2015).

Also initial approaches for incorporating automation innovation into Lean Production emerged in the 90’s and were called Lean Automation. These days, there are new ranges of Lean Automation application due to capability of Industry 4.0 technologies. Such as implementation of flexible, powerful and affordable Cyber Physical Systems (CPS). New areas of application include enhancing existing Lean Production solutions as well as extending Lean Production’s applicability to different production types.

2.8.1 The current stand of Lean Production and Industry 4.0

Besides being smart, studies reveal that commitment to Industry 4.0 yields a lean factory, (Sanders et al, 2016). Earlier in this section the benefits of LSS are discussed in detail. Furthermore, the capabilities and benefits of combining these two principles are discussed.
Lean Production describes in a non-technological manner, the approach to organized production and managing processes to acquire reduced lead time with minimum costs and highest quality (Ōno, 1988). Its simplicity and high effectiveness had been reasons why Lean Production became famous in 1990s. Today, it is still a fundament of production systems at many OEMs and is used among various business domains (Herlyn, 2011). Key concepts are reduction of waste, a continuous improvement process and a change in production control towards demand oriented production. Lean Production contributes faster reaction on changing market demands, smaller batches and transparent plus standardized processes to mass and batch production (Womack et al., 2007).

Seemingly today there is a conflict between strong abnormalities in market requirements and the required levelled capacity utilization. This is in conflict with an also required order-oriented production and direct connection of production to market demands. Although Lean Production supports a higher variety of products, its fixed sequence of production and fixed cycle times are not suitable for production of highly specialised items. Considering that Lean Production does not account for possibilities of modern information and communications technology (ICT), changes in production processes, or cycle times require considerable time and efforts adjustments of Kanban, (Dickmann, E., 2007). Hence, Lean Production’s suitability for future shorter product life cycles and highly specialised items production is limited.

2.8.2 Capability of Industry 4.0

Industry 4.0 demonstrate an amplified integration of ICT into production. By this means, it could complement the established Lean Production to match future requirements. According to Kolberg & Zuhlke, 2015, in spring 2014, VDMA, Bitkom and ZVEI, three leading German associations of mechanical engineering, ICT and electrical industry, released a definition for Industry 4.0. According to them, Industry 4.0 aims for optimization of value chains by implementing an autonomously controlled and dynamic production. Enablers are the availability of real time information and networked systems (Acatech–Plattform Industrie 4.0, 2014). Instruments to reach this increased automation are CPS which are equipped with sensors and a communication interface, to function autonomously and interact with their production environment (Broy, 2010; Lee, 2008). As a result, a factory becomes ‘smart’. Smart planning optimizes processes in real time where humans take a central position. With the support of innovative ICT they become Smart Operators who supervise and control ongoing activities.

2.8.3 Lean Automation as combination of two disciplines

Lean Automation gets consolidating automation technology with Lean Production. This term turned out to be extensively mainstream in the 1950s, not long after pinnacle of Computer Integrated Manufacturing (CIM). In the most recent decade, science was no longer giving careful consideration to Lean Automation. In any case, with regards to Industry 4.0 new solutions are accessible for consolidation of automation technology with Lean Production.
“Ultimately, Lean Automation comes down to applying Lean concepts where manual processes are required, but minimizing these through balanced application of technology. Lean and Automation are sometimes looked at as two branches off the same ‘industrialization’ tree – each one with its own leaves, but neither dependent on the other. Rather, Lean and Automation are more like the branches and the roots, both part of the industrialization tree, but both contributing equally to the overall health of that tree. Lean processes feed Automation, and Automation supports effective process” says Polka, 2014.

At time, Lean and Automation are perceived as two branches off the same ‘industrialization’ tree, each one with its own particular leaves, yet neither reliant on the other. Rather, Lean and Automation are more like the branches and the roots, both part of the industrialization tree, but both contributing equally to the overall strength of that tree. Lean processes feed Automation, and Automation supports effective process. In this way, these two terms are not mutually exclusive. However, for industrialists who have experienced Lean transformation, or for those who are currently experiencing one, there is a likelihood of acquiring disappointing results. Many factors contribute to this, but the headliner is that processes alone can only get you so far. Indeed, they can bring you entirely far, but there is a reason that since Lean was acquainted with industry somewhere in the range of 75 years back, the numerous iterations of the concept have evolved to incorporate technological integration to a certain degree. Technology designed to enhance Lean methodologies serves to accelerate and sustain process excellence.

2.9 INTEGRATION OF INDUSTRY 4.0 AND LEAN SIX SIGMA

More technology will be installed in the processes in the near future and may become smarter, but remain processes. This indicates that there will still be Six Sigma cases existent even then. Capabilities and deviations must be mastered, drifts must be controlled and there will be needs to pinpoint the influential parameters in an even greater ocean of many, (Hohmann, 1998).

With more automation and the potential capacity to mass production to conform to remarkable demands, these becomes a convenient excuse considerably minimal repetition in high variety, low volume production. Consequently absence of factual importance ought to become extinct. Smart automated processes should deliver more data and faster to which smart objects will add theirs, creating a perpetual data surge. This surge would require evolution of six sigma as it will enter a major data world. Six sigma statistical techniques will not dissect such mass data, however correlation analysis. The newly developed statistical administration and control will be multi-criteria based as required by the new processes.

Theory of Constraints, Lean and Six Sigma, are the processes continuous improvement approaches, prominently known as TLC. Six sigma has high probability of being passed over to the machines due to its nature. Future machines and equipment will assume control separately or in joint efforts, measurable controls, real-time analysis and self-rectification. This will therefore lessen the requirement for
specialists to those building the inserted six sigma knowledge. All things considered, problems will in any case be knowledgeable about the future even with smart factories. The best approach to comprehend and settle them won't change on a very basic level, (Hohmann, 1998). New tools will emerge, however great old DMAIC, PDCA, quality improvement techniques will still be utilised. Despite conceivable exchanges to smart devices, critical thinking and problem solving will in any case require instinct and thinking which must be carried out by human. Therefore, until the point that manmade intelligence demonstrates human proportionate capacities, human factor will still be required in smart factories.

LSS has already been implemented by numerous organisations, of which its core concept revolves around increasing productivity and reducing cost of operation simultaneously. The questions are whether factories that already use lean should switch to Industry 4.0? Maybe both systems could work simultaneously? What about businesses that just started to think about implementing a method that will help them cut unnecessary costs, which system should they choose?

Industry 4.0 is a quite new concept which is still being developed. The idea behind Industry 4.0 (otherwise known as smart factory) is to use modern technologies to improve manufacturing processes. In the ideal world, all machines in factory should on its own connect with one another through Internet or internal network system passing real-time information. Such work should be faster and more cost-effective.

Lean Six Sigma is a much older concept which emerged around late 1980. Acclaimed Toyota industrial facilities are considered as the origin of this idea, thus alternatively it's called The Toyota Way. The essential perception of lean is to reduce waste, increase productivity and customer satisfaction. Although this movement was created for the purposes of improving factory’s operations, lean can be adopted by any business or service, (Hohmann, 1998).

2.9.1 Could Lean Six Sigma and Industry 4.0 cooperate?

Both concepts can cooperate at some level. In spite of the fact that there are specialists who bring up that in a few zones there may be a conflict between the two ideas. However, it must be recalled that Lean Six Sigma and Industry 4.0 work on alternate level but their idea is indistinguishable. They both seek higher effectiveness of the company at lower cost (which doesn't mean lower standards!). LSS handles processes whereas Industry 4.0 deals with software and advanced technologies. Stefanie Peitzke, 2016 points out in her article, “Lean production meets Industry 4.0”, that any factory wanting to explore possibilities of implementing Industry 4.0 in their processes must first have some production system established. Stefanie suggests working with a rule in mind “first process maturity, then Industry 4.0”.

Likewise, if the mining industry decides to adapt the most current modern technologies trending, known as Industry 4.0, it is vital that professionals that could help bring set ideas to life be sought. It is at most significance that such people have knowledge of mining strategies. Software engineers who are hired to design a network should, in particular, have lean production knowledge and Industry 4.0 knowledge.

Industry 4.0 is a German concept and it is based on 4 design principles.
• Interoperability: The ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP).

• Information transparency: The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.

• Technical assistance: First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.

• Decentralized decisions: The ability of cyber physical systems to make decisions on their own and to perform their tasks as autonomous as possible. Only in case of exceptions, interferences, or conflicting goals, tasks are delegated to a higher level.

Analysing the above stated principles one will realise that some of the existing industries can move towards industry 4.0 by using six sigma methodologies and tools like, FMEA, DMAIC approach and hypothesis testing. If a new plant is being set up or new products being designed then DFSS can be used.

In my personal conviction, Lean Six sigma is not a tool or technique. It is a procedure of approaching problems and discovering coherent and viable solutions.

2.10 SUMMARY

This section of the study reviews ERP system and Lean Six Sigma general, including the foundation, their implications and benefits in a mining industry. The origin and definition of ERP systems and Lean Six Sigma are addressed as well as possible implementation success factors and the possibility of their integration. From the literature, it is not clear which basic success factors are more influential in two dimensions of success, project and business. The proposed hypotheses did not indicate precisely which dimension of success is focused on. Subsequently, the impact of independent factors on each of the success dimensions are tried.

It is recommendable that organisations search for a more flexible, open licensing model that will allow it to deploy the solution more completely throughout its enterprise. Everyone at the company adds value to the products and services an organisation provides; the most effective system will capture important facts about everything going on as it happens.

Streamlining business processes and subsequently increasing productivity, eliminating waste of time and resources furthermore reducing costs, are the key considerations of an organization. They could be provided by utilizing some suitable
tools and strategies, such as, ERP Systems and Lean Six Sigma Methodologies. Their internal benefits for an organization have been separately explained.

By using technology to establish a groundwork for business processes, an integrated Lean Six Sigma environment that conveys sustainable, repeatable performance and profitability within reach is coordinated. An ERP foundation provides prevailing functionality for mining planning, execution, and quality maintenance while an open integration platform connects the enterprise to the supply chain to achieve the greatest efficiencies in time and cost to deliver the following benefits:

- Increased responsiveness: rapid reaction to the market changes and exploit developing opportunities without excess inventory being held.
- Superior efficiency: Improved order fill rates, incremented on-time deliveries, and elevated production volumes with shorter lead times, while increasing the value added per product, per employee, and per resource.
- Reduced operating costs: Minimize the costs associated with exception resolution, inventory management, data management, and more – while intensifying the highest levels of quality and customer service.

With current modernised software advancement methodologies and conveyance over the Internet, software vendors can release changes very frequently. Software changes and system software modernisations are done with a minimal customers efforts.

Owing to challenges such as depressed commodity prices, declining revenues, increasing production costs and high energy costs, the South African and Africa in general, mining industry need to embrace new solutions based on the fourth industrial revolution transformation, (Liedtke, 2017). He emphasizes that such developments would bring about growth to Africa’s mining experts pool.

Technology innovations have brought enormous advantages for businesses in various sectors relative to reduction of costs, enhanced productivity and efficiency. These have also to a certain degree promoted the investment in education and training developments, which develops more highly skilled personnel in Africa as whole. Consequently leading to leading to improved socioeconomic development. Thus, as discussed in this section, it is imperative for South African mining industry to embrace modern technologies which will create opportunities and increment the demand for skilled personnel which will be provided through education and training in the mining industry.

The terms of Lean Automation and Industry 4.0 have been portrayed in this section, and it is evident that the incorporation of innovative automation technology in Lean Production is an up to date and capable theme.

Nevertheless, there is an absence of an exhaustive structure which consolidates Industry 4.0 solutions with methods of Lean Production. Exclusively a comprehensive concept for adaptable integration of manual as well as automated working stations is missing. With CPS, there are equipment solutions as an interface for working stations accessible. Required communication etiquettes exist partly. Only a domain specific
standard for an automated decentralized production control in Lean Production is absent. In short, Industry 4.0 and Lean Production do not eliminate each other. Together they can add value to users. Thus, need for deepened research in the field of Lean Automation. Focusing on transferring existing Industry 4.0 solutions into Lean Production and implementing CPS as standardized building blocks for working stations.

SECTION 3: METHODOLOGY

3.1 INTRODUCTION

The studies reviewed have tried to establish the cause of ERP system-implementation failure from a general point of view. In this study, this topic is investigated from the point of view of an ERP project manager who had previously headed the implementation of an ERP system in a mine and the employees who were all well placed in the system and used it frequently. The identification of the factors that are vital for effective implementation of ERP systems is important to numerous organisations.

Certain studies, for example, Somers and Nelson (2004) have recognised critical success factors, which eased this task for this study. These factors were, however, tested in a developing country setting, Bahrain by (Kamhawi, 2007), among other areas. The current study intended to broaden this stream of research, based on a mining organisation in South Africa, by examining these factors in two success dimensions: project success and business success. In addition, the current literature on the integration of the ERP system and LSS principle was systematically evaluated in an attempt to enhance the system for better mining business performance and enhanced process quality.

To analyse every one of the information gathered, both quantitative and subjective techniques will be employed. Quantitative analysis will involve computation of descriptive statistics, mostly percentages. These will help in clearly noting the relationship in a quantitative sense. Descriptive analysis will be carried out to describe and give the overall sample size, for example, the average age, the proportion of sex and experience in using the system. The data from the questionnaires will be analysed using Statistical Package for Social Science, version 23 (SPSS 23) for percentages and frequencies to analyse the relationship among the factors in ERP implementation.

Subjective analysis will handle the logical and factual interpretations, comparisons and explanations on the study findings. Word narration on findings will be used particularly on the information that was obtained through interviews and observation.
3.2 RESEARCH DESIGN

3.2.1 Survey Items

Both quantitative and qualitative research approaches were used in the study, with the survey, interview and observation used as data-collection methods. Using the quantitative approach, questionnaires with closed questions were used for the survey because this type of questionnaire is suitable when the variable is known. All respondents were exposed to similar categories of responses. Closed questions are easy to analyse, can be more particular and answering them does not take up an excessive amount of time for the respondent. All of the respondents were asked similar questions, which were divided into three sections. To create the closed questions, guidance was sought from STATKON, the statistics consulting organisation that works with the University of Johannesburg, so that the questionnaire would yield data that lent itself to analysis. The questionnaire was used to complete a survey of a mining organisation that had previously implemented an ERP system, as mentioned above. The results of the survey were used to prepare questions for interviewing ERP expert in relation to the most important factors highlighted by the results of the literature study. This was a key part of the study, as it related theory with practice to build a solid ground for further discussion.

3.2.1.1 Independent variables: ERP critical success factors

The eight critical success factors discussed by Somers and Nelson (2004) were identified as the independent variables in the study. The survey questionnaire focused on these variables (see Appendix A).

1. **Technical Fit**

To evaluate the compatibility of the ERP system with the existing system used by the organisation, four questions were created. These questions additionally addressed the issues of smooth movement of data and key business processes to more advanced technology and the reliability of the ERP system.

2. **Organisational Fit**

Items that measured organisational fit were developed to assess whether the implemented ERP system addressed all the organisation’s requirements. Alignment of the organisation’s business and IT techniques with the ERP system was evaluated. Another critical question concerned the quality of the communication of the documents used in the organisation with those of the ERP data items (e.g. financial report sheets and sales report sheets).

3. **Business Process Re-engineering**

Five questions were designed in connection with BPR. These questions requested that the respondents evaluate the level of BPR required to fit the ERP packages used.
4. **Top Management Support**

Four questions were created to distinguish the level of top management support related to ERP system implementation. Questions concerned the degree of top management support, planning, training and team contribution with respect to the respondents' ERP implementation projects.

5. **Project Planning**

Questions created on this factor aimed to distinguish the effectiveness of the implementation of project planning. One question was about the respondents' understanding of how the implementation of the ERP system would contribute to the organisation's overall strategies.

6. **User Participation and Training**

Five questions were created to assess the respondents’ satisfaction with the ERP system and how familiar they were with the system. Measuring items incorporated questions that concerned the training provided with the system, ease of use of the components of the ERP system that the respondents used and the degree of overall satisfaction with the system.

7. **Organisational Resistance**

The questions used to measure organisational resistance were about both resistance to using the system and embracing the change brought about by the implementation of the system.

8. **Effective Communication**

Five questions were developed to assess the degree of effective communication about the expectations of the ERP system. Items involved questions concerning project team promotion and progress, contribution from the users, and clear and continuous communication between the vendor and the organisation.

3.2.1.2 **Dependent variables: ERP implementation success dimensions**

These two success dimensions were identified by Kamhawi, 2007 as the dependent variables that measure the success of the ERP system implementation.

1. **Business success dimension**

Five questions were developed to evaluate the ERP system’s effect on the success of the mining business. Two questions were about operations’ cost-saving funds and revenue increments. Another question with regard to business success concerned enhanced cash management, as proposed by previous authors (Thangavelu 2015). It is believed that after ERP implementation cash management is improved; hence, a positive relationship exists between business success and ERP implementation.
2. **Project success dimension**

As described in the previous section, the degree of project success can be evaluated in terms of time, cost, quality and scope as common project management contexts applied. Therefore, four questions were developed, which asked whether the ERP implementation project was completed on time, on budget and with good quality and, finally, whether the scope of the system was coordinated with the organisation's needs.

3.3 **POPULATION OF THE STUDY**

The targeted population of the study was a mining business. The emphasis was on mining organisations situated in South Africa that had displayed success in implementing and using ERP systems. The mining and metals industry is broadly perceived as critical for society and as a key contributor to sustainable development. This meant that the selection of this industry was affected by its high contribution to the South African economy, which is around 18% and over 50% in foreign exchange earnings (Smit, 2013). An interest in conducting the study was created by the perception that: "A better improvement of the mining industry processes, yields a better improvement of the economy and higher employment creation." (Smit 2013). Likewise the variety of ERP implementation success factors from industry to industry stimulated an interest in the researcher for this subject. Mining is a typical large capital enterprise, with heavy equipment and large plants. In order to accomplish the best return on resources, considering that it is a capital-intensive business and needs to keep production costs low, mine equipment and plants normally run continuously. Thus, the core focus for any ERP in this industry is to keep the heavy equipment and plants running through effective capacity and maintenance management. ERP aids in preventing time wastage by accurate production scheduling and in avoiding unexpected breakdowns by planning preventive maintenance tasks, which are essential aspects of business performance.

3.4 **SAMPLING PROCEDURE**

The study aimed to include about 300 respondents working in mining organisations and with experience in using an ERP system as a part of the industry. These respondents were expected to give a reasonable perspective of which factors are critical for the success of an ERP system. The Human Resource/IT manager of each organisation was requested ahead of time to provide a list of potential respondents for the study. Only IT and non-IT staff members who were well placed in the ERP system-implementation process in their organisation were selected for the purpose of this study as these people were expected to be aware of the critical factors that would influence ERP success or performance. The respondents needed to be actively involved in their organisation's ERP system to have the capacity to give precise insight into the organisation's ERP implementation and use.
3.5 THE SAMPLE

Owing to a lack of time and funds to reach all the mining organisations around South Africa, a sample of 302 respondents from two organisations was used in this study. According to Chamber of Mines, in 2009 about 600 000 people were employed in the South African mining sector. Thus, the sample of approximately 300 used in this study represents a ratio of 1:200 of the employees in this sector.

3.6 INSTRUMENTATION

The content validity of the survey questionnaire instrument was established through the adoption of the relevant constructs in the literature. Changes were made in wording of the questionnaire, where necessary, to suit the context of the study. For the data obtained from a study to be valid, the empirical measurement of the data must reflect clearly what the concept under study implies (Trochim, 2005). Accordingly guidelines to validate the instrument were followed so as to capture the required data.

The study instrument was set out on the basis of the conceptual ERP success model proposed by Kamhawi (2007) for his empirical investigation in Bahrain. Each variable was given at least three questions for reliability purposes. Most questions in the survey were primarily adapted from relevant previous research related to IS acceptance or success. All items were measured on a 7-point Likert scale, from "strongly disagree" to “strongly agree”. Items in the survey are described in Appendix A.

3.7 DATA COLLECTION

Data was gathered from both primary (survey and observations) and secondary (semi-structured interviews) methods as explained in detail below.

3.7.1 Primary Data

As per Kothari (2013), data that is collected for the first time and is original in character is said to be a primary data. The primary data in this study was gathered directly from the respondents through surveys and open discussion interviews with ordinary workers for the purpose of answering the research questions.

3.7.2 Secondary Data

Kumekpor (2002) views secondary data as information that has been gathered previously for some purpose other than the current study. In this study, extensive literature review and interviewees were considered to be the secondary sources. The respondents were expected to have concise information about the topic, which they had gathered through their diverse experiences in heading an ERP implementation project and in their involvement in various industries and decision-making processes. This assisted in backing up the perception of the employees captured through the survey as primary data.
3.8 ETHICAL CONSIDERATIONS

Prior to the initiation of the study and to incorporating the respondents in the study, their consent was sought. This was achieved by first contacting the relevant manager and introducing the study to them. Once access to employees as potential respondents was granted by the manager, these employees (respondents) were provided with relevant information about the study (i.e. the purpose, the significance of their participation and the information they would provide and what was required of them as an organisation). Their consent to participate in the study was then sought. Providing the respondents with information about the study aided in getting them to open up and provide the relevant information that was required for the study. The survey tools that were distributed among the respondents included a letter that assured them of the confidentiality of the information they provided. No type of identification was used in the instrument (e.g. names of the respondents). This meant that the subjects were anonymous.

3.9 DATA PREPARATION

To ease the task of statistical analysis of the factors identified, these factors were coded as follows: Technical Fit (TF); Organisational Fit (OF); Business Process Re-engineering (BPR); Top Management Support (TMS); Project Planning (PP); User Participation/involvement and Training (UPT); Organisational Resistance (OR); Effective Communication (EC); ERP Project Success Dimension (ERPPSD); and ERP Business Success Dimension (ERPBSD). The items that measured each construct were numbered accordingly in no particular order of perceived influence.

3.10 DEFINITION OF RESEARCH VARIABLES

The mean of each item that measured each perceived construct was computed as indicated in Section 4.4. Sub-section 3: Attitudes and Perceptions. Therefore, to measure the significance of each variable/factor, an overall average for all the items was computed. The degree of influence of each factor was ranked according to the overall mean of the items measuring each variable (i.e. the variable with the highest overall mean of the items was said to be the most influential on ERP implementation success and vice versa). To translate the respondents’ behaviour into a score that validly represented the behaviour, Section C of the questionnaire, which explored attitudes and perceptions regarding the ERP system, was designed to use a 7-point scale that represented that behaviour in a numerical form to be analysed statistically.

3.11 HYPOTHESIS-TESTING PROCEDURE

ERP system implementation is a newly explored subject. The arguments arising around this subject are mostly individual perspectives that are yet to be proven as in this study. The percentages, frequencies and overall averages presented in this study to test the postulated hypotheses on the relationship between identified factors and ERP implementation success, together with simple graphic analysis, forms the basis of virtually every quantitative analysis of data. This sets a foundation for further
analysis that may be considered in a study of this nature, such as correlation analysis and regression analysis.

SECTION 4: FINDINGS, ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

This section presents the research findings through discussions and interpretation. These are based on the research objectives, identified problems and questions that arose about the subject as discussed in the first chapter of the study. The questions posed are discussed through the dependent variables (project success dimension and business success dimension) and the independent variables (organisational fit, technical fit, business process re-engineering, top management support, project planning, user participation and training, organisational resistance and effective communication).

This section is arranged in three sub-sections. In the first sub-section the respondents’ background information is presented; the second explores habits and preferences with regard to ERP system consumption; and the third explores the factors associated with the successful implementation of an ERP system and the attitudes and perceptions regarding the ERP system.

4.2 SUB-SECTION 1: RESPONDENTS’ BACKGROUND INFORMATION

4.2.1 Respondents’ Profile

The respondents who completed the survey questionnaire came from a group of workers who used an ERP system in their organisations and were well placed in the system to be aware of the factors that influenced its success. The section displays the respondents’ age and duration of using the system either in the mining industry in which they worked at the time of the study or in other industries. This background information aided in analysing and understanding which workers would provide accurate responses. The results of the analysis are presented below using tables and descriptive statistics. These are set out according to the questionnaire section and items.

4.2.2 Respondents’ Background Information

A sample of 302 respondents filled in the survey questionnaire. Approximately 77% of the respondents were male and about 23% female. This indicates that there were more males than females involved in the use of ERP systems and this could be because there are more male employees in mining organisations than female employees.
The study used age categories to further ensure anonymity and avoid easy identification of the respondents. All age groups were considered in this study, with the majority of respondents (44%) found to be in the 45 – 55 age group.

Table 4.2: Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-34</td>
<td>19</td>
<td>6.3</td>
<td>6.3</td>
</tr>
<tr>
<td>35-44</td>
<td>88</td>
<td>29.1</td>
<td>35.4</td>
</tr>
<tr>
<td>45-55</td>
<td>133</td>
<td>44.0</td>
<td>79.5</td>
</tr>
<tr>
<td>Over 55</td>
<td>62</td>
<td>20.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

The question on how long the respondents had been using the ERP system was asked to ensure that they had adequate experience to respond effectively to the questionnaire.

Table 4.3: Duration of ERP utilisation

<table>
<thead>
<tr>
<th>Duration of ERP utilisation</th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 years</td>
<td>23</td>
<td>7.6</td>
<td>7.6</td>
</tr>
<tr>
<td>6-10 years</td>
<td>58</td>
<td>19.2</td>
<td>26.8</td>
</tr>
<tr>
<td>11-15 years</td>
<td>91</td>
<td>30.1</td>
<td>57.0</td>
</tr>
<tr>
<td>16-20 years</td>
<td>86</td>
<td>28.5</td>
<td>85.4</td>
</tr>
<tr>
<td>More than 20 years</td>
<td>44</td>
<td>14.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
It was of importance to establish how long the respondents had been placed in the ERP system in the mining industry. This enabled the researcher to determine whether they were the relevant respondents for the survey conducted and whether their experience of using an ERP system in the mining industry was adequate.

| Table 4.4: Length of ERP utilisation in current industry |
|-------------|-------------|-------------|
|             | Frequency   | Per cent    | Cumulative Per cent |
| 0-5 years   | 56          | 18.5        | 18.5                  |
| 6-10 years  | 85          | 28.1        | 46.7                  |
| 11-15 years | 90          | 29.8        | 76.5                  |
| 16-20 years | 50          | 16.6        | 93.0                  |
| More than 20 years | 21 | 7.0 | 100.0 |
| Total       | 302         | 100.0       | 100.0                 |

4.3 SUB-SECTION 2: HABITS AND PREFERENCES

All the respondents expressed that they had an ERP system implemented in their companies. Table 4.5 below indicates the respondents’ answers to the question about whether they had an implemented ERP system in their organisations. This aided to ensure that all the selected respondents were relevant to the study.

| Table 4.5: Implemented ERP system |
|-------------|-------------|-------------|
|             | Frequency   | Per cent    | Cumulative Per cent |
| Yes         | 302         | 100.0       | 100.0                 |

ERP implementation is said to bring about a restructuring of the business process to effectively align it with the functionalities of the system. Thus the respondents were asked to provide their thoughts on whether their business process had restructured as a result of the implementation of ERP. Table 4.6 presents the responses. A total of 94% of the respondents indicated that the implementation of the system had brought about the restructuring of the business process while the other 6% indicated there had not been any restructuring of the process.
It has been consistently argued that the key to successful ERP implementation is change management that ensures that people are ready for the new system, enthusiastic or positive about the changes it will bring and aware of how the system will affect their individual jobs. Thus, the question, “Do you think the working culture has changed completely after implementation of ERP?” was posed to the respondents and Table 4.7 below presents their responses. Of all the respondents, 89% thought that there had been a change whereas the remainder (about 11%) thought that there had not been any changes imposed by the implementation of the ERP system.

Table 4.7: Change in work culture post ERP implementation

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>18</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Yes</td>
<td>284</td>
<td>94.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

A proper implementation of an ERP system may increase or decrease employees’ workload. Table 4.8 below shows that about 19% of the respondents in this regard indicated that the workload had incremented; however, employees were able to complete their tasks. The remaining 81% indicated an evenly distributed workload, with employees thus being able to complete their tasks.
“Do you think ERP and Business Process Re-engineering/Restructuring (BPR) implementation is able to develop a systematic and effective work culture?” This was posed to the respondents in the questionnaire to assess the degree to which ERP implementation and BPR had created an effective organisational culture in their organisations. As indicated in Table 4.9 below, about 95% of the respondents expressed that this had been the case.

Table 4.9: Development of effective work culture through ERP and BPR

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>16</td>
<td>5.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Yes</td>
<td>286</td>
<td>94.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

It is the goal of most organisations to reduce operational cost and use resources efficiently while increasing output. Respondents were requested to indicate their opinion on whether the implementation of ERP had been helpful in the reduction of operational costs and in increasing productivity. The results are presented in Table 4.10 below.
The implementation of an ERP system entails explaining in detail the roles to be taken by the parties that will be affected by the changes it brings about. One of the requirements of this survey was for the respondents to express whether the goals to be achieved and the tasks to be undertaken in this project were clearly defined for them. The results are presented in Table 4.11 below.

**Table 4.11: Clear definition of the goals and tasks to relevant parties**

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>14</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Yes</td>
<td>288</td>
<td>95.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

To ensure that the system is working as anticipated and the organisation is reaping the best of its benefits, the activities have to be tracked throughout the implementation and use of the system. To ensure that the organisation is moving in the right direction or actually moving at all, the progress needs to be monitored. There is no stipulated formula for how often tracking should be undertaken, but it is an ongoing activity that should run as long as the duration of the implementation project and post that too. The respondents were asked, “Does the management keep track on the activities in the organization due to ERP implementation?”

**Table 4.12: Tracking of activities due to ERP implementation**

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>6</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Yes</td>
<td>296</td>
<td>98.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
Respondents were asked if the problems of the company were resolved in an efficient manner with the help of the ERP solution and the results are presented in Table 4.13 below. However, it was found throughout the course of the study that ERP does not necessarily “solve” problems. A well-implemented ERP system will at most times make an organisation’s business processes more efficient and easier to manage and will solve unfulfilled business needs. On the other hand, when implemented improperly, it may cause more problems than it solves. Wrong data, inefficient business processes, high maintenance costs and frustrated employees are some of the problems it may cause.

Table 4.13: Efficient problem resolution with ERP solution

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>23</td>
<td>7.6</td>
<td>7.6</td>
</tr>
<tr>
<td>Yes</td>
<td>279</td>
<td>92.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Massive information is being generated in today’s business, and information becomes a starting point for virtually all activities performed in a company. ERP has tremendous functions and capabilities for real-time information sharing across the business processes. Organisations need effective information sharing from all business areas to drive a rapid momentum in performance globally. Five items were used to measure the degree of the respondents’ satisfaction with information sharing within the organisation brought about by the ERP solution implemented in the organisation, as indicated in Table 4.14 below.

Table 4.14: Satisfaction with information sharing through ERP solution

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No comment</td>
<td>1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Not at all</td>
<td>4</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>To very little extent</td>
<td>12</td>
<td>4.0</td>
<td>5.6</td>
</tr>
<tr>
<td>To some extent</td>
<td>188</td>
<td>62.3</td>
<td>67.9</td>
</tr>
<tr>
<td>To a great extent</td>
<td>97</td>
<td>32.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
In rating the respondents' satisfaction with ERP and business process restructuring in the organisation, the measuring items were structured from “dissatisfactory” to “highly satisfactory” as indicated in Table 4.15 below. Of the 302 respondents, 182 (about 60%) indicated that they were satisfied with the system, while the number of highly satisfied respondents equalled the number of averagely satisfied respondents (at 19.5%). Only 0.7% of the respondents were dissatisfied.

Table 4.15: Respondents’ satisfaction with ERP system

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Per cent</th>
<th>Cumulative Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissatisfactory</td>
<td>2</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Average</td>
<td>59</td>
<td>19.5</td>
<td>20.2</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>182</td>
<td>60.3</td>
<td>80.5</td>
</tr>
<tr>
<td>Highly satisfactory</td>
<td>59</td>
<td>19.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>302</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

4.4 SUB-SECTION 3: ATTITUDE AND PERCEPTIONS

The respondents’ attitudes and perceptions were measured by a 7-point scale. For the sake of analysis, “Strongly disagree”, “Disagree” and “Somewhat disagree” are grouped as “Disagree”, while “Somewhat agree”, “Agree” and “Strongly agree” are grouped as “Agree”. Respondents’ perceptions of the items that measure each factor are shown in Tables 4.16 to 4.24 and the items are explained in Appendix A.

Table 4.16: Technical Fit (TF)

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF1</td>
<td>(N) 4</td>
<td>80</td>
<td>218</td>
</tr>
<tr>
<td>(%)</td>
<td>1.3%</td>
<td>26.5%</td>
<td>72.2%</td>
</tr>
<tr>
<td>TF2</td>
<td>(N) 5</td>
<td>63</td>
<td>234</td>
</tr>
<tr>
<td>(%)</td>
<td>1.7%</td>
<td>20.9%</td>
<td>77.5%</td>
</tr>
<tr>
<td>TF3</td>
<td>(N) 2</td>
<td>65</td>
<td>235</td>
</tr>
<tr>
<td>(%)</td>
<td>0.7%</td>
<td>21.5%</td>
<td>77.8%</td>
</tr>
<tr>
<td>TF4</td>
<td>(N) 0</td>
<td>62</td>
<td>240</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>20.5%</td>
<td>79.4%</td>
</tr>
</tbody>
</table>
Table 4.17: Organisational Fit (OF)

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF5</td>
<td>0</td>
<td>63</td>
<td>239</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>20.9%</td>
<td>79.2%</td>
</tr>
<tr>
<td>Av %</td>
<td>0.7%</td>
<td>22.1%</td>
<td>77.2%</td>
</tr>
</tbody>
</table>

Table 4.18: Business Process Re-engineering (BPR)

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPR1</td>
<td>2</td>
<td>55</td>
<td>245</td>
</tr>
<tr>
<td>(%)</td>
<td>0.6%</td>
<td>18.2%</td>
<td>81.1%</td>
</tr>
<tr>
<td>BPR2</td>
<td>5</td>
<td>58</td>
<td>239</td>
</tr>
<tr>
<td>(%)</td>
<td>1.7%</td>
<td>19.2%</td>
<td>79.1%</td>
</tr>
<tr>
<td>BPR3</td>
<td>2</td>
<td>42</td>
<td>258</td>
</tr>
<tr>
<td>(%)</td>
<td>0.7%</td>
<td>13.9%</td>
<td>85.4%</td>
</tr>
<tr>
<td>BPR4</td>
<td>1</td>
<td>63</td>
<td>238</td>
</tr>
<tr>
<td>(%)</td>
<td>0.3%</td>
<td>20.9%</td>
<td>78.9%</td>
</tr>
<tr>
<td>BPR5</td>
<td>1</td>
<td>55</td>
<td>163</td>
</tr>
<tr>
<td>(%)</td>
<td>0.3%</td>
<td>18.2%</td>
<td>81.5%</td>
</tr>
<tr>
<td>-----</td>
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</tr>
<tr>
<td>Av %</td>
<td>0.7%</td>
<td>18.1%</td>
<td>81.2%</td>
</tr>
</tbody>
</table>

Table 4.19: Top Management Support (TMS)

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMS1</td>
<td>0</td>
<td>53</td>
<td>249</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>17.5%</td>
<td>82.4%</td>
</tr>
<tr>
<td>TMS2</td>
<td>1</td>
<td>60</td>
<td>241</td>
</tr>
<tr>
<td>(%)</td>
<td>0.3%</td>
<td>19.9%</td>
<td>79.9%</td>
</tr>
<tr>
<td>TMS3</td>
<td>10</td>
<td>48</td>
<td>253</td>
</tr>
<tr>
<td>(%)</td>
<td>0.3%</td>
<td>15.9%</td>
<td>83.8%</td>
</tr>
<tr>
<td>TMS4</td>
<td>0</td>
<td>48</td>
<td>254</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>15.9%</td>
<td>84.1%</td>
</tr>
<tr>
<td>Av %</td>
<td>0.2%</td>
<td>17.3%</td>
<td>82.6%</td>
</tr>
</tbody>
</table>

Table 4.20: Project Planning (PP)

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP1</td>
<td>0</td>
<td>53</td>
<td>249</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>17.5%</td>
<td>82.5%</td>
</tr>
<tr>
<td>PP2</td>
<td>0</td>
<td>45</td>
<td>257</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>14.9%</td>
<td>85.1%</td>
</tr>
<tr>
<td>PP3</td>
<td>0</td>
<td>56</td>
<td>246</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>18.5%</td>
<td>81.4%</td>
</tr>
<tr>
<td>Av %</td>
<td>0.0%</td>
<td>17.0%</td>
<td>83%</td>
</tr>
</tbody>
</table>
Table 4.21: *User Participation and Training (UPT)*

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPT1  (N)</td>
<td>0</td>
<td>41</td>
<td>261</td>
</tr>
<tr>
<td>(% )</td>
<td>0.0%</td>
<td>13.6%</td>
<td>86.4%</td>
</tr>
<tr>
<td>UPT2  (N)</td>
<td>0</td>
<td>50</td>
<td>252</td>
</tr>
<tr>
<td>(% )</td>
<td>0.0%</td>
<td>16.6%</td>
<td>83.4%</td>
</tr>
<tr>
<td>UPT3  (N)</td>
<td>3</td>
<td>42</td>
<td>257</td>
</tr>
<tr>
<td>(% )</td>
<td>1.0%</td>
<td>13.9%</td>
<td>85.2%</td>
</tr>
<tr>
<td>UPT4  (N)</td>
<td>0</td>
<td>40</td>
<td>262</td>
</tr>
<tr>
<td>(% )</td>
<td>0.0%</td>
<td>13.2%</td>
<td>86.8%</td>
</tr>
<tr>
<td>UPT5  (N)</td>
<td>0</td>
<td>62</td>
<td>240</td>
</tr>
<tr>
<td>(% )</td>
<td>0.0%</td>
<td>20.5%</td>
<td>79.5%</td>
</tr>
<tr>
<td>Av %</td>
<td>0.2%</td>
<td>15.6%</td>
<td>84.3%</td>
</tr>
</tbody>
</table>

Table 4.22: *Organisational Resistance (OR)*

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR1   (N)</td>
<td>1</td>
<td>50</td>
<td>256</td>
</tr>
<tr>
<td>(% )</td>
<td>0.3%</td>
<td>16.6%</td>
<td>83.1%</td>
</tr>
<tr>
<td>OR2   (N)</td>
<td>1</td>
<td>46</td>
<td>255</td>
</tr>
<tr>
<td>(% )</td>
<td>0.3%</td>
<td>15.2%</td>
<td>84.5%</td>
</tr>
<tr>
<td>OR3   (N)</td>
<td>0</td>
<td>44</td>
<td>258</td>
</tr>
<tr>
<td>(% )</td>
<td>0.0%</td>
<td>14.6%</td>
<td>85.4%</td>
</tr>
<tr>
<td>Av %</td>
<td>0.2%</td>
<td>15.5%</td>
<td>84.3%</td>
</tr>
</tbody>
</table>
Table 4.23: Effective Communication (EC)

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC1</td>
<td>1</td>
<td>47</td>
<td>254</td>
</tr>
<tr>
<td>(%)</td>
<td>0.3%</td>
<td>15.6%</td>
<td>84.1%</td>
</tr>
<tr>
<td>EC2</td>
<td>0</td>
<td>48</td>
<td>254</td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>15.9%</td>
<td>84.1%</td>
</tr>
<tr>
<td>EC3</td>
<td>3</td>
<td>52</td>
<td>247</td>
</tr>
<tr>
<td>(%)</td>
<td>1.0%</td>
<td>17.2%</td>
<td>81.8%</td>
</tr>
<tr>
<td>EC4</td>
<td>3</td>
<td>48</td>
<td>251</td>
</tr>
<tr>
<td>(%)</td>
<td>1.0%</td>
<td>15.9%</td>
<td>82.8%</td>
</tr>
<tr>
<td>EC5</td>
<td>1</td>
<td>59</td>
<td>242</td>
</tr>
<tr>
<td>(%)</td>
<td>0.3%</td>
<td>19.5%</td>
<td>80.1%</td>
</tr>
<tr>
<td>Av %</td>
<td>0.5%</td>
<td>16.8%</td>
<td>82.6%</td>
</tr>
</tbody>
</table>

Table 4.24: Overall perceptions of influencing factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Disagree (Av %)</th>
<th>Neutral (Av %)</th>
<th>Agree (Av %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TF</td>
<td>0.7%</td>
<td>22.1%</td>
<td>77.2%</td>
</tr>
<tr>
<td>2. OF</td>
<td>0.3%</td>
<td>18.9%</td>
<td>80.8%</td>
</tr>
<tr>
<td>3. BPR</td>
<td>0.7%</td>
<td>18.1%</td>
<td>81.2%</td>
</tr>
<tr>
<td>4. TMS</td>
<td>0.2%</td>
<td>17.3%</td>
<td>82.6%</td>
</tr>
<tr>
<td>5. PP</td>
<td>0.0%</td>
<td>17.0%</td>
<td>83%</td>
</tr>
<tr>
<td>6. UPT</td>
<td>0.2%</td>
<td>15.6%</td>
<td>84.3%</td>
</tr>
<tr>
<td>7. OR</td>
<td>0.2%</td>
<td>15.5%</td>
<td>84.3%</td>
</tr>
<tr>
<td>8. EC</td>
<td>0.5%</td>
<td>16.8%</td>
<td>82.6%</td>
</tr>
<tr>
<td>Overall Av %</td>
<td>0.4%</td>
<td>17.7%</td>
<td>82%</td>
</tr>
</tbody>
</table>

The findings show that, on average, 0.4% of the respondents disagreed that the identified factors are influential in the implementation of ERP. An average of 17.7% showed a neutral perception, meaning that they were not really sure whether these factors are influential or not. On the other hand, the majority, 82%, indicated that they agreed that these factors are influential.

The perceptions of the success of the ERP system were captured from employees well placed in the system, managers who headed the implementation and an ERP expert who had been involved in various system-implementation projects in various
industries and in making vital ERP improvement decisions. Although no evidence was obtained regarding which factor(s) are influential in each of the two success dimensions focused on in this study, the results show which success dimension is largely considered to indicate the successful implementation of an ERP system. In most cases, in almost every organisation, an ERP system is adopted to improve the process or operation of the business. Therefore, the results shown in Tables 4.25 and 4.26 indicate that 82% of the respondents agree that when all the business objectives of implementing ERP are achieved, the implementation is perceived to be successful. Regarding the project dimension, 80% of the respondents favoured success in this dimension as pointing to the success of the overall ERP. This shows that ERP is said to be a success if it performs according to its expectations in the business process and the organisation reaps the intended benefits.

The ERP expert interviewed indicated that it is essential to correlate these two dependent factors (success dimensions) to achieve complete success of the implementation of the system. According to this expert:

Completing implementation within budget and anticipated time, reducing operational costs, improving decision making and problem solving, among other benefits, will be a complete achievement of the intention of implementing the system in the first place.

The questions that directed the interview are presented in Annexure B and discussed later in this section.

Table 4.25: ERP Business Success Dimension (ERPBSD)

<table>
<thead>
<tr>
<th>Items</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERPBSD1</td>
<td>0</td>
<td>49</td>
<td>253</td>
</tr>
<tr>
<td>(N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>16.2%</td>
<td>83.7%</td>
</tr>
<tr>
<td>ERPBSD2</td>
<td>4</td>
<td>60</td>
<td>238</td>
</tr>
<tr>
<td>(N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>1.4%</td>
<td>19.9%</td>
<td>78.8%</td>
</tr>
<tr>
<td>ERPBSD3</td>
<td>0</td>
<td>52</td>
<td>250</td>
</tr>
<tr>
<td>(N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>17.2%</td>
<td>82.8%</td>
</tr>
<tr>
<td>ERPBSD4</td>
<td>0</td>
<td>45</td>
<td>257</td>
</tr>
<tr>
<td>(N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>14.9%</td>
<td>85.1%</td>
</tr>
<tr>
<td>ERPBSD5</td>
<td>0</td>
<td>60</td>
<td>242</td>
</tr>
<tr>
<td>(N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>0.0%</td>
<td>19.9%</td>
<td>80.1%</td>
</tr>
<tr>
<td>Av %</td>
<td>0.3%</td>
<td>17.6%</td>
<td>82.1%</td>
</tr>
</tbody>
</table>
In accordance with the discussion in one of the previous sections (Section 3) of this study, a number of factors were ranked according to their relevance. Post the factor analysis in the current study, the information was converted to numerical form and each factor was related to ERP implementation success according to their frequencies, means and rankings. Table 4.27 below presents the overall means and standard deviations of the eight factors used in this study. These factors are then ranked according to their means in descending order (from the highest mean to the lowest). As the unit of analysis in this study is two organisations, multiple responses were averaged to be used as the organisational-level factors.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Overall mean</th>
<th>Standard deviations</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TF</td>
<td>5.06</td>
<td>.755</td>
<td>7</td>
</tr>
<tr>
<td>2. OF</td>
<td>5.17</td>
<td>.750</td>
<td>4</td>
</tr>
<tr>
<td>3. BPR</td>
<td>5.14</td>
<td>.754</td>
<td>6</td>
</tr>
<tr>
<td>4. TMS</td>
<td>5.22</td>
<td>.745</td>
<td>1</td>
</tr>
<tr>
<td>5. PP</td>
<td>5.16</td>
<td>.697</td>
<td></td>
</tr>
<tr>
<td>6. UPT</td>
<td>5.16</td>
<td>.690</td>
<td>5</td>
</tr>
<tr>
<td>7. OR</td>
<td>5.21</td>
<td>.730</td>
<td>2</td>
</tr>
<tr>
<td>8. EC</td>
<td>5.18</td>
<td>.742</td>
<td>3</td>
</tr>
</tbody>
</table>

As can be seen in Table 4.27, Total Management Support (TMS) ranked first among the identified factors influencing ERP implementation success. Lack of commitment of top/senior management is one of the major risk factors for ERP projects.
Organisational Resistance (OR) took second place followed by Effective Communication (EC) as the third-most-influential factor. These two factors actually work hand-in-hand. There is a common perception that generally people do not like change, and ERP involves change. This explains why resistance to change is common in ERP projects. However, certain key activities can aid in minimising this resistance, such as effective communication and training.

Because Organisational Fit (OF) (which ranked fourth) has a vital impact on ERP implementation success, project managers must first evaluate organisational fit of ERP, based on the relevant ERP knowledge. This analysis requires complete understanding of critical organisational processes and comprehensive knowledge of complex ERP systems prior to the adoption of the system.

Every project has various steps and phases, and ERP projects are no exception. These steps and rules help to guide the project to a successful end. Project planning (PP) helps to outline when to commence certain stages, how they will be executed, what needs to be done and when it needs to be completed. This planning encompasses designing the process of implementation, including time schedules and deadlines. Roles are clearly defined, responsibilities are assigned and a contingency plan put in place. A team has to be chosen for every project undertaken and its participation is vital for that project. Although ERP implementation affects the entire organisation, it is essential to pick key employees whose responsibility it will be to get input from others and share it with the group. This, together with ongoing training for users, will increase the willingness to participate of the entire workforce (UPT).

Ranking sixth, business process re-engineering (BPR) plays a critical role in ERP implementation. Once senior management supports the project, resistance due to anxiety about change has been eliminated, the project has been outlined clearly and effectively communicated to the affected parties and the users have been or are being trained – now the current process should be analysed. Non-value-adding activities should be eliminated and the process restructured to create value for the customer. The ERP system package then needs to be modified to suit the organisational needs. In this way, employees will develop a sense of ownership, consequently increasing their participation in and enthusiasm about the project.

On the seventh place is Technical Fit (TF). This is the evaluation of the fitness of the organisation’s technical environment relative to the potential vendors. It also incorporates the costs the organisation will incur to support the new ERP environment. It is important to assess the strengths and gaps of the organisation’s technical environment and the implications of migrating to a particular ERP system.

In a nutshell, the descriptive analysis demonstrates the variance in means and standard errors in factors, which proves that the arguments proposed, that these factors will all influence equally to the ERP implementation success cannot be accepted.
4.5 EXPLORATORY ANALYSIS
An application of content and factor analysis applied in the study demonstrates the validity of the investigation on the degree of match. Where the placed respondents in the ERP system provide perspectives on the degree to which the test items (CSF) identified match the test objective (Successful ERP implementation).

4.5.1. Confirmatory Factor Analysis (CFA)
There were eight hypothesized factors which are assumed to have a strong impact on the two success dimensions, project and business success. The double-headed arrows between the success dimensions indicate an assumption that the two dimensions are correlated. The arrows from the dimensions to the factors represent linear coefficients or factor loadings. Figure 4.1 demonstrates a clear hypothesis about the factor structure known as confirmatory factor model which is imposed on data in structural equation modelling. The objective is to acquire estimates of the parameters of the model, i.e. the factor loadings, variances and co-variances and the residual error variance. The absence of arrows going from factor to factor means that the loading in the factor matrix are fixed to zero. For each success dimension, the one loading is fixed to one. This enabled the scale of the dependent variables to be determined. With 95% level of confidence, the critical ratio (C.R) of 1.96 or higher and -1.96 or less indicate a two-sided significant level of 5%. In confirmatory factor analysis, the C.R. indicate that all factor loadings are significant. Loehlin, (1998) indicates that in structural equation modelling it is usual to analyse co-variance matrix and not the correlation matrix, for sound statistical reasons.

![Figure 4.1: Confirmatory Factor Analysis (CFA) on data collected.](image)
4.5.2. Multiple Regression Analysis

Figure 4.2 demonstrates the multiple regression analysis on the perceptions of the respondents on the critical success factors that influence ERP implementation success. It furthermore clarifies two things. First, it shows that in multiple regression analysis, independent variables are correlated. Thus they are equally important as they all play an important role in the success of ERP implementation. “They work hand-in-hand and if one is considered insignificant and is ignored, that may hinder the implementation and utilisation of the system to be a success. All of them are important basically.” Secondly, the residual error in multiple regression is an unobserved latent factor. The real strength of SEM is that we may specify and estimate more complex path models with intervening factors between dependent and independent variables.

Figure 4.2: Perceived influence of critical success factors on ERP implementation
ERP systems and the LSS philosophy are explained in detail in the literature review. In accordance with the literature review, critical points were discussed with an expert on the LSS philosophy and ERP systems in semi-structured interviews. Five interviews were conducted with the specialist and are analysed in depth in this section. The expert interviewed was an ERP system expert working as an independent business continuous improvement consultant in various business sectors.

For this study, exploratory and descriptive study designs were adopted. Explaining ERP systems and LSS strategy in detail by utilising primary and secondary resources used a descriptive study design, while interviewing an expert was considered exploratory. The questions that guided the interviews with the expert are presented below, along with the answers given by the expert in response to the questions.

4.5.3 Interview Questions and Answers

1. How did you go about implementing ERP in an organisation?

Answer:

“First of all there has to be a definition of a business need which in most cases is identified by the project sponsors. Thereafter a project charter is developed to present the statement of work.

“Secondly project structure/breakdown is drawn to outline the scope of work and the requirements for the project (i.e. human resources, capital, equipment, etc.).

“Then thirdly project measures and control are established. This is where the governance comes in (i.e. implementation partners and clients).

Lastly, then the implementation is put in place. This is the actual development of the technical system according to business needs. At this point the return on investment is based on the previous work.”

2. What is the biggest strength that lead the project to succeed?

Answer:

“Executing the project structure very effectively and efficiently.”

3. How did you measure the project success?

Answer:

“There is always a budget and other resources invested in every project undertaken. However the core measures are, in most cases, completion of the project within the designated budget and time. And also the reaping of the expected benefits relative to the intention of implementation.”
4. About eight factors (organisational fit, technical fit, business process re-engineering, user participation and training, organisational resistance and effective communication) have been concluded from the findings to be very critical. Could you inform us how these factors influence prior to, during and post the ERP implementation?

**Answer:**

“As you indicate, they are very critical. That means the success of the ERP system implementation is dependent on the comprehensive evaluation of this factors prior to the commencement of the implementation. Because the process of implementation is continuous, there’s no time where companies can say: we are now perfect. These factors would have to be revised over and over during the implementation process even post that. This enables the company to assess if they in the right direction and if the system is actually bringing about the expected benefits.”

5. The next factor would be project planning. What is your view on this factor?

**Answer:**

“It is always important to have a plan of everything you do in life. Even in our everyday lives, we have plans. ERP is the same. It is a project; it has to have a plan. An effective one for that matter. Like any other project that has various steps, ERP is of no exception. Once the business need is identified, and implementation have been decided on, be sure to appoint team of experienced employees who know the business very well and what effect the implementation will have on various aspects of business. Now begin a search for an appropriate package. But this is to be done after the problems the company is facing are established, their causes and what exactly is expected of the ERP system that will address the core source. You have to address as many ‘what if’ situations as possible to have a contingency plan which will be very helpful in this instance”.

6. The findings showed interdepartmental cooperation to be very critical after strong project management, so could you please explain this in detail.

**Answer:**

“An organisation is a system which incorporates all the departments aggregated to form it. Therefore, all the departments are to be integrated and work hand-in-hand, as the improvement and the quality of the processes is the entire organisation’s responsibility. The purpose of undertaking the project in the first place is to improve operational processes of the organisation and ensure quality output. This can … is the responsibility of each department and that can be effectively executed with the cooperation of all the units in the organisation. Thus, yes indeed interdepartmental cooperation is a vital factor for high level of improvement.”
7. The next factor from the findings was organisational fit.

Answer:

“One of the enquiries that needs to be addressed when considering ERP system implementation is: ‘Does the organisation’s current infrastructure and interface fit the ones of the ERP system intended to be implemented?’ This factor is often overlooked and underestimated but it is very critical to the success of the implementation project. It is important to understand what changes should be made by the organisation internally to make effective use of the new ERP solution. Many customers fear change and few understand the amount of change that is required. Ineffective change management can be a barrier to success.”

8. What would you say about technical fit?

Answer:

“This basically means that organisational artifacts are in conjunction with the ones of the ERP system. IT industry has now introduced some exciting ways to sell more solutions! Two key areas need to be taken into consideration:

1. Internal technical audit – The internal technical audit should check the current state of your IT environment in such areas as current hardware, software, FTEs [Full-time equivalents], and internal skill levels.

2. External technical approach – Determine the technology required by the ERP provider such as hardware requirements, database requirements, hosting offering (Cloud, SaaS, etc.). Take the advice of the ERP provider to ensure your infrastructure is correct and don’t expend less resources on small areas that could improve performance massively in an attempt to economise. You don’t want a slow new solution!”

9. If you can kindly shed some light on effective communication.

Answer:

“Many relationship experts will tell you that good communication is the key to keeping a marriage together. It's also one of the main factors in helping companies keep their ERP projects from hitting the rocks. When successfully implementing ERP, companies must develop a detailed communication plan … ‘Why are we doing it, what are the purposes, what's the scope of the project and what are we trying to accomplish by putting the project in?’ … Without a clear communication structure and strategy, those workers who will use the ERP system often can't get their concerns or comments about the project heard … This communication can take many forms -- such as newsletters to users, email updates or town-hall-style meetings -- but it needs to be adhered to throughout the project's duration. We've got to keep people engaged and excited about the project -- no communication means no excitement, and that's where one of the breakdowns occurs.”
10. How can effective user participation and training be promoted by senior managers? What effect does it have on the success of ERP system?

Answer:

“The introduction of a new information system such as an ERP system will definitely change the way people work. These changes arise from a new platform, new and different interfaces, data entry is changed and report formats are different. Users often find these changes unnecessary and therefore refuse to accept them. One of the ways to address and reduce the impact of these changes is to encourage user participation in the implementation of ERP systems. These can be achieved through training and educating users.

“User training and education is considered as one of the important factors in generating ERP implementation failure because of one main reasons: training is significant in an ERP implementation project not only to familiarise users with the new ERP system but also to help in the organisational change process. Training and educating people and keeping them informed throughout the implementation process must be addressed to achieve the benefits of an ERP system.

“There are quite a few people who have worked on this subject in the past and they discovered that user participation and training have a positive impact on the likelihood of ERP system success. Trained user participation by choice is the best, because it leads to better understanding of system requirements; the more the participation of the users, the more satisfied they tend to become, and this participation builds support for the system during implementation.”

11. What effect does organisational resistance have on the success of the ERP system?

Answer:

“No matter the size, age, scope or complexity of your business, ERP implementations are difficult. Even with many executives claiming their organisation’s employees are ‘ready for change,’ implementing enterprise system always creates change resistance organisation-wide.

Even though we’d all like to think that the pain of our decaying legacy systems are enough to spur the desire for change – and in many cases it does – resistance kicks in and employees become aware of how complex and different the changes are. Fear of losing your job, fear of perceived diminished value to the organisation. Some of the causes of resistance are: fear of not being in control of business processes and procedures, dislike of standard, shared business processes, and inability or unwillingness to accept change.”
12. What are the effects of users taking part in implementation of ERP system?

**Answer:**

“Users get a sense of ownership from partaking in the implementation of this system. It increases their enthusiasm about the project. Consequently their productivity. That is why it is very important to make them part of each and every phase of the implementation process, through frequent consistent communication, to decrease resistance levels.”

13. What are the factors affecting the success or failure of ERP implementation?

**Answer:**

“One of the top reasons ERP implementations fail is because the software doesn’t meet basic specific business requirements. However, purchasing an ERP application is only half the battle. A well-designed implementation plan is the key to success.”

- What factors can lead users to use or intend to use ERP systems?

**Answer:**

“There could be numerous reasons why companies implement ERP system, such as to better serve customers, position the company for growth, ease the jobs of employees, reduce costs, etc. However, this reasons can be aggregated to one core reason, which is: to improve business performance.”

- What factors can make ERP implementation projects successful?

**Answer:**

“Actually all the factors you identified in this project can make ERP implementation project a success if are executed properly. However, to that, I think you could add other few factors like a clear understanding of the strategic goals; organisational change management; data accuracy, which is a critical element to making informed business decisions; and focused performance measures.”

14. How can we define the success of ERP implementation?

**Answer:**

“Success when it comes to ERP implementation is largely due to how well have the contingencies been planned, how reasonable are the set expectations and how the lines of communication are created between the front-line users and everyone else in between.”

- What are the indicators to evaluate ERP implementation success?

**Answer:**

“In my experience those would be:
1. **Visible results:** this would be having a new system up and running without shutting down the company or severely impairing operations. Similarly, if the project came in on schedule and within budget is one of the visible measures.

2. **Measurable impact:** during the planning process, measurable results are projected, for example cost saving and revenue increases. There are then tools used to measure these results such as total cost of ownership (TCO) and return on investment (ROI). After implementation, the very same tools can be used to measure the results and have a good sense of how ERP has improved the bottom line.

3. **Tangible benefits:** measurable benefits are often tangible. But not all tangible benefits are measurable. Let’s make an example. ERP systems can give employees more and better information for doing their jobs. Thus errors they make will be very few and communication will be better. Error reduction is both tangible and measurable. But the improvement of communication can be quite obvious and real to employees and managers. They may also be harder to measure. However, measurable or not, all the tangible benefits should be included in a post-implementation evaluation to determine if the ERP project was a success or not.

4. **Generalised improvements:** there may be some benefits which were not projected during the planning process which might be measurable but not attributable. For example, ERP implementation may significantly improve customer relations. This can produce results like increased sales, more repeat sales, high customer retention rates, a better public image, etc.”

15. How do we approach implementation to avoid failure?

**Answer:**

“Have a clearly defined plan; understand the business needs, along with strong communication, change management and top management support. It is essential to remember that software doesn’t determine the success or failure of the implementation. It is solely about how useful it is to the user.”

- What are the relationships between factors and success indicators?

**Answer:**

“The success factors directly influence the ERP system success indicators. The integration of success factors and success indicators helps the organisations to make quality ERP system measurement instruments and tools. However, correlations among success factors and success indicators have to be established using some suitable tool in present conceptual model.”
What should companies do to make ERP implementation projects successful and run the system effectively?

Answer:

“They should try to adhere to some ground rules such as:

1. Understand your incumbent system

The decision to purchase a new ERP system has been made, but why? There are many reasons a new ERP system will be sourced, but it is important to understand that the implementation of a new ERP system will not simply create a return on investment or solve the issues of the business. These come from the process improvements; the ERP system is a tool and improving the way a business uses the tool can reap benefits. The business may have outgrown the system, or the system may be non-supported, but whatever the reasons the system and the processes inside and outside of the system must be understood.

2. Homework and collaboration

Once a business has come up with clear defined goals that the new ERP system must achieve and defined some tangible metrics to judge success then the next step is to find the right product and the right vendor.

3. Budget control

To be able to control a budget you need as a business to identify the real costs of ERP. These costs can include hardware, training, organisational change management, developments, staff cover for project members and the software. The identification of a clearly defined budget scope is critical and difficult.

4. Resources and team

Implementing an ERP project requires an internal project manager and team. The most successful implementation projects have at least a 100% dedicated internal project manager to ensure the project is kept on track, on budget and moving in the right direction. The key members of the team need to take ownership for the project and to cascade this responsibility down through departments. The ownership is achieved through involvement and ensuring all areas of the business contribute to, and feel a part of the project. The key members are critical. They have to adopt a positive attitude towards the ERP change. They must be influential, be able to win over resistance and promote the project within the business. To enable this they must be respected or in areas of responsibility.

5. Training and understanding – user acceptance

There are many philosophies on how best to train staff, but the simple rule to follow is to actually train the staff. During implementations there are many methods of training, but before any of this can really commence the software must be understood by the business, and the business must be understood by the ERP partner.
This is not simply how the incumbent software is used, but the business processes, requirements and the reasons behind why transactions and processes are undertaken. This understanding will lead to further questioning and mapping of processes to the new software to see how the software can be leveraged to full potential to meet the needs of the business.

6. Data migration

The common response to the question ‘What data from your current system do you want migrating to your new system?’ is ‘Everything. Whilst this is possible, it would probably cost more and take more time than the current ERP project being undertaken. One common requirement or request is for sales history to be migrated. Once the automated areas have been decided the next issue is the data itself. The final data routines should be finalised months in advance of a go live. This means to ensure the best possible results from the data migration project the routines must be run in full in advance of the live data and the end users must test, test and then test again.

7. Go live perpetually

At the end of months and months, or even years and years, the business and the team will finally manage to drag themselves across the finish line. The business has made it, at last! That is it; the project is completed; there is relief all around as people can now concentrate on their day jobs.”

16. In your experience, how would you rank these factors according to their significance in both implementing and running the system effectively? (from the most significant to the least)

Answer:

“I frankly would not be able to do that because all these factors are equally important. They all play equal roles in the success of ERP implementation. They work hand-in-hand and if one is considered insignificant and is ignored, that may hinder the implementation and utilisation of the system to be a success. All of them are important basically.”

17. What is the possibility of integrating the ERP system functionalities with Lean Six Sigma principle for highly improved business processes and performance especially in a mining company?

Answer:

“ERP systems usually execute their logic upon the organisations. LSS strategy deals with the defects in the business processes. Therefore, they seem to be very different from each other viewed from the outside. However, they could perfectly support each other in some cases; thus making their integration possible.
Considering their relationship, the aim of LSS strategy is to improve the business processes by understanding the best conditions for the business requirements. It provides process definition to the companies. ERP systems might benefit from this definition and the improvement capability of LSS strategy during their pre-implementation and implementation process. They (ERP systems) could be potential enabler for distributing these data collected from the business processes and provide standardised processes and information management systems to the organisations in order to support the LSS projects and any other business activities. It is therefore evident that there is a mutual relationship between the ERP systems and the LSS strategy.

LSS projects might be more sustainable with the help of the ERP systems. In this sense, they can enhance each other although one of them should be prioritised. Due to the fact that they are both significant investments, thus the organisations should not be overloaded by putting these two big jobs in the centre of their businesses.”

18. A question about their relationship: It seems that they (ERP systems and Lean Six Sigma Strategy separately) might have some problems within their individual work cycles despite their benefits to the companies’ business processes. Do you think that one of them might perfect the other’s shortcoming(s)? Could you evaluate this point based on your experiences?

Answer:

“I'm not sure if ‘perfect’ is the right word. Both have a part to play. Care must be taken, however, not to overload the organisation. It is a big job to implement ERP and will use much management resource. To implement Lean Six Sigma, doing it effectively will also take much resource. If approach is in place and effective then the benefits should help more effective implementation.

I think integrating both of them makes the business processes more effective because one of them is related to ‘data change’ while the other one is regarding ‘the changing ideas’. Both of them are very important for a re-engineering.”

The questions regarding the Industry 4.0 were not included in the interview questions and a questionnaire as it is an emerging concept that is however striving to achieve a common goal as ERP, Lean and Lean Six Sigma. It aids organisations with current challenges by becoming more flexible and making reacting to changes in the market easier. It can increase the speed of innovation, leading to faster design processes. The conclusions reached on the subject of the integration of industry 4.0 and other principles discussed in the study are founded on the extensively reviewed literature and the researcher’s observation relative to the significant role it plays in today’s business world and the possibility of integrating it with ERP and Lean Six Sigma.
4.6. INDUSTRY 4.0, ERP AND LSS COMBINATION

The Lean Production worldview has turned into the significant way to deal with creating exceptionally proficient procedures in industry since the mid 90’s. After the sudden end of the Computer Integrated Manufacturing (CIM) period, which at long last was bound to bomb because of its unruly multifaceted nature of the required computerization innovation, the Lean approach was fruitful in light of its high viability by lessening intricacy and keeping away from non-esteem making process steps. Today, the term Industry 4.0 portrays a vision of future generation. Many individuals are at any rate suspicious or even unfriendly towards this new approach. This position study gives an outline over existing mixes of Lean Production and computerization innovation, additionally called Lean Automation. Moreover, it talks about real Industry 4.0 foundations and connections them to the well-demonstrated Lean approach. Cases of joining both are smart watches for supporting and connects them to the well-demonstrated Lean approach. Cases of joining both are keen looks for supporting Cyber Physical Systems (CPS) for adaptable Kanban production scheduling.

The bureau of Innovative Factory Systems (IFS) at the German Research Centre for Artificial Intelligence (DFKI) distinguished four empowering influences for the Smart Factory: Smart Products know their creation procedure and arrange it with Smart Machines. The Smart Planner advances processes progressively. In this condition, people take a focal position. Upheld by inventive ICT they end up plainly Smart Operators who manage and control progressing exercises.

University of South Denmark, 2012 together with toy producer Lego A/S created approaches for incorporating automation innovation in u-shaped assembly stations, otherwise called Chaku lines. Particularly human machine collaboration was in the concentration of this task. Thus, they built up a local order management system which shifts ordinary assignments of ERP system to representatives at Chaku lines. As indicated by them, mechanization of significant worth including assignments is very exceptionally sensible because of the way that speculations are amortized inside shorter time. Plus, the rehash exactness and accuracy of machines is higher than of people. Then again, complex procedures, special case dealing with and strategic assignments are regular capacities where automation isn't sensible. (Bilberg and Hadar, 2012).

In 2013, the optical order framework iBin as an expansion for Kanban containers was introduced. A camera in the module distinguishes the charging level of the receptacle and iBin reports the status to a stock control framework wirelessly. Furthermore, iBin is additionally ready to send orders automatically to suppliers. Thus, support stock can be diminished and spare parts can be planned, (Würth Industrie Service GmbH and Co. KG, 2013).

The continuous research venture Lean Intelligent Assembly Automation likewise addresses Chaku lines. The consortium, which comprises out of e.g. Adam Opel AG and Fraunhofer Institute for Manufacturing Engineering and Automation IPA, creates
robot-based answers for aid workers in assembly undertakings inside Chaku lines. Objective is to improve manual assembly assignments with a specific end goal to make them more profitable for greater bunches.

On other adaptable material supply framework for production lines, rather than fixed interims, an IT framework computes round outing interims for the transport system in light of progressive requests. In the primary model, gathering of information is carried out by checking quick response (QR) codes which contain information about the item to which is attached. Communication with representatives of the transport system is acknowledged by ordinary tablet PCs. With this order-oriented material supply system extends of way can be diminished by approximately 25% at a similar level of supplier’s unwavering quality (Lappe et al., 2014).

As per above demonstration, combining computerization innovation and Lean Production can be valuable. As opposed to prevalent thinking, Lean Production does not exclude mechanisation. Ono in the 60’s asserted that procedure ought to be automatized and administered by workers. He called this standard Autonomation (Ōno, 1988). This relates to Industry 4.0, by which people upheld by creative innovation play a similar part.

The Synchronized Production System, a further improvement of Lean Production for application in nations with high wages, moreover incorporates approaches for coordinating automation innovation. With the term Low Cost Intelligent Automation Takeda 2006, asserted that applications for mechanization ought to be produced with simple to acknowledge instruments. Institutionalized, cost-effective arrangements ought to be supported over individualized solutions. Both, Lean Production and Industry 4.0, support decentralized structures over huge, complex machines and both go for little modules with low level of multifaceted nature (Takeda, 2006; Zühlke, 2010).

4.6.1 Benefits of combining these principles

As depicted in the previous section, coordination of Industry 4.0 solutions matches Lean theory and the specified illustrations demonstrated practicality. Industry 4.0 can be incorporated in Lean Production and past that enhance Lean Production by expanded coordination of ICT often facilitated by ERP systems. This advantage quickens the move of Industry 4.0 from science to reality. Practically speaking, new solutions must increase the value of customers and must have a satisfactory hazard. The integration of Industry 4.0 solutions, which are highly associated with high investments, is particularly lucrative in zones where cost-saving and straightforward techniques for Lean Production are not totally satisfying the present necessities. Applying Industry 4.0 to build up Lean Production could bring down dangers of integration because of existing guidance for the authoritative combination. In addition, generation forms in Lean Production are in contrast with different sorts of industrialists more institutionalized, more straightforward and lessened to fundamental work. Subsequently, they are less perplexing and uphold the establishment of Industry 4.0 solutions.
4.6.2 Factors for conceivable integration

The distinguished empowering specialists can be associated with a couple of strategies for Lean Production. The factors impacting on the conceivable integration are described below.

4.6.2.1 Smart Operator

In accordance with the method by which employees are to be notified swiftly in the occurrence of failure, the Smart Operator could reduce time from failure occurrence until failure notification. Equipped with smart watches, employees receive error messages and error locations close to real time. In contrast with across the board signal lights, recognizing failures does not depend on location of employees anymore. Moreover, CPS equipped with appropriate sensors recognize failures and automatically trigger fault-repair actions on other CPS.

A constantly stream of pieces could be upheld by aiding systems for employees based on e.g. enlarged reality. Information about process durations within the visual field of employees support just-in-time proceeding of goods. In addition, new employees get individualized information about essential errands to get along in coordinated productions.

4.6.2.2 Smart Product

With regards to continuous improvement processes, also called Kaizen, Smart Products could gather process data for the analysis amid and post its production. Rather than manual information securing for value stream mapping it is conceivable to assemble data individualized per item and production line naturally. From one perspective, along these lines of information securing is less labour-intensive and then again, information is more precise.

Moreover, a Smart Product could contain Kanban information to control production processes. In 2014, a completely de-central controlled production based on Smart Products was demonstrated in Germany. The displayed working stations delivered self-sufficiently as indicated by a work routine on the item. In spite of the fact that it was push-controlled production, this idea could be embraced for an order-oriented control system.

4.6.2.3 Smart Machine

Specialized establishments help workers to keep away from errors. This is likewise upheld by Poka Yoke. With their computing capacity and connectable sensors, CPS could be coordinated quick and adaptable in fault inclined procedures for supporting. Optically indistinguishable parts can be recognized. Industry 4.0 could besides reinforce Lean Production's prerequisite for an adaptable, modular production. For a long while now, measured working stations in light of institutionalized physical and IT interfaces, which can be adaptably reconfigured to new production lines have been illustrated in smart factories.
4.6.2.4 Smart Planner

Although Lean Production aims for a one-piece flow and a highest possible product variety, it is not suitable for individual single-item productions. With the Smart Planner, traditional Kanban systems with fixed amount of Kanban, fixed cycle times and fixed round trips for transporting goods turn into dynamical productions automatically adopting to current production programs. Decentralized, in working stations integrated CPS could negotiate cycle times and thus find the optimum between highest possible capacity utilization per working station and a continuous flow of goods. Within the state-funded project RES-COM, DFKI already demonstrated how a semantical description of working stations supports optimization of production processes by different business objectives, like throughput time or efficacy. Applied to Lean Production, this approach could enable Lean Production to be implemented not only in mass and batch production, but also in job shop production.

Even though solutions according to Lean Automation already exist and research is still ongoing, they are mostly applications for single, isolated aspects. To ensure modularity and exchangeability, a system which advocates the integration of Industry 4.0 solutions into Lean Production is required. Earlier in this section the concept of Low Cost Intelligent Automation is mentioned. Unfortunately, this concept does not consider modern ICT, especially innovative assistance systems. The potential of CPS in production is not fully explored yet. First approaches are based on the service oriented architectures and describe a generic architecture. Nevertheless, a comprehensive, integrated system which describes where and how CPS can be integrated is still missing. The combination of CPS and Lean Production in one system can satisfy these requirements.

4.7 SUMMARY

ERP, Lean Six Sigma and Industry 4.0 are very different principles that individually play a significant role in systematically improving the performance of an organisation. This study is focusing on the integrations of these principles and the impact of such integration. However, the study does not imply that they are interchangeable rather interrelated. Through implementing concepts of Industry 4.0, and its integrations with ERP systems and LSS, numerous mining organisations develop an opportunity to fundamentally improve the entire production planning, optimize the flow of goods, optimize the quality of processes and products, strengthen the customer and supplier relationships as well as the potential of offering new business models. Moreover, these organisations expects a further automation of processes and a high level of digitalization which should make carrying the errands easier and reduce workload. Moreover, organisations anticipates a noteworthy decrease of the entire production lead time and simultaneously a reduction of buffer stock as well as the elimination of overproduction through implementing an Industry 4.0 driven decentralized and self-organized production structure. Apart from these chances, companies perceives the main upcoming challenges are filtering and processing the huge amount of new information which is provided by Industry 4.0 in order to avoid information overload.
Furthermore, the determination of the defined rules in which the autonomous smart machines and systems can decide on their own is another possible challenge.

SECTION 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This section presents a summary of the findings discussed in the previous section, perceptions of what factors influence the success of ERP implementation and suggested solutions to ERP implementation problems. It also presents conclusions drawn from the findings and their implications, and makes practical recommendations and suggestions for further research.

Since it is not clear which critical success factor might influence differently to the two dimensions of success, project and business, the hypotheses did not specify which dimension is targeted. Therefore, the null hypothesis (H₀) states that on average, the degree of influence of all the identified factors to the two success dimensions will be the same. The alternative hypothesis (Hₐ) is that some of the factors will be more influential than others. With a 95% level of confidence, the strength of the data determined whether the null hypothesis can be rejected or accepted. The validity of the study is demonstrated from a number of perspectives of respondents that are well placed in the ERP system and utilise it on remarkable frequent basis to be aware of the most influential factors. A combination of confirmatory factor analysis and multiple regression analysis, as a general structural equation modelling (SEM) technique, was applied to test the postulated hypotheses in context of the relationship/impact of identified factors to ERP implementation success.

5.2 SUMMARY OF THE MAIN FINDINGS

The findings have shown that ERP systems are vital elements of business process improvement. They link together an organisation’s strategy, structure and business processes with its IT system. However, every company that decides to implement ERP should understand ERP as a broad and complex system that involves a large number of resources, and great effort and cost to integrate ERP into the enterprise.

After reviewing the literature and analysing the data, the researcher was able to draw up a list of critical success factors, the rank of their criticality, and the different opinions regarding their importance among the respondents of the survey (both employees and the implementation project managers) and the ERP expert. These findings show that ERP implementation is a serious issue in the mining business. The factors that influence ERP success in the mining industry are described below.

**Top management support** was cited as the first major factor by all the respondents. There are some vital points related to ERP projects that top management has to take seriously: senior management needs to understand its role in driving the project and selling it to the organisation at large. It also needs to support the project by providing
the necessary resources, employing realistic plans and making room for disruptions and unavailability. Lastly, it should set up a forum to deal with any unexpected negative effects on the project.

Among the ground rules to be adhered to when implementing ERP to make it a success is the establishment of a team with key members to win over resistant staff members. This indicates that taking into consideration organisational resistance, which ranked second is essential for ERP implementation success. This research has shown that the human factor; that is, operators/users of the technology's refusal to adopt the technology wholly and to use the potentials of the technology fully, is an important issue in implementing changes in mining companies. To overcome this problem, management has to embark on a structured programme to educate the users about the potential benefits of the new system. This may in many ways reduce the resistance that is likely to arise and enhance the likelihood of a successful implementation. Effective communication also plays a very important role in the success of ERP implementation. Relative to resistance and involvement of the employees, focusing on this factor is essential. It enables users/operators/employees to gain a thorough understanding of the system and its complexity, which in turn eases their adaptation to the system. Managers ought to ensure effective conveyance of the goals of the implementation and the effects it will bring to the affected parties. They also need to ensure that what is communicated is clearly understood by those relevant parties. Effective communication can make the new system penetrate the organisation, enhance employees’ willingness to change and take part, and maximise the support from vendors and consultants, which means that an organisation can make better use of the technical resources from ERP.

Moreover, participation of the users is an essential variable in the success of the implementation of ERP. However, this depends on the degree of training provided to the users and their understanding of the system. Hence, as mentioned above, effective communication is vital in this regard. In addition, a thorough mapping of what is to be done, when, how and by whom, throughout the implementation process, also plays an important role in achieving success. This is known as project planning. Most ERP systems are not built but adapted and thus they involve a mix of BPR and package customisation. This makes them unique and their implementation goes beyond technical concerns but also presents a socio-technical challenge since it affects how users perform their tasks. Owing to their participation, most users understand, accept and use the system.

Adaptation of ERP systems involves the restructuring of business processes. Thus, it is vital first to identify the real business needs and modify the system to address such needs. No ERP solution comes out of the box and perfectly meets each organisation’s needs. While an ERP system that has been specifically developed for mining businesses and is delivered with built-in “best practices” may address the majority of the business requirements, there still are processes that are unique to each mining organisation. Many ERP packages still run on technology with inflexible
platforms and architectures that cannot be easily customised without using complex tools or costly source-code changes. This, of course, diminishes the value of the ERP system. The solution should have embedded tools that are easy to use (for the end user) for modifying or extending the value of the system.

Furthermore, for the modification of the system to be possible, the organisation’s technical fitness has to be evaluated relative to the vendor’s and the solution should support the extended enterprise. Some solutions only provide functionality for specific areas of a business (e.g. customer relationship management, financials, production). A solution should be selected that provides functionality for the organisation as a whole. A comprehensive, integrated solution minimises or eliminates the need for separate applications, spreadsheets and a bypass of a recognised problem. It is important that the solution is built on a common database, data that is entered flows through the system from step to step, processes are streamlined and customer, operational and financial visibility is improved across the organisation.

The findings support the opinions of the ERP expert and those expressed in previous studies, which indicate that the identified factors are influential in the successful implementation of ERP, relative to their ranking and in accordance with their significance. The overall perceptions (see Table 4.24 in the previous section) show that the majority of the respondents (82%) strongly believe that these factors do influence the success of ERP implementation. While 17.7% neither agreed nor disagreed, 0.4% disagreed that these factors influence ERP implementation success. This view is inconsistent with the majority. It is, however, not evident from the findings which factors are influential in which success dimension out of the two focused on in this study: project success dimension and business success dimension. About 82% of the respondents expressed a strong belief that business dimension is the appropriate measure of success of ERP implementation versus the 80% who indicated project dimension as the appropriate measure. There is a slight difference between the two; however, looking at bottom line, the business dimension does stand out as the best measure. The ERP expert’s perspective seems to be inconsistent with the findings. She indicated that the two success dimensions need to correlate in order to achieve complete success. The perspective from which the dimensions are viewed may disagree with the findings. The project manager’s perspective, which is based on the completion of the project within time and budget, is certainly likely to differ from the stakeholders’ perspective, which is based on the improvement of the processes, productivity and profitability.

Looking at the various opinions of the respondents relative to their habits and preferences regarding the ERP system, the findings indicate that 100% of the respondents indicated that an ERP system had been implemented in their organisation, which made them eligible to take part in the survey. It is evident from the findings that ERP implementation brings about the restructuring of the business process, which 94% of the respondents supported. ERP implementation affects the entire organisation; therefore, it would be helpful for the companies to convey the
employee responsibilities, revise their incentive systems, deploy effective skills development tools and reduce resistance to avoid failure or not achieving significant benefits.

To a certain degree, if not completely, ERP systems affect the way employees undertake their tasks, as 89% of the respondents answered yes to the question about whether ERP does change the work culture. Change management may be a vital variable in this regard, as it will aid the companies to ensure the readiness of the employees for the new system and enhance their enthusiasm for and positive attitude toward the changes. In the light of the decreased workload brought about by ERP and BPR, companies have created a participative environment that encourages employees at all levels to contribute towards setting goals, solving problems and making other decisions that may directly affect them. This has evenly distributed the workload, enabling employees to complete their tasks on time, and has consequently developed an effective work culture.

According to the respondents, the goals and tasks were clearly defined, and the activities undertaken were tracked owing to implementation of ERP system. Other evident benefits included reduction of operational costs, increased productivity and efficient resolution of problems with ERP solutions. Thus, it appears that employees are satisfied with the information sharing and use of the ERP system in general.

5.3 IMPLICATIONS OF THE FINDINGS

ERP systems and LSS strategies are not only academic subjects but are also implemented on an individual basis in practice. Their combination has been evaluated as potentially useful for companies. However, there have been some doubts about the cost and benefits. If a cost and benefit analysis shows that the implementation is feasible, the initiative of the combination of those approaches will undeniably be beneficial for the companies. Thus, if a company has an ERP system or adopts an LSS strategy within its structure, it should definitely try to consolidate them. In this way, the combination might be less expensive than just using one of them. Even if this seems costly for a company from outward appearances, implementing and subsequently integrating them should be attempted on the back of a cost and benefit analysis as their advantages might far outweigh their disadvantages. Therefore, hesitating to launch a trial of the combination of the two does not seem sensible.

5.4 CONCLUSION

There is no doubt that further research is a pre-requisite in order to reach a point whereby empirical studies with regards to the relationship between the critical success factors and ERP implementation success are sound, endorsed and legitimate. This study pursued to extend a deeper understanding and insight into influential factors that ought to be considered by mining organisations, stakeholders and academics when strategic plans of adopting technological advancements i.e ERP systems, are
developed and implemented. Hopefully this study offered a stride in the right direction at to what are the underlying considerations of dynamic adoption of technological innovations and how this can be leveraged in differential access to new information and knowledge about enhancing organisations performance and competitive advantage. Overall, this study contributes to the research on the successful implementation of the ERP system in the mines and continuous business process improvement. It adds to the discussion on prototypic key factors that compel both the project and business success dimensions of an organisation and the possibility of ERP, LSS and Industry 4.0 principles.

Conclusions were drawn regarding the research question and the objectives of this research. All the identified factors that are perceived to be influential in the success of ERP system implementation are concluded to be just that, influential. No factor is more important than the others. However their degree of influence to the implementation success varies as their means and standard variations differs. The descriptive analysis that demonstrates the variance in mean and standard errors in factors proved that the argument proposed, that these factors will all influence equally to the ERP implementation success cannot be accepted. All the factors work hand-in-hand for complete anticipated success and benefits. ERP systems could provide information management to the LSS projects which need historical data. On the other hand, LSS strategy improves the ERP implementations by defining the business processes. Thus, an organisation’s language might be understood better by the ERP system and the probability of ERP failure could be reduced. From these conclusions drawn from the findings, it is evident that these interrelated approaches together offer better solutions to companies.

In the 2017 World Economic Forum (WEF), the commentators had observed that the world is evolving into a Fourth Industrial Revolution which includes developments in cloud computing, genetics, artificial intelligence, robotics, the internet of things, nanotechnology, 3D printing and biotechnology, etc. (Schwab, 2017). The 2017 WEF was themed “responsible and responsive leadership” in pursuit of global multi-stakeholder engagement and collaboration as how global leaders should respond to the technological developments in a socially responsible and inclusive manner in order to preserve humanity and social coherence. There has been a significant fundamental shift as to how human beings produce, consume and relate to one another and this is driven by the converging the physical world, the digital world and human beings (Mölders, 2016). Lack of resources and capabilities of South African mining organisations to respond to such global technology-driven advancements has serious implications. It equally offers a tremendous opportunity to advance economic development goals by adopting the right strategic approaches. The prevailing strategic efforts to automate and digitalize processes have been adopted by many companies globally to appropriate value in pursuit of achieving and sustaining competitive advantage. Nevertheless, mining organisations have the freedom to decide on their strategies, but the success of such strategies will always be influenced by external environmental factors. It is our hope that our academic research guides us to make
the right strategic choices relative to integration of these principles for enhanced performance and competitive advantage in mining organisations.

5.5 RECOMMENDATIONS

From the lessons learnt in this study and the conclusions drawn, it is recommended that mining companies should adopt and implement ERP systems and integrate them with LSS strategies to achieve better benefits and consequently improve their business processes as the core goal. Management should thoroughly understand the needs of the business and adhere to the ground rules, as indicated by the expert on this matter. All the factors that are identified in this study as influencing the success of the implementation should be executed appropriately and none should be omitted because they are perceived as being insignificant. This might hinder the successful implementation of the system.

A structure for Industry 4.0 as a supplementation to Lean Production should, from one perspective, contain proposals which Industry 4.0 solutions could sensibly reinforce Lean Production. Contrasting Industry 4.0 empowering agents and techniques for Lean Production gives an outline over conceivable connections. Next, recognized methodologies ought to be portrayed more in detail and necessities and extra advantage must be evaluated. Other than this confined applications, the system ought to characterize interfaces how this solutions can supplement each other and how to implant them into a current domain. Like service oriented structures, in the domain of Lean Production CPS can offer required administrations of a working station to adjacent and larger systems.

This will enable flexible addition of working stations to the production lines and can process commands from a superior production control system. Moreover, CPS can trade information with sensors or can interact by means of human machine interface with employees at working stations. Thus, manual working stations can be reinvigorated with automation technology and the other way around, without changing predominant execution framework. CPS decouple correspondence between working stations and IT frameworks. Plus, the interfaces of these working stations are free from employees and devices working in this working station.

In the previous section, the study distinguishes challenges which emerge or may emerge through Industry 4.0. This section depicts conceivable recommendations relative to such challenges. First, there is assurance of necessities and expectations of customers and other interested parties which ought to be the priority objective of the mining companies intending to adapt industry 4.0. Second, an organization’s quality strategy and quality objectives ought to be established. Third, processes and responsibilities, which are necessary to accomplish improvement objectives, have to be determined. Moreover, appropriate resources should be determined and provided with a specified end goal to ensure the fulfilment of the objectives. Further, techniques to measure the productivity and viability of each process must be established and
applied. Additionally, means ought to be determined in order to prevent unconventionalities and dispose of their causes. In conclusion, a process of continual improvement ought to be established and applied.

5.6 LIMITATIONS OF THE STUDY

As discussed above, a combination of the ERP system and LSS strategy is implementable. Despite various discussions on the relationship between ERP and LSS and the advantages for companies to integrate them, the high level of hesitation against the new implementation is a limitation. A limitation of this study was that experimental research could not be conducted even though it might have presented the benefits better. This research involves the manipulation of independent variables to determine their effect on dependent variable. Thus, the findings do not indicate which of the identified factors have the greatest influence on the two success dimensions that were focused on in this study.

During the data-collection process, difficulties were encountered in gaining access to the mining companies. The limited time and resources of which this study was carried out with made it difficult to cover comprehensively all factors which influence the ERP implementation success. It was only conducted in two mining companies which were available.

5.7 SUGGESTIONS FOR FURTHER RESEARCH

The limitations of this study need to be kept in mind when analysing its significance. The opinion of about 300 employees in the mining companies and one expert is not necessarily representative of the entire mining industry. There may be some questions that remain unanswered; therefore, further studies are required for more exhaustive answers.

There are numerous avenues for future research and extensions of this study. Future research could further test and refine constructs and relationship on wider business environment populations. Other studies could use different methodologies such as correlation and regression to explore the other factors or the relationship between independent factors. Also in-depth treatment could be given to the issue of which factors are more influential in which success dimension.
APPENDIX A: SURVEY INSTRUMENT

Independent Variables: ERP Critical Success Factors

Different opinions are indicated by the numbers;

1. = Strongly disagree
2. = Disagree
3. = Somewhat disagree
4. = Neutral
5. = Somewhat agree
6. = Agree
7. = Strongly agree

1. Technical fit (TF)
- The ERP application was compatible with the legacy system software that was retained? (Minimal interfacing)
- The ERP system was compatible with the existing hardware.
- There was a smooth movement of data and key business processes to more advanced and contemporary technology.
- There is no difficulty in exporting data from the ERP system to other systems currently used in the company.
- I believe that the ERP system is very reliable

2. Organisational fit (OF)
- The name and meaning of the ERP data items correspond to those of the documents used in our company (eg sales report sheet, financial report, etc).
- I believe that the process built in the ERP system that we implement meet all the needs required from the organisation.
- User interface structures of your ERP system are well designed to the work structure required for conducting business in the company.
- Company’s business and IT strategies are well aligned, enabling a successful ERP system implementation.
- The culture of the organisation has grown through infusing it in the information artifacts of the company.

3. Business Process Re-engineering (BPR)
- The company customized the ERP package to the business process with a minimal amount of business process re-engineering.
- The company’s business processes were heavily re-engineered to fit ERP packages.
- The mission and the strategic goals of the company were reassessed when implementing ERP system.
- ERP system covers company’s necessary business functions.
- The business functions of the ERP system are well defined.
4. Top Management Support (TMS)
- ERP system receives strong active support from the top management in the organisation.
- The success of ERP system implementation effort was due to the active championing by key senior management.
- ERP is well-aligned with the business processes.
- Senior management strongly supports the utilization of the ERP system.

5. Project planning (PP)
- There was an effective project planning for the ERP system.
- When the ERP system initiative began, there was consensus about its specific objectives.
- There was clear understanding of how implementing this system will contribute to the company's overall strategies.

6. User participation and training (UPT)
- I believe that the company interaction with ERP system is clear and understandable.
- The company provided extensive training with the ERP system.
- Learning to use the ERP system has been easy for employees.
- The company is dedicated in ensuring that the employees are familiar with the ERP system.
- I find it easy to get the ERP system to do what I want it to do.

7. Organisational resistance (OR)
- There haven't been many users resisting the ERP system.
- There haven’t been many cases blaming occurrence of business problem upon ERP system.
- There wasn’t any resistance in adapting to change brought about by the implementation of ERP system.

8. Effective communication (EC)
- The expectations on the ERP system were communicated clearly at every level.
- Employees were told in advance the scope, objectives, activities of ERP system and to admit the occurrence of change.
- There was a promotion of project team and the project progress was communicated to the entire organisation.
- Input was required from the users of ERP system in relation to what they require, their comments, reaction and approval.
- The ERP vendor communicated frequently and clearly with the organisation throughout the implementation process.
Dependent Variables: ERP Implementation Success Dimensions

*ERP business success dimension*
- I believe that implementing ERP system has helped to reduce inventory level.
- Implementation of ERP has helped to reduce number of employees.
- Implementing ERP system has helped to improve cycle times.
- The implementation of ERP system has helped to reduce cost of procurement.
- I believe implementing ERP system has helped the company to improve cash management.

*ERP project success dimension*
- The cost of ERP project was significantly within the expected budget.
- The ERP system implementation project was within the expected duration.
- The performance of ERP system is at the expected level.
- The ERP implementation progressed well as was originally planned.
REFERENCES


Humphreys, D. 2001. “Sustainable Development: can the mining industry afford it?” Resources Policy.


