# 7 THEORY OF CONSTRAINTS

## 7.1 INTRODUCTION

Eli Goldratt developed the Theory of Constraints in the mid 1980's. It evolved from the production scheduling software called OPT (Optimised Production Timetables), developed and marketed by the company that Goldratt was the chairperson of (Rahman, 1998:p336) & (Goldratt, 1998:p1). The concepts of OPT was illustrated in a novel, The Goal. The formulation of Theory of Constraints as an operational management philosophy evolved over the years too not only encompasses shop floor activities but all aspects of business. This chapter will explore the different aspects of the Theory of Constraints.

## 7.2 OVERALL MANAGEMENT PHILOSOPHY

A comprehensive definition of the Theory of Constraints is provided by Geyser (1995:1): "The Theory of Constraints is an overall management approach which enables management to focus on the identification and elimination of the organisation's constraints and to implement a process of ongoing improvement in order to achieve the organisation's goal". Normally the objective of an organization, or its goal, would be to make profit, in the short term as well as the long term. Therefore the Theory of Constraints ensures profit maximisation by focusing on the constraint/s within the organization.

Bushong, Talbott & Burke (1999:p53) refer to Theory of Constraints as "...a systems approach based on the assumption that every organization has at least one factor that inhibits the organization's ability to meet its objectives. Simatupang, Hurley & Evans (1997:748) elaborates on this idea by stating that Theory of Constraints is "...a series of interdependent elements joined together like a chain for a common purpose. The weakest link serves as a constraint that prevents the system from achieving its goal". It is clear that the constraint in any system restricts the performance of the system in relation to its goal (Siha, 1999:p255).

Rahman (1998:p337) builds on the concept of constraint management by stating that there must be at least one constraint within every system, and that this is not necessarily a bad thing as it presents opportunities for improvement.

The Theory of Constraints can therefore be described as an operational management philosophy that manages the organisation as a chain and focuses on the weak links within the chain, with the aim to make profit now and in the future.

## *7.3 THE KEY VALUES OF THE PHILOSOPHY*

### 7.3.1 Causality vs. Necessity

One of the basic building blocks of Theory of Constraints is the issue of causality and necessity (Houle, 1998:p1). Causality is the logical thought process of "if...then". When you want to undertake an action, you ask yourself: "if I do this, then something specific will happen to me". Necessity is looking at a situation from the future backwards. The statement would be: " to have a certain result, I must do something specific, or obtain something". By not only looking at a "if...then" phrasing but at "if...then...because" it is possible to clarify the reasons why things will happen, and that can lead to the surfacing of certain assumptions. The current reality (as it is perceived) can be altered by asking these questions together. That will provide solutions that can prevent negative results, or it can enhance positive results.

These two concepts are used to provoke the thinking processes regarding the perceived reality. It challenges the perception of current reality and in doing so surfaces the assumptions that may exist and also assists in creating an understanding of the environment that the reality exists in. A thorough understanding of the problem is created leading to solutions that are clearly thought out and projected into the future.

### 7.3.2 Constraints

A company can be viewed as a chain where the links represent the different processes that exist in the company. All the different processes in the value chain, e.g. procurement,

manufacturing, distribution, sales and marketing, are essential in turning raw material into final products delivered to the client. These individual processes are integrated and as in a chain, there is always one weak link that limits the strength of the whole chain. That weak link is defined as the constraint of the system. A constraint can be physical (a resource, raw material etc) or managerial in nature (a policy on overtime, marketing focus area).

A constraint is anything that limits a system from achieving its targets and/or a higher level of performance than the baseline. The importance to know where the constraint in a system is located cannot be underestimated. Goldratt (1986: 179) states that "An hour lost at a bottleneck is an hour lost for the total system" and "bottlenecks govern both throughput and inventories". Also, as the constraints determine the performance of the system, any improvement in the performance of the constraint will improve the performance of the system (Rahman, 1998:p337).

According to Burkhard (1999:p2) there exist four types of constraints: physical constraints, supply constraints, market constraints and policy constraints. There are rarely more than two constraints in a system. The challenge for the business owner is to identify the constraint/s and to manage them. This is achieved by using the five focusing steps of the Theory of Constraints.

### 7.3.3 Five focusing steps for continuous improvement

A practical approach to identify and manage the constraints is defined in five steps (Goldratt & Cox, 1992: p303). It is important not to skip a step as that can lead to a process breakdown, which in turn may lead to wrong decision-making regarding the identification and management of the constraints.

1. *Identify the constraint(s)*

   There are various ways to do this. The most obvious method to determine where a physical constraint is located is to find the pile-up of work-in-process before a workstation. More analytical methods would be to determine the tempos of workstations (the unit with the slowest tempo could be the constraint), determine where the workers are always working (no idle-time) etc. To determine a managerial or policy constraint it

is necessary to make use of the Theory of Constraints thinking processes (specifically the Current Reality Tree), as described in paragraph 7.5.

*2. Exploit the constraint(s)*

When the constraint has been identified, it must become the focus area of operational planning and management. This unit must not be allowed to stop because of other system inefficiencies. Everything needs to be done to ensure constant production at this workstation. This can be done by scheduling the priority entities being processed by the constraint to have preference, placing a buffer before the constraint to ensure constant feed, ensuring that only feed products of the right quality is processed by the constraint (to prevent unnecessary rework) and installing good quality control for the products moving downstream from the constraint (as a unit that has been processed by the constraint and that is scrapped later is lost for ever as a final product – there are no spare units). A managerial constraint should not be exploited but eliminated. (Rahman, 1998:p337) The managerial constraint should be replaced by a policy that will support increased throughput.

*3. Subordinate everything else to the constraint(s)*

This implies that every other component (non-constraints) in the system must be adjusted to support the effectiveness of the constraint. The constraint should determine the production schedule of the manufacturing chain. The non-constraints will need to work according to the tempo of the constraint. Non-constraints by definition have extra production capacity. This extra capacity must not be used to produce more units than the constraint is capable of at 100% utilisation. Non-constraints are therefore allowed to have idle time.

*4. Elevate the constraint(s)*

In this step the constraint is broken. It is essential that the order of these steps is followed, and managers must restrain from jumping to this step. The logical order of these steps will ensure that the optimal solution is found within a shorter time period. There are many ways of elevating a constraint, e.g. adding additional resources, work can be outsourced or the product can be re-designed to send it through another unit.

*5. Do not let inertia set in: refocus on the next constraint(s)*

When the constraint has been broken the performance of the system will rise, but soon another constraint will emerge. As soon as this happens the cycle needs to be repeated. The policies and rules made when exploiting a constraint, needs to be re-examined. It may be that those rules and policies have become constraints in themselves.

Rahman (1998:p336) illustrates the concept graphically in figure 7.

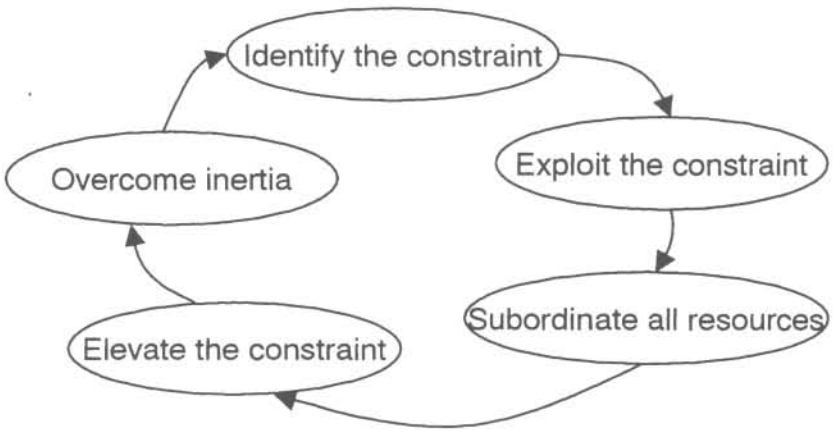


**Figure 7: Theory of Constraints five focusing steps**

### 7.3.4 Constraint based measurements

Traditionally companies use financial measurements (ROI, NPV etc.) when evaluating and making business decisions. These companies operate in the "cost world". In this world the focus is on cost cutting, not increasing sales. But there is a limit to cutting costs: a point is soon reached where further cost cutting results in the loss of operational efficiency. When looking at the fundamental measurements of the Theory of Constraints cost is captured in categories but not allocated to products. The three fundamental measurements are:

- Throughput: the rate at which the system generates money through sales
- Inventory: all the money the system invests in purchasing things the system intends to sell
- Operating expense: all the money the system spends in turning inventory into throughput

These fundamental measurements are described in more detail in paragraph 7.5.

When using throughput as the main driver for making business decisions there is no limit to the performance increases that can be realized in a company. Such companies concentrate on increasing and expanding their market demand (increasing their throughput). Donlin (1993:p52) states, "Where throughput is the focus, every action is geared to moving the company forward". When the three fundamental measurements are used in business decision-making, the bottom line measurements are impacted, moving the company towards greater profitability. The following table shows the link between the Theory of Constraints measurements and the traditional bottom line measurements.

**Table 10 : Theory of Constraints impact on bottom line(Goldratt, 1986, p31)**

| FUNDAMENTAL MEASUREMENTS | BOTTOM LINE MEASUREMENTS | | |
|---|---|---|---|
| | Net profit increase | Return on investment increase | Cash flow increase |
| Throughput ↑ | √ | √ | √ |
| Inventory ↓ | | √ | √ |
| Operating expense↓ | √ | √ | √ |

## *7.4 IMPACT ON FUNCTIONS*

The Theory of Constraints has a profound impact on the way a business is run. It requires a total mind shift, as the traditional methods and thinking within a business are no longer valid.

### 7.4.1 Finance

Many companies have elaborate financial and non-financial measurements that are not necessarily contributing to the goal of an organisation. Rexford, Lockamy III & Cox III (2002:p197) conducted an experiment to determine the performance of a company using

traditional cost accounting versus constraint based accounting. They came to the conclusion that the performance of a company will dramatically improve when making use of the fundamental measurements of the Theory of Constraints and focusing on constraint management. One reason lies in the fact that the concept of "product cost" does not exist within the Theory of Constraints. In constraint-based accounting all indirect and direct labour cost is treated as fixed operational costs, and cost is not allocated to a product. Business decisions are made by evaluating the constraint, and calculating the impact on the business based on the throughput - and operating cost per constraint minute (Geyser, 1995:p1). Rexford et.al (2002:p191) explains that traditional cost accounting methods assume independence between events; therefore the sum of the individual improvements in the system is equal to the improvement of the system. Constraint-based accounting recognizes the constraint as the limiting factor with regards to the system's ability to perform.

### 7.4.2 Marketing and sales

In a throughput world the organisation's ability to achieve vast sale increases is not limited by policy constraints, as would be the case in a cost world organisation. By using the five focusing steps the focus is placed on those issues that prevent sales; those issues that are making customers unwilling to buy more of the company's products (Geyser, 1995:p3). More innovative approaches to new product development, market niche creation, product range etc. can be developed. The emphasis of the marketing department changes to develop an offer that the client cannot refuse. Houle (1998:p6) refers to this approach as the "Implementable Unrefusable Offer".

Marketing and sales also have a role to play in the identification and management of the company's constraints. Their marketing strategies must revolve around the performance of the constraints, as the constraints dictate the product throughput, and therefore the sales (Geyser, 1995:p3). If a sales team base their strategy on profitability ranking derived from traditional cost-absorption accounting, it may be that the products that use the constraint most efficiently are not highly ranked. This can lead to the wrong marketing strategy, in that the constraint is not being utilized to the fullest (Burkhard, 1999:p5).

### 7.4.3 Scheduling

The Theory of Constraints uses a scheduling technique known as DBR (drum-buffer-rope) scheduling (Goldratt & Fox, 1986, p98). This technique consolidates all scheduling around the tempo of the constraint. The drum is the rate of production of the constraint. The whole plant produces according to this beat. The reason is that the constraint's production rate is the slowest, thus non-constraints are limited in their production to ensure a low inventory level. If for some reason non-constraints fall behind, they have excess capacity to catch-up. The rate of raw material releases is synchronised with the drum, thus the concept of a rope between the first workstation and the constraint. Provision is made for disruptions in the production that can cause the constraint to stop, by building a buffer in front of the constraint. This buffer is referred to as a time-buffer, as it is linked to the average time it will take to restore any disruptions in the stations preceding the constraint.

A buffer is also placed before all assembly stations where parts moving through a constraint are combined with other non-constraint parts. This is to ensure that products are finished and shipped on time.

The advantages of this approach are: (Goldratt & Fox, 1986:p96)

- Current throughput is protected.
- Future throughput is enhanced.
- Operating expense is not increased (no extra equipment or operators needed to cover for inefficiencies in system)
- Inventory is reduced

Goldratt & Fox (1986:p100) describe the steps for implementing the drum-buffer-rope scheduling technique:

- Determine the constraint (market demand could be one).
- Determine the schedule of the constraint by taking into account its limited capacity and the market demand that it must satisfy.
- Schedule the succeeding operations normally from the constraint's schedule. When a part leaves the constraint the next operation can start, and so forth.

- The preceding operations are scheduled to include the production of the time-buffer just in front of the constraint.
- Build in a time-buffer before any assembly where a constraint feed and non-constraint feed is combined. Now backtrack from this time buffer to schedule when the non-constraints should start producing.

As this is a constantly changing environment where constraints are constantly elevated and broken the schedule must constantly be refined to fit the new constraints.

Rahman (1998:p339) lists nine rules to be followed when following Theory of Constraints scheduling:

- Balance flow rather than capacity. This requires a different approach to releasing raw materials into the system, materials handling etc.
- The level of utilization of a non-constraint is not determined by its own potential but by a constraint in the system.
- Utilisation and activation of a resource are not synonymous.
- An hour lost at a bottleneck is an hour lost for the total system.
- An hour saved at a non-constraint is just a mirage.
- Constraints govern both throughput and inventories.
- The transfer batch may not (and many times should not), be equal to the process batch.
- The process batch should be variable and not fixed.
- Schedules should be established by looking at all the constraints simultaneously, knowing that lead times are the result of a schedule and cannot be predetermined.

### 7.4.4 Project management

Traditionally when a project plan is developed people tend to combat the uncertainty of predicting estimated task durations by including safety time. Safety time is therefore built into all tasks, leading to a very conservative project duration estimate. Project managers know this, and usually cut the estimated task duration times. As the task owner knows that he built in safety, he will wait until the last moment to start with the task, usually too late (as

other critical tasks also stake a claim to his time). This is one of the factors that lead to projects rarely being completed on time.

The Theory of Constraints has a different approach to project management called Critical Chain Scheduling. The critical chain is defined as the longest chain of dependant steps within the project (Rand, 2000:p176). Patrick (1998,p1) defines critical chain management as: " it identifies and protects what's critical from inevitable uncertainty, and as a result, avoids major impact of Parkinson's law at the task level while accounting for Murphy's law at the project level". He describes the paradigm shift that is needed, in that project managers must shift their focus from ensuring that milestones are achieved to the only date that matters, the final due date of the project.

The Critical Chain method differs dramatically from normal project management thinking in the following ways:(Patrick, 1998:p1-7) & (Jacob & McClelland, 2001:p1-12)

- Tasks' estimated durations are only based on the time needed to do the work without any safety time built in.
- Aggregated safety factors are built in by utilising buffers of time. Feeding buffers are built in where a non-critical task feeds a critical chain task. The feeding buffers protect the critical chain from execution variability along the paths that feed it. A project buffer is built in at the end of the chain, with the aim to protect the project from the effects of execution variability along the critical chain.
- Non-critical resources working on a task that will be passed on to a critical resource, will warn the critical resource in advance that they (non-critical resources) are nearing the end of their task. This will enable the critical resource to prepare for the task and immediately work on it when it is passed on.
- A work ethic called "relay runner work ethic" calls for people to begin work as soon as they have been assigned to a task, to work continuously until completion of the task, and to provide immediate notification of the completion of the task. This is in contrast with traditional project management where resources often wait until the last moment to start with a task, and rarely inform anyone if the task is finished ahead of time.
- Project control is accomplished not through tracking due dates, but through a concept called "Buffer management". It is a process of managing the aggregated safety in the feeding and project buffers.

- The progress of a project is not measured in terms of the progress already made (% completed), but by determining the amount of work left, the status of the project and the size of critical tasks buffers.

## 7.5 PROBLEM SOLVING AND MEASUREMENT TOOLS & TECHNIQUES

### 7.5.1 Thinking processes

Many operational and system problems (e.g. under production, not meeting sales targets, high production costs) are manifested in inappropriate policies and behavioral patterns. To solve these types of problems / constraints three questions must be answered: what to change, what to change to, and how to cause the change (Houle, 2001p3). The "what to change" question could be very difficult to answer as a problem may have many undesirable effects (UDE's) that cloud the real problem. Usually the effort in problem solving is directed at solving the UDE's but the core problem is not identified and solved. Therefore a UDE may be eliminated but many more will surface until the core problem has been identified and rectified. Cooper & Loe (2002:p137) state, "An accurate identification of the core problem provides a platform to analyse the roots, rather than the symptoms of success and failure". The Theory of Constraints' thinking processes are a set of logical tools that assist people in answering the questions of "what to change, what to change to and how to cause the change". Goldratt (1998b:p5) developed the thinking processes with the aim to:

- Enable people to rapidly identify the core erroneous policy.
- Enable the construction of new policies without bringing on new problems.
- Enable the construction of a feasible implementation plan that would not be hampered by resistance to change.

There are five thinking processes that are used (Rahman, 1998:p341):

*What to change?*

- The Current Reality Tree (CRT) determines the root causes and core problems.

*What to change to?*

- The Evaporating Cloud (EC) reveals underlying assumptions.

- The Future Reality Tree (FRT) transforms innovative ideas and interventions into powerful solutions.

*How to cause the change?*

- The Pre-Requisite Tree (PRT) removes possible obstacles form blocking the solutions.
- The Transition Tree (TT) formulates a detailed implementation plan.

The different thinking processes are discussed in the following paragraphs, (SAPICS, 1994:p1-11).

## CURRENT REALITY TREE (CRT)

The CRT focuses your thinking to identify the core problem (s) of a situation. Undesirable effects are usually attacked in an effort to solve problems. This does not have a lasting effect. The CRT is used to determine the causality between the undesirable effects and then arrive at the core problem(s). The process starts off by listing all the different UDE's that exist. The different UDE's are connected to each other, by asking the questions to determine the causality and necessity between them. These questions are continuously asked until the one or two core problems are identified – those problems that lead to all the UDE's. Figure 8 is a graphical representation of the basic outline of a CRT.

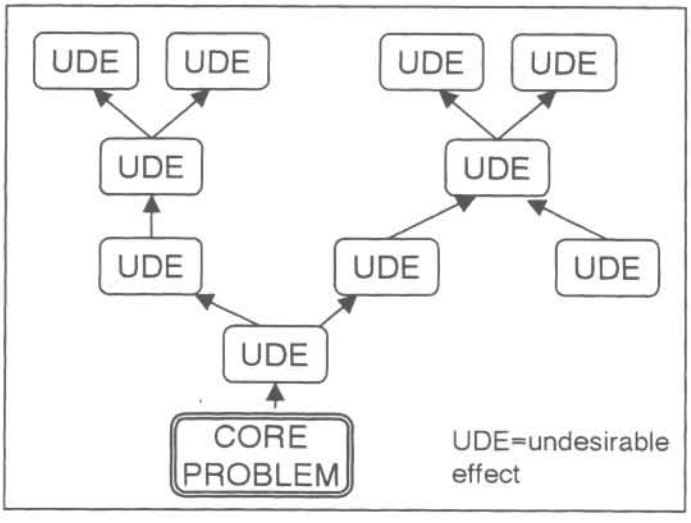


**Figure 8: A basic outline of a current reality tree (Sapics, 1994)**

A company that is battling financially will be used as an example to illustrate the different trees. The company's sales are down, customer complaints are pouring in, and the share

price is taking a tumble. Figure 9 shows the CRT constructed for this company. The core problem of the company is identified as the fact that cost is higher than sales volume.

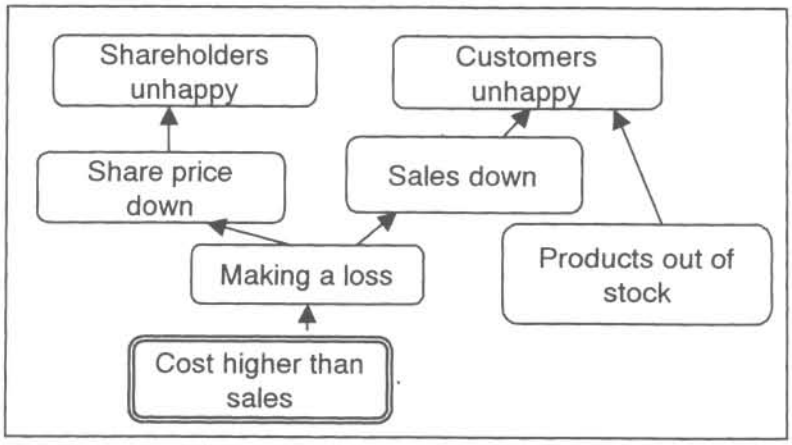


**Figure 9: Example of a CRT**

## THE EVAPORATING CLOUD (EC)

When the core problem(s) have been identified by die current reality tree, the question " what has prevented us from eliminating the root cause in the past?" invariably arises. The answer usually lies in the conflict between opposing forces. An example can be *laying off people vs. not laying off people*, both requirements to achieve a goal. Once these opposing forces have been identified evaporating clouds can be built. The challenge now is to be very innovative in challenging the assumptions underlying these opposing forces. This is a crucial step to ensure the successful elimination of the core problem(s). In challenging the assumptions creative ideas for the solution are generated. Figure 10 provides the conceptual outline of an EC.

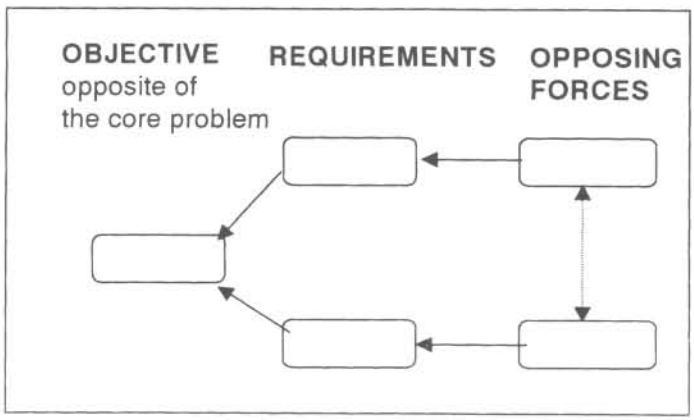


**Figure 10: A conceptual outline of an evaporating cloud (Sapics, 1994)**

Building on the example provided, an EC for the company in trouble could be as shown in figure 11. The objective of the company is to obtain the opposite of the core problem, in this case to make a profit (sales being more than the cost). To enable this they need to produce more products, and as the company is working on a two-shift system they need to work overtime to achieve the extra output.

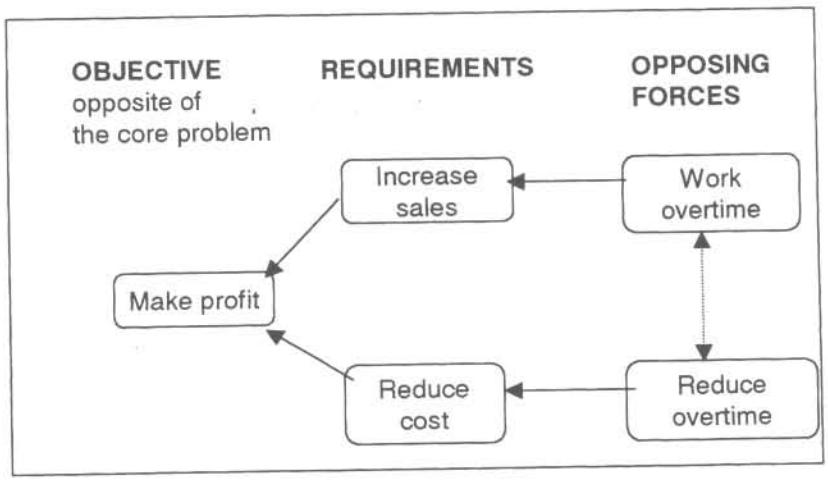


**Figure 11: Example of an EC**

The underlying assumption is that the only method to increase production is to work overtime. When management discussed the dilemma with the unions, they decided to bring in another shift that will be manning the constraint resource. This will be far cheaper for the company than paying extra overtime over a long period (while also staying within the overtime restrictions of the labour law and therefore not paying penalties) and more work opportunities are created with the additional shift.

## THE FUTURE REALITY TREE (FRT)

The ideas generated from the EC need to be changed into a solution. All the interventions needed to create the solution must be determined. The future reality tree should be a mirror image of the current reality tree. All the UDE's are transformed into desirable effects (DE's). A well-constructed future reality tree will reflect all the positive effects that will stem from the interventions as well as the actions needed to eliminate the root causes. It may be

that negative branches are identified. A negative branch is a concern that stems from the proposed change. Specific injections are needed to trim the negative branch, i.e. eliminate the concern. Figure 12 illustrates the conceptual outline of a FRT.

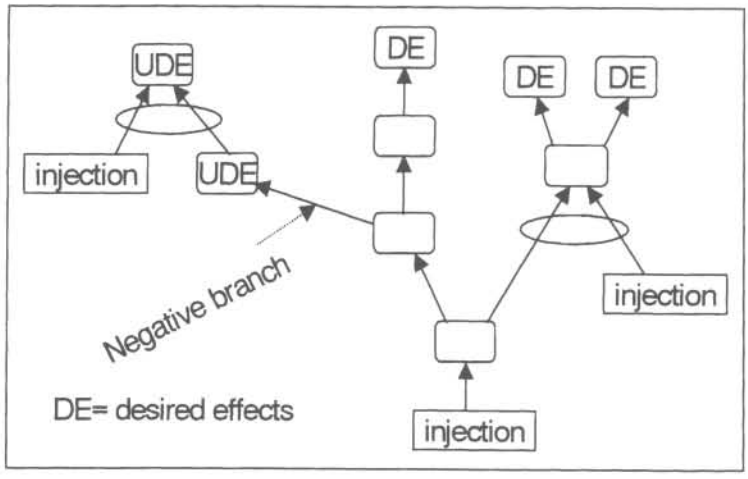


**Figure 12: A conceptual outline of a FRT (Sapics, 1994)**

In the example the solution decided upon was to add an additional shift. The result of this is depicted in the FRT in figure 13. The injections needed to insure that the solution works, are "HR handles change management effectively", "sales force can sell additional volume in negative market", and "competent people are available". These are the critical factors that must be in place to achieve the DE's.

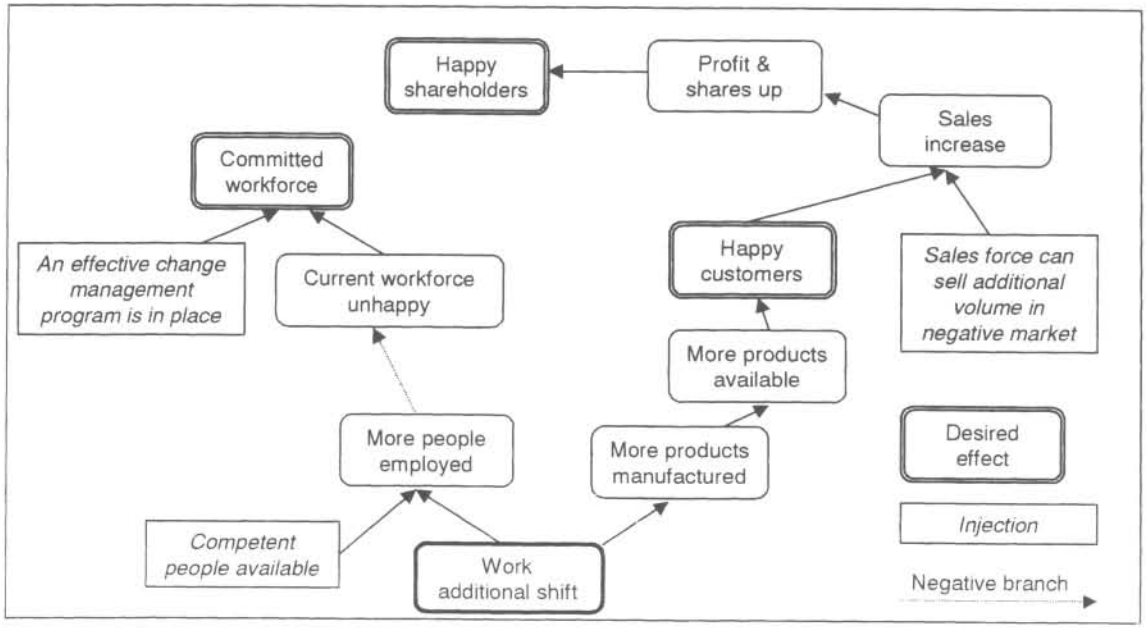


**Figure 13: Example of a FRT**

## THE PREREQUISITE TREE (PRT)

The FRT is the outline of the solution. The injections needed to achieve the solution are not described in detail, and the assumption is that they are achievable. However, there may be certain obstacles that can prevent these injections from happening. The PRT is used to determine these obstacles and to develop ideas to overcome them. These ideas are known as "intermediate objectives". Every obstacle must have intermediate objectives developed that will overcome the obstacle. Refer to figure 14.

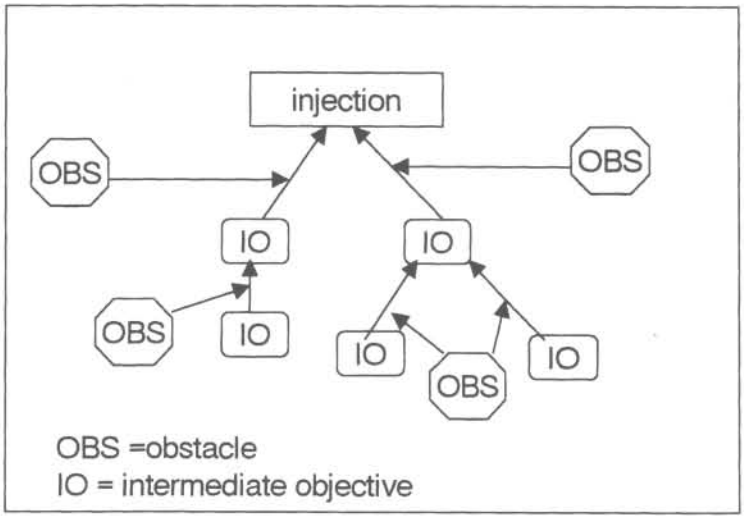


**Figure 14: A conceptual outline of a PRT (Sapics, 1994)**

Referring to the example, a PRT was developed for the injection "an effective management program is in place" (figure 15). This enables the company to understand clearly what must be done to ensure that all the injections are in place, leading to a successful implementation of the third shift solution.

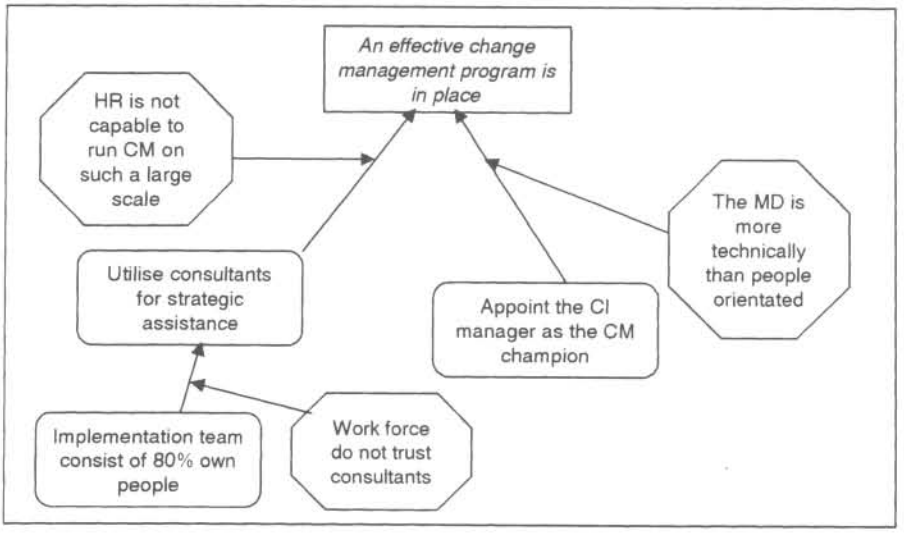


**Figure 15: Example of a PRT**

## THE TRANSITION TREE (TT)

The TT is used in conjunction with the FRT to arrive at a detailed implementation plan. It transforms the strategic outline reflected in the FRT into a tactical outline. The steps that need to be taken by specified persons to reach the intermediate objectives as shown in the PRT are plotted in a time sequence. An example of the design of a FRT is depicted in figure 16.

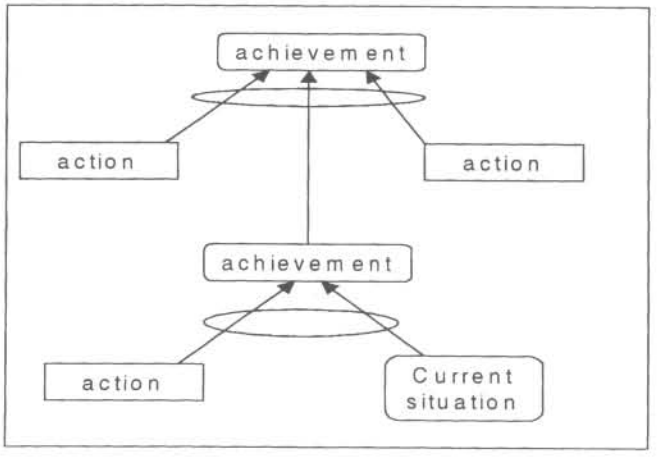


**Figure 16: An outline of a TT (Sapics, 1994)**

The one Intermediate Objective identified in the example was to utilise consultants to assist with the change management needed. The detail action plan to appoint the consultants is shown in the TT in figure 17.

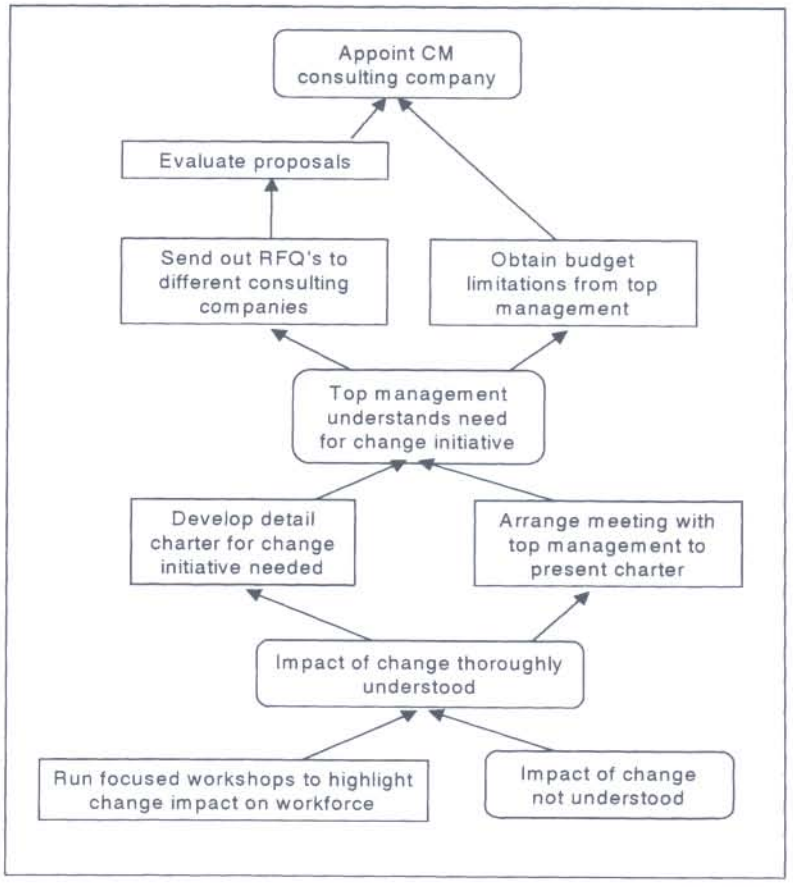


**Figure 17: Example of a TT**

## SUMMARY OF THE THINKING PROCESSES

To summarise the use of the five thinking processes, the transition tree was used. It shows the process that starts of with UDE's, through the development of solutions and the final implementation plan. Refer to figure 18.

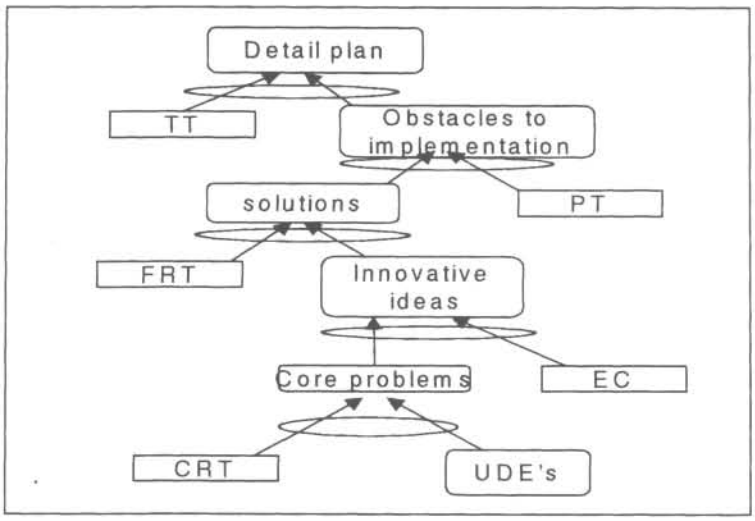


**Figure 18: Graphic outline of use of tree's**

### 7.5.2 Fundamental measurements for the entire system

To measure the entire system, the three fundamental measurements of throughput, operating expense and inventory, as well as the traditional measurements of net profit and return on investment are used.

Throughput, operating expense and inventory were briefly touched on in paragraph 7.2.4. In the following paragraphs these measurements are discussed in more detail (Goldratt, 1987:p4-13).

**Throughput**

*The rate at which the system generates money through sales*

The words "through sales" is very important, as it stresses the fact that increasing the finished goods stock without selling it does not contribute positively to the net profit of the company. Furthermore, throughput cannot be achieved from internal money transfers, because no money enters the system. A sale only takes place at the point where money exchanges hands and it is an irreversible transaction.

The unit for throughput is an average rate at a convenient time period, e.g., R/month. The Rand value equals the sales made in the period minus the purchased materials that went into these sales. More clearly, " throughput is ... sales minus all the money paid per item to entities which are external to the system" (Goldratt, 1987:p6).

**Inventory**

*All the money the system invests in purchasing things the system intends to sell.*

Normal financial methods determine "cost of goods sold" as "purchase price of raw material" + "value added" (labour, overhead). The "net profit" is then calculated as "sales" minus "cost of goods sold". To be able to show a high profit per financial period the "value added" items are moved around between periods. This can lead to a situation where a reduction of inventory (good practice) reflects as poor performance on the financial statement. Most companies are forced by external parties to report inventory as an asset. The Theory of Constraints does allow for this, but an internal reporting system that differs from this approach is used to base business decisions on. In this approach value added to inventory is disregarded. Finished goods are valued according to the price paid for the materials used in it, without any allocated cost.

Items used in operating the plant (e.g. hydraulic oil) are added to inventory when purchased. As it is consumed it is transferred from Inventory to Operating Expense. This also applies to other assets like buildings and machinery. Depreciation is allocated to operating expense. All capital investment forms part of inventory.

**Operating expense**

*All the money the system spends in turning inventory into throughput*

Operating expense is the money used to change raw material into saleable product. All maintenance and operational material, labour, utilities and sundries will be classified as operating expense the moment it is used. All the costs that can be linked to the conversion of inventory into throughout are included. There is no difference made between fixed, variable, direct or indirect cost. The salary of the managing director is handled in the same way as that of the shop floor worker.

It is now very easy to define waste. Any expense that does not contribute to converting inventory into throughput is waste and should be avoided.

**Traditional bottom line measurements**

Using only throughput, inventory and operating expense as measurements, management is capable of measuring the performance of the company. As the traditional measurements of return on investment and net profit are so entrenched it would be unwise to totally disregard them. Goldratt (1988a:p14) describes the link between the fundamental measurements and the bottom line measurements as follows:

Net Profit = Throughput minus Operating Expense:

(NP = T – OE)

Return on investment = Throughput minus Operating Expense divided by Inventory:

(ROI = (T –OE)/I)

Non-financial measurements, for example productivity and inventory turns, can also be expressed using a combination of throughput, inventory and operating expense.

Inventory turns = Throughput divided by Inventory

(Inventory turns = T / I)

Productivity = Throughput divided by Operating Expense

(Productivity = T/OE)

### 7.5.3 Control measurements

Goldratt (1988a:p15) describes a set of measurements called "control measurements". These are supportive of the fundamental measurements in that they can be utilised to measure the total system but also sub-systems. The three measurements, Throughput-Rand-Days, Inventory-Rand-Days and Local-Operating-Expense are discussed below.

**Throughput-Rand-Days**

This measurement deals with quantifying the magnitude of the deviation of the plant from its promised commitments to clients. It measures things that were supposed to be done and were not done. Many plants measure this in either number of shipments missed or number of units not sent. When the size of the orders and the selling prices of the units do not differ these measurements are sufficient. As soon as these differ it is necessary to introduce a different measurement. Throughput -Rand-Days are the value each order has when assigning a value equal to its selling price multiplied by the number of days the shipment is late.

The target of Throughput-Rand-Days is zero.

**Inventory-Rand-Days**

Inventory-Rand-Days measures things that we should not do but were done anyway, for example building a high finished goods inventory to increase the efficiencies of certain equipment.

Companies measure finished goods inventories in Rand value and time value. To calculate Inventory-Rand-Days these metrics are multiplied. For example a R2 million inventory with a 5-day period until it is sold (finished inventory) equals an Inventory-Rand-Days value of 10. By calculating the Inventory-Rand-Days the focus is placed on inventory reduction. To decide how much inventory to reduce, the concepts of Customer-Tolerance-Time and Product-Lead-Time are used. Customer-Tolerance-Time is the time from when a customer places an order until he expects delivery. Product-Lead-Time is the elapsed time to produce the product without giving it any special priority versus other products. If the Customer-Tolerance-Time is more than the Product-Lead-Time it is not necessary to hold any finished goods inventory. For the opposite scenario finished goods inventory should be held to cover the expected demand in the interval equal to Product-Lead-Time minus Customer-Tolerance-Time.

**Local Operating Expense**

Local-Operating-Expense is the expense the local area (department) has full control over. This refers to the direct expenses that the area has control over, without any allocated costs. These allocations must not be included in the expense account used for this measurement, but captured where it actually occurs. An example is the allocation of overhead Information Management (IM) cost. The local area may be a user of IM facilities but do not incur any cost – therefore the cost should not be allocated. If the local area did expend IM cost (i.e. buying a new computer) that cost will be included in the Local Operating Expense account.

## *7.6 IMPLEMENTATION*

The prerequisites for a successful and sustainable implementation of Theory of Constraints are discussed next.

### 7.6.1 Change management

The Theory of Constraints implies a dramatic change from the traditional way of doing things. It is therefore important for management to have a formal change management program in place. This program must allow for a gradual change in the processes, but all the while keep the momentum of the implementation. Jacob & McClelland (2001:p11) describe an implementation process that is specifically designed to obtain the support and collaboration of all parties.

- Senior management needs to determine what changes are required, and what their specific roles will be in facilitating these changes.
- The organisation needs to be informed on what will change, why it is necessary, what the benefits are and when and how they (the people) will participate in the changed process.
- Previously trained experts analyse the business to map the generic Theory of Constraints solution to the business and identify areas for customisation.
- The whole organisation is involved in the new process; they are trained and their new roles are assigned.

- A specific date is assigned to the "go-live" of the new system.
- The process of continuous improvement starts.

When implementing the Theory of Constraints effective, fast and constant communication is essential. People and processes will be evaluated differently and that may cause some uncertainty in the workforce. People may be moved around due to constraint management activities, and they may perceive these changes negatively. Management needs to constantly reassure employees and involve them in the process from the beginning (Miller, 2000, 50).

### 7.6.2 Stagnation

Goldratt (1998b:p5) discusses the danger of stagnation within a company that operates according to Theory of Constraints principles. Stagnation can occur in three different ways. Firstly, a company can ignore step five of the five focusing steps. Step five forces one to revisit all the assumptions made when elevating a constraint. If the company does not re-evaluate the process constantly and check if the constraint identified is still valid, erroneous decisions are made that will lead to a loss. Secondly, a company may have used the five focusing steps to manage their physical constraints and have achieved dramatic results in a very short time. But as soon as the constraint becomes an external one, such as the market, the company often does not identify it and therefore cannot improve further. Thirdly, Goldratt (1987:p40) discusses the danger of being satisfied with your current position. When a company has gone through a major change and achieved substantial results, the danger is that they can become complacent and not embark on a continuous improvement program.

## *6. CONCLUSION*

In this chapter the management philosophy Theory of Constraints was discussed. Theory of Constraints is an operational management philosophy that manages the organisation as a chain and focuses on the weak links within the chain, with the aim to make profit now and in the future. The key values of Theory of Constraints and the impact these values have on the functions within a company, as well as the unique measurement tools and techniques used were discussed. Finally the pre-requisites for successful implementation of the Theory of Constraints in a company were detailed.