CONSTRAINTS MANAGEMENT OF A CONTINUOUS-BATCH PROCESS

by

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SUMMARY

Constraints Management of a continuous-batch process

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In 1984, Eli Goldratt published his novel "The Goal – a process of ongoing improvement". Constraints Management has since evolved into a field of study, still widely debated and written about today. Most companies soon realized that the principles of Constraints Management could no longer be ignored to stay competitive.

The South African Breweries (now SABMiller plc) is the world's leading brewer in developing markets. The company has dominated the South African liquor market for years and is currently the second largest brewing company in the world, operating in Africa, China, Europe and the USA, yet even a company with this reputation can still be ignoring the basic principles of Constraints Management.

This dissertation concentrates on the application of Constraints Management in a selected brewery in South Africa. The measures used in one of SAB's most successful breweries will be tested against Constraints Management principles, illustrating how the practice of driving performance measures without focusing on the constraint can lead one away from the goal of the company.

Rosslyn Brewery is a brewery driven by traditional brewing industry performance measures. The key drivers of the brewery have always been to increase factory efficiency and reduce costs. Rosslyn set the benchmark for packaging efficiency within SAB. The problem is that the packaging operation is not the constraint in the brewery. The throughput of the brewery is determined by the operation feeding into packaging, i.e. filtration.

The end result is that even though the packaging lines have the best efficiency, they still have to stop and wait for beer to become available from filtration, resulting in downtime, frustration and eventually costly overtime and weekend work.

The core conflict of the brewery is the trade-off between running all the resources as efficiently as possible, and thereby decreasing product cost, and running only the constraint as efficiently as possible, resulting in an increase in throughput. The Thinking Process was used to evaluate the conflict and a solution developed.

The solution consists of the following:

1. The brewery has to adopt Constraints Management using the 5 step process of ongoing improvement. The capacity constraint has to be exploited and all other operations subordinated, to ensure that products are not produced for the sake of improving efficiency.

2. The operational measures of the brewery have to be changed from increasing factory efficiency and reducing R/hl to increasing throughput, decreasing inventory and decreasing operating expense.

3. The production schedule and raw material release for the whole plant need to be determined by filtration. This requires a change in the current advanced planning solution to incorporate the principles of Drum-Buffer-Rope.

If the decision is made and actions taken, the brewery will be able to survive the next decade, even if there is a further decline in the market. If not, the focus will still be on reducing product cost, whilst improving the efficiency of all operations. This will lead to further line closures and retrenchments, doing nothing more but reducing SABMiller’s potential future capacity and flexibility.

Key terms:

1. Brewery
2. Constraints Management
3. Continuous-batch process
4. Core Conflict
5. Drum-Buffer-Rope
6. Planning
7. Scheduling
8. Theory of Constraints
9. Thinking Process
10. World Class Manufacturing

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1. INTRODUCTION

Tell me how you measure me, and I will tell you how I will behave. If you measure me in an illogical way…do not complain about illogical behaviour.
– Eli Goldratt

Successful companies will always have something in common; good performance measurement, acting on indicators and making bold decisions timeously. Successful implementations of world best practices can only be achieved by constantly measuring, interpreting the findings, and adjusting behaviour accordingly.

"*You cannot manage anything that you are not able to measure*" is often quoted to emphasize the importance of a good measurement system. A safe assumption that can be made, is that the existence of the accounting practices as we know them today, have evolved around the need for measurement. If a group of people is left in seclusion without any purpose or guidelines given to them, they will soon define their own goals and measures to reach these goals. Everything in today's life is measured and it drives the behaviour of individuals, groups and societies.

Given the fact that measurement is such an integral part of the success of a company, one of the key areas of concern will always be the relation between performance measures and the behaviour induced by these measures. Smith [2000a:1] makes the following statement regarding this dilemma: "*No matter how ridiculous people's actions appear, I can consistently tie their actions to their honest attempts to comply with measurements, policies and strategies, either written or unwritten.*"

An even worse effect is that of conflicting measures. Consider the classic case of production vs. procurement. The production department is always driven by efficiency targets. This implies that the machines on the production lines must be running constantly, every available minute in the day, and cannot afford to wait for anything, whether it is spare parts, labour or raw materials. On the other hand the procurement manager has a never-ending goal to reduce inventory levels and spare parts and drive down costs by buying in large batch sizes, sourcing from different suppliers etc.

The maintenance controller will quickly tell you that it is impossible to achieve machine efficiency targets if procurement has a goal to reduce spares in the central store. Every minute that his machine stands, money is poured down the drain. He then compensates for the spares availability problem by building his own satellite store. These satellite stores can be found in almost every workshop, because it is a "cardinal sin" if a breakdown should occur and the spare part is not available. The procurement manager is also very quick to counter this argument by indicating how many spare parts have been lying in the stores for years without once being drawn from the stores, and will proudly show you how much money he has saved for the company by reducing the inventory levels in the spare parts store. This classic problem of conflicting measures is one of the reasons why companies are willing to spend millions on expensive ERP solutions.

1.1. Background

The Theory of Constraints (TOC) is a management philosophy made popular by Dr. Eliyahu Goldratt, which strives to bring a company back to its goal to make money now and in the future. TOC has been successfully applied to specific situations such as production scheduling, distribution, project management and marketing. One of the tools in TOC is a Thinking Process with the aim to address problems associated with performance measurement, policy and strategy alignment around constraint measurement. The field of study for this dissertation will be the application of TOC, or Constraints Management. In the dissertation the measures used in one of South Africa's most successful companies, the South African Breweries (SAB) will be tested against Constraints Management principles, illustrating how the practice of driving performance measures without focusing on the constraint can lead you away from the goal of the company.

Smith [2000b:1] illustrated how using the Theory of Constraints leads to an increase in Economic Value Added (EVA), a key driver in SAB. He used Goldratt's Thinking Process to illustrate how the generic TOC measures of Throughput, Inventory and Operating Expenses lead to an increase in EVA. It also illustrates that using only EVA, without focusing on the constraint of the system, can also drive the wrong behaviour and actually decrease EVA.

Steenkamp [1995:1] used an evaluation research paper to illustrate the usefulness and applicability of the Theory of Constraints. It was conducted through questionnaires to companies that had at that stage implemented TOC in South Africa. An interesting point was that the TOC implementers (mostly people who have been on a Jonah course) felt that performance measurement was not a significant success factor. It should also be noted that all the implementations were at the initial stages and no real groundwork had been done at that stage in South Africa.

In the majority of the literature it is accepted that the three operational performance measures (Throughput, Inventory and Operating Expense) defined by Goldratt are adequate measures to review the "health" of a company. The argument is that the operational performance measures should differ from standard reporting measures, because these measures will bring the focus of the operation back to the constraint resource, system or policy. Traditional performance measures derived from standard financial reporting systems, can drive behaviour away from the goal of the company to make more money now and in the future.

South African Breweries (now SABMiller plc) is the world's leading brewer in developing markets and the second largest overall by volume, employing over 38 000 employees, with beverage sales of just under 100 million hectolitres per year. In the past SAB embarked on numerous World Class Manufacturing techniques with varying success. Two of the most successful implementations to date have been the Integrated Management Practices (IMP) and Best Operating Practices (BOP) programs. IMP focused specifically on team dynamics, while BOP was concerned with maintenance practices and work design. The key achievement of these two programmes was that the lowest level worker was empowered to take ownership and perform in his specific area of responsibility, i.e. the operational performance measures were well defined and are used to drive the desired behaviour.

As is the case with many programmes aimed at achieving continuous improvement, these two programmes have evolved further over the 5 to 10 years of implementation. Different levels of success have been achieved in the departments at the various breweries. One of the best implementations in SAB, in the writer's opinion, was at the Rosslyn Brewery in Pretoria.

At Rosslyn Brewery the success levels of the implementation however, differ between departments or functional areas. The packaging department is streets ahead of the rest of the brewery and is the key driver of BOP in the brewery. The brewing department has also had a reasonable successful implementation together with engineering or utilities while the operations or distribution function has only recently been exposed to world-class practices.

Despite these implementations the brewery has been under a lot of pressure to reduce costs, whilst volume traditionally allocated to the brewery has been moved to other breweries. This has resulted in one packaging line being "moth balled" and other lines running 1 shift a day. The two key areas of concern in the brewery as a whole is still the implementation of problem solving techniques and performance measurement. It seems like a paradox to argue that implementation of the world class manufacturing measurements are the key to the success achieved, but performance measures is also one of the key problem areas. The reality is that the performance measures per department are well established, extremely exhaustive and are excellent indicators of the state of health of the brewery, but these measures fail to provide a global optimum solution for the brewery.

Smith [2000a:viii] illustrates this concern in the following statement:
"*Across-the-board cost reduction initiatives are standard fare in business. Companies assign team leaders or champions to drive programs throughout the organization. They spend tremendous amounts of time and money on external consulting services and in-house training programs. At the end of the day, the health of the business is measured based on return-on-investment, and accounting is called in to measure the results and evaluate the individual functional areas of the business' performance - which program delivered its result (inventory down, cost down, cycle time down, quality up, sales up) and which did not; which functional areas of business did well and which did not, who and what improved and who and what failed to improve. The results are published, the feedback loop completed, and the next year's round of improvement programs and targets begins again,* <u>*and we have missed the big picture*</u>*.*

Why, with all of these wonderful programs, incredibly talented people, and huge investments of time and money, do we fail to make lasting and real bottom-line improvements?"

1.2. Scope of the Study

Rosslyn Brewery is a brewery driven by traditional brewing industry performance measures. These measures guide and determine the behaviour of the employees in the brewery.

The fact that performance measures drive behaviour is not necessarily a bad attribute and is in fact probably the main reason why the Rosslyn plant is held in such high esteem both inside and outside SAB. In this dissertation it will be illustrated that even when driving the perceived correct performance measures, a company can still be destroying value instead of contributing to the bottom line.

Specific questions that will be studied are:

What are the true performance drivers in the Rosslyn Brewery? These drivers are defined as thé one or two performance measures that dictate all or most of the actions taken and decisions made in the brewery. These drivers normally surface when the organization is going through a difficult period.

What is the constraint of the brewery? There is more to this question than to only determine where the source of constraint of the brewery is situated; because the constraint defines inventory levels as well as the extent the organisation is achieving its goal. The constraint is not necessarily a physical constraint; a policy can also be a constraint. The principles of Constraints Management will be discussed and applied to the current situation.

***What is the core conflict in the brewery and how should it be addressed*?** It is evident that a conflict does exist given the fact that the brewery looses volume and faces the threat of closure, the year after being voted the best brewery in SAB.

The dissertation will be an empirical study, specifically aimed at developing new methods to improve the performance of an existing system. Mouton, [2001:158] defines an implementation evaluation research study as "*…one that aims to answer the question of whether an intervention (programme, therapy, policy or strategy) has been properly implemented, whether the target group has been adequately covered and whether the intervention was implemented as designed.*"

In this research the focus will be shifted away from whether the intervention (World Class Manufacturing practices) was properly implemented as designed and whether the target group has been reached, to whether the intervention is driving the desired behaviour of making money now and in the future. The assumption is made that the intervention has been properly implemented in Rosslyn Brewery, the target group adequately covered and the intervention implemented as designed. The reason for making this assumption is explained in detail in chapter 3.

The following chapter outline will be used to arrive at a conclusion:

Chapter 1 – Background chapter that represents the reasoning for selecting the particular problem, the rationale of the study and a description of the research design and methodology used.

Chapter 2 – A background is given to the processes found in the brewing industry as well as a description of the value chain in SAB. At the end of the chapter the reader should have a basic understanding of the processes involved in the brewing industry and the complexities encountered in a brewery value chain.

Chapter 3 – A strategic overview is given of the implementation of world class practices and processes in SAB. It is important that the reader is familiar with the interventions that brought SAB to the situation of world dominance they currently enjoy.

Chapter 4 – The basic concepts underpinning Constraints Management are explained.

Chapter 5 – The chapter will describe where the constraint is situated in the brewery and describe the reasoning behind this conclusion. The reader should understand that the constraint of the brewery determines the Throughput of the value chain.

Chapter 6 – The key performance measures in Rosslyn Brewery are highlighted. The objective is to explain to the reader how performance is measured in Rosslyn Brewery specifically.

Chapter 7 – The core conflict in the brewery is identified by utilising the Current Reality Tree as defined in Goldratt's Thinking Process. The process seeks to answer the question: "What to change?"

Chapter 8 – The solution to the core conflict is determined utilising a Future Reality Tree. The question "What to change to?" is answered.

Chapter 9 – Advanced Planning & Scheduling (APS) is a crucial component in the implementation of Constraints Management and a widely debated topic today. The key concepts of Drum-Buffer-Rope vs. process flow scheduling are addressed in this chapter.

Chapter 10 – Finally suggestions will be made on how to cause change by implementing a project to achieve the solution. The final question is "How to cause change?"

Chapter 11 – Conclusions will be made, contributions of the research highlighted and proposals for future research will also be tabled.

Figure 1-1 and Figure 1-2 represents the outline of this dissertation to illustrate the objectives of each of the chapters. This is known as a "Transition Tree" in the Thinking Process. The conventions for reading the diagram are as follows:

If statement 1 ***and*** statement 2 were true ***then*** statement 3 should be true. The statements are all indicated by rounded boxes with a differentiation of rectangles to indicate chapter outlines. The and-statement is depicted by the ellipse covering the connectors. For example: ***If*** "The reader is unfamiliar with the research objectives" ***and*** "Chapter 1 describes the reasoning for the selection of the particular problem and the rationale behind the selection of the type of study" ***then*** "The reader understands that the objective of the study is to demonstrate that performance measures can destroy value if not applied without considering the constraint of the organisation"

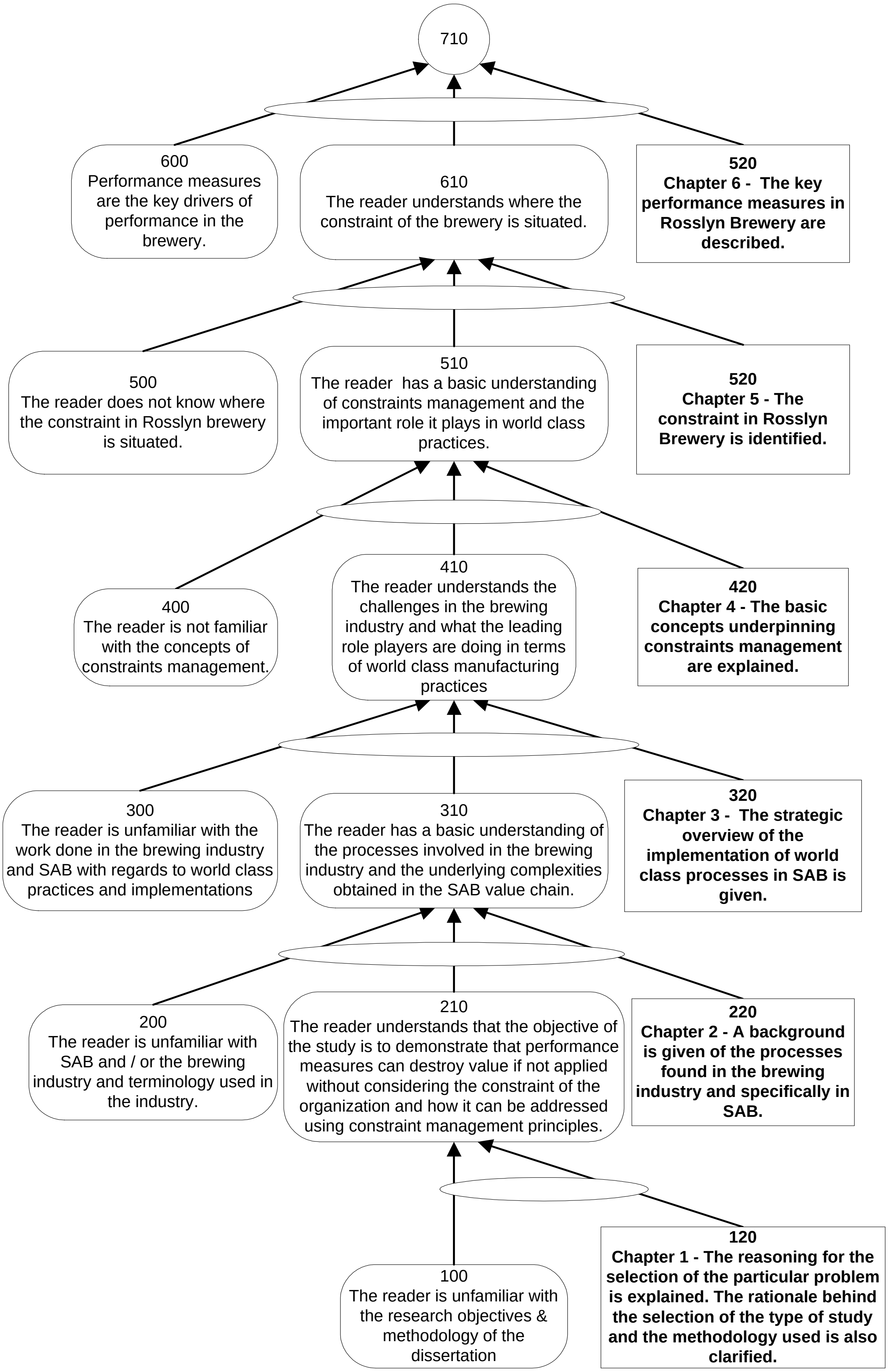

Figure 1-1: Structure of the Dissertation

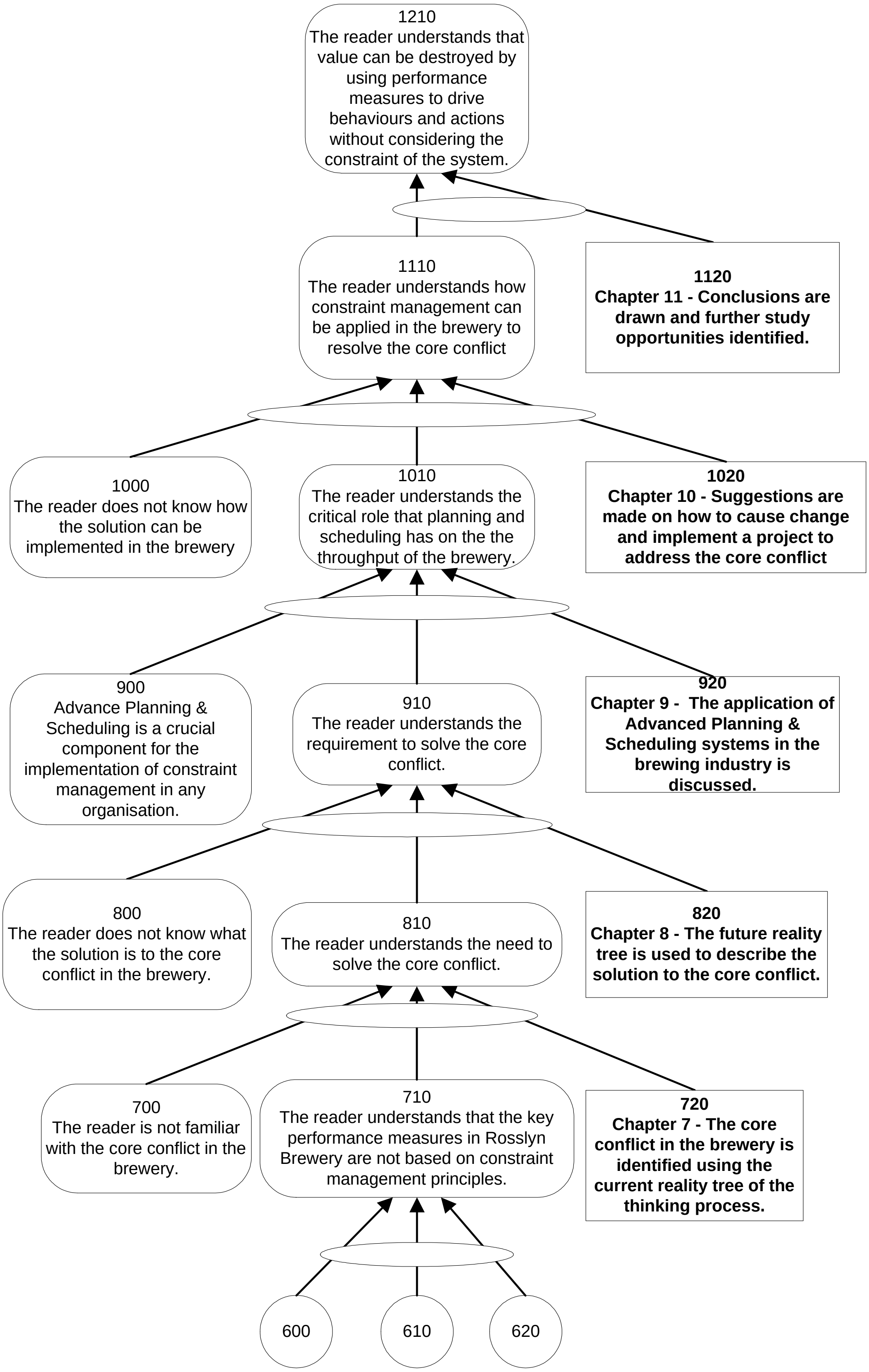

Figure 1-2: Structure of the Dissertation (continued)

2. BACKGROUND TO THE BREWING INDUSTRY

You can't be a real country unless you have a BEER and an airline – it helps if you have some kind of football team, or some nuclear weapons, but at the very least you need a BEER
- Frank Zappa

2.1. Purpose

The purpose of this chapter is to give the reader an insight into the processes involved at a brewery as well as to provide some background on Rosslyn Brewery.

The first paragraph describes the sales history in SAB and illustrates to the reader the seasonality in sales in the South African brewing industry.

The subsequent paragraphs describe the processes in a typical brewery consisting of the brewing process, packaging process and operations and distribution processes. At the end of each discussion general observations with regards to the processes are included.

The chapter ends with a short discussion on what is defined as the Value Chain of the brewery and provides a definition for continuous and batch processes.

2.2. Sales

Rosslyn Brewery has traditionally been known as "the flexible" brewery in SAB's beer division. The reason for this is that this brewery has spare capacity and is normally used in peak periods to produce volume for other regions that cannot produce the volume required. There are two very distinctive peaks in the production plan for the brewery every year as illustrated in Figure 2-1. The "perceived peak" in July and even September is where other breweries are on shut-down and Rosslyn had to produce their volume.

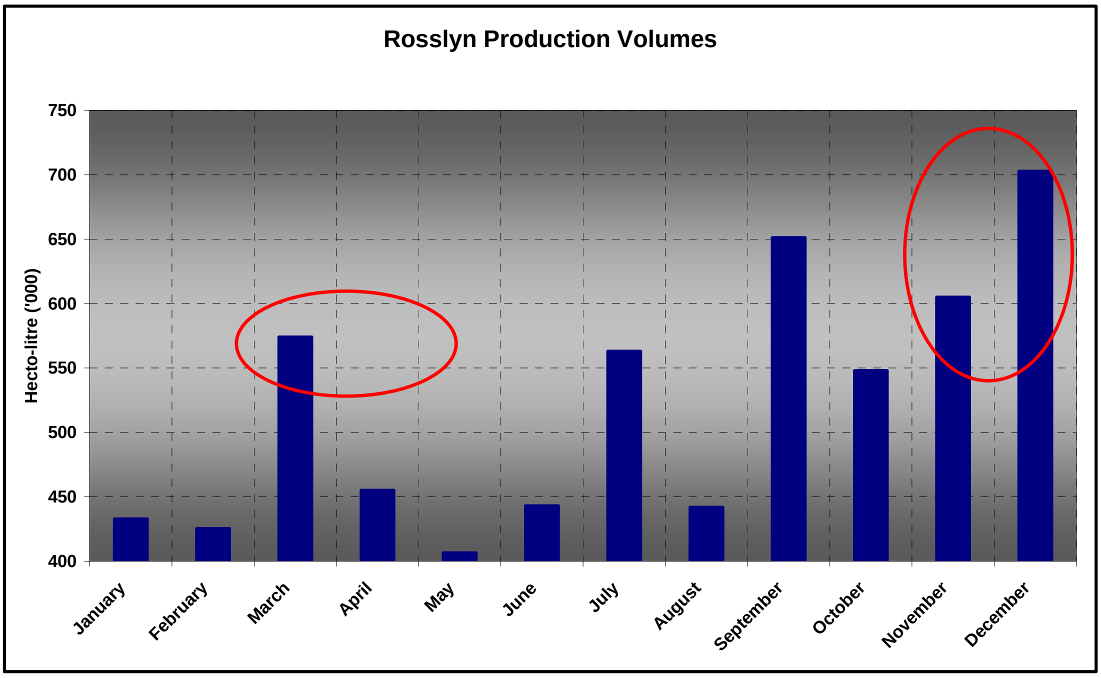

Figure 2-1: Seasonality of Rosslyn Production Volumes

The first peak period for beer consumption is towards the end of March and the beginning of April. There are normally a lot of South African holidays in this period, which invariably increases the beer sales. This is not as significant a peak period as the end of the year peak. The sales volumes normally increases by ± 400 000 - 500 000 hl during this period.

The second peak period normally starts in October to the end of December. The sales volume in this period reaches a peak volume of nearly double the normal volume. This is clearly illustrated in Figure 2-2. Over the past few years this peak period has become shorter and higher. In the past the highest sales volume would be spread over a period of 4 –6 weeks, but now the same volume is sold in a period of 2 –3 weeks at the end of December. The sales peak period lags the brewing peak by 2 weeks. The sales volume increases dramatically in the week (and even day) before each of the public holidays in December.

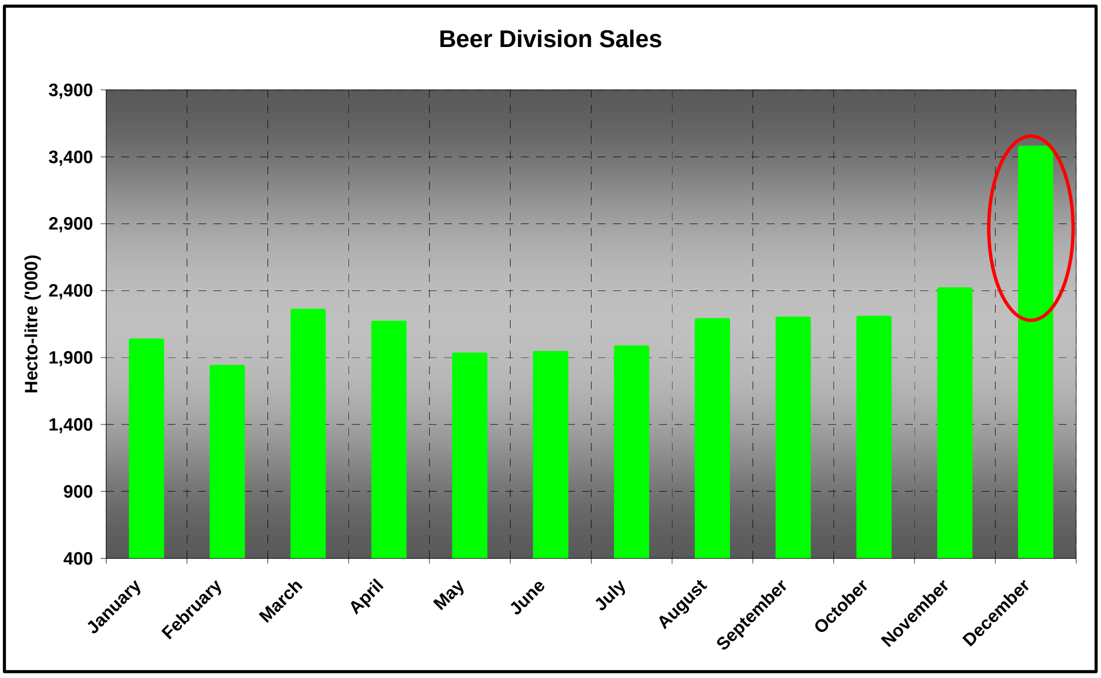

Figure 2-2: Beer Division Sales Profile

In a normal period Rosslyn will deliver loads to Gauteng, Limpopo Province, Northwest, Mpumalanga, Northern Cape and the Free State. In peak periods this might be extended into Eastern Cape, Western Cape and Kwazulu Natal. Although Rosslyn is the only brewery that uses rail transport to the remote depots, the average distribution cost is still significantly higher than that of the other breweries.

2.3. The Brewing Process

In the brewing industry the following 9 processes are described:

1. Malting
2. Milling
3. Mashing
4. Brewing
5. Cooling
6. Fermentation
7. Racking
8. Maturation
9. Filtration

A short overview of each of these processes is given in the following paragraphs.

2.3.1. Malting

The malting process is a raw material preparation process and is not performed in the brewery. The goal of the malting process is to prepare the raw material (barley) for use in the brewing process and takes place in the maltsters. Malt is a product from the malting process. Each step of the malting process unlocks the starches hidden in the barley. The malting process consists of 3 steps: steeping, germination and kilning. In the steeping process the barley is added to water and allowed to soak for about 40 hours. The grain is then spread out on the floor of a germination room for about five days where rootlets begin to form. This is referred to as germination. The goal of the germination is for the starches within the grain to break down into shorter lengths. At the end of this step, the grain is called green malt. The green malt now goes through a high temperature drying in a kiln. After kilning the result is finished malt. The malt can then also be roasted to produce "black malt" which is used in stouts such as Castle Milk Stout.

2.3.2. Milling

Milling is the cracking of the grain, for a particular batch of beer. Milling the finished malt allows it to absorb the water it will eventually be mixed with.

2.3.3. Mashing

Mashing converts the starches, which were released during the malting stage, to sugars that can be fermented. The milled grain is dropped into warm water in a large cooking vessel called the mash-tun. In this mash-tun, the grain and water mix to create a cereal mash. Because water is such a vital part of the brewing process, the water itself is a key ingredient. This sugar rich water is then strained through the bottom of the mash and the mixture is now called wort.

2.3.4. Brewing

The wort now goes to the brew kettle where it is brought to a boil. The boiling stage of brewing involves many technical and chemical reactions.

During this stage, important decisions will be made affecting the flavour, colour and aroma of the beer. Hops are added during the boiling and will add the bitterness and aroma to the beer. Measurement and control feedback loops are absolutely critical in this section.

2.3.5. Cooling

The wort is transferred quickly from the brew kettle through a device called the lauter tun to filter out the hops and spent grains. The wort is then transferred to a heat exchanger to be cooled. It is important to cool the wort to a temperature where yeast can safely be added, because yeast does not grow in high heat. This whole process from milling up to this stage is performed in the brew house and takes approximately 3.5 hours to complete.

2.3.6. Fermentation

After passing through the heat exchanger, the cooled wort goes to the fermentation vessel. In Rosslyn Brewery up to 3 brews can be blended in a single fermentation vessel. The brewer now selects a type of yeast and adds it to the fermentation tank. This is where the "real magic" of brewing happens – where the yeast ferments the wort sugars into alcohol and CO_2. The duration of the fermentation process is 12 days or 288 hours for all the lagers brewed in SAB. The reason for the long period is to give the yeast time to convert all the fermentable sugars into alcohol and CO_2. No unfermented sugars should be left in the beer after the fermentation process, as it will adversely affect the taste and clarity of the beer. Finally the yeast will be removed from the fermenting vessel bottoms and re-used.

2.3.7. Racking

During this phase, the brewer moves, or racks, the beer into a new tank called the storage vessel. Racking is therefore only a description for moving the beer from the fermenting vessel to the storage vessel.

2.3.8. Maturation

This process is also known as "finishing". In this process the beer is allowed to age for a period from 4 up to 10 days.

All the lagers spend 6 days in maturation, except Amstel Lager which will stay in the storage vessels for 10 days. In total the fermentation and storage process takes 18 days. Castle Lager is on a 12/6 process indicating 12 days in fermentation and 6 days in storage, while Amstel is on a 14/10 process.

2.3.9. Filtration

The final "brewing process" is filtration. The rough beer is filtered by passing it through an inert powder called Kieselguhr. The objective of the filtration process is to provide the required clarity. After the filtration process the beer is transferred to holding tanks known as bright beer tanks and is now ready for packaging.

2.3.10. General Observations

- The brewing process is a typical push system.

- The raw materials used in the brewing process are water, malt, hops and yeast. In South Africa we also use maize in addition to malt. The maize is a source of starch for the fermentation process and the breweries believe that it gives the beer a "more drinkable" characteristic. Maize is a product that is widely available in South Africa. In other countries, such as the United Sates and China, potatoes or rice are used in addition to the malt. It is because of this additive that SAB do not brew most of their lagers according to the "Reinheitsgebot".

- Modern brewers use a technique called high gravity brewing. This basically means that the beer is brewed with what brewers call an high extract and then diluted with de-aerated water at the latest possible step before packaging. This allows the brewers to produce greater volumes of beer with the same consistency.

2.4. The Packaging Process

There are four main processes in the packaging of beer:

1. Filling
2. Crowning and Seaming
3. Pasteurization
4. Labelling

Other processes include palletising and depalletising, unpacking and packing of returnable cartons and plastic crates and full bottle inspection.

The most popular container in South Africa is the 750 ml returnable bottle commonly known as the "quart". To accommodate the packaging of beer into quarts, the returned bottles have to be washed and inspected for defects and foreign objects.

2.4.1. Filling

After filtration the beer is pumped into bright beer tanks where the final quality control tests are done. De-aerated water or D-water is added to the beer before entering into the bright beer tanks. D-water is brewing water, which has been sterilised, de-aerated and carbonated. After a standing period of about four hours the beer is pumped to the filler. There are two fillers in the one packaging line in Rosslyn that are capable of filling 60 000 bottles in one hour. The filler is a rotary machine with filling tubes that are inserted in the bottles. The modern fillers have the capability to automatically detect underfills and reject them. Other inspection equipment, referred to as full bottle inspectors, is also added after the filling process to ensure that each bottle has been filled to the correct fill height.

2.4.2. Crowning and Seaming

After the container has been filled, the next thing to do is to close it up. With bottles this is done using a crown cork in a crowning machine. Cans are closed up on a seamer. The crowning machine and seamer are part of the fillers. It is critical that no air or oxygen is introduced in the filling process, as it causes quality defects. The introduction of air into the beer will result in microbial contamination and cause the beer to become rotten. To prevent any oxygen pick up, CO_2 is blown over the top of the can before seaming and in the case of bottles water is squirted into the neck of the bottle before crowning.

2.4.3. Pasteurization

Although the product may be biologically clean at the time of filling, minor infection with bacteria, brewery yeast, or wild yeast would cause a rapid breakdown of the product. Pasteurization in a bottle or can is the process used to stabilise the product.

Basically, the process involves subjecting the product to sufficient heat to destroy or inactivate microbiological life. SAB uses mainly tunnel pasteurizers for this purpose.

2.4.4. Labelling

For bottles the final process before the palletising is labelling. The labelling machines are also rotary machines. Label glue is applied to a pallet, which in turn removes the label from a magazine and glues it to the bottle, which rotates in a different direction. Various sets of brushes ensure the smooth application of the label onto the bottle. The ink coding of the bottles is done directly after the labeller as well as a final full bottle inspection to reject any underfills or quality defects such as leaking bottles, missing labels etc.

2.4.5. Other processes

- Empty quart bottles are removed from their crates in an unpacking machine. The machines used in Rosslyn are also rotary machines capable of removing the bottles from 12 crates during one rotation. The same principle applies for the packing machine that places the filled quarts into empty crates.
- The crates with full bottles are stacked into pallets of 66 crates with the help of a palletiser. A depalletiser is used to de-layer or break down the pallet of 66 crates. The cans and 340 ml non-returnable bottles are also palletised and depalletised in a similar manner.
- The quarts returning from trade have to be washed and sterilised before being re-filled. A mechanized bottle washer is used to remove all the labels from the bottles and sterilise them.
- There are various types of inspection equipment on the line apart from the full bottle inspection equipment, referred to as “All Surface Empty Bottle Inspectors”. These machines will use gamma rays or x-ray or high frequency sound to detect if there are any defects on the bottle or foreign objects inside the bottle. The main objective of these machines is to ensure that all the defective products can be removed before being sold to the customer. This inspection operation is crucial for all returnable containers.

2.4.6. General Observations

Although each of the 5 packaging lines has the same types of machinery, the capacity of these machines differ and therefore the constraint on each of the lines is a different machine.

The physical constraints on the lines can be either the filler or the pasteurizer. A V-profile, shown in Figure 2-3, determines at what speed the conveyor belts should be set to ensure continuous flow. In the design process the V-profile will also be drawn to determine where in the line a buffer should be added to ensure that the line operates with the minimum disruptions.

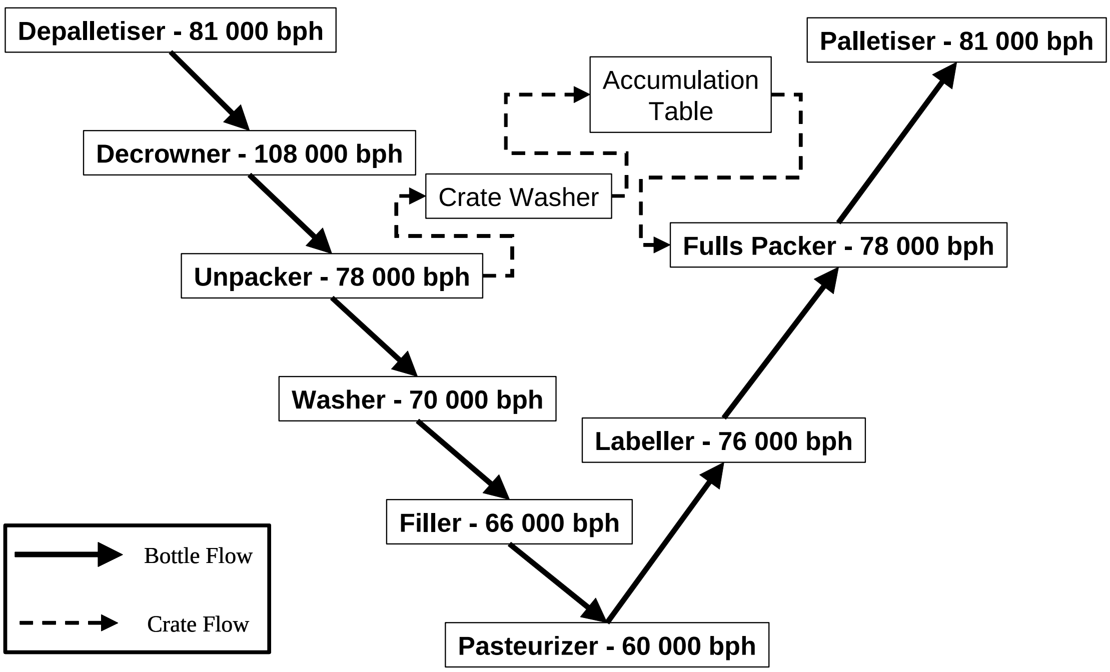

Figure 2-3: A typical V-profile of a packaging line

In Figure 2-3 it is clear that the Throughput of the packaging line is determined by the pasteurizer and will be limited to 60 000 bottles per hour. An accumulation table will be built in front of the pasteurizer to ensure that there are not too many interruptions to the filler.

2.5. Interdepot and Distribution processes

The beer is stored in the warehouse for a maximum period of 10 days. It is distributed to a number of depots and this operation is called the interdepot operation in SAB. In the depots the beer can be stored for up to 28 days from production date and then has to be sold. The distribution operation is the transport from the depot to the customer or outlet. A sales forecast is prepared on a weekly basis, which will be used as input for the packaging plan.

2.6. The Value Chain

At this point it is important to clarify what is referred to as the value chain of the brewery as well as the type of production processes employed in the brewery.
"*The value chain disaggregates a firm into its strategically relevant activities in order to understand the behaviour of costs and the existing and potential sources of differentiation. A firm gains a competitive advantage by performing these strategically important activities more cheaply or better than its competitors" [Porter, 1985:33-34]*.

The value chain consists of the processes which "add value" to the product and can therefore be broken down into the following generic areas:

- Brewing (Including fermentation, maturation & filtration)
- Packaging
- Interdepot
- Distribution

In addition to these areas there are also the following functional areas which are as critical, but fulfill a supporting role:

- Finance (including procurement)
- Utilities (supply of hot water, compressed air, CO_2 and refrigeration to the brewery)
- Marketing Support
- Human Resources
- Engineering (project management, risk management, asset care & safety)

2.7. Production Process Classification

The packaging operation is a continuous-batch process. In Chase & Aquilano [1995:62] the packaging process in a brewery is used as an example of a continuous production process. The statement is made: "*The Miller Brewing Company's facility is an example of a continuous production process. Beer is brewed, bottled, packaged, and shipped on one long production line with specialized automated equipment.*"

In the explanation of a continuous flow process the following definition is given for continuous flow: "*Conversion or further processing of undifferentiated materials such as petroleum, chemicals, or beer…*

As on assembly lines, production follows a predetermined sequence of steps, but the flow is continuous rather than discrete. Such structures are usually highly automated and in effect constitute one integrated machine that must be operated 24 hours a day to avoid expensive shutdowns and start-ups."

A batch process is then defined as " *…a somewhat standardized job shop. Such a structure is generally employed when a business has a relatively stable line of products, each of which is produced in periodic batches, either to customer order or for inventory. Most of these items follow the same flow pattern through the plant. Examples include heavy equipment, electronic devices, and specialty chemicals."*

The processes in a brewery do not fit exactly into either of the quoted definitions. Even though packaging is used as an example the process also has certain batch characteristics, i.e. the production process has very clear set-up and shutdown procedures and is produced in batches, which can vary from a few hours up to 7 days. If it is compared to chemical, petroleum or even bottle melting processes the differences are obvious. The manufacturing lines in these factories are run 24 hours a day, 7 days a week to avoid expensive start-ups and shut downs.

In many cases, like the bottle producing plant, a kiln is involved, which, when switched of even for a short period can have disastrous consequences and result in serious quality problems. It is for this reason that the packaging process should be defined as a continuous-batch process.

The canning line in Rosslyn has stopped and started-up for 3 or 4 brand changes a day. In a niche brewery, like Chamdor Brewery, the packaging line at one stage accommodated three batches of different brands simultaneously, one in depalletising, the other in the middle section (probably in the pasteurizer), while the third batch was being pumped into the filling tubes. This example definitely does not display the characteristics of the continuous process in the definition.

The brewing process is a process with a stable line of products, produced in periodic batches and is also not a continuous process as described above. In fact the processes of mixing, monitoring, cooling and transfer is probably similar to that of the specialized chemicals used as an example in the definition of batch processes.

The production-planning problem is created by the fact that a batch process (brewing) feeds into a continuous-batch process (packaging). In Rosslyn a batch of 40 000 hl is brewed every 18 days. This has to then feed into a production line with a rated capacity of 31 300 hl/day. The storage/buffer management between brewing and packaging is critical.

2.8. Conclusion

The brewing process is an ancient process that has evolved over the centuries. It is described as an art and a science and these days a lot of emphasis is placed on the fact that it is a “natural” process, not artificial as in the case of cold drinks. The packaging process utilises state of the art technology available in the fast moving consumer goods (FMCG) industry. The challenge of the brewery is to manage these vastly different processes as a synchronized production system.

This chapter’s aim was to give the reader a basic understanding of the processes involved in the brewing industry and the underlying complexities obtained in the SAB value chain. In the next chapter the key performance measures which have been defined by Rosslyn Brewery are highlighted.

3. WORLD CLASS PRACTICES IN SOUTH AFRICAN BREWERIES

The way to get things done is not to mind
who gets the credit for doing them
- Benjamin Jowett

3.1. Purpose

The purpose of this chapter is to familiarize the reader with world class practices in SAB.

3.2. Background to Integrated Management Practices (IMP) and Best Operating Practices (BOP)

SAB embarked on a World Class Manufacturing (WCM) drive a number of years ago. As part of the manufacturing strategy, a programme called Quality Production Upgrade Strategy (QPUS) - Best Operating Practice (BOP) was developed. The process later became known only as the BOP implementation.

The programme was based on the principles of…

- continuous improvement,
- elimination of waste,
- simultaneous improvement of quality and productivity, and
- respect for employee contributions

…through

- broadly based education and training,
- top management understanding and commitment to the principles,
- use of systems to highlight problems and give feedback,
- entrenching multi-disciplinary problem solving teams,
- standardized Best Operating Practices for each operation or task,
- focusing on customer needs both internal and external, and
- entrenching IMP principles and values.

This approach resulted in certain paradigm shifts in management practices and a marked culture change amongst employees, e.g.:

- Breakdown of rigid department barriers.
- Encouraged cross-disciplined interaction via problem solving and coaching.
- Subjecting people at all levels to cross-disciplinary training.
- Enablement of the shop floor to react to the situational issues.
- Responsibility for quality and performance placed on the shop floor.

"As often stated in the TQM and JIT literature as well, the success of any program that involves major cultural change in an organization depends critically on the involvement of top management" [Noreen, Smith & Mackey, 1995:xxiii]. The involvement of top management was probably the success factor behind the BOP implementation in SAB. The buy-in was obtained from top management level and then rolled down to every employee on the shop floor. Some issues like breaking down of department barriers and multi-disciplinary problem solving can still be improved, but a definite step-change was achieved through the BOP implementation.

The following critical outputs (performance measures) were defined:

- Downtime (machine downtime).
- Yield (material usage).
- Quality.
- Efficiency.

The process was first rolled out in the packaging departments of the various breweries. Multi Disciplinary Teams (MDT) teams were created with set goals and performance measures.

The goal setting process is a crucial component of BOP and starts with the regional SEC (Senior Executive Committee or Level 4) team defining a three-year business plan based on the strategies and initiatives from head office. The middle management teams (Level 3) then develop goals from the business plan and Level 4 goals.

The line managers roll it a level down to Level 2 (maintenance personnel and production supervisors) and Level 1 (operators).

These goals are formally reviewed on an annual basis and regular team-on-team reviews take place where teams from across departments or disciplines review the progress of other teams against these goals. All these processes were established to create the environment for continuous improvement and continuous learning in the breweries.

Figure 3-1 is a graphical example of the goal setting process as applied in SAB:

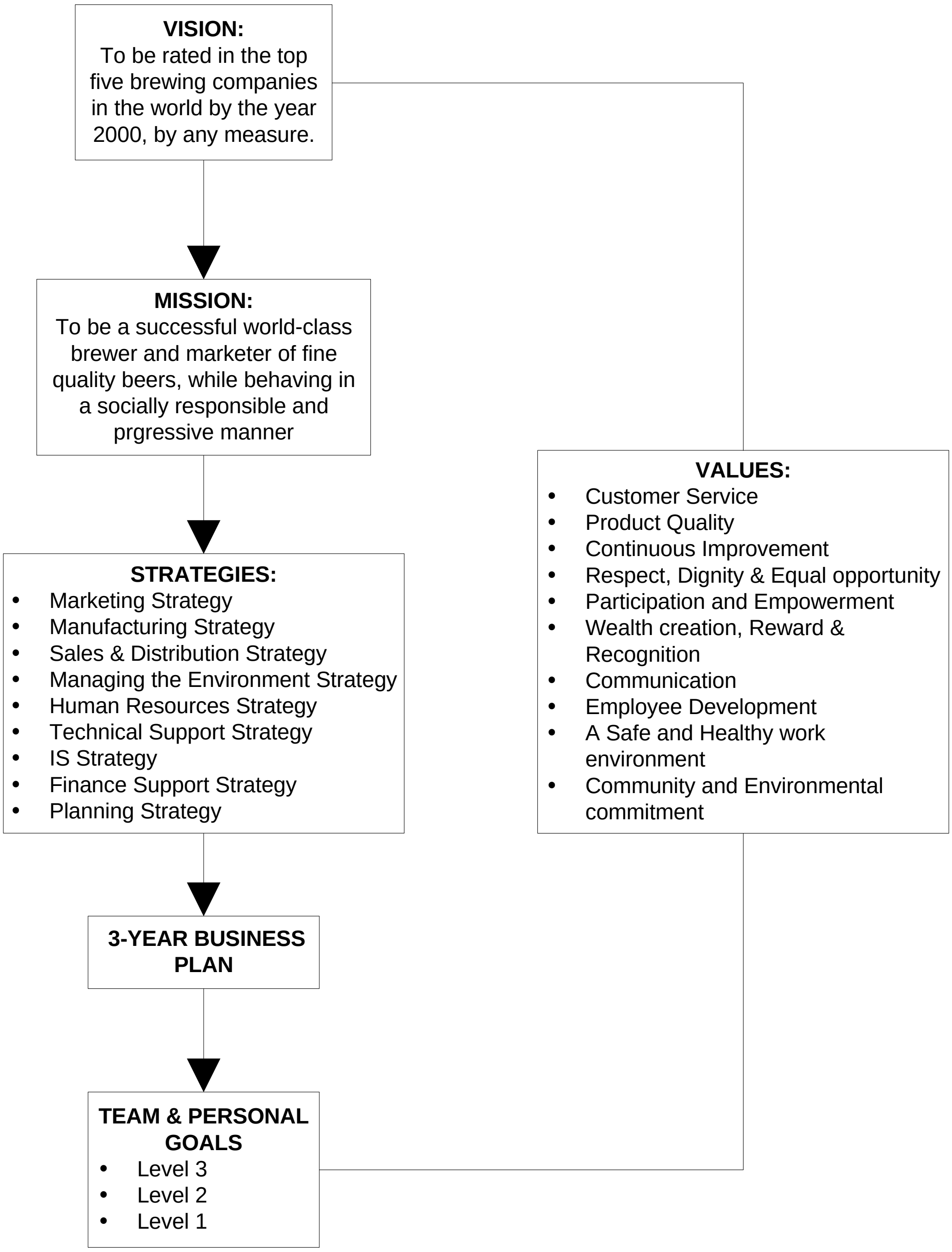

Figure 3-1: The Goal Setting Process in SAB [Cluett:1995]

The bulk of the work involved in BOP was developing operating procedures and work instructions. For every machine/process in the packaging line the following formally documented procedures and work instructions are required:

- Safety.
- Start Up.
- Operating Instructions.
- Shutdown.
- Changeover and Set-up.
- Quality and Performance Measurements.
- Cleaning/Sterilising/Housekeeping.
- Plant Maintenance (including modification, schedule change and job card system).

These procedures were developed utilising the Level 2 Multi Disciplinary Teams and the operators were trained in the operating procedures and work instructions after completion. Every operator had to understand the impact that he/she had on the performance of the line. This iterative process is still in place to manage the packaging lines in all the breweries.

Although the initial process was sound and very generic, there were some obstacles in rolling it out to the other departments. These problems could be contributed to the fact that the other processes were not part of a highly stressed, production driven environment with all the pressures associated with it, or that the teams weren't exposed to so many resources as in packaging, but the second roll-out had many more difficulties. There were, however, very successful implementations in the brewing and utilities departments of a number of other breweries.

3.3. South African Breweries' Strategic Performance Measures

The following strategic performance measures have been defined by the SAB head office to realize the various strategies, mission and vision of SAB.

This is not an exhaustive list of measures, but gives a good indication of all the areas that are covered in the SAB performance measurement system. One of the areas not covered in this thesis is the specific application of Safety, Health and Environmental issues in SAB.

3.3.1. Financial Performance

The three main financial targets set by SAB are:

- Growth in EVA.
- Annual attributable profit growth.
- Annual price increase to be below the South African Consumer Price Index (CPI).

These three measures have always been main focus areas in SAB, not necessarily in the order stated above. The CPI has always been an extremely important measure. The fact that SAB has managed for a number of years (>20), to keep price increases below the CPI has been presented as one of the reasons why the company is so successful.

Two specific measures used to achieve these targets are:

- Variable cost increases.
- Real fixed cost productivity.

3.3.2. Market Share and Volume

The marketing targets have been defined as follows:

- Increase beer's share of total drinks.
- Maintain share of conventional liquor.
- Move towards greater internationalisation of brands.
- Reach domestic sales target.

In the past few years the focus has shifted away from the South African beer market towards other world markets, especially in Africa, Asia and Eastern Europe.

SAB has realized that it is still important to protect the South African beer market, although the share of the total volume can (and will) become less significant in future. SAB still enjoys a significant share of total drinks (>50%) in the South African Market and still has a monopoly in the beer industry in South Africa. The South African liquor market has dramatically decreased over the past few years and therefore the globalization strategy is crucial to maintain sales volumes.

3.3.3. Production Performance

The production performance targets are:

- To continuously improve divisional factory efficiency, while producing quality product to plan.
- To be recognised internationally as a leader in product and packaging quality.

Production performance measures:

- Trade Quality Assessment (TQA) – various measures e.g. appearance, drinkability, outer packaging quality etc.
- Integrated Quality Measurement System (IQMS) - various measures e.g. foam stability, dissolved oxygen in product etc.
- Beer Taste Results.
- Factory Efficiency.

The production performance targets hinge around achieving factory efficiency targets, whilst maintaining quality standards. Factory efficiency is mainly measured in brewing and packaging at the moment, and the performance target set out here refers to the packaging hall factory efficiency target of >72%.

3.3.4. Customer Service

There are various sales specific and distribution specific targets set by SAB with the goal to rank first among liquor companies in all these service attributes. These targets will not be discussed in more detail here, although the warehouse performance measures are explained in more detail later in this chapter.

3.3.5. Organisational Culture

Specific human resource targets for Adult Basic Education and Training (ABET), management and self-management practices have been defined in the Integrated Management Practices (IMP) Process. These measures are also beyond the scope of the dissertation, although they have made a significant impact on the success of the WCM implementation.

3.3.6. Community Relations

The target for community relations is to rank in the top three amongst the other large SA companies with regard to social performance and responsibilities and to make a meaningful impact in key areas of community upliftment. The Markinor image survey is used to measure this target.

3.3.7. Equity

Targets are set to ensure that SAB is representative of South Africa's race and gender demographics at all levels in all disciplines. These targets have been set (and achieved) for a number of years running.

3.4. Conclusion

To stay competitive and remain a world leader in your industry it is critical to benchmark and understand where you are in relation to your competitors and leading companies in other industries. Measurement is not only crucial for benchmarking but also for adjusting behaviour and making operational decisions. Companies can fall into a trap where everything is measured to exhaustion and the information not interpreted and used to base decisions on and modify behaviour. In Rosslyn there are some warning signals of this condition of over-measuring, but generally there are key drivers, that are constantly monitored and adjusted and are, very importantly, linked to the global strategy of the company.

In the next chapter the global strategy will be further explored by examining the Theory of Constraints. The basic principles underpinning TOC will be explained with specific focus on the performance measures as defined in a TOC environment. The flaws of existing performance measures and accounting principles will also be explored.

4. THE THEORY OF CONSTRAINTS

Obstacles are those frightful things you see when you take your eyes off your goal.
- Henry Ford

4.1. Purpose

The purpose of this chapter is to provide the reader with the background of the Theory of Constraints or Constraints Management as it is currently referred to in literature. The chapter starts with the history of TOC, followed by an explanation of the five-step process of ongoing improvement; a discussion on measurements used to manage the continuous improvement process and concludes with the Thinking Process.

4.2. What is the Theory of Constraints?

"The core idea in the Theory of Constraints is that every real system such as a profit-making enterprise must have at least one constraint. If it were not true, then the system would produce an infinite amount of whatever it strives for. In the case of a profit-making enterprise, it would be infinite profits. Because a constraint is a factor that limits the system from getting more of whatever it strives for, then a business manager who wants more profits must manage the constraints. There really is no choice in the matter. Either you manage constraints or they manage you. The constraints will determine the output of the system whether they are acknowledged and managed or not" [Noreen, Smith & Mackey, 1995:xix].

The Theory of Constraints was developed and popularised by Dr. Eliyahu M. Goldratt. TOC, as it is commonly called, comprises two major groups of techniques; robust applications for dealing with generic problems within each of the organisational functions on the one hand, and generic problem solving tools on the other hand. TOC recognises that organisations exist to achieve a goal. The goal of the company is "*to make money*" *[Goldratt, 1992:40]* now and in the future. A factor that limits a company's ability to achieve more of its goal is referred to as a constraint.

TOC focuses the organisations' scarce resources on improving the performance of the true constraint, and therefore the bottom line of the organisation. Goldratt uses a chain analogy to help illustrate why this is the most effective way to get immediate results.

4.3. The Chain Analogy

A company can be compared to a chain. The activities which constitute business are really a chain of dependent events. That is to say we don't ship parts until they are packaged, and we don't package until they are manufactured, etc.

Conventional wisdom believes that an improvement in any one link in the chain is an improvement to the whole chain. Global improvement is then the sum of all the local improvements. Every link constantly fights for scarce resources to ensure that the particular activity can be optimised or improved. Managers will take actions to optimize any or all local operations.

The performance of any organisation is directly related to its constraints. Similar to a chain, it does not matter whether most of the links are very strong; if only one weak link fails, the whole chain fail.

Figure 4-1, adopted from [Sullivan, 1998:44], illustrates how the chain analogy is applied to a general supply chain.

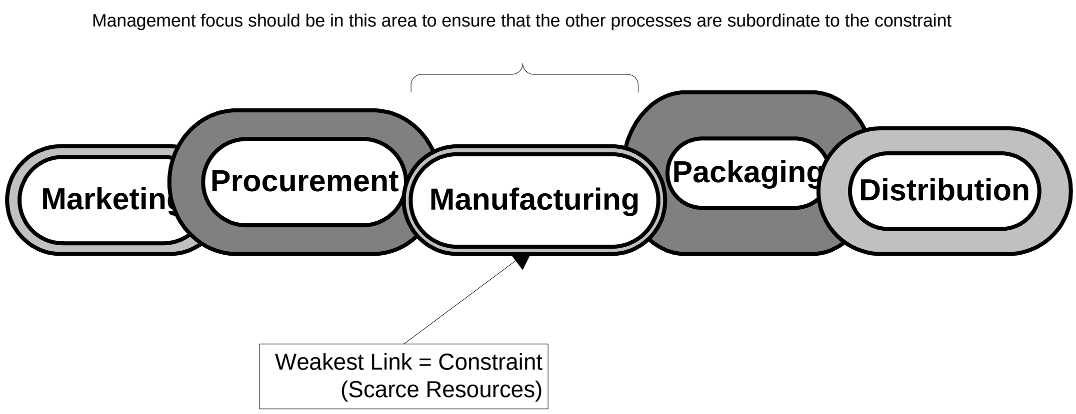

Figure 4-1: The Chain Analogy

TOC refers to two worlds [Sullivan, 1998:36-39]. The first one is the cost world, where the goal is to reduce costs and all management decisions are based on cost accounting measures. The second one is called the Throughput world. This is the situation defined by TOC and aims at improving Throughput by focusing on the constraint in the organization.

The Throughput world approach believes that:

- Most improvements of most links do not improve the chain.
- Global improvement is <u>not</u> the sum of local improvements.
- The primary measurement should be chain strength (compared to chain weight) and resources should be channeled to the weakest link or the constraint in the system.

4.4. The Goal and Measurements

4.4.1. Bottom Line Measures

It is generally agreed that there are three bottom line measurements of making money. A company needs to make a **net profit,** an absolute measurement of making money. An additional measurement is required to show how much money was made relative to the money invested in the business, a measure like **return-on-investment/equity/assets.** These two measures seem sufficient, but there is a third (survival) measurement, called **cash flow.** These three measures give a good indication of whether a company is making money. [Goldratt, 1992:45-47]

4.4.1.1. Net Profit

Although the three bottom line measures have not changed from the traditional measures used, it is applied slightly differently in Throughput Accounting.

Table 4-1, adjusted from Noreen, Smith & Mackey [1995:14], indicates the difference between the traditional view of Net Profit and how it is applied in Throughput accounting.

Conventional Variable Costing	*Throughput Accounting*
Revenue	**Revenue**
- Direct materials	- Total variable costs
- Direct Labour	
- Variable overhead costs	
= Contribution Margin	**= Throughput**
- Fixed Expenses	- Operating Expenses
= Net Profit	**= Net Profit**

Table 4-1: Comparison of Variable Costing with Throughput Accounting

Net Profit is therefore the Throughput minus Operating Expenses in TOC terms.

4.4.1.2. RETURN ON INVESTMENT

"Return on Investment (ROI) is defined as the product of an investment centre's margin multiplied by its turnover. The margin of the ROI formula is a measure of management's ability to control expenses in relation to sales. The turnover portion is a measure of the amount of sales generated in an investment centre for each dollar invested in operating assets" [Garrison, Noreen 1994:540 – 541].

The ROI formula can be expressed as:

$$\text{Return On Investment} = \text{Margin} \times \text{Turnover}$$

$$\text{where Margin} = \frac{\text{Net Profit}}{\text{Sales}}$$

$$\text{and Turnover} = \frac{\text{Sales}}{\text{Average Operating Assets}}$$

$$\Rightarrow \text{Return On Investment} = \frac{\text{Net Profit}}{\text{Sales}} \times \frac{\text{Sales}}{\text{Average Operating Assests}}$$

$$\text{Return On Investment} = \frac{\text{Net Profit}}{\text{Average Operating Assets}}$$

Figure 4-2 is a graphical representation of the elements contained in the ROI formula.

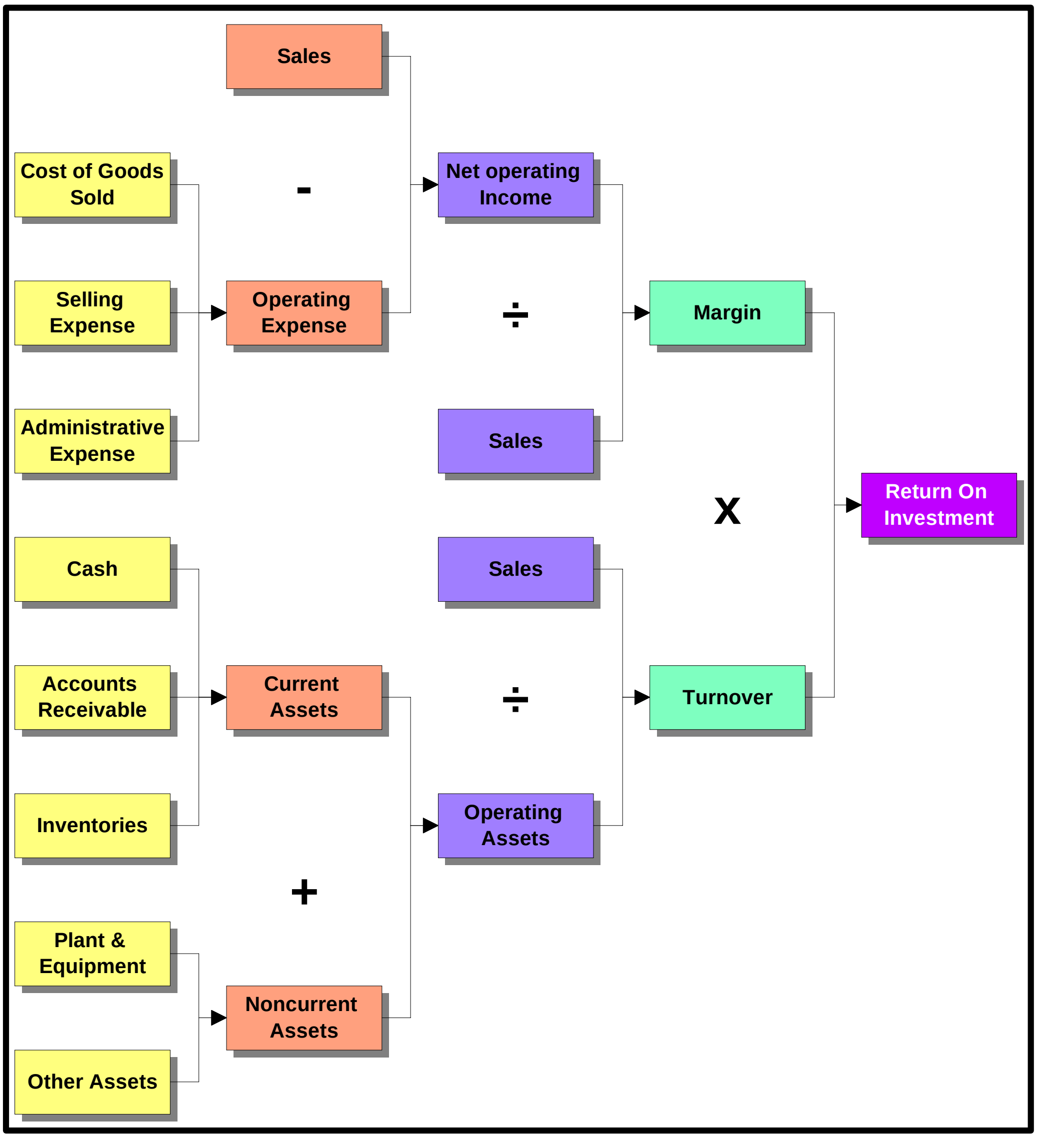

Figure 4-2: Elements of Return on Investment

In the past, managers have tended to focus only on the margin earned and not the turnover of assets. That is why this relative measure has been introduced. The measure of ROI has been adopted in Economic Value Added (EVA), which is a performance measure preferred in most large corporations. Economic Value Added is calculated in the following manner [Mäkeläinen, 1998:5 - 8]:

$$\begin{aligned}
&\text{Economic Value Added} = \text{Net Profit - Capital Costs}\\
&\text{where Capital Costs} = \text{WACC} \times \text{Invested Captial}\\
&\text{and WACC} = \text{Weighted Average Cost of Capital}\\
&\text{or alternatively}\\
&\text{Economic Value Added} = (\text{ROI - WACC}) \times \text{Invested Capital}
\end{aligned}$$

The WACC is a function of the cost of debt and cost of equity, e.g.:
Assume the risk free rate of a company is 5.2% (at this level it is the best to put your money in a bank and earn interest), the company risk premium is 2.8% and the equity risk premium is 1.2%. These two figures will differ from company to company, based on their risk profile, type of industry and various other factors that they want to bring into consideration.

$$\begin{aligned}
&\text{Cost of debt} = \text{risk free rate} + \text{company risk premium}\\
&\text{Cost of equity} = \text{risk free rate} + \text{about 6\% equity risk premium}\\
&\text{Cost of debt} = 5{,}2\% + 2.8\% = 8\%\\
&\text{Cost of equity} = 5.2\% + 1{,}2 \times 6\% = 12.5\%\\
&\text{WACC} = 8\% \times 55\% + 12.5\% \times 45\% = 10\%
\end{aligned}$$

This measure is preferred to ROI for the following reasons:

1. The ROI measure can steer the company in the wrong direction if the primary goal is to maximize ROI. The following example illustrate this case:
   Assume a company has Capital Employed of 100, Operating Profit of 30 and works with a Capital Cost of 10%.

   $$\text{Return on Investment} = \frac{\text{Operating Profit}}{\text{Capital Employed}} = \frac{30}{100} = 30\%$$
   $$\text{EVA} = \text{Operating Profit - }(\text{Capital Employed} \times \text{WACC}) = 30 - (100 \times 10\%) = 20$$

   An opportunity exists with a capital requirement of 20, a return of 20% per year.

$$\text{Change in yearly operating profit} = 20\% \times 20 = 4$$
$$\therefore \text{ROI} = \frac{(30+4)}{(100+20)} = \frac{34}{120} = 28\%$$
$$\text{EVA} = 34 - (120 \times 10\%) = 22$$

If the goal is to maximize Return on Investment, this decision would not be made because the Return on Investment would decrease by 2%. This is not the case with the Economic Value Added calculation.

2. EVA is a measure that can be translated into day-to-day operations because it is an easier concept of profitability than ROI.

   It is argued that Return on Investment is not used at lower levels in the organisation to make day-to-day decisions and therefore EVA is an easier measurement. I do not agree with this statement because Return on Investment is an absolute measure and should not be used on an operational level. Furthermore I have found that the concept of Working Average Cost of Capital is also difficult to explain to the lower levels in the organisation.

   "It is true that where Return on Investment is used in organisations on a lower level (i.e. not the shareholders), the capital base is left with very little attention to operating activities and operating profit is emphasized. Therefore the meaning of capital efficiency is often forgotten and some operating people do not even realize that tying money in inventories or sales receivables is costly" [Mäkeläinen, 1998:5].

3. EVA (in contrast to ROI) is an unambiguous measure, i.e. increasing EVA always increases the position of the shareholders.

One point of caution should be made. The statement is made "*that EVA is an absolute measure that can easily integrate into operating activities since all cost reductions and revenue increases are already in terms of EVA (reduction in cost in one period = increase in EVA in the same period). In a similar fashion capital increases/reductions are also fairly easy to turn into change of EVA" [Mäkeläinen, 1998:5].*

This can easily drive the mentality of cutting costs instead of making money now and in the future. The drive for capital reductions can also influence the company negatively by removing the flexibility of the company to adjust to statistical fluctuations in the market. Smith [2000b:1] proved in his dissertation the danger of focussing on EVA without considering the goal of the organisation.

4.4.1.3. CASH FLOW

The Cash Flow statement is a statement that is drawn up to reflect all the sources and uses of cash in the company for a financial period. It is a simple calculation starting with the opening cash balance, adding all receipts and deducting disbursements. It also includes financing activities and then calculates the cash balance at the end of the period. This is a very important measure to assess whether a company is in a good state of health or not and is therefore called the survival measure by TOC.

The three measures defined above, give shareholders and potential investors an indication of how well the company is performing. It is a fact that "*the purpose of traditional accounting is to provide consistent and uniform information to stockholders, regulatory agencies and lenders*" *[Smith, 2000a:46]*.

4.4.2. Operational Measures

Net Profit, Return-on-Investment and Cash Flow are absolute measures capable of measuring the goal of the organisation. *"However, the measurements which we refer to as fundamental quantities are the measurements that enable us to judge the impact of a local decision on the company's goal. Every manager knows all too well that the bottom line measurements are quite impotent in judging the impact of a local decision" [Goldratt, 1990:15].*

The Theory of Constraints defines three operational measures that relate directly and indirectly to the absolute financial measurements. These measures are Throughput (T), Inventory (I) & Operating Expense (OE).

4.4.2.1. THROUGHPUT

"Throughput is the rate at which the system generates money through sales" [Goldratt, Fox; 1986:29] or:

$$\text{Throughput} = \frac{(\text{Sales - Total Variable Costs})}{\text{Time}} = \text{Contribution Margin}$$

In practice the Contribution Margin is simplified as Sales minus Direct Labour.

- A rate implies that something is generated over time; therefore it is essential that the denominator of the formula has to be time. The time in this formula actually implies the period (or financial year) under scrutiny.
- Building to stock is not Throughput, i.e. if we have produced something and haven't sold it, it is not Throughput, it is still Inventory. Throughput is therefore the rate at which the system generates cash through sales.
- If the Throughput of the organisation can be increased, while maintaining the same level of Inventory and Operating Expense, then all three bottom line measures (net profit, return-on-investment & cash flow) will increase.
    - If Throughput increases, it implies that sales have increased. If the cost of goods sold and the Operating Expenses stay the same the net income before tax will also increase.
    - In short, return-on-investment is the net profit divided by average operating assets. If the net profit increases (as indicated above), it implies that the nominator becomes bigger and ROI increases.
    - Cash flow will increase because more sales imply that more money flows into the system through a higher net profit.

4.4.2.2. INVENTORY

"Inventory is all the money the system invests in purchasing things the system intends to sell" [Goldratt, Fox; 1986:29].

- Inventory is made up out of two categories:
  - Machinery, building, etc. (if owned) is one type of "inventory" i.e. fixed and moveable assets.

    Defining fixed assets as Inventory can create confusion when the definition of Inventory is analysed. The principle underlying this type of Inventory to be included, is that all fixed and moveable assets must allow the goal to be achieved.
  - If the goal can be better achieved by getting rid of (selling) this type of Inventory then one must do so to be consistent in striving for the goal. Selling this type of Inventory implies that its sale generates more profits than continuing its usage to convert raw material into sold goods. This explains why organisations are sold as running concerns.
  - Raw materials inventory, work in process (WIP) inventory and finished goods inventory are the other type of "Inventory".
- If Inventory decreases (by e.g. reducing work in process) while Throughput and Operating Expense remains level, there will be a direct impact on ROI and cash flow, but not on net profit, because net profit is defined as Throughput – Operating Expense.
- There is however an indirect impact on Operating Expense and Throughput. Table 4-2, adopted from Swain, Bell [1999:17], illustrates the indirect effect of Inventory reduction on net profit from a Generally Accepted Accounting Practices (GAAP) point of view as well as from an Throughput Accounting perspective:

	GAAP Basis			*Throughput Basis*		
	Scenario 1 Constant Inventory	**Scenario 2 Build Inventory**	**Scenario 3 Shrink Inventory**	**Scenario 1 Constant Inventory**	**Scenario 2 Build Inventory**	**Scenario 3 Shrink Inventory**
Sales	100 tons	100 tons	100 tons	100 tons	100 tons	100 tons
Production	100 tons	110 tons	90 tons	100 tons	110 tons	90 tons
Revenue	R 500,000	R 500,000	R 500,000	R 500,000	R 500,000	R 500,000
- Materials	R 50,000[a]	R 50,000[a]	R 50,000[a]	R 50,000[b]	R 55,000[c]	R 45,000[d]
Throughput	R 450,000	R 450,000	R 450,000	R 450,000	R 445,000	R 455,000
- Conversion Cost	R70,000[e]	R63,636[f]	R77,778[g]	R70,000[h]	R70,000[h]	R70,000[h]
- Selling & General Admin. Expenses	R 350,000	R 350,000	R 350,000	R 350,000	R 350,000	R 350,000
Net Profit	R30,000	R36,364	R22,222	R30,000	R25,000	R35,000

Table 4-2 : Inventory Effects of GAAP versus Throughput Accounting

Assumptions

1. Sales Price is R5,000 per ton
2. Materials Costs are R500 per ton
3. Conversion cost (labour and manufacturing overheads) is R70,000 per period.
    a. 100 tons sold × R500 per ton
    b. 100 tons produced × R500 per ton
    c. 110 tons produced × R500 per ton
    d. 90 tons produced × R500 per ton
    e. 100 tons sold × (R70,000 ÷ 100 tons produced)
    f. 100 tons sold × (R70,000 ÷ 110 tons produced)
    g. 100 tons sold × (R70,000 ÷ 90 tons produced)
    h. Assumed fixed in the short run at R70,000 per period

- A reduction in inventory implies an increase in conversion cost on a GAAP basis. It wrongfully implies a negative effect on Net Profit because the conversion cost is allocated per product produced.
- On a Throughput Accounting basis the effect of reducing inventory is shown in the cost of direct materials. The reduction of inventory implies a reduction in products produced and therefore a reduction in direct material costs. This will increase Throughput and in turn increase the Net Profit.

- A second indirect impact of reducing Inventory that is not shown in the table, is on carrying cost. Carrying cost, which is also an Operating Expense, will also decrease if Inventory is reduced.
- A reduction in Inventory will decrease the average operating assets. This implies that the denominator in the ROI calculation becomes smaller and the result increases. Return-on-investment will increase if Inventory is reduced.
- Inventory has an influence on the operating activities, investing activities and the financing activities in the cash flow statement. A reduction in Inventory will lead to an increase in cash flow.

4.4.2.3. OPERATING EXPENSE

*"Operating Expense is all the **money** the system spends in turning Inventory into Throughput" [Goldratt, Fox; 1986:29].*

- All expenses are lumped together and thought of as one big fixed amount, in short all expenses except money paid to suppliers for raw materials.
- All employee time is generally "Operating Expense" (direct, indirect, sick, operating etc.), unless workers are paid per unit produced, a practice very seldom encountered today. This definition of Operating Expense includes not just direct labour, but also management, computers, and even secretaries.
- If there is a reduction in Operating Expense whilst maintaining the level of Throughput and Inventory, all three the financial measures will increase.
  - The link to the net profit is obvious. Net profit is defined as sales minus expenses. A reduction in expenses will increase the net operating profit.
  - If the net profit increases, it will lead to an increase in return-on-investment, provided that the operating assets stay constant. This is why we need to keep the Inventory portion constant or at least ensure that it doesn't increase.
  - By reducing the Operating Expense, it implies that less cash is being spent, which will have a positive effect on the cash flow at the end of the year.

Figure 4-3 illustrates these concepts in a graphic form:

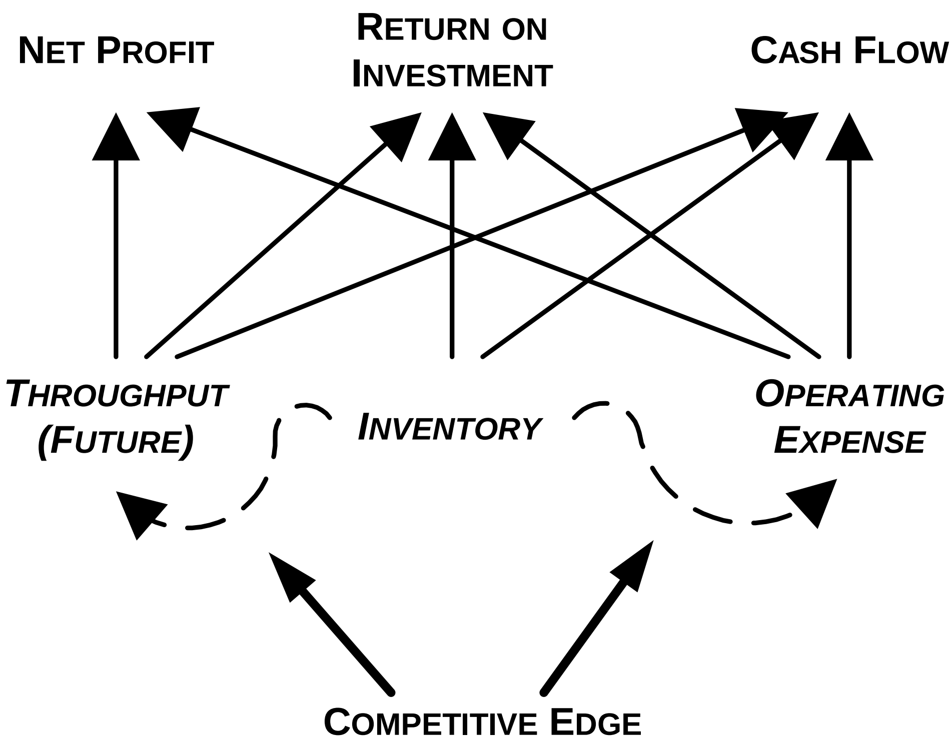

Figure 4-3: Competitive edge impact on the bottom line [Goldratt, Fox; 1986:67]

By implication Inventory influences the bottom line measures 8 times compared to the 3 times each of the other two measures. It is therefore a measure that cannot be considered lightly. Even though the impact of Inventory reduction is significant, it is still subordinate to an increase in Throughput. Inventory reduction also has a limit, mainly achieved in Just-In-Time (JIT) systems.

4.4.3. Application of TOC Performance Measures

The question is asked whether these performance measures should carry the same weight and if not, how they rank in relation to each other. In order to understand this relation we need to refer back the cost world and Throughput world as mentioned earlier in this chapter.

In the cost world:

- Decreasing Operating Expenses is definitely the number one measurement, because companies usually have relatively high control over their expenses.

- Increasing Throughput is always important, but it ranks second, because it is believed that companies are at the mercy of the marketplace and have less control over sales.
- The inventory portion tends to fall into a grey area; it is a necessary evil that must be lived with to protect sales, but too much is clearly bad.

In the Throughput world:

- Increasing Throughput is unquestionably number one, because it has the greatest potential impact on the bottom line and also has no upper limit.
- Decreasing Inventory is second, because excess work in process and finished goods jeopardise future Throughput.
- Decreasing Operating Expense is ranked third because significant reductions (which are usually capacity reductions) jeopardise future Throughput.

The actual question to be answered is *"How do you manage a company in a world where increasing Throughput is the number 1 priority, reducing Inventory second, and reducing Operating Expense is a tactic only after serious efforts at number 1 & 2?" [Sullivan, 1998:39]*.

The answer to this question will require a concerted effort driven from the top management of an organisation and implies (in most cases) a dramatic paradigm shift from our current operating practices.

4.4.4. Other Operational Performance Measures

In order for a company to achieve a good net profit, a high return on investment and a positive cash flow, it has to use some operational measures such as **efficiency, productivity** and **utilisation**. The question that TOC asks, is not about the validity of these measurements, but their usefulness as operational measures.

Take the case where more material is released for the purpose of improving the utilisation of a certain resource. If this resource can produce faster than the constraint (which it must be able to do since it is not the constraint), this improvement in utilisation will not increase sales and therefore not improve net profit and ROI.

Instead, work in process will increase, lead times will get longer and there will be more pressure on cash flow.

In a similar fashion, supposing a company spends money to improve the efficiency (do more with the same) of a non-constraint resource. One will not increase shipments, but will probably increase work in process, and will both increase Inventory and Operating Expenses and again not improve net profit and return on Inventory.

4.4.5. The Process of Ongoing Improvement

It may be relatively easy to conceptually recognise that an organisation must have a constraint, but it may be quite another thing to positively identify it. The five-step process of ongoing improvement has been developed to provide the steps necessary to deal with the constraint.

4.4.5.1. IDENTIFY THE SYSTEM'S CONSTRAINTS

In order to manage a constraint, it is firstly necessary to identify it. This knowledge will help the company to determine where an increase in efficiency and utilisation would lead to increased profits.
Concentrating on a non-constraint resource would not increase the Throughput because there would not be an increase in the number of orders fulfilled. There might be local gains, such as a reduction or elimination of the queue of work in process, but if that material ends up waiting longer somewhere else, there will be no global benefit. To increase Throughput, flow through the constraint must be increased.

The constraint of the company is not always an internal capacity constraint. In a lot of cases it is the market (i.e. the facility can produce more than the market demands). The constraint can also be some kind of policy or procedure that limits the Throughput of the organisation. An example of a policy constraint is something like "*customers must have credit card accounts to buy our products. This policy immediately prevents any sales to people without credit card accounts and can become a constraint" [Swain, Bell; 1999:13]*.

One of the easiest ways to see where the constraint (without using calculations or rated capacities) is situated, is to study the build-up of work in process inventory in a system. The constraint is the operation with the highest pile of work in process inventory.

Four scenarios can exist in an operation [Goldratt, Fox; 1986:85]. The type of operation will determine where the excess inventory in the system will accumulate.

Figure 4-4 defines the different scenarios that can exist with a constraint operation.

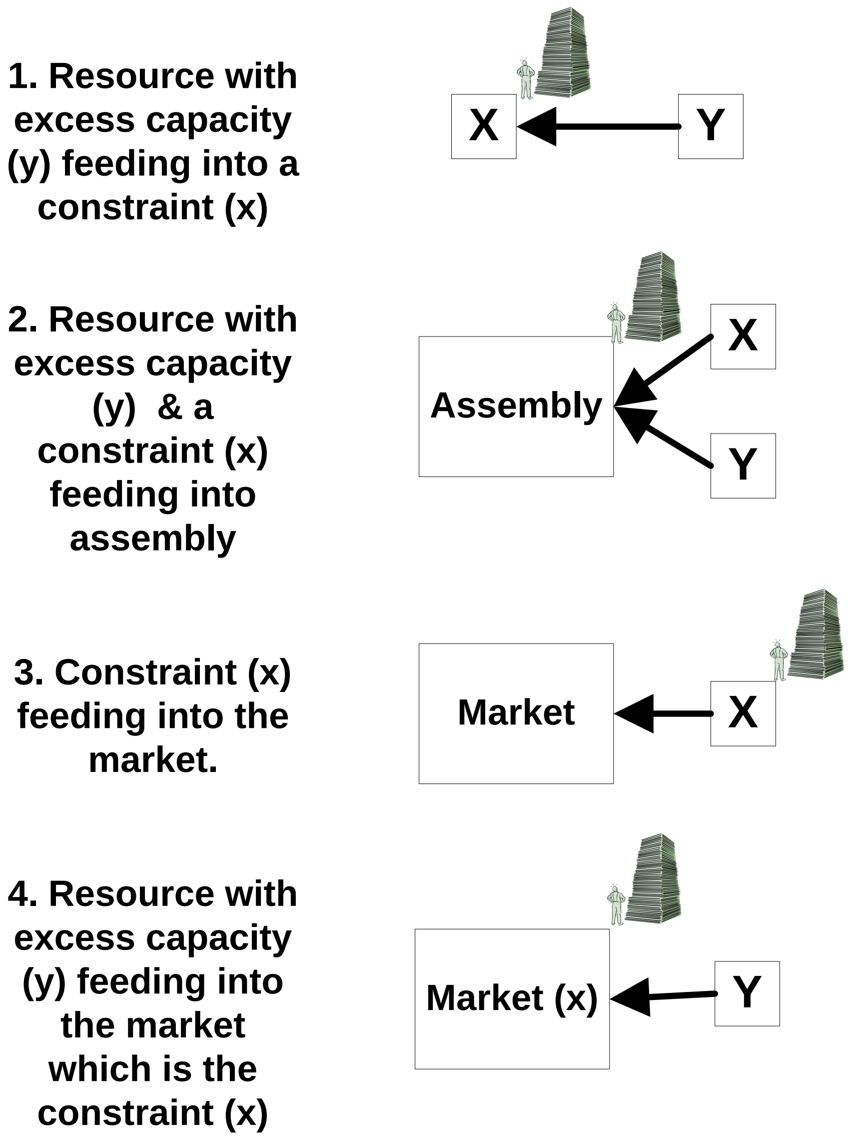

Figure 4-4: The cause of excess inventories [Goldratt, Cox; 1992:207]

In almost all the cases the build-up of work in process inventory is directly in front of the constraint, except in the second scenario where the constraint feeds into an assembly operation. There will probably still be a build-up of work in process in front of the constraint, but in this situation the build-up will be in front of assembly because a non-constrained resource is also feeding the assembly line. The work in process inventory in this case will consist mainly of the products from operation Y.

4.4.5.2. DECIDE HOW TO EXPLOIT THE SYSTEM'S CONSTRAINTS

Once the constraint is identified, the next step is to focus on how to get more production within the existing capacity limitations, providing it is a physical constraint. Goldratt [1992:297] refers to this as exploiting the constraint. There normally are many innovative ways to increase the constraint's capacity without necessarily having huge capital expenditures. In more cases than not, the constraint is usually in the market, but the principle is still the same; get the most out of a scarce resource, do not waste it! Policy and behavioural constraints cannot be exploited or subordinated to as they are inherently wrong and do not relate to scarcity of capacity. In these cases it must be elevated (removed) and replaced with valid policies and positive behaviour.

4.4.5.3. SUBORDINATE EVERYTHING ELSE TO THE DECISION OF EXPLOITING THE CONSTRAINT

Exploiting the constraint does not ensure that the materials needed next by the constraint will always show up on time. This is often because these materials are waiting in queue at a non-constraint resource which is working on something that the constraint doesn't need yet. Subordination is necessary to prevent this from happening. The principle of subordination is to schedule your non-constraints in such a way that the constraint never has to incur any idle time by waiting for material, even if the non-constraint has to stop in the middle of a batch or do an extra set-up. This usually involves significant changes to current (and generally long established) ways of managing the non-constraint resources.

The non-constraint resource requires what TOC calls “sprint capacity”. Consider a non-constraint resource which is situated after the constraint in the production process. If this resource breaks down, for whatever reason, it needs the capacity to be able to recover before creating a backlog that ultimately stops the constraint from producing. The same applies for a resource in front of the constraint.

After all the processes have been subordinated to the constraint, one may find that the constraint has been broken. This is normally referred to as Capacity Constrained Resources (CCRs). A CCR is a constraint because of a schedule or policy.

In some cases the constraint can be totally removed by adopting a different schedule. It is therefore necessary to check whether the constraint has been broken.

If the constraint had not been broken and performance is satisfactory, the process returns to exploitation of the constraint. If performance is not satisfactory the constraint should be elevated (step 4).

If the constraint has been broken another question arises: “Do you want the constraint to move?” It can be argued that the core competency which provides a competitive advantage should be the constraint of the organization. If the constraint is this core competency, do you really want to focus all your management attention and scarce resources on something else? A strategic decision may be made to leave the constraint and elevate the capacity of the non-constraint resources that have become constraints in the process.

4.4.5.4. ELEVATE THE SYSTEM’S CONSTRAINT

After the constraint has been identified, the available capacity exploited, and the non-constraint resources subordinated, the next step is to determine if the output of the constraint is enough to supply market demand. Elevation can be through increasing the capacity of the constraint resource, even outsourcing production. Elevation normally involves an investment to increase capacity and cannot be done immediately, versus exploitation, which has very little cost and can be done in a relatively short period of time.

4.4.5.5. IF THE CONSTRAINT HAS BEEN BROKEN IN A PREVIOUS STEP, GO BACK TO STEP 1 BUT DO NOT ALLOW INERTIA TO CAUSE A NEW CONSTRAINT

Once the output of the constraint is no longer the factor that limits the rate of fulfilling orders, it is no longer the constraint. Step 5 is to go back to Step 1 and identify the new constraint – because there always is one. Inertia refers to the inertia not to remove old rules and policies. In the previous steps rules and policies were set up to exploit, subordinate and elevate the constraint. Once the constraint is broken, these rules, policies and procedures are no longer valid because there will now be a new constraint and must be removed. If not, these rules and policies will become the next constraint. The five-step process is then repeated.

4.4.6. Application of the five-step process

A prerequisite to applying the five-step process of ongoing improvement is to define the goal of the organisation. As discussed earlier, the goal of the organisation has to be to make money now, as well as in the future. This reasoning has been described in greater detail by a number of authors, e.g. Sullivan [1998:1]. The goal of the company will never be achieved if constraints have not been identified and managed. In turn constraints cannot be managed if not measured. The measures will indicate to the personnel working in the company whether every action they take and decision they make will bring them closer to the goal.

A number of companies have identified a constraint in their organisation and then set out feverishly to remove the constraint, without the intention of measuring or managing the process or policy. The opposite is also true, that the companies have an enormous drive to maximize performance targets without having identified constraints within the organisation. Both of these actions will not bring the company any closer to the goal. These two actions (identifying the constraint and defining performance measures) cannot be separated from each other or done in isolation.

Figure 4-5 has been drawn up to explain the steps and decisions involved in the five-step process of ongoing improvement [PJ Pretorius, personal communication, 12 December 2001]:

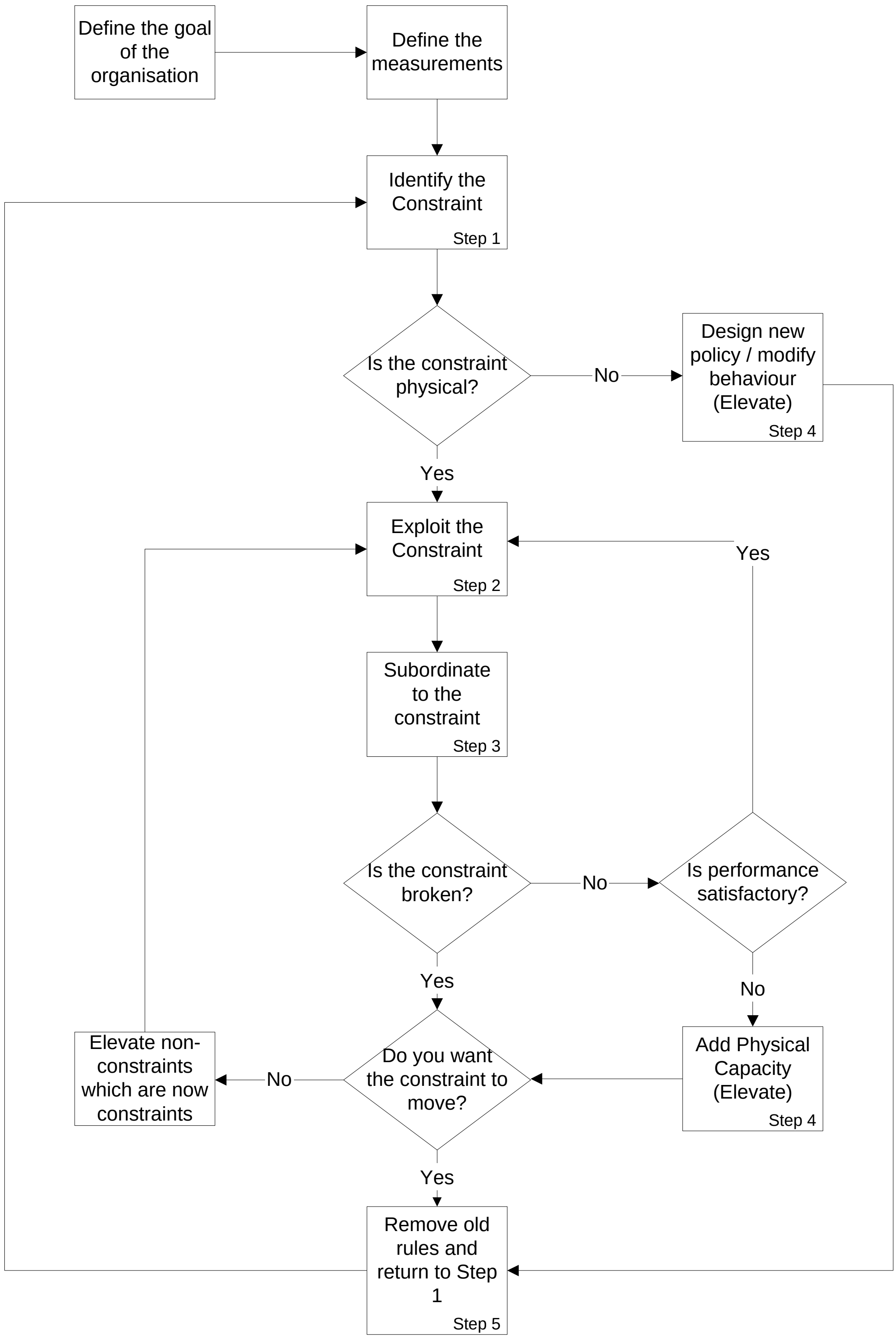

Figure 4-5: The Five-Step Process of Ongoing Improvement

If the constraint of the system is not a physical constraint, i.e. it is a policy or procedure, the process will immediately move to step 4. A new policy has to be designed or a procedure put in place to modify behaviour. The Thinking Process was developed to address this area and will be explained later in the chapter.

A fundamental principle of TOC is that the combination of dependent events (such as the steps in a production system) and statistical variation (or "Murphy" who is always present) makes it literally impossible to ever fully balance a line. There will always be a constraint in the system. What creates chaos is allowing the constraint to move around and a so-called "balanced" system will always experience a moving constraint due to statistical variation. For that reason, "*companies that get the greatest financial benefit from TOC are those that make a strategic choice of where they want the constraint to be. They then manage their entire operation (product design, marketing, capital, inventory, hiring, etc.) accordingly. This allows the company to manage the constraint to their advantage rather than allowing the constraint to manage them*" *[Noreen, Smith & Mackay 1995:1]*.

4.5. Synchronous Manufacturing

"Synchronous Manufacturing refers to the entire production process working together in harmony to achieve the goals of the firm. Synchronous manufacturing logic attempts to coordinate all resources so that they work together in harmony or are synchronized. In such a synchronous state, emphasis is on the total system performance, not on localized performance measures such as labour or machine utilization" [Chase & Aquilano, 1995:755].

Goldratt [1986:72] uses the analogy of a troop of soldiers on a forced march to illustrate the concept of synchronised manufacturing. The road that the soldiers march on is the material being processed. Each of the soldiers represents a machine or process. The weakest soldier is the one that marches the slowest and is therefore the constraint in the system. The spreading of the troops on route represents the work in process inventory. Closely packed troops mean lower inventory, while spreading troops represent high inventory.

A scheduling system called the Drum-Buffer-Rope approach was defined to ensure that process is synchronised, taking the constraint into consideration.

Since the weakest soldier determines the pace, the first soldier should not be allowed to go faster than the weakest soldier does, otherwise the troop would spread. This is achieved by tying a rope from the weakest soldier to the first soldier in the row. The soldiers following the weakest soldier will be able to march faster than him and consequently they will be always on his heels (no spreading). The first soldier could also march faster than the weakest soldier, but is constrained by the rope to march at the same speed as the weakest soldier. The soldiers between the weakest soldier and the first soldier are also faster than the first soldier and will therefore be on the first soldier's heels. The only spreading will be right in front of the weakest soldier. The length of the rope will determine the size of this gap.

- The drum is the pace of the troops and is dictated by the weakest soldier. In practice this means that the constraint of the system will determine the Throughput and Inventory levels of the plant.
- The rope tied to the soldier in front is the release of raw materials. The raw material release for the first process will determine the amount of work in process Inventory in the system. This should be in synchronisation with the constraint operation.
- The slackness of the rope will provide a time buffer for the constraint operation to ensure that the constraint keeps occupied all the time. The size of the buffer will be determined by the amount of statistical variation before the constraint to make sure that there will always be work waiting for the constraint, irrespective of breakdowns before it.

4.6. Drum-Buffer-Rope Scheduling & Buffer Management

The APICS Dictionary [Cox III, Blackstone; 2002:36] defines **Drum-Buffer-Rope** as *"a generalized technique used to manage resources to maximize 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 maximize Throughput.*

The rope is a communication process from the constraint to the gating operation that checks or limits material released into the system to support the constraint."

Another definition [Smith; 2000a:98] describes Drum-Buffer-Rope as *"a method of scheduling manufacturing plants based on identifying the resources that constrain the plant's output. By scheduling and managing the constraining resources, the plant can manage the entire operation using exploitation and subordination techniques described in the five-step TOC process."*

It is clear that Drum-Buffer-Rope is a technique used to exploit the constraint of the system. The constraint determines the pace at which the plant operates and everything else is subordinated to it.

"Buffer management, in turn, is a process in which all expedition in a shop is driven by what is scheduled to be in the buffers. By 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 occurrence is used to prioritise improvement activities" [Cox, Spencer; 1998:18].

To implement the five-step process, the company has to first identify the constraint and then exploit it in the second step. Goldratt [Goldratt, Fox; 1986:98] developed a technique to ensure that the constraint is exploited and the other resources subordinated to the constraint. Through implementing this scheduling technique and applying buffer management the benefits of TOC can be realized.

DBR assumes that the constraint is a physical constraint and not a policy or procedure.

The following questions and answers were defined during the implementation of a DBR schedule and are intended to be used as a guideline for other implementations [Smith 2000a:98 – 103].

1. ***What is a drum?*** A drum is a strategic operation that has limited resources and determines the flow of work through the system.

A system can go only as fast as the slowest or most overloaded resource. This resource is the constraining resource and is used in the second step of the five-step process, as the drum.

The drum is the Master Production Schedule (MPS) for the constraint. "*Under material requirements planning (MRP), the Master Production Schedule is a statement of time-phased production requirements for the item to meet the customer requirements. Under Constraints Management, the MPS is the plan of action at the constraint*" *[Cox, Spencer; 1998:74].*

2. ***What is a buffer?*** A buffer is a pocket of time represented by work in process which is reserved in front of the drum, the constraining resource, and the shipping due date. The buffer is to protect the due dates of the drum schedule and the shipping schedule. Buffers protect the ability to keep the drums from starving and give a protective cushion to ensure on-time shipping. Successful execution of the Master Production Schedule (drum) is performed by managing the buffers.

3. ***What is the rope?*** The rope is the length of time necessary to accomplish processes in front of the drum or shipping dates. Quantifying the time necessary to complete the processes in front of drums and shipping establishes the necessary release date to support the drum and shipping schedules.

4. ***How do we measure the rope release performance?*** Monitor on-time releases to the schedule to support the drum schedule and or non-drum operations to support the shipping schedule. This is part of subordination.

5. ***How do we know the rope is the right length?*** If parts arrive within the buffer times at the buffers in front of the drums and shipping, the rope is of the right length. Parts arriving early or late to the buffer reveal a problem in performing to the rope length.

6. ***How do we measure everyone else's performance to support DBR?*** Subordination tracked by on-time material release to the floor and support of the drum/shipping schedule tracked by buffer management at the drum buffer and the shipping buffer. The longer work waits in an area to be worked, the farther the part will penetrate into the buffer. Tracking holes in the buffer to root causes or areas with queues, reveals areas in the shop in need of subordination; the improvement process should be focused here.

   The solution is to send resources, improve fixtures and training, reduce setups, offload to other areas - whatever is needed to increase flow. Subordinate as an organization to make sure this area gets all the help it needs.

7. ***What is sprint capacity?*** Sprint capacity is an area's ability to catch up when it gets behind schedule and also help other areas that may be behind schedule. Sprint capacity defines an area's ability to recover from a typical "Murphy" (late parts, machine downtime, operator absence, quality rework problems).

As can be seen above, Drum-Buffer-Rope is a production planning tool devised to implement the theory of constraints in an organisation. This tool will be further exploited in later chapters when applied to the processes in Rosslyn Brewery.

The other production-planning tool used widely in industry is Just-in-time (JIT). At first glance it seems that Constraints Management (CM) and JIT are in conflict, but in fact both of these methods try to achieve the same objective of eliminating waste from the production process through the use of continuous improvement to achieve the organizational goals.

"JIT attacks the production problem by a rigorous assault on the causes of statistical variability. As a result, over time a steady flow of material is achieved which greatly eliminates waste from the system. The driver of continuous improvement is inventory reduction throughout the system" [Cox, Spencer; 1998:98].

"Under Constraints Management, inventory is removed from all operations except where it provides strategic benefits. The CM approach uses inventory to reduce the impact of statistical variability.

Throughput and due date performance are protected, while JIT tools can be implemented to eliminate the cause of statistical variability" [op cit].

4.7. The V-A-T Logical Structure Analysis

"Businesses are often viewed as either product centred, comprised of marketing and sales, or production centred, compromised of engineers and planners. This functional view of a business can often lead to good managers making bad decisions" [Cox, Spencer; 1998:101].

The V-A-T Analysis is an approach that breaks down the traditional barriers and views the organisation as an interaction of both products and processes. By seeing the organization in this systems view, three general categories of production structures emerge, each structure requiring a different approach to management planning and control.

4.7.1. The T-shaped Logical Structure

The first structure is the T-shaped structure, depicted in Figure 4-6, which is most common in modern production facilities. The most common characteristic of a T-shaped logical structure is that it is possible to deliver numerous combinations of end products from a limited number of similar steps. Final assembly and delivery are typically based on actual customer orders assembled from standard components that are stocked.

"Typically, management erroneously perceives the problem as a need for better forecasting, improved inventory control in warehouses and reduced unit cost by controlling overtime and set-ups and introducing automation and simplified designs" [Chase, Aquilano; 1995:774-775].

The major problem in this structure is misallocations of orders to customers. Management can focus on relatively few control points by creating a buffer to protect the Throughput of the constraint.

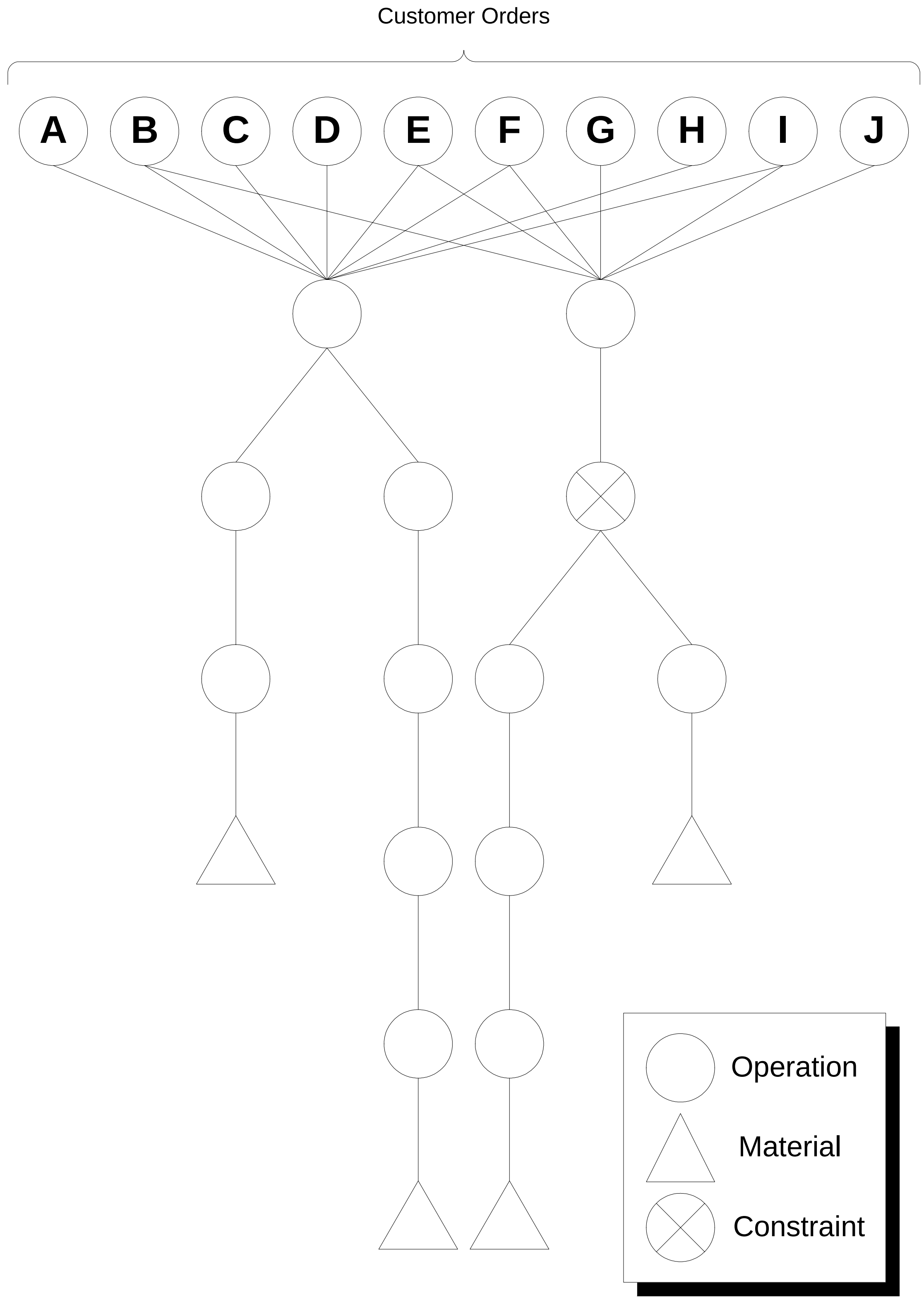

Figure 4-6: T-shaped Logical Structure [Cox, Spencer; 1998:110]

4.7.2. The V-shaped Logical Structure

Where the T-shaped structure is commonly found in consumer products such as appliances and valves, the V-shaped structure is typical in process industries. Figure 4-7 shows an example of a typical V-shaped logical structure. Examples of V-shaped plants include textiles, oil refining, steel, chemical, paper, film and plastic manufacturers.

"*In a V-plant there are few raw materials and they are transformed through a relatively standard process into a much larger number of end products*" *[Chase, Aquilano, 1995:772].*

Problems that occur in a V-plant show up as poor customer service, poor delivery and high inventory of finished goods. Another characteristic is that normally, once a product has passed an operation, the material can not be rerouted to a different product.

The divergent control point dominates the V-shape structure, while the convergent control point dominates the T-shaped logical structure. The management of these control points is similar. The constraint sets the system Throughput pace and is scheduled as the drum of the operation. A buffer is created to protect the constraint from any disruptions from previous activities. In many cases the constraint is located at the divergent operation, making the allocation of the correct time, in the space buffer after the constraint, crucial to the operation.

The gating activity is managed in the same manner as with the T-structure. Management of material release is usually easy because generally only one gating activity exists, compared to the several possibilities in the T-structure.

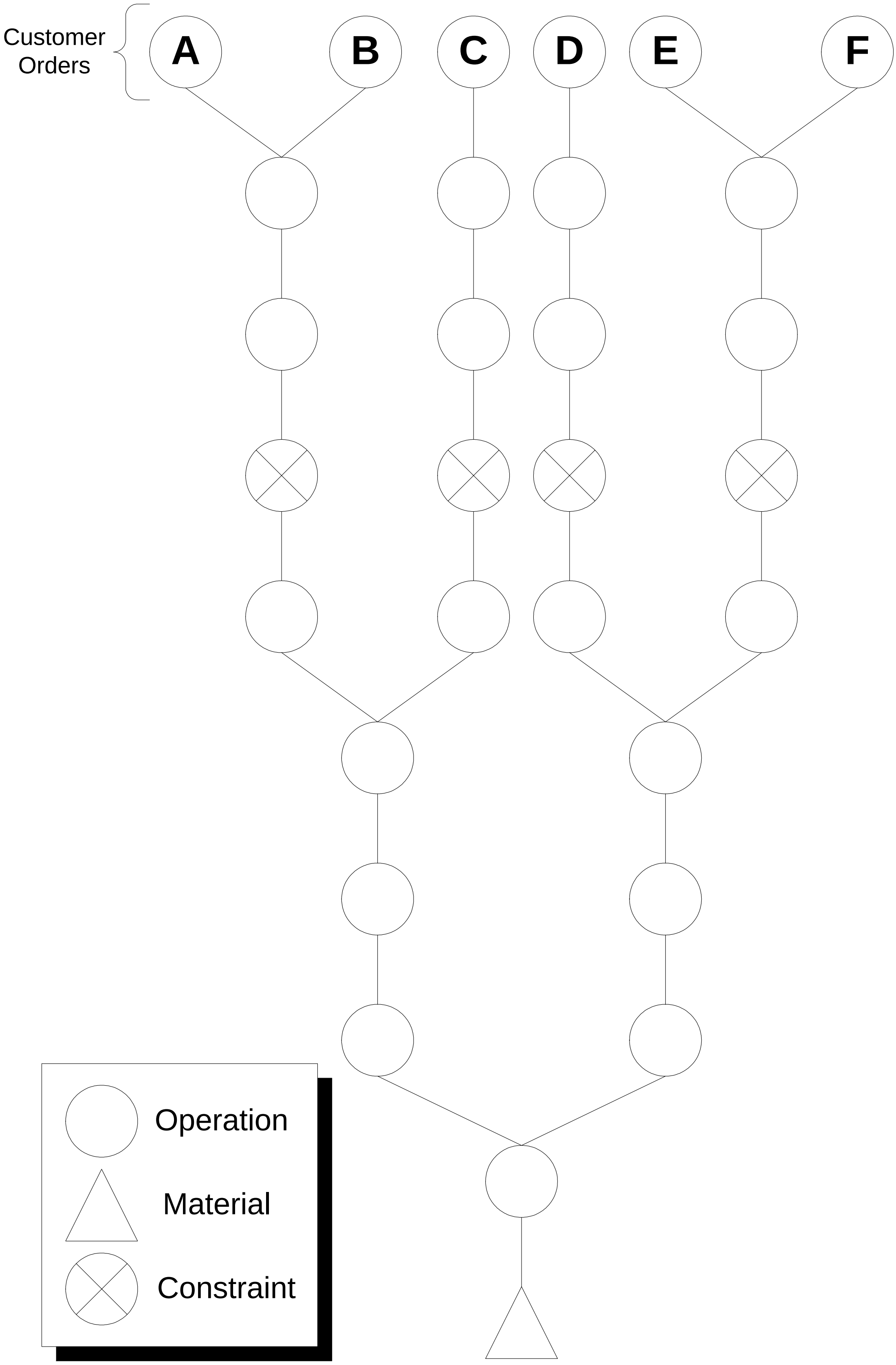

Figure 4-7: V-shaped Logical Structure [Cox, Spencer; 1998:113]

4.7.3. The A-shaped Logical Structure

"The A-structure is characterised by having numerous combinations of activities that are required to provide relatively few end items for customer orders" [Cox, Spencer, 1998:115].

As was the case with the T-structure there are points where different products converge to complete a single order. However, in an A-structure (Figure 4-8), there are activities that occur after the convergence of the resources, and the A-structure tends to have fewer common components and tends to supply fewer end items to final customers than the T-structure. Another unique characteristic of the A-structure is the wide variety of routings, or sequence of activities, that are required to fulfil customer orders.

The A-structure is often found in a job shop serving industries such as aerospace, planes, automotive and capital goods.

The constraint is more difficult to detect in an A-structure and like in the case with the T-structure the convergent or assembly point is used as the gating operation.

As is the case with a generic Drum-Buffer-Rope implementation, the structures above are defined to determine the key focus points in the system that will determine the Throughput of the operation.

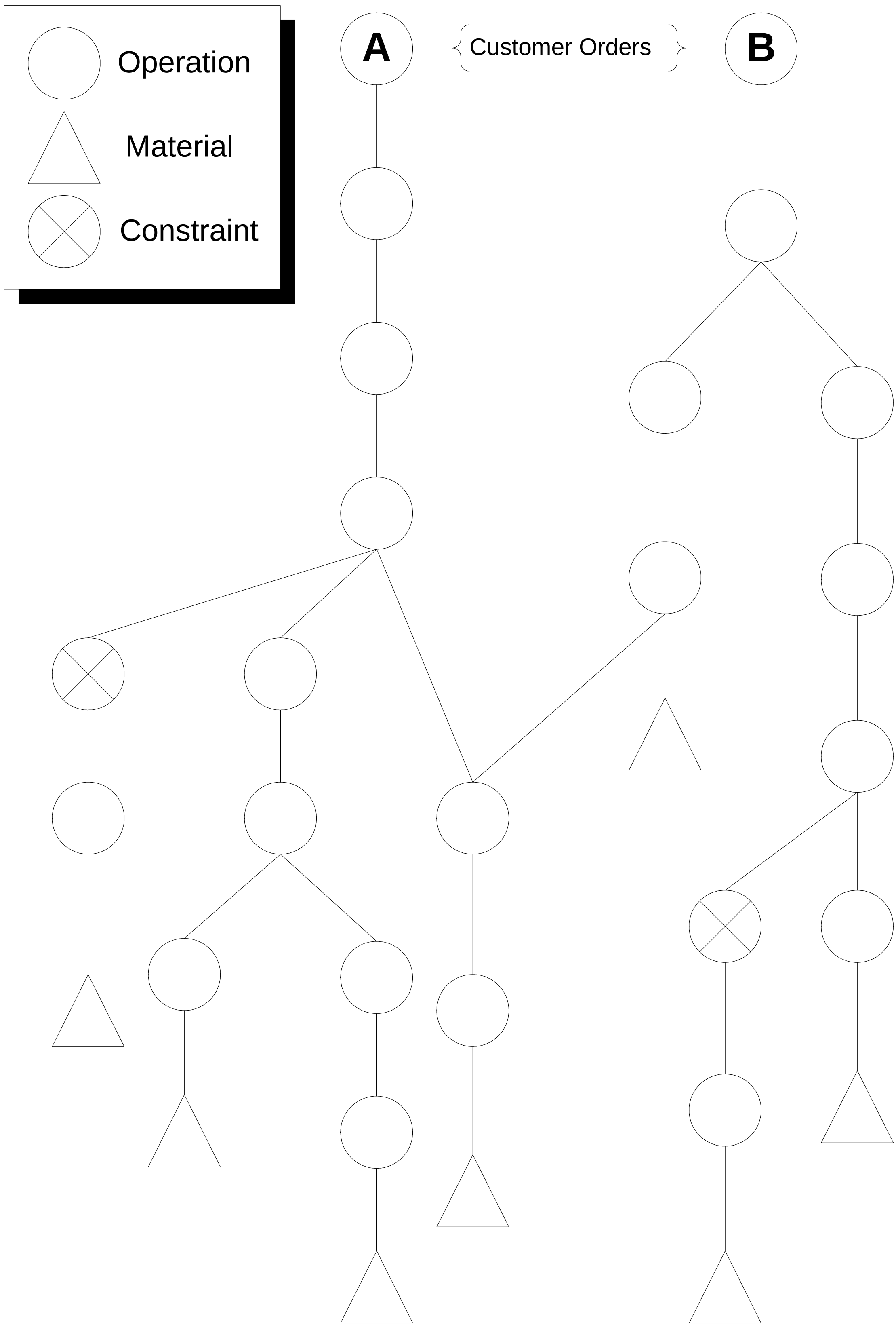

Figure 4-8: A-shaped Logical Structure [Cox, Spencer; 1998:1998:116]

4.8. The Thinking Process

In situations when the constraint is not as easily sighted, the Thinking Process will provide the tools necessary to identify the core problem or core conflict and the tools needed to deal with it effectively.

The Thinking Process is a set of problem-solving tools defined by Goldratt. It involves the rigorous application of effect-cause-effect logic to answer the following three questions:

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

4.8.1. What to Change?

The first question is the equivalent to the first step of the five-step process of ongoing improvement: "Identify the Constraint." Since these processes are generally used when the constraint is not a physical resource, there usually is no physical evidence (such as work in process inventory) to point one to the constraint. Instead one has to map out what is currently going on in the system. The core conflict is derived from the three-cloud technique and the logic mapped in a cause-effect structure called the "Current Reality Tree."

There are three primary steps to answer the question: "What to change?"

1. Identifying the core conflict
2. Validating the core conflict
3. Identifying the policies, measurements and behaviour supporting the Undesirable Effects (UDEs)' existence.

4.8.1.1. Identifying the Core Conflict

As a prerequisite to identifying the core conflict a list of all the Undesirable Effects (UDEs) should be drawn up. *"Undesirable Effects are the systems problems. They are unavoidable derivatives of the core problem" [Goldratt, 1994:95].*

Undesirable Effects always have one thing in common and that it that they cause conflict in the organisation. *"The conflict might be between existing policies, measurements and behaviours and what we think they should be, or inconsistencies across the different parts of an organisation and how they operate" [Houle, 2001:104].*

An UDE should be…

- a complete statement.
- an effect, not a presumed cause.
- something that exists in today's reality.
- negative in its own right.
- not a presumed solution.
- a single effect.

A good example of stating UDEs is when you are sick and visit a doctor. The first thing he does is to ask you to list all the symptoms that you experience. UDEs should be a list of symptoms that you complain about. A general rule is to list between 7 and 10 UDEs, otherwise the process becomes to cumbersome.

The three-cloud process was designed to bring order to the number of UDEs listed in the first step. Each of the UDEs is expressed as a conflict between two opposing sides in an Evaporating Cloud Diagram.

What is an Evaporating Cloud in TOC terminology?

"The cloud is a logical diagram of conflict designed to force us to examine our logic around why we are insisting we must take certain actions. Examining the reason why we believe the action is necessary can cause us to come up with a breakthrough solution to our conflict. The solution is only a win if both sides of the conflict's needs are protected" [Smith, 2000a:103].

Figure 4-9 is an example of a generic cloud diagram. The diagram is drawn up by writing down an action associated with the UDE in block D.

The second step is to write down the exact opposite of the action in block D'. This would be the action you would prefer to see.

The third step is to write down what need you are trying to satisfy with the action in D, or if you can not identify a need, to write down why you tolerate the action in D. On the opposite side of the diagram the need for D' is written down or the question, what is being jeopardized by D, answered. The last step of drawing up the cloud diagram is to write down what is the common objective being achieved with both the needs in B & C.

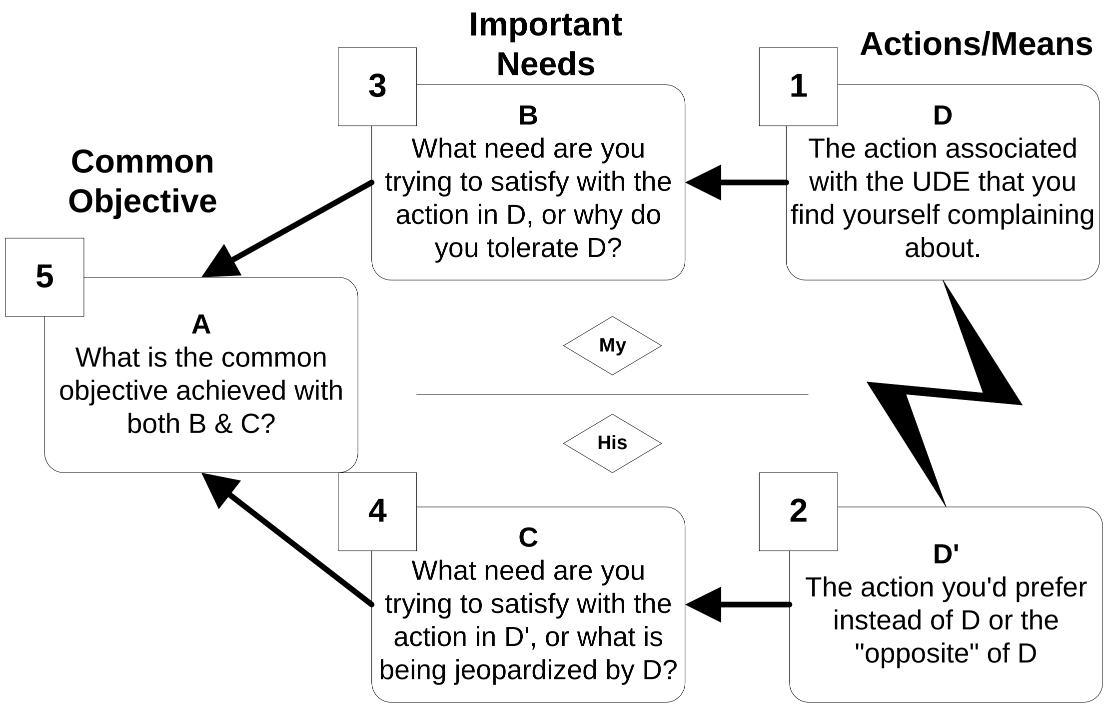

Figure 4-9: Evaporating Cloud Diagram [Houle, 2001:114]

The three-cloud process selects three UDEs and builds an evaporating cloud diagram for each. Out of these three cloud diagrams a core conflict cloud (C^3) is drawn. This cloud summarizes all of the one-UDE clouds.

4.8.1.2. VALIDATING THE CORE CONFLICT

"To validate that we have correctly identified the core conflict, we use a Current Reality Tree (CRT). Using rigorous, lock-tight, cause-and-effect logic, you attempt to build a Current Reality Tree that shows precisely how the three-cloud diagram unavoidably causes each of the UDEs to exist" [Houle, 2001:107].

The Current Reality Tree is drawn up by turning the three-cloud diagram on its head and linking all the remaining UDEs to the actions D & D'. If you are able to connect all the UDEs, you have proved that you have correctly identified the core conflict.

4.8.1.3. IDENTIFYING THE POLICIES, MEASUREMENTS AND BEHAVIOURS SUPPORTING THE UNDESIRABLE EFFECTS (UDES)' EXISTENCE.

For each of the UDEs there will be a policy or procedure, behaviour and measurement that allow the UDE to exist. The final step in what to change is to identify these policies, measurements & behaviours (PMBs).

"*If you want to resolve the UDEs once and for all, you must identify the formal/informal PMBs that allow the UDEs to persist and remove or modify them*" *[Houle, 2001:221]*.

There are two complementary techniques used to identify PMBs:

- Brainstorming
- A systematic, step-by-step, logical process

The "Jonah" course developed a detailed 20 step process for constructing a Current Reality Tree and is recommended for readers interested in Thinking Process tools.

4.8.2. What to change to?

There are four phases in answering this question:

1. Finding a way to break out of the core conflict
2. Defining the Desired Effects (DEs) and Strategic Objectives (SOs) of the solution
3. Constructing a complete solution that resolves all of the UDEs
4. Not creating any new negative effects

4.8.2.1. BREAKING THE CORE CONFLICT

"In the three-cloud diagram the core conflict has been identified. Breaking this conflict will provide the starting point for constructing a complete solution.

Behind each and every arrow in the three-cloud diagram, exists at least one logical assumption. Each assumption provides opportunities to "evaporate the cloud" and finally break the core conflict that is causing all of the UDEs" [Houle, 2001:265].

This is referred to as an injection. The injection is the breakthrough idea that will get rid of the conflict between the actions defined in D & D'. The first step in answering the second question is to write down the injection for the three-cloud diagram.

4.8.2.2. DEFINING DESIRED EFFECTS AND STRATEGIC OBJECTIVES

The second step is to write down a desired effect for each of the UDEs identified in the first step. The Desired Effects is not enough to achieve the goal of the company and therefore strategic objectives must also be listed.

"*We define strategic objectives so that we may later ensure the complete solution is aligned with the global, long-term objectives of the system overall*" *[Houle, 2001:270].*

A Future Reality Tree is then constructed in the same fashion as a Current Reality Tree with the difference that the injection is used as a starting point and the DEs & SOs linked to it. The purpose of the Future Reality Tree is to identify what additional things need to be put in place to guarantee that the Desired Effects will be unavoidable effects of implementing the whole solution.

4.8.2.3. CONSTRUCTING A COMPLETE SOLUTION THAT RESOLVES ALL OF THE UDES

A number of changes have to be made to ensure that all the desirable effects and strategic objectives are realised. These changes are drawn into the Future Reality Tree and are called tactical objectives. The tactical objectives are defined to ensure that a complete solution is provided.

4.8.2.4. NOT CREATING ANY NEW NEGATIVE EFFECTS

The unintended negative consequences of the proposed solution are usually identified at this point, using what are called "Negative Branches".

If these bad things that result from a good action can be prevented, then one can be sure the cure will not be worse than the disease. The process of removing the negative branches is referred to as trimming the negative branch reservations.

4.8.3. How to change?

The third question is: "How to cause the change?" The simple answer is to involve the people who are going to have to live with the change to create the action plan that is needed for implementation. The Thinking Process pro-actively involves those who are most effected by the change. These people are solicited for their vision of what obstacles might prevent the organization from moving forward on this breakthrough solution. The workers are used to generate all the additional ideas that are necessary to implement the original injection. Once these are known, a plan is mapped out. The tools used when answering question 3 are the Prerequisite Tree and the Transition Tree.

There are five steps to answer the "how to change" question:

1. Chart the course by mapping out the dependencies between the injections and the tactical objectives e.g., which must be implemented first, second, third, which can be done in parallel, etc.

2. Then list all the obstacles to be faced when implementing each tactical objective and the immediate objective to be used to overcome them. Finally sequence the immediate objectives into a roadmap for implementing the complete solution, a Prerequisite Tree.

3. The next step is essential because the challenges of implementing the technical obstacles pale in comparison to getting the active collaboration of key players needed to approve and implement the solution. This crucial step is learning how to systematically get someone's buy-in. Use the TOC's 6 steps to buy-in as the framework on which Transition Trees are to build to design specific buy-ins.

The six steps to buy-in are:

- Get consensus on the core problem (three-cloud diagram & Current Reality Tree).
- Get consensus on the direction of the solution (three-cloud diagram)
- Get consensus that the solution solves the problems and achieves the desirable effects and strategic objectives (Future Reality Tree).
- Ensure all significant negative side effects have surfaced and been trimmed (negative branch reservation).
- Ensure all major obstacles to implementation have surfaced and addressed (Prerequisite Trees).
- Ensure the commitment of all leadership to making the implementation successful (leadership commitment).

4. Now that one has the approval and active participation of all the key players needed for the implementation, one give substance to all the detailed actions required to implement the immediate objectives and the tactical objectives on the Prerequisite Tree. In this process, the Transition Tree is employed to precisely design action plans where there is any doubt of complete success.
5. Finally, the results of the previous step are transformed into a detailed project plan to synchronize and manage all of the resources involved to implement the complete solution throughout the entire system for which it was designed.

4.9. Constraints Management

Theory of Constraints consists of the following components [Cox, Spencer, 1998:15-16]:

1. A logistics branch, with the scheduling methodologies of Drum-Buffer-Rope and buffer management, the V-A-T logical structure analysis and the five-step focussing process

2. A second branch consisting of the performance measurement system, specifically focussing on Throughput, Inventory and Operating Expense, the product mix decisions and applying Throughput dollar days and Inventory dollar days.

3. A third branch concerning the Problem Solving / Thinking Processes consisting of effect-cause-effect (ECE) diagramming and its components, the ECE audit process and evaporating cloud methodology.

Constraints Management is a synonym for TOC to overcome the connotations of the term “theory”.

Figure 4-10 is a diagram illustrating the different aspects of the theory of constraints.

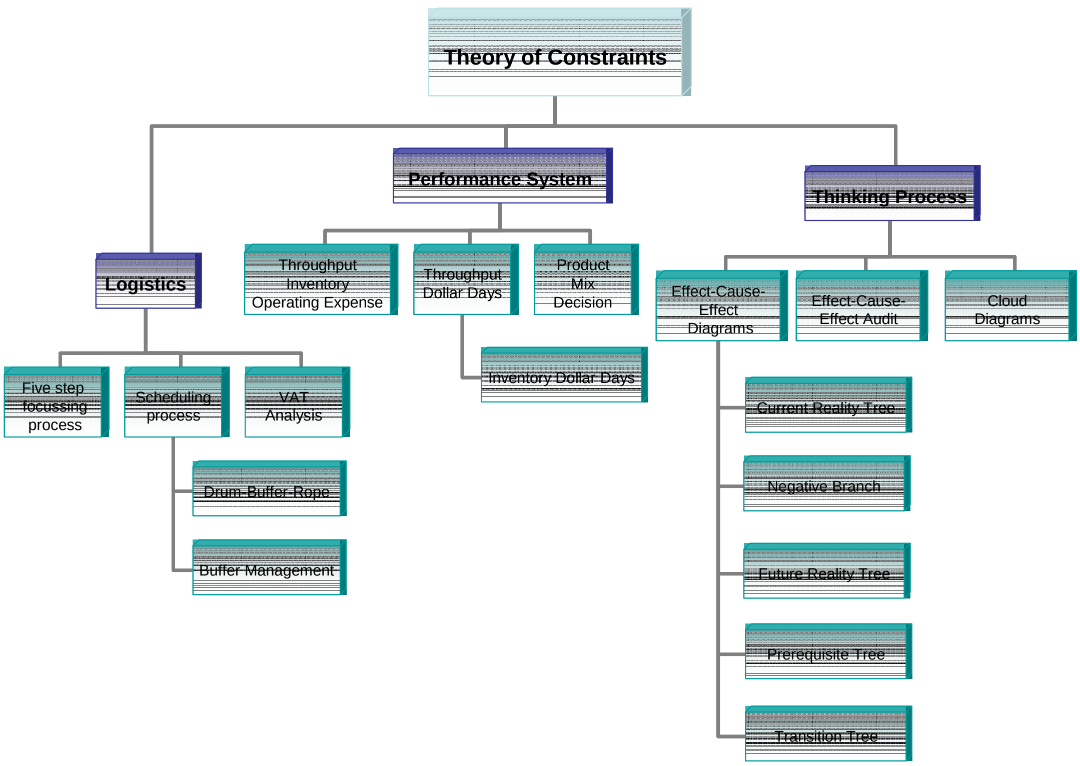

Figure 4-10: Diagram of Constraints Management

4.10. Conclusion

This chapter gave a general overview of the Theory of Constraints and the different tools available to help a manager to focus his organisation on the goal of making money now, as well as in the future.

In the next chapter the performance measures used at Rosslyn Brewery will be described. The chapter will also indicate which measures are the “key drivers” in the brewery. These will then be tested against TOC principles in later chapters.

5. IDENTIFYING THE CONSTRAINT IN ROSSLYN BREWERY

It is not that I'm so smart. It's just that I stay with problems longer.
- Albert Einstein

5.1. Purpose

The purpose of this chapter is to explore the processes in Rosslyn Brewery to determine where the constraint is situated.

In the first section a general overview is given of the value chain and the capacities of the processes followed by a further, more detailed description of each section.

The constraint is identified and the reasoning behind the decision explained in the last section of the chapter.

5.2. Rosslyn Brewery Value Chain Capacities

The processes in a typical brewery have been explained in chapter 2. Figure 5-1 gives a graphical illustration of the processes and their rated capacities in the Rosslyn Brewery value chain.

For the purpose of analysis the value was divided into three sections. The first section includes all the processes from brewing up to maturation; the second from filtration up to packaging and the third section are the warehousing and distribution functions.

The first section has the typical characteristics of a batch process. This section is often referred to in the brewing industry as "brewing", although it encompasses the processes of fermentation and maturation as well. This section is the longest in the total cycle and takes 18 days to complete. Even though some blending can take place, these processes have to run through to conclusion once started. The characteristics of the product can not easily be changed in this section and whole batches of beer have to be dumped if there is a quality problem or if a batch has been produced that wasn't required.

The second section is more flexible, but still exhibits the characteristics of a continuous-batch process. The process rating is normally in hectolitres per hour (hl/hr) and a good estimate for one product to follow the cycle through the system is 1 – 2 days.

The third section comprises the warehousing and distribution processes. In this section the final product is delivered to the market. A quality standard has been set by SAB that no beer older than 28 days should be sold into retail, as it then runs the risk of going over the shelf-life of three months in the outlet before being sold. In reality the fast movers are sold (to the consumer) within a week and the slower movers within 3 to 4 weeks.

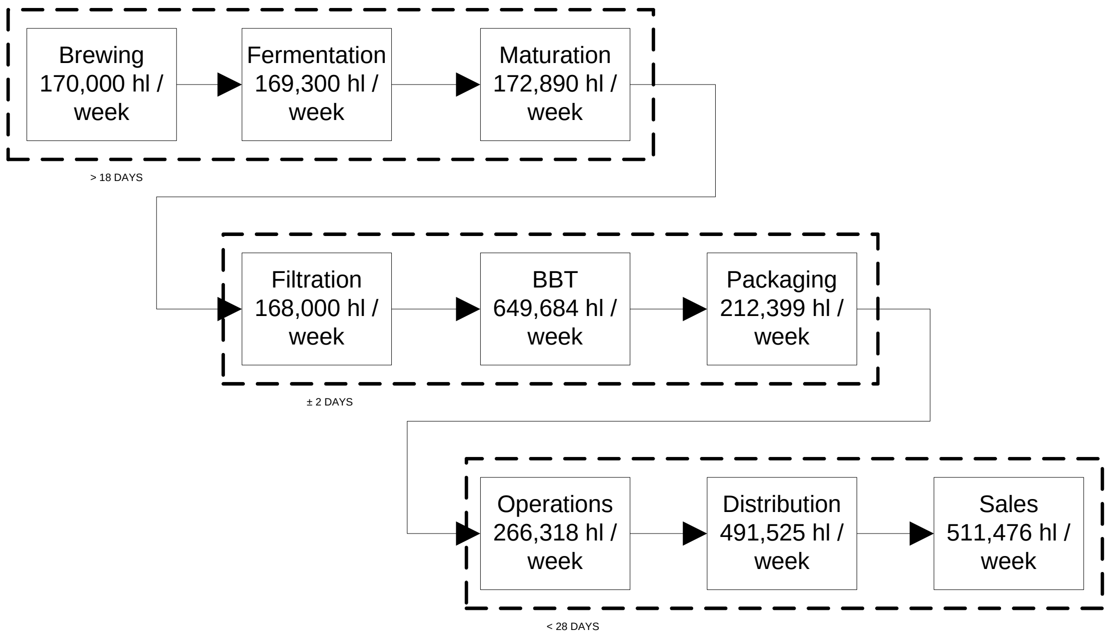

Figure 5-1: Value Chain Planning Process in Rosslyn Brewery

5.3. Analysis of Brewing to Maturation Capacity

The first section is a push system. The raw materials are added to the process and the brewing process started. The brews are then blended into the fermentation vessels and the yeast added and finally through the racking process blended again into the storage vessels.

In Rosslyn Brewery the beer is blended with other brews and vessels at least four times before packaging. The standard in some first world breweries is up to 20 blends before packaging.

This enables the breweries to provide a beer of consistent quality and taste. The storage vessels act as a work in process buffer during the normal periods. A normal buffer of about 15% is maintained in the storage vessels. In the brewing peak period no buffer can be kept in the storage vessel, because the demand is too high. The minimum duration for this process is just over 18 days. The beer can be stored in the storage vessel for a longer period, but past experience has shown that the risk of quality defects is higher if the mature beer stays in the storage vessel for more than 48 hours after the 18 days have expired.

Rosslyn Brewery has two brew houses, one with a rated capacity of 67 475 hl/week (normal gravity) and the other one with a capacity of 102 541 hl/week (normal gravity). Both of these brew houses can do 49.4 brews per week. Brew house 1 has an average brew length of 1030 hl and brew house 2 one of 1545 hl. Table 5-1 illustrates how these capacities were obtained.

Rosslyn Brewery normally dilutes the high gravity beer by 44%, but this percentage can vary significantly. It is firstly dependent on the brand being brewed, e.g. Castle Lager has a normal gravity of 11.3°P while Carling Black Label is 12°P. Degrees Plato (°P) is a measure used to indicate gravity and one degree of Plato is achieved when one kg of sugar is dissolved in one hundred kg of beer. Secondly the gravity can vary from one brew to the next.

BREWING	UNIT	BREW HOUSE 1	BREW HOUSE 2	TOTAL
Avg. collected brew length	hl	**1,030**	**1,545**	**2,575**
HG brands	hl	1,030	1,545	
Avg. brew cycle time	hr	**3.00**	**3.00**	
Brew house efficiency	%	95%	95%	
Maintenance & cleaning	hr	12.0	12.0	
Avg. brews per week	no.	**49.4**	**49.4**	**98.8**
Avg. HG factor	%	**42.1%**	**44.0%**	**43.1%**
HG brands (94%)	%	44.0%	44.0%	
Castle Milk Stout (6%)	%	12.5%	0.0%	
Cum. loss (to warehouse)	%	**6.7%**	**6.7%**	**6.7%**
WEEKLY RATED OUTPUT:				
BREWS/WEEK	no.	**49.4**	**49.4**	**98.8**
VOLUME/WEEK	hl	**67,475**	**102,541**	**170,016**

Table 5-1: Brewing Capacity

Notes:

1. HG = High Gravity

There are a total of 94 fermenting vessels in Rosslyn. Phase 1 has 32 fermenting vessels with a rated capacity of 2060 hl each and 11 @ 3090 hl each. Phase 2 has 50 fermenting vessels with a rated capacity of 3090 hl each. The phase 1 fermenting vessels are dedicated to brew house 1 and phase 2 fermenting vessels to brew house 2. Two to three brews are normally blended in a single fermenting vessel. The total rated capacity for fermentation will be the maximum that can be stored in the fermenting vessels in a week. This is 255,440 hl as indicated in Table 5-2.

CELLARS (FERMENT)	UNIT	FV GROUP 1	FV GROUP 2	FV GROUP 3	TOTAL
Vessel group		32.5 x 2060	11 x 3090	50 x 3090	
Brews/vessel	no	2.0	3.0	2.0	
Brews/vessel group	no	65.0	33.0	100.0	198.0
Vessel group working volume	hl	66,950	33,990	154,500	255,440
Avg. process time	days	**11.8**	**12.0**	**12.0**	**11.9**
HG brands	days	12.0	12.0	12.0	
Castle Milk Stout	days	10.0			
Avg. HG factor	%	**41.4%**	**44.0%**	**44.0%**	**43.1%**
Occupancy	%	**89.5%**	**80.5%**	**83.5%**	**84.5%**
Cum. loss (to warehouse)	%	**6.7%**	**6.7%**	**6.7%**	**6.7%**
WEEKLY RATED OUTPUT					
BREWS/WEEK	no	**34.4**	**15.5**	**48.7**	**98.6**
VOLUME	hl	**46,750**	**21,444**	**101,106**	**169,300**

Table 5-2: Fermentation Capacity

The fermentation process takes 12 days to complete. This implies that if all the vessels were filled to their capacity in one week, there will be five days in the next week where the fermenting vessels are unavailable. The rated capacity for fermentation is therefore 169,300 hl/week.

In total there are 54 storage vessels. In phase 1 there are 32 storage vessels with a rated capacity of 2060 hl and 22 of 3090 hl in phase 2. The phase corresponds again with the brew house, except that there are 5 combi-tanks included in phase 1 that can be used for both brew houses. Table 5-3 illustrates the capacity calculations for the maturation process.

CELLARS (STORAGE)	UNIT	SV GROUP 1	SV GROUP 2	SV GROUP 3	TOTAL
Vessel group		27 x 2060	5 x 2060	22 x 3090	
Brews/vessel	no	2.0	1.3	2.0	
Brews/vessel group	no	54	6.5	44	104.5
Vessel group working volume	hl	55,620	10,300	67,980	133,900
Avg. process time	days	**6.1**	**5.9**	**6.0**	**6.0**
HG brands	days	6.0	6.0	6.0	
Castle Milk Stout	days	8.0			
Avg. HG factor	%	**42.1%**	**40.4%**	**44.0%**	**42.2%**
Occupancy	%	**81.5%**	**81.0%**	**81.0%**	**81.2%**
Cum. loss (to warehouse)	%	**4.1%**	**4.1%**	**4.1%**	**4.1%**
WEEKLY RATED OUTPUT					
BREWS/WEEK	no	**50.4**	**6.3**	**41.6**	**98.3**
VOLUME	hl	**70,734**	**13,442**	**88,714**	**172,890**

Table 5-3: Maturation Capacity

As is the case with fermentation, the total capacity for maturation is the total volume that can be stored, i.e. 133,900 hl. In this case the process time is only 6 days and therefore the total rated capacity for maturation is 172 890 hl/week at normal gravity.

5.4. Analysis of Filtration to Packaging Capacity

The process from filtration to packaging shows the characteristics of a pull system. The packaging programme dictates when the beer will be released from storage vessel and be filtered. Table 5-4 gives an indication of the volumes that can be obtained in filtration.

FILTRATION	UNIT	FILTER 1	FILTER 2	TOTAL
Avg. collected run length	hl	**4,100**	**5,000**	**9,100**
HG brands	hl	5,000	5,000	
Castle Milk Stout	hl	1,500		
Filtration rate	hl/hr	650	650	
Avg. HG factor	%	**42.6%**	**44.0%**	**43.3%**
HG brands	%	44.0%	44.0%	
Castle Milk Stout	%	12.1%	0.0%	
Machine efficiency	%	85.0%	85.0%	
Avg. run cycle time	hr	**8.37**	**8.78**	
HG brands	hr	8.78	8.78	
Castle Milk Stout	hr	4.92		
Factory hours	hr	168.0	168.0	
Maintenance & cleaning	hr	5.0	5.0	
Operating hours	hr	163.0	163.0	
Avg. run cycles per week	no.	**19.5**	**18.6**	**38.0**
Operating stops	hr	48.7	46.4	
Operating efficiency	%	60%	61%	
Cum. loss (to warehouse)	%	**2.7%**	**2.7%**	**2.7%**
WEEKLY RATED OUTPUT				-
VOLUME/WEEK	hl	**77,682**	**90,318**	**168,000**

Table 5-4: Filtration Capacity

Rosslyn has 2 candle filters each rated @ 650 hl/hour. The filtration capacity is very reliant on the filtration run length because the set-up time is relatively small. The average run length for a filtration process is ± 5000 hl. The rated capacity at this run length is 168 000 hl/week. A simulation study was done on the filtration run length indicating that optimum capacity of a 172 000 hl can be achieved with a run length of about 9200 hl. After this the total Throughput starts deteriorating again. The run length is very reliant on the volume required by the packaging line and seldom, if ever, reaches the 9000 hl run length for a consistent period of time.

Table 5-5 describes the capacities of the bright beer tanks in Rosslyn Brewery.

BRIGHT BEER STORAGE	NO. OF VESSELS	RATED CAP. (HL)	TOTAL CAP. (HL)	PROCESS TIME (HR)	HL/WEEK
Set 1	6	1,100	6,600	6	132,314
Set 2	9	550	4,950	6	99,081
Set 3	3	550	1,650	6	37,785
Set 4	8	1,100	8,800	6	152,935
Set 5	10	1,100	11,000	6	227,569
Total	**36**		**33,000**		**649,984**

Table 5-5: Bright Beer Tank Capacities

The bright beer tanks have a total volume of 33 000 hl. The rated capacity was calculated @ 649 684 hl/week assuming a 7 day week as in all the other processes. The assumptions were based on the packaging lines running at full capacity. An interesting fact though, is that the bright beer tanks do not have enough volume for the packaging lines to produce at maximum rated capacity. This constraint is induced by the set up of the flow control mechanism. It restricts certain lines to certain bright beer tanks. A few years ago another simulation was done and at that stage showed that the bright beer tanks were the actual constraint in the operation. After the simulation, the control mechanism was changed to allow more flexibility in the system. This had the desired effect, but will still not accommodate the full packaging capacity. The bright beer tanks are also used as a work in process buffer to ensure that the packaging lines are continuously fed without any interruptions.

Table 5-6 illustrates the volumes that can theoretically be packed in the Rosslyn packaging hall.

PACKAGING	UNIT	LINE 1	LINE 2	LINE 3	LINE 4	LINE 5	TOTAL
Line rating							
750 Ret	hl/hr	315			315	450	1,080
340 Nrb	hl/hr		170				170
340 Can	hl/hr			408			408
450 Can	hl/hr			408			408
Factory hours	hr/wk	168	168	168	168	168	
M & C hours	hr/wk	16.8	16.8	16.8	16.8	16.8	
Operating hours	hr/wk	**151.2**	**151.2**	**151.2**	**151.2**	**151.2**	
Line stoppages	hr/wk	3.25	5.25	5.75	2.25	1.75	3.65
Machine efficiency	%	85.0%	90.0%	90.0%	85.0%	85.0%	87.0%
Operating efficiency	%	**83.2%**	**86.9%**	**86.6%**	**83.7%**	**84.0%**	**84.9%**
WEEKLY RATED OUTPUT							
750 Ret	hl/wk	39,614			39,881	57,165	136,660
340 Nrb	hl/wk		22,330				22,330
340 Can	hl/wk			43,109			43,109
450 Can	hl/wk			10,300			10,300
Total Hall	hl/wk	39,614	22,330	53,409	39,881	57,165	**212,399**

Table 5-6: Packaging Capacities

Notes:

1. 750 Ret = 750ml Returnable bottle
2. 340 Nrb = 340ml Non-returnable bottle
3. 340 Can = 340ml Can
4. 450 Can = 450ml Can
5. M & C = Maintenance and Cleaning

The packaging plant consists of 5 lines which in total can produce 212 399 hl/week. Although the packaging process is clearly not the constraint in the operation it is the most costly operation and therefore is given special treatment. All the production plans are determined from the packaging plan and the aim of the whole brewery is to ensure that the packaging line is fully utilised and factory efficiency of above 72% maintained.

The packaging programme is determined in such a way to optimise the efficiency of the total hall and to ensure long production runs as far as possible. In effect it is treated in the way that the constraint of the operation should be treated.

5.5. Analysis of Operations to Market Capacity

The warehouse and distribution processes in the brewery are referred to as operations. Rosslyn Brewery has two warehouses with a total capacity of 112 028 hl. The Throughput of the warehouse has been determined by considering the volume of beer that can be distributed on road and rail in a week. The maximum Throughput of the warehouse is in approximately 266 318 hl/week. The average interdepot volume planned for Rosslyn is only 120 183 hl/week. This may change if sales trends continue to go down or can go up if there are any production problems at other breweries.

The depot Throughput has been determined by using the interdepot volume that can be handled by Rosslyn's major customer base. These depots are Waltloo, Garankuwa, Witbank, Rustenburg, Nelspruit, Bloemfontein, Mafikeng, Kimberley and Ermelo. Together they contribute to nearly 85% of the volume distributed out of Rosslyn. An adjustment was then made for the other depots making up the remaining 15% of the volume. The Throughput for the interdepot operation in the depots is 491 525 hl/week and the volume allocated to Rosslyn only 372 728 hl. The depot acts as a finished goods buffer for the value chain before it is distributed to the final customers.

The market Throughput was more difficult to determine. Sales are influenced by the volume of SAB beer bought by the consumer in a year. There are various factors influencing consumer behaviour such as brand loyalty, lowest price and availability to name a few. In order to determine the sales directly affected by Rosslyn Brewery, the assumption was made that the sales would be in the same ratio as the contribution of Rosslyn's interdepot volume towards the total volume distributed in all the regions. Rosslyn's market Throughput is therefore 114 667 hl/week. It is evident that the market is the constraint in the whole value chain. The potential sales for the whole of beer division is actually 5 111 476 hl/week.

Rosslyn’s ability to take a larger share of the sales volume, is also limited by the specific brands and packaging types produced at the brewery.

The trend in the beer market these days are towards smaller, “curvy” bottles with sophisticated labels and neck foils, where Rosslyn Brewery was mainly designed to produce high volumes in quart bottles with standard bulky labels.

5.6. Rosslyn Brewery Logical Structure

The processes in the brewery exhibit the characteristics of a T-shape logical structure (depicted in Figure 5-2). This is enforced by the fact that beer is part of the fast moving consumer goods industry and that the T-shape is often associated with consumer products. It can also be argued that the V-shape structure is applicable because the characteristics of the different variants are determined early in the process.

It is more accurate to say that the brewing processes exhibit more of the V-shape characteristics and the packaging and operations processes more of the T-shape characteristics. The brewery is again a hybrid of different classifications, similar to the discussion on production process classifications in chapter 2.

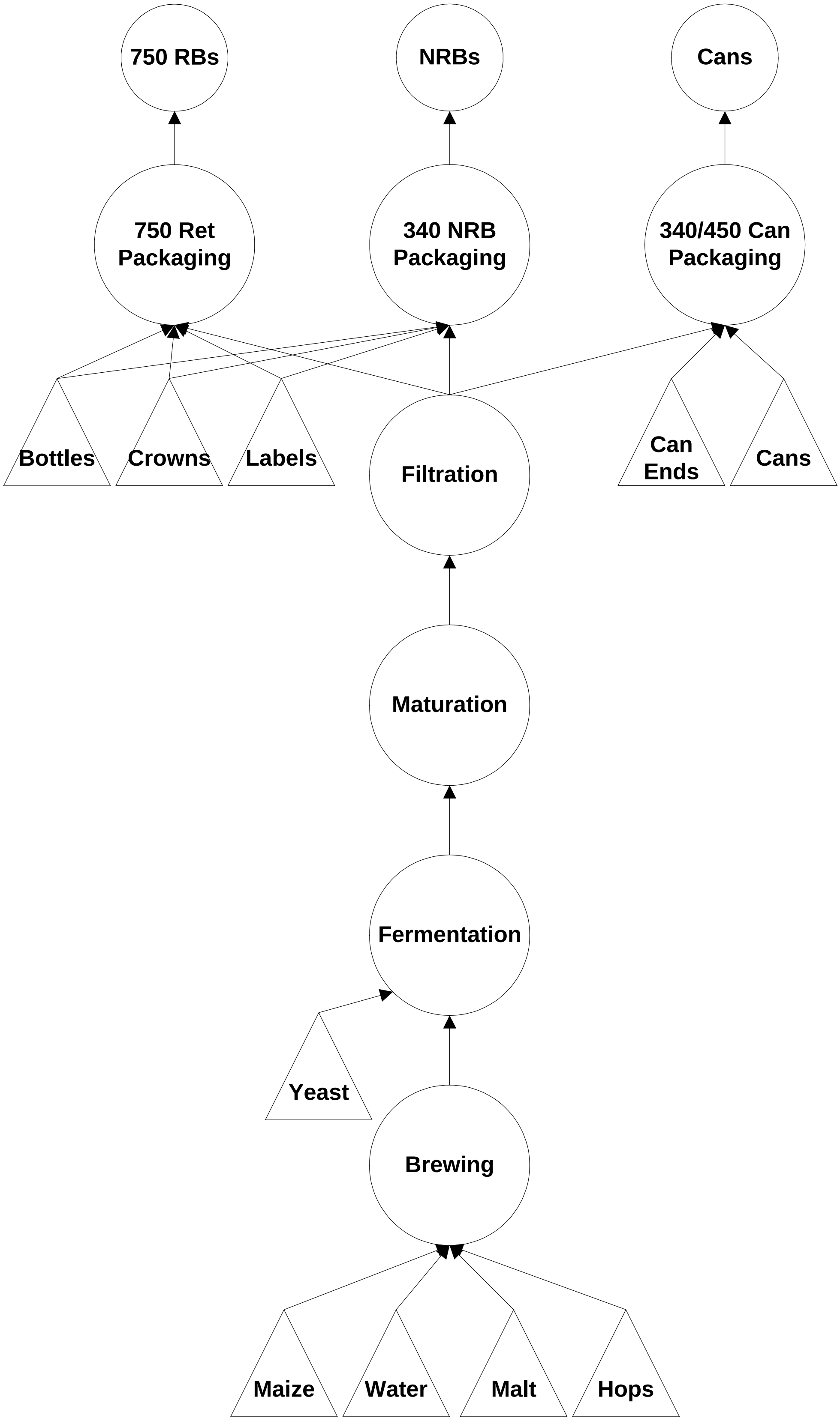

Figure 5-2: Rosslyn Brewery V-A-T Logical Structure

Some of the characteristics of a T-plant [Chase, Aquilano; 1995:774] which are present in the brewery are:

- Two distinctive processes and flows: Fabrication and Assembly. Fabrication in this case implies brewing and packaging is assembly.
- Overtime and expediting in fabrication are random and frequent
- A very high degree of commonality of parts is dominant
- Fabrication is done in huge batches (e.g. the brewing and fermentation batches)
- There is a large amount of inventory at common stocking levels between fabrication and assembly (bright beer tanks)
- The drive to attain efficiencies and dollars shipped is evident

Some of the characteristics of a V-plant [Chase, Aquilano; 1995:773] which are present in the brew house are:

- Products use essentially the same sequence and processes.
- Equipment is generally capital intensive and specialized.
- There are a limited number of routings.
- Each product crosses a resource only once.
- It tends to produce a large number of items in a small amount of time.

Chase and Aquilano [1995:774] describe the following conventional tactics for corrective action, which are all evident in the brewery:

- Strict control of overtime (management perceives abuse of overtime and restriction of use aggravates the problem)
- Automation of processes (this makes matters worse since flexibility is lost through automation)
- Better planning of labour needs (the illusion is that there are too many workers)

The suggested solution for the problems, [Chase, Aquilano; 1995:775] is to:

- Reduce batch sizes
- Use Drum-Buffer-Rope in fabrication to control flow

5.7. Identifying the constraint

After clarifying that the goal of an organisation is to make money and defining performance measures to guide your actions, the next essential step is that the brewery clearly understands where the constraint in the system is situated.

- The constraint determines the Throughput of the brewery, without knowledge of where it is situated it is impossible to maximize Throughput.
- The capacity of the constraint will determine how flexible the brewery will be to deliver varying peak sales volumes.
- By exploiting the constraint capacity, the brewery will be able to produce beer at the highest Throughput & best quality, whilst contributing to the bottom line of SAB.

Table 5-7 gives a summary of the rated capacities explained above and indicates where the constraint is situated.

Value Chain Component	***Subsection***	***hl/week***
	Brew house 1	67,475
	Brew house 2	102,541
Total Brewing		**170,016**
	Ferment Phase 1	68,194
	Ferment Phase 2	101,106
Total Fermentation		**169,300**
	Storage Phase 1	84,176
	Storage Phase 2	88,714
Total Maturation		**172,890**
	Filter 1	77,612
	Filter 2	90,318
Total Filtration		**168,000**
	BBT Set 1	132,314
	BBT Set 2	99,081
	BBT Set 3	37,785
	BBT Set 4	152,935
	BBT Set 5	227,569
Total BBT Storage		**649,684**
	Line 1	39,614
	Line 2	22,330
	Line 3	53,409
	Line 4	39,881
	Line 5	57,165
Total Packaging		**212,399**
Total Operations		266,318
Total Distribution		491,525
Total Market		**114,667**

Table 5-7: Rosslyn Brewery Capacity Constraints

It is obvious that the constraint of the brewery is in the market. The calculated sales volume out of Rosslyn for this period in question is only 114 667 hl/week. Even the internal capacity constraint, which is the filtration process, has more than enough capacity to serve this demand.

In the December peak period of 1999 it became quite clear that the constraint of the system does not lie within the brewery but actually in the market. This was evident from the fact that the depots had exceptional high days of cover and the sales weren't materialising, to such an extent that production had to be cut in the normally critical peak weeks. The market constrains the Throughput of the Rosslyn Brewery value chain.

The market constraint is actually induced on the brewery by volume allocations from central office. Volume is allocated per brewery in accordance with the brewery's performance on various factors, mainly cost/hl and a track record of high reliability. Rosslyn "competes" for volume mainly against the Alrode brewery which is situated in the same geographical area, Gauteng, and services the same customer base.

A further disadvantage against Rosslyn is the fact that there is no divisional brand-pack combination produced in this brewery. Most of the breweries, apart from Polokwane and Rosslyn, produce at least one brand-pack combination that is unique to the brewery and therefore can supply in the demand for the whole country. Although these volumes are small, they are often delivered in a load that is made up with the mainstream brand-packs as well, reducing the Rosslyn "sales" even further.

On the other hand, this extra capacity of Rosslyn Brewery is strategically used in peak periods to supply all the areas where shortages occur. In a normal situation the brewery rarely has enough capacity to serve the demand requirement of the December peak.

5.7.1. The Capacity Constrained Resource (CCR)

There is one process in the brewery with a lower capacity than the other operations. Filtration can only produce 168 000 hl/week when working full time. This rated capacity can be achieved at a factory efficiency of 76%. In the past the filtration department had not been able to achieve these efficiency targets and only made significant improvements in the last couple of years. Nevertheless, filtration is justifiably the capacity constraint of Rosslyn Brewery. This corroborates with the actual problems in the plant. Filtration is normally under a lot of pressure and has been the cause for many production line stoppages.

Fermentation and maturation can also be defined as capacity constrained resources, because their utilization is close to capacity and they can become a constraint through scheduling practices. Filtration on the other hand has a real capacity constraint and has to work over weekends to supply the packaging plant. Given the current allocated volumes to Rosslyn, filtration actually has enough capacity to satisfy demand. It is therefore only an internal constraint. In peak periods the volumes may increase enough for filtration to become the true constraint of the value chain. The poor filtration efficiency in the past has also amplified the capacity problem and inevitably caused stoppages in the packaging operation.

There is also a school of thought that argues that the constraint of the operation moves throughout the process. It is dependant on the product mix and the difference in the process times at the CCRs. In Rosslyn it is probably not as evident, because only the main stream brands are produced in the brewery. They all have very similar characteristics and process times. In spite of this the brewery has experienced space shortage in the fermentation and storage vessels in the past. Many projects have subsequently been launched, aimed at resolving the storage space shortage through simulations and linear programming. The results were time and again that the storage space is sufficient for the amount of beer produced. The storage or capacity problem is a function of scheduling practices and late release of beer. The problem in not that the constraint is moving, but that the CCR becomes a constraint through the application of policies and past practice. If there are a number of CCRs in the brewery, it will create the illusion that the constraint is moving all the time.

5.7.2. Where should the constraint be situated?

At this point in the five-step process of ongoing improvement, the following question is asked: “Is the constraint a physical constraint?” If the answer is yes then the process continues with exploiting the constraint by implementing the Drum-Buffer-Rope schedule. If the constraint is a policy or procedure, a new policy has to be written and/or behaviour modified. This step is also known as elevation of the constraint.

TOC also has a specific answer for dealing with a constraint in the market place. "*The thought process tools are most critical now to combine marketing, engineering, operations and finance to use the competitive edge factor the plant has created and go after the market*" *[Smith, 2000a:75].*

The solution is to use the Thinking Process tools to determine how to improve Throughput by increasing sales in the market. It is also implied that this step is only taken at step 4 of the process, i.e. to elevate the constraint. In the case of Rosslyn it would not be wise to try and increase Throughput by targeting the market, without managing according to the constraint.

The second question that can be asked is where do you want the constraint to be? In Rosslyn's case it would be ideal if packaging could be the constraint, but this will require serious capital investment in a system that already has excess capacity. The capacity of the two CCRs, fermentation and maturation, are not significantly more than filtration. In fact fermentation can only produce 1300 hl/week more.

Filtration will be easier to manage as the constraint, because it is a gating operation between the brewing processes and packaging. Efficiency is already measured and emphasis placed on machine reliability and uptime. The challenge in Rosslyn's case is to subordinate the packaging process to filtration.

5.8. Conclusion

Although the market is the clear constraint of the system, it should be viewed with caution.

- It will be hard for the brewery to gain volume, without taking it away from another brewery, especially in a declining (or stagnant) beer market in South Africa.
- As long as the key decision drivers behind volume allocations remain product cost based, it will be difficult to gain more volume, even if one implements TOC principles in the brewery. It is crucial that the process be driven from the top and all breweries measured in the same way.

- Rosslyn Brewery does not deal directly with the end consumers, i.e. the beer is "sold" to depots which deal with the retailers and wholesalers. This implies that there are also no marketing skills available in the brewery.

Even though the actual constraint is external to the brewery, the focus should still remain on the internal operations. This will allow the system to focus on the global optimization of the brewery, be flexible enough to react quickly to volume changes and increase Throughput, whilst reducing Inventory and Operating Expense. In the next chapter the current performance measurement system in Rosslyn will be explored with the objective to identify the key drivers influencing performance in the brewery.

6. KEY PERFORMANCE DRIVERS AT ROSSLYN BREWERY

Our world exists only through our perception of it. Change our perception of our world and we change the world -- for us.
Roger Dawson

6.1. Purpose

In this chapter the key performance measures utilised in Rosslyn Brewery will be described. The objective is to explain how performance is measured in Rosslyn Brewery specifically and indicate what are the key drivers influencing most or all operational decisions in the brewery.

The first section of the chapter describes the performance measurement in South African Breweries Ltd. or Beer South Africa as it is now referred to. The three absolute measures, Net Profit, Return-on-Investment and Cash Flow are used as a basis to review SAB's performance over the last 10 years.

The second section of the chapter takes the reader one level down and describes the operational measures defined in the different departments at Rosslyn Brewery.
In the last section the key performance drivers are described.

6.2. Performance Measurement in South African Breweries

6.2.1. Throughput

The following information has been extracted from the SAB financial statements to indicate the performance of the company against the goal defined by TOC. Figure 6-1 gives us an illustration of the Throughput over the last 10 years:

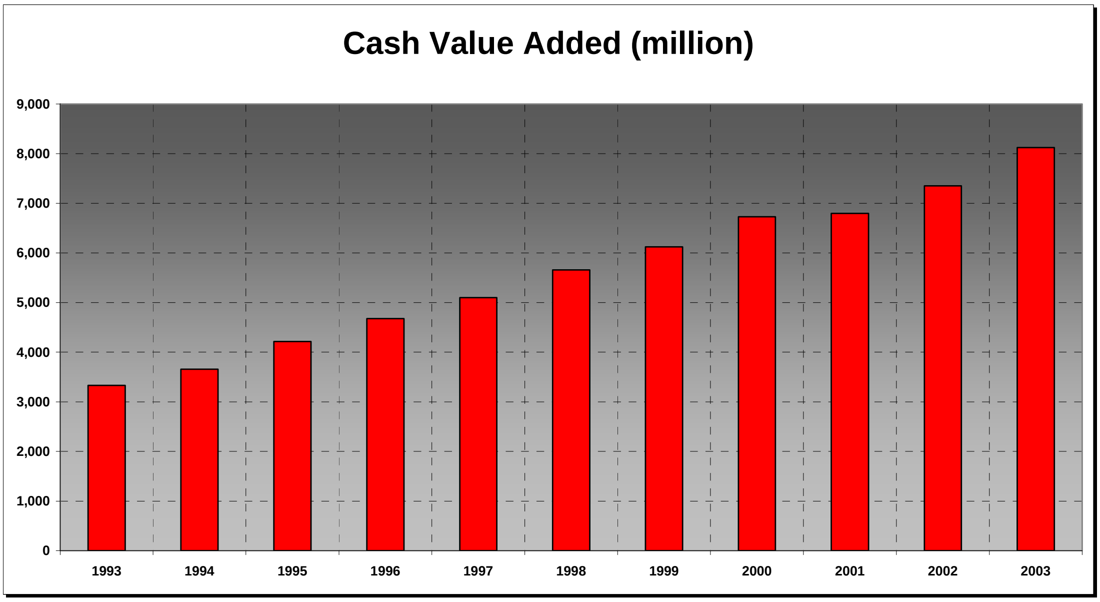

Figure 6-1: Cash Value Added (Throughput)

SAB reports a cash value added statement, which is the closest measure to the Throughput calculation defined by TOC.

$$\text{Cash Value Added} = \text{Income} - \text{Cost of Sales}$$
$$\text{where Income} = \text{the money received from sales of product and other investments}$$
$$\text{Cost of Sales} = \text{the money paid for raw materials}$$

The difference between cash value added and Throughput is that the cost of sales is supposed to include all variable costs in terms of the TOC definition, whilst in this case it only includes the variable cost of raw materials. For the purposes of this illustration it is a good enough estimation.

The year-on-year growth in Cash Value added shows the following interesting picture in Figure 6-2:

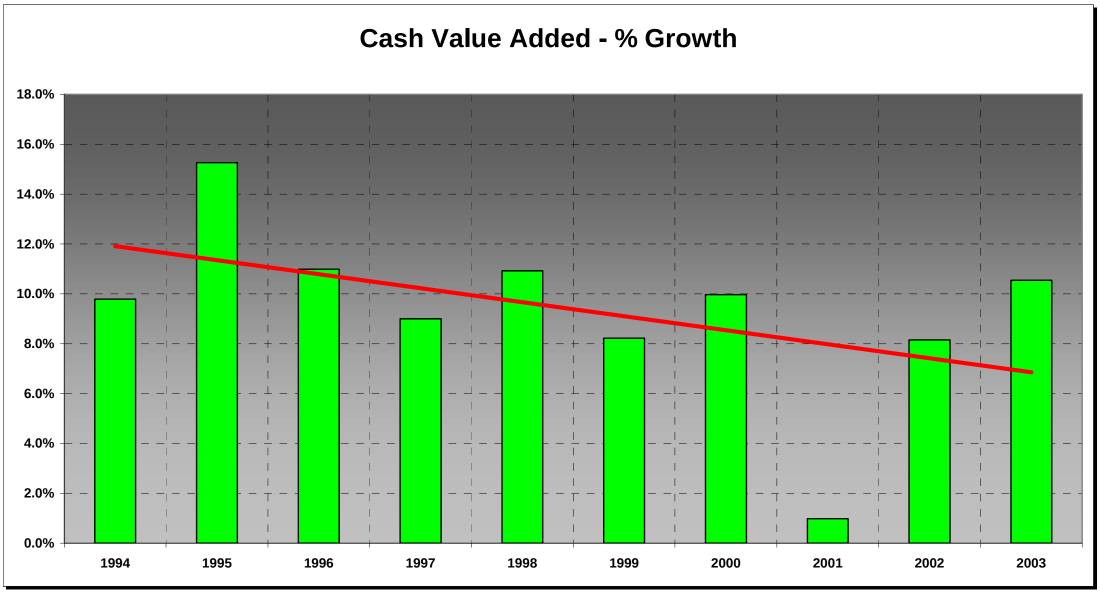

Figure 6-2: Growth in Cash Value Added (Throughput)

The growth in Throughput has been steadily declining over the years. The immediate reaction is that it is a negative sign, but we must keep in mind that it implies an average growth over 10 years of 9.4%. Except for 2001 where there was a growth of only 1%, any company operating in the FMCG environment would be satisfied with these results.

There have also been some external factors influencing this growth, such as:

- Real competition in the form of Alcoholic Fruit Beverages and other brands in the premium sector of the liquor industry, taking beer's share of the total drinks away, especially in the younger generation where the future growth potential is situated.
- Attempts from Namibian Breweries and others challenging the purity of SAB's beers through the "Reinheitsgebot". It can be argued that the impact of this attempt wasn't that damaging as it only affected a very small portion of the market, but still enough to cause a decline in sales growth.

- SAB's focus to develop the operations overseas. SAB has focussed on developing the beer market in other third world countries, probably at the cost of some growth potential in South Africa.
- The phenomenal growth of the cell phone industry and the introduction of the lottery in South Africa have also had a detrimental effect on not only beer sales, but all consumer goods in South Africa.

There is one question that can be asked: "Is the decline in Throughput growth also because there is too much focus on decreasing Operating Expenses? One of SAB's finest achievements is that they have managed to keep the price of beer increase less than the Consumer Price Index for the last 25 years. This is a clear indication that there is a huge focus on cost reduction in the organisation.

The growth in sales (Figure 6-3) shows a similar trend line than that of Throughput, as expected.

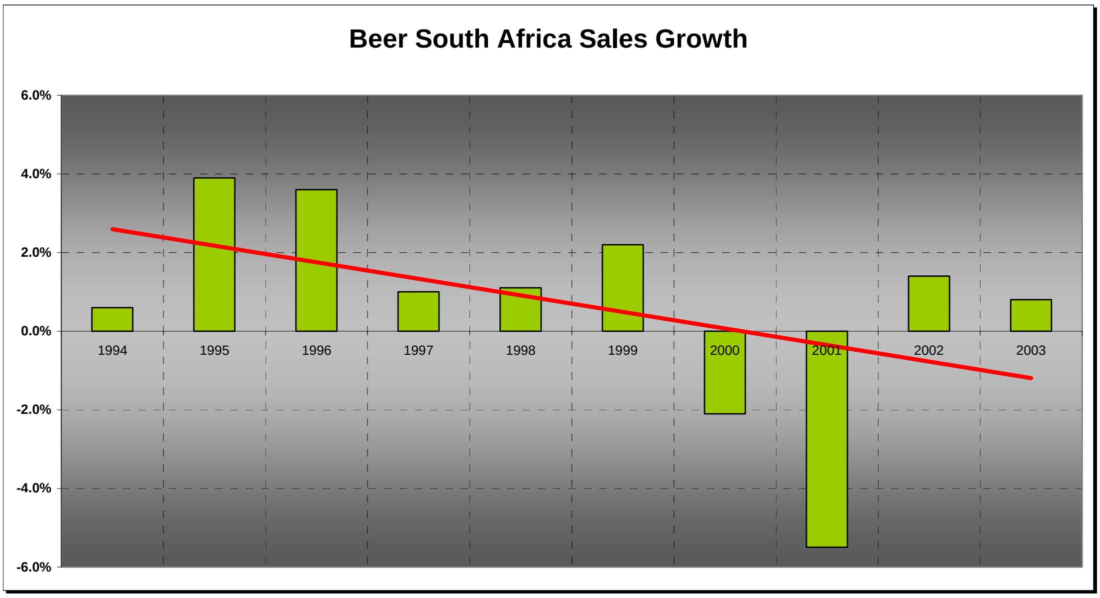

Figure 6-3: SAB's Sales Growth

It is clear that there was positive sales growth for a number of years and then two years of serious decline as a result of the above mentioned factors. Another factor that can not be ignored is the impacts of the weaker rand, resulting in a reduction in consumer spend on non-essential commodity items.

6.2.2. Return-on-Equity or EVA

In the earlier years of the last decade (1990 – 1994) SAB reported on Return-on-Equity in their annual reports. The average ROE for the company was 17.3%, which is very good in comparison to other industries in FMCG and South Africa.

These days EVA is an internal measure in SAB and annual EVA growth targets are set for every brewery and depot. Therefore, for the purpose of the dissertation, the focus will be on EVA instead of ROE. The following table indicates the growth in EVA over the last 10 years:

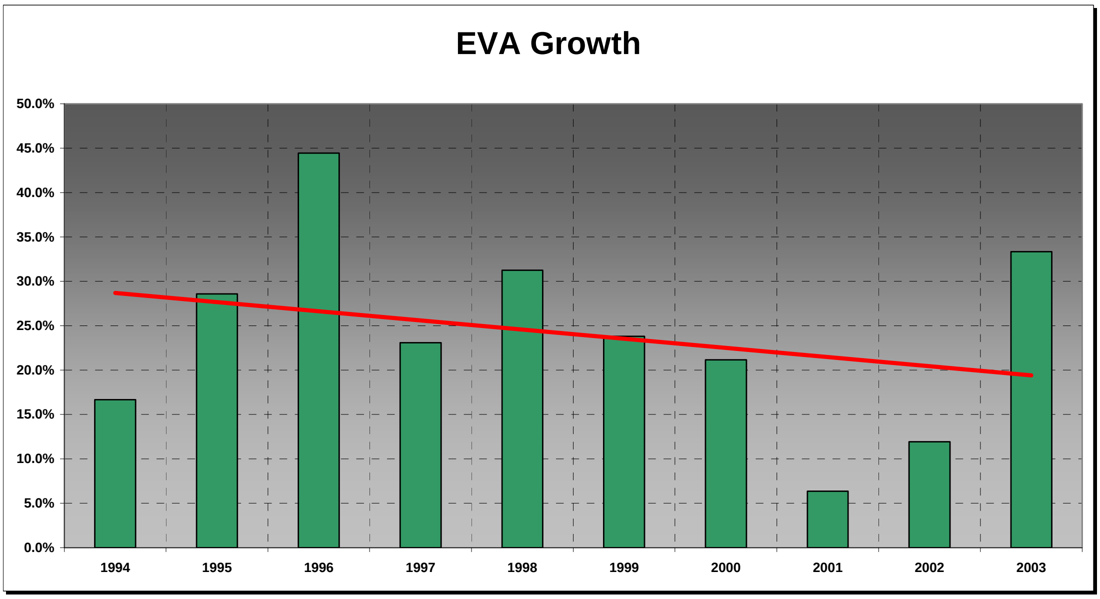

Figure 6-4: SAB's EVA growth

The same comment applies as for the Throughput trend; even though the trend line is negative, a positive EVA has been maintained over the last ten years. The question is whether this trend could have been different had there been a TOC implementation?

6.2.3. Cash Flow

The brewing industry is a cash intensive industry. The cash flow of SAB is probably the best of all the industries in South Africa and an enormous amount of tax is paid every year to the government (58.1% of the money earned). The asset base cannot compare to the mining industry, telecommunications or petrol industry, but in terms of cash flow SAB is stronger than the best in those industries.

Unfortunately the cash flow for Beer South Africa could not be obtained for the past five years, but the cash flow for the group is shown in Figure 6-5. The figure shows the increase or decrease in cash flow for the financial years after dividends and other financing activities have been included. The effect of acquisitions can be clearly seen on the graph.

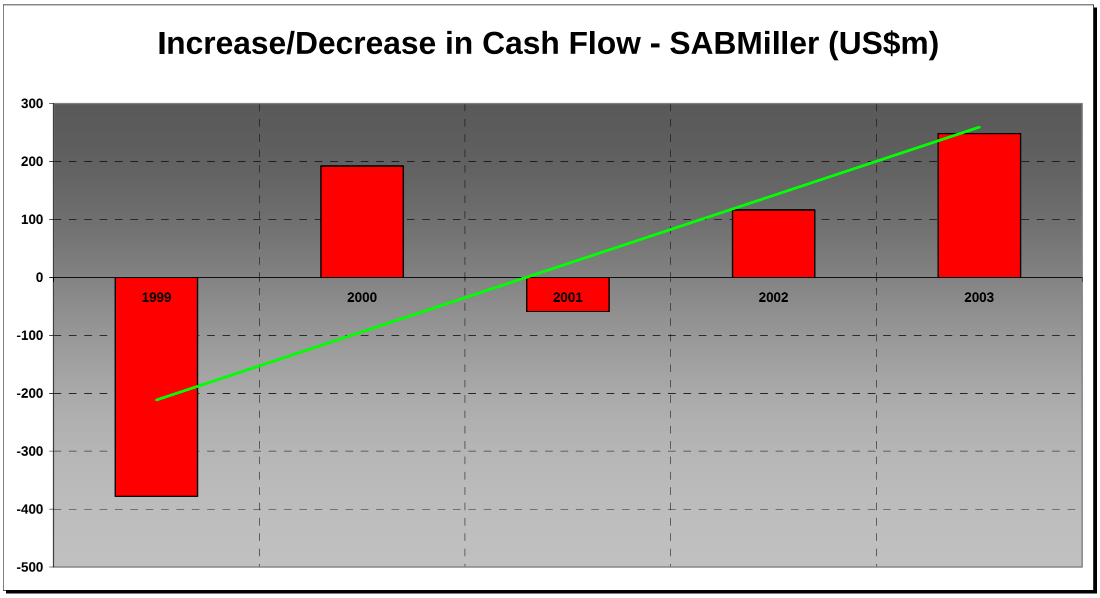

Figure 6-5: SABMiller's cash flow

Cash flow is the only one of the three bottom line measures that has a positive trend, although the base and evaluated period are not the same as with Throughput and EVA analyses.

By studying the bottom line measurements, SAB is in a sound position, although the negative trends in sales and EVA growth will be an issue of concern to the directors and shareholders.

6.3. Performance Measurement at Rosslyn Brewery

There are a number of operational performance measures in Rosslyn Brewery, each developed to measure the progress against the strategic goals and targets defined by the directors. For the purpose of this dissertation, only a few operational measures used in the brewing, packaging and operations departments will be highlighted.

6.3.1. Brewing & Packaging

Table 6-1 gives an indication of some of the measures used in the brewing and packaging departments. They have been grouped in the four key areas defined by the Best Operating Practices implementation.

Downtime	Yield	Quality	Efficiency
Planned Downtime	Beer Loss	RE (real extract)[4]	Factory Efficiency[1]
Unplanned Downtime	Bottle Breakages (Cullet)	Foam stability	Operating Efficiency[2]
Production Stoppages	Neck & Body Labels	Dissolved Oxygen[5]	Machine Efficiency[3]
Allowed Stoppages	Can loss	Volumes & Fill Heights	Adherence to plan
	Water Usage	Torn/Missing/Skew Labels	

Table 6-1: Packaging and Brewing Performance Measures

1. Factory efficiency is measured against a rated capacity for each line or brewing process. The formula is:

$$\text{Factory Efficiency} = \frac{\text{Actual Volume Produced}}{(\text{Rated capacity (hl/hr)} \times \text{Factory hours})} \times 100$$

   Factory hours are all the scheduled production hours minus any downtime caused by external factors out of the brewery's control, such as power failures etc.

2. Operating efficiency is calculated in the same manner, except that operating hours are used instead of factory hours. Operating hours is factory hours minus any downtime incurred as a result of other departments in the brewery.

3. Machine efficiency is calculated using machine hours. Machine hours is operating hours minus any downtime that is not machine related, i.e. operator errors, raw material shortages etc.

4. Real extract is a measure used in brewing to indicate what the alcohol levels in the beer are. This measure is a good indication of when the beer has finished fermenting and needs to be moved to the storage vessels.

5. Dissolved Oxygen (DO) is a measure in particles per million. It is crucial that there is no air pickup in the process, as it will adversely affect the beer quality and shelf life. DO is measured in brewing, in packaging and in operations to determine if there is any oxygen introduced in the system.

6.3.2. Operations

When the beer reaches the operations department very little can be done about improving quality, except to maintain the quality by keeping it in a cool place out of direct sunlight. Warehouse temperatures are therefore monitored. The key issues here are to ensure that the beer is distributed on time and the performance measures in Table 6-2 are defined to achieve this goal.

Downtime	Yield	Quality	Efficiency
Forklift Breakdowns	Beer Loss	Warehouse Temperatures	Turn Around Time (TAT)[2]
	Bottle Breakages (Cullet)	Dissolved Oxygen	Dropped loads / Adherence to plan
	Broken or damaged crates	Beer age[1]	

Table 6-2: Operations Performance Measures

1. Beer is a perishable product and therefore cannot be stored too long in a warehouse. The beer age is measured to ensure that the oldest beer is always dispatched first and that there is no beer older than 10 days on the warehouse floor.

2. Turn Around Times (TATs) are measured from the moment a truck enters the brewery until it leaves. At Rosslyn the queue waiting time outside the brewery is also monitored. The TATs are used for scheduling purposes.

6.4. The Key Performance Drivers in Rosslyn Brewery

As indicated in the previous paragraphs there are a number of measures in Rosslyn Brewery that are aligned with the goals and strategy of the organisation.

If one measure has to be chosen as thé key driver behind the performance in the brewery, this measure would have to exhibit to the following characteristics:

1. It will be widely known and published (not only in the department where it is measured).
2. It will be a measure which is common to all the breweries.
3. It will be a measure which is discussed on a daily basis on all levels of management.
4. It will be very influential in performance management reviews, i.e. bonuses and increases will be determined by it.
5. Special events will be held and incentives given to employees who make a significant contribution to the department/section achieving the set target.

The measure in Rosslyn Brewery which exhibits the above characteristics is packaging efficiency. This is further evident in the fact that the first target set by head office for production performance is to "continuously improve divisional factory efficiency". Although factory efficiency is also measured in brewing, the packaging hall factory efficiency is the determining factor.

As important as factory efficiency is in the packaging environment, so is quality in brewing, which constitutes the second Rosslyn key performance indicator. It may be because brewing is a batch process without the pressure of working all the time as in packaging where every hour lost is a potential catastrophe. Brewing will rather ensure that the batch produced (> 1000 hl at a time) conforms to quality standards, because it is impossible to produce another batch in time that conforms to the required quality standards. The rule of getting it right the first time is essential, as there aren't any second chances. Brewing Internal Quality Measurement System (IQMS) is the key driver in that department.

The third measure that is a key driver in Rosslyn, is costs. Every brewery is measured in terms of R/hl produced. Volumes are allocated per brewery according to this measure and therefore a crucial part of every day management is to save costs wherever possible. The R/hl figure is not only a variable cost, but includes the fixed cost allocated per department per cost centre.

If these three measures were to be ranked for Rosslyn it will be in the following order:

1. Efficiency
2. Cost
3. Quality

Although this cannot be scientifically proven, efficiency displays all 5 the characteristics mentioned above. Cost is second because it displays all the characteristics, except perhaps the one where special functions will be held and incentives given if targets are achieved. It does not mean that incentives and functions are not given as reward for achieving cost cutting targets, but in a lesser way than when a production efficiency target is achieved. The same applies for quality, with the additional drawback that the quality targets are not widely published and therefore it is only ranked third.

Although it seems as if quality will be traded off first, this is not really true. There are critical (consumer detectable) quality measures which will never be compromised, even at the expense of cost and efficiency. There are many examples of batches of beer that were dumped because it did not comply with one of these measures. There is a second set of non-critical quality measures (normally concerned with appearance of the package) that will not be detected by the customer or is not very important to him. These measures might be traded off for efficiency and cost, e.g. scuffing on quart and pint bottles.

The question is whether cost is more important than quality and efficiency. It is difficult to observe, as it an all-encompassing measure that affects every decision made. There is a constant trade-off though between achieving efficiency targets and reducing costs.

6.5. Conclusion

From an analyst's point of view who studies the absolute measures, SAB will be a blue-chip company worth investing in. The company makes a profit, increases EVA year-on-year and has a very healthy cash flow. It has also expanded operations in other countries and is, rightfully, the second largest brewery in the world by volume.

On the second level is clear why the brewery has performed so well. There are a number of operational measures in place and Rosslyn Brewery specifically is a manufacturing facility that is constantly benchmarked by other world class plants.

Yet, it is also evident that the brewery (and SAB) is driven by a cost world mentality. This is evident from the constant focus on reducing costs and improving efficiency. One of the general managers in SAB always used to comment in the following way when he was confronted with a new innovation or evidence of good performance: "Yes, it is very good, but is it sustainable?" This is the question that TOC asks; "You can ignore the bottleneck and still run a profitable business, but is it sustainable?"

The next chapter will utilise the Thinking Process to describe the conflict that exists in the brewery between constantly trying to reduce costs and improve efficiency.

7. THE CORE CONFLICT IN ROSSLYN BREWERY

When a problem comes along, study it until you are completely knowledgeable. Then find that weak spot, break the problem apart, and the rest will be easy.
- Norman Vincent Peale

In 1999 Rosslyn Brewery was unanimously voted as the best and most improved brewery in SAB. The award was based on a number of performance measures that were carefully reported on during the year. Although the performance measures used to evaluate the breweries were very comprehensive, the weighting was very much towards results in IMP implementations, packaging efficiencies and safety, health and environmental issues. In the two years after the award, the beer market in South Africa came under immense pressure resulting in a significant market decline. SAB had a critical look at production and where these reduced volumes should be cut. Volume was immediately taken away from Rosslyn, because the R/hl to produce beer there was too high. The situation culminated in the closure of the canning line in 2001 and a significant reduction in shifts on the other packaging lines in Rosslyn. In this chapter the Thinking Process will be used to determine the core conflict of the brewery.

7.1. Purpose

As described in Chapter 4 the first section of the Thinking Process seeks to answer the question “what to change?” The following steps are used in the section:

1. Identify Undesirable Effects (UDEs)
2. Draw up cloud diagrams for 3 of these UDEs
3. Identify the core conflict cloud (C^3)
4. Validate the C^3 by constructing a Current Reality Tree (CRT)

The purpose of this chapter is to answer the question of “what to change?” within the guidelines prescribed by the Thinking Process.

7.2. Identifying the Core Conflict Cloud (C^3)

The first step in the Thinking Process is to identify the Undesirable Effects (UDEs). The following 10 UDEs were identified for Rosslyn:

1. Beer is not available to be packaged as planned.
2. Packaging lines wait for beer to become available.
3. Filtration has to work weekends and so incur overtime costs, to adhere to the packaging plan.
4. Filtration efficiency is low.
5. A lot of effort (and money) is put in to increase operational efficiencies in all operations.
6. The production schedule of the brewery changes frequently after finalization.
7. The packaging lines in Rosslyn Brewery are being closed.
8. Volume is allocated to other breweries based on a lower R/hl.
9. The R/hl produced in Rosslyn increases or is to high.
10. Efforts to reduce costs are negated by overtime incurred on weekends.

There are many more effects that can be identified, but the list was specifically limited to 10 and those related to that influences the Throughput of the brewery. Three of these UDEs were chosen and represented in Evaporating Cloud Diagrams in Figure 7-1.

The cloud diagram should be read in the following manner: In order for (A) Rosslyn to be the lowest cost producer in SAB, (B) the running cost of the brewery has to decrease. The running costs of the brewery decreases (B) as a result of (D) the packaging lines being closed.

The same applies for the bottom section: In order for (A) Rosslyn Brewery to be the lowest cost producer in SAB, (C) the cost (R/hl) to produce beer in the brewery must be low. The cost of producing beer will be low (C) if (D) all the packaging lines run continuously.

The (D) packaging lines in Rosslyn Brewery are being closed is in direct conflict with (D') the packaging lines must run continuously. This conflict is represented by the lightning bolt.

The assumption that underpins the arrow between (A) and (C) is that Rosslyn Brewery's cost decreases as the volume produced increase.

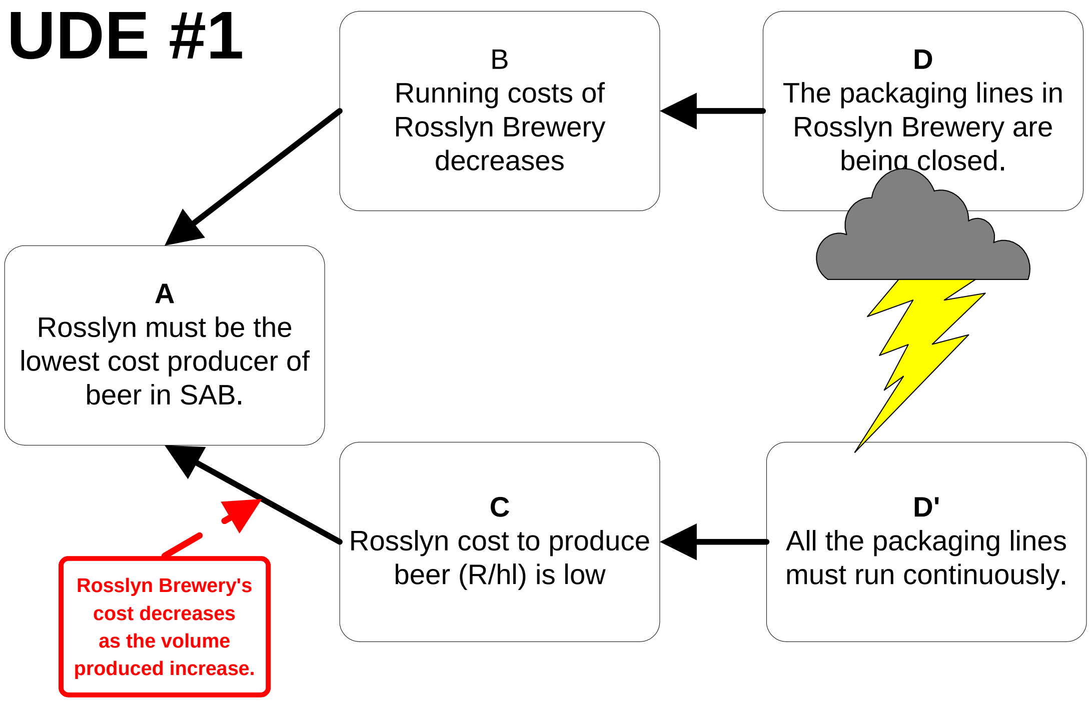

Figure 7-1: Evaporating Cloud - UDE #1

The first, and probably most significant UDE from a packaging point of view, is that the production lines in Rosslyn Brewery are being closed or "moth balled".

The canning line which was closed had been running a 4 x 8 hour shift system, less than 5 years ago and was the benchmark for all canning operations in SAB, achieving operating efficiencies above 90% for a whole year. The conflict is that the packaging lines are closed to reduce to running costs of the brewery, but they actually have to run continuously to reduce the R/hl of production in Rosslyn. Both of these actions strive to achieve one objective of ensuring that Rosslyn is the lowest cost producer in SAB.

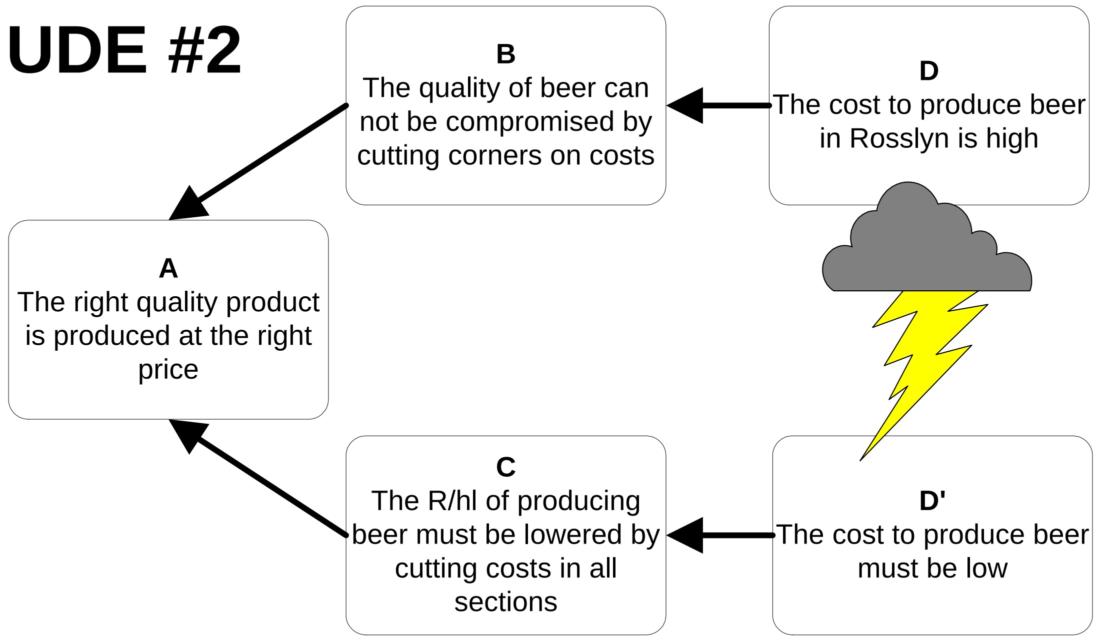

Figure 7-2: Evaporating Cloud - UDE #2

The second evaporating cloud is concerned with the quality aspects of brewing beer. SAB has very high quality standards for not only beer, but also packaging quality. These standards have to be adhered to and come at a cost. The quality can not be compromised by cost cutting to ensure that the right quality product is produced at the right (lowest) price.

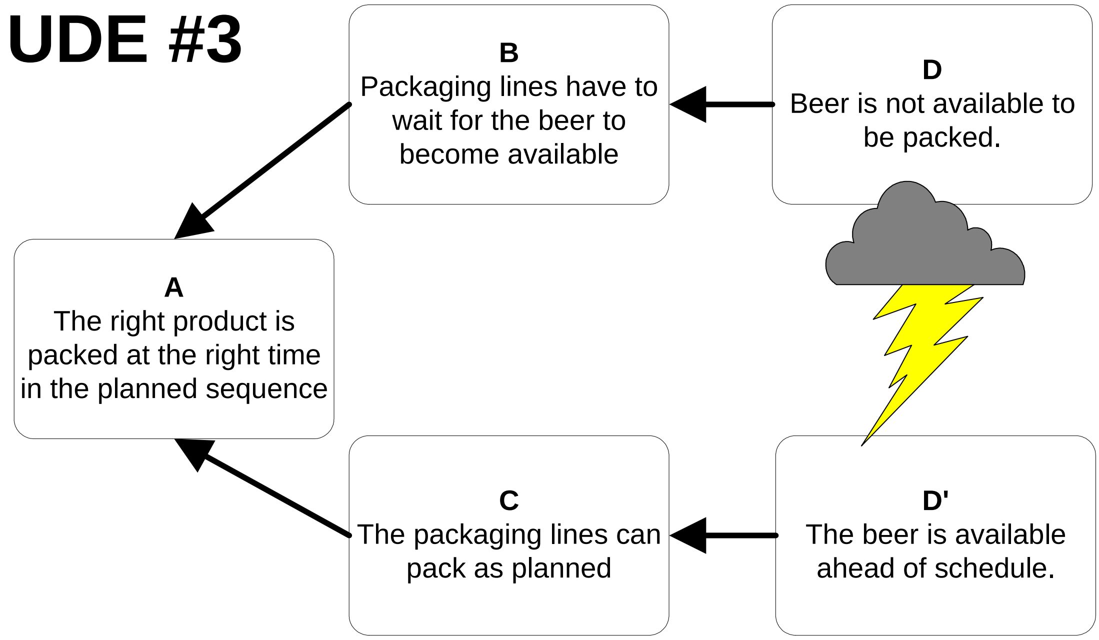

Figure 7-3: Evaporating Cloud - UDE #3

The third evaporating cloud highlights the problem of scheduling on the brewery level. The packaging lines regularly have to wait for beer to become available, usually at the exact time when they run at their best efficiencies with no stoppages.

The three evaporating clouds are combined into one cloud depicting the core conflict of the brewery. This is known as the three cloud process (C^3) in Thinking Process terms.

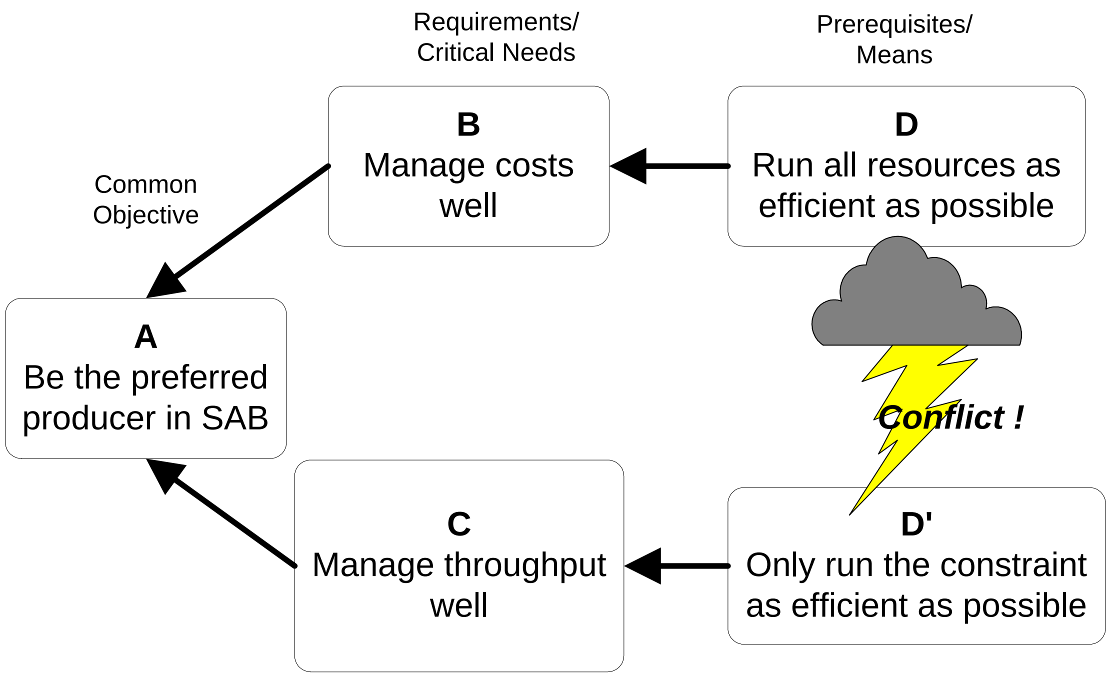

Figure 7-4: The C³ cloud diagram

The C³ cloud is drawn up to verbalize the core conflict in the brewery. The common objective underlying all the UDEs is to ensure that Rosslyn Brewery is the preferred producer of beer in SAB. The conflict exists because there are two requirements, one to manage costs well and the other to manage Throughput well. Each of these requirements has a prerequisite action which is in direct conflict with one another; the one to run all resources as efficient as possible and the other to only run the constraint as efficient as possible.

The first step is to validate whether this is really the core conflict by connecting it to all the identified UDEs. This process is done by drawing up a Current Reality Tree.

7.3. Constructing the Current Reality Tree (CRT)

The Current Reality Tree uses the C³ diagram as a base and then establishes links to all the other UDEs that were identified. The process of connecting the UDEs is done by using rigorous cause-and-effect logic. *"Every connection in a CRT must explain, irrefutably, why the effect is an unavoidable consequence of the cause in today's reality" [Houle, 2001:178]*

The TOC Thinking Process advocates 7 tools, called the categories of legitimate reservations that consist of a serious of questions to assist in rigorously constructing and scrutinizing the cause-and-effect logic.

These categories are:

1. Clarity – Is the "if…then…" statement a crystal-clear, lock-tight, irrefutable explanation of why the effect is an unavoidable consequence of the cause?
2. Entity Existence – Do each of the entities (if and then statements) really exist in today's reality as stated?
3. Casualty Existence – Is the effect an unavoidable consequence of the cause?
4. Predicted Effect Existence – Is there another effect that exists to further substantiate the cause's existence?...or Is there another effect that would exist if the cause really did result in the effect?
5. Cause Insufficiency – Does the cause by itself always result in the effect? If not…when does it?
6. House on Fire – Does the cause explain why the effect exist?...or Is the cause how we know the effect exists?
7. Additional Cause – Is the cause the only cause of the effect, or is there another that's at least as significant.

These questions are asked in a specific sequence for every casual relationship that was identified and provides a "check-list" to ensure that all angles are covered when defining the CRT.

Figure 7-5 depicts the Current Reality Tree that was drawn up for Rosslyn Brewery.

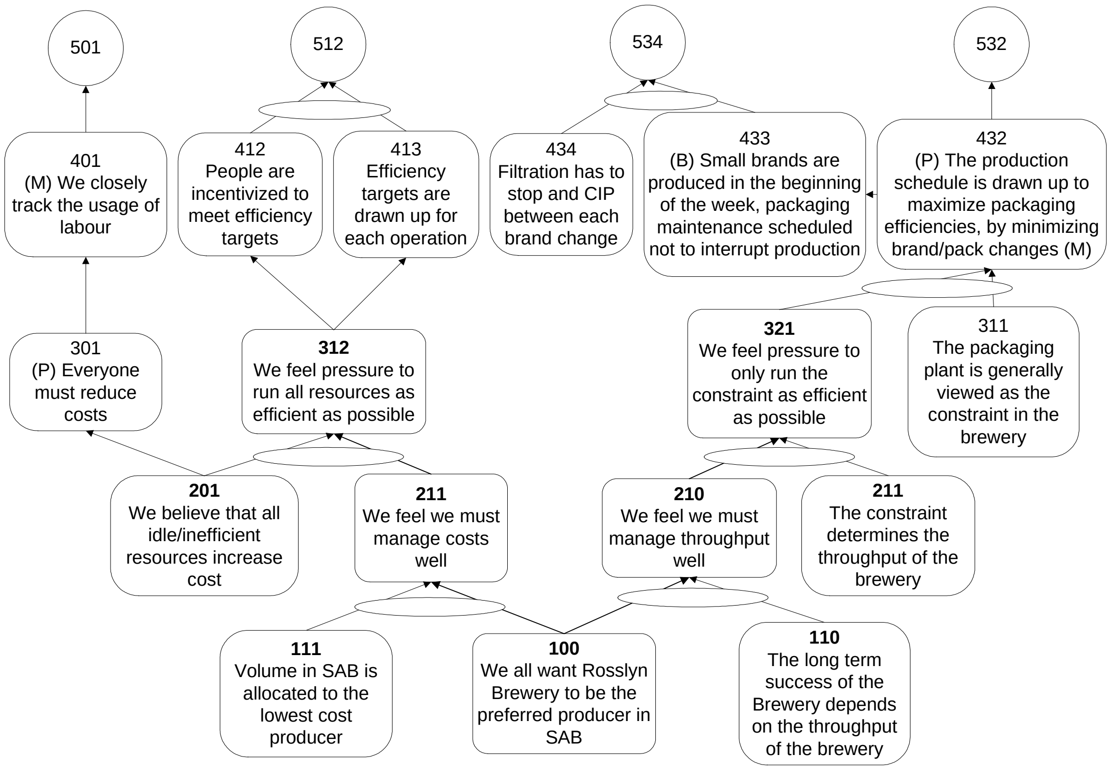

Figure 7-5: Current Reality Tree (section 1)

The Current Reality Tree also follows the "If…then…"-notation that were used in the Transition Tree in Chapter 1, e.g. ***If*** (100) we all want Rosslyn Brewery to be the preferred producer in SAB, ***then*** (211) we feel we must manage costs well, ***because*** (111) volume in SAB is allocated to the lowest cost producer.

The C^3 cloud diagram forms the base of the tree in nodes 100, 210, 211, 312 & 321. Behind each of the arrows in the cloud diagram is an assumption. These assumptions are listed in nodes 110, 111, 201 & 211. The nodes with a P, M or B in brackets are policies that were defined and measures or behaviours resulting from these policies.

The notation to read the branches are from the bottom upwards with a if-then statement, e.g If we feel we must manage Throughput well (210) and the constraint determines the Throughput of the brewery (211), then we feel pressure to only run the constraint as efficient as possible (321).

The second portion of the CRT is in Figure 7-6.

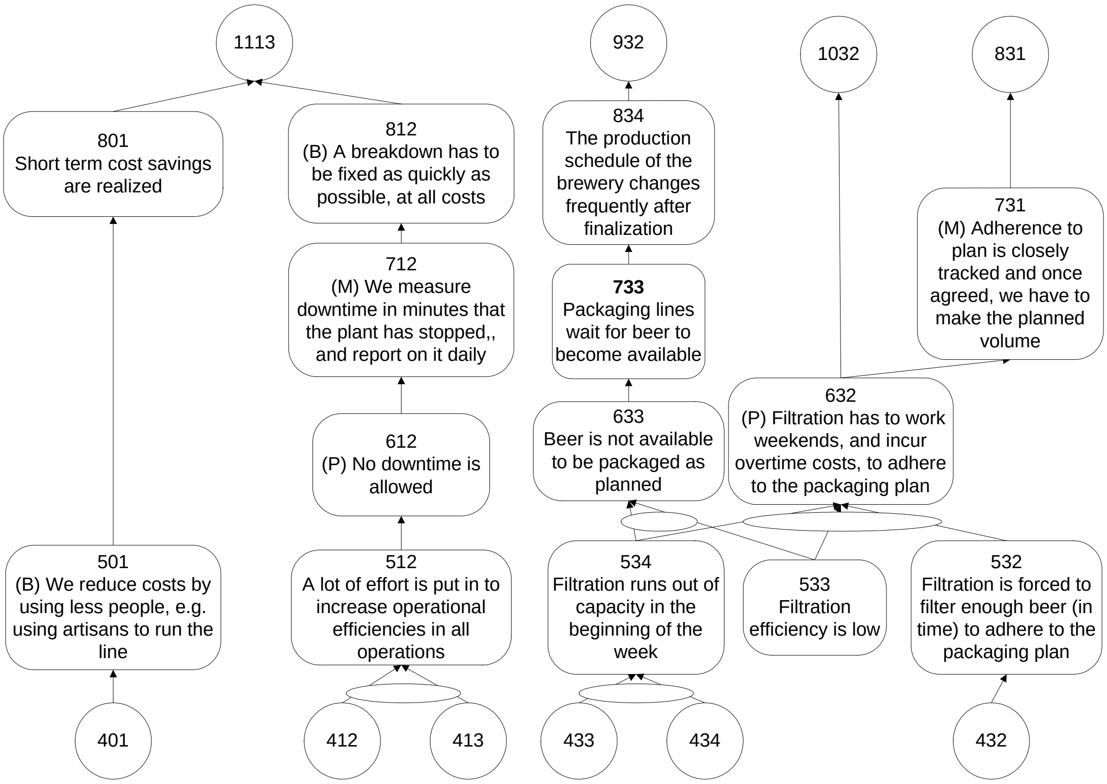

Figure 7-6: Current Reality Tree (section 2)

This portion of the tree deals specifically with the scheduling problem in the brewery and a number of the UDEs form part of this section. It is also clear that the scheduling problems are the results of policies in the brewery.

The third and last section is in Figure 7-7.

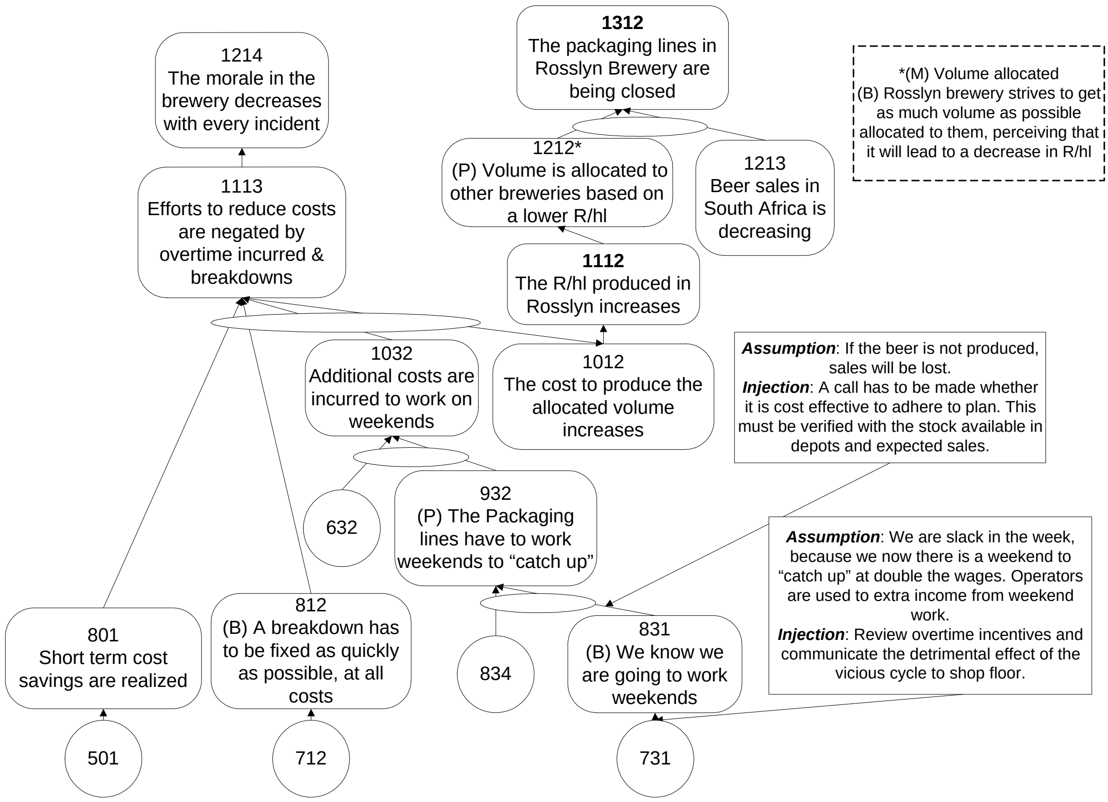

Figure 7-7: Current Reality Tree (section 3)

The reality tree ultimately leads to the current issue of packaging lines that are being closed. Some assumptions and possible injections have also been shown to provide more insight into the arrows connecting the blocks.

7.4. Conclusion

The Current Reality Tree is a very powerful tool to graphically illustrate the core conflict in any organisation and how it contributes to all the identified problems. It demonstrates how the honest actions derived from policies that were set up to improve performance actually have the opposite, negative effect than intended.

In the case of Rosslyn Brewery the policies were put in place to ensure that the packaging lines, the most expensive equipment to run, were fully utilized. In turn the constraint of the system is ignored, leading to unnecessary overtime and an increase in cost in spite of honest attempts to cut costs and to ensure that Rosslyn is the lowest cost producer in SAB.

In the next chapter, a solution will be sketched, using the Future Reality Tree. It is always crucial to know where you want to go to before starting to plan the route on how to get there. The purpose of the Future Reality Tree is to answer the "To what to change?" question.

8. THE SOLUTION FOR THE ROSSLYN CORE CONFLICT

Yes, you can be a dreamer and a doer too, if you will remove the one word from your vocabulary: impossible.
- Robert Schuller

8.1. Purpose

The objective of this chapter is to describe the solution to the core conflict identified in the previous chapter. The Thinking Process uses the Future Reality Tree to define the solution to the problem.

The following three steps are used to develop a Future Reality Tree:

1. Find a way to break the core conflict.
2. Make sure that the solution is sufficient to solve all of the UDEs.
3. Complete the solution by ensuring it doesn't create any new negative side effects.

8.2. Breaking the Core Conflict

Behind every arrow, including the conflict arrow, in the C^3 cloud diagram there is at least one logical assumption. Each assumption provides many opportunities to evaporate the cloud or break the conflict and remedy all the UDEs. These opportunities are referred to as injections. Figure 8-1 shows the C^3 diagram again with the assumptions behind the arrows and the injection to break the conflict arrow.

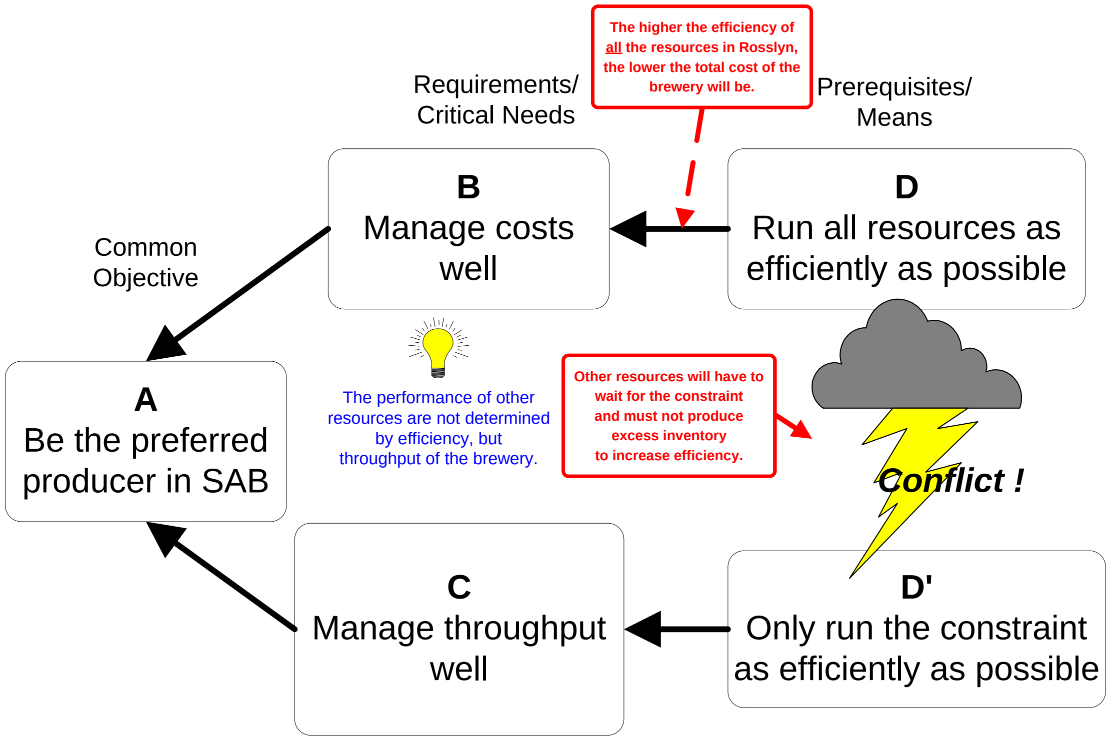

Figure 8-1: The injection to break the core conflict

In Rosslyn's case the old paradigm exists that all resources must be working all of the time. The assumption is that the total cost of the brewery will decrease if there are no idle resources. This is not true if the resources work on producing products that will not be sold, thereby creating inventory. In a brewery's case the risk of picking up quality problems increase and the beer will have to be discarded at a high cost. The injection that will break the conflict is to ensure that the performance of the resources are not determined by efficiency or utilization, but by the Throughput of the brewery. Throughput is defined as the number of units of finished product that were sold to the end consumer. This implies that other resources will have to wait for the constraint and not produce excess inventory to increase their efficiencies.

The concept of the balanced plant, described by Goldratt and Fox [1986:178] has already been explored in Chapter 4. The conventional rules is to balance the capacity of the plan and then to try and maintain the flow. The balanced plant works well in a perfect world without any statistical variation in demand and interdependencies on other operations and suppliers.

Different equipment in the plant also run at different capacities and if the factory rule considers activation and utilisation of a worker as the same, the result will be high work in process inventories and frustration on the shop floor. In a continuous-batch setup like a packaging line, the impact may not be immediately visible, but the moment a supplier is late, or the demand of a specific product changes, the inefficiency of the balanced plant will be clearly visible. There is absolutely no way a brewery as a whole can be "balanced" in terms of capacity and all the operations run at their maximum efficiency.

"The sum of local optimums is not equal to the global optimum [Goldratt, Fox; 1986:179]."

8.3. The Future Reality Tree

In order for a Future Reality Tree to be drawn up, a desirable effect has to be drawn up for each UDE. The list of Desirable Effects (DEs) is:

1. Beer availability is 100%.
2. Packaging lines never have to wait for beer to become available, except when planned to wait.
3. No overtime has to be incurred in Filtration to adhere to the production plan.
4. Filtration efficiencies are high (World Class Standard).
5. A lot of effort is put in to increase the Throughput of the brewery.
6. Once finalized and agreed, the production schedule rarely changes.
7. CAPEX is allocated to Rosslyn for improvement projects and expansions.
8. Volume is not allocated on a R/hl basis, but on total cost and best quality.
9. The total cost to produce beer in Rosslyn is the lowest in SAB.
10. Overtime is only incurred in peak periods, i.e. not a regular occurrence to adhere to plan.

In addition to desirable effects, strategic objectives (SOs) are also defined:

1. Rosslyn is the preferred producer in SABMiller.
2. Employee satisfaction is at an all time high.

3. Customers are delighted with the quality of beer produced in Rosslyn.
4. Cost savings is no more an axe hanging over people's heads.
5. Cash is never a constraint or a concern.
6. Rosslyn Brewery is the benchmark for all the breweries in SABMiller.

The Future Reality Tree is drawn up in a similar fashion as the Current Reality Tree. The base of the Future Reality Tree is the C^3 injection and links have to be established, through rigorous cause-and-effect analysis, to all the DEs and SOs that were defined. Figure 8-2 depicts the completed Future Reality Tree for Rosslyn Brewery.

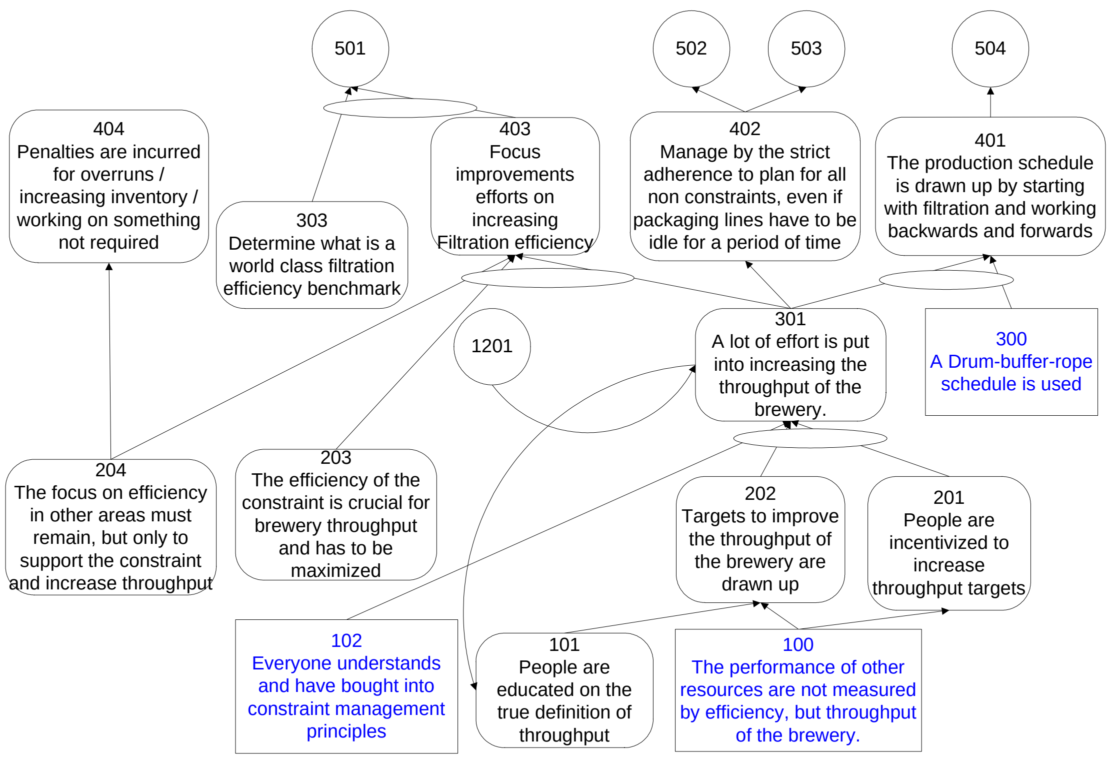

Figure 8-2: Future Reality Tree (section 1)

The Future Reality Tree has a similar structure to the Current Reality Tree, with the significant difference that it contains reinforcement loops. The more reinforcement loops there are, and the longer they are, the better the solution.

The second section of the Future Reality Tree is in Figure 8-3.

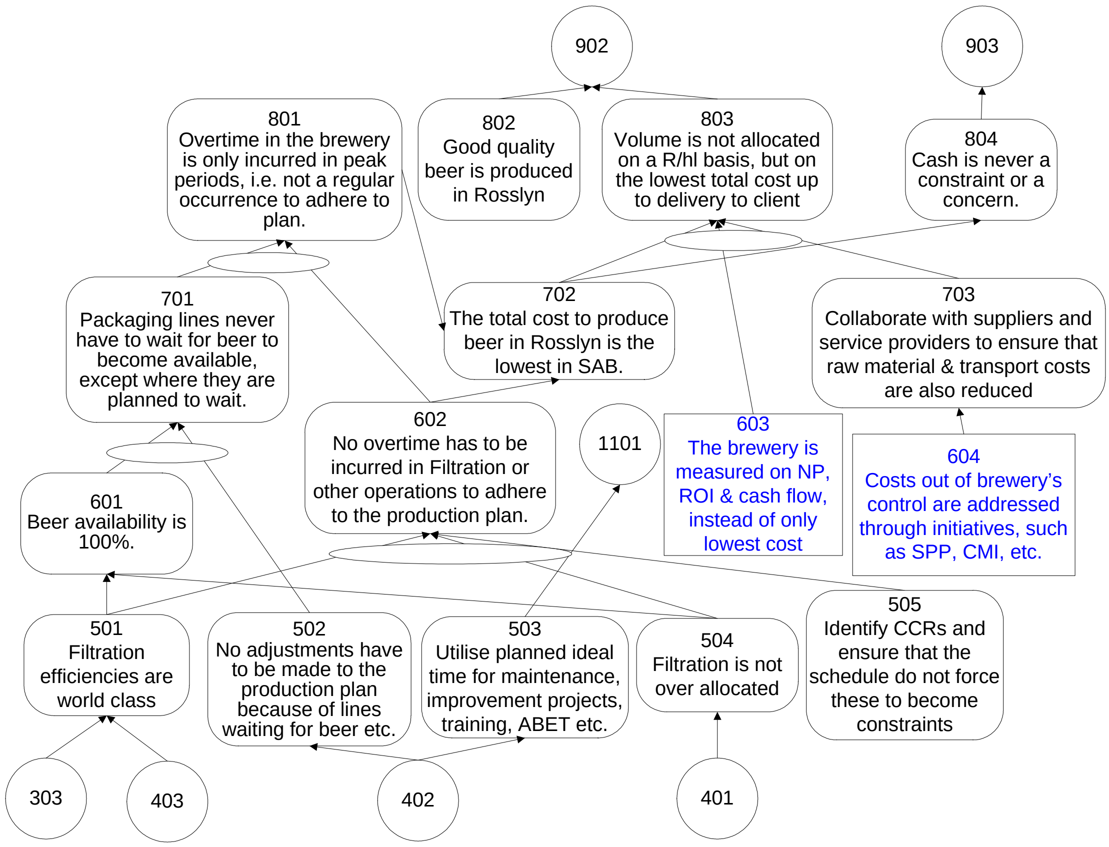

Figure 8-3: Future Reality Tree (section 2)

The tree is read in the same manner as the CRT with an if-then statement for each branch. Assumptions that have a significant influence on the connector are also highlighted, e.g. the brewery is measured on Net Profit, Return on Investment & Cash Flow, instead of only the lowest cost (R/hl).

The third section of the Future Reality Tree is in Figure 8-4.

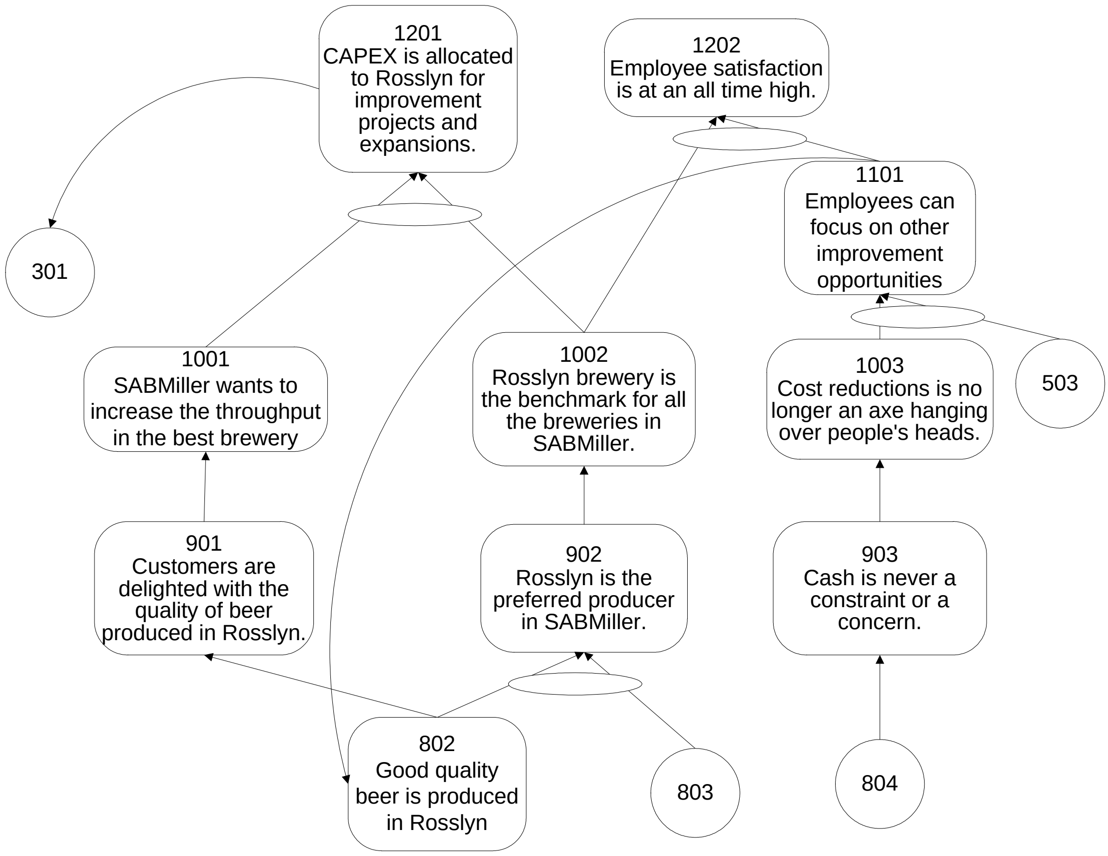

Figure 8-4: Future Reality Tree (section 3)

The ultimate strategic objective is to ensure that Rosslyn is the benchmark brewery in SABMiller on all aspects, even employee satisfaction.

8.4. Avoiding Negative Side Effects

The Thinking Process defines 9 “passes” or checks to ensure a deeper level of clarity and understanding of the solution. These are:

1. Building the DE map
2. Creating a skeleton
3. Defining the injections
4. Constructing rigorous Cause-and-Effect
5. Policies, Measurements and Behaviours

6. Engineering in loops
7. Connecting to the Strategic Objectives
8. Negative Branch Reservations
9. Grounding Flying Pigs

The first two steps are the same as when you are creating a Current Reality Tree. The objective is to create a diagram linking all the DEs, The third step introduces injections from the Current Reality Tree that are required to get from one entity to another. The fourth step is concerned with constructing rigorous Cause-an-Effect using the Categories of Legitimate Reservations that was described in Chapter 7. The 5 steps considers all the policies, measurements and behaviours that were defined in the Current Reality Tree and ensure that it is included in the Future Reality Tree in the form of an injection. In the sixth step loops are engineered into the solution to create positive momentum. The loop ensures that every time a specific action takes place it, another action will result creating a positive momentum, e.g. When (1101) employees focus on other improvement opportunities, (802) good quality beer is produced in Rosslyn. In the seventh pass the Strategic objectives that were identified are brought into the solution. The eighth pass identifies Negative Branch Reservations (NBR), i.e. identifying anything that could possibly go wrong, and use it to improve the solution.

Figure 8-5 is an example of one of the NBRs defined in the Future Reality Tree. The branches are identified as either positive (+), neutral (o) or negative (-). The Negative Branches are then “trimmed” by identifying injections that will negate the effect of the negative branch. The negative effect is indicated in red, and the injections in blue in the example.

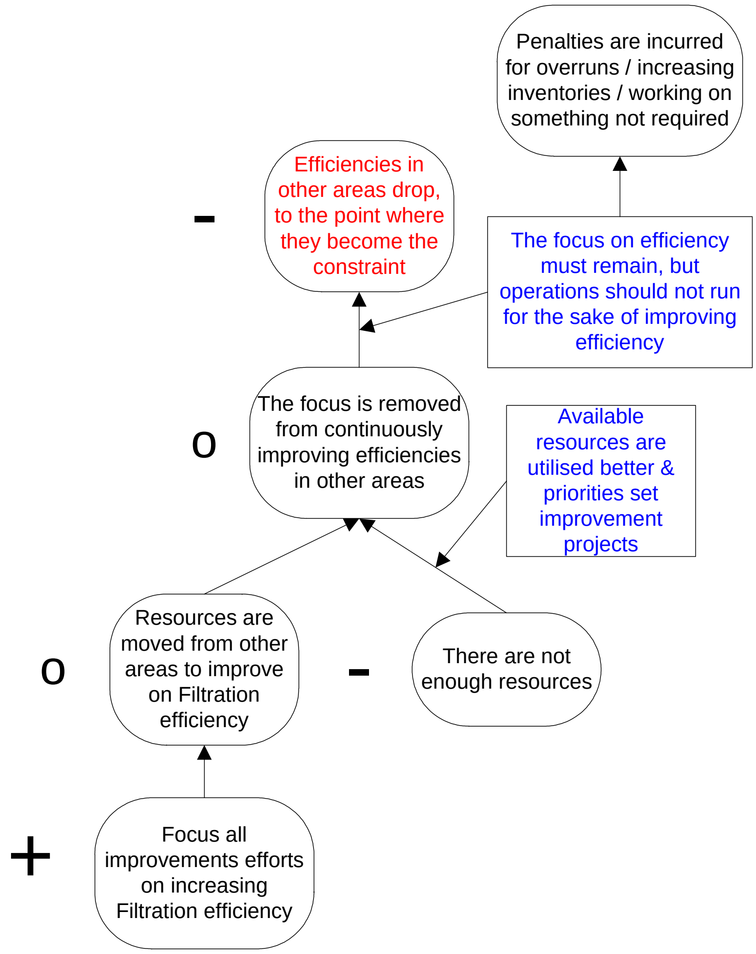

Figure 8-5: Negative Branch Reservation

The ninth pass is called "Grounding Flying Pigs". *"When building the Future Reality Tree we assume that we have a fairy godmother who, if we need pigs to fly for our solution to work, would make pigs fly! …now we need to ground those flying pigs and make those injections practical" [Houle, 2001:334].*

There are three ways to ground flying pigs:

- Loops
- Negative Branch Reservations
- Mini Prerequisite Trees

"When all of these passes have been completed, you have a complete solution – a practical strategy for achieving all the Desired Effects and Strategic Objectives." [Houle; 2001:335]

8.5. Conclusion

The Future Reality Tree shows in no uncertain way that there is a feasible solution to the core conflict. In the case of Rosslyn's core conflict, it is clear that the solution exists in the revisiting of the production schedule and the way the different processes are measured. In the next chapter we will investigate how two different scheduling regimes, Drum-Buffer-Rope and process flow scheduling can be applied to the brewery to ensure that the constraint is the key driver of Throughput in the brewery.

9. THE APPLICATION OF ADVANCED PLANNING AND SCHEDULING IN ROSSLYN BREWERY

There is no more difficult art to acquire than the art of observation, and for some men it is quite as difficult to record an observation in brief and plain language.
- William Osler

9.1. Purpose

The purpose of this chapter is to explore Advanced Planning and Scheduling systems (APS) and their applicability to Rosslyn Brewery.

In chapter 4 it was shown that there is a critical question that has to be asked after the constraint has been identified. The answer to the question: "Is the constraint a physical constraint?" will determine what action to be taken. If the constraint is a physical one the next step is to exploit the constraint. If the constraint is not a physical one, i.e. the constraint is a policy or procedure, this policy or procedure needs to change.

There are two issues with regards to the constraint in Rosslyn. The first is that there is definitely an internal physical constraint in the form of filtration, and an external physical constraint, the market. On the other hand there is a policy constraint which is the way in which the production schedule is generated, due to another policy constraint, namely the importance of product cost in comparing one brewery to another. This is a policy/procedural constraint and needs to be removed as a first priority to ensure that inertia is not created. After the policy constraint is removed, a Drum-Buffer-Rope scheduling system needs to be implemented to ensure that the constraint is exploited and everything else is subordinated to this decision. The third step would then be to elevate the constraint by increasing the market demand. In Rosslyn Brewery's case the market demand can only be increased by increasing total SAB sales and then having volume allocated to the brewery by central office. This is an exercise that is not directly under Rosslyn Brewery's control. The Thinking Process can again be used effectively here to guide management in the right direction.

The last thing that needs to happen is for Rosslyn to gain volume at the expense of Alrode or another brewery through a local optimization that does not bring SAB as a whole, closer to the goal of making money now and in the future.

9.2. The Planning Process

The Master Production Schedule in Rosslyn Brewery and other breweries are determined by a central planning team. This schedule is determined by considering the short term sales forecast (SSF), brewing volumes, raw material constraints and warehouse space availability. All these factors are updated on a weekly basis. Rosslyn then also has an internal planner that is responsible for scheduling the detailed plan for the week. This plan is communicated to central planning and discussed with the filtration, brewing and operations teams in a weekly planning meeting. The process is well entrenched in Rosslyn and follows the principles of Process Flow Scheduling (PFS) that will be discussed later in this chapter.

The problem is that the schedule is created by scheduling the packaging lines first. The brewing plan is then derived from the packaging line schedule and the release of raw materials into brewing determined by the packaging line requirements. The shipping schedule is also determined by the expected product coming off the packaging lines, and in peak times there is only a time buffer of half a day. This planning process has been perfected in Rosslyn and is one of the reasons why the packaging efficiencies are world benchmarks. The only problem with this process is that packaging is not the constraint of the brewery and therefore does not determine the Throughput of the brewery. To illustrate this point, the following scenario has been developed.

Table 9-1 is an actual production plan for packaging for a week in the peak period of 1998. This specific week was chosen, because the volume planned for the week was 172 310 hl. If there is no stock available in maturation or bright beer tanks, then filtration will not be able to filter this volume.

BRAND PACK REPORT BY HECTOLITRE

WEEK 2 ENDING: 12-Dec-1998

	BRAND	LINE 1	LINE 4	LINE 5	750	LINE 2	LINE 3			TOTAL
					TOTAL		340	450	TOTAL	
	CASTLE			8120	8120	3347				11468
S	LION									
U	HANSA									
N	MILK STOUT		2741		2741					2741
	BLACK LABEL									
	TOTAL		2741	8120	10861	3347				14209
	CASTLE			4437	4437			5481	5481	9918
M	LION	1946			1946	541		523	523	3009
O	HANSA		1337		1337					1337
N	MILK STOUT		4421		4421			1357	1357	5778
	BLACK LABEL	4131			4131	1545		1621	1621	7298
	TOTAL	6077	5759	4437	16273	2087		8981	8981	27341
	CASTLE			7332	7332					7332
T	LION						2218		2218	2218
U	HANSA	1521	3296		4817	2468	458		458	7744
E	MILK STOUT							262	262	262
	BLACK LABEL	4637			4637	119	2218		2218	6974
	TOTAL	6158	3296	7332	16786	2588	4895	262	5158	24531
	CASTLE			8041	8041		1259		1259	9300
W	LION									
E	HANSA	3183	5191		8374	3126	7273		7273	18774
D	MILK STOUT									
	BLACK LABEL									
	TOTAL	3183	5191	8041	16415	3126	8533		8533	28074
	CASTLE			9104	9104		8017		8017	17121
T	LION									
H	HANSA	6065	6052		12117	3645				15762
U	MILK STOUT									
	BLACK LABEL									
	TOTAL	6065	6052	9104	21220	3645	8017		8017	32883
	CASTLE			9207	9207	1816	8188		8188	19210
F	LION									
R	HANSA	5421	5313		10734	1634				12368
I	MILK STOUT									
	BLACK LABEL									
	TOTAL	5421	5313	9207	19941	3449	8188		8188	31577
	CASTLE			5865	5865	3269				9134
S	LION									
A	HANSA		1954	2606	4561					4561
T	MILK STOUT									
	BLACK LABEL									
	TOTAL		1954	8472	10426	3269				13695
W	CASTLE			52105	52105	8432	17465	5481	22945	83482
E	LION	1946			1946	541	2218	523	2741	5228
E	HANSA	16190	23144	2606	41940	10874	7732		7732	60546
K	MILK STOUT		7162		7162			1619	1619	8781
	BLACK LABEL	8768			8768	1665	2218	1621	3840	14272
	TOTAL	**26903**	**30306**	**54712**	**111921**	**21512**	**29633**	**9244**	**38877**	**172310**

Table 9-1: Packaging Production Plan - Scenario 1

Table 9-2 is a proposed filtration plan that has been drawn up in accordance with the packaging plan.

PLANNED FILTRATION VOLUMES							
Filter 1 Capacity (hl/day):		11097					
Filter 2 Capacity (hl/day):		12903			WEEK ENDING :	12-Dec-1998	
	BRAND	FILTER 1	FILTER 2		BRAND	FILTER 1	FILTER 2
SAT	CASTLE	-	12,903	WED	CASTLE	-	12,903
5-12	LION	979	-	9-12	LION	-	-
	HANSA	1,337	-		HANSA	11,097	-
	BLACK LABEL	-	-		BLACKLABEL	-	-
	MILKSTOUT	8,781	-		MILKSTOUT	-	-
	TOTAL VOLUME	11,097	12,903		TOTALVOLUME	11,097	12,903
SUN	CASTLE	6,751	5,605	THU	CASTLE	-	12,903
6-12	LION	4,249	-	10-12	LION	-	-
	HANSA	97	-		HANSA	11,097	-
	BLACK LABEL	-	7,298		BLACKLABEL	-	-
	MILKSTOUT	-	-		MILKSTOUT	-	-
	TOTAL VOLUME	11,097	12,903		TOTALVOLUME	11,097	12,903
MON	CASTLE	-	3,459	FRI	CASTLE	-	9,134
7-12	LION	-	-	11-12	LION	-	-
	HANSA	4,123	9,444		HANSA	4,561	-
	BLACK LABEL	6,974	-		BLACKLABEL	-	-
	MILKSTOUT	-	-		MILKSTOUT	-	-
	TOTAL VOLUME	11,097	12,903		TOTALVOLUME	4,561	9,134
TUE	CASTLE	9,300	867	CUME	CASTLE	16,051	57,774
8-12	LION	-	-		LION	5,228	-
	HANSA	1,797	12,036		HANSA	34,012	21,480
	BLACK LABEL	-	-		BLACKLABEL	6,974	7,298
	MILKSTOUT	-	-		MILKSTOUT	8,781	-
	TOTAL VOLUME	11,097	12,903		TOTALVOLUME	71,046	86,552
						157,598	

Table 9-2: Proposed Filtration Plan - Scenario 1

The following assumptions were made:

1. Castle Milk Stout is only filtered on filter 1 as per brewery policy.
2. The filtration plan is a day ahead of packaging to allow for quality checks and standing time in the bright beer tanks. The assumption is that all the volume for the next day has to be filtered today. This is not the always the case in practice.

In scenario 1 a total of 157 598 hl can be filtered. Even though filtration can filter up to 168 000 hl per week, the packaging plan further restricts the Throughput. The packaging plan has been drawn up to minimize set-ups and maximize packaging production runs. In a normal period the packaging plan would have included maintenance in the week as well.

The maintenance would have been spread over the lines, because the resources are shared. This would have restricted the plan even further.

Figure 9-1 indicates the problem with the current packaging plan. The plan has been drawn up to do all the smaller brands and pack changes during the first section of the week. The implication is that the packaged volume peaks on Wednesday and Thursday and on Monday and Friday there is less volume than filtration is capable of delivering. The result is that 14 615 hl (8.5% of total volume) cannot be packed. In the peak period every hector-litre not packed is a lost sale.

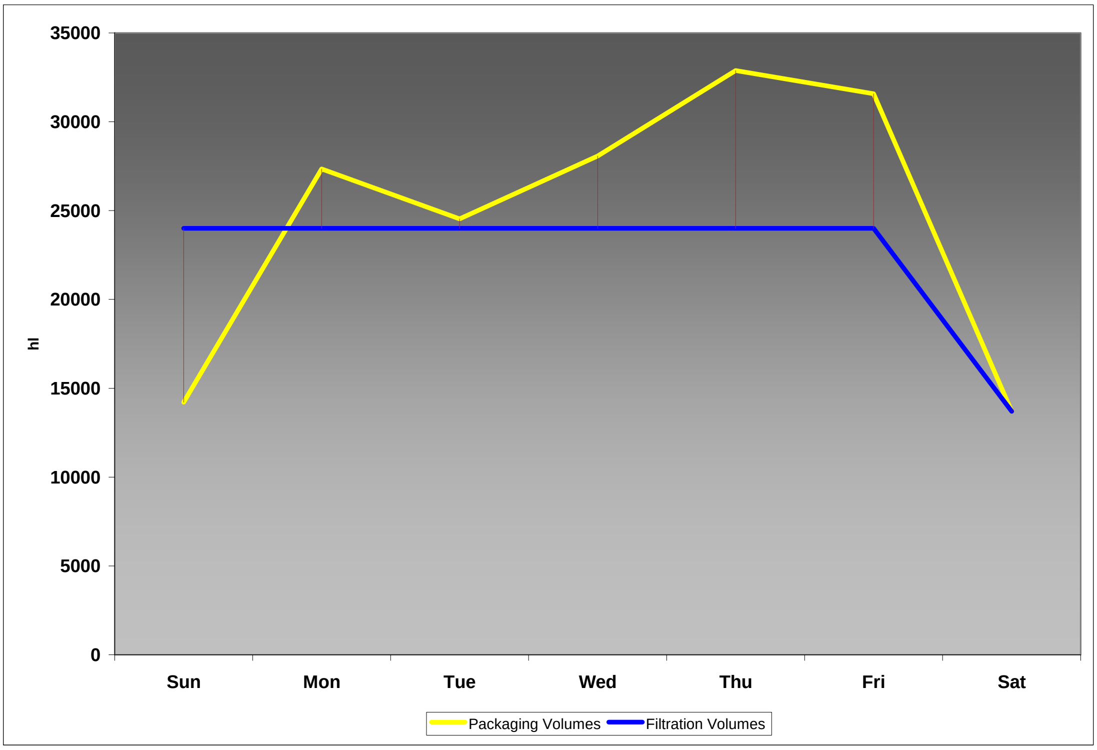

Figure 9-1: Variance Graph - Scenario 1

To illustrate the effect of scheduling the constraint first, the filtration plan in Table 9-3 has been drawn up with the objective to maximize the volume filtered.

PLANNED FILTRATION VOLUMES							
Filter1Capacity(hl/day)		11097					
Filter2Capacity(hl/day)		12903			WEEKENDING:	12-Dec-1998	
	BRAND	FILTER1	FILTER2		BRAND	FILTER1	FILTER2
SAT	CASTLE	-	12,903	WED	CASTLE	-	12,903
5-12	LION	2,316	-	9-12	LION	-	-
	HANSA	-	-		HANSA	11,097	-
	BLACK LABEL	-	-		BLACK LABEL	-	-
	MILK STOUT	8,781	-		MILK STOUT	-	-
	TOTAL VOLUME	**11,097**	**12,903**		TOTAL VOLUME	**11,097**	**12,903**
SUN	CASTLE	-	12,903	THU	CASTLE	-	12,903
6-12	LION	2,912	-	10-12	LION	-	-
	HANSA	-	-		HANSA	11,097	-
	BLACK LABEL	8,185	-		BLACK LABEL	-	-
	MILK STOUT	-	-		MILK STOUT	-	-
	TOTAL VOLUME	**11,097**	**12,903**		TOTAL VOLUME	**11,097**	**12,903**
MON	CASTLE	-	12,903	FRI	CASTLE	-	6,064
7-12	LION	-	-	11-12	LION	-	-
	HANSA	5,010	-		HANSA	11,097	6,839
	BLACK LABEL	6,087	-		BLACK LABEL	-	-
	MILK STOUT	-	-		MILK STOUT	-	-
	TOTAL VOLUME	**11,097**	**12,903**		TOTAL VOLUME	**11,097**	**12,903**
TUE	CASTLE	-	12,903	CUME	CASTLE	-	83,482
8-12	LION	-	-		LION	5,228	-
	HANSA	11,097	-		HANSA	49,398	6,839
	BLACK LABEL	-	-		BLACK LABEL	14,272	-
	MILK STOUT	-	-		MILK STOUT	8,781	-
	TOTAL VOLUME	**11,097**	**12,903**		TOTAL VOLUME	**77,679**	**90,321**
						168,000	

Table 9-3: Proposed Filtration Plan - Scenario 2

The maximum Throughput achievable in filtration is 168 000 hl per week.

The resultant packaging plan is indicated in Table 9-4.

BRAND PACK REPORT BY HECTOLITRE

	WEEK 2	5659	5697	8166		3190	7630	ENDING:		12-Dec-1998
	BRAND	**LINE 1**	**LINE 4**	**LINE 5**	**750 TOTAL**	**LINE 2**	**LINE 3** 340	450	**TOTAL**	**TOTAL**
	CASTLE	2088		8166	10254	2649				12903
S	LION					541	1252	523	1775	2316
U	HANSA									
N	MILK STOUT	1465	5697		7162			1619	1619	8781
	BLACK LABEL									
	TOTAL	3553	5697	8166	17416	3190	1252	2142	3394	24000
	CASTLE	387		8166	8553	1525		2825	2825	12903
M	LION	1946			1946		966		966	2912
O	HANSA									
N	MILK STOUT									
	BLACK LABEL	2682			2682	1665	2218	1620	3838	8185
	TOTAL	5015		8166	13181	3190	3184	4445	7629	24000
	CASTLE	5659			5659		4588	2656	7244	12903
T	LION									
U	HANSA			1820	1820	3190				5010
E	MILK STOUT									
	BLACK LABEL		5697		5697					5697
	TOTAL	5659	5697	1820	13176	3190	4588	2656	7244	23610
	CASTLE	2083			2083	3190	7630		7630	12903
W	LION									
E	HANSA		2931	8166	11097					11097
D	MILK STOUT									
	BLACK LABEL		390		390					390
	TOTAL	2083	3321	8166	13570	3190	7630		7630	24390
	CASTLE			6588	6588	1068	5247		5247	12903
T	LION									
H	HANSA	896	5697		6593	2122	2382		2382	11097
U	MILK STOUT									
	BLACK LABEL									
	TOTAL	896	5697	6588	13181	3190	7629		7629	24000
	CASTLE		4737	8166	12903					12903
F	LION									
R	HANSA	4663			4663	2372	4062		4062	11097
I	MILK STOUT									
	BLACK LABEL									
	TOTAL	4663	4737	8166	17566	2372	4062		4062	24000
	CASTLE		4737	8166	12903					12903
S	LION									
A	HANSA	5659	960		6619	3190	1288		1288	11097
T	MILK STOUT									
	BLACK LABEL									
	TOTAL	5659	5697	8166	19522	3190	1288		1288	24000
W	CASTLE	10217	9474	39252	58943	8432	17465	5481	22946	90321
E	LION	1946			1946	541	2218	523	2741	5228
E	HANSA	11218	9588	9986	30792	10874	7732		7732	49398
K	MILK STOUT	1465	5697		7162			1619	1619	8781
	BLACK LABEL	2682	6087		8769	1665	2218	1620	3838	14272
	TOTAL	**27528**	**30846**	**49238**	**107612**	**21512**	**29633**	**9243**	**38876**	**168000**

Table 9-4: Proposed Packaging Plan - Scenario 2

In scenario 2 there is still a shortage of 4310 hl for the week. It was decided that the least impact on sales will be to take this volume out of Hansa Pilsener quarts. In practice this volume would have been produced by another brewery, or replenished from stock.

The effect of the schedule change is illustrated in Figure 9-2:

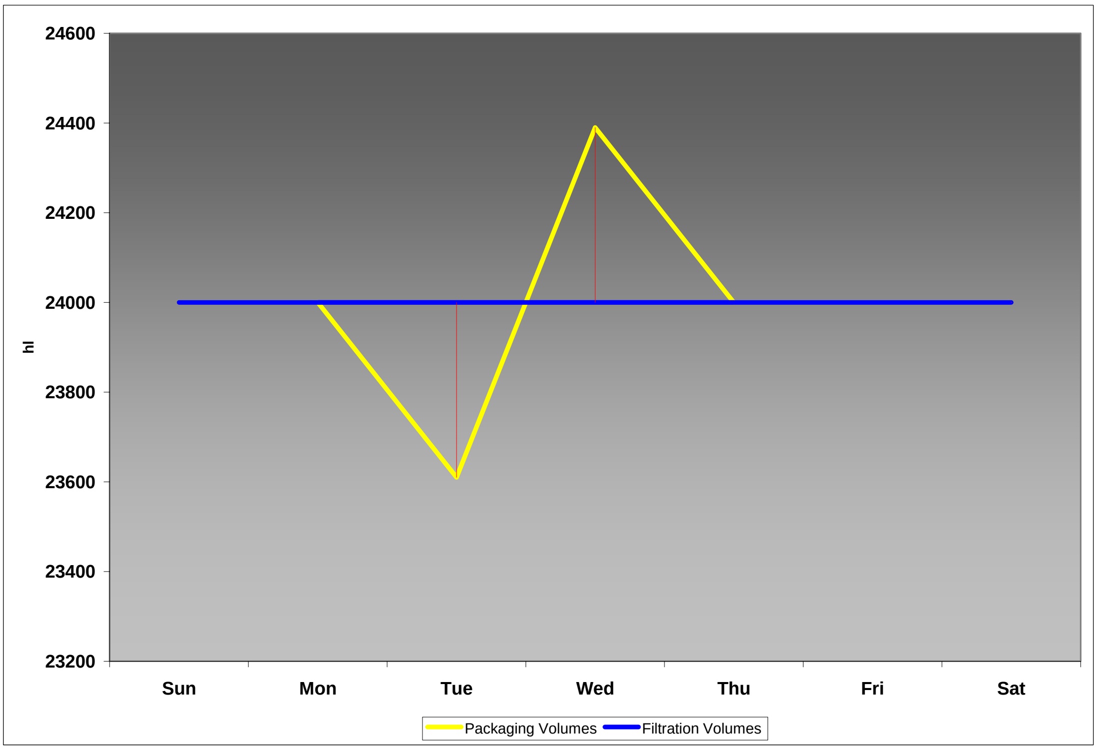

Figure 9-2: Variance Graph - Scenario 2

The variance is a result of a decision made to leave 390 hl of Black Label on Line 4 to be packaged on the next day. This resulted in one less start-up operation and can be accommodated by the spare capacity available in packaging and bright beer storage.

Table 9-5 is a summary of volumes planned in the two scenarios.

	Scenario 1			Scenario 2		
	Planned Volume Packaging	Filtration Capability	Variance	Planned Volume Packaging	Filtration Capability	Variance
Sun	14,209	24,000	9,791	24,000	24,000	0
Mon	27,341	24,000	-3,341	24,000	24,000	0
Tue	24,531	24,000	-531	23,610	24,000	390
Wed	28,074	24,000	-4,074	24,390	24,000	-390
Thu	32,883	24,000	-8,883	24,000	24,000	0
Fri	31,577	24,000	-7,577	24,000	24,000	0
Sat	13,695	13,695	0	24,000	24,000	0
Total	**172310**	**157695**	**-14615**	**168000**	**168000**	**0**

Table 9-5: Summary Table

In the first scenario the total volume of 172 310 hl was scheduled, but cannot be achieved. In the second scenario only 168 000 hl was planned as per the constraint capacity.

Table 9-6 shows the effect of the schedule change on the packaging production plan.

	Scenario 1	Scenario 2	Variance
No. of Brand-packs	17	17	0
Achievable Volume	157,695 hl	168,000 hl	10,305
No. of start-ups/brand changes			
Line 1	3	8	5
Line 2	5	7	2
Line 3	10	11	1
Line 4	2	6	4
Line 5	2	3	1
Shortest run planned			
Line 1	1,521 hl	387 hl	-1,134 hl
Line 2	541 hl	541 hl	
Line 3	523 hl	523 hl	
Line 4	1,337 hl	960 hl	-377 hl
Line 5	2,606 hl	8,166 hl	5,560 hl
Average length of scheduled production runs			
Line 1	3,843 hl	2,753 hl	-1,090 hl
Line 2	2,151 hl	2,151 hl	
Line 3	3,240 hl	2,777 hl	-463 hl
Line 4	3,788 hl	3,856 hl	68 hl
Line 5	6,839 hl	7,034 hl	195 hl

Table 9-6: Effect on production schedule

1. By scheduling according to the constraint in the brewery, the Throughput can be increased by 10 305 hl, which is a very significant volume in peak period.
2. The number of start-ups and brand changes on every line has increased as expected. There will also be idle time on the packaging lines. Line 4 doesn't have any work on the Sunday and this time can be utilised for maintenance. Line 5 only has to run 1820 hl on one day, which is only 5½ hours of production, again leaving ample time for routine maintenance schedules.
3. The shortest run on Line 4 is 4.04 hours and Line 1 will have to start up for a production run of 1.64 hours. Line 1 also has to do three brand changes on that day.
4. The average run length has not decreased dramatically with line 1 again the worst off with a reduction of 1090 hl.

Schedulers are often tempted to save set-up times and maximize production runs, especially in a perceived continuous process such as packaging. The main reasoning is to minimize the set-ups and changeovers from one brand-pack to the next.

This type of scheduling results in filtration not being able to filter enough beer for packaging, especially towards the end of the week. Weekend work then has to be scheduled to complete the packaging programme resulting in unnecessary overtime which increases cost.

By introducing a small change in the scheduling procedure at Rosslyn Brewery, a significant impact on the Throughput of the brewery is implied. This change will definitely result in increased Throughput in the peak periods.

The injection required in this process, is to start the schedule with filtration and determine the release of raw material to brewing from filtration and also to define time buffers to protect this operation.

9.3. Exploitation Measures

The exploitation of the constraint is achieved through implementation of the Drum-Buffer-Rope scheduling system. The drum is the process that determines the Throughput by determining the rate at which raw material is released into the system.

In the example above the release of raw materials into the brewing process will also be derived from the filtration plan in contrast to the current practice of scheduling the raw material release in brewing from the packaging production plan. Unfortunately this is also the practice in the central planning operation. This process may apply to other breweries where the packaging process is definitely the constraint of the system, but cannot be applied to Rosslyn. The impact of raw material release is not as significant as the filtration schedule in Rosslyn because of the protective buffers in fermentation and maturation.

The production rate of the constraint will serve as the drumbeat of the entire system. The first important measurement is therefore to ensure that the production rate of the constraint is measured. In the case of Rosslyn it implies filtration efficiencies. Although filtration efficiencies are measured and recorded in Rosslyn, not nearly as much emphasis is placed on it as in the packaging process. In a previous chapter it was indicated that the key performance drivers in brewing is the internal quality measurement system (IQMS). This is also the case in filtration. I am not implying that filtration shouldn't care about quality any more, but that more emphasis should be placed on filtration efficiencies and uptime. The definition of Throughput specifically defines it as product sold to ensure that the quality is good enough for a sale. The filtration efficiency can be further enhanced by ensuring that maintenance schedules are meticulously followed (as is the case in packaging) improving the reliability and uptime of the filters. Furthermore no time should be wasted by waiting for raw material, blockage from upstream processes, operators sitting idle etc. This is one area where JIT principles can be used to identify areas of waste and eliminate it.

"*An inventory buffer will also be placed in front of the constraint. This buffer contain only the inventory needed to keep the constraint busy during the next predetermined time interval and is therefore referred to as a time buffer" [Goldratt, Fox; 1986:98].*

A time buffer will protect the Throughput of the plant against any disruption that can be overcome within the predetermined time interval. The buffer size needs to be fixed and then constantly monitored. In practice the raw material release to brewing should be done earlier to create a time buffer to protect the constraint against "Murphy". The size of this buffer can best be determined through trail and error.

In order to ensure that the inventory will not grow beyond the level dictated by the time buffer, we must limit the rate at which raw material is released into the plant. A rope should be tied from the constraint to the gating operation that releases material into brewing. The material will only be released when "pulled forward" by the constraint. The gating operation in the brewery is the mash-tun. This is the vessel where all the raw materials are added together and the brewing process starts. The brewing schedule looks very much different from the filtration and packaging ones in that it shows the exact time when the brewing process must be started. The changes required are again minor, in fact, no changes to the current reporting system will be needed, and the only difference is that the filtration plan will be used to determine when the brewing process should start and not the packaging plan.

9.4. Monitoring the queue / buffer

Monitoring the queue on a real-time basis is an essential part of a DBR reporting system. *"Non-drums with chronic queuing problems will consistently show up in the buffer-management reporting structure as a source of severe buffer penetration or drum and shipping schedule misses. Tracking the frequency and cause of severe buffer penetration and drum schedule or shipping schedule misses is the best indicator of operations with insufficient surplus or sprint capacity" [Smith, 2000a:79].*

In Rosslyn Brewery's case there is no physical queue in front of filtration. The operation that transfers the beer between fermentation and maturation and between maturation and filtration is called racking. The time buffer in front of filtration will be depleted if the racking operation is not up to standard. The drum schedule misses can be derived by monitoring the adherence to plan for the racking operation. If there is a poor adherence to plan in racking it will result in drum schedule misses.

9.5. Meeting the Drum schedule

Provided we have correctly scheduled the realistic capacity of the real drum, the first question is: "Are we meeting the drum schedule?" "*Missing the drum schedule creates potential of missing a shipping date. The first measure of the drum is a measure of on-time performance to the drum schedule*" *[Smith, 2000a:80].*

The filtration schedule and adherence to the plan is measured in the "Filtration Weekly Efficiency Report", as well as the "Machine Downtime Report". The reasons for not meeting the schedule is recorded and investigated in Small Business Units. Factory efficiency and adherence to plan will indicate how many times the shipping deadlines will be met or missed. Operating efficiency will indicate whether there is a subordination problem, e.g. if a schedule is missed because there was no raw material available, it can be an indication that a process before the buffer is not subordinate to the constraint. Machine efficiency is an indication of whether the constraint is utilised to its full potential capacity. "*Constraint resource measures are focused on utilization and efficiency*" *[Smith, 2000a:81]*.

Some basic questions and answers to rate the constraint on its exploitation efforts are:

1. ***Is the machine manned throughout breaks and lunches?*** The filters in Rosslyn are already operating on a continuous shift basis (especially during peak periods) and therefore also have staggered breaks for lunch and tea.
2. ***Does the operation lose uptime at shift change?*** This is also not a major concern in filtration. The only reason for losing time during a shift change is if there is a Small Business Unit meeting, but if a new filter run is scheduled to start on the shift change someone will be dedicated for the task.
3. ***Is an operator or set-up technician spending time at some other function (paperwork, cleanup, chasing down parts or tools) that reduces the ability to keep the resource running?*** This is definitely an area of concern and has probably been negatively affected by the BOP II implementation. In this implementation higher skilled persons were employed and some lower levels trimmed. Although the department would have benefited with more skilled operators and supervisors, the negative side of it is that more paper work will be generated. This issue requires further investigation to determine the real impact on filtration Throughput.
4. ***Is there a machine/operator/skilled person who can relieve some of the drum's workload?*** There has been an enormous drive in Rosslyn Brewery over the last few years to move to multi-tasking of operators and artisans.

These initiatives will, specifically in brewing, pay off soon and result in any operator not only being able to operate another machine/process (like the drum), but also do routine maintenance tasks on that machine.

5. ***What is causing the drum downtime, and can we find a way to stop or decrease the downtime?*** One of the successes in Rosslyn is the functioning of Small Business Units and regular problem solving sessions are held. This is also driven further by goals and performance measures against which employees and teams are measured and rewarded for.

6. ***Where and how can I increase capacity at the drum and who can do it?*** Apart from scheduling in accordance to the filtration process, the next step will be to increase capacity by acquiring a third filter. An application has been made to central office and was under consideration.

9.6. Subordination Measures

The ability to subordinate will define a company's ability to succeed with the Theory of Constraints. Utilization of the constraint is dependant on effective subordination. "*Successful subordination requires all non-constraint resources to understand their relationship to the constraint and to define their actions by the impact the action will have on exploiting the constraint*" *[Smith, 2000a:89]*.

This is probably going to be the key to the successful implementation of a Drum-Buffer-Rope implementation in Rosslyn. The Thinking Process needs to be applied to develop a structured method of selling the concept to management, specifically in the packaging environment.

9.7. Bridging the gap between Throughput Accounting and GAAP Financial statements

Throughput accounting is essentially the same as direct costing or variable costing, as commonly defined in traditional managerial accounting textbooks.

For companies committed to maintaining variable contribution information, there are two choices available:

- Maintain their accounting systems on full-absorption, GAAP basis with separate calculations and analysis of variable contribution information.
- Maintain their accounting systems on a variable contribution basis with a monthly reconciliation to GAAP.

There are four basic strategic decisions that companies commonly make with standard cost information:

1. Product priority
2. Product pricing
3. Additions or deletions of a product
4. Capital investment and process improvement decisions

Of these decisions, only the last one will be made at the brewery. The other decisions remain the responsibility of head office, with input from the brewery. It does not however, imply that the brewery has no input in the decision-making and will definitely affect the operation at the brewery. The company has to be careful about what decisions are made, based on local optimum implied by the financial reporting system. A Throughput accounting system will probably be the best alternative for reporting production performance and making decisions that affects the brewery directly.

9.8. Process Flow Scheduling

At the moment SAB is considering Process Flow Scheduling (PFS) as an alternative advanced planning process for all the breweries in South Africa.

"*Process Flow Scheduling is a scheduling framework that uses the process structure to guide scheduling calculations. Process clusters are scheduled using a material-dominated or a processor-dominated scheduling technique. Cluster schedules are linked using a reverse flow, forward flow, or mixed flow scheduling strategy. PFS is applied in flow manufacturing environments" [Taylor & Bolander, 1994:164].*

One of the leading brewers in the world, Coors Brewing Company uses the mixed flow model of process flow scheduling to plan the activities in a brewery. The SAB planning process at the moment does not differ dramatically from PFS, but has not been fully adopted and standardized over all breweries.

The flowchart in Figure 9-3 shows the two-phased nature of the approach and the control points that have been put in place to ensure that the brewery can fulfil in all the distributor orders.

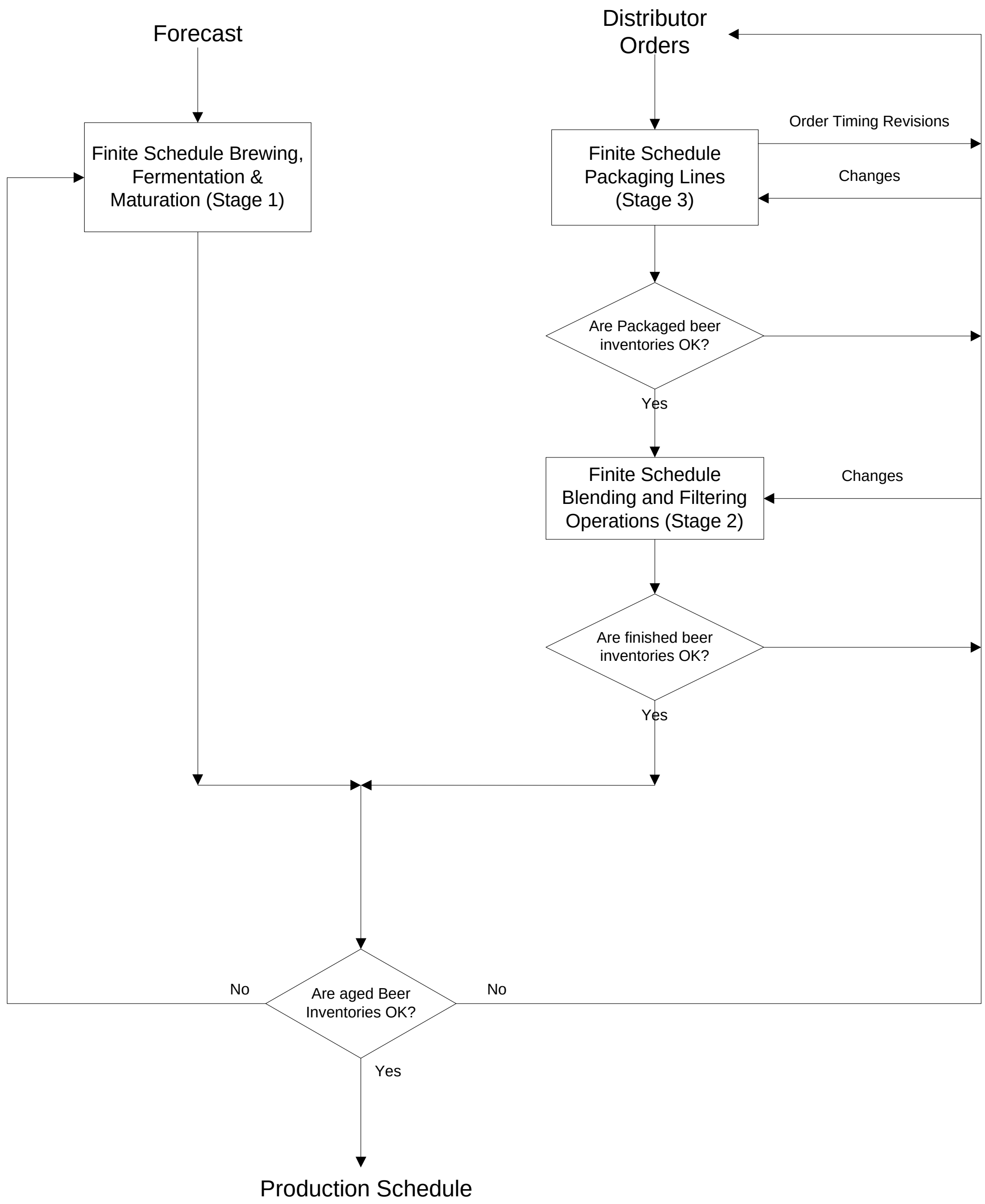

Figure 9-3: Coors Brewing Scheduling Flowchart [Taylor & Bolander, 1994:47]

In this process the planning and scheduling focus of the stages varies in content and approach. Stage 1, the brewing stage, is scheduled as a make-to-stock operation, because the system is a push system at this stage. Brand forecasts are used to create schedules for brewing. Completion of each brew forward scheduled the needs for fermentation tanks.

Completion of fermentation, likewise forward schedules the need for aging tanks. Therefore the brewing schedule defines the downstream tank requirements for fermentation and aging. Inventory mixes are continuously evaluated, and brewing schedules are changed when inventories are too small or too large.

Packaging, in turn, is scheduled as a make-to-order environment and drives the other stages. Packaging operates in a market pull system. Most package types are scheduled for production every week and particular attention is paid to product sequences (which can result in major or minor setups) and line rates while trying to load trucks and railcars directly from packaging lines. This packaging schedule defines the brands and volumes to be blended in the bright beer tanks. If the blending stage can support the packaging schedule, the schedule is then finalized, packaging crews assigned, transportation to distribute the products arranged, and packaging material schedules finalized. If any of the above material or capacity requirements cannot be met, the schedules are reworked until a feasible plan is developed. As a last resort, customer orders are placed on allocation.

The Coors scheduling process is also iterative. In the short run, scheduling conflicts between brewing and packaging result in scheduling changes on the packaging lines. Lead times in brewing prevent short-run changes in the brewing schedule.

Coors brewing illustrates an outside-in mixed scheduling logic. The push from brewing meets the pull from customer orders at the aged beer inventories. The outside-in scheduling process allows the de-coupling of the long-lead-time brewing operations from the short-lead-time, order-driven blending and packaging operations. The de-coupling also occurs at a point in the process where there is a significant increase in the number of items; relatively few brands are produced, however several hundred products are sold because of variations in packaging.

SAB is in exactly the same situation as Coors Brewing Company and follows a similar process. The forecast used to schedule brewing is a 13 week rolling forecast, based on the updated sales forecast, and is already broken down to brand and pack level. It is therefore also used to schedule the packaging process, although the schedule length varies from 1 week to 3 months. The de-coupling of the two processes is also in blending, which takes place in the Bright Beer Tanks.

The other difference is that in SAB's case, the distributors are also part of the company, which is not the case in Coors. The distributor orders will therefore be determined by Central Planning and dictated to the depots, based on the forecast of sales.

The only problem with the type of scheduling used by both these breweries, is that the constraint of the brewery is ignored. The customer orders are directly linked to the packaging process as it is the start of the second stage in the brewery and all the process around it forward or backward scheduled to satisfy the demand. As shown in this chapter, if the constraint of the brewery is in another process, like filtration, it will be better to link distributor orders to filtration instead of packaging and then schedule the processes around it. This will ensure that the maximum Throughput can be obtained and that customer demand is met. The interesting part will be if brewing, or any of the other process in stage 1 is the constraint of the brewery. That situation will require an even more frequently updated forecast and smaller batches to ensure that the brewery is more flexible to changes in demand.

The argument in the brewing industry that the constraint of the brewery moves, has been discussed in a previous chapter. It is the author's opinion that this is not true and in his experience with Rosslyn Brewery it has been observed that other processes, such as storage and fermentation become the constraint, because of scheduling or operating inefficiency. They are definitely Capacity Constrained Resources (CCRs) as described by Goldratt. The argument of the moving constraint is now being used to justify why Process Flow Scheduling should be used instead of Drum-Buffer-Rope. It is the author's opinion that a combination of these two scheduling processes should be used on the brewery level instead of playing them up against each other.

No brewery can be scheduled without PFS, because of the push-pull system that exists by design, and when the market is not the constraint the brewery will not be able to meet demand if Drum-Buffer-Rope principles are not applied.

9.9. Conclusion

Rosslyn Brewery can implement a combination of Drum-Buffer-Rope and Process Flow Scheduling system with relative ease, because a lot of the World Class Manufacturing principles have been entrenched in the operation.

The planning and reporting functions have been well defined and tested in packaging and needs to be implemented and refined in especially filtration. This chapter has demonstrated some of the changes that will be required in terms of scheduling procedures in the brewery. The next chapter will deal with the other obstacles to cause change and how the final step in the Thinking Process assists in drawing up a plan for implementation.

10. IMPLEMENTING CONSTRAINTS MANAGEMENT PRINCIPLES IN ROSSLYN BREWERY

Difficulties strengthen the mind, as labour does the body.
- Seneca

10.1. Purpose

This chapter deals with the final step in the Thinking Process, seeking to answer the question "How to cause change?" We are now familiar with the core conflict and have bought into the solution to the problem, but we now have to form an implementation plan for the process. For the purpose of the dissertation these steps could not be validated with the applicable parties in SAB, but can still provide a guideline for the implementation of such an intervention in future.

The final step in the Thinking Process is to answer the question "How to cause change"

The steps are:

1. Chart a course for implementing all the tactical objectives
2. Secure the active collaboration of all the key players who must approve or be involved in implementation
3. Detail the specific actions required
4. Manage the roll-out of the implementation plan

10.2. The tactical objectives

Tactical objectives are defined by taking all the injections in the Future Reality Tree and identifying obstacles for their implementation. For the purposes of this dissertation only two of these tactical objectives have been described to illustrate the Thinking Process. In reality every objective will have to be scrutinized and obstacles and intermediate objectives defined.

The two crucial objectives chosen are:

1. Everyone in the brewery understands and has bought into Constraints Management principles.
2. The three primary measures for the brewery is net profit, return on investment and cash flow, instead of lowest R/hl.

For each of the obstacles an intermediate objective is set. Table 10-1 & Table 10-2 describe the obstacles and intermediate objectives for two injections in the Future Reality Tree:

Tactical Objective # 1: Everyone understands and has bought into Constraints Management Principles.

	Obstacles	**Intermediate Objectives**
1.	Board approval and go-ahead is required	Board approval is obtained to implement Constraints Management at all breweries
2.	Constraints Management has to be given a SAB flavour	Training material is written and a strategy formulated to communicate principles to the work force
3.	May be viewed as just another WC initiative and not taken seriously	The importance of CM is explained and shown that it encompasses all WC improvement efforts
4.	May require union buy-in/negotiation	Union buys into process and helps to sell it to the shop floor. It is not seen as an imitative to cut heads or increase work load.
5.	General Manager has to believe in principles and not overrule subordinate and exploitation decisions	General managers fully believe in CM principles and actively drives implementation
6.	There are no money allocated for such a project	The necessary funds are allocated to the project by head office
7.	It requires a paradigm shift (especially from Packaging fraternity) to move away from constantly improving efficiencies at all cost	A proper change management program is developed to assist in the behavioural changes required in the organisation

Table 10-1: Tactical Objective #1

Seven obstacles were identified that all deal with the behavioural aspects. They identify the mind-sets that need to be changed, as well as the key influences of change in the brewery. These are crucial first steps that will determine whether the process is successfully implemented or not.

The second objective is directly related to the core conflict and describes how the measurement in the brewery needs to be adjusted for a Constraints Management implementation.

Tactical Objective # 2: The brewery is measured on NP, ROI & Cash Flow instead of only lowest R/hl

	Obstacles	Intermediate Objectives
1.	Board approval and go-ahead required	Board approval is obtained to implement Constraints Management at all breweries
2.	A different form of financial reporting on Brewery level is required	Throughput accounting is adopted for financial reporting on the brewery level
3.	The inherent focus on R/hl on director level needs to be changed	The focus on all levels in SAB is on improving Throughput
4.	A shift is required away from cost reductions to Throughput increase	The focus on all levels in SAB is on improving Throughput

Table 10-2: Tactical Objective #2

The key success factor required to implement these tactical objectives, is to change the performance incentive (best brewery award) in SAB. At the moment the achievement of packaging efficiency targets is a huge contributing factor to the award. The focus needs to be moved away from achieving efficiency targets, to increasing Throughput by focusing on the constraint in the brewery.

The tactical objectives as well as intermediate objectives are used to build the Prerequisite Trees. A number of actions will be defined to provide the links between these objectives. These actions are then used in the Transition Tree that will be used as a basis for the project plan.

"*The tool known as a Prerequisite Tree is a time-sequenced road map that leads the team from the current old environment into the new solution" [Smith; 2000a:39]*.

The intermediate objectives defined in Table 10-1 and Table 10-2 are used as the building blocks in the Prerequisite Tree. They start with the board approval task and then build up in sequence until all the tactical objectives have been met. Figure 10-1 describes the first section of the Prerequisite Tree in detail.

The obstacles that need to be overcome have also been included to remind the reader of the reasoning behind and importance of realizing the intermediate objectives.

In the second section of the Prerequisite Tree, shown in Figure 10-2, all the intermediate objectives lead up to the implementation of all tactical objectives. The tactical objectives are indicated in blue to differentiate them from the intermediate objectives.

The Prerequisite Tree draws up a map for implementation, which now has to be fleshed out in a detailed project plan. The tool used as a transition to a proper project plan is referred to as a Transition Tree and will be described in the next section.

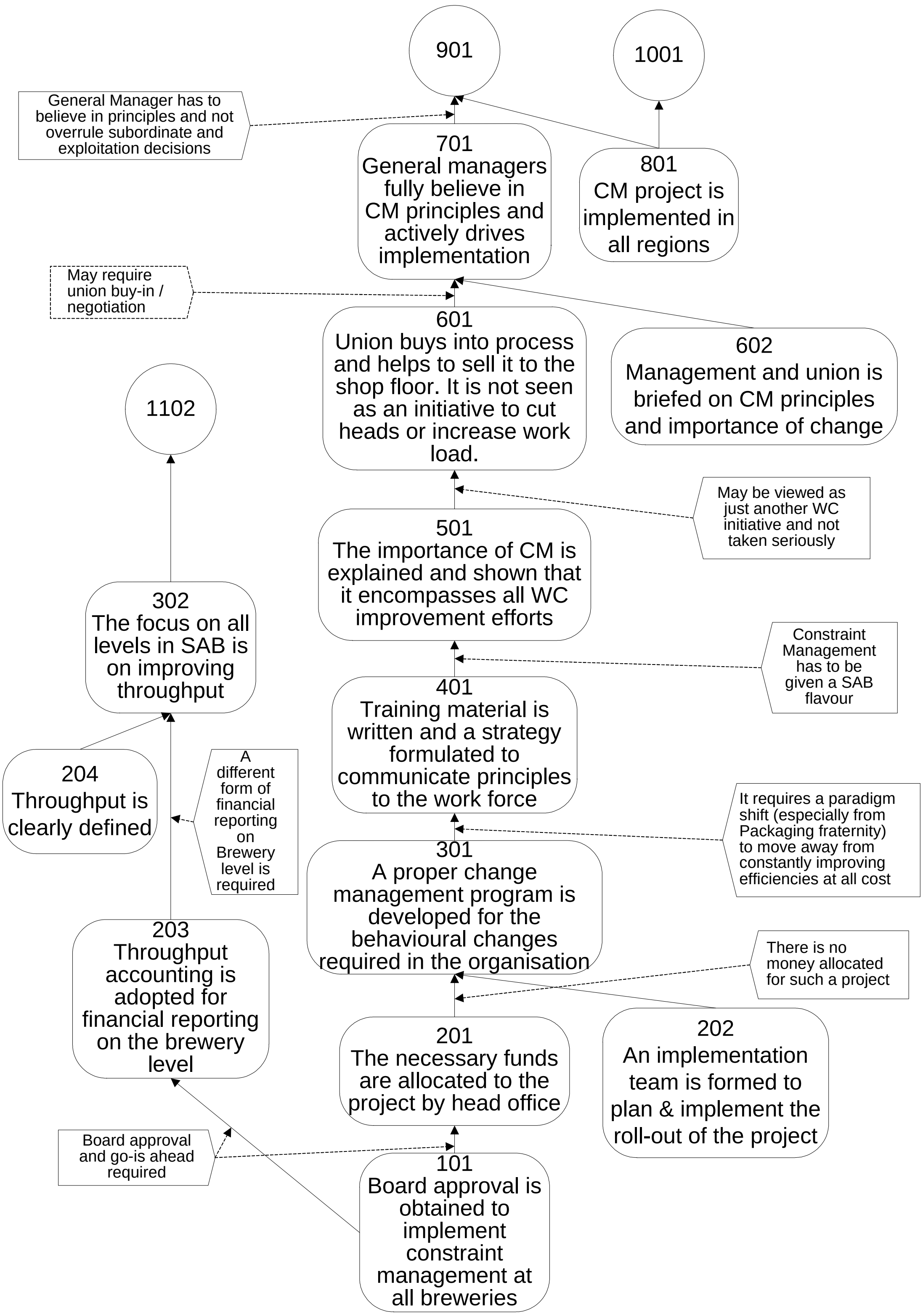

Figure 10-1: Prerequisite Tree (section 1)

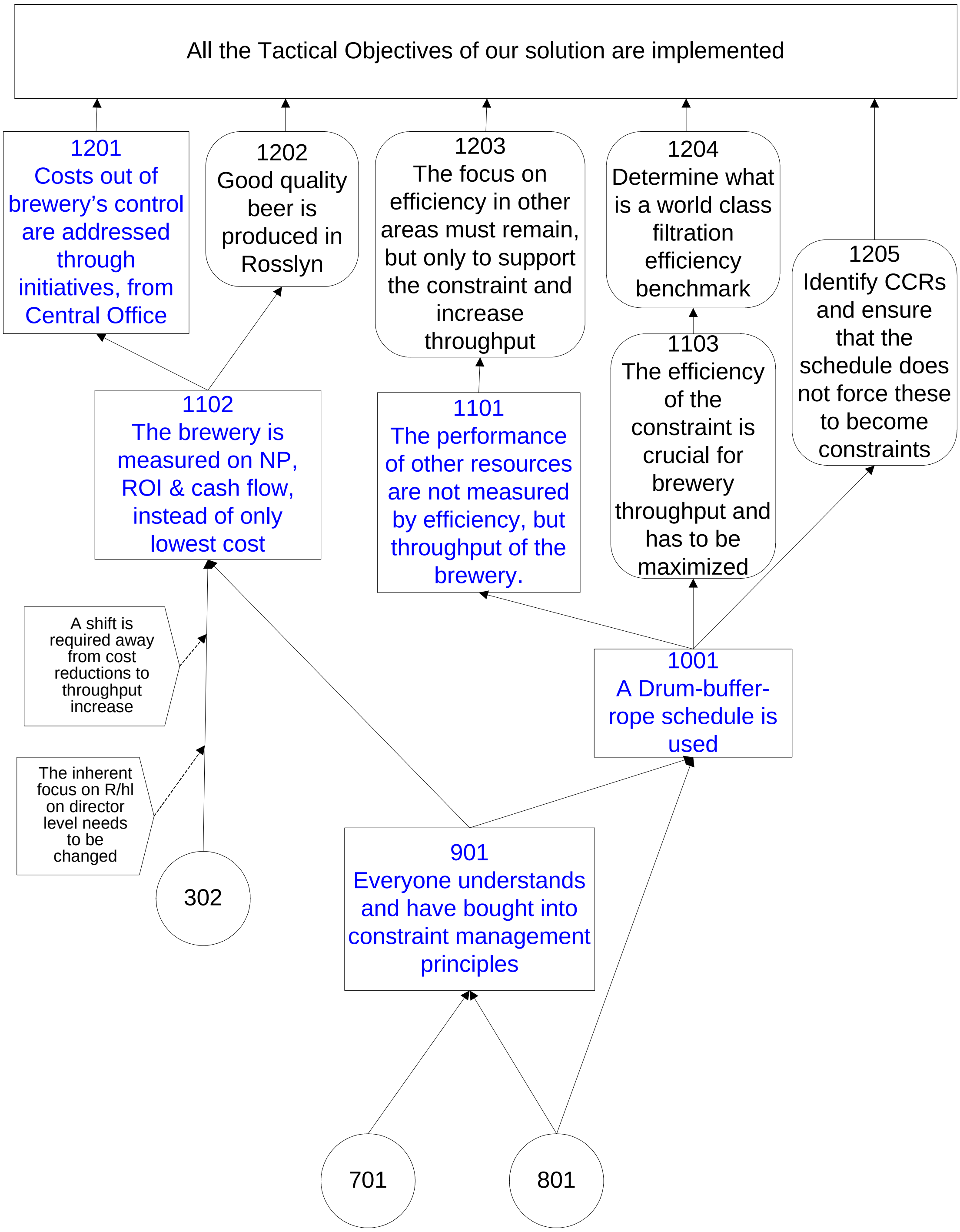

Figure 10-2: Prerequisite Tree (section 2)

There are two themes emerging from the Prerequisite Tree. The one leg is to change the existing operational performance measures in the brewery to be aligned with those measures defined by Goldratt and other authors and the second one is to change the scheduling paradigm in the brewery.

It requires more than just changing the way that the brewery schedules its resources, but it also requires a shift to exploit filtration and subordinate all other operations to this one.

The major challenge for this paradigm shift will be in packaging which has enjoyed all the attention and resources over the years.

As with every successful intervention it has to be driven from the top. Therefore the first prerequisite is to obtain board approval. It has been proven time and again in the history of SAB that where board approval had been given and directors actively pursued these initiatives, the implementations were successful and benefits obtained. The examples are numerous, from Best Operating Practices to the removal of additives in the beer right to the implementation of IMP and fleet management practices in the depots. Another outstanding example is also the lead that SAB has taken in South Africa in the development of new products to counter the threat from the Alcoholic Fruit Beverage (AFB) market. The other key role players in this implementation will be the general managers (and their executives teams) of the breweries as well as the union. The union has demonstrated that they can play a major role in the change management process, especially with the intervention like the Competency Acquisition Process (CAP) and even with the ERP implementations. The first "shift" in thinking will be required from these three parties. If they accept Constraints Management principles and reach consensus to implement the principles, it will be a success.

The second leg of the tree is aimed at changing the measures defined and reported by the finance fraternity. If there is one thing that has been written about consistently over a number of years in Constraints Management literature, it is about changing the existing paradigm in finance.

There has always been a constant argument between cost accounting and Throughput accounting disciples [Noreen, Smith & Mackey; 1995] and [Smith; 2000a]. These readings indicate that the Thinking Process has been used with success to bridge the gap between finance and operations and that the companies that were bold enough to take the step and change their operational measures have reaped the benefits. Cox & Spencer [1998:131-237] describes three case studies of successful TOC implementations in detail. In the first case the company has adopted the TOC operational measures, but the traditional accounting system remains in place and is used to report the operating results to headquarters. It is for this reason that the Prerequisite Tree defines specifically that the measure should be changed on a brewery level.

It seems that the most successful implementations have all been those which have adopted two sets of reporting, one internal one to give an indication of the health of a plant and then an external one to shareholders and headquarters. The second and third case studies demonstrate how Drum-Buffer-Rope can be successfully implemented to replace old scheduling regimes. Although the two companies in these case studies operate in a different environment, the one implementation has been rewarded by the assignment of new products to the facility in question and the other use TOC performance measures extensively in the factory to evaluate management actions. Both of these are desirable effects for Rosslyn Brewery.

10.3. Transition Tree

After the plan has been drawn up in the Prerequisite Tree, detailed actions need to be devised to achieve these objectives. These actions are listed in the Transition Tree as illustrated in Figure 10-3 and Figure 10-4.

The reader has already been introduced to a Transition Tree in chapter one of this dissertation. The Transition Tree has a formal structure, always consisting of the intermediate objective, an action plan (in rectangles) and the obstacles identified. It is also read in the If…then… e.g. *If* (310) there are cost associated with the successful implementation of such a project *and* (300) the project has been approved and details of the implementation drawn up *and* (320) the process of applying for funds has been completed and approval obtained, *then* (400) the necessary funds will be allocated to the project by head office. The higher level tactical objective is an irrefutable consequence of action in combination with the lower level tactical objective to overcome the obstacle identified.

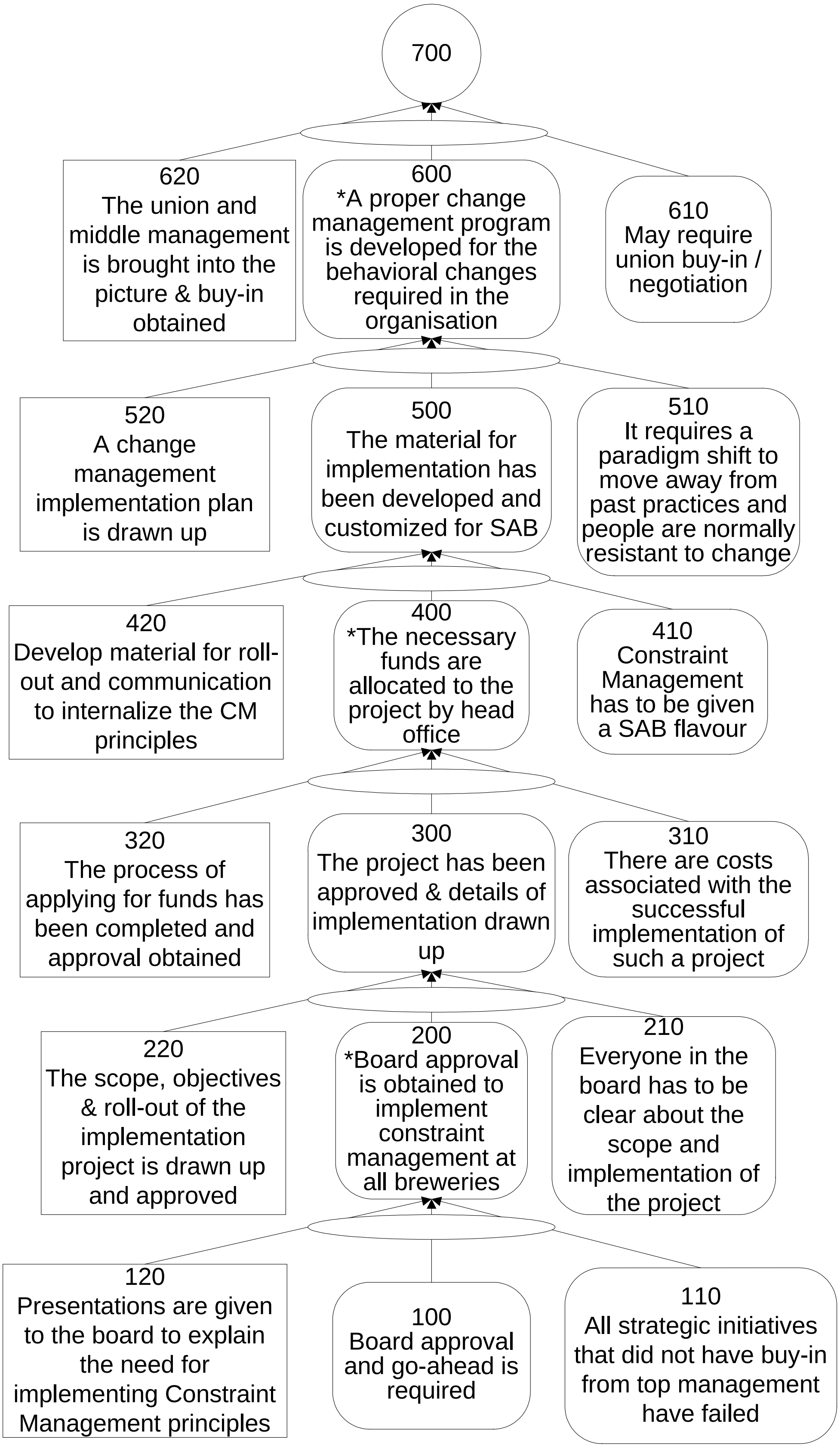

Figure 10-3: Transition Tree (section 1)

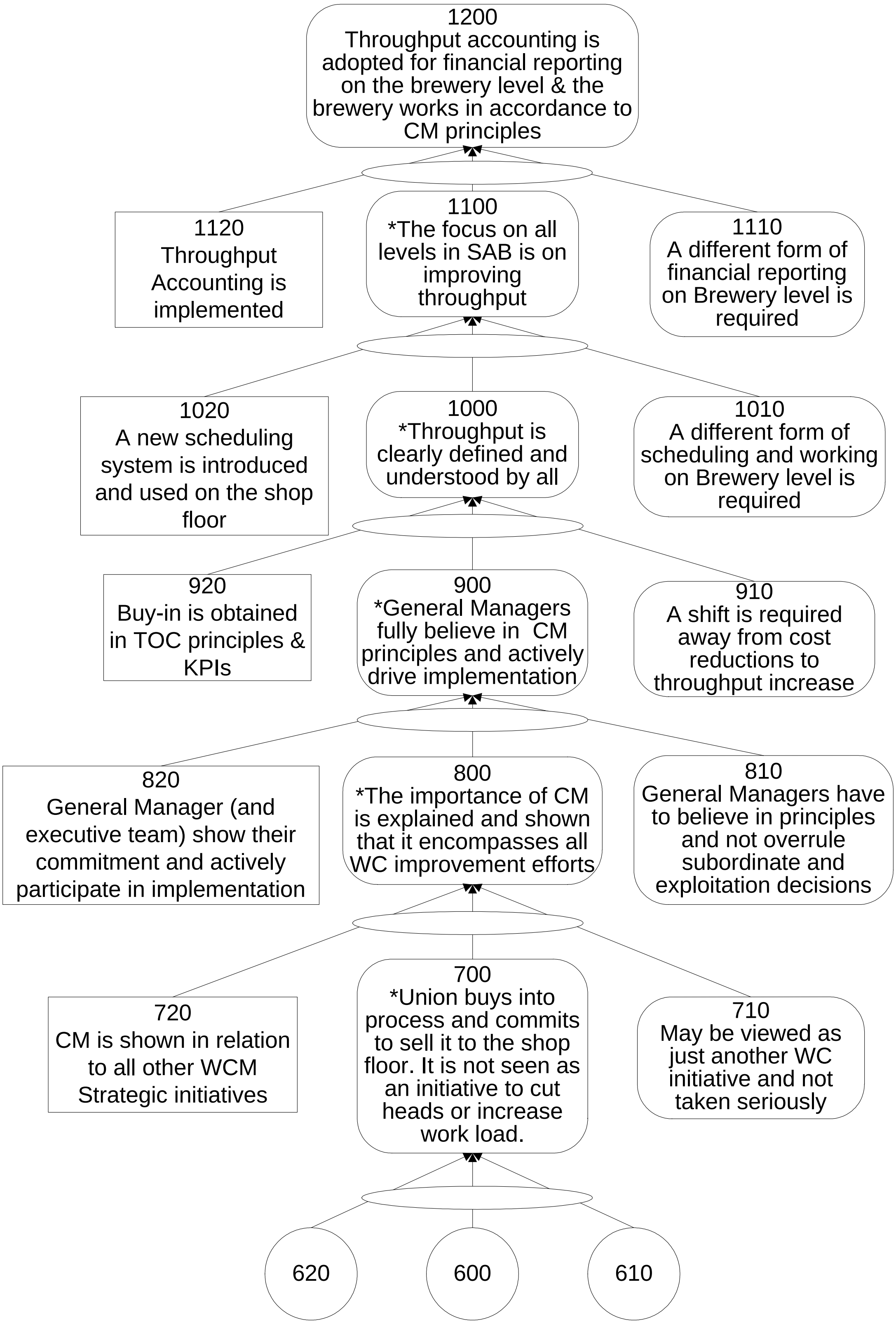

Figure 10-4: Transition Tree (section 2)

The Transition Tree demonstrates the sequence of events to achieve the final objective. It will be used to draw up a detailed project plan with resources, cost and time allocations. Even though the tree may seem very simplistic, a lot of detail is involved in achieving the objectives in the middle row of the diagram, the main ones being to obtain board approval, release funds for the project and then draw up a detailed change management program for the implementation. After these three actions have been completed, it will be crucial to obtain the buy-in from the champions that will drive the process and also tutor these parties in Constraints Management principles.

It should also be noted that there are significant time frames involved in some of these tasks, e.g. "(920) Buy-in is obtained in TOC principles and KPIs". This is a long process of training, coaching and mentoring on the principles of Constraints Management. The KPIs also have to be developed in conjunction with the shop floor to ensure that buy-in is obtained.

Although the Transition Tree describes all the actions in sequence, some of these may be implemented in parallel, e.g. (1020) a new scheduling system is introduced and used on the shop floor, can (and should) probably be started in conjunction with (1120) Throughput accounting being implemented. Even though the structure defines that tasks 1000, 1010 and 1020 have to be completed before the next level can start, there is a lot of preparation work that can be done for implementing Throughput accounting before rolling it out and it is this work that can be performed in parallel with the previous level.

One last obstacle for board approval which needs to be mentioned is the justification of the project. One of the challenges for the TOC practitioners is to publish the quantified savings obtained from successful implementations. The companies that have embarked on TOC implementations are very willing to indicate by how much their work in process and finished goods inventory have reduced, how their Throughput has increased and extra volume allocated to the factory, but are reluctant to quantify the savings obtained. Some information is rightfully still kept in-house, because it is viewed as a competitive advantage for the company or factory.

Unfortunately, when trying to justify a project, quantification is required and the same applies to Rosslyn Brewery. In the case of Rosslyn, the financial benefit will be in the reduction of overtime in all departments, as well as the stoppages to the packaging line. At the moment, with the volume allocated to the plant, the stoppages caused by filtration are probably very little and overtime not incurred at all, so to demonstrate a saving in this area will be difficult. The increase in Throughput for SAB as a whole during peak periods will have a more significant impact than the saving in Operating Expenses.

The intangible benefits for the brewery are the ones that will really make the difference. These include:

- Focussing improvement efforts and CAPEX in the correct areas.
- Building capability to react quickly to changes in market volumes.
- Becoming the benchmark brewery in the world.
- Having satisfied and motivated employees.
- Continuous improvement efforts will increase when the work force understands the "big picture"

The following statement by a vice president of a company [Noreen, Smith & Mackey; 1995], is worth noting: *"I can't say that TOC solved all our problems, but if we hadn't switched over, we probably wouldn't be here today"*.

10.4. Conclusion

As is the case with many world class manufacturing initiatives, a successful Constraints Management implementation can only materialize if the buy-in is obtained from the top level of management, or the board of directors. In SAB it has been proven in the past that where the board approval has been obtained and the buy-in obtained on all levels, the implementations were very successful yielding fantastic results. The key is to use the learnings from Rosslyn Brewery as a starting point for the implementation of Constraints Management in all SABMiller breweries.

Although a lot of work still needs to be done before an implementation of this nature can be justified to the board, the trees in this chapter provide a useful framework for a starting point. It may be difficult to justify the project financially, but if the current world trend in beer sales continues, Constraints Management may soon be justified as a survival mechanism for the brewery.

In the final chapter conclusions will be drawn and further study opportunities explored.

11. CONCLUSIONS

Not all who wander are lost.
- J.R.R. Tolkien

11.1. Purpose

The purpose of this chapter is to summarise the findings of the research and to draw final conclusions. The practical application of the research is discussed and recommendations for further research are made.

11.2. Summary of research results

The aim of this dissertation was to demonstrate that even though a company can be in the top ten in the world and rightly deserves to be there, it can still be destroying value by using performance measures which drive behaviour and actions without considering the constraint of the system. Pretorius [Personal communication on 5 April 2004] highlights this point when he states that: “Making decisions without properly accounting for the constraint is like playing Russian roulette with one chamber empty. You have an extremely good chance of ending up in a bloody mess…. and very dead!”

To substantiate the above, one specific brewery in SAB was chosen and evaluated in terms of the key performance drivers and problem areas. The brewery chosen was honoured as the “Best Brewery” in SAB in 1999 and yet, a few years later, volume was taken away and a packaging line closed. The following three questions were defined to illustrate how a brewery, making a concerted effort to perform well, can still be moving away from “the goal”:

- What are the true performance drivers in the Rosslyn Brewery?
- What is the constraint of the brewery?
- What is the core conflict in the brewery and how should it be addressed?

The answers to these three questions have demonstrated to the reader how a brewery with well entrenched world class practices can be destroying value by not considering the constraint of the system.

11.2.1. The key drivers in South African Breweries

The key performance driver in Rosslyn Brewery is efficiency. Nearly all behaviour and decisions are influenced by packaging efficiency and cost reductions. Packaging has traditionally been the most expensive operation in the factory and has therefore received the most attention and resources. It seems that this view is also shared by head office and other breweries, evident from the attention given to efficiency improvements in the breweries.

An unfortunate principle (unwritten truth) in SAB is that the only way to reach a global optimum is by ensuring local optimums. The development into a globally competitive company and the increase in competition in South Africa have probably changed the view of many inside SAB, but there are still evidence of individual breweries competing for money and resources to achieve local optimum solutions.

There is also a third performance driver, and that is quality of the product. If these three measures were to be ranked for Rosslyn it will be in the following order:

1. Efficiency
2. Cost
3. Quality

The trade-off between efficiency and cost is marginal. Certain times of the year, the focus on cost reduction will receive the most attention and other times efficiency improvements will be the be all and end all.

Although it seems as if quality will be traded off first, this is not really true. There are critical (consumer detectable) quality measures which will never be compromised, even at the expense of cost and efficiency. There is a second set of non-critical quality measures (normally concerned with appearance of the package) that will not be detected by the customer or is not very important to him. These measures might be traded off for efficiency and cost, e.g. scuffing on quart and pint bottles.

11.2.2. The constraint in Rosslyn Brewery

The internal capacity constraint in Rosslyn Brewery is situated in the filtration operation. Goldratt has always stated that it is easy to identify and exploit a capacity constraint in a factory, the difficult part is to subordinate to it. The constraint will be visible, i.e. there will be mountains of work in process be waiting in front of the constraint operations, or the operators will immediately, without thinking, be able to tell you which machine causes the most downtime. Rosslyn Brewery is no different and the filtration operation is the "problematic operation" in the brewery.

One of the key learnings from TOC is to focus on the global optimization and not local optimums. For this reason the whole value chain was considered to identify the constraint. The analysis indicated that the true constraint is an external constraint in the market.

Even though Rosslyn has an internal capacity constraint in filtration, there is enough capacity available to serve the market demand.

11.2.3. The core conflict in Rosslyn Brewery

The core conflict of the brewery is best illustrated in Figure 11-1.

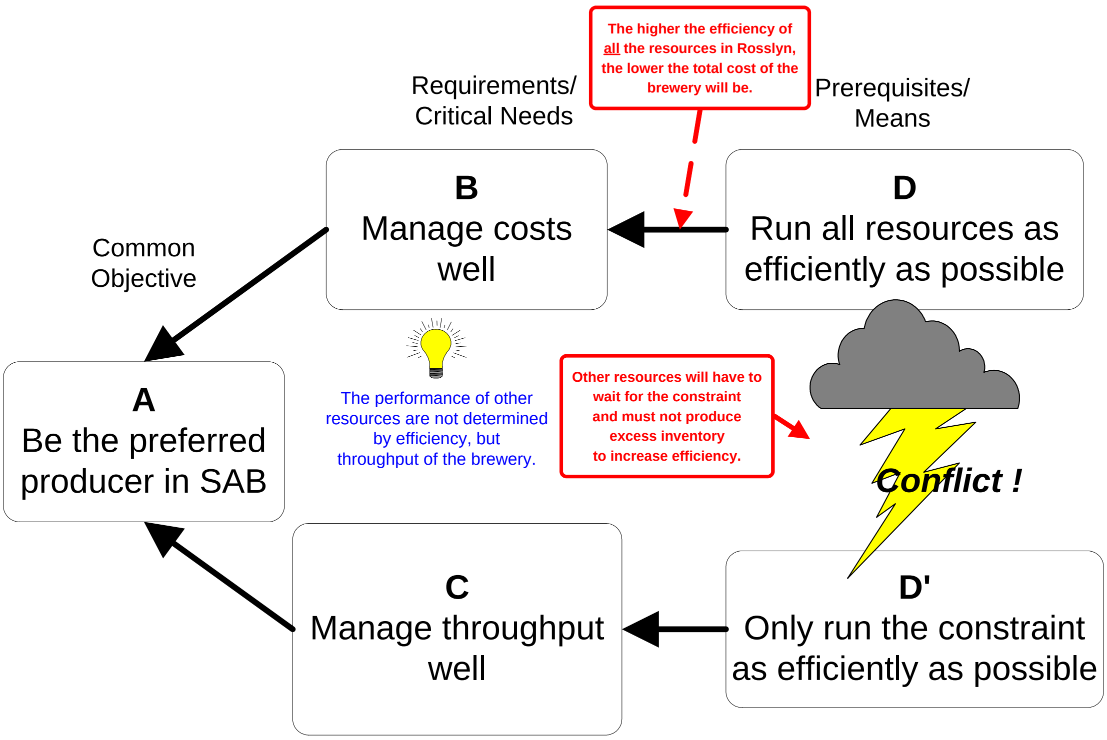

Figure 11-1: The Core Conflict

The conflict is to run all the resources of the brewery as efficient as possible or to only run the constraint (filtration) as efficiently as possible.

In order to break this conflict an injection is required, i.e. the performance of other resources in the brewery (including packaging) should not be determined by efficiency, but by the throughput (and therefore the utilization of the constraint) of the brewery. The implication is that the other resources have to wait for the constraint and must not produce excess finished goods (that will not be sold) to increase efficiency. The practical application of this situation can only be achieved through the implementation of a Drum-Buffer-Rope scheduling system. The implementation of a Drum-Buffer-Rope system in practice was beyond the scope of the dissertation; instead the Thinking Process tools (Future Reality Tree, Prerequisite Tree and Transition Tree) were used to develop a road map for implementation by identifying potential obstacles and how they can be addressed during an implementation project.

11.2.4. Contributions of the research

The contributions of the research are the following:

- It provides an insight into the brewing industry and the unique challenges that of the beer market.
- It emphasises how crucial it is for any business to focus on the global optimum, by considering the constraint of the operation.
- It highlights the impact that policies, measures and behaviours have on the daily operations in a brewery.
- It demonstrates the application of the Thinking Process tools.
- It provides a road map for implementation and further development of these concepts within SAB.

11.3. The principal conclusions of the research

The dissertation demonstrated the old principle of going back to basics. Rosslyn Brewery has a string of achievements and is still providing an excellent service for SABMiller, although there are real concerns from employees that it looks like the brewery is destined to be closed.

One of the reasons is probably that in a declining beer market, the focus was immediately shifted to cost reduction and it seemed as if all the good world-class practices were forgotten. "If we do not reduce our R/hl to that of Alrode, we will be closed down"… not an uncommon phrase in other industries going through a recession, yet time and again companies realise that they are in the situation because the focus has moved away from that which is really important. In Rosslyn's case the packaging operation and the efficiencies of this operation became so crucial that everything in the brewery was governed by it, and it worked for a while, but is not sustainable. The basics in this case are that the brewery has to sit down again, identify the true constraint and focus their operations according to system management principles.

This thesis has provided a roadmap for the brewery to implement these activities. As long as the focus remains on improving packaging efficiencies and driving down costs, there is no way that a TOC implementation in Rosslyn can reap the true benefits. In fact the brewery will be punished for poor packaging efficiencies and volume taken away and given to other breweries. It is therefore crucial that not only the brewery changes its practices, but that the measurements from head office are also re-evaluated and aligned to give a clearer picture of the actual state of health of each and every brewery.

11.4. Further Research

It is obvious that the work done in this dissertation can be taken further and maybe even proved in practice. Further research can be done to evaluate the situations in other breweries in South Africa and other countries. If the results of these studies come to the same conclusion, it will be an even more compelling case for the implementation of Constraints Management in SABMiller.

Further research is also required to investigate the market constraint. The market is probably the one constraint common to all the breweries in SABMiller. The tinking process tools can again be used to:

1. Identify all the undesirable effects visible in the current market (high taxation, decline in alcohol consumption etc.)
2. The C^3 diagram and Current Reality Tree can be drawn up to describe the current situation accurately.
3. A Future Reality Tree can be developed to describe the desired situation.
4. The Prerequisite Tree and Transition Tree can provide the marketing director with a feasible action plan that can be implemented to break the market constraint.

The key to success would be to develop a "winning formula" that can provide SABMiller with the next step change, whether it is the implementation of Constraints Management principles in the South African operations or a marketing strategy that will take them to no. 1 in the world.

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