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IN

THE FACULTY OF ENGINEERING AND THE BUILT
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SCHOOL OF MECHANICAL AND INDUSTRIAL
ENGINEERING

DEPARTMENT OF QUALITY AND OPERATIONS
MANAGEMENT

THE EFFECTIVE APPLICATION OF THE THEORY OF
CONSTRAINTS

ROWLAND MINE SHAFT- MARIKANA- LONMIN:
A CASE STUDY

We accept this report as conforming
to the required standard

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EXTERNAL EXAMINERS: ........................................................................................................
........................................................................................................................................

THE UNIVERSITY JOHANNESBURG

AUGUST 2016
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KEYWORDS
Bottlenecks
Buffer Management System
Constraints
Inventory
Lean
Mining Production Flow
Ore Mining Throughput
Resources
Theory of Constraints (TOC)

LONMIN - MARIKANA
ABSTRACT
The Theory of Constraints (TOC) identifies constraints which are otherwise labelled as waste by lean. TOC isolates these constraints and provide resources in order to buffer and/or eliminate them completely. TOC’s underlying premise is that organisations can be measured and controlled by variation on three measures which are throughput, operational expense and inventory. TOC challenges managers to rethink some of their fundamental assumptions about how to achieve the goals of their organisations, what they consider productive actions, and about the real purpose of cost management in order to maximise throughput through sales. It is about understanding bottlenecks to a process and better managing these bottlenecks to create an efficient process. Even though outcomes are the intended results, the inputs are considered vital. The study identifies inputs that are causing constrains and explains the methodology to isolate them and work on how and when to apply TOC to minimising these constraints’ impact. In order to prove TOC, a research was carried out in the Lonmin mine situated in Rustenburg in South Africa, where TOC was used to resolve recurring problems. The end results have shown that when a problem area is isolated, conditions observed, resources allocated at the problem area and action taken to address problems immediately, positive results can be achieved.
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<tr>
<td>DBR</td>
<td>Drum Buffer Rope</td>
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CHAPTER 1
INTRODUCTION

1.1 PROBLEMATIC

Lonmin embarked on seeking solution to its overall operational efficiency and product output but realised that it is difficult to meet expected production levels due to bottlenecks in the operations, starting from the mining section. Lonmin believed that the Theory of Constraints (TOC) could be integrated with various initiatives. For TOC to lead to solutions of the problems encountered there was a need to fix objectives through identifying the bottom up & down streams. Thus the TOC Mining Production Flow application was identified to substantially increase profitability.

1.2 LONMIN AND RESEARCH PERSPECTIVE BACKGROUNDS

During a Lonmin Strategy Review in 2012 held from 17 to 24 October, an important conclusion drawn was that Lonmin could increase its production to reach a steady flow at its processing plants and in so doing, improve the profitability of the company. On 23rd October 2012, a presentation was made on the potential of Theory of Constraints (TOC) Production Flow Solution for Mining Company. Resulted from this presentation was a decision of exploring ways to successfully introduce TOC process at Lonmin. The desired outcome was to ensure constant flow at the beneficiation plants, starting from the mine, and ensure an overall reduction of unit cost which will require at least a 10% improvement of the platinum production. From the mining subsequent meetings on 9th and 22nd November 2012, a request was received to tailor Lonmin approach by incorporating aspects of the TOC Mining Production Flow process and the inclusion of the Best Practice teams. During a follow up, the Lonmin Vice-President requested a full shaft change approach which should serve as a model for other shafts.

Lonmin went through disruptive industrial action and realised that the playing field in the mining industry changed significantly in a very short time. In order to meet the new challenges, new thinking was required. The company embarked on an established road to operational excellence since early in 2012 and this approach incorporated various modern as
well as well-established approaches to business improvement. As part of this process, Lonmin developed an operating model that was designed to increase the efficiency of the production output through the diligent application of this framework. It focused on safety, production, people and cost.

TOC is one of the most modern approaches to operational excellence in the industrial world. The TOC derived for mining, known as TOC Mining Production Flow, has been developed over more than a decade and it has demonstrated improvement in production output and costs through a process that involves ground breaking new mental models and new operating practices through people and good teamwork. It has demonstrated a sustainable increase in production flow of between 7% and 40% in various mining operations and in various countries and the resultant unit cost reductions were between 10 and 30%.

Lonmin needed a new “flavour of the month” on top of its improvement processes. For this reason there was a request to include parts of the best practice approach of TOC Mining Production Flow to be tailored to fit within Lonmin’s current reality and dynamics and to slot into Team Effectiveness Training program as seamlessly as possible.

This proposal of the TOC Mining Production Flow process also aimed to offer best practice application approach as one possible effective alternative as Lonmin tailored problem solving approach. The proposal also served to define project scope and budget to apply the process of TOC Mining Production Flow at Lonmin.

1.3 PROBLEM STATEMENT

The balanced capacity chain on the shaft remains the Achilles heel of the shaft. It is a systemic problem and very difficult to turn around while working under pressure trying to maintain the current performance. The process to set up a buffering and protective capacity, that is required to be in place in order to “unbalance” the production capacities, is under way but taking long due to the system unresponsiveness to output capacity which it was not designed for, to the extent often unsettled system. It could not be overemphasised whether the shortfall between the targeted and the then production would remain the same as long as the balanced capacity chain existed.

The performance of the Rowland shaft, the pilot site where TOC was to be applied, although improving due to the diligent attention and dedication of the Mine Overseer and Mine
Managers, the core drive towards filling the head gear was still to get people to their work station as fast as possible to generate more tons of ore through increased number of blasts, therefore the increase of tons of mined ore.

The combined effect of variation and interdependence of miners’ activities caused an important number of blast losses. Further to that, the standard recurrence of working but curbing in this endeavour was not bringing about significant improvement on the output of ore but rather the decrease of production. The buffers of material in production and skills for production improvement were critical, as there are other technical projects like adding more chairs to the chairlift, enlarging the cage capacity, man carriages grout pumping, etc. The performance trend of the shaft over several months clearly indicated that the mine dealt with a balanced capacity chain and, which clearly was a SYSTEM problem. The buffering and protective capacity system required to be put in place in order to “unbalance” capacities handling which became an absolute necessity rather than a luxury replacement. In the case of such a replacement not been done on required time there could be resulted a shortfall between target and real performance, in terms of output/input ratio, as never expected. The performance of the shaft was not improving since buffers and protective capacity were not installed. The approaches to work through were deeply entrenched and these were very difficult to have the status quo changed. Almost every step of production was met with some obstacles, but TOC could have them addressed. The mining process was taking much longer than anticipated and there seemed to be no end to stoppages and derailments as well as other operational challenges that did not help get to the state of a stable production. The core drive towards filling the head gear was still to generate more tons by increasing the blasting tons and this required the increase in protective capacity in the blasting horizon.

1.4 PROBLEM EXPLORATION EMPHASISED IN THE CASE OF PILOT SITE

It was decided on a step by step implementation approach and Rowland Shaft identified as the pilot site. Implementation commenced during March 2013 and several bottlenecks have been identified that negatively impact’s on the production flow. The main bottlenecks found were linked to the Rowland decline shaft extension - the constraints of moving employees through the system to their workplaces and back, the unavailability of critical stock items close to the workplace and lastly the lack of a labour buffer mitigating the risk of lost blasts due to non-availability of employees and inefficient recruitment lead time.
The identified bottlenecks have been or are in the process of being addressed. One of the main challenges of any change remains the people and their entrenched work practices and processes. The operational room has been implemented to challenge existing work practices and management focus areas and significant progress has been made through this daily intervention of focussing shaft management from a reactive to a proactive mode.

Several of the major systemic obstacles towards the desired improvement have been identified and these will be addressed on the shaft level as well as corporate level during the next 4 months. These include the standard templates used for planning and control of materials and crew sizes, recruitment processes, performance measurements, etc.

1.5 THE PURPOSE OF THE STUDY

Consistent delivery from the mining operations down the value chain remains one of the key operational challenges faced by Lonmin. By implementing the TOC Production Flow approach, we will challenge the established management philosophy including the way we measure efficiencies of “more with less”, to a philosophy of “more with the same,” even “more with more” if required, which will increase consistent production flow, with the required results down the value chain, resulting in increased production output and reduction in unit costs.

The process considers various elements, with a key focus placed on increasing production output through the identification and performance improvement of production bottlenecks, creation of buffers within the production line to ensure consistent production flow and the provision of enabling resources. Furthermore, the process utilises paradigm shifting mental models and new work practices applicable to both people and production teams.

1.6 OBJECTIVES OF THE STUDY

The implementation of the TOC philosophy will ensure increased production volumes from the mining operations, consistent and stable production flow down the value chain and an overall reduction in unit cost. An initial improvement in production output of between 5% and 10% is targeted.
1.7 SCOPE AND DEMARCATION OF THE STUDY

This study focused on TOC, culture and lean concepts to assess the maturity level of constraints and waste as lean within the mine industry of South Africa. The study confirmed how TOC can be used to improve competitiveness to ensure sustainable growth and wealth creation within the mining industry. The study was limited to primary sources of information gained from the mining industry in South Africa, with specific reference to the Lonmin facilities of South Africa available up to 2015. Secondary sources of information were limited to those generally available on the Internet, in the form of English language documents, and generally available literature sources. The study focused on Lonmin mine; all these sites are remote sites in South Africa. The scope included all managers, engineers, technologist, technicians and specialists across all functions.

Rowland Shaft Total Tons

![Rowland Shaft Total Tons Chart]

Figure 1.1: Rowland tons performance. Source: (Researcher, 2013)

1.8 RATIONALE, THEORETICAL OR CONCEPTUAL BACKGROUND/FOUNDATIONS

Management will accept the principles of flow and the weakest link, the governing principle of a systems approach and that the system should be managed holistically. Management will accept these four primary principles for TOC Mining Production Flow to be successful:

- Set the Primary objective towards maximising FLOW of the system as a whole (NOT to reduce cost by first intent);
- Determine a mechanism to prevent local variation to be passed on to the system as a whole (this is done through buffer management);
• Develop a mechanism to guide each link on when to work and when to stop (sequence and constraint dependency);
• Abolish local efficiency measures (in favour of flow measurements).

The total flow of a mine’s output is determined by only a few critical factors; the key focal points or constraints of the system. The performance of the constraints of the system is determined not only by their own capability, but is significantly impacted by the performance (variation) of all the other links in the chain, within a system of interdependence. Optimised, reduced costs are the consequences of stable and predictable operational excellence.

• The system’s performance is determined by the people in the system and the way they behave.
• A mine is a highly complex adaptive system with many agents, layers of organisation and a very high degree of interdependence. Operational excellence is the result of many factors, but the primary attention should be on the way people interact and align through team learning, shared vision, personal mastery and sharing of mental models.

The people within the system encompass a collective genius that can be harnessed through the application of the basic principles of dialogue, calmness, pro-activeness, problem solving, facilitation, mutual caring, significance and purpose.

1.9 SIGNIFICANCE OF THE STUDY

This study intends to provide the advance knowledge with a summary of the TOC implementation project at Rowland its associated benefits, leanings.

The implementation of the TOC philosophy will ensure increased production volumes from the mining operations, consistent and stable production flow down the value chain and an overall reduction in unit cost. An initial improvement in production output of between 5% and 10% is targeted.

It was decided on a step by step implementation approach and Rowland Shaft identified as the pilot site. Implementation commenced during March 2013 and several bottlenecks have been identified that negatively impact’s on the production flow. The main bottlenecks found were linked to the Rowland decline shaft extension - the constraints of moving employees through the system to their workplaces and back, the unavailability of critical stock items
close to the workplace and lastly the lack of a labour buffer mitigating the risk of lost blasts due to non-availability of employees and inefficient recruitment lead time. The identified bottlenecks have been or are in the process of being addressed. One of the main challenges of any change remains the people and their entrenched work practices and processes. The operational room has been implemented to challenge existing work practices and management focus areas and significant progress has been made through this daily intervention of focussing shaft management from a reactive to a proactive mode.

1.10 ASSUMPTIONS

Management will accept the principles of flow and the weakest link, the governing principle of a systems approach and that the system should be managed holistically. Management will accept these four primary principles for TOC Mining Production Flow to be successful:

- Set the Primary objective towards maximising FLOW of the system as a whole (NOT to reduce cost by first intent);
- Determine a mechanism to prevent local variation to be passed on to the system as a whole (this is done through buffer management);
- Develop a mechanism to guide each link on when to work and when to stop (sequence and constraint dependency);
- Abolish local efficiency measures (in favour of flow measurements).

The total flow of a mine’s output is determined by only a few critical factors; the key focal points or constraints of the system.

The performance of the constraints of the system is determined not only by their own capability, but is significantly impacted by the performance (variation) of all the other links in the chain, within a system of interdependence.

Optimised, reduced costs are the consequences of stable and predictable operational excellence. The system’s performance is determined by the people in the system and the way they behave. A mine is a highly complex adaptive system with many agents, layers of organisation and a very high degree of interdependence. Operational excellence is the result of many factors, but the primary attention should be on the way people interact and align through team learning, shared vision, personal mastery and sharing of mental models.
The people within the system encompass a collective genius that can be harnessed through the application of the basic principles of dialogue, calmness, pro-activeness, problem solving, facilitation, mutual caring, significance and purpose.

1.11 LIMITATIONS

There are several initiatives within Lonmin and people might experience attention overload and there should be awareness towards it, Lonmin will allocate at least one person on each mine to assist, act as convenor and record progress. This person will be exposed to more of the TOC principles and should act as the future facilitator on the mine. Lonmin will allow modifications to the information system to enable the newly determined measures to be recorded and reported.

1.12 DELIMITATIONS

- Identify and actively manage the constraints through participation and support of the Operational Rooms and daily attention.
- Ensure that the focus remains on exploiting the constraints and subordinating the organisation to the requirements of the constraints and the system as a whole.
- Actively support the process of reducing the impact of variation and interdependence through buffer management and establishing and maintaining adequate protective capacity.
- Evaluate operational and financial performance on the agreed TOC Mining Production Flow based approach.
- There is limited literature review on TOC.
2.1 INTRODUCTION

The Theory of Constraints is an overall management philosophy introduced by Goldratt(1984). The concept was adopted in Goldratt(1997) and extended to TOC in Goldratt(1999).

An earlier propagator of the concept was Wolfgang Mewes in Germany with publications on power-oriented management theory (Machtorientierte Führungstheorie, 1963) and following with his Energo-Kybernetic System (EKS, 1971), later renamed Engpasskonzentrierte Strategie as a more advanced theory of bottlenecks. The publications of Wolfgang Mewes are marketed through the FAZ Verlag, publishing house of the German newspaper Frankfurter Allgemeine Zeitung. However, the paradigm Theory of Constraints was first used by Goldratt.

The TOC has evolved over the past 20 years from a production scheduling technique to a systems methodology which is primarily concerned with managing change. Klein & DeBruine (1995) state that originally Goldratt set out to devise a systematic approach to identifying what was preventing a company from achieving its goal of making money for its owners. The approach was first used in a manufacturing environment and reported at an APICS conference in 1980. Hrisak (1995) advises that TOC is now used worldwide by companies of all sizes. He states that many managers who routinely use TOC believe they understand their businesses for the first time.

From this understanding they gain a sense of control and of being able to act proactively. Hrisak (1995) further says this is because TOC empowers managers by providing a consistent framework for diagnosing problems. The TOC methodology now encompasses a wide range of concepts, principles, solutions, tools and approaches, the description of which is beyond the scope of this paper. TOC is perhaps not normally considered by systems modellers to be part of the systems literature, but it is a system methodology in that it strives to ensure that any changes undertaken as part of an ongoing process of improvement that will benefit the system as a whole, rather than just part of the system. At its most basic level, TOC provides
managers with a set of tools that guide the user to find answers to the basic questions relating to change,

Namely:

- What to change?
- What to change to?
- How to cause the change?

Goldratt (1990b), Klein & DeBruine (1995) & Dettmer (1997) state that TOC views an organisation as a chain composed of many links, or networks of chains. Viewed as a constrained system, a chain’s links that all contribute to the goal and each link is strongly dependant on the other links. The chain, however, is only as strong as its weakest link. Goldratt’s TOC states that the overall performance of an organisation is limited by its weakest link. He states that if an organisation wants to improve its performance, the first step must be to identify the system’s weakest link.

Collaborative replenishment policy has been proposed to authorise a supplier to decide when and how much stock should be delivered to a retailer’s site as it sold. Collaborative performance metrics has also been presented to encourage the individual chain member to contribute to the goal of optimising supply chain profitability. These two strategies help the chain members to ensure the swift and the smooth flow of products to end customer and maintain the level of trust amongst them. However, the application of TOC should be adopted with care due to its intensive training requirements and radical approach that requires experimental learning. Further research is recommended to refine the TOC approach in dealing with the quantification of replenishment and emergency levels, the evaluation of the self-enforcing property of collaborative metrics, and the inclusion of reverse logistics.

2.2 **What is TOC?**

According to Barnard (2010) in 1980’s, an Israeli physicist, Eli Goldratt, started applying the mindsets and methods of the hard sciences to the “soft” science of managing and improving organisations through his results he then named the work Theory of Constraints (TOC). This is the system that is mostly used by the manufacturing companies, to meet the overall goal of the organisation while minimising the constraints that might have an effect to the production or manufacturing process in producing exactly what is expected.
Bramorski (1997), states that the Theory of Constraints has been successfully used by several manufacturing organisations worldwide to improving their competitiveness.

Further as stated by Sahi (1999), Theory of Constraints is a management philosophy that has been successfully used in a wide variety of manufacturing and it is time to transfer it to service.

According to McNeese (2014) and Krajewski et al (2010), constraints are what keep an organisation from reaching the system’s goal by limiting its performance and restricting its output. In TOC, constraints are defined as anything that restrains a system to perform its best to achieve its main goal. According to Goldratt (1990) TOC begins with a question – what is the goal of a company? Every company is built to achieve a purpose. So, when we engage in debate about taking an action in any part of the company, we must talk about that action and its impact on the purpose of the company. This is the only logical way to hold the discussion. So, what is the purpose (or goal) of a company? And who gets to decide? Only one group can determine the company’s purpose – the owners.

Bates defines TOC defines constraints as a process or process step that limits throughput. Rand (2000) states that in production planning terms the system's constraint is the bottleneck. According to Mahapatra and Sahu (2006) constraints should be identified and logically solved to improve the performance of the system. As any system with an organisation has a constraint and needs a continuous improvement to ensure the system is always improved to be more efficient. According to Sheffield (2002), TOC focuses on the efficiency of all processes as a whole rather than of any single process.

TOC is defined by Krajewski et al (2010) as a systematic management approach that focuses on actively managing those constraints that impede a firm’s progress towards a goal. It is also defined by Şimşit et al. (2014) as a management philosophy which is focused on the weakest ring(s) in the chain to improve the performance of systems. Siha (1999) mention that TOC is an overall management philosophy that recognises constraint on any system restricts the maximum performance level that the system can obtain in relation to its goal.

The organisation’s goal is its reason for existence. According to McNeese (2014) companies are intended to make profit, so in reality the goal of any company is one and only, which is to make profit in a short and long term. McNeese (2014) emphasises this statement as it was implied by the management who is also the developer of TOC field Eli Goldraft. Opposing
what was implied by the management guru Edwards Deming, who stated that money may be one of the measures of how well an organisation is doing but it is not the company’s goal. Rand (2000) mentioned that the system’s constraint is that part of the system that that constrains the objective of the system for money making organisations.

Mabin (1990) states that the motive behind Eli Goldraft’s model was set out to devise a systematic approach to identifying what was preventing a company from achieving its goal of making money for its owners making money for its owners. Sahi (1999) emphasise that for most manufacturing and service organisations the goal of the organisation is to make a larger profit now and in the future, as the goal is to make a profit, constraints on manufacturing and service organisations keep the organisation from making a higher level of profit.

According to McNeese (2014) every goal has the necessary condition if it is achieved. Simatupang (2004) states that stakeholders may develop necessary conditions that must be met to allow the system to continue operating, for examples necessary conditions can be quality, competitive advantage, technology leadership, cash flow and satisfied employees. Through all these aspects then an organisation can reach its overall goal of making profit. TOC is being summarised into two contexts namely every system must have at least one constraint and the existence of constraints represent opportunities for improvements. According to Rahman (1998) if very system does not have at least one constraint, then in such system the profit making of the organisation will be unlimited.

2.3 EMERGENCE OF TOC

According to Mabin (1990) the TOC has evolved over the past 20 years from a production scheduling technique to a systems methodology which is primarily concerned with managing change. This is in 1984 when the TOC was developed by Eliyahu Goldratt who, according TOC institute (2015), completed his BS; then completed his MS and Doctor of Philosophy. Eliyahu Goldratt was known as a scientist, physicist, author, educator and consultant.

Tom Mcmullenhas used scientific methods to create concepts in management which have proven to be of great value to industry. TOC was known through his book which he published with his co- author Jeff Cox titled “The Goal. The subtitle of the book is A Process of ongoing Improvement”. It shows that the offers identified the challenges and common mistakes which the manufacturing companies come across. Hence Nieminen, (2014) states that it is highlighted in the novel (The Goal) that the problem in manufacturing organisations
can be solved focusing on the facts that actually mattered with respect to making money and communicated these facts through the novel. It is emphasised by Mabin and Balderstone, (2003).

The Theory of Constraints is a multi-faceted systems methodology that has been developed to assist people and organisations to think about their problems, develop breakthrough solutions and implement those solutions successfully. According to Bates most people are first exposed to the concepts through Goldratt in 1984 by his book “The Goal”. According to n his book, The Goal (1992b), physicist Eliyahu Goldratt relates the story of an embattled plant manager searching for ways to improve plant performance. Most people are first exposed to the concepts through his book The Goal. According to the TOC institute (2015) TOC is a systematic focus on efforts, energy and attention to the system constraints. Through the manufacturing the, system was applied in many disciplines within both the service and products producing organisation. According to Scoggin (2003) within the past 10 years, the thinking process (TP) and its set of logic tools (Goldratt 1994) have been evolving to provide a framework to help understand the existing situation, identify desirable strategies to meet goals and implement improvements within organisations. Many organisations in services and manufacturing are applying the TOC to ensure that organisations goals are obtained.

Watson et al. (2007) in a recent review of the evolution of TOC break up TOC into five evolutionary stages

1. The Optimised Production Technology (OPT) stage (circa 1979-1984)
2. The Goal and The Race stage – OPT as a continuous improvement philosophy (circa 1984-1990)
5. The Critical Chain stage – TOC applied to Project Management (post 1997)

2.4 APPLICATION OF TOC

Mabin (1990) informed that TOC was first used in a manufacturing environment; and now used worldwide by companies of all sizes. TOC can be applied in both the manufacturing and the service firm with the main objective of making money. According to Şimşit et al. (2014) Originally TOC is used to plan the production process and allocate resources, but its content
is improving day by day as the technology evolves and competition between rival companies increases in the business world. Nowadays it can be used a kind of management philosophy and can be integrated with cost accounting system. McMullen Jr, (1998) states that TOC as a management system has been used in the whole or in part by industrial corporations, service companies, non-profit organisations, military and intelligence operations, families, friends and individuals all over the worlds to improve performance; to analyse opponents more accurately; to create better work environments and to improve relationships.

According to the TOC institute (2015); its application is designed to solve business problems in a particular practical and effective manner. Furthermore, according to Mabin (1990), many managers who routinely use TOC believe they understand their businesses for the first time as they gain a sense of control and act proactively within their organisations. Bramorski (1997) states that TOC helps in identifying the weakest elements of processes that occur within organisations as constraints Eliyahu Goldratt suggested the step by step process to follow when working with the TOC process. Which according Rahman (2008) this working step by step process of TOC provides a focus for a continuous improvement process.

The step by step process of is a TOC involves identifying and managing constraints in order to improve organisational performance. Mabin (1990) indicates that TOC strives to ensure the system is an ongoing process of improvement which will benefit the system as a whole and not just a process. According to Sahi (1999), the TOC philosophy could be applied to everyday operations decisions as well as to the continuous improvement effort. Pegels and Watrous (2005), mentions that TOC can be thought of as a continuous improvement process, because no matter how well an organisation performs, there will always be at least one constraint that limits the organisation from becoming a little better. Şimşit et al. (2014), state that since 30 years TOC has been successfully implemented by almost every sector and within almost every size of companies. The following are the five TOC process:

1. Identify the system's constraints.

   The strength of a chain is determined by its weakest link, need to determine how to strengthen the chain first by identify the weakest link. This is the constraint, the bottleneck. It is what prevents the company from obtaining more of the goal over time. The flow of work through the company has to be examined to find the constraint.

   According to Mabin (1990) the first step indicates that identify the operation that is limiting the productivity of the system. This may be a physical or policy constraint as,
Mahapatra and Sahu (2006) states that these may be physical materials, machines, people, demand level or managerial. According to Rand (2002) in production planning terms the system's constraint is the bottleneck. In Step 1 this needs to be identified. If it is a machine, for instance, then the maximum possible utilisation needs to be achieved. This may mean running the machine during the lunch hour, with operators staggering their break, or reducing the number of changeovers. It will mean ensuring that there is always work for the machine to do.

2. Decide how to exploit the system's constraints.

The second step is to strengthen the constraint by making the weaker link stronger and to get more out of the constraint, mentions that there are different types of constraints, e.g., physical or policy. We will focus on physical constraints here. There are two ways to strengthen the constraint: get more out of what you have or add. According to Rand (2002) in step 2 if this is the constraint, then there is no point running other machines at a higher production rate: so every other planning decision needs to be subordinated to the schedule required to keep the bottleneck machine running, furthermore states that adding more capacity increases the cost and TOC sees controlling costs as a necessary condition for success. So, this second step focuses on getting as much out of the constraint as possible – not on adding capacity. Some techniques that are helpful here include Kaizen events to reduce setup times, experimental designs to increase throughput, and statistical process control (SPC) to help maintain the gains and work on continual improvement.

3. Subordinate everything else to this decision.

According to Rand (2002), in step 3 to improve the objective the system's constraint may need to be elevated. In the case of the bottleneck machine, for instance, it might be run during an additional shift, thus increasing its output. The constraint, the capacity of the machine, has been increased, or elevated.

4. Elevate the system's constraint.

According to Rand (2002), the difference between Step 2 and Step 4 relates to the amount of investment required, whether in terms of time, effort, money, or willingness. The difference is sometimes pithily expressed as whatever we can do tomorrow is Step 2°. The application of Step 4 may have changed the system's constraints with its increased capacity, the original bottleneck may no longer be constraining the system, so the new bottleneck needs to be identified, and the process repeated (Step 5).
5. If any of the system's constraints has been violated, go back to Step 1.

Rand (2002) mentions that in Step 5 this is a process of continual improvement. Though this example comes from the production environment, TOC is applicable to every system.

There is a manufacturing technique called the Drum Buffer Rope (DBR) scheduling method for TOC. According to Nieminen (2014), DBR evolved from the scheduling software called optimised production technology (OPT), which was first introduced as a commercial system by Goldratt and his associates; it is a planning and scheduling solution which is generated from the TOC. Denisa, (2012) states that today production planning and scheduling becomes very important part of production management because companies have to react to dynamic market conditions and rising customers’ requirements for shorter delivery times, lower prices and better quality and services. According MAC (1999) to DBR process was designed as a means of implementing the five-step process of continuous profit improvement and therefore represents a tremendous leap forward in managing the shop floor from a profitability perspective.

Balderstone and Mabin (1998) states that the DBR scheduling system, together with the general principles espoused in The Goal were elements of TOC that became part of successful manufacturing management. As it is emphasised by Elftman (1999) that DBR is a newer system of production control that follows the TOC philosophy. In doing so, it concentrates on managing the flow of products to meet the bottleneck constraint’s needs. Since the bottleneck acts as a valve controlling the system’s throughput, managing the bottleneck’s throughput manages the system’s throughput. To maximize the system’s throughput, the bottleneck must utilise all of its available capacity. According to Gupta and Snyder (2009) DBR is the generalised technique used to manage resources to maximise throughput. The drum is the rate or pace of production set by the system’s constraint.

The buffers establish the protection against uncertainty, so that the system can maximise throughput. The rope is a communication process from the constraint of the gating operation that checks or limit material released into the system to support the constraint. Mahapatra and Sahu (2006) mentioned that the DBR systems operate by developing a schedule for the system’s primary resource constraints. Schragenheim and Dettmer (2000) stated that the concepts of DBR actually preceded the Five-Focusing-Steps and the notion of the throughput world in the development of the TOC paradigm.
2.5 **TOC BUFFER MANAGEMENT SYSTEM**

According to Dager (2014) TOC drives inventory levels down to help make the enterprise leaner and not tie up so much of its capital in unneeded inventory. Gupta and Snyder (2009) states that a buffer management system is the process in which all expediting in a shop is driven by what is scheduled to be in the buffers (constraint, shipping, and assembly buffers). Gupta and Snyder (2009) further states that expediting this material into the buffers, the system helps avoid idleness at the constraint and missed customer due dates. In addition, the causes of items missing from the buffer are identified, and the frequency of occurrences is used to prioritise improvement activities. Schragenheim and Ronen (1991), mentions that buffer management serves as an alarm system that serious and urgent problems which threaten to disrupt the plan and cause real damage. Barnard (2010) illustrates that applying the TOC 5 Focusing steps to improving planning and execution management of operations also called Drum Management it will reduce the main causes of low throughput, long lead times, poor due date performance and higher operating expenses inventory due to internal bottleneck(s).

2.6 **TOC BOTTLENECKING AND IMPLICATION OF BOTTLENECKING AND CONSTRAINTS**

Hohmann (2014) stated that a bottleneck (resource) is a resource with capacity less or equal to demand while a constraint is a limiting factor in an organisation’s performance, an obstacle to the organisation achieving its goal. While Elftman (1999) mentions that in a factory the bottlenecks are usually those machines or processes which control the throughput of the system, while according to Goldratt (1990) Constraints are what keep us from reaching the system’s goal. According to Pegels and Watrous (2005), the TOC precept is to identify and focus on bottlenecks in any operation because they are the source of interference in any attempt at improving productivity and throughput. By eliminating the bottlenecks in any operation, substantial improvements will therefore follow automatically. So the relatively simple approach of TOC is to identify the bottleneck and then take whatever action is necessary to remove that bottleneck. Denisa (2012) mentions that in manufacturing process it means that this bottleneck holds down the amount of products that a company can produce. Then we can say that bottlenecks control the throughput of the whole production system.
2.7 **TOC TECHNICAL ANALYSIS**

TOC has now been developed into a powerful and versatile management theory, as a suite of theoretical frames, methodologies, techniques and tools. According to Mabin and Balderstone (2003) it is now a systemic problem-structuring and problem-solving methodology which can be used to develop solutions with both intuitive power and analytical rigour in any environment.

2.8 **TOC IN OPERATIONS AND STRATEGIC VIEW**

For many years TOC have been implemented in the manufacturing industries. MCA (1999) states that TOC has broad applications in manufacturing organisations as it can be used in conjunction with other management techniques such as total quality management (TQM) and just-in-time (JIT) to provide a comprehensive, linked set of techniques that emphasise continuous improvement in all areas of operation. According to Balakrishnan (2008) in the industry clearly many organisations have benefited from TOC, whether in concert with other philosophies such as JIT and TQM or alone (APICS-The Association for Operations Management has played an important role in popularising TOC.

2.9 **TOC IN FINANCE**

According to MAC (1999), TOC helped guide this process toward greater profitability and improved cash flow.

2.10 **THE THINKING PROCESS AND BUSINESS ANALYSIS**

The thinking process of the TOC the philosophy is more concerned with the fact that organisation is adapting to change. Scoggin et al. (2003) states that organisations can be viewed as dynamic systems undergoing periodic transformations as they seek to survive and prosper by adapting to their changing environments; managers need to be continually monitoring their performance and seeking to develop and implement positive change. According to Mabin(1990) TOC Thinking Processes are more useful in deciding what to change, what to change to, and how to cause that change to occur. In much the same way as the 5 Focusing Steps focus on the constraint, the Thinking Processes focus on the factors that are currently preventing the system from achieving its goal.
Mabin (1990) states that TOC Thinking Process tools are then used to deduce what the causes of those symptoms are, what needs to be done to correct those causes, and how such corrective actions could be implemented. In this way, the TOC approach is to map the system from the point of view of the current problems, rather than try to model the whole system. The TOC through the thinking process is the method of identifying and resolving problems. According to Abdi et al. (2014), TOC is used to identify the bottlenecks in the production line and Thinking Process (TP), as one of the TOC tools, is used to identify the constraints of management and policy as opposed to the physical limitations in the existing system. Goldratt believed that thinking process enables managers to tackle policy constraints by finding the answers to the basic questions relating to change, Taylor 111 and Sheffield (2003) mention that Goldratt developed his Thinking Process to pinpoint the constraint, or weakest link that holds back a system’s overall production rate. The three change steps discussed below are the tools that manage to identify the weakest link or the constraints and come to the effective and efficient interventions to implement.

The thinking process has three steps in implementing creative or innovative change the response to a certain constraints that may not be seen before the change occurs. These three states are normal, what to change, and what to change to and how to make the change. According to Taylor 111 and Sheffield (2003), because the constraint is not always obvious, Goldratt (1992a) developed the thinking Process, a series of steps to locate the constraint (What to change), determine the solution (What to change to), and implement the solution (How to make the change). Abdi et al. (2014), states that Goldratt believed that thinking process enables managers to tackle policy constraints by finding the answers to the basic questions relating to change. Gupta and Snyder (2009) further emphasis that from an ongoing improvement process perspective, TOC suggests an organisation must ask three fundamental questions concerning changes to accelerate its improvement process. As according to Scoggin et al. (2003), responding to these three questions, provide managers with guidance as they seek effectively to implement the change sequence.

What to change?

The question to ask according to Gupta and Snyder (2009) is how do organisations identify the weakest link, i.e. the constraint(s)? Taylor 111 and Sheffield (2003) according to the core problem is also the weak link in the operation when it concerns achieving the goal of the company. Gupta (2013) identified the system constraints, root causes or core problems responsible for a significant majority of the undesirable effects (UDEs). Taylor 111 and
Sheffield (2003) mentions that this root cause needs to be exposed and eliminated through analysis of cause-and-effect relationships, which uncovers the core problem associated with the UDEs.

What to change to?
Once the weakest link is identified, how should organisations strengthen the weakest link by developing practical and good solutions?

How to cause the change?
How should organisations implement the solutions?

2.11 LEADERSHIP IN TOC AND TOC CULTURE

TOC advocates suggest that managers should focus on effectively managing the capacity and capability of these constraints if they are to improve the performance of their organisation, AMC (1999). The cause of failure in the implementation of TOC is due to lack of management cohesion. According to Barnard (2010), one of the major challenges in organisations is defining and communicating the necessary and sufficient changes on TOC that required sequences of these changes and related contributions to all functions within the organisation and all levels within these functions. Managers and employees that do not know their contribution to the goal of the organisation, question the contribution of others in the organisation, feel disempowered due to gaps between authority and responsibility, face conflicts between local vs global or short vs. long term optima, of failure can result in disharmony that will jeopardise the achievement of the organisational goal.

2.12 TOC IN PEOPLE MANAGEMENT AND LEADERSHIP

TOC can have an impact on people as individual and within the organisation. People can use the TOC for their own personal development, while it can also be used within the organisation to ensure the achievement of the overall goal. Nagarkatte and Oley (2010) states that the Theory of Constraints (TOC) has Thinking Process (TP) tools to help people think systematically about how to manage real life constraints. A constraint is something that stands in the way of achieving a goal. According to Barnard (2010) TOC acknowledges that people only resist change when a change is considered a “lose” situation for them or stakeholders; it also considers that a “win-lose” situation between stakeholders in an organisation will always deteriorate and lead to a “lose-lose” situation. Ensuring that change
to be a “win” for stakeholders is the key to turning resistance to change into an active
situation contributing to commitment to lead to a successful implementation of change. Managers need to start applying the mindsets and methods of the hard sciences to the “soft”
science of managing and improving organisations which is suggested by Goldratt.

2.13 CONFLICTS RESOLUTION IN TOC AND TEAM EFFECTIVENESS

Nagarkatte and Oley (2010) state that TOC provides a logical and proven way to develop conflict resolution, decision making, problem solving and effective management in personal as well as institutional projects. According to MAC (1999), it differs from other manufacturing techniques in that it concentrates on determining the relationships among resources in resolving conflicts to create a smooth flow of product and is applicable to all types of processes whether they are repetitive, process, or job shop. Drum-buffer-rope also provides an improved method of focusing protection so that the impact of disturbances on smooth production flow can be minimised.

2.14 CRITIC OF TOC AND TEAM MEETINGS

According to Balderstone and Mabin (1998), some companies failed in their attempts to adopt OPT, the software package based on Goldratt’s method, such failure was usually diagnosed as an inability or unwillingness by the organisation to discard old traditions, and embrace the new philosophy and the new measures that were concomitant with successful adoption. The TOC believes in looking into the system as a whole, when implemented the management has to consider the whole system. Balderstone and Mabin (1998) further stated that the most common measures that need to be reviewed are accounting measures, as TOC promotes the use of global system-wide measures, rather than local measures.

The motivation for this is that if a system as a whole is to achieve its goal, it is best for the system’s individual parts to work as a team in “sync” rather than at their own individual speeds. Mentions that Şimşit et al. (2014) TOC views processes as they are rings of the same chain instead of thinking they are independent from each other. At the same time, theory focuses on the weakest points which are bottlenecks for the entire company and try to determine the relationship of these bottlenecks. Therefore, this integrated management philosophy changes the way of thinking of managers and become an important tool for solving root problems. Simsit et al. (2014) further states that companies, whether they are in
the production or service sector should be more focused on understanding their own structure in terms of processes to survive in a global competition. In this situation, TOC becomes an important problem structuring and solving methodology which changes the way of thinking of managers.
CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Unlike most research methodologies, this chapter deals with the TOC principles applied at the Rowland Shaft which served as pilot site. It followed that TOC framework, the process, the procedure and the steps necessary to complete conceptual work, guided the design of work process and strategy to most sensitive analytic aspects at Rowland Shaft and training were provided to all employees to rollout TOC. The researcher who’s business optimisation manager at Lonmin took the initiative of TOC testing and was tasked to improve productivity in Lonmin starting with the mining process.

The aim of the case study was to improve the current production level and performance by 20%, the reason why Lonmin embarked on finding a solution to their efficiency and product output, but realised that it is difficult to meet the production levels due to bottlenecks in the operations. For TOC to work the company needed to stabilise the objectives through identifying the bottom up & down streams. The objective of the TOC Mining Production Flow application was to increase the profitability of the mine substantially through the application of various solutions within TOC and the related technologies.

The chapter followed by the decision made by management to improve the production non-performance and improve by 20%.

The researcher was assigned to introduce TOC and he followed the in this Chapter.

3.2 RESEARCH DESIGN

This chapter describes the research methodology adopted in this research. Topics such as the research objective and research approach will be discussed as will the data collection and research methods. The strategy and quality of the research design will also be presented.
It has been observed that there was low productivity over the years. This has led to the senior management deciding to allow business improvement section to introduce TOC in order to improve the productivity. The reasons for such are as follows:

### 3.2.1 Reasons for TOC Applications

The aim was to improve current revenue by between 5% and 10% on the current production profile 5500 tons per month.

- The tactics was to improve the current buffer management by implementing more (Skills labour, Material store and additional engineering equipment
- The aim was to also Improve the current leadership team by improving the core skills and knowledge around the concept of Theory of Constraints
- Improve the frontline productions teams in improving the way they do things.

### 3.2.2 Reasons for leading to the decisions

Improving the current production profile by 20%, Improving the way we do business.
Improving and protecting the revenue streams by implementing buffer management systems,
Improving frontline productions teams by providing the ability and means to do the work
Improving the problem solving mechanism by allowing the team 10% problems and 90% of the time and solutions, Improving strengths and TOC competencies to enable the concept to be fully applied.

### 3.2.3 The Procedure started with the following to sensitise management workers

- Workshop and Lecture TOC concept with Senior Management – ½ Day;
- Workshop and lecture TOC concept with Middle Management 1 Day;
- Workshop and lecture TOC concept with Supervisor ½ Day;
- Practical presentations and demonstration of the concept TOC for all level;
- Books and Articles issued to allow more understanding.

### 3.2.4 Changes introduced to introduce TOC

- Conduct Business value analysis;
- Conduct potential business TOC opportunities;
- Follow a step by step approach to identify important constraints and bottlenecks;
- Analyse further business units for more opportunities;
• Analyse existing buffer management systems;
• Analyse leadership and management assessment capability to change.

### 3.2.5 Meeting/Training and the related

• Where the Generals meet to decide on the tactics of the next 24 hours – A community where improvement is generated;
• Understanding the big picture of the Current Reality - a place where you come to listen and share;
• A ‘how do I help you’ opportunity - Focused on solutions (share) and outcome (not bitching and moaning);
• Where really good decisions are made;
• When we leave, everybody present must know what we have to do to help the System to perform better (Bottlenecks & Optimised Flow).

### 3.3 PILOT STUDY

In view of the fact that this research aimed at determining the role which measures play within a mining, the body of research embraced a holistic view of performance, innovation and measurement within a company. This was done through intense planning where anticipated alternative explanations or threats was conducted by developing a well-organised system for recording data and apparatus such as computers and video cameras tape recorders were used. The study was conducted in the specific shaft or mine called Rowland Shaft.

The following are the steps towards the implementation of TOC at the Rowland Shaft; it stipulate the project milestone, the original baseline and the actual completion dates

**Table 3.1: TOC implementation at Rowland mine. Source: Researcher’s (2013)**

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Original Baseline</th>
<th>Extended Baseline</th>
<th>Actual Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior operations management workshops (exposure to the principles of TOC mining production)</td>
<td><strong>End February 2013</strong></td>
<td><strong>02 February 2013</strong></td>
<td><strong>06 February 2015</strong></td>
</tr>
<tr>
<td>Project Milestones</td>
<td>Original Baseline</td>
<td>Extended Baseline</td>
<td>Actual Completion</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
<td>-------------------------</td>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Data gathering to understand the operations, the current reality, core problems &amp; improvement potential</td>
<td>End February 2013</td>
<td>09 March 2013</td>
<td>11 March 2015</td>
</tr>
<tr>
<td>Establish an operational model by tailoring the TOC mining production flow principles to the specific mine’s total flow chain</td>
<td>End March 2013</td>
<td>17 April 2013</td>
<td>01 July 2015</td>
</tr>
<tr>
<td>Establish a functional Operational Room to manage the bottleneck, buffers and system subordination</td>
<td>End March 2013</td>
<td>15 March 2013</td>
<td>15 March 2015</td>
</tr>
<tr>
<td>Refine and roll out the TOC principles and mine specific solution to next level supervisors and refine the models and measures</td>
<td>End May 2013</td>
<td>04 May 2013</td>
<td>01 July 2015</td>
</tr>
<tr>
<td>Establish reflection meetings and continuous improvement initiatives</td>
<td>End May 2013</td>
<td>12 March 2013</td>
<td>12 March 2015</td>
</tr>
<tr>
<td>TOC Deployment: Timeline to be established for the rollout to the whole of the mine</td>
<td>June 2013</td>
<td>31 Jan 2014</td>
<td>On going</td>
</tr>
</tbody>
</table>
3.4 INTRODUCING TOC AT ROWLAND SHAFT

3.4.1 Step 1- Decide on the Suitable Implementation Site for the Roll Out:
Conduct a short TOC based data gathering exercise to determine the current reality and core problem(s) of the current situation with the intent of identifying the site with the highest potential for success while at the same time have the highest potential for Lonmin. The options are to either select a VP section or only a specific shaft. Once a specific implementation site is selected, the detail process will be agreed between the TOC Mining Production Flow facilitators and Lonmin. It is essential that the particular VP is really willing to allow this process and to support it fully.

3.4.2 Step 2: Senior Operational Management Workshops
Conduct two (2) day training, exposure and thinking process that will expose the senior team of the selected operation to the fundamental concepts of TOC, dialogue and good teamwork. The existing mental models will be challenged and alternatives and new ways to improve the operations will be developed with the inputs of the responsible managers. A guiding plan for understanding and successful implementation will follow, indicating the requirements for
success and how to overcome expected obstacles. People to attend: VP, Mine manager, Shaft Manager, Mine Overseers and Section Heads of all operational and support functions.

3.4.3 Step 3 Establish an Operational Model by Tailoring the TOC Flow Principles

Analyse and develop a TOC Mining Production Flow Effectiveness Model for the total mine flow and determine the road map required to achieve the desired results with a high degree of certainty. The outcome is a conceptual framework of where the constraints are, where they ought to be, the application of buffer management and the system logistics required to support and enhance the total flow of the mine:
- High level Effectiveness model – a model that will visually show the direction of the solution
- Determining factors that impact on the flow
- Determine the circular cause and effects of all the major contributing factors that negatively impact on flow
- Determine and prioritise the improvement actions that are required to increase the flow
- The minimum primary measurements for improved output and logistics

3.4.4 Step 4 Establish the Daily Operations Room Functionality

Daily operational functionality is based on the principles of open dialogue and the TOC Flow Effectiveness models, to measure, report and act according to the agreed critical constraint and buffer measurements. The process involves coaching and guiding on the TOC model as well as open dialogue for good communication and teamwork. Specific coaching is required to move from the typical daily reporting to the desired functional War Room behaviour. This forms the core driver of the change process.

A suitable location for the War Room is required where all the relevant people can meet for 30-40 min per day. Initially, this will be done manually (sheets against the wall) but over time the measures and reports could be built into the information systems and reported electronically after the actual meetings have taken place. Daily data will be captured and forwarded to the TOC Specialist facilitators for review and comment on a weekly basis. The electronic reporting can later be scaled up to be available to the senior executives as high level visibility of the overall Lonmin Operations “Dashboard”. During this process, it will be
required to do specific experiential learning exercises to establish the mental framework for a properly run War Room as well as to develop the appropriate name and behaviours for it.

3.4.5 Step 5 Select Suitable Half Levels and do Detail Roll Out

Although the blueprints for all the half levels are similar, each half level is unique and therefore the TOC Mining Production Flow approach must be tailored for every half level. The intent is to select half levels (at least 3) that are different in the kind of constraints they have (trimming, development, stopping, etc.) and develop the solution for it in the practical environment. The selection of the “model” implementations are therefore very important; for the specific half level, for the value to Lonmin and to building the experience of the Best Practice Teams for future roll outs.

3.4.6 Step 6 Refine and Roll out the TOC Principles and Mine Specific Solution

Roll out the theory and the applicable half level and mine model to the next level supervisors and to the level of Mine Overseers, Shift Supervisors and Foremen levels. Once this has been completed, the roll out will be extended to all the service departments on the mine. During this process, the TOC Flow Effectiveness Modes will be refined with the contributions from the roll out program as well as new insights and lessons learned from the Daily War Room. People to attend: First round: Section heads mining, Mine Overseers, Engineers and Foremen.

Second round: Next level Supervisors of all the other functions on the mine.

3.4.7 Step 7 Establish BI –Weekly Reflection Meetings Establish

Establish a culture of continuous improvement through reflection meetings every two weeks. These meetings are conducted on the principles of open dialogue, where new ways of talking and listening to each other are cultivated. During these meetings, the trends and learning experiences are evaluated, decisions are taken on next steps and anticipated changes in bottlenecks and buffer management are discussed. The impact of policies, measures and procedures are documented and discussed and then good decisions are made to improve the operation of the mine as well as the system as a whole. In a companywide implementation, this phase is absolutely crucial for success. People to attend: VP’s, Mine Managers, Section heads, Mine Overseers and selected other contributors.
3.5 CONCLUSION

The steps were designed by the researcher and TOC was introduced TOC at Rowland mine, all the steps were done practical, all meetings were held every morning at 7:00 attendance by all stakeholders (e.g. Vice President, Section Managers, Supervisors, HR and finance Managers).

TOC has been highly welcomed and accepted by all the stakeholders due to the question it ask the following Chapters (4 and 5 will explain).
CHAPTER 4

STEP 4 INTRODUCING THE TOC IMPLEMENTATION

4.1 INTRODUCTION

The following is the explanation suggested to introduce the steps explaining how TOC was implemented in the Rowland mine; this chapter explains how TOC implementation process was elaborated.

This chapter explains the process that was taken to implement TOC following the methodology as explained in Chapter 3. All the steps leading to the success of TOC are listed.

Consistent delivery from the mining operations down the value chain remains one of the key operational challenges faced by Lonmin. By implementing the TOC Production Flow approach, establish management philosophy will challenge the established management philosophy including the way we measure efficiencies of “more with less”, to a philosophy of “more with the same,” even “more with more” if this required, which will increase consistent production flow, with the required results down the value chain, resulting in increased production output and reduction in unit costs.

The implementation of the TOC philosophy will ensure increased production volumes from the mining operations, consistent and stable production flow down the value chain and an overall reduction in unit cost. An initial improvement in production output of between 5% and 10% is targeted.

The process considers various elements, with a key focus placed on increasing production output through the identification and performance improvement of production bottlenecks, creation of buffers within the production line to ensure consistent production flow and the provision of enabling resources. Furthermore, the process utilises paradigm shifting mental models and new work practices applicable to both people and production teams.

The chapter starts with the roll out framework following the steps taken.
4.2 THE ROLL OUT FRAMEWORK

It was decided on a step by step implementation approach and Rowland Shaft identified as the pilot site.

Figure 4.1: The Roll out Framework. Source: (Researcher, 2013)

4.2.1 Conduct Senior Operations Management workshops

Figure 4.2: The Roll out Framework I. Source: (Researcher, 2013)

The following steps as shown in Figure 4.1 were taken to apply TOC. It is important to follow the process exactly as listed due to the fact that each step is consecutively following the given order.

The introduction followed by the below activities:

- Day training, exposure and thinking process that exposes the senior team to the fundamental concepts of TOC (Operations, Buffer management and Project management), dialogue and good teamwork.
- Challenge existing mental models and present alternatives and new ways to improve the operations.
- A guiding plan for understanding and successful implementation, indicating the requirements for success and how to overcome expected obstacles.

The meeting between senior managers were taken in 2013 where TOC was discussed and to proper awareness and understanding through TOC workshops for the ROWLAND all management and supervisory teams.
4.2.2 Develop TOC Flow Model.

TOC is a management philosophy that focuses on flow of the system as a whole, a significant mental shift towards a new way of doing business, replaced local optimisation (silo) with optimised flow (system), shifting from “CONTROL” to “ENABLEMENT”.

It is a new way of thinking, not a plug and play application, deep understanding & commitment is required, If we try to plug TOC into the existing system as an add on, it will bring short term results (demonstrated), but will ultimately fail, have to ensure that current culture, behaviours & measures will support the approach and not block it.

The following steps shown below are what guide the development of an effective TOC flow model:

- Many of the regular measures and behaviours will have to be changed
- It requires a new strategic thinking
- Determine Operating Rules for TOC flow chain

4.2.3 Determine Operating Rules for TOC Flow Chain

Daily operations which are discussed in details in war room 4.4.3. Gives detail of the discussion relation to problems encountered in the shaft. Line manager and shaft managers are called upon to give details of the current production situation.

- Require particular parts of the mine to re-align themselves with the overall flow of the system as a whole
• These rules will establish the basics for day-to-day War Room decision making; for the immediate requirements, the ramp up process and longer term.
• Prerequisites for maximised operational flow.
• Communicated, verified and re-visited until all the parties involved have bought into the concepts.

### 4.2.4 Implement Daily Operations (Ops) room

**Figure 4.5: The Roll out Framework IV. Source: (Researcher, 2013)**

Establish the Daily Operations Room (War Room), based on the TOC Flow Effectiveness model, to measure, report and act according to the agreed critical constraint and buffer measurements and the established operating rules.

- Specific coaching to replace the typical daily reporting to functional War Room behaviour.
- Meet for 20-40 min per day, the core driver of the change and improvement process.
- Reporting done manually on sheets against the wall.

### 4.2.5 The Next level training and facilitation

**Figure 4.6: The Roll out Framework V. Source: (Researcher, 2013)**

The importance of training cannot be overemphasised. Training is the backbone of successful production output. Training applies theory and adapts the applicable mine model to the Shift Supervisors and Foremen levels. Once such a training has been completed, the roll out will be extended to all the service departments on the operation.
During this process, the TOC Flow Effectiveness Models are refined and adjusted with the contributions from the roll out program as well as new insights and lessons learned from the Daily War Room.

### 4.2.6 Reflection Meetings and continuous improvement

The war room situation always leads to actions that need to be taken in order to remedy situations/bottlenecks/problems. Establish a culture of continuous improvement through reflection meetings every two weeks.

- Conducted on the principles of open dialogue, where new ways of talking and listening to each other are cultivated.
- Trends and learning experiences are evaluated, decisions are taken on next steps and anticipated changes in bottlenecks and buffer management are discussed.
The Figure 4.8 above shown developed to position strategic how we will need to reflect on the bigger picture and reflect on step no 7 and reflect on step no 9.

4.3 AWARENESS & UNDERSTANDING OF PRODUCTION FLOW

TOC implementation commenced during March 2013 and several bottlenecks have been identified that negatively impact’s on the production flow. The main bottlenecks found were linked to the Rowland decline shaft extension - the constraints of moving employees through the system to their workplaces and back, the unavailability of critical stock items close to the workplace and lastly the lack of a labour buffer mitigating the risk of lost blasts due to non-availability of employees and inefficient recruitment lead time. The identified bottlenecks have been or are in the process of being addressed. According to Mabin and Balderstone, (2003) it is now a systemic problem-structuring and problem-solving methodology which can be used to develop solutions with both intuitive power and analytical

Figure 4.9: Revenue Potential Template. Source: (Researcher, 2014)

The initial calculation of the TOC analysis is to answer the question of true potential and true capability, the maximum revenue potential as indicated in the Figure 4.8, The intent is to highlight and create the conversation of changing the way we do business looking at the rear
mirror view rather than the talk around protecting and guarantee revenue; this is the most important step for TOC.

- Initial TOC unit business analysis
- Initial view of constraints and bottlenecks
- Initial management view of opportunities for improvements

One of the main challenges of any change remains the people and their entrenched work practices and processes. The operational room has been implemented to challenge existing work practices and management focus areas and significant progress has been made through this daily intervention of focussing shaft management from a reactive to a proactive mode. Since the implementation of underground stores and a revised bonus scheme, Rowland shaft has experienced several instances where the average weekly production exceeded 7500t/d, with the original performance averaging below 6000t/d.

Several of the major systemic obstacles towards the desired improvement have been identified and these will be addressed on the shaft level as well as corporate level during the
next 4 months. These include the standard templates used for planning and control of materials and crew sizes, recruitment processes, performance measurements, etc.

1. The tonnages performances for the past 6 years
2. The Figure 4.10 indicates the downward tonnages performances as a results focusing in the following:
   - The world of efficiencies;
   - The world of less for more;
   - The world why approach.
4.4 TOC FLOW MODEL (CONSTRAINTS, BUFFERS & METHOD)

The TOC methodology now encompasses a wide range of concepts, principles, solutions, tools and approaches, the description of which is beyond the scope of this paper. TOC is perhaps not normally considered by systems modellers to be part of the systems literature, but it is a systems methodology in that it strives to ensure that any changes undertaken as part of an ongoing process of improvement that will benefit the system as a whole, rather than just part of the system. At its most basic level, TOC provides managers with a set of tools that guide the user to find answers to the basic questions relating to change.

Namely:

- What to change?
- What to change to?
- How to cause the change?
Develop a TOC Production Flow Model for the mine and link this to the overall flow of the company as a whole.

It includes the following:

- High level Effectiveness model
- Primary measurements for improved output and logistics
- Determine and prioritise the improvement actions
- The minimum primary measurements for improved output and logistics
Buffer management therefore represents a crucial attribute of the Theory of Constraints. There are many ways to apply buffers, but the most often used is a visual system of designating the buffer in three colours: green (okay), yellow (caution) and red (action required). Creating this kind of visibility enables the system as a whole to align and thus subordinate to the need of the constraint in a holistic manner. This can also be done daily in a central operations room that is accessible to everybody.

- The total flow of a mine’s output is determined by a few critical factors. These are the key focal points or constraints of the system.
- The performance of the system’s constraints is determined not only by their own capability, but is significantly impacted by the performance of all the other links in the chain, within a system of variation and interdependence.
- Maximised flow, reduced costs and increased profits are achieved by application of the principles of optimised flow, buffer management and protective capacity.
- Through the TOC Production Flow methodology, the performance of the chain is firstly lifted substantially and then it is stabilised at the new, higher levels of total chain performance.
- Once the overall flow performance is increased and is stable, the unit costs are derivatives of the truly variable cost plus the total operating expenses of the system as a whole. Optimised costs are a consequence of stable and predictable operational excellence.
- The four primary principles for successful TOC based TOC Production Flow application are the following:
  - Set the Primary objective to maximise FLOW of the system as a whole and NOT to reduce input cost
  - Determine a mechanism to prevent local variation to be passed on to the system as a whole through buffer management
  - Develop mechanisms to guide each link on when to work and when to stop
  - Substitute local efficiency measures in favour of flow measurements

According to Dager (2014) TOC drives inventory levels down to help make the enterprise leaner and not tie up so much of its capital in unneeded inventory. Gupta and Snyder (2009) states that a buffer management system is the process in which all expediting in a shop is driven by what is scheduled to be in the buffers (constraint, shipping, and assembly buffers).
4.5 TEAM ALIGNMENT

It is to give authorisation to employees within their divisions or teams to make minor decisions. As in a team employees have their leaders who help them to make team decisions. Here the best way to manage people in a workplace environment is to allocate a leader in a division and that leader has to be empowered to make decisions. Therefore you can easily manage the people but the leader has to be an employee involved, a committed employee who is emotionally attached to the organisation, it’s not easy to find such people. Nagarkatte and Oley (2010) states that TOC provides a logical and proven way to develop conflict resolution, decision making, problem solving and effective management in personal as well as institutional projects.

4.6 CONDUCTING MEETING AND THE WAR ROOM CONCEPT

The Strategic intent of the TOC Mining Production Flow application is to reframe the normal business management towards a holistic approach of improving the output of the system as a whole. The Theory of Constraints (TOC) is a comprehensive management approach with the fundamental understanding that most companies consist of complex, interdependent systems. Within the complexity of multiple resources, systems, products, markets and suppliers, a diversified focus becomes inevitable.

![Gulliver's Travels](Figure 4.14:Gulliver's Travels. Source: (Swift et al., 1983)
Establish the Daily Operations Room functionality, based on the principles of open dialogue and the TOC Flow Effectiveness models, to measure, report and act according to the agreed critical constraint and buffer measurements. The process involves coaching and guiding on the TOC model as well as open dialogue for good communication and teamwork. Specific coaching is required to move from the typical daily reporting to the desired functional War Room behaviour (with reference to the Figure 4.4.). This forms the core driver of the change process.

A suitable location for the War Room (Figure 4.4) is required where all the relevant people can meet for 30-40 min per day. Initially, this will be done manually (sheets against the wall) but over time the measures and reports could be built into the information systems and reported electronically after the actual meetings have taken place. Daily data will be captured and forwarded to the TOC Specialist facilitators for review and comment on a weekly basis. The electronic reporting can later be scaled up to be available to the senior executives as high level visibility of the overall Lonmin Operations “Dashboard”. During this process, it will be required to do specific experiential learning exercises to establish the mental framework for a properly run War Room as well as to develop the appropriate name and behaviours for it.

According to Barnard (2010), one of the major challenges in organisations is defining and communicating the necessary and sufficient changes on TOC that required sequences of these changes and related contributions to all functions within the organisation and all levels within these functions. Managers and employees that do not know their contribution to the goal of the organisation, question the contribution of others in the organisation, feel disempowered due to gaps between authority and responsibility, face conflicts between local vs global or short vs. long term optima, of failure can result in disharmony that will jeopardise the achievement of the organisational goal.
4.7 THE INITIAL TOC TRAINING

4.7.1 Team Behaviour
In the team building process people or rather employees need to build trust amongst them first. A manager can give them tasks which will help them trust one another first. Those tasks may involve testing their reliability to one another. In that case a successful team may be built. In a team there are also individuals which may be a bit problematic therefore having a team leader would be useful, just for ensuring the effectiveness of individual team members within the team. Emergence of a leader can be the main factor eliminating variations or problems in teams, and be used as a TOC technique.

![Team Behaviour Diagram](image)

- The Score Board reflects the outcomes of the system (Results).
- But it does NOT give any indication of the desired behaviour that is required to produce the system’s outcomes (Means).
- Switch from Management by Results to Management by Means.

![Behaviour Chart](image)
This training provides for the following learning outcomes:

- Know how to improve effectiveness without incurring additional costs.
- Learn how local efficiency can worsen system effectiveness.
- Adapt Lean to deal with risk and unanticipated events.
- Focus management efforts and allocate resources for the best effect.
- Simplify problem solving and get a win – win solution rather than a compromise.
- Meet your commitment: deliverables on time and within cost.
- Improve inventory turnover and shorten lead times.

4.7.2 Subordination
4.7.2.1 Workshop methodology  (Buffering and protective capacity system alignment in all functions)
Theory of Constraints builds on the insight that a Constraint, usually a single Constraint, limits the effectiveness of any system in achieving more of its unlimited goal. The methodology consists of a five step cycle, with each step focused on the Constraint:

- Identify the Constraint which currently limits system performance (i.e. the ‘Bottleneck’).
- Exploit the Constraint (i.e. Wasted or lost time at the constraint cannot be recovered.).
- Subordinate non-constraints to the Constraint (i.e. ‘Use spare capacity at non-constraints to help the constraint reach 100% of its capacity’).
- Elevate the Constraint (i.e. ‘innovate to get greater than 100% of the capacity constraint’).
- Identify the new Constraint (i.e. ‘Continue the improvement’)

4.7.2.2 Example of TOC Dashboards
To apply TOC effectively and practically Figure 4.18 is an example of the typical charts that are used for monitoring and control
4.7.2.3 Example of TOC Dashboards
To apply TOC effectively and practically, Figure 4.18 is an example of the typical charts that are used for monitoring and control.
4.7.2.4 Example of TOC Dashboards
To apply TOC effectively and practically, Figure 4.18 is an example of the typical charts that are used for monitoring and control to further analysis the constraints and identify opportunities.

![TOC Model](image)

**Figure 4.20: TOC Dashboards used.** Source: (Researcher, 2014)

4.8 KEY MEASUREMENTS & VISIBLE MANAGEMENT

In order to determine proper, global and simple MEASURES of performance, the goal for Rowland Shaft is “Make more money now and in the future” and the measurements of such a goal are given by throughput accounting as: throughput, inventory, and operating expenses. According to Abdi et al. (2014), TOC is used to identify the bottlenecks in the production line and Thinking Process (TP), as one of the TOC tools, is used to identify the constraints of management and policy as opposed to the physical limitations in the existing system. Goldratt (1984) believed that thinking process enables managers to tackle policy constraints by finding the answers to the basic questions relating to change, Taylor 111 and Sheffield (2003) mentions that Goldratt (1997) developed his Thinking Process to pinpoint the constraint, or weakest link, that holds back a system’s overall production rate. The three change steps discussed below are the tools that manage to identify the weakest link or the constraints and come to the effective and efficient interventions to implement.
4.9 LEADERSHIP APPROACH TO TOC

According to Barnard (2010) TOC acknowledges that people only resist change when a change is considered a “lose” for them or other stakeholders and also that a win - lose between stakeholders in an organisation, will always deteriorate to a “lose – lose” situation. Ensuring that changes will be a win stakeholder is the key to turning resistance to change, into active contribution and commitment to successfully implement the right changes. Managers needs to start applying the mind-sets and methods of the hard sciences to the “soft” science of managing and improving organisations which is suggested by Barnard(2010).

- The system’s performance is determined by the people in the system and the way they behave. This is dependent on aligned leadership and the mental models that drive behaviour
- The people within the system encompass a collective genius that can be harnessed through the application of the principles of dialogue, problem solving, facilitation, mutual caring, significance and purpose
• Operational excellence is the result of many factors, but the primary attention should be on the passion and the way people interact and align through team learning, shared vision, personal mastery and sharing of mental models
• A mining company is a highly complex adaptive system with many agents, layers of organisation and a very high degree of interdependence
• Daily focus through a well-structured people process is essential for success

4.9.1 Changing the Mind-set of the Operations

One of the best things that you can do is to invest in your employees’ capabilities by providing an education and training program through which they can enhance their skills and develop their competences in relation to their tasks within the company. Regular training has a direct impact on their performance since these tend to improve the way they perform their tasks, leading to increased efficiency that more than makes up for the expense of the training. At the same time, investing in employee talents does not just lead to proper quality control and management; you are also conveying your belief and trust in their capabilities. By actually investing time and money into their learning, it shows your employees that they are worth it to you.

4.9.2 Thinking People before Production

Investing in your employees is one great way to foster a positive work environment, one in which they feel a sense of empowerment and confidence to do their tasks. With the combination of confidence and actual technical know-how, your employees’ efficiency will certainly increase in the long run. Another way to foster a positive work environment toward effective quality control and management is by recognising achievements through incentives. These can come in many forms, such as an award, a gift, a verbal praise, and so on. Such incentives encourage not just the one being praised, but also all other employees, to do well in their respective tasks. By giving your employees something to work for, other than their pay check, you are inspiring them to go the extra mile for the good of the entire company.

4.9.3 Effective Communication and Effective Employee Engagement

Communication is a better tool that can be used to bring you closer to your employees. By gaining the trust of your employees and increasing their willingness to work and exert their
best efforts can be achieved by giving them more room to express their ideas and opinions. A democratic leader is one who uses a “bottom-up” approach in coming up with major decisions. By including them in the dialogue, you can make decisions that can have a positive influence on quality control and overall quality management. They are the people who are doing the actual work every day. Their suggestions on how to make things work better should be encouraged and valued. According to the TOC institute (2015), its application is designed to solve business problems in a particular practical and effective manner. Furthermore, according to Mabin (1990), many managers who routinely use TOC believe they understand their businesses for the first time as they gain a sense of control and act proactively within their organisations.

4.10 THE PRODUCTION LOST BLAST ANALYSIS CRITICAL CONTRIBUTING FACTORS

4.10.1 Cash Conservation

The way that the cash conservation strategy is being implemented means that very often managers who have the authority to approve certain expenditure do not do so but rather escalate the decision upwards in the organisation. The result is a much longer and arduous process of getting decisions made regarding the putting of the necessary protective capacity or buffers in place to support the desired increase in the primary flow, namely tons produced. Examples are the length of time that it took to get the underground half level material stores in place, the buffer of skills, and the spare winch per half level at Rowland Shaft.

4.10.2 Standard Crew Size Template

The policy of having a standard crew size for stopping and development crews ignores many of the factors that influence whether the crew can achieve a good blast every day. It fails to take into account the amount of time the crew spend travelling to the work place, the quality and pressure of the compressed air available at the face, the quality and reliability of the rock drills, the specific geological conditions, what the crew is expected/has to do besides drill, blast, support and clean (e.g. equipping, slipping, lodging, etc.), to name just a few. The standard crew size is built into the budgets and into the SAP system. Once it is in the SAP system, it is once again a long and arduous process to change it. “The Computer Says NO!”
4.10.3 Standard Bill of Material

The Standard BOM for stopping and development crews also fails to take into account the specific conditions under which each crew is operating, for example, geological conditions, the quality of the materials supplied, etc. The Standard BOM can be over ridden but this again requires many signatures and is time consuming. The result is that some crews do not have the materials that they require, when they require them and therefore beg, borrow or steal from other crews as well as hoarding materials.

4.10.4 Inflexible Budgets

If there is a need to acquire something/spend some money for something that is not in the budget, then it is once again a long and arduous process to get the expenditure approved. This includes the appointment of additional people.

4.10.5 Recruitment Process

The recruitment process is very long 80+ days. However, it is difficult for them to start the process without there being a vacancy according to the SAP system and without approval to fill the vacancy. Once again the process of getting the vacancy into the SAP system and the approval to fill it can be long and arduous and only once this has been completed can recruitment officially start the process to fill the position.

4.10.6 Balanced Score Card

Although efficiencies no longer form part of the balanced score card, we have come across situations where managers delay or refuse to make a decision which will in the long term be of benefit to them and the company but which will negatively impact on their balanced score card in the short term. This becomes more of an issue the closer we are to the year end. Furthermore some managers complain that they have no idea, until the end of the year, of how they are performing with regard to the balanced score card. This substantially reduces the effectiveness of the balanced score card as a tool to drive the desired behaviour.
4.10.7 Standard Manning/Staffing Template

The current standard template does not cater for the refresher training when the mining personnel return from their annual leave. If every person doing the refresher training passes then the average days spent in training is 9 days. There is a further one day spent in admin and one day for medical bringing the total days that the person is not available to production, to at least 11 days.

4.10.8 Bonus System

There are two things about the bonus schemes that are problematic:

- The fact that the bonuses are capped means that high performers are not motivated to perform above the maximum.
- The penalties that may be deducted put a very negative connotation to the bonus schemes. The same objective as targeted by the penalties can be achieved by having a separate bonus for that element (safety, quality, production and attendance). If all the targets are met then the total of all the bonuses can be made to equal what would have been paid under the current bonus system. This will result in a bonus system that does not have any negative connotations to it.

4.10.9 Meetings

There is a general tendency throughout the organisation to arrange and to cancel meetings at very short notice. Besides being disrespectful towards the people who have to attend the meetings, it is extremely disruptive to proper planning of people’s work days and results in important discussions and decisions being delayed.

4.11 THE PRODUCTION TONNAGES ANALYSIS
Figure 4.20: TOC Tonnage Performance. Source: (Researcher, 2014).

The above Figure 4.20. shows critical findings resulting in the downwards trend of the organisation.
CHAPTER 5

FINDINGS, DISCUSSIONS, AND CONCLUSIONS

5.1 INTRODUCTION

Rowland shaft implemented the Theory of Constraints to resolve the identified constraints in the operation. The major bottlenecks were identified but not executed before the TOC process commenced. To date a number of projects have been identified and the operation is starting to see the benefits in the consistency and improvement in tonnage output.

The TOC helped with the initial enabling of the infrastructure and systems and furthermore, the process assisted in facilitating a paradigm shift in the current established practices of dealing with people and teams which is a continuous process of engagement through the Care & Growth model & Leadership Growth model. This continuous process of engagement together with the current management focus has resulted in improved performance seen at Rowland.

The objective of Theory of Constraints was to identify the specific constraints per shaft and debottleneck the shaft in order to increase the process flow. The process targeted constraints relating to, movement of people, ore handling, material, and optimisation of the half levels.

This Chapter explains, the before and the after and follow the procedural steps.

5.4.1 TOC Solutions Approach for LONMIN

- Awareness & Understanding of Production Flow;
- TOC Flow Model (Constraints, Buffers & Method);
- Key Measurements & Visible Management;
- Daily War Room Practice & Habits;
- “Mine Overseer” (MO) Section Flow Picture;
- Material Availability: Stores & Replenish on consumption;
- Skills Availability: Labour Buffers;
- Engineering Availability: Equipment Buffers;
- Leadership approach on TOC.
5.2 AWARENESS & UNDERSTANDING OF PRODUCTION FLOW

The Rowland shaft leadership team and all the management went through two (2) days’ workshop in introduction of the concept of TOC; prior to the introduction of TOC the Rowland team did not follow TOC design principles.

TOC is a Management Philosophy that has focus on Flow of the system as a whole, a significant Mental Shift towards a new way of doing business, replace Local Optimisation (silo) with Optimised Flow (system), shifting from “CONTROL” to “ENABLEMENT”; It is a New Way of Thinking, not a Plug and Play application, deep understanding & commitment is required.

If one tries to plug TOC into the existing system as an add-on, it will bring short term results (demonstrated); but will ultimately fail. It therefore calls to ensure that current culture; behaviours and measures will support the approach and not block it although many of the regular measures and behaviours will have to be changed. Such an attempt requires a new STRATEGIC THINKING.

What TOC was introducing is a different approach completely from the way the Rowland team did always; TOC introduced the new questions and perspectives and approach in order to achieve the sense of urgency and identify opportunities rather than the rear view mentality and post-mortem of why. As a result the important question to ask is what help the team needs to achieve change.

TOC is a very different management philosophy as it brings new insights that are controversial by intent. It has been seen experienced and highly successful TOC as a “Different world” of thinking, new framework which requires reframing of the Old Mental Models. Big CHALLENGE for Lonmin required good insight into what needs to change; facilitating such a change is a challenging endeavour.
The Rowland team were leaving in the world of BLACK BOX mentality:

- The world of yesterday and world of what to think not how to think;
- The world of I and not the world of WE;
- The world Demand and Control not the world on enablement;
- The world of in GOD we trust in people we don’t rather than the world parent to parent conversation;
- The World that says GO and DO rather than the world that says Lets GO.

To prove the preceding assertions, an assessment was conducted to confirm the Rowland team then current approach, a questionnaire designed and feedback confirmed that Rowland team was deeply entrenched and there was a need to change by approach the future using the mentioned TOC principles. According to Barnard (2010), one of the major challenges in organisations is defining and communicating the necessary and sufficient changes on TOC that required sequences of these changes and related contributions to all functions within the organisation and all levels within these functions.
Table 5.1: The Testing Awareness Questionnaires.

Source: (Researcher, 2014)

<table>
<thead>
<tr>
<th>Testing Understanding</th>
<th>Answers</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Involvement and Empowerment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Are you highly involved in your work? Describe it in your own words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you think people are positive about working here? What are your comments?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. What do you think needs to change</td>
<td></td>
<td></td>
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<tr>
<td><strong>B. Leadership Engagement</strong></td>
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<td></td>
</tr>
<tr>
<td>1. Do you think leadership is supportive? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you think they act and behave according to the values? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. How is your relationship? What do you think needs to change</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. Mine Overseer (Team Effectiveness)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Do you think Mine Overseer are supportive? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you think they promote teamwork? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Are they encouraging positively or are they reactive? What do you think needs to change</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. Shift Supervisor (Team Effectiveness and Relationships)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Do you think Shift Supervisor are supportive? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you think they promote teamwork? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Are they encouraging positively or are they reactive? What do you think needs to change</td>
<td></td>
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</tr>
<tr>
<td><strong>D. Miners (Quality in Decision Making)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Do you think Miners are supportive? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you think they promote teamwork? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Do you get involved in decision making? What do you think needs to change</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. Team Leader (Team Effectiveness and Relationships)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Do you think you are empowered enough to make decisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you think they promote teamwork? Why do you say so?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Are they encouraging positively or are they reactive? What do you think needs to change</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Are you happy if not why</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. What do you think needs to change</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.2.1. Results of the Mine Manager defining what needs to change:

Graph 5.1: The Results of the Mine Manager. Source: (Researcher, 2014)
5.2.2. Results of the Mine Overseer defining what needs to change

Graph 5.2: The Results of the Mine Manager. Source: (Researcher, 2014)

5.2.3. Results of the Shift Supervisor

Graph 5.3: The Results of the Mine Manager. Source: (Researcher, 2014)

The results in Graph 5.3 conducted from a sample just to determine the extent of the problem, the concerns highlighted in yellow concerns we need to focus on.
5.3 TOC FLOW MODEL (CONSTRAINTS, BUFFERS & METHOD)

The next step undertaken with the Rowland team was to define the existing current mental and technical view of how to approach the production flow principles and to assess whether the buffer management system is in place and to determine what to change and to what to change to.

The first step was to analysis the Rowland key core business which is to produce raw rough platinum in tonnages quantity of 7,000 tons per day amounting to 168,000 tonnages a month. The total employees of 4,000 including contractors a business unit which more than 10 years old, the first step to define the then current production approach to analysis the following designed principles guided by TOC:

- The revenue potential and achievement measured in Tonnages;
- To determine the percentage of loss over the past 6 years to define the extent of the problem;
- To analysis whether the buffer management system thus exit.

5.3.1 The Revenue Potential and Achievement Measured in Tonnages

![Figure 5.2: TOC Tonnage Performance. Source: (Researcher, 2014)](image)
The Figure 5.2 above is indicating that for the past 6 years there has been a steady downward trend of revenue losses in tonnages for the target of 200,000 tons per month a 30% to 40% year by year.

The reasons for the revenue losses have been the existing management and strategic philosophy

The following reasons underneath explains:

The following where critical findings rooted in the practices at Rowland:

- Managing efficiency rather production flow principle;
- Managing in Silos rather the flow of the system as a whole;
- Manage by budget rather than manage by constraints;
- Manage individual KPI rather than Buffer management;
- Management by numbers rather than management by means;
- Behaviour management not as a leader but as a boss.

5.3.2 Determining the percentage of loss over the past 6 years and the extent of the problem

The then current revenue potential is calculated in simple calculation that says 1 Blast is equal to an amount of R250,000.00 turnover and total cost are estimated at R100,000.00 and those are made of the 3M`s (Men, Machine and Material).
A blast is measured by 100 tonnages generated defined by the following picture in Figure 5.4:

Figure 5.4: Blasting Procedure. Source: (Researcher, 2014)

So, if you lose the blast per day it’s a loss amounting to R150,000.00.

So Rowland plans to Blast an average of 70 Blast per day amounting to 21 million a day and had 30% to 40% revenue loss a day which means money lost and, the difficulty with mining production system is that when a blast is lost, its loss is forever and cannot be reversed and is calculated per time because the afternoon shift needs to clean the tonnages blasted and the night shift transport the tons. The blast is highly regulated by law because of its risk to injure the employees; so the rule is that when we blast every person should be out of the mine to the
surface and the centralised blasting system may be executed as shown in Figure 5.5 below explaining the mining system.

5.3.3 Analysis whether buffer management system is implemented

To analyse the buffer management system the criteria guided by TOC production flow principle is deployed; the criteria seeks to determine that enough buffer management is in provision. The provision is guided by rules of availability of man, machine and material, the protection and guarantee that all the constraints identified do not limit the system to perform and that performance can be assured against all odds.

To achieve the buffer management system as described above, TOC becomes specific in its advice when it suggests that the following must be put in place:

- Buffer of additional labour to assist with absenteeism;
- Buffer of a material stores system to be constructed and with at least 2 week material available to assist with logistics, transport and planning, as they can fail from time to time because of the infrastructure design in mining; for instance material may be on the surface and needs to be delivered 400m down the mine and 3km where work
needs to be conducted and if the mine needs to deliver daily to many of the levels underground, and Rowland shaft has 21 levels to deliver to daily;

- Buffer for Engineering spare per each and every levels.

The then current Rowland production flow did not have all the buffer management system as described in point 5.2. .

The schematic underground design enables further analysis to be conducted and it can provide a clear visible underground picture of what the mining shaft look like. In the Rowland’s case the picture points 1, 2, 3 and 4 in the below explain the typical mine design

Figure 5.6: TOC Mining Analysis Schematic. Source: (Researcher, 2014)
In the case for Rowland the TOC assessment and analysis conducted clearly indicated that there is no buffer management system in place.

Gupta and Snyder (2009) further emphasis that from an ongoing improvement process perspective, TOC suggests an organisation must ask three fundamental questions concerning changes to accelerate its improvement process. As according to Scoggin et al. (2003), responding to these three questions, provide managers with guidance as they seek effectively to implement the change sequence.
5.4 KEY MEASUREMENTS & VISIBLE MANAGEMENT

In the world of TOC measurement system, it is a must that the objective of the measurement system should be to make visible to management all that is invisible from all levels; to enable identified bottlenecks and constraints visible extensively in order to apply the law of focus which elaborates the identification constraints needs visible at any given time. The daily measurement system is deployed to enable immediate performance of the system to be well managed; it continues to promote the other law, the law of variability to identified variability and inconsistency of the production system, key measurement system is part of the TOC production flow design principle to ensure that there is no limit to performing the system.

In the case of Rowland team, it was then identified that none of the above mentioned key measurement and visible management arguments in point 5.3 were found in place; the then system focused on the rear mirror view mentality the following concerns were identified.

The following existing mentality were identified and highly deeply entrenched as it has been a practice for the last 6 years referring to the tonnage Figure 5.2.

5.4.1 Managing a Number of Past Details

- Old, deeply rooted management models wants to manage yesterday’s details, mainly because it is certain;
- The believe that the numbers and costs are the true language of business;
- Systems are geared for detail, believe everything is important and want to optimise everything;
- The Rowland team gets so tangled in the detail that we lose the bigger picture.

5.4.1.1 The Rowland team personal ego & hierarchy

- The personal ego wants to be in control and instruct, and believing that it knows the answers;
- Ego is the root cause of “rule by fear” and regulation; it makes the individual in power even more powerful;
- The multiple levels of hierarchy support ego behaviour, “the king is in charge of his/her troops”;
- The more levels, the more abstractions, the more measures and required behaviours to abide by them, the more time it takes up.
5.4.1.2 Daily war room practice & habits

TOC introduced the concept of the “war room” which is to provide management with the environment and a daily space to can engage for open conversation on the limiting factors on production concerns and buffer management system performance on the identified constraints. This approach allows the management to engage and discuss openly on critical issues as arise. It followed that a particular guide on a setup which are the following points of need to be followed:

- Where the Generals meet to decide on the tactics of the next 24 hours – A community where improvement is generated;
- Understanding the big picture of the Current Reality - A place where one comes to listen and share;
- A ‘how do I help you’ opportunity – A focus on solutions (share) and outcomes (not bitching and moaning);
- Where real, correct and accurate decisions are made;
- When we leave, everybody present must know what we have to do to help the System to perform better (Bottlenecks & Optimised Flow).

5.4.1.3 Ground rules of the Operations room

- Start on time every day at an agreed time (30 - 40 minutes time limit);
- Information accurate, relevant and visible (filled in before we start);
- Create clear visibility to align more people with the overall picture;
- Focus on problem / issue – not the person;
- No surprises – (become more pro-active);
- Everybody comes prepared, with an open mind to resolve problems;
- Win-win solutions: We stand together against the issues, not one another;
- Red buffer situations are early indicators for continuous improvement;
- Facilitator that hold the context: Process and Content, Reflect at the end;

In the case of the Rowland team it was identified that none of the above exit in anyway, an analysis of all existing meetings was conducted to check if there is any trace of Operations room guiding principles and rules, what was identified was that the following setup exit.

- The War Zone itself – the war is reality out there;
• A regular production feedback session;
• Where people try to look good for themselves or their own departments;
• Where we deal with every type of issue or red herrings;
• Where we hide things;
• A finger pointing encounter or a fire fighting activity (although it might happen);
• A place where we play the man instead of the ball – not an interrogation process;
• Where we try to cover everything, we focus!

Figure 5.9: TOC Mining Analysis Schematic Workshop. Source: (Researcher, 2014).

5.5 MINE OVERSEER (MO) SECTION FLOW PICTURE

The TOC flow model as explained in the 5.3 does not end in the analysis of the shaft only, it continues to further analysis the existing business unit called the MO section and which is an extension of the business unit that contributes in the share of production. MO which is a production section, in the case of Rowland, the shaft consists of 5 mine overseer sections ranging based on the size of the volume of platinum and its grade.

The TOC concept seeks to analyse further the design throughput and identifies specific mine overseer section bottlenecks because different section pose unique challenge and opportunities; and it is of high importance to invest in the further analysis in a way to deliver confidence that all system variable are known, therefore when in provision of TOC answer
that all section are been covered, the Figure 5.9 following is a dashboard used to summarise each section.

The Figure 5.9 is the raw version used during the workshop for the analysis.

Figure 5.9: TOC Mining Analysis Schematic. Source: (Researcher, 2014)

The following picture is the typed final version:

Figure 5.10: TOC Mining Analysis Schematic. Source: (Researcher, 2014)
In the case of Rowland the Figure 5.10 is an illustration of what was then deployed to ensure that the TOC analysis can be conducted given that the Rowland team’s approach did not have any form of analysis existing, except the KPIs sheet on production measures. It is of high importance, in the case of TOC, to follow the dashboard steps 1,2,3,4 and 5 as identified on the dashboard.

The steps are as follows:

1. Identify the bottleneck unique to that section;
2. Identify the performance in tonnages to know if it is been performing or not;
3. Identify the potential of revenue and blast planned;
4. Identify the project to be executed for buffer management system;
5. Compile the action plan.

5.6 MATERIAL AVAILABILITY: STORES & REPLENISH ON CONSUMPTION

The TOC concept in its application form suggests the operational supply chain mechanisms the “TOC way” which advises that the concepts of material availability MUST all the time avoid any error or loss that may occur to subsequently generate a bottleneck hindering the performance. The TOC way also opposes the material availability management that ensures the system is in provision of all the material. The following set of criteria design is suggested by TOC for performance:

- It is required LESS stock than current system;
- Underground Stores = 1.5 weeks’ stock;
- Shaft stores = 2 weeks’ stock;
- Central stores stock dependent on Replenishment Times from suppliers (< 2 weeks).

In the case of Rowland, the shaft did not have any stores in place; hence none of the above mentioned criterion was found in place. The existing system was highly depended on the shaft logistic and very effective planning system and sometime hidden stores for those that can break some of the rules.

The following explains the then Rowland system:

- The planning is monthly activity and highly dependent on the production schedule;
The material is scheduled daily per section to prevent any misfortune of a hazard blast.

There is an existing penalty imposed for poor planning to constrain employees who would not update information on material shortage.

The cost containment efforts allow planning low so it benefits the request of saving 10% monthly.

5.7 SKILLS AVAILABILITY: LABOUR BUFFERS

TOC principles around labour buffer suggest enabling the system by having more employees so to avoid any production loss due to absenteeism. It further suggests that when facing challenges with labour issues, continuous production is not hindered because of the number of employees enough to cover up. The concept challenges the mental model around standard labour number of the crew; it poses a challenge on the existing mechanism of measurement of the efficiency of the crew; it also suggests that in the business of making money or showing of efficiencies, the crew needs to perform accordingly.
It is often as a challenge by some human resources practices to suggest TOC’s approach seen as throwing money to solving the problem; but the counter argument is that Theory of Constraints understands the changing world requirements on safety at all times rather than hope that all is well.

In the case of the Rowland team, there was no buffer for labour at all cost that the production losses indicated 10% was due to labour's absence.

For the period October 2012 to April 2013, Rowland Shaft lost more than 40,000 tons per month as a result of lost blasts. Of this amount, more than \( \frac{1}{3} \) (an average of 13,400 tons per month)

![Graph 5.4: TOC Mining lost Blast. Source: (Researcher, 2014)](image)

The following sections shows the results achieved after applying TOC effectively at Rowland Shaft.

**5.8 TOC SOLUTIONS APPROACH FOR LONMIN**

- Awareness & Understanding of Production Flow;
- TOC Flow Model (Constraints, Buffers & Method);
- Key Measurements & Visible Management;
- Daily War Room Practice & Habits;
- MO Section Flow Picture;
- Material Availability: Stores & Replenish on consumption;
- Skills Availability: Labour Buffers;
• Engineering Availability: Equipment Buffers;
• Reflection Meetings: Continuous Improvement;
• Leadership approach on TOC.

5.9 AWARENESS & UNDERSTANDING OF PRODUCTION FLOW

The TOC application related to the concepts evoked in points 5.8 yielded some exciting results for the Rowland team; the change came through investing in new values system and behaviours around moving away from the old traditional system in terms of the following:

• To achieve the incredible results came through tough change in leadership, a new senior manager was employed to lead the new change;
• One on One workshop were conducted every month to ensure that new behaviours are enabled;
• The shift bosses which is the level below management to ensure proper alignment and accountability;
• Books and Videos on TOC were provided to continue to invest in the competency required for TOC.

The first month of the change was shown through tonnage performance:

![Graph 5.5: TOC mining performance improvement. Source: (Researcher, 2014).](image)

The change moved the tonnages form average 5000 tons to 6300 tons which is a 20% increase.
The change was highly welcomed by the management and the board for showing promise and delivered confidence.

In the Graph 5.1 it was explained that a leadership assessment was conducted and a second leadership assessment conducted after 90 days with implementation of actions by TOC solutions approach as described in point 5.8.

The results of the mine manager were as follows:

Graph 5.6: The Results of the Mine Manager. Source (Researcher, 2014)

Graph 5.7: The improved results before and the after. Source: (Researcher, 2014)
Graph 5.8: The Results of the Mine Overseer. Source: (Researcher, 2014)

Graph 5.9: The improved results before and the after. Source: (Researcher, 2014)

Graph 5.10: The results of the shift supervisor. Source: (Researcher, 2014)
5.10 **THE TOC CHANGED THE LEADERSHIP APPROACH FROM LOCAL THINKING TO GLOBAL THINKING**

The analogy in Figure 5.12 explains the that Rowland shaft team was designed in the world of few on TOP thinking rather an engaged organisation, the organisation shown in Figure 5.12-1 defines an organisation which is guided by the operational mentality approach which promotes telling, in structural and boss mentality.

The organisational approach in Figure 5.12-2 defines the journey that Rowland team invested in the world of engagement, the world where everyone is involved the world where care and growth is the strength and the approach, the world where leadership drives and serve the employees, the world where leaders wins the heart and minds of the people so to win the effective behaviours around the organisation, the team which invest in a progressive TOC program with a living book.
Scoggin et al. (2003) states that organisations can be viewed as dynamic systems undergoing periodic transformations as they seek to survive and prosper by adapting to their changing environments, managers need to be continually monitoring their performance and seeking to develop and implement positive change.

5.11 TOC FLOW MODEL (CONSTRAINTS, BUFFERS & METHOD)

The TOC flow model is a step to identify opportunities and create a sense of focus on achieving results. the Rowland team welcomed this phase by identifying what is critical for them to execute, create a sense of responsivity around the identified bottlenecks, acknowledge the before picture explained in the Figure xxx then identified and priorities a list of projects to answer the constraints, buffers and bottlenecks.

The Rowland Shaft engaged in the projects that were implemented, run and concluded within 90 days; and once the projects were complete the graph in Figure 5.14 – 2 (Right) represent the 90 days and the key projects execution, the graph clearly shows that there we began to notice an upward trends.
The Rowland team realised that the focus and the scale of expertise that is highly needed in the TOC progressive plans, and the maximisation on the scale of performance by applying global focus rather than local focus, and being able to achieve the synergies that can be through employees and partnerships of high performing teams.

TOC was made known to the leadership at the Rowland shaft with a focus on production flow principles and the way to achieve its application through working on organisational culture and value systems, as well as keeping in mind that applying TOC is not a once project but
rather an exercise of enabling an environment growth and the related features to create a winning formula for TOC implementation.

Figure 5.16: TOC Improved performance. Source: (Researcher, 2014)

The graph in Figure 5.16 shows the journey in the application of TOC realising whether the concept was applied effectively for experimenting the progress of achieving outstanding results, a first record of tons mined reaching 8000 tons after 120 days, a record never more achieved the past a 5 years. TOC application was the only answer as to how such a record could have been possible again at Rowland shaft.

The following is the continuous plan of the shaft year by year.

Graph 5.12: TOC Improved performance. Source: (Researcher, 2014)
As earlier stated, the following were critical findings rooted in the practices at Rowland:

- Managing efficiency rather than production flow principle;
- Managing in Silos rather than the flow of the system as a whole;
- Manage by budget rather than manage by constraints;
- Manage individual KPI rather than Buffer management;
- Management by numbers rather than management by means;
- Management behaviours as like BOSS not a leader.

The Figure 5.17 following defines the extent of the critical concerns that needed immediate attention in order for TOC to begin to influence the Rowland team, the assessment as explained above was done in the early days of TOC introduction, it is part of most important pillars of success around TOC team effectiveness and authentic behaviours.

To achieve the very important change shown in Figure 5.17 TOC positioned some actions critical for growth. To ensure that critical constraints are identified, well-managed as well as portraying trend for the future, the following actions were taken:

- Once more continuous indirect and informal TOC coaching on how to decide, which is a daily exercise;
- Influencing the manner and paradigm towards production flow principle achieving that, by attending all if most of the meetings;
• Changing the way of thinking; influencing how we think by informally telling stories on “Did you know stories on TOC?” or for example attending a morning meeting and instead of asking “What happened?”, “What can we do?” and “Who needs help?”;

• The following verbal expressions made sounded wrong but needed to micro manage some important attributes to making TOC successful. These were expressions, made on passages, voices expressing statement such as that “Do not believe it” or Do not promote it” or “Did not understand…” because they did not experience TOC in its existence; therefor it was of duty to regularly coach all employees and align their behaviour to the right direction;

• To always allow a team to reflect and take step back to deploy a new approach to the new thinking in meetings and all the forums;

• To convince teams that it is okay to break the old traditional mentality and views if TOC concepts are well understood and adapted, keep looking for its meaning always remembering that it sells how to think not what to think and it is not prescriptive in its nature.

Figure 5.17: TOC Improved performance. Source : (Researcher 2014)
5.12 KEY MEASUREMENTS & VISIBLE MANAGEMENT

TOC promotes the efforts of visibility and transparency; it seeks to achieve sense of opportunity in 60 seconds called one minute critical thinking especially and that is why it promotes visibility in charts, posters and dashboards, and the Rowland team achieved improvements that in context.

The following actions were promoted by the Rowland team:

**The Organisation as a Community of Humans**

- Our organisations are more a community of humans than a combination of resources;
- Our organisations are complex adaptive systems that are actually very good at managing themselves;
- We just need to align with the bigger picture through the principles of Flow;
- We lost the ability to reflect on reality as well as the art of thinking together;
- We do not know how to harness the collective genius and therefore are much worse off.

The results in Figure 5.17 are explained in the concepts of the Operations ROOM explained in point 5.4.1.3.

**Costs**

- To the outcome of the results with TOC application Rowland spent R21,199,081.31 on the TOC project. Production improvements during the period have taken the shaft from 5500 Tons to 7500 Tons of production per day. The improvements achieved were due to TOC application and the continued management focus.
- A further R12,300,000.00 to be spent on new & current Projects identified to enhance the buffers on other shafts. By completing the first projects outstandingly it is expected that the average on production average can be taken and maintained up to 8500 tons daily.

5.13 MATERIAL AVAILABILITY SYSTEM

This approach uses several new rules to protect availability with fewer inventories than conventionally required. Before explaining these new rules, the term Replenishment Time (RT) must be defined. RT is the sum of the delays, after the first consumption following a delivery, before an order is placed plus the delay after the order is placed until the ordered goods arrive at the ordering location.
1. Inventory is held at an aggregation point(s) as close as possible to the source. This approach ensures smoothed demand at the aggregation point, requiring proportionally less inventory. The distribution centres holding the aggregated stock are able to ship goods downstream to the next link in the supply chain much more quickly than a make-to-order manufacturer can. Following this rule may result in a make-to-order manufacturer converting to make-to-stock. The inventory added at the aggregation point is significantly less than the inventory reduction downstream.

2. In all stocking locations, initial inventory buffers are set which effectively create an upper limit of the inventory at that location. The buffer size is equal to the maximum expected consumption within the average RT, plus additional stock to protect in case a delivery is late. In other words, there is no advantage in holding more inventories in a location than the amount that might be consumed before more could be ordered and received. Typically, the sum of the on hand value of such buffers is 25–75% less than currently observed average inventory levels.

3. Once buffers have been established, no replenishment orders are placed as long as the quantity inbounds (already ordered but not yet received) plus the quantity on hand is equal to or greater than the buffer size. Following this rule causes surplus inventory to be bled off as it is consumed.

4. For any reason, when on hand plus inbound inventory is less than the buffer, orders are placed as soon as practical to increase the inbound inventory so that the relationship On Hand + Inbound = Buffer is maintained.

5. To ensure buffers remain correctly sized even with changes in the rates of demand and replenishment, a simple recursive algorithm called Buffer Management is used. When the on hand inventory level is in the upper third of the buffer for a full RT, the buffer is reduced by one third (and do not forget rule 3). Alternatively, when the on hand inventory is in the bottom one third of the buffer for too long, the buffer is increased by one third (and do not forget rule 4). The definition of “too long” may be changed depending on required service levels, however, a general rule of thumb is 20% of the RT. Moving buffers up more readily than down is supported by the usually greater damage caused by shortages as compared to the damage caused by surpluses.

Once inventory is managed as described above, continuous efforts should be undertaken to reduce RT, late deliveries, supplier minimum order quantities (both per SKU and per order)
and customer order batching. Any improvements in these areas will automatically improve both availability and inventory turns, thanks to the adaptive nature of Buffer Management.

A stocking location that manages inventory according to the TOC should help a non-TOC customer (downstream link in a supply chain, whether internal or external) manage their inventory according to the TOC process. This type of help can take the form of a vendor managed inventory (VMI). The TOC distribution link simply extends its buffer sizing and management techniques to its customers’ inventories. Doing so has the effect of smoothing the demand from the customer and reducing order sizes per SKU. VMI results in better availability and inventory turns for both supplier and customer. More than that, the benefits to the non-TOC customers are sufficient to meet the purpose of capitalising on the decisive competitive edge by giving the customer a powerful reason to be more loyal and give more business to the upstream link. When the end consumers buy more the whole supply chain sells more.

One caveat should be considered. Initially and only temporarily, the supply chain or a specific link may sell less as the surplus inventory in the system is sold. However, the immediate sales lift due to improved availability is a countervailing factor. The current levels of surpluses and shortages make each case different.

5.14 THE STORE SYSTEM

![Image of TOC Stores System](Figure 5.18: TOC Stores System. Source: (Researcher, 2014))

The aim of the store system is to ensure availability of material per half level.
How will it work?

- A well-constructed store is established on each Half Level
- A dedicated store person that controls it
- People draw material from the store as needed and each transaction is recorded in a book
- On the next day, one copy of the transactions is used to order the replenishment material from the main stores
- Another copy of the actual consumption is sent to the MO for control purposes

When the material arrives on the shaft, it is sent down to the store and the store is

- The store person has a list of all material required in the store and he/she makes sure that everything needed is available
- An accurate account of all transactions can be obtained from the system

The specification listed below needs to apply

- Constructed as per survey lay out plan
- Position displayed on underground plans
- Constructed in through ventilation
- Proper illumination
- Proper Shelving
- Notice boards displaying – Underground Material Store
- Equipped with required safety equipment
- Must be secured by a lockable door and a issuing counter
- Key control system in place
- Material control sheets
- Competent material store controller / deputy to run store

Figure 5.19: TOC stores system. Source : (Researcher, 2014)
- Ordering / issuing system in place
- Auditing system in place

Figure 5.20: TOC stores system Source: (Researcher, 2014)

### 5.15 COLLABORATIVE REPLENISHMENT POLICY

Another key question is: “How Should a supply chain be changed in terms of its inventory policies and information handling to facilitate better collaboration and the usage of supply chain wide perspectives and measures? The constraint-based approach proposes the need for a replenishment system to better match supply with demand, in conjunction with applying information technology for control and to accelerate the improvement process.
5.16 THE REPLENISHMENT SYSTEM

Figure 5.21: TOC Stores System. Source: (Researcher, 2014)

Figure 5.22: TOC Stores System. Source: (Researcher, 2014)
The underground half-level materials store is stocked according to the relevant BOM and is under the control of the M.O.

When the mining crew requires material from the half-level store, the team leader completes a materials request form and sends one of the team members to the store to sign for and collect the requested material.

If the item is a reusable item, then the broken item must be handed in at the store before the new item will be issued.

The material is recorded in the issue/replenishment request book by the stores controller and the crew member signs for the material against their employee number.

Every day, one copy of the issue/replenishment request remains in the book, one copy is sent to the M.O. for their record, and the other copy is sent to the surface clerk for capture into the SAP system.

When there is sufficient material to fill a car, the surface store fills the car and sends it underground to the relevant underground store.

The half-level stores controller receives the materials and stores them in the appropriate manner and place in the store.

The broken but reusable materials that are returned to the half-level store are placed in an empty car and sent to the surface for refurbishment.

Waste materials are placed in the waste bin car and when it is full, it is sent to the surface for proper disposal.

![Figure 5.23: TOC Stores System. Source: (Researcher, 2014)](image)
5.17 THE LABOUR BUFFER TOC APPROACH THE BEFORE AND AFTER

The RDA function on the mine is to support the RDO due to the long drilling methodology on Rowland Shaft. If the RDO is absent from work the RDA cannot or will not accept the function as the RDO; although fully trained to do the function of the RDO. Similarly, if the
RDA is absent, the RDO will struggle to complete the required drilling during the time that he/she is able to drill. The effect is that the panel or development end will not be blasted.

Various options were looked at and the only feasible solution to eliminate the position of RDA by promoting all RDA’s to RDO’s and to have sufficient RDO’s in each crew to ensure that they can achieve the required amount of drill holes. This will require cooperation between the RDO’s to support each other while each drill hole is collared.

![Diagram of Looking at a Stopping Environment](image1)

*Figure 5.26: TOC Current labour approach. Source: (Researcher, 2014)*

![Diagram of TOC Buffer Management System](image2)

*Figure 5.27: TOC buffer management system approach. Source: (Researcher 2014)*
To accommodate the change we have engaged with finance to understand the impact the change would have on the budget at the shaft as a whole.

5.17.1 Sizing and Buffering of Production Crews.

The number of RDO’s required by each crew is determined mainly by the following factors:

- The amount of time that the crew has at the face;
- The number and depth of the holes that need to be drilled;
- The skill of the RDO’s and;
- The quality of the drilling machines and the compressed air supplied.

In a standard crew there should be 5 RDO’s – 3 drilling the face and 2 drilling roof bolting. However, in order to ensure that we hardly ever miss a blast due to the drilling not having been completed in the time available, we need to put two buffers in place, namely:

- A time buffer at the face. When calculating the number of RDO’s required by the crew, you need to include a buffer (it is recommended that this buffer be one and half hours) that will compensate for the inevitable hiccoughs that will occur from time to time and which will lose the crew some drilling time during their time at the face, and
- A buffer of RDO’s who will be ready to join a crew before they move to their workplace in the event of a RDO being absent.

With these two buffers in place, there should be very few occasions when the blast is lost due to insufficient RDO’s and time at the face. The other critical positions that require buffering are the winch operators and loco drivers. From initial discussions with stakeholders indications are that the proposed changes will be supported by organized labour and the management structures on Rowland Shaft.

Figure 5.29: RDO and RDA setup. Source: (Researcher, 2014)
5.18 CONCLUSIONS

As early as 2012 (before TOC application) the shaft team identified the current projects as being critical for Rowland. Unfortunately these projects were not deemed to be mission critical due to capital prioritization and management directive. With the introduction of TOC these same projects were approved and executed. The question posed is why we needed TOC to successfully promote these projects. After the initial engagements, the shaft achieved its new record production, with a good margin. The spirit was good, the vibe was positive and the Mine manager took the Ops Room to a level of good performance. Then a fatality occurred, the shaft stood for a week, the spirit was broken, the approach toughened, a senior MO resigned, another MO was moved to another section, then it was the Christmas break and now the strike.

The shaft did not achieve a steady state of operation and if we will have to do it again, we will have to start almost as from scratch. Did TOC fail? To some degree it did, but it did not have a reasonable chance to succeed. If the company had a clear vision of how to go ahead and it was supported from all avenues, who knows? The reason it took so long to see visible results was that it took extensive presence from the TOC team to facilitate a new way of doing things. It took long and strongly verbalised discussions to get out of the local optima and cost control thinking modes into flow and buffer management thinking. Some could not make the switch in thinking. The roll out time took more than three times longer than previous implementations, mainly because the system is so rigid and people knew that they were not allowed to challenge the status quo – it was just extremely hard and took almost for ever!

The managers that took on the challenge were really supportive and most of the things we asked for were given, it just took extremely long. Our experience is that the Lonmin system is rigid, it is inflexible and very slow to adapt and most people just do not have the will power or the courage to risk going against it. The second was the appointment of a new senior mine manager at the shaft. Almost from day one in the month he took over, the spirit or vibe of the shaft changed. People were supported and encouraged to do the right things. It was like a fresh wind that was blowing and it all just fell into place and formed this phenomenal music of success. The vibe was almost tangible; people looked forward to coming to work again. The leadership bottleneck was overcome. In the second month, the shaft got a section 54, but
recovered back to almost full performance within two days – what a major achievement by the team!

In addition, the daily Ops Room could not be established properly due to the many activities on the shaft and the unavailability of operational managers. The Ops Room is conducted three times per week, of which one meeting is very short, leaving only Mondays and Fridays. This, in hindsight, does not yield the desired change in culture and alignment that is required for a higher level of performance. The Ops Room need further refinement in order to really assist the MO’s and other functions.
REFERENCES


