A CRITICAL INVESTIGATION OF PLANT OPTIMIZATION, TO IMPROVE THE PRODUCTION PROCESS OF MERCEDES-BENZ COMMERCIAL VEHICLES IN SOUTH AFRICA. (Jan 2004 – Sept 2004)

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By

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DECLARATION

Hereby I, Desalin Rajoo Naidoo, declare that this research thesis is my own original work and that all the sources have been accurately reported and acknowledged, and that this document has not previously in its entirety or in part been submitted at any university in order to obtain an academic qualification.

D.R Naidoo 31 January 2005

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ABSTRACT

The research thesis reflects a positive improvement to the plant efficiency through strategic optimisation planning and controlling systems. It's important to note that the set goals of the research were achieved, with total employee buy-in contributing to the success and sustainability of these improvements.

Purposive sample methods allowed for the twenty employees from a total of 172, to be interviewed for both the pre and post testing. The paradigm of the research contributed to integrative communication between brainstorming and action. The efforts of the total workforce must be commended, for strategically aligning the organizational goals and objectives to realization.

The content of the thesis, show a direct relationship between the plant optimisation and the increase in the production volumes. The understanding of the downtime reports for the period specified is a direct reflection to the improvement in **quality**, and the reduction of the overall poor workmanship graphs indicates positively to the reduction in **cost**. The last value driver, **on-time delivery** shows a vast improvement in maintaining the customer satisfaction, when considering the increase to the production volume capacity.

These improvements have made further volume increases probable, and the understanding of Ikhwezi Trucktech management to negotiate with realized information for future capacity planning.

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CHAPTER 1: INTRODUCTION

1.1 Setting of the study

Economic empowerment is an integral part of South Africa's transformation process, encouraging the redistribution of wealth and opportunities to previously disadvantaged communities and individuals, including blacks, women and people with disabilities. The empowerment process has been identified as crucial to the future viability of the country's economy.

Black Economic Empowerment (BEE) companies have shown tremendous growth since 1994, when the first major black consortium listed on the Johannesburg Stock Exchange (JSE).

Increasingly, foreign and local companies are seeking BEE partners in order to establish working relationships or joint ventures, thereby securing state approval for government contracts. Public-private partnerships are popular with the government, as are initiatives such as the Build-Operate-Transfer scheme, where projects are financed, built and operated by private enterprises for a period of time, before reverting to the government. A BEE partner may add ten points onto any government contract.

BEE companies are well represented in the financial services sector, the media, forestry and pulp and paper, oil and energy, beverages and fishing industries. Notable BEE firms outside of the JSE include Black Like Me (cosmetics) and Pamodzi.

Affirmative action policies have seen increasing numbers of senior black personnel, particularly in government parastatals. With the Employment Equity Bill going into effect in stages during 2000, these policies have become standard for all larger companies.

According to *Towards a Ten Year Review*, a discussion document reviewing the impact of the government's policies since 1994, the proportion of top managers who are black grew from 12% to 13% between 2000 and 2001, while the number of senior managers grew from 15% to 16%. The proportion of skilled professionals and middle managers grew even more slowly, by 0.2%.

These figures show that empowerment in the workplace is continuing, albeit very slowly.

Progress was also slow in extending black ownership, with a recent estimate of black equity in public companies indicating 9,4% in 2002 compared with 3,9% in 1997, from being virtually non-existent before 1994.

According to the document, the number of Previously Disadvantaged Individual (PDI) directors of public companies grew from 14 (1.2%) in 1992 to 438 (13%) in 2002, but the proportion of PDI executive directors remains very small.

As far as women are concerned, their progress in the workplace has been equally slow. Just 13% of top managers in 2001 were women, only 1% better than 2000. Women in senior management grew a little faster, by 1,7% to 17,7%.

Evidence from the 2001 census suggests that the proportion of black managers and professionals has increased relative to their white counterparts, although the rate of change is still very slow - the proportion of black managers, senior officials and legislators rose from 42,5% in 1996 to 44,3% in 2001.

Progress among professionals, associated professionals and technicians shows that blacks now comprise 61,4% of these groupings in 2001, up from 57,6% in 1996.

There is a relative scarcity of skilled black candidates, and, as a result of the high demand for qualified black managers and professionals, salary packages have risen fast and there has been very high job mobility. The Skills Development Act of 1998 aims to correct this problem by developing the skills of the South African workforce, and improving the employment prospects of previously disadvantaged individuals. www.bmfonline.co.za

A core motivation for the formation of Ikhwezi Trucktech (Pty) Ltd (ITT) was primarily to provide a real employment opportunity for Previously Disadvantaged Individuals (PDI) in an impoverished province of the Eastern Cape in South Africa. In June 2003, ITT contracted Empowerdex, an independent Empowerment rating agency, to audit the company's black economic empowerment and employment equity initiatives. After its investigations, ITT was given a Black Economic Empowerment (BEE) - A rating in accordance with Empowerdex findings. In terms of Empowerdex's criteria, the rating indicates that ITT has strong direct empowerment credential, human resources development indirect empowerment, as well as operational and financial capacity.

The company has 150 employees of which eighty five percent are PDI's who are employed on a contract basis. A total of 40% of the salaried staff are PDI's and ITT has an Employment Equity Committee that includes a diverse sample of the company's employees. Total procurement for the last financial year amounted to R23,5 million, of which R19,1 million (81%) was from PDI suppliers. Once again Empowerdex rated Ikhwezi Trucktech's BEE procurement as excellent.

1.2 The Manufacturing Company

Ikhwezi Trucktech (Pty) Ltd (ITT) was formed in January 2002, after DaimlerChrysler South Africa (DCSA) decided to outsource its commercial vehicles manufacturing division.

The DCSA manufacturing plant in East London, at the time, had succeeded in winning the international DaimlerChrysler contract to manufacture the right hand drive version of the W203 Mercedes Benz C-Class for export in terms of the South African Motor Industry Development Program (MIDP). As a result of the plant's integration into DaimlerChrysler's global manufacturing network, it was decided to discontinue the relatively low volume manufacture of Commercial Vehicles (CV) from Completely Knock Down (CKD) kits and instead import the truck as Fully Built Up (FBU) units, using the benefits of the MIDP import tax credits earned through C-Class exports.

The senior management of the CV division, however, realized there was an opportunity to outsource the CV Semi Knock Down (SKD) kits, and at the same time provide a Black Economic Empowerment (BEE) opportunity.

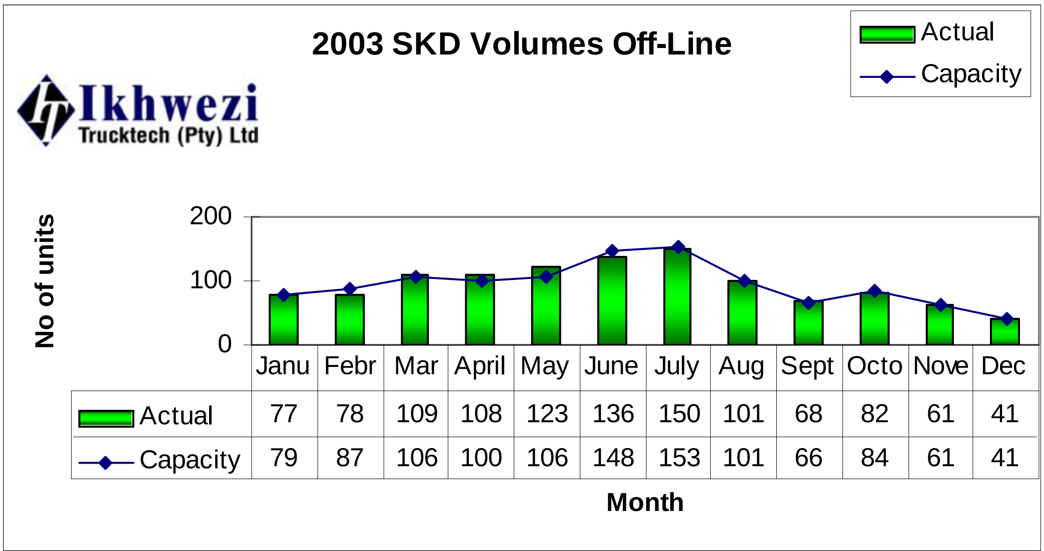
ITT successfully won the contract to assemble and prepare all DCSA commercial vehicle requirements for the South African market, using the company's modern CV facility. Almost all DCSA employees who had been involved in CV manufacturing joined the new company. Currently the organization assembles all Actros, Atego, Freightliner and Canter for DCSA, with the semi-knockdown parts being supplied from DaimlerChrysler Germany (DCAG).

It is important to understand at this point that ITT exists within a unique value chain, with DCAG being its sole supplier of SKD units and DCSA being its sole customer of the finished product. The marketing of commercial vehicles in South Africa is the responsibility of DCSA. Currently in South Africa Mercedes Benz Commercial Vehicles are market leaders with a thirty five percent market share.
(DCSA Star, May 2004: 6)

1.2.1 Problem definition and motivation for the study

In October 2003, Ikhwezi Trucktech received confirmation from DCAG of the expected increase to the production volumes for 2004. The increase in production calculated at being between thirty to forty percent of current output. This demand required an investigation to be conducted into the plant's capability of handling the proposed increases to the production volumes. Presently the capacity of the plant has been designed to cope with current demand of commercial vehicles in South Africa. The future demands for commercial vehicles will prove to be in excess of the production capacity unless strategic optimization planning and control systems are re-engineered. The purpose of this research is to investigate and find solutions to the restricting factors that may hinder the fluency of production, and to establish whether the plant size may be a limiting factor to the expected increased volumes.

Figure 1.0: 2003 SKD Volumes Off-Line for a period of 12 months

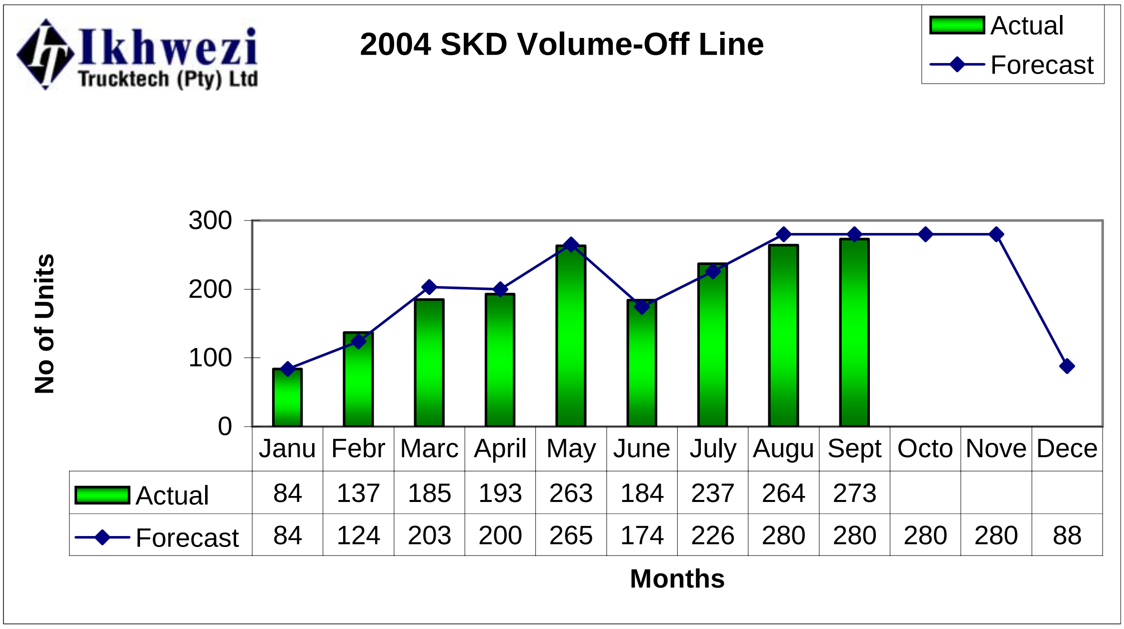


	Janu	Febr	Mar	April	May	June	July	Aug	Sept	Octo	Nove	Dec
Actual	77	78	109	108	123	136	150	101	68	82	61	41
Capacity	79	87	106	100	106	148	153	101	66	84	61	41

Figure 1.0, reflected above illustrates the production volumes of semi-knock down vehicles that were assembled during the 12 month period of 2003. During the same period the production volumes were established at being between 5 and 6 units per day depending on the time available for production. The statistics above for 2003 also reflect, a 42% failure to achieve the Off-Line Production Volumes. System re-engineering became an immediate concern, as volume for 2004 was expected to increase by 40%. Another constraint from marketing suggested, that the measurement for on-time delivery would be decreased from 90% to 85% for 2004. This reinforced the initiative to optimize the production processes and logistics controls to secure all future plans for improvement of ITT.

The objective of ITT, at its inception in 2002, was to adopt a labour-intense manufacturing structure to create employment in the impoverished province of the Eastern Cape. When plant optimization became a reality, automation would thus not be a major contributor in achieving the increase in production volumes projected for 2004. Therefore alternative strategies were considered to maintain the organizational objective of being labour-intensive apart from being semi-automated.

Figure 1.1: 2004 SKD Volume Off-Line for a period of 12 months.



	Janu	Febr	Marc	April	May	June	July	Augu	Sept	Octo	Nove	Dece
Actual	84	137	185	193	263	184	237	264	273			
Forecast	84	124	203	200	265	174	226	280	280	280	280	88

Figure 1.1, shows a clear indication of the increased volumes that are expected for 2004. The forecasted figure for 2004 has been confirmed by DaimlerChrysler (Germany), and is expected to be in excess of the 40% planned increase for the same period. During the peak period for commercial vehicle sales in South Africa, a 30% increase to the production outputs will have to be achieved to ensure that Daimler Chrysler (South Africa) can sustain their market leader status.

Surprisingly, the expected volume increase of 2004 of 40% was temporarily stated, as the production forecasted for 2004 reflected an increase of in excess of 100% to the previous production year. At this point the management of ITT made strategic decisions to optimize the production process to make certain that the forecasted quantity demands would be sustained for 2004. The pressure from DaimlerChrysler (Germany) intensified the process when the option of ordering units as fully built-up (FBU) to subdue the production demands was revoked. DCAG clearly stated that only units with special engineering execution would be delivered as FBU's. The urgency of plant optimization was fast becoming a reality. ITT found itself on a "burning platform" to either optimize the plant and processes or stand the risk of losing the opportunity of growth and development. More realistically, its contract to build and assemble commercial vehicles for DCSA was at stake.

1.3 Aim of the Study

- To improve the production process, with the aim of increasing the plant efficiency for period January 2004 to September 2004
- To re-engineer the system design to maximize outputs from for period January 2004 to September 2004
- To eliminate constraints that are limiting the system from achieving it designed goals.
- To establish whether the plant size will be a limiting factor to the increase in production volume.
- To ensure that the on-time delivery to customers are maintained.

1.3.1 Outline of the study

The study is divided into seven chapters. Excluding this introductory chapter in which the problem is defined, the research motivated, and the aim and the method of the study provided, the chapters are organized as follows:

1.3.2 Chapter 2 – Literature review

The literature review section is divided into a few main headings, which are aligned with the research goals. The headings are as follows:

- Systems Design
- Theory of constraints
- Documentation analysis
    - Benchmarking
- Management theories

1.3.3 Chapter 3 – Research methodology

The research methodology chapter describes the methodology employed in the development of the action research model. It identifies and briefly outlines the paradigm of the research and describes how the sample was determined and then the ethical considerations that had been acknowledged in overcoming the initial barriers of change. Incorporated in this section is the understanding of the DaimlerChrysler Operating Model, to sustain the changes and to measure the continuous improvement of the operation.

1.3.4 Chapter 4 – Operating model

This chapter will describe the framework that will be used throughout this research, in trying to solve the problems being experienced at Ikhwezi Trucktech. The model incorporates the inclusion of theory, experience and benchmarking to ultimately achieve a workable solution.

1.3.5 Chapter 5 - Results and analysis of results

This chapter reports and analyses the results. The result established in this section will be included in the production system in an effort to optimize the system design, to cope with the increase in volume or any other constraint that may hinder the successful of increase efficiency.

1.3.6 Chapter 6 – Discussion of results

The discussion of results will analyze the current scenario that exists within the plant. The focus will be to improve the support from Germany and to compare the results with theory, to ensure that the key value drivers at Ikhwezi Truchtech are maintained (Quality, Cost and Delivery).

1.3.7 Chapter 7 – Recommendations

The chapter will reflect the improvements that have been implemented to support the increase to the plant efficiency and on-time delivery to customers. The DaimlerChrysler Operating Model will be introduction to Ikhwezi Trucktech, to create a measuring tool whereby the employees can determine continuous improvement and sustainability. The results of the post testing will illustrate the employee perception of the plant improvements and efficiencies.

1.3.8 Chapter 8 – Conclusion

This chapter will show, assuming that the results have been achieved, the learning points through understanding the optimization process at Ikhwezi Trucktech (Pty) Ltd and the journey of the implemented improvements.

CHAPTER 2 – LITERATURE REVIEW

2.1 History of system movement

In 1926 a remarkable book on systems thinking appeared. The author was a Cambridge graduate, and a distinguished South African Boer General called Jan Smuts. The title of this book is Holism and Evolution and it is a treatise on systemic thinking with particular emphasis on the teleological development of man, and the world around him. The many ideas and concepts expressed by Smuts was uncommon at the time, such as for example, that the whole development properties meta to those of its parts (synergistic process), and that these meta-characteristics cannot be inferred from study of its parts. (Smuts, 1926:146)

He recognized purposeful behaviour, and the fact that such systems are dynamic, evolutionary, and creative. Smuts' thinking represented a departure from that of the traditional, scientific method. At the time, this departure was being reflected in a number of institutions of learning in Europe. Ten years later, Ludwig von Bertalanffy summed up the current ideas of systems thinking when he expounded the views on General Systems Theory. During World War II, great strides were made in the use of systems idea and planning military operation, logistics networks, armament manufacture and procurement of military equipment. (Smuts, 1926: 231)

These strides made such a positive impact that by the end of the war a number of new disciplines had made their appearance.

- Operations research (later known as management science) was hailed as a system based, multidisciplinary activity, almost guaranteed to solve any problems successfully.
- There were a large number of hard methodologies represented. These approaches had one common aim, which was to approach a problem situation in a systematic manner.
- With the introduction of computers (von Neumann machines), the science of systems stimulation was given a boost. Although stimulation has been used for econometric analysis prior to 1922, powerful post-war computational power

opened up many new possibilities. The club of Roman studies and the work of Jay Forrester are classic examples of this development. (Forrester 1968). Computing also fostered the use of iterative mathematics and pivoting techniques, which although known for many years had not been used for solving large problems because of the immense computational efforts required. A well known example is George Dantzig's simplex algorithm for solving linear programming problems (K, Sandrock, 1999: 9).

In the early 1950's the idea of taking a holistic view of a problem situation and then trying to model it using systems concepts started to gain momentum. The results achieved through this avenue were good, and systems analysis started to replace the reductionism approaches that had been used before World War II. However, virtually all these new methodologies were "hard" in the sense that, they were based on the following underlying assumptions:

- The problem is well-structured
- The problem should be represented in a quantitative model (be it an analytical model or a simulation model).
- The system containing the problem may be regarded as been purposive in nature.
- The system (containing the problem) is nearly – decomposable.

Because of the initial effective use of the hard system paradigm, the shortcomings associated with the assumptions listed above were not obvious to the analysts of the post-war era. It was only later on that it became apparent that the hard methodologies were not providing optimal results. (K, Sandrock, 1999: 8-9).

The first to realize that something was wrong was that generally referred to as 'management' and, in particular, 'top management'. Although management could not identify the real evil of the hard systems approach, their use of intuition, know how, and 'gut feel' when examining recommendation proffered by systems analysts, led them to decide against implementation more and more frequently. This was disappointing for the analysts who repeatedly raised the cry: "Management does not understand us".

- The second group to become suspicious was made up of systems thinkers of the calibre of C West Churchman (1971), R L Ackoff (1979), C E Lindblom (1979), P

> Checkland (1970) et al. These analysts realized that the assumptions underlining the hard approach were too restrictive, especially the assumption that the system containing the problem may be regarded as being purposive in nature. This assumption is almost always violated in the real world because systems in industry are what are known as “human activity systems”, a term which is automatically purposeful (and not purposive) behavior. (K, Sandrock, 1999: 9).

It was this shortcoming, the failure to explicitly recognize purposeful behavior, which had earlier alerted management to the fact that “something was wrong”. However, it was all four assumptions, which caused systems thinkers to start to question the validity of the hard systems methodologies of the post-war era. As a result of this questioning, a new approach to systems engineering began to emerge around 1970.

Wymore (1976) speaks of almost every systems engineer when he states that, in more than twenty years of consulting, it was seldom the mathematics or the analytical tools that gave him trouble but “because methodological mistakes were being made, other problems were created: psychological, organizational, political and so on”.

It is only very recently that management has realized that one of the essential ingredients of successful Total Quality Leadership is an appropriate, pervasive organizational culture. The Japanese, who are credited with first realizing this, started to change the thinking of all employees so as to have a quality culture pervade the organization.

The development of systems engineering took a dramatic turn when Peter Checkland introduced the subject of systems thinking and practices in the Department of Systems Engineering, Lancater University, around 1970. This subject is a synthesis of most of the really useful systems concepts that have been proposed by various thinkers, together with his own original idea and approaches. Subsequent to Checkland’s work is that of Peter Senge, author of the Fifth Discipline, who introduced the concept of a learning organization (LO). There is currently a great deal of interest in the LO concept, but it is implicit in Checklands work, and is not an entirely new idea. (K, Sandrock, 1999: 8-10).

Important Definitions: before progressing to the details of systems design, a few definitions need to be highlighted to add clarity to understanding.

2.2 Definition of a system

C.W. Churchman's definition of *a system* is " a set of parts coordinated to accomplish a set of goals." G. Jenkins states that, "a system is any grouping of resources with a "definite objective". P. Checkland, on the other hand, defines a system as "a structured set of objectives and/or attributes, together with the relationship between them."

According to W E Deming (1993), the following is an operational definition of a system:

1. There is an aim or singular purpose to which an interdependent set of processes is directed.
2. There is an underlying structure of core processes that can be observed and charted.
3. The core processes act on inputs to produce outputs (transformation).
4. Interdependency is present and definable most of the time.
5. Variation is present in the output of the interrelated processes.
6. There is an optimal range of acceptable performance.
7. If the system is in control it has a definable identity and a definable capability.
8. Standardization can help or hurt the system's capability to produce satisfactory results.
9. People are an extremely important part of the system and are seldom to blame for any attendant inefficiency.

2.3 Systems approach

According to Churchman's definitions of a systems approach, "we are going to look at the whole organization and after we understand the whole organization as a system, we will proceed to the specific problems." Miles (1973), however states, "the systems approach is just plain common sense and that each concept, each step is the reasonable thing to do." Checkland, states, "A system approach is that outlook which, in a problem confronting situation, seeks **not** to be reductionist."

The development of systems approach leans positively towards the development of systems engineering. Systems engineering is the professional, intellectual, and academic discipline for adapting a systemic approach to the analysis and design of complex systems.

2.4 Systems engineering

This definition places systems engineering at a meta-level to that of either systems analysis or systems design. The latter are seen to be two sub-disciplines of systems engineering. Furthermore, systems engineering is regarded as a discipline for analyzing **complex** situations. Systems Analysis is a systematic approach for investigating the full problem situation. Its goal is to create a model by which the existing situation may be suited and analyzed abstractly. Systems Design means to develop a blueprint in which a new system will be created or an existing system modified. Warning: " *when each part of a system performs independently as well as possible, the whole will seldom function well*." (R. Ackoff, 1973). (K, Sandrock, 1999: 14-15).

2.5 **Demings PDCA Cycle**

The cycle starts with the P (for plan) stage, which involves an examination of the current method or the problem area being studied. This entails collecting and analyzing data so as to formulate a plan of action, which is intended to improve performance. Once a plan for improvement has been agreed, the next step is the D (for do) stage. This is the implementation stage during which the plan is tried out in the operation. This stage may itself involve a mini-PDCA cycle, as the problems of implementation are resolved. Next comes the C (for check) stage where the newly implemented solution is evaluated to see whether it has resulted in the expected performance improvement.

Finally, at least for this cycle, comes the A (for act) stage. During this stage the change is consolidated or standardized if it has been successful. Alternately, if the change has not been successful, the lessons learned from the 'trial' are formalized before the cycle starts again. It is the last point about the PDCA cycle, which is the most important – the cycle starts again. It is only by continuous improvement philosophy the PDCA cycle quite literally never stops. That improvement becomes part of every person's job. (M. Pycraft, et al, 2000: 668).

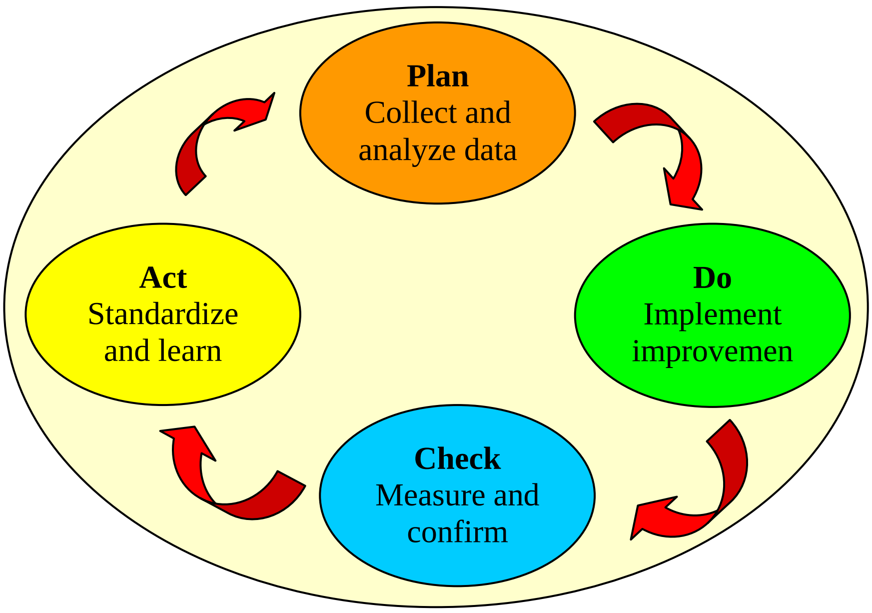


Figure 2.0 – PDCA CYCLE

2.6 Theory of constraints

2.6.1 What is TOC?

Dr Eliyahu Goldratt first described the Theory of Constraint, in his work *The Goal*. TOC is a management philosophy that views an organization as a complex system consisting of a number of component subsystems. It strives to improve the performance of the system by studying it in its entirety, rather than treating the organization as a collective of non-interacting components. (Goldratt, 1992: 47)

Complex systems are not constrained by many aspects of the system, but very often by only one. For example: the flow of material through a chemical plant is limited by the operation that has the longest processing time, and the flow of traffic through a town is probably limited to several bottlenecks or poorly synchronized traffic lights. A constraint is anything that prevents the system from doing more of what it was designed to accomplish. For a business, it would be whatever keeps the business from generating more profits.

Organizations also have constraints that are not physical. These constraints can be obsolete rules, poor training, or policies that negatively influence organizational behaviour. For example: a rule that states “we only make and sell product that gives us a 15% margin” might be a constraint in a facility that has excess production capacity. Applying Theory of Constraints thinking requires a major paradigm shift from the traditional management focus on cost control, to that of eliminating barriers to Throughput, which is defined as the rate at which an entity achieves its objectives, e.g. produces money through sales. (Goldratt, 1990: 14)

Where is TOC used?

The Theory of Constraints has been used at three different levels:

a) Production Management - TOC was initially applied here to solve production bottlenecks, improve job scheduling, and reduce inventory.
b) Throughput Analysis – Application of TOC has caused a shift from cost-based decision making to decision-making based on the continuous improvement of processes in which system throughput, system constraints, and capacities at critical points, are key elements.
c) Logical Processes - This third level involves the application of TOC reasoning to attack a variety of process problems within organizations. TOC logic is applied to identify the factors that are preventing an organization from achieving its goals, to develop solutions to the problem, and to enable the individuals involved with the process to implement the required changes themselves.

2.6.2 Systems

Theory of Constraints studies the behaviour of systems, especially human organizational systems. A system is a bounded activity, which takes input from outside the boundary, transforms it in some way, and sends it back as output. A water pump is a simple system. It is bounded, it takes in water, increases the water pressure, and sends the transformed water back outside the boundary. All profit-making organizations are money pumps. They are business systems, which attempt to increase a flow of incoming cash into a greater flow of outgoing cash. When and if the pump generates a positive cash pressure, some or all of the difference between its input and output is skimmed off by the owner of the business before being routed back to the pump.

2.6.3 Constraints

TOC recognizes that the inevitable constraints within any system are incredibly important both for understanding exactly how the system works, and also for improving the system. A constraint is something that constricts the flow within a system- “a bottleneck”. A valve is a variable constrictor of a pipeline. The valve that is most closed in many-valved pipe is the constraint, the single thing that determines the overall amount of water flowing through the pipeline per unit of time. Since the valve is constricting the flow, it doesn’t matter how fast water is pumped into the system, the overall flow rate will be set by the cubic meter per minute that the valve will allow.

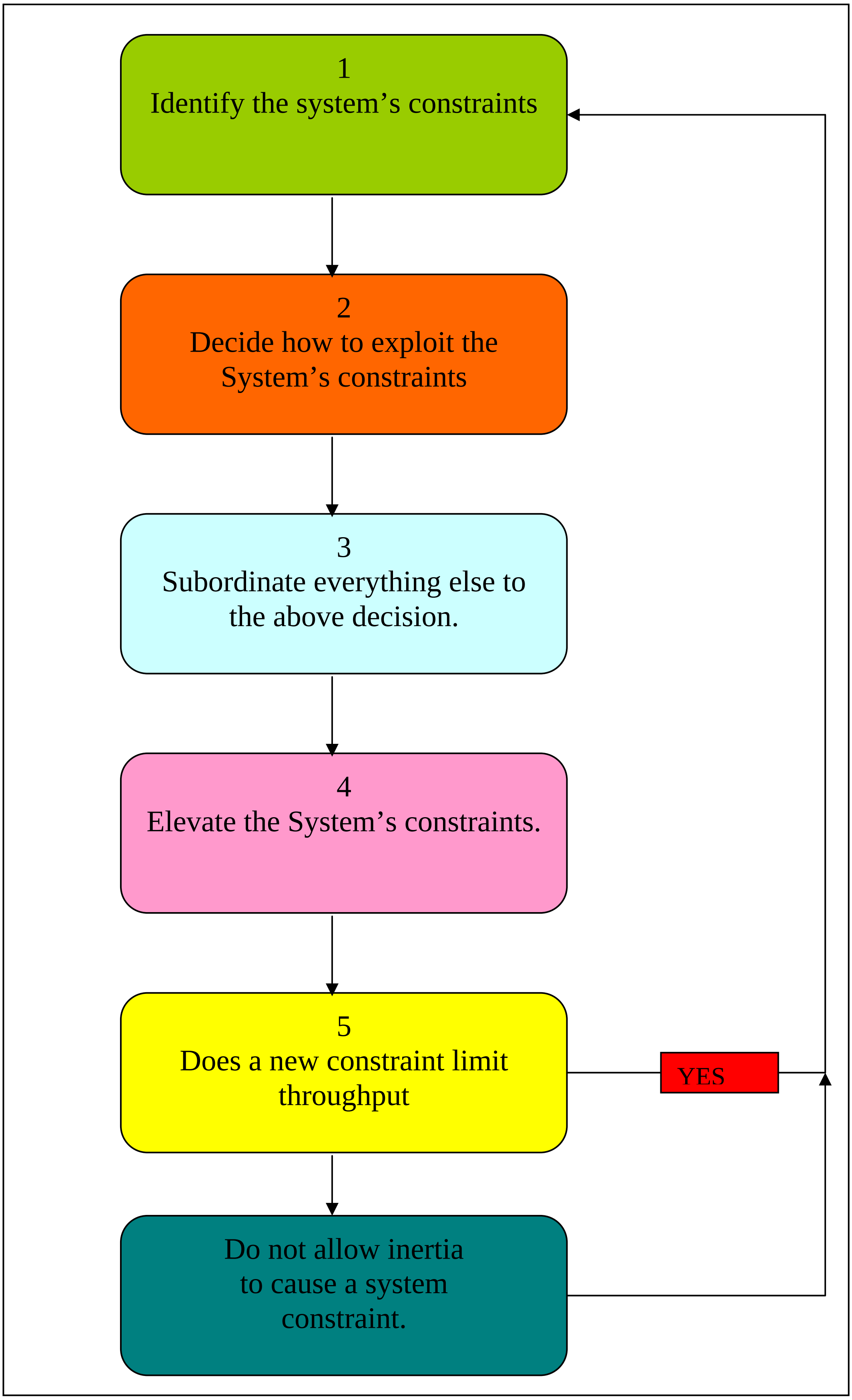
Within a production manufacturing process the slowest worker in the plant is the assembly line constraint. Constraints are inevitable. If you eliminate one another one crops up somewhere else, or the load on the system itself becomes the constraint. Similar things happen in business systems. Bottlenecks move around but never go away. (K. Sandrock, 1994:25).

2.7 How is TOC applied?

TOC is like a lens; it focuses on the system's constraints first and foremost. To manage constraints "rather than be managed by them", Goldratt proposes a five-step Process Of On Going Improvement. The steps in applying TOC are as follows:

1. **Identify** the System's Constraints.
2. Decide how to **Exploit** the System's Constraints.
3. **Subordinate** everything else to the above decision.
4. **Elevate** the System's Constraints.
5. If in the previous steps a Constraint has been broken, **Go back to Step 1**.

Figure 2.1 The Five-step process of TOC



2.7.1 Step 1: Identify

In order to manage a constraint, it is first necessary to identify it. This knowledge helps the company determine where an increase in "productivity" would lead to increased profits. Concentrating on a non-constraint resource would not increase the throughput (the rate at which money comes into the system through sales) because there would not be an increase in the number of products assembled. There might be local gains such as a reduction or elimination of the queue of work-in-process waiting in front of the resource. 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

2.7.2 Step 2: Exploit

Once the constraint is identified, the next step is to focus on how to get more production within the existing capacity limitations. Goldratt refers to this as exploiting the constraint. One example from *The Goal* concerned a company in which the labour union agreed to stagger lunches, breaks, and shift changes so the machine could produce during times it previously sat idle. This added significantly to the output of the machine, and therefore to the output of the entire plant. To manage the output of the plant, a schedule should be created for the constraint. The schedule showed the sequence in which orders would be processed and their approximate starting time.

2.7.3 Step 3: Subordinate

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 that is running a job that the constraint doesn't need yet. Subordination, which is Step 3, is necessary to prevent this from happening. Subordination involves significant changes to current (and generally long-established) ways of doing things at the non-constraint resources.

The most important component of subordination is to control the way material is fed to the non-constraint resources. Conventional wisdom says that if a resource is idle it is losing money. Conventional practice, then, is to keep efficiencies high by releasing enough material to keep everyone busy - regardless of whether the constraint can process that much material. TOC wisdom says that non-constraint resources should only be allowed to process enough materials to match the output of the constraint. The release of materials is closely controlled and synchronized to the constraint schedule. In contrast to the constraint, non-constraint resources do not have a schedule. Workers are instructed to begin immediately when work arrives at their stations, to work at normal speed (i.e. do not slow down so that work expands to fill the available time), and immediately pass the finished parts on to the next operation. If there is no material waiting to be processed, the non-constraint resources will be idle, and that is OK. In fact, preventing non-constraint resources from overproducing is necessary to reach the goal of making more money, now and in the future.

2.7.4 Step 4: Elevate

After the constraint is identified, the available capacity is exploited, and the non-constraint resources have been subordinated, the next step is to determine if the output of the constraint is enough to supply market demand. If not, it is necessary to find more capacity by "elevating" the constraint. In *The Goal,* schedulers were able to remove some of the load from the constraint by re-routing it across two other machines. They also outsourced some work and brought in an older machine that could process some of the parts made by the later model machine. These were all ways of adding capacity, or elevating the constraint. It is important to note that to "elevate" comes after "exploit" and "subordinate." Following this sequence ensures the greatest movement toward the goal of making more money.

2.7.5 Step 5: Go Back to Step 1

Once the output of the constraint is no longer the factor that limits the rate of fulfilling orders, it is no longer a constraint. Step 5 is to go back to Step 1 and identify a new constraint -because there always is one. The five-step process is then repeated.

It may appear that implementing TOC involves a never-ending series of trips through the five-step process - a kind of tool to assist in more perfectly balancing a production system. This is not the case. A fundamental principle of the Theory Of Constraints is that the combination of dependent events (such as the steps in a production system) and normal variation (which 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. 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 investment, hiring, etc.) accordingly. This allows the company to manage the constraint to their advantage rather than allowing the constraint to manage them. (E.M. Golddratt, 1990: 5-8).

2.8 Resistance to Change

Everyone knows the problem of resistance to change. If your organization is somewhat stable, there must be significant factors (usually in the form of feedback mechanisms) that are keeping it that way. Any attempt to change the organization will automatically trigger these feedback loops; causing what most management specialists call 'resistance to change.' Even though the TOC and TQM methods are logical, and most of them are quite simple, implementation can be very difficult if you do not recognize and deal with the resistance that is sure to develop.

You must deal with resistance at three levels. The first is the individual behaviour level. You can influence this significantly by changing the day-to-day feedback delivered by peers, management, and formal measurement systems. The second level is the social group in the company. This often requires significant facilitation, as the norms of group behaviour are very powerful and reinforced in many subtle ways. The top level is the organizational level, where senior leadership has the greatest influence.

Dr. Goldratt uses a model he calls the “six layers of resistance.” It is a somewhat helpful model. It is primarily a cognitive model, and while necessary, frequently not sufficient to overcome organizational resistance.

Our experience in implementing TOC, and especially Critical Chain Project Management is that it always succeeds if management takes an active leadership role, and never succeeds if they take a more passive “let it happen,” or “hope it will happen” role. The nice thing about TOC is that it very rapidly reduces the quantity of problems that management has to deal with, so once started; there is a positive feedback to carry it to completion. (E.M. Goldratt, 1986:35).

2.9 Goldratt's Solution to initiating change

Goldratt proposes a two-step approach to the problem of initiating in an organization. The first step is the use of the effect-cause-effect methodology to isolate the real problem. The second step is to ensure buy-in in the development of every science, three distinct stages exist: classification, correlation and effect-cause-effect.

About thirty years ago, both in the United States and in Japan, production scheduling was systemized with the use of MRP (Manufacturing Resource Planning). For the first time, a systematic approach was taken to shop floor scheduling of Bills Of Material (BOM), routine, inventory files, work-in-process files, and order files were all organized into a single data base. This was really the first stage of classification.

The United States took many years to accomplish and assimilate the first stage. The Japanese moved almost immediately to the second stage of correlation. Dr Taichi Ohno, Executive Vice President of Production in Toyota discovered the methodology called the Toyota Production System and the Kanban approach which in the US they are combined under the name of Just-in-Time (JIT). Dr Ohno never asked the question “WHY?” he is reputed to have said, “my system does not make sense at all, but it works.”

According to effect-cause-effect methodology, if the goal of the organization is to make money through sales, and we are able to measure Throughput, Inventory, and Operating Expense, we can use this information to make correct decisions that improve bottom line performance. Effect-cause-effect methodology involves speculation of the cause for a particular effect, then predicting (and verifying) another effect from the same cause. The more effects that can be predicted in this way, the more light is shed on the likely root cause problems. This has never been true for decision making through the use of management accounting. Thus one of TOC's challenges is to precipitate a paradigm shift in management thinking, from cost base decision making to one that is theory based and has been shown to explain behaviour.

Buy-in is ensured through the use of Socratic method, which is a teaching strategy employed by the Greek philosopher Socrates with his pupils. In the Socratic method, a questionnaire, the teacher typically attempts to have the students create a solution to a question or problem by asking them questions that lead them in the direction of the correct answer or solution. This process continues until the student finds the answer. When the method is successful the person implementing the solution has found the solution for himself/herself and buy-in is ensured.

2.10 Prescribing Simple Solution to Problems

Once the root cause of the problem is identified, having the relevant team identify a methodology to remove the problem becomes the next challenge. Goldratt never talks about solving problems at this level, but rather he talks about causing the problem not to exist. This is consistent with his view of constraints and constraint removal. His reasoning is that constraint removal is not consistent with compromise, and that the problem solving in business is typically a compromise. Compromise does not generally eliminate the root cause problem, but rather works around it. Typically, the compromise is some cause of action between the real solution of constraint elimination, and conflicting policy of personality. This is an easy political choice than taking on the more difficult cause of both eliminating the real problem and handling the resulting political problem. (K. Sandrock, 1994:9). Having discussed Goldratt, the next impact point to the process would be to ensure that the management theories are synchronized with the system re-engineering.

2.11 Management Theories

As global competition heats up, the need to identify and implement strategies that yield competitive advantage increases. Managers are continually searching for the one perfect approach that will once and for all gain advantage over their competitors. Alas, there is no one perfect solution. Peter Drucker addressed the perfect solution myth:

> "For more than a century - from J.P. Morgan and John D. Rockefeller in the United States, Georg Siemens in Germany, Henri Fayol in France, through Alfred Sloan at GM, and up to the present infatuation with teams - we have been searching for the one right organization for our companies. There can no longer be any such thing. There will only be organizations - as different from one another as a petroleum refinery, a cathedral, and a suburban bungalow are from one another, even though all three are buildings.

> Every organization in the developed countries (and not only businesses) will have to be designed for a specific task, time and place (or culture)." (Drucker, 1964:24)

This quote identifies, describes and contrasts the popular management models, approaches and philosophies embraced by production and operations managers in the U.S. since the mid 1970s. These models, approaches and philosophies were adopted in an effort to gain competitive advantage. Economic Order Quantity (EOQ), Material Requirement Planning (MRP), and Material Requirement Planning II (MRP II) attacked the costs associated with raw materials, work-in-process and finished goods inventories. The success of Japanese competitors brought interest in the Just-In-Time philosophy. Interest in JIT was followed closely by Total Quality Management, Theory of Constraints and Time-Based Competition. Finally, the current focus on Supply Chain Management the most recent element. Each has proven valuable, but none has proved to be a panacea. Each focused the organization on a particular variable or set of variables that would lead to competitive advantage. All the models, approaches and philosophies are valid. The development and implementation of one does not invalidate the others but merely expands their value. (K. Sandrock, 1994:22).

2.11.1 EOQ, MRP and MRP II

In an effort to reduce average manufacturing costs, the manufacturing process was buffered by raw materials, work-in-process, and finished goods inventories. Inventory waste resulted from obsolescence and damage due to extended storage of raw materials, work-in-process and finished goods. The manufacturing process itself generated waste through scrap and rework.

Attempting to control finished goods inventory levels, manufacturers adopted the EOQ inventory model. The model proved appropriate for independent demand situations by balancing, ordering and setup costs. EOQ proved to be unsuitable for dependent demand environments, however. The adoption of EOQ reduced costs and waste associated with finished goods inventory. EOQ cannot be considered a full-blown Production and Operation Management (POM) philosophy, but rather a decision rule that applies only under very limited circumstances.

In response to the need for an inventory model that worked well in dependent demand environments, MRP was introduced in the early 1970s. MRP assisted with controlling work-in-process inventory costs as well as raw materials inventory costs and helped to reduce lead times. EOQ was incorporated into MRP systems and used to determine lot sizes. Successful MRP required precise bills of material and inventory information and was complicated to implement (Fogarty, Blackstone, Hoffman, 1991). The success of MRP and improvements in computer hardware and software technologies led to development of the more encompassing MRP II that integrated marketing and financial planning with production planning. MRP and MRP II served to attack Work- in-progress and finished goods inventories and effectively reduced lead times.

2.11.2 Just-In-Time

U.S. manufacturers discovered the JIT philosophy in the mid 1970s. They had used EOQ and developed MRP and MRP II to minimize inventories and lead times. There was a need, however, for a system that attacked waste throughout the manufacturing system. Toyoda and Ohno had developed such a system at Toyota Motor Company (Togo and Wartman, 1993).

Kiichiro Toyoda is attributed with originating the JIT philosophy as he prepared to manufacture automobiles at his new Koromo plant in 1938.

> "In [Kiichiros] operating factory he hung a sign that read: JUST IN TIME. What he meant, he told the workers, was that no component for a car should be produced before it was needed. Components should be made, therefore, just in time." (Tugo and Wartman, 1993: 79)

Taiichi Ohno began work for the Toyota Motor Company in 1943 and was charged with making the manufacturing processes efficient and adaptable. During the next thirty years Ohno worked to more fully develop and implement the JIT manufacturing system. By the mid 70s, Toyota’s success brought Ohno to the attention of U.S. manufacturers who saw the value of his JIT system and hoped to duplicate it (Ohno, 1988).

CHAPTER 2 – *Literature Review*

JIT is defined as the philosophy of eliminating waste in the total manufacturing process (Hay, 1988, 1). Organizations focused on elimination of waste to achieve competitive advantage (Vokurka and Davis, 1996).
Fogarty, Blackstone and Hoffman (1991) list the basic tenets of the JIT philosophy.

1. All waste should be eliminated
2. JIT is a never ending journey
3. Inventory is waste
4. Customers define quality
5. Manufacturing flexibility is essential
6. Mutual respect is a necessity
7. Team effort is required
8. Employees are sources of improvements

Vokurka and Davis offer evidence that through the implementation of JIT, U.S. manufacturers have significantly improved their inventory performance (1996, p. 57). The U.S. is currently in the seventh year of economic expansion. In past recoveries, inventories rose at a faster rate than sales. During this recovery the reverse is true (Vokurka and Davis, 1996, p.57). Further, they state that JIT has had a significant impact on smoothing the business cycle.

Inman and Mehra (1993) identify these benefits of JIT implementation.

1. Downtime reduction
2. Inventory reduction
3. Work space reduction
4. Increased quality
5. Increased labour utilization
6. Increased equipment utilization
7. Increased inventory turns

The benefits combine to reduce costs and increase service (Inman and Mehra, 1993), both of which can lead to competitive advantage. It should be noted that many of the tenets of JIT remain as components of TQM and TOC. The focus has been on gaining competitive advantage by striving to be the low cost provider of the manufactured service or product. Having looked at the Management Theories it is necessary to show how these theories blend into the implementation of Total Quality Management.

2.11.3 Total Quality Management

Dr. Deming's 1950-51 lectures on statistical quality control in Japan mark the beginnings of what we now call TQM philosophy (Nonaka, 1995). The focus in Japan expanded to include quality. The works of Deming, Juran, and Crosby became popular during the early 1980s in the United States, and TQM became the battle cry for competitive advantage (Juran, 1995). TQM combined a management philosophy with an established set of tools and techniques. Primarily TQM required a focus on the customer’s definition of quality, continuous improvement of the production process, and the use of statistical quality control techniques (Juran, 1995). Ahire lists ten constructs of TQM implementation (1996, 19).

1. Top management commitment
2. Customer focus
3. Supplier quality management
4. Design quality management
5. Benchmarking
6. Statistical Process Control (SPC) usage
7. Internal quality information usage
8. Employee involvement
9. Employee Training
10. Employee empowerment

Much of JIT has been incorporated in TQM. The beginnings of Statistical Controlling Methods can also be seen in the list of constructs. The importance of JIT did not fade but became an assumption. To be competitive, an organization had to minimize waste and produce a quality product at the same time. A primary focus on the quality variable through the implementation of TQM resulted secondarily in cost reductions. An important outcome of TQM was an increase in sales as customers began to recognize improved product and service quality. The follow paragraph will illustrate the total integration between Total Quality Management and the Theory of Constraints.

2.11.4 Theory of Constraints

Once competitors incorporated the double focus of waste and quality management, it was necessary to search elsewhere for advantage. TQM required continuous improvement. Goldratt's primary contribution with TOC was identifying where improvement efforts should be focused. Goldratt and Cox published *The Goal* in 1984 and shifted the focus to throughput management. While JIT proponents advocated dramatic reductions in all inventory levels, Goldratt recommended protecting constraints using inventory buffers and a drum-buffer-rope approach (Umble and Srikanth, 1990). Now managers had to effectively manage waste, quality and also identify and exploit constraints on the factory floor to improve throughput. Improved throughput would, for a time, generate a competitive advantage. Soon, however, competitors had also read *The Goal* and were as effectively identifying and exploiting constraints. The ultimate effect of implementation of TOC is an increase in throughput, which implies increased sales. (K. Sandrock, 1994:19).

2.11.5 The relationship between TQM, TOC, JIT and MRP

Each of the three major management movements of the eighties and nineties, Just-in-Time (JIT), Total-Quality-Management (TQM), and Theory of Constraints (TOC) and Manufacturing Resource Planning (MRP), claim to be the answer to solving existing management problems. The three are really different facets of the same management philosophy.

Deming demonstrates that a quality management philosophy rests on the use of the concept of system, systems thinking, process measurement, and a never-ending cycle of process improvement. TOC is actually a focus methodology for performance system thinking (using the concept of throughput rather than cost control) on the business entity as a whole, so as to focus on changes in constraints that are directly limiting better total-system throughput. JIT and MRP focus on the emphasis of waste reduction and resource scheduling is a specific application of TOC to one area of the business. Thus, JIT and

MRP are sub-sets or consequences of TOC that is itself a sub-set of TQM. (K. Sandrock, 1994:22).

2.12 Systems Thinking

Systems Thinking (ST) is emerging as a powerful and innovative philosophy for building a learning organization and for providing the necessary framework for managing complex business issues. The principles and tools of systems thinking are helping many organizations rethink their fundamental structures and practices.

ST helps us to see the wholes and interrelationships, allowing us to focus intelligently on complex patterns that are at work in our organizational systems. Through the framework of systems thinking we can see how our actions shape current reality, then look beyond the traditional boundaries, and examine systematic structures that are really shaping the business. In creating a learning organization, system thinking enhances both the quality of thinking and the quality of decision-making.

ST sounds complex, but it's really creating better, wiser solutions. It helps us recognise the basic forces working behind all activities, people, and problems, so that we are in a position to stop wasting time repeatedly trying to fix symptoms and instead get to the heart of the matter.

System thinkers are able to dramatically reduce their "busy work load" by identifying and taking the surprisingly few number of key actions that influence systematic forces, instead of fighting against them. Using this approach, persistent problems are addressed in new and effective ways. (K. Sandrock, 1994:1).

2.12.1 Impact of Systems Thinking on Organizational Change

Traditional approaches to organizational management have emphasised the analysis of individual problems and incremental change, but this will no longer suffice as companies continue to experience complex changes. It is becoming increasingly more difficult to see the consequences of our decisions and to learn from experience. Systems thinking has given companies a tool with which they can better cope with the constant change. It allows individuals to see processes over time and to break away from the assumption that have prevented lasting results. Systems' thinking is now being used in combination with other organizational change strategies (Gardner and Demello, 1993:18).

2.12.2 Reengineering of Organizational Changes

One such organizational change is often called reengineering. Reengineering is not simply an elimination process to gain productivity. Unlike downsizing and restructuring, reengineering requires a re-evaluation of assumptions and beliefs about process, systems, structure, people, culture, practices, and technologies. (Moravec, 1995: 15).

According to (Allee, 1995), rethinking of mental models requires a working knowledge of systems thinking. Reengineering always requires action at the systems level. It involves breaking own of a system that appears in many cases to be working just fine. For this reason, it is paramount that more than business processes be addressed. The whole socio-technical system or corporate culture must be considered, making it critical that all employees understand and use systems thinking methodologies. (K. Sandrock, 1994:3).

2.12.3 Integration for Organizational Change

Another type of change that organizations are undertaking is systems integration. It does not entail the revamping of every aspect of the company, but rather it " seek(s) to synchronize processes that share a natural relationship to a common goal". (Cavaleri and Fearon, 1994). Encouraging innovation in work processes is a central purpose of integrating systems. This work improvement strategy focuses on improving these relationships whether they are technical or human. Systems thinking must be employed to bring about this type of integration, because a point of reference for understanding interrelationships is needed.

Systems thinking involves, learning to learn which is called generative learning. This type of learning helps people to discover their own patterns of thinking, which inherently facilitates systems thinking. In turn, systems integration is aided, because employees can increase their ability to see new relationships (Cavaleri and Fearon, 1994)

Areas in need of systems integration may become apparent by using concurrent learning. This type of learning is similar to generative learning. Workers are encouraged to combine the actual work experience with learning to learn. They use systems thinking to view their work in terms of customer satisfaction and adding value to the organization, to see how their work is related to the work of other people in the organization, and to identify any patterns or relationships that were previously unnoticed.

Employees begin to understand how they are working and how other people or processes are influencing them. Through electronic communication individuals can express any unusual conditions that might warrant further attention. (Cavaleri and Fearon, 1994: 3-4).

2.13 Benchmarking

A planned approach to benchmarking is necessary to gain the full value of a time investment. The discussion of process benchmarking is structured using the six-step model presented as the plan, search, observe, analyse, adapt, and improve. The goal of the benchmarking project is to continuously improve a key business process with the objective of achieving customer satisfaction that exceeds the satisfaction delivered by your competitors. (Pycraft et al, 2001: 656)

1.1.1 Types of Benchmarking

There are many types of benchmarking (which are not necessarily mutually exclusive),

- **Internal benchmarking:** is a comparison between operations or parts of the operations, which are within the same total organization.
- **External benchmarking:** is a comparison between an operation and other operations, which are part of a different organization.
- **Non-competitive benchmarking:** is benchmarking against external organizations, which do not compete directly in the same market.
- **Competitive benchmarking:** is a comparison directly between competitors in the same or similar markets.
- **Performance benchmarking:** is a comparison between the levels of achieved in different operations.

- **Practice benchmarking:** is a comparison between an organization's operation practices, or ways of doing things, and those adopted by another operation. (Pycraft et al, 2001: 656-657)

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

Selltiz, Johoda, Deutsch and Cook, (1966) suggest that for any research to be purposeful, it should discover answers to the research question.

The literature review on plant optimisation and managing constraints dealt with in Chapter 2, presented a theoretical framework of the variables associated with bottlenecks and increased efficiencies. This chapter explains the research methodology/process that has been used in the empirical investigation of the plant optimisation and managing constraints.

3.2 Goals of the research

The overall goals of the research are to enable Ikhwezi Trucktech (ITT) to improve its production processes and effectively increase the plant efficiency. The method of eliminating the impact of constraints is closely tied with the methodology practised by Eliyahu Goldratt the period of the research from January 2004 to September 2004.

3.2.1 Objectives of the Research

- To improve the production process, with the aim of increasing the plant efficiency.
- To re-engineer the system design to maximize outputs.
- To eliminate constraints that limits the system from achieving its designed goals.
- To establish whether the plant size will be a limiting factor to the increase in production volume.
- To ensure that the on-time delivery to customers is maintained.

3.3 Research Process

The action research model will represent the method undertaken to conduct research at ITT. The model is divided into eight steps.

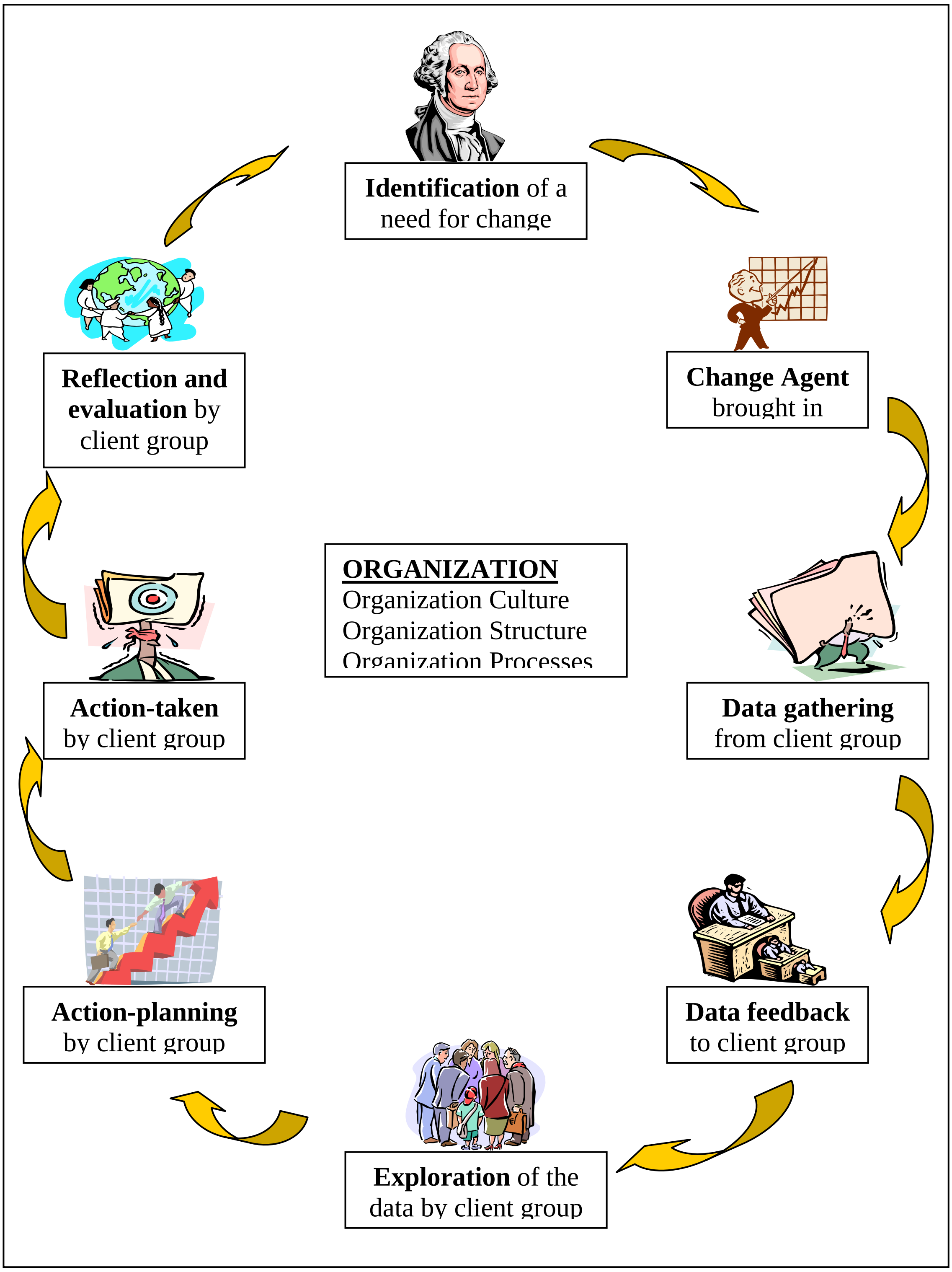


Figure 3.0 – The Organizational Development Cycle

3.3.1 Identification for a need for change

In October 2003 DCAG had approached ITT with a proposal to increase volumes in South Africa. At that stage of ITT's existence the organization was producing six units per day for which was seldom achieved. ITT had recognized the need for change to align itself with the expectation of increased volumes.

The organization had realized that in order to secure the potential growth of the organization, strategic planning had to be considered to optimise the production process to increase the efficiencies in maintaining the expected volumes.

3.3.2 Change Agent

The engineering department at ITT, was tasked with the responsibility of ensuring that the optimization process would be sustainable. Initially, ITT followed an extremely lean support structure within the engineering department. Additional manpower was employed to ensure that a dedicated person could be assigned the task of optimizing the plant efficiency and managing change within the organization.

3.3.3 Data gathering from client group

A purposive sample group was selected and interviews were conducted to allow for two-way communication between operators and management in an effort to create total organizational buy-in. Operators were given the opportunity to be active members in the change process, suggestions and ideas were analysed in group sessions eliciting operator interaction and brainstorming activities.

These suggestions were acknowledged and, together with theory surrounding optimisation processes and existing documentation at ITT, the best possible solution for the organization was determined.

Consultant industrial engineers were contracted to shed new light and assistance with change management. The reason for this consultation results from the lean structure at

ITT. The decision was made rather to employ professionals for the short term than to create employment inefficiency within the department.

Some of the immediate and common suggestion from the interviews were collected and addressed to ensure that the process of optimisation would consider the collective improvements of the organization as a integrative system. The table 3.0, is reflective of the common concerns highlighted during the pre-test interviews. The basis of this information, allowed the management at ITT a clear indication of "where" to start with the system improvement.

Pre-test interview										
Concerning Issues	**Hand tools**	**Air tools**	**Grading**	**Line supply**	**Manpower**	**Sub Assy**	**Quality**	**Facilities**	**Processes**	**Floaters**
Management (Janet)									X	
H Plant (Latuca)		X			X			X		
904 01 (Voeps)		X			X					
904 02 (Harry)	X								X	
904 03 (Makella)		X		X		X				
904 04 (Queens/Mba)	X	X			X					
904 05 (Ryan)	X	X		X	X					
904 06 (Ross)	X	X	X							
904 07 (Spider)	X	X				X				
904 08 (Tsaw/Jacs)	X						X			
Mervyn (Team manager)		X								X
905 10 (Mohammed)		X	X		X					
905 11 (Phumlani)	X	X			X					
905 12 (Ryan)		X	X			X				
905 13 (Benjamin)	X	X								
905 14 (Lance)		X	X	X		X				
905 15 (Shoota)			X		X					
905 16 (Pual)		X	X							
905 17 (Peter/ Daniel)							X			
Enerst Team manager		X								X

Table 3.1 – Finding from the Pre-Test interviews

3.3.4 Data feedback to client group

Continuous feedback loops were developed to allow 360-degree communication. This process proved to be a remarkable tool in aligning the organization goals and future objectives. It also created common understanding within the tasks teams and objectives were seen as short-term challenges.

The feedback was often attached to theory, specifically to the systems thinking methods of Goldratt and Sandrock. The most feasible option was then accepted by the team and implemented, monitored and measured. Management feedback meetings were scheduled, for the team to express their needs and concerns to improve assembly processes.

3.3.5 Exploration of the data by client group

The information received from the consultant engineers and the suggestions from the shop floor, together with the necessary theory pertaining to the optimisation process, were reviewed and analysed by the task teams to ensure that the best possible plan was actioned. Many of the initial implementations had to be altered to ensure continuous development and re-engineering of the systems design, but all changes were completely motivated and sanctioned by this task team.

3.3.6 Action-planning by client group

Clear objectives were set to ensure the group was guided by the criteria required for the increased volumes at ITT. It was important for the task team to understand the concepts of cycle time, takt time and line speed to be able to achieve the requirements set for the organization by DCAG. Therefore, the action taken had to incorporate the best possible solution through trial and error.

In the detail planning, the organizational infrastructure, jigs and tools were analysed and many changes were implemented to improve the situation. The task team had opportunities to shift boundaries and challenge fixed ideas. This was carefully implemented with constant reference to the necessary theory and past experiences at other manufacturing plants. Many of the ideas were benchmarked with the processes and changes at DCSA (Passenger vehicle assembly). The high level of synergy and motivation that exists between the task team was eventually cascaded throughout the organization and managing change became a “sheer pleasure”.

3.3.7 Action-taken by client group

The implementation of change had become a joint decision between the task team, the operators and the management at ITT. A platform was created where employees could freely suggest their ideas, be those ideas successful or not as this was viewed as a valuable

effort on the road to improving the plant efficiency. Employees were allowed to make mistakes in seeking the optimal solution to the perfect process flow.
It was also acknowledged through pre-test interviews that the employees viewed suggestion-making a threat to their job security and, at this stage of the research, it was clear that this mindset had been altered.

3.4 Reflection and evaluation by client group

The post-test interviews reflected positive feedback on the organizational changes and the working environment. Constant monitoring of the process layout and design is continuously being reviewed for improvement.

ITT has adopted the system of "Kaizan" incremental steps for continuous improvement. The system currently in operation at ITT has made it possible for the organization to meet with demands set by DCAG. It is also the understanding of the employees at ITT that through the system of "Kaizan" further improvement is possible.

During the post-test interviews the participants in the research were measured against their satisfaction level of the change process. The pre-test concerns were also incorporated into the overall satisfaction of the improvements. The suggestion of continued improvement and growth is highlighted in Chapter 7-Recommendations. The interviews of the post-test findings was measured on a Likett scale as shown in Table 3.1

Extremely Dissatisfied	Dissatisfied	Moderate	Satisfied	Extremely Satisfied
		1	8	11

Table 3.2 – satisfaction level of the sample group during post-test interviews

The results above reflects a positive employee satisfaction during the change process, the following chapters will indicate the method of sustainable and continuous improvements adopted

3.5 Selection of research method/instrument

The research was conducted within the critical theory paradigm. The method of this research was action research based. This paradigm is conducted with a view to finding a solution for a particular practical problem situation in a specific setting, Welman et al (2002, pp. 21).

The data gathered from this method will include both quantitative and qualitative methods, therefore a pre and post-test will be required to determine whether a satisfactory solution has been achieved. Interviews were conducted with the sample group, with the aim of encouraging the participants to express their production knowledge and experiences. This could lead to improving the overall efficiency of a particular area.

In applying the Theory of Constraints to an existing problem that is restricting the plant efficiency, the steps were as follows:

- Identifying the constraint.
- Appling the five-step procedure to the identified constraint.
- Consider and evaluate the pre-test interview findings, of the operator at the specific line station where the constraint is located.
- Review documentation of DCSA and ITT to assist with the evaluation of the constraint.
- Consider the benchmarking findings at DCSA, to re-engineer the systems design.
- A combination of these steps will lead to a suitable solution that will then be implemented.
- Post-test results will determine whether the solution can be considered an improvement or if further system design needs to be addressed.

DaimlerChrysler South Africa policy’s documentation on value drivers such as quality, cost, and on-time delivery, were analyzed to ensure that the customer satisfaction is maintained. This indicator determined whether the implemented process changes would improve or satisfy the promised delivery dates of commercial vehicles to the customer.

3.6 Population and sampling procedure

3.6.1 Interviews

A purposive sampling method was implemented to comprise the sample group, this group was interviewed for both the pre and post tests. One operator per line station together with the management team constituted the structure of the sample group. To maintain consistency throughout this process the same sample group was interviewed for the duration of the research.

The method of interviewing was conducted with selected operators and management to establish the initial problem areas, which constituted the pre-test findings. The post-test was conducted with the same sample group to determine whether the process improvements could be acknowledged. The final test would be to integrate the improvement strategies into outputs and ensure that these improvements are maintained in every value chain.

The Mercedes-Benz commercial vehicle production line comprises seventeen line stations. One operator per line station was interviewed for the duration of ten minutes. During this interview, the interviewee had the freedom to express areas of concern and suggested solutions to those problems. The operator also had the opportunity of expressing feasible methods of improving the efficiency of a particular line station. The understanding of this approach was to hone in on the knowledge base trapped within the operators. The assumption made at that point was that the operators at the various line stations, have the knowledge of how to best perform their tasks.

The quality inspectors on line contributed to the sample group. Their input, through interviews, was of importance in maintaining the quality standards of the past if improved changes were implemented.

3.6.2 Ethical considerations

The initial consideration was to address the organization as a whole, informing the total sample of this research proposal and method of sampling, to avoid creating a sense of discrimination. This also allowed for complete employee buy-in to the improvement strategies and planning.

A sample group was reflective of all race groups, eliminating any intention of racial discrimination in the group selection. This also contributed to total organizational buy-in.

3.6.3 Benchmarking (DCOM)

A benchmarking exercise was conducted which included DaimlerChrysler South Africa's C-Class production process. The purpose was to focus mainly on the logistical areas and process flow of material. Another area of DCSA that was considered is the DaimlerChrysler Operating Model (DCOM). This model was used to optimize both the process and the policy of the organization. The information gathered from these audits would be customized to suit the processes and policies at Ikhwezi Trucktech with the intention of increasing the plant efficiency and productivity.

Since the benchmarking was conducted with DCSA, ITT had contacted the Automotive Industry Development Center (AIDC) to implement the Tirisano shop floor improvement program. The Tirisano program is closely aligned with the DCOM fundamentals and serves to challenge operators to think "out of the box".

The second AIDC initiative is presently being adopted at ITT. The "cluster program" will allow the organization to engage in optimization strategy with the assistance of other organizations in a similar environment. The "cluster program" is designed for top management to align their thinking with the Tirisano philosophy, and to facilitate the change process.

3.7 The Emerging Operating Model of ITT

The information extracted from the action research model in figure 3.0 and the steps in applying the Theory of Constraints was instrumental in the development of the Operating Model. The combination of the elements in each of these criteria was incorporated into the design and implementation of the specialized model unique to the organization of Ikhwezi Truckteck (Pty)Ltd.

The following chapter will outline the detailed working of the Operating Model and the adaptation to the systems thinking methodology of Goldratt, Deming and Sandrock. The Operating Model is displayed in Figure 4.0, and the continuous improvement model is displayed in figure 4.1, which encompasses the Deming methodology of Plan, Do Check and Act, as part of the improved sustainability.

3.8 Summary

The task of optimization is a logical process, but importantly, it is the incremental continuous improvements that lead to major impact and eventually contributed to the difference from “ordinary to exceptional”.

The following chapter will indicate a uniquely developed Operating Model, but most significantly, the method that ITT adopted to extract the relevant information to ensure the improvement of the plant efficiency.

CHAPTER 4 – Operating Model

4.1 Introduction

Figure 4.0, is the operating model which was designed to incorporate a diverse dimension in problem solving and bottleneck / constraint unraveling. The primary function of the model is to draw information from different sectors of the organization, with an attempt to find a workable solution that would increase production efficiencies and organizational outputs.

In order to achieve a workable solution, the model requires the use of many different factors that may influence or contribute to the problem. One of the factors that is considered in reaching a workable solution is the **theory of constraints**. This adds the theoretical framework by which problems or constraints can be dissolved. When developing this model an assumption was made, that the operator at a particular area of production, will best understand a workable solution for the constraint area. This understanding is to try and extract the tacit knowledge that lies within the operator. Another area that was important to the development of Ikhwezi Trucktech, was the factor of **benchmarking** and **documentation analysis** of both DaimlerChrysler South Africa and existing documentation at Ikhwezi Trucktech. Ikhwezi Trucktech considered the implementation of the DaimlerChrysler Operating Model (DCOM) as part of their benchmarking exercise, to maintain conformance with practices at a DaimlerChrysler Corporate Level.

Documentation analysis is viewed as being a critical part to improving the productivity of commercial vehicles in South Africa. This factor will also prove to be important when implementing sustainability programs based on the current DaimlerChrysler Operating Model.

The intention of this model is to add equal weighting of contributions towards obtaining a workable solution. A deduction can be made, that if these factors are integrated into the decision making process, a workable solution will definitely be achieved. With the progress of sustainability being built into the decision making process, corporate buy-in will form a fundamental element to the "soul" of the model.

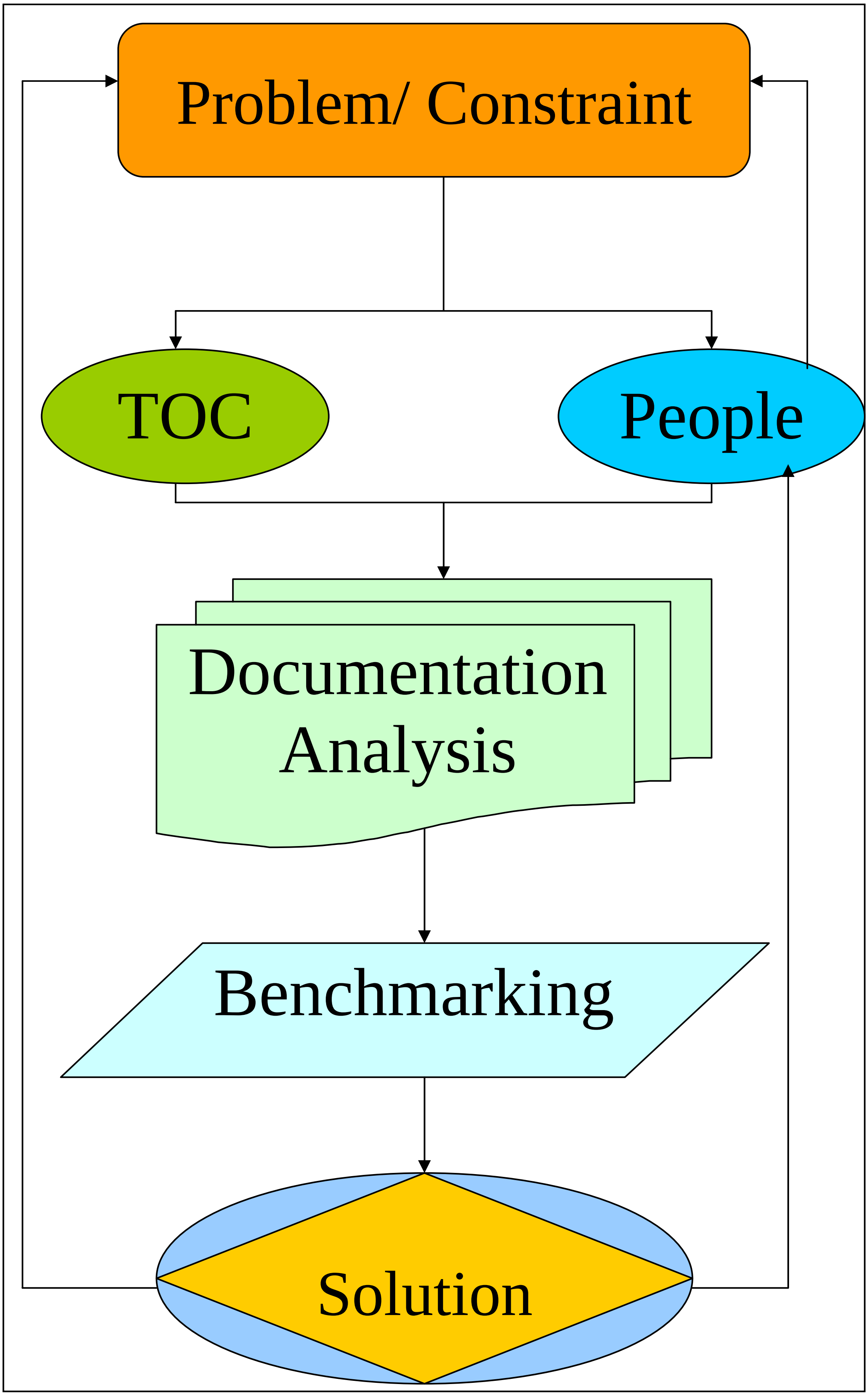


Figure 4.0 – Operating Model for Decision Making

4.2 Problem/Constraint

The problem or the constraint is, determined by the area of the production plant that is the least productive. Productivity can be affected by a host of factors such as, absenteeism, punctuality, logistic systems, tools, facilities and the working environment.

Logistical systems such as material resource planning (MRP) and just-in-time (JIT), are systems that were developed to ensure that the customer demands could be achieved by reducing all inventory stock to a minimum. Therefore, production is directly driven by the demand to achieve on time delivery to the customer. When a constraint becomes realized, the repercussions directly impacts on the daily production thus affecting the production targets and ultimately contributing to a delay in the service delivery to the customer.

If a constraint develops within the production plant or within systems leading towards the production lines, this problem can have a negative impact on on-time delivery. In the case of Ikhwezi Trucktech, on-time delivery is determined within a four-day window period. These four days are determined from the moment the unit enters into the production plant or assembly hall, until final sign out.

Ikhwezi Trucktech will be penalized if a unit exceeds this four-day window period and also be penalized if the units are dispatched within the four days. The unit can only be dispatched on the promised date, which is determined by the customer (DCSA). These penalty clauses can affect the bottom line of the organization, and therefore it is of utmost importance that constraints within the system are immediately resolved or managed correctly to reduce the risk of “being late”.

The intention of this exercise is to determine the constraints area within the production process until the final stage where the unit is signed out to the customer. It is also acknowledged that not all constraints can be solved, but in some cases constraints need to be managed correctly to ensure production efficiencies are maintained. The advantage of managing a constraint will allow the constraint to be stagnant in one area of the production process, rather than having the constraint moved throughout the plant.

4.3 Theory of constraints

The first factor that will contribute in analyzing the constraint is the theoretical framework of the TOC. The five-step approach (as discussed in Chapter 2- Literature Review), will provide the necessary structure and logical approach in determining root cause analysis to solving constraints.

"Every manager is overwhelmed with problems, or as some would call it opportunities" (Goldratt, 1990:15). We often tend to focus on problems that can be solved or the most obvious problems, but this is not necessarily focusing on the problem that should be corrected. Thus, if the idea of continuous improvement needs realization then the starting point should be, "What to change to?". It is important to establish, from the outset, the core of the problems. Such problems are those, that when solved, will have major positive spin-off to increasing productivity. This is more effective than drifting between small problems that have minimal impact to productivity and major contribution to time wasting.

The next step, once the core problem has been identified, is to determine, "What to change to". It is important to clarify this point, alternatively the identification of core problems can lead to chaos and panic. However the construction of simple and practical solutions will help to ease this uncertain state. "In today's world, where almost everybody is fascinated by the notion of sophistication, this ability to generate simple solutions is relatively rare" (Goldratt, 1990:7). History has demonstrated, that complicated solutions don't work but simple one's might. When the solution is known, and only then, is the most difficult question faced, "How to cause the change?"

These three stages, combined with the five-step procedure to problem solving, will be used extensively in this model to overcome constraint barriers. The demand posed on the organization for 2004, will require that all the constraints be eliminated or managed effectively to sustain growth and profitability for Ikhwezi Trucktech, in the long term.

4.4 People in the organization

Due to constant change in the business environment, companies need to change their structures, processes and their people's capabilities. None of the other factors can change before the people on the shop floor change. Such a change should ideally be led by a change from top management. Sometimes change is as a result of a burning platform (urgent need), but to change proactively is always a more desirable approach.

This model will try to extract, the tacit knowledge trapped within the operators at a specific line station. The operators will be given the opportunity of adding to the change process to optimize the productivity. Tacit knowledge is, knowledge acquired by the operator through experience and time. The operating model will allow the operator freedom to add value to constraint areas by drawing information based on experience. During this phase the operator will be interviewed to elicit a contribution to the problem prior to change. The decision-making process and implementation, concerning the constraint will be conducted in team format. **It is important to note that the people of an organization are central to the success, profitability and sustainability of that organization.**

The next step would be to plan for the change, and to create short term wins. That would mean that an action plan is drawn up for the division or department, and timeframes are assigned to the tasks of the action plan. It is an important motivational strategy to celebrate the progress of the action plan, but victory should not be declared too soon, as it may hamper further development, as staff may relax their efforts in the face of the victory.

The change that happens within the department must not be done in pockets of isolation, but the change should ideally be anchored in the change of the organization's culture. Both the leadership of the organization, as well as the external environment affects the organizational culture. The way the leaders, including the leaders of the department, handle change can determine whether it will be successful transition or not. It should be remembered that an organization is about the **"people, people, people".**

4.5 Documentation Analysis

Documentation analysis will provide an important source of the data-gathering program, to ensure that the change can be implemented in relation to previous similar situations. The source will also offer guidelines that could be followed in trying to integrate change with new concept introduction.

The understanding of work content times, takt times, cycle times and employee loading will reflect the line balance, and the efficiency that the change can contribute to the overall productivity. These efficiencies are pertinent when determining the final cost to manufacture or assemble a unit within the production plant. Documentation analysis will provide insight into determining realistic targets for production on a daily basis, which will also allow manpower calculation and quality specifications to be achieved.

The implementation of change can be aligned with the holistic corporate culture when compared with previous planning and controlling systems.

4.6 Benchmarking

Benchmarking exercises were conducted which included DaimlerChrysler South Africa's, C-Class production process. The purpose was to focus mainly on the logistical areas and process flow of material.

Another area of DCSA that was considered is the DaimlerChrysler Operating Model (DCOM). This model is used to optimize both the process and the policy of the organization. The information gathered from these audits would be customized to suit the processes and policies at Ikhwezi Trucktech with the intention of increasing the plant efficiency and productivity. The exercise will contribute to the sustainability of processes, policies and new change development, which will be measurable to the employees at Ikhwezi Trucktech.

In June 2004, the management of Ikhwezi Trucktech decided after benchmarking the organization with DCSA's, DCOM structure, to have the similar fundamentals to DCOM implemented at Ikhwezi Trucktech. The Automotive Industry Development Center (AIDC) was approached to lead change and implementation at Ikhwezi Trucktech with the introduction of the Tirisano Shop floor Improvement program. The program shared the common building blocks as seen within the DaimlerChrysler Operating Model. To ensure success of the program, total organizational buy-in was required at all levels of management, labour unions, and work force. The agreement had to be signed between these parties to affirm their commitment to the program.

The concern from the trade unions was that if shop floor improvements were successful, this should not lead to the retrenchment of staff. Management at Ikhwezi Trucktech had to re-assure all the relevant parties, including AIDC, that all improvements would be viewed as a contribution to improved efficiencies but would not lead to retrenchments. Instead, the additional staff would be relocated to different areas of the plant, were increased volumes are also expected, for example the new introduction of the Mitsubishi FUSO which is due for launch in January 2005. The union, at this point, agreed to the program and AIDC was given complete support.

The model below highlights, the building blocks in striving towards continuous improvement to quality, cost and on-time delivery for the customers. The model also focuses strongly on the Deming model of Plan, Do, Check and Act, to ensure that the continuous improvements are measured and set targets are reached. This cyclical nature of the model, allows for the continuous improvement to be challenged and new targets to emerge.

A cross-function core team was selected and a model area was ear marked for the initial improvement plan and the learning points to be implemented. The team consisted of eight members, which were representative of the demographics of the organization. The core team would undergo an intensive learning experience of the different building blocks of the model. The plan for the team in the future, will be to roll-out the Tirisano philosophy to the different departments at Ikhwezi Trucktech, this process could lead to the development of a new department similar to DCSA structure, to allow for continuous improvement and process efficiency are maintained. The core team will become empowered to lead change within the organization to ensure sustainability, growth and profitability.

4.6.1 The Temple of Improvement

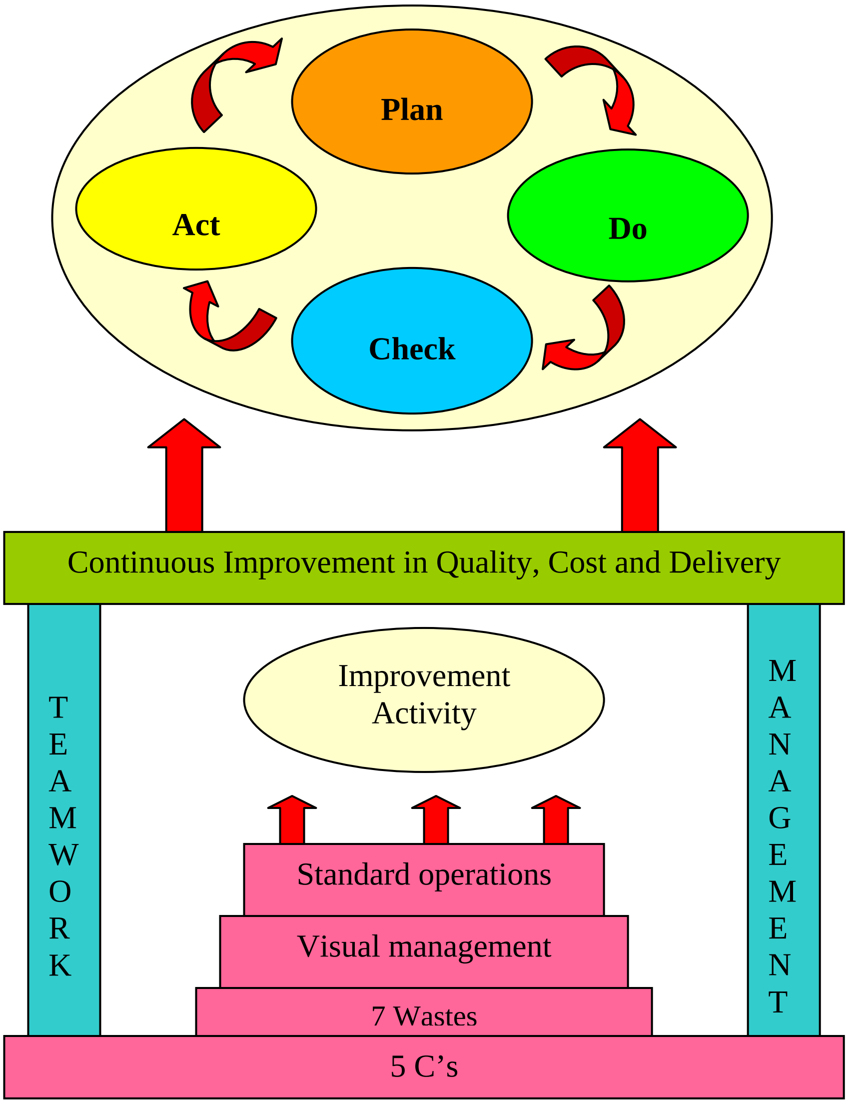


Figure 4.1 – The Tirisano model of Continuous improvement.

The Temple of Improvement shows the four building blocks with the direct support from management and teamwork, to contribute to the achievement of quality, cost and on-time delivery. The model incorporates Deming's model of PDCA, to create the continuous cyclical movement of the improvement.

The 5 C's are represented by five words starting with the letter C, to guide understanding of the process of improvement. The 5C's are as follows:

- **Clear out**: to remove all fixtures from the model area, to allow for identification of defects and to challenge all fixed ideas.
- **Clean and check**: allow for fixtures destined to the model area to be clean and checked for defects, or whether maintenance is required.
- **Configure**: allow for the remodeling of the work area, and to challenge fixed ideas, to optimize the efficiency of the work area.
- **Conformity**: to be guided by current protocol within the manufacturing industry and to abide within the safety and quality standards.
- **Custom and practice**: to ensure that the changes are measured as an improvement to the process of increasing the efficiency of the work area.

The 7 Wastes: these are 7 ways in which production can become inefficient, if the following wasteful factors are overlooked.

- **Over production**
  - Creates a space problem.
  - Leads to damages of sub-assemblies and parts.
  - Increase in operator motion, to locate additional space.

- **Inventory**
  - Over-delivery of stock from the supplier
  - Too many incomplete parts between process (work in progress)
  - The storage of the finished products

- **Transportation**
  - Unnecessary handling of parts.
  - Double handling of parts
  - Empty handling equipment, (forklift carrying no parts)

- **Bad quality**
  - The production of incomplete work
  - Reworking or repairing the unit after the assembly process

- **Idle time**
    - The operator is waiting to perform a task
    - The equipment is awaiting an operator
    - The operator loading is not balanced to the cycle time
    - To many operators working at the same time, restricting the process efficiency

- **Process**
    - Doing more work that is requires,(excessive set-up time or trying to locate parts that are incorrectly locate to the production area.)

- **Operator motion**
    - Eliminating unnecessary walking, bending, turning and reaching for parts to perform a specific task.

Visual management and standard operations: These techniques need to be coupled with the 7 wastes and the 5C’s (where all debris and unnecessary items are removed and every tool has a clearly marked storage place visible from the work area) to status indicators (often in the form of shadow boards), and from clearly posted, up-to-date standards work charts to displays of key measurables and financial information on the cost of the process. The precise technique will vary with the application, but the key principle does not: everyone involved must be able to see and must understand every aspect of the operation and its status at all times

4.7 Solution

The combination of these factors, the Theory of Constraints, People (tacit knowledge), documentation analysis and Benchmarking will afford Ikhwezi Trucktech the opportunity to reach a workable solution to problems or areas of restriction to production. These decisions would be derived through the implementation of task teams and constant interaction between the management and employees.

The important mind-set is to consider all the available suggestions and as a task team decide on the option that has most merit, in increasing the productivity of the plant. A complete organizational buy-in will ensure that constraints/bottlenecks are addressed with the urgency it requires, to convert wasted time and necessary non-value added time to value added time that can be measurable.

4.8 Summary

The operating model forms the framework by with process constraints can be illuminated in an efficient and effective way. The Model have allowed Ikhwezi Truchtech, the opportunity of systematically analyzing a constraint or problem without neglecting the important stakeholders involved in the process.

The detailed methodology required to understanding the effectiveness of the model, is in progress of being transferred to the workforce through training programs, dedicated specifically to the development of the organization through continuous learning

CHAPTER 5 – RESULTS AND ANALYSIS OF RESULTS

5.1 Introduction

Under the MIDP (Motor Industry Development Program), South African manufacturers and suppliers are increasingly exposed to global market pressures. This forces them to continuously improve their business processes and strategically design and implement processes to improve product quality, reduce costs and enhance delivery performance. These improvements can only be achieved through strategic planning and innovative thinking.

The Engineering Department was approached to address the needs of the organization, with an objective to contribute to the establishment of a viable South African automotive industry, which is competitive locally and internationally.

This chapter, firstly, analyses the current situation around Mercedes-Benz Commercial vehicles (MBCV), with regards to the takt time, cycle time studies of operations per workstations and observed areas of waste. Secondly, it illustrates the line balance for (MBCV) using the work content time per operation and required manpower. Thirdly, it addresses the line supply issue at (MBCV) highlighting a number of improvement requirements.

It is important to understand that the scope of the thesis was to achieve a 30% to 40%, increase in the plant efficiency in maximizing the processes and procedures to truck assembly at Ikhwezi Trucktech. This milestone had been achieved within the second month of conducting this research (April 2004).

This increase in productivity had allowed for further growth for the organization. DaimlerChrysler Germany (DCAG) decided to utilize the opportunity in South Africa, by increasing production volumes to an expected 280 units per month by August 2004. In comparison with 2003 for the same period, 120 units were scheduled for production. This resulted in an increase of production output of 133% when compared with the same period for 2003. This chapter will reflect the results, and calculations to ensure that this increase in production could be sustainable for the organization.

5.2 The Past Production Process – (March 2002-December 2003)

The Mercedes-Benz commercial vehicles are assembled on a highly technologically advanced production line. This system was designed and developed by DaimlerChrysler South Africa (DCSA), but with the formation of Ikhwezi Truchtech (ITT) as a Black Economic Empowerment (BEE) organizational wing of DCSA, the existing premises to assemble these vehicles were leased to ITT.

The conveyor system currently available at ITT operates with a variable speed setting, which can be altered to control the takt times or cycle times of assembly. During the initial period of ITT's existence, the conveyor system was not used for this purpose. Instead, the assembly process was extremely manual and labour intensive. The units were physically pushed along the production line from one workstation to the next, until the unit was completed and eventually signed out to the customer.

From March 2002 until December 2003, the production volumes at ITT were established at 6 units per day, and maybe for this reason, no fixed takt times, cycle times, work content times or line balancing of employee loading were established. With the relatively low volumes, the above factors were ignored, provided that the unit volumes were achieved from production. This was also not sustainable, as production targets were not always achieved on monthly bases as shown in Chapter 1 (graph 1.0).

The situation was tolerable in maintaining the on-time delivery to the customer. DCSA also made an adjustment to their efficiency of 90% for ITT to achieve on-time delivery. This was to compensate for any wrongly supplied parts from Germany or parts that were not supplied at all, which are termed short supplied. The lead-time, for the subsequent delivery to arrive in South Africa was approximately two weeks, and hence the reason for the 10% adjustment to the on-time delivery. Therefore, if ITT produced 90% of their planned production per month, this was considered as 100% of the on-time delivery expected by DCSA.

In the next phase of ITT's existence, adapting to the increase in production volume would prove to be crucial for future growth and sustainability of the organization. The integration of all systems will prove to be the "big test".

5.3 The Present Production Process – (January 2004 – September 2004)

January 2004 saw ITT take quantum leaps into systems thinking and process re-engineering. The integration of theoretical research and corporate buy-in into challenging the fixed methods of production allowed for this speedy transition to improve plant efficiency and increased volume capacity.

The organization has moved away from a “push system” of production to a “pull system”. The units are now fixed to the production line at predetermined spacing, dependant on the work content of the unit. This also allows for actual takt times to be determined, ensuring that the daily production target can be achieved at a constant line speed. The move to pinning the units at set intervals assisted in reducing the ergonomics of the employees from physically pushing the units between workstations, thus creating additional time for actual production.

Time studies were the primary step in establishing the work content and the overall cycle time required to assemble the finished products. Due to the variation in the model mix, the number of employees, was determined by using the total cycle time of the highest work content unit. Coupled to this factor was the customers demand or daily target, to ensure that the correct takt time would be achieved at the correct line speed. The procedure involved studying the working content time for each model, then allocating the manpower requirement per workstation for the highest work content time for a specific model at that workstation.

The process sustainability was the next logical step. This was achieved by studying the employee loading to ensure that all the necessary documentation, tooling requirements and process sheets were in place, so that the operators could comfortably build the product “first time right”. This process also allowed for the work loading per station to be shared equally by the operators at a specific line station.

5.4 The Crown and Pinion of the Present Production Process

5.4.1 Cycle Time

The cycle time of a product layout is the time for completed products to emerge from the operation. Cycle time is a vital factor in the design of the product layout and has a significant influence on most of the other detailed design decisions. It is calculated by considering the likely demand for the product over a period and the amount of production time available in that period (Pycraft: 244).

The cycle times at ITT, had to be calculated using three different models. The primary reason for this decision was to establish an accurate understanding of the concepts of value adding, non-value adding and waste time, of each of the models. The Actros (2648ls/33) and Axor (1835LS/3) had the highest work content per station. Therefore the assumption was to allocate the manpower as per the highest work content. The Atego (1017/48) was included as the lowest work content unit, to establish the idle time per line station due to the decrease to the operator loading per station. This measure would indicate the degree of inefficiency that the lower work content units would contribute to the product system.

The nature of the production plant, due to a facility constraint, is that all models pertaining with Mercedes-Benz commercial vehicles are assembled on one production line. The model mix between Actros and Atego are vastly different and, ideally, separate production lines would be recommended, but this is not the case as business decisions are calculated on efficiencies and not “best fit”. Certainly, if volumes of the lower work content units were to increase to profitable levels then this option will be considered to separate the model on independent production lines.

Presently, the line speed of the production process is governed by the cycle times of the highest work content units. The Table below will reflect the cycle time of the various models used in the research, with the actual work content time per line station.

Overall Work Content Time on 2640-48LS/33					
Avg. units per shift: 1		Avg. available minutes: 444 min			
Station No.	**Operation Description**	**VA (min)**	**NNVA (min)**	**Waste (min)**	**Cycle time(min)**
Down- Leg					
H-plant	Chassis Preparation	71.39	90.94	31.71	194.04
904 01	Bracketry & Valves	150.35	37.48	0.00	187.83
904 02	Electrical Harness & Air Piping	266.39	7.91	0.00	274.30
904 03	Steering Box & Battery Box	72.59	4.65	0.00	77.24
904 04	Frt. & rear springs, Stabilizers, Contr. arms	37.29	7.88	0.00	45.17
904 05	Rear Axle, Rear Shocks	95.54	8.15	0.00	103.69
904 06	Front Axle, Front shocks	36.36	9.33	0.00	45.69
904 07	Drive Shaft, Sensor, Compressor pipes	40.67	2.50	0.00	43.17
904 08	Quality inspection & Rectification	0.00	0.00	0.00	0.00
904 09	Turn over	0.00	24.43	0.00	24.43
Up- Leg					
905 10	Rear axle piping, Fuel tank, Engine drop	176.93	8.21	0.00	185.14
905 11	Radiator, Silencer	45.07	1.50	0.00	46.57
905 12	Cab cross member	85.60	2.98	0.00	88.58
905 13	Cab drop	42.70	16.46	0.00	59.16
905 14	Cab trim	179.16	31.50	3.54	214.20
905 15	Wet Bay	28.26	0.00	2.50	30.76
905 16	Tyre Bay	51.93	17.81	0.00	69.74
905 17	O Inspection, Rectification, Programming	43.91	0.00	0.00	43.91
	VALUE ADDED (VA)	1424.12			
	NECESSARY NON-VALUE ADDED (NNVA)		271.72		
	WASTE (W)			37.75	
	OVERALL CYCLE TIME	1733.59			

Total VA (min)	**Total NNVA (min)**	**Total Waste(min)**
1424.12	271.72	37.75

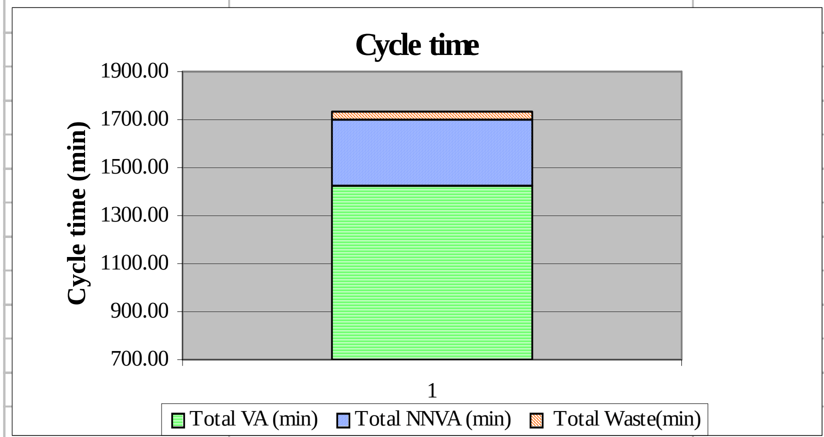


Table 5.1 – the WCT of the Actros 2648LS/33

Overall Work Content Time on 1835-40LS/33

Avg. units per shift: 1 | Avg. available minutes: 444 min

Station No.	Operation Description	VA (min)	NNVA (min)	Waste (min)	Cycle time (min)
Down-Leg					
H-plant	Chassis Preparation	31.20	0.00	0.00	31.20
904 01	Bracketry & Valves	108.64	24.53	0.23	133.40
904 02	Electrical Harness & Air Piping	251.13	7.02	0.00	258.15
904 03	Steering Box & Battery Box	78.65	13.25	8.31	100.21
904 04	Frt. & rear springs, Stabilisers, Contr. arms	36.26	6.64	0.00	42.90
904 05	Rear Axle, Rear Shocks	38.83	5.92	0.38	45.13
904 06	Front Axle, Front shocks	29.54	9.09	0.00	38.63
904 07	Drive Shaft, Sensor, Compressor pipes	16.69	3.02	0.00	19.71
904 08	Quality inspection & Rectification	0.00	0.00	0.00	0.00
904 09	Turn over	9.97	22.49	0.00	32.46
Up-Leg					
905 10	Rear axle piping, Fuel tank, Engine drop	196.26	18.89	13.85	229.00
905 11	Radiator, Silencer	81.53	5.59	6.29	93.41
905 12	Cab cross member	34.65	4.75	1.97	41.37
905 13	Cab drop	38.62	20.23	1.80	60.65
905 14	Cab trim	188.99	19.61	8.71	217.31
905 15	Wet Bay	19.52	2.38	0.00	21.90
905 16	Tyre Bay	44.31	17.61	0.00	61.92
905 17	Q inspection,Rectification, Programming	29.77	5.34	1.53	36.64
	VALUE ADDED (VA)	**1234.56**			
	NECESSARY NON-VALUE ADDED (NNVA)		**186.36**		
	WASTE (W)			**43.07**	
	OVERALL CYCLE TIME	**1463.99**			

Total VA (min)	Total NNVA (min)	Total Waste(min)
1234.56	**186.36**	**43.07**

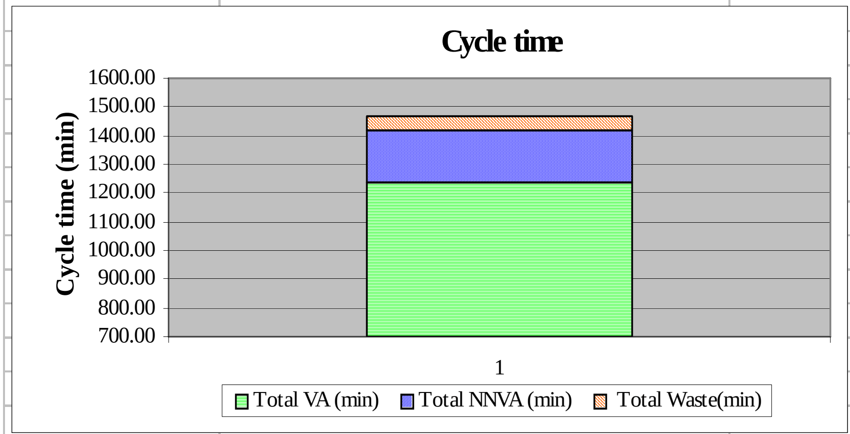


Table 5.2 –the WCT of the Axor 1835LS/36

Overall Work content Time on 1017/48					
Avg. units per shift: 1		Avg. available minutes: 444 min			
Station No.	**Operation Description**	**VA (min)**	**NNVA (min)**	**Waste (min)**	**Cycle time**
Down- Leg					
H-plant	Chassis Preparation	0	20.29	0	20.29
904 01	Bracketry & Valves	126.27	8.14	0	134.41
904 02	Electrical Harness & Air Piping	207.58	0	0	207.58
904 03	Steering Box & Battery Box	26.4	27.55	0	53.95
		18.25	24.22	0	42.47
904 04	Frt. & rear springs, Stabilizers, Contr. arms	35.83	13.98	0	49.81
904 05	Rear Axle, Rear Shocks	42.3	0	0	42.3
904 06	Front Axle, Front shocks	26.9	0	0	26.9
904 07	Drive Shaft, Sensor, Compressor pipes	32.94	0	0	32.94
904 08	Quality inspection & Rectification	0	0	0	0
904 09	Turn over	0	33.02	0	0
Up - Leg					
905 10	Rear axle piping, Fuel tank, Engine drop	168.64	6.04	0	174.5
905 11	Radiator, Silencer	19.85	14.87	0	34.72
905 12	Cab cross member	43.48	0	0	43.48
905 13	Cab drop	125.59	0	0	125.59
905 14	Cab trim	192.99	12.15	0	205.14
905 15	Wet Bay	32.67	0	0	32.67
905 16	Tyre Bay	68.13	0	0	68.13
905 17	Q inspection,Rectification, Programming	19.27	6	0	25.27
	VALUE ADDED (VA)	**1187.09**			
	NECESSARY NON-VALUE ADDED (NNVA)		**166.26**		
	WASTE (W)			**0.00**	
	OVERALL CYCLE TIME	**1353.35**			

Total VA (min)	**Total NNVA (min)**	**Total Waste(min)**
1187.09	**166.26**	**0.00**

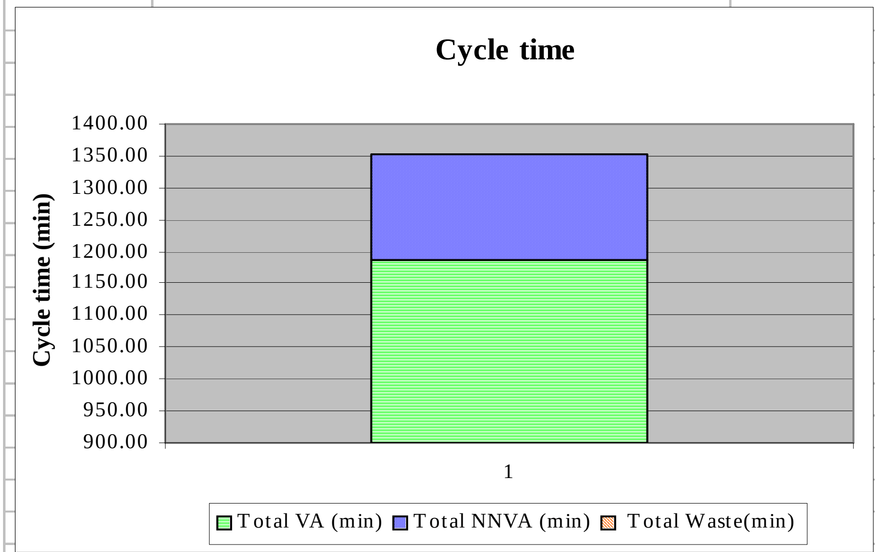


Table 5.3 – the WCT of the 1017/48

5.4.2 Takt Times Calculation

Takt time is the fundamental concept dealing with regular, uniform rate of progression of products through various stages. Takt time is most simply the average rate at which customers buy products and hence the rate at which products should be manufactured. It is calculated as follows:

$$\text{Takt time} = \frac{Available time}{Customer\ demand}$$

Current customer demand as of September 2004 was 14 trucks per day or 63 trucks per week. The available working time (minutes) according to Ikhwezi's working time model is given below:

(Refer to Appendix 1 for the detail working time model at ITT)

Monday	=	510
Tuesday	=	510
Wednesday	=	480
Thursday	=	510
Friday	=	210
Summation	=	2220
Average	=	444 (equal to summation / 63)

Since the available working times differ (and in particular Friday), it makes sense to say that the weekly demand relates to a weekly available time (= 2220 minutes) and hence an average takt time of 444 minutes. If one considers what should be assembled on a daily basis, the content will differ. One has to take the ratio of time for a specific day to the average takt time. Therefore:

Monday	=	510/35.24= 14.47 units per day
Tuesday	=	510/35.24= 14.47 units per day
Wednesday	=	480/35.24= 13.62 units per day
Thursday	=	510/35.24= 14.47 units per day
Friday	=	210/35.24= 5.96 units per day
Summation	=	2220/35.24= 63 units per week

On a daily basis, with customers demand equal to 14 units, the takt is simply the available working time divided by the customers demand, but on a weekly basis, the takt is 2220 minutes with an average daily takt of 35.24 minutes. To keep to customer demand on a weekly basis, refer to the units per day calculated above. This is the amount that has to be assembled on a daily basis to reach weekly demand.

At the initial stage of the optimisation strategy, major down time had been recorded due to mechanical failure of the production lines. (Refer to Appendix 2 for the history of the down time report measured from April 2004 to August 2004). ITT had no option but to include a factor into the calculation to allow for down time and to still achieve production targets. ITT initially allowed for 100 minutes down time per day for various inefficiencies that may have occurred, then gradually reducing the down time to an acceptable 50 minutes per day. This inefficiency would result in the re-calculation of the takt time. Therefore the available time was reduced to accommodate for the down time factor:

Monday	=	510-50 = 460
Tuesday	=	510-50 = 460
Wednesday	=	480-50 = 430
Thursday	=	510-50 = 460
Friday	=	210-50 =160
Summation	=	1970
Average	=	444 (equal to summation / 63)

Allowable down time = 250 minutes

Then: the takt time was reduced to:

$$\text{Takt time} = \frac{\text{Available time-allowable downtime}}{\text{Customers demand}}$$

The current customer demand is 14 trucks per day or 63 trucks per week. This demand still needed to be achieved with a reduction in the available time.

Monday	=	460/31.27= 14.71 units per day
Tuesday	=	460/31.27= 14.71 units per day
Wednesday	=	430/31.27= 13.75 units per day
Thursday	=	460/31.27= 14.71 units per day
Friday	=	160/31.27= 5.11 units per day
Summation	=	1970/31.27= 63 units per week

The downtime averaged at being 50 minutes per day, but effectively the days with the higher available time were allowed the even proportion of the total allowable down time per week. It is important to note that the highest work content units was determined from the information conducted by an external team of Professional Industrial Engineers, hired at ITT to perform time studies on the Mercedes-Benz production line, for the entire model range.

The information used in the calculations, re-assured that the Actros (model 2648LS/33), had the highest work content or longest cycle time in the production process. This information could be used to a certain extent of the results, as the Axor (model 1835LS/36), had reflected a work content time (WCT) that was higher than that of the Actros at certain line stations, and the Atego range had proven to have a lower WCT, when compared with the Actros or Axor model ranges. Therefore, the decision was taken for this reason, that the manpower per station will be determined at the highest WCT for any model at a specific station. (Refer to Table 5.1, Table 5.2 and Table5.3 above)

To explain and understand the code that is reflected along side each model.
E.g. 2648 LS 33, **26** refers to the gross vehicle weight, **48** indicates the horse power of the truck at 480 hp (power of the engine), **L –** refers to the air suspension, **S –** shows the type of truck (truck tractor) and **33** refers to the wheelbase as 3.3 metres.

Therefore, from the explanation above, the wheelbases between models were determined as being a major variable when considering the rate of rotation of the production line, to make certain that a constant takt time could be achieved. The variables established as being key in ensuring that the customers demands were achieved, are as follows

- **Line speed –** to ensure a constant takt time is maintained.
- **Wheelbase –** this impacted directly on the takt time, longer wheelbases had longer cycle times on line.
- **Work content time –** the allocation of the manpower for the lower work content units.
- **Unit spacing –** this refers to the gaps between the units on line, to ensure that the work content can be completed at the allocated takt times.
- **Line balancing** – ensures that the operator loading at each line station was balanced to the takt time at that station.

5.4.3 Manpower Requirements

The current customer demand equates to 14 units per day or 63 units per week. Current direct labour amounts to 70 operators. Based on the information highlighted in 5.4.1, and the current demand, it is necessary to identify the actual manpower required, to maintain an efficient production plant. The calculation will reflect the maximum number of operators to assemble the highest work content unit at the prescribed takt time of 31.27 minutes.

The cycle time of the Actros (2648LS/33) will be used in the majority of the calculations, as this unit has the highest work content time illustrated from the time studies (see Appendix 3). The cycle time of 1733.59 would be considered for the manpower calculation. This includes value adding, necessary non-value adding and waste of all operations to assemble a unit.

5.4.4 Effective available time

The effective time available between 70 operators to assemble one truck is:

Effective available time = (no of operators) x takt time
= 70 x 31.27
= 2188.9 minutes

Therefore, theoretically, the number of operators actually required on the line is:

$$\textbf{Theoretical No of operators} = \left(\frac{\text{Time to assemble one truck}}{\text{Effective available time}}\right) \text{x current no of operators}$$

= [1733.59/2188.9] x 70

=55.44 operators

However, practically an efficiency factor should be incorporated. 80% efficiency is assumed based on DaimlerChrysler corporate norm. The calculation will not be accurate; if the operators were to be evaluated at 100% efficiency this is not practical.

Therefore:

Actual No of operators = Theoretical No of operators/ efficiency factor

= 55.44 / 0.8

= 69.3 operators

This is significantly aligned with the requirements from the production line, which indicates a high level of efficiency. The manpower calculation reflects, a balance of work content required to assemble the highest work content unit, at the takt time needed to satisfy the customer's demands.

5.5 Work content study

The work content time refers to the actual time required to perform a specific operation, at each line station that contributes to the process of continuous assembly. The individual time for each line station is recorded, to determine the actual total cycle time of the unit. The work content is useful in establishing the line balance per line station, to equitably balance the employee loading or the redistribution of the workload to maintain a constant takt time at each working station. (Refer to Appendices 3,4,5 for the actual time study report generated for the Actros, Axor and Atego respectively).

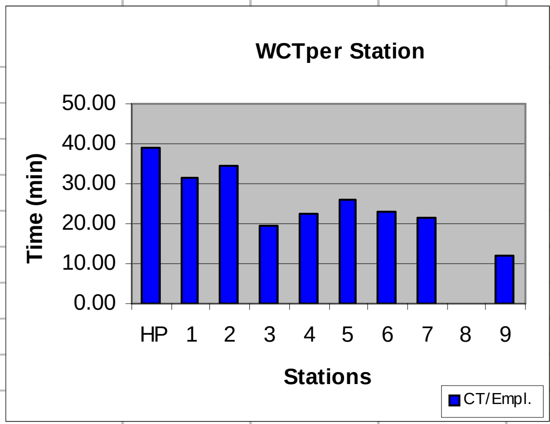
The main focus of the work content times is used to optimise the production process. This is determined by analysing and maximising the value added time, reducing the non-value adding time and eliminating all wasteful activities. The combination of these factors will allow for a fluent approach to systems and process design. The analysis of the work content time is the initial stage in achieving the required line balances to optimise any process successfully. It serves as almost a guiding point, in illustrating the direction to follow.

When work content times are correctly analysed the spin-offs are directly related to improved efficiencies. It also allows for the identification of problem areas and, where process reengineering needs to be addressed. It is a fundamental step that is vital to ensure that the overall process development is successfully introduced. The information below will indicate how the work content studies at ITT were used to obtain increased efficiencies within the production area.

5.5.1 Analysis of the Work Content Time for Actros

WCT/ Station 2648LS/33

Down - Leg	No. of Empl.	Cycle time(min)	CT/Empl.
HP	5	194.04	38.81
1	6	187.83	31.30
2	8	274.30	34.29
3	4	77.24	19.31
4	2	45.17	22.58
5	4	103.69	25.92
6	2	45.69	22.84
7	2	43.17	21.59
8	2	0.00	0.00
9	2	24.43	12.22



Up - Leg	No. of Empl.	Cycle time(min)	CT/Empl.
10	10	185.14	18.51
11	2	46.57	23.29
12	3	88.58	29.53
13	3	59.16	19.72
14	10	214.20	21.42
15	1	30.76	30.76
16	3	69.74	23.25
17	2	43.91	21.96

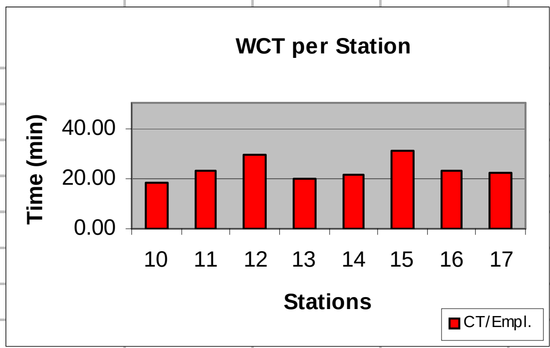


Table 5.4 – the WCT per station of the Actros 2648 LS/33

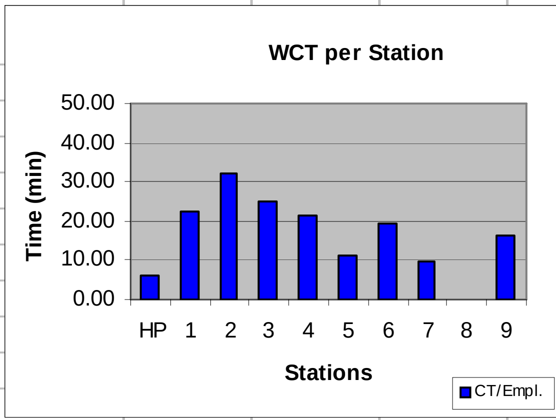
The work content time for the Actros was shown to have the highest cycle time. Initially the manpower requirements for the plant were determined using these times. The cycle time divided by the number of employees will indicate the takt time allowed at each line station. It is understandable that the takt time was established as 31.27 minutes to ensure that the customer's demand of 63 units is achieved per week.

It is evident that in station HP, station 1 and 2, the takt times have exceeded the allowable time of 31.27 minutes. It is for this reason that when the higher work content units are in production, the manpower from areas of lower work content are moved to areas where the work content requires additional labour. ITT's contingency plan for this shortcoming was to multi-skill and to provide training for individuals that were highlighted as being exceptional operators. These positions were termed "the floaters".

5.5.2 Analysis of the Work Content Time for Axor

WCT/ Station 1835LS/36

Down - Leg	No. of Empl.	Cycle time(min)	CT/Empl.
HP	5	31.20	6.24
1	6	133.40	22.23
2	8	258.15	32.27
3	4	100.21	25.05
4	2	42.90	21.45
5	4	45.13	11.28
6	2	38.63	19.32
7	2	19.71	9.86
8	2	0.00	0.00
9	2	32.46	16.23



Up - Leg	No. of Empl.	Cycle time(min)	CT/Empl.
10	10	229.00	22.90
11	2	93.41	46.71
12	3	41.37	13.79
13	3	60.65	20.22
14	10	217.31	21.73
15	1	21.90	21.90
16	3	61.92	20.64
17	1	36.64	36.64

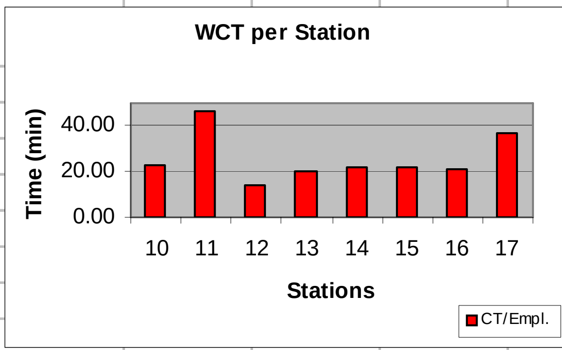


Table 5.5 – the WCT per station of the Axor 1835LS/36

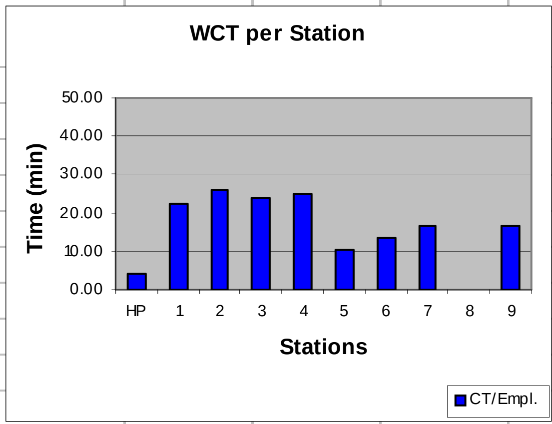
Work content time for the Axor reflects that at certain line stations the takt times are higher than that of the Actros. The management at ITT decided that highest work content for each line station would be considered when finalizing the manpower. Therefore, in the event of the higher work content times shown for Axor, the manpower requirements were then based on these takt times.

The imbalances of the work content time between models creates extreme difficulty in optimising the employee loading per station due to the model mix. Therefore, the understanding is acceptable that during high work content production the employee loading would be maximized, and when low work content units enter into production the inefficiency in manpower loading can be absorbed due to the low volumes. It is also important to note that the employee loading is determined at an 80% efficiency rate, so when low volume units are experienced this can be considered as a “recovery period”.

5.5.3 Analysis of the Work Content Time for Atego

WCT/ Station 1017/48

Down - Leg	No. of Empl.	Cycle time(min)	CT/Empl.
HP	5	20.29	4.06
1	6	134.41	22.40
2	8	207.58	25.95
3	4	96.42	24.11
4	2	49.81	24.91
5	4	42.30	10.58
6	2	26.90	13.45
7	2	32.94	16.47
8	2	0.00	0.00
9	2	33.02	16.51
Up - Leg	**No. of Empl.**	**Cycle time(min)**	**CT/Empl.**
10	10	174.68	17.47
11	2	34.72	17.36
12	3	43.48	14.49
13	3	125.59	41.86
14	10	205.14	20.51
15	1	32.67	32.67
16	3	68.13	22.71
17	1	25.27	25.27



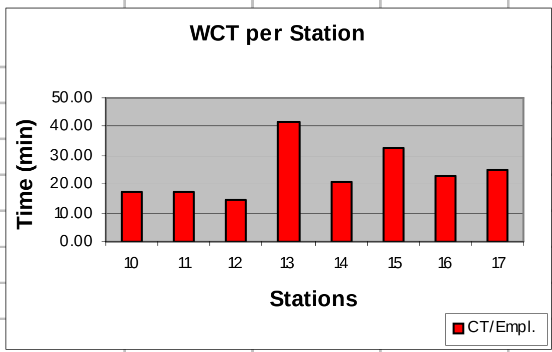


Table 5.6 – the WCT per station of the Atego 1017/48

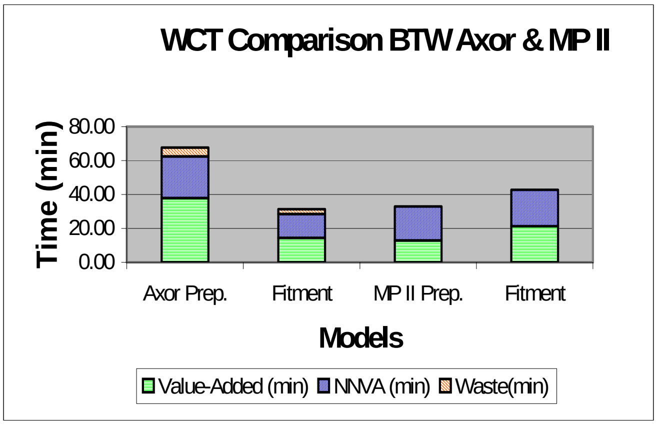
The work content time of the Atego as shown above is considerably lower than both the Actros and Axor models. When considering the WCT at station 13 for which the takt time is shown to be 41.86, the contingency plan is to utilize the additional labour on line by strategically moving the manpower from line stations to assist with the increased workload.

In the tables shown above, station 8 is shown as having no work content time, although two operators are allocated to this work station .The primary function at station 8 serves as a quality buy-off point and all checks and rectifications are performed to ensure the unit meets with its quality standards specified by engineering documentation. Therefore, the ratio between manpower to the work content for the Atego range has overall efficiency of 61%, compared with Actros and Axor at 80% efficiency.

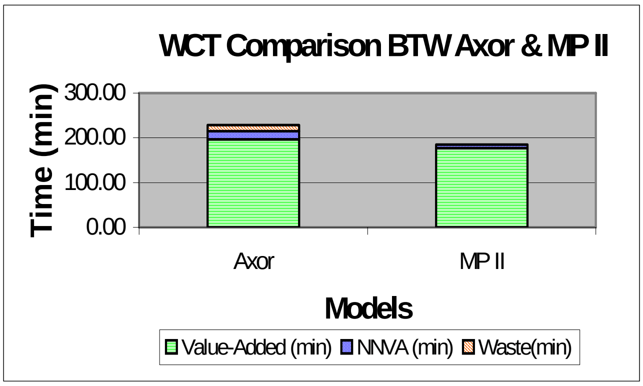
5.5.4 Comparison of the WCT between Axor and Actros

Comparison of the WCT Between Axor & Actros

904 03	Value-Added (min)	NNVA (min)	Waste (min)	Cycle time (min)
Axor Prep.	37.81	24.64	5.31	67.76
Fitment	14.37	14.00	3.00	31.37
MP II Prep.	12.86	20.00	0.00	32.86
Fitment	21.29	21.32	0.00	42.61
Comments:				



905 10	Value-Added (min)	NNVA (min)	Waste (min)	Cycle time (min)
Axor	196.26	18.89	13.85	229.00
MP II	176.93	8.21	0.00	185.14
Comments:				



905 11	Value-Added (min)	NNVA (min)	Waste (min)	Cycle time (min)
Axor	81.53	5.59	6.29	93.41
MP II	45.07	1.50	0.00	46.57
Comments:				

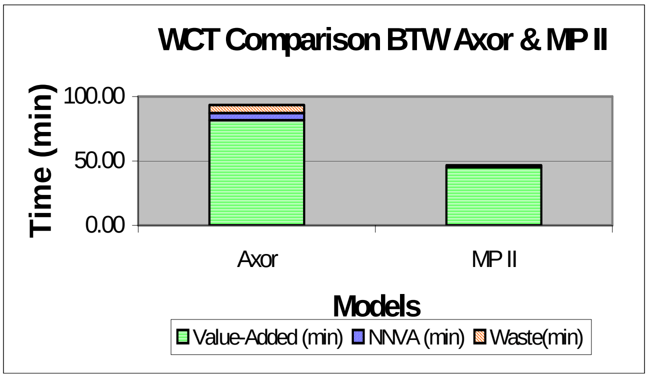


Table 5.7 – the WCT difference between Axor and Actros

For these workstations, the Axor WCT is shown as being higher than that of the Actros and therefore the manpower requirements at these line stations would be dependent on the WCT for the Axor.

Manpower = WCT per station / takt time.

5.6 Employee Loading

The employee loading was only considered for the Actros 2648LS/48, as this unit has the overall highest work content per station. In determining the employee loading the actual functions per line station had to be measured as per activity per individual. The results shown in appendix 6, indicates the value added, non-value added and wasteful activities that each operator contributes to the overall cycle time.

When optimizational processes are conducted, the ideal is to eliminate the wasteful activities and minimize the non-value added times, thus maximizing the value added time for each activity per station. Value added time refers to the activity that contributes to the value of the unit. Non-value added refers to activities that need to take place before the value added phase, (e.g. all sub assemblies will be considered as non-value added but all fitments of parts will be considered as value added time). Wasteful activities refer to the idle time that a operator has apart from performing the activities required at that line station (e.g. smoke breaks, extended tea breaks, etc).

The employee loading at each station had to be considered as independent cells – each workstation would be viewed as a single cell. The analysis of each station had to be calculated to ensure that the loading of each operator was below the takt time of 31.27 minutes. In the case of station 90401 and station 90402, it is evident that some operators will be experiencing excessive work loading. It is for this reason that multi-skilled operators (floaters) were introduced to the production area to assist these line stations of higher work content times in reducing the overall employee loading to a calculation within the boundaries of the allowable takt time.

The actual times recorded therefore reflect a takt time above the allowable standard for operations. The introduction of floaters has proven to beneficial in assisting with bottleneck areas or constraint areas within the production process. It has been evident that during the production of high content units and with the strategic management of the floaters, constraint areas were diluted. The work content times reflected in appendices 6, incorporates the production process from chassis assembly until final sign off from the mechanical line. (See Appendix 7 for the detail layout of the production area being measured).

5.7 The Balancing Techniques

With other basic layout types, there are a number of techniques available to help in the line-balancing task. Again, in practice, the most useful and most used techniques are the simple heuristic approaches. Foremost amongst the latter is the precedence diagram. The precedence diagram is the representation of the ordering of the elements, which comprises the total work content of the product. A circle represents each element. The circles are connected by arrows, which signify the ordering of the element or order at which each activity is conducted in sequence of events that contributes to the assembly of the final product (Pycraft, 2001:247).

The general approach is to calculate elements from the precedence diagram to the first line station, starting from the left in order of the columns until the work allocated to the line station is as close to, but less than the takt time. When that line station has reached its work capacity without exceeding the cycle time the technique is to move to the next line station until all the work elements are allocated. The key issue is how to select an element to be allocated to a line station, when more than one element could be chosen. Two heuristic rules have been found to be particularly useful in assisting with this decision.

- Simply choose the largest element, which will fit into the time remaining in that line station.
- Choose the element with the most "followers", that is the highest number of elements, which can only be allocated when that element has been allocated.

(Refer to Appendix 8 – for the detailed workings of the precedence diagram from H-plant (chassis assembly) to station 90517).

The precedence diagram together with the employee loading per line station would be the direct contributor in assisting with the line balance per station. The evidence of the calculations from appendix 7& 8 will assist in determining the line stations that would require additional manpower to ensure that the available time needed to perform the specialized task would be below the cycle time at that station. This information would also indicate the utilization of floaters to strategically align the higher work content stations to be within the allowable takt time of 31.27 minutes. The Actros 2648LS/33 has the highest work content time and therefore, by planning for the worst case scenario in the production process, this will ensure that the majority of the different models would conform to the required takt time of 31.27 minutes.

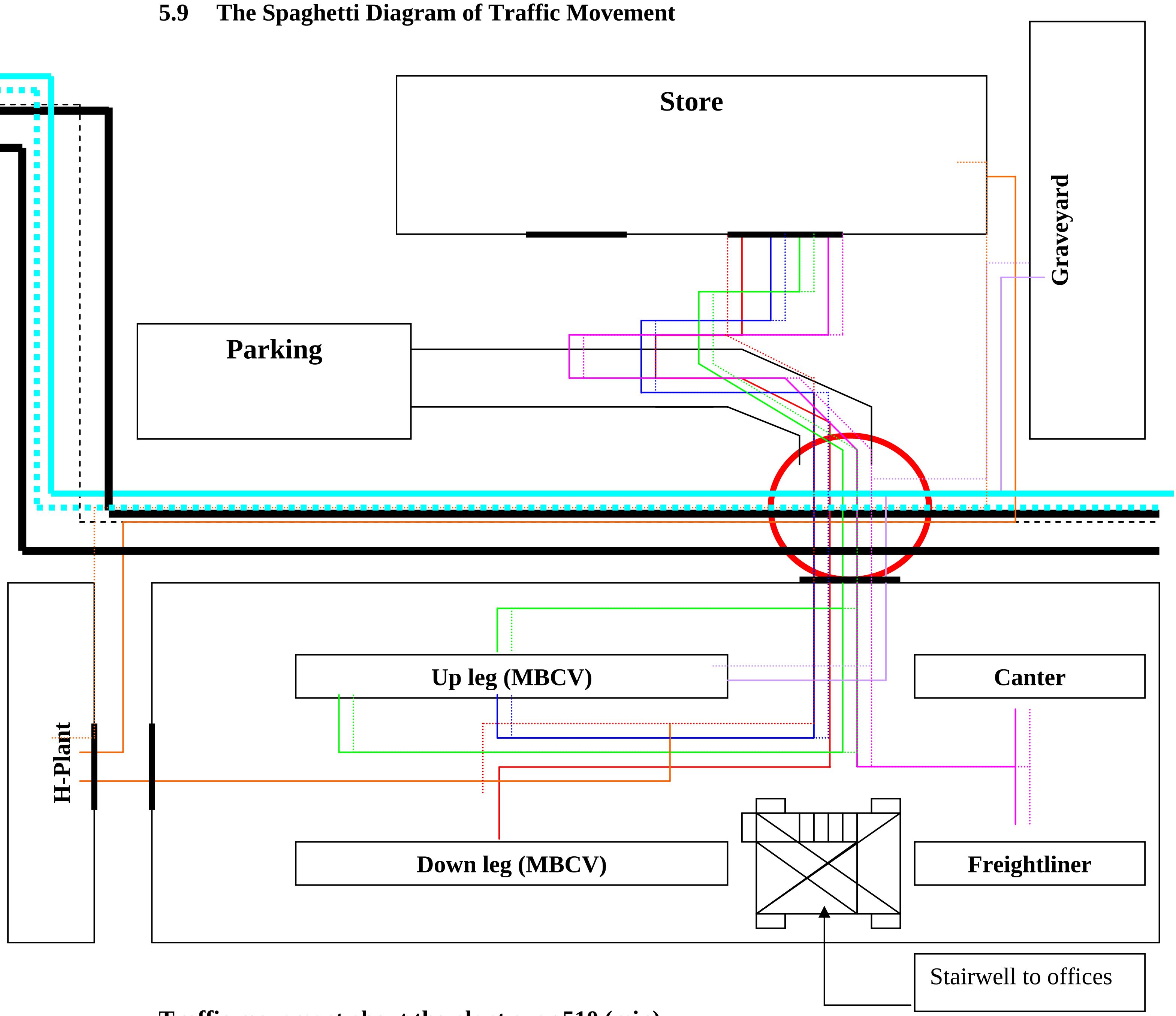
5.8 Line Speed

The last and final phase of this process is to ensure that a constant line speed is achieved in maintaining the customer's demand. Appendix 9 will reflect the ramp-up phases of the speed of the production line in assuring that the customer's demands are achieved.

At ITT, the conveyor speed is measured in Hertz (Hz). To achieve 14 units off-line per day the requirement was to obtain a line speed of 2.18 meters per minute. At this line speed, a factor of allowable downtime was also included to achieve a takt time of 31.27 minutes. Appendix 9 will also reflect the number of units that can be achieved at different line speeds, ranging from 50Hz to 63Hz.

The calculation will also reflect the different models that were timed and the average takt times for those models. Another factor that had proven to be extremely important was the wheelbases, which varied between the models. It can be observed that the highest work content units had the shorter wheelbases and the lower work content units had the longer wheelbases. Therefore, the spacing between the units (gaps), of the lower work content unit were smaller and the higher work content units had larger unit spacing to ensure that the takt times per unit could average at 31.27 minutes.

5.9 The Spaghetti Diagram of Traffic Movement



Traffic movement about the plant over 510 (min)_

	Solid line (in)	Dash line (Out)	Total No. (in-plant)	Total No (out-of-plant)
Forklift D-leg			62	61
Forklift U-leg			28	28
Forklift Cab & engine			34	34
Forklift Chassis			19	19
Forklift FL			11	11
Units offline				14
General flow of traffic			187	187

5.10 Forklift Traffic

The table above reflects the forklift traffic from the unboxing area to the production line, and the number of movements through the constraint area, highlighted by the red circle on the diagram.

It is important to note that the movement between the unboxing area and the production line is approximately 300 metres, with the total forklift movement for 269 complete trips between the two departments. Therefore the total distance travelled by forklift traffic is eighty-one kilometres per production day.

When the production plant was optimised to achieve the increased volumes as required by the customer, an interesting discovery unfolded. The forklift traffic had become a critical part of the calculation, in ensuring that the unboxed parts were delivered to the production areas just-in time. It was then evident that the number of forklifts had to be increased, and the workload per forklift driver had to be divided to accommodate for the increase in the production volumes. New forklift routes were also mapped, to redirect the traffic away from the constraint area. This initiative resolved the bottleneck area, thus resulting in an increase to the production flow and supply to the assembly process.

The spaghetti diagram also indicated to the management of ITT that, due to the increase in the production volumes, the plant size was soon becoming a limiting factor. Many external factors contributed in motivating the increase to the parking spacing available to units that were completed and awaiting despatch to the customer. Additional parking areas had to allocated for units that were incomplete due to the wrong or short supply of parts from Germany, and, with the increase in production volumes, the parking area was quickly depleted. This also created loads of uncertainty in determining the completed units from those that were incomplete and awaiting parts.

The motivation at this point had become defined, in approaching DCSA to increase the yard spacing for vehicle parking and the unboxing area for container de-stuffing, purely based on the reasons of increased production volumes. The request had also motivated for two separate parking areas for completed or despatched units and incomplete or "graveyard" units.

5.11 Logistic Flow

5.11.1 Orders and Shipment

In the past, monthly orders were placed at DCAG (Woerth plant) by DCSA Marketing division, based on the production capacity at ITT. The ordering procedure was altered and the orders were broken into weekly orders' quantities, matched to ITT's weekly capacity, rather than a complete month's order. An optimal model mix of the Mercedes-Benz commercial vehicles is ordered and approved by the ITT logistics department before the official order is generated

ITT's production methodology is to maintain a "smoothed production", avoiding short time where possible. ITT tried to establish this by introducing weekly ordering in time buckets in line with its capacity.

The confirmed order is returned to DCSA Marketing and ITT, with a desired pack date or final inspection date. The pack date enables easier production planning at the ITT plant. The DCAG plant confirms the order three months prior to the date in which the order is shipped to South Africa. The confirmed orders give suppliers a three months' lead-time in which to supply components Just-In-Time to the production line.

The introduction of a new reporting tool, the "Expected Receipts Report"(ERR), gives an easier view of the monthly arrivals by model. The report takes the monthly orders/packs and allocates the units to transport vessels based on a planned shipping schedule, made available by the DC-contracted shipping lines. The accuracy of the ERR is measured, and the suppliers will be compensated for inaccuracies resulting in poor forecasting – customer's cash flow is not affected as a result of obsolete or non availability of stock.

The purpose of matching the order to ITT's capacity ensures a smooth production flow and reduces inefficiency through the production process.

A three months' lead-time allows sufficient reaction time from the ITT plant to meet any additional requirements in terms of increased capital investment, additional manpower and training.

Shipping volumes are known well in advance. Each vessel has a twenty-one day cycle time. Shipping notification is sent to ITT once the vessel has sailed, confirming the volume of units per vessel. The units are then scheduled or sequenced to the production line.

5.12 Production sequencing

DCAG monthly packs run in sequential order, one pack month must be built out before the next. A later pack month will contain advancements in the design and technical documentation. It is important to coordinate this when units from two different pack months arrive on one vessel.

Better scheduling improves the ability to meet the customer demands, it reduces stock holding of inventory and reduces the work in progress. ITT has reduced its stock holding cost by introducing one centralised supplier that coordinates the complete stock logistics function. Potential risks are taken away from ITT, enabling the plant to focus on its primary objective; “production of a world-class product”.

A weekly sequence meeting is held to ensure transparency among the key players in the production process. The team consists of the representatives from a cross-section of team managers, process engineers and production planning. The weekly discussion promotes teamwork and creates a platform for suggestions.

5.12.1 Sequencing units takes a number of factors into account:

- Priority units that are already sold and allocated to customers
- New engineering changes which require changes in work content and new models which require verification of new local parts fitted and training
- The model-mix, e.g. separating units that are too similar, to avoid fitment errors from the production area.
- Container packing – DCAG packs units in commission ranges of 4 units and units are matched to container numbers on a vessel ensuring easier unboxing
- Supplier capacities and constraints
- The number of units per vessel
- Plant capacity in each area i.e. unboxing, production lines and Final Inspection and Vehicle Preparation centre (VPC) – by considering the work content per model and the available Takt times
- Public holidays and external factors affecting the normal shift pattern

Once the vessel has sailed, the shipping department conducts the monitoring of the vessel. Notification will be communicated to the ITT plant if there are delays or early arrivals of the vessel.

Each ‘leg’ in the production process at ITT has a planned start and end date. These achieved milestones are measured against the plan at each point. The delivery date to customer is set per shipment of units and is referred to as the Promise Date.

There is a freeze point once the schedule is determined and the promise date is set. There can be no changes made to the schedule, except under extreme conditions.

5.13 Production Planning

Where targets are set, the measurement should be achieved. For both dwell time and on-time delivery to be met, the supply from Germany must be kept in line with the targets set. ITT introduced a monthly measurement on DCAG, to show the status of their supply to South Africa.

Table 5.8 shows how the supply from Germany has improved since the measurement was introduced, thus contributing to the increased efficiency of the plant overall. Each component supply problem is given an error code e.g.
1 = wrong supply from Germany
2 = short supply from Germany (not supplied at all)
3 = received defective or damaged from Germany

By recording the fault the quality inspectors are all aware of the supply constraint and there is increased urgency to order the defective part, because the supply has a direct impact on the delivery to customer. Each employee has an incentive based portion of their annual remuneration package, which is governed by on-time delivery, cost and quality targets.

Supply problems are recorded throughout the production line and written up against a unit number. All problems pertaining to a unit will be written on the job card. The month's units are tallied up and recorded as a percentage of the total units coming off the production line.

5.14 Supply from DCAG

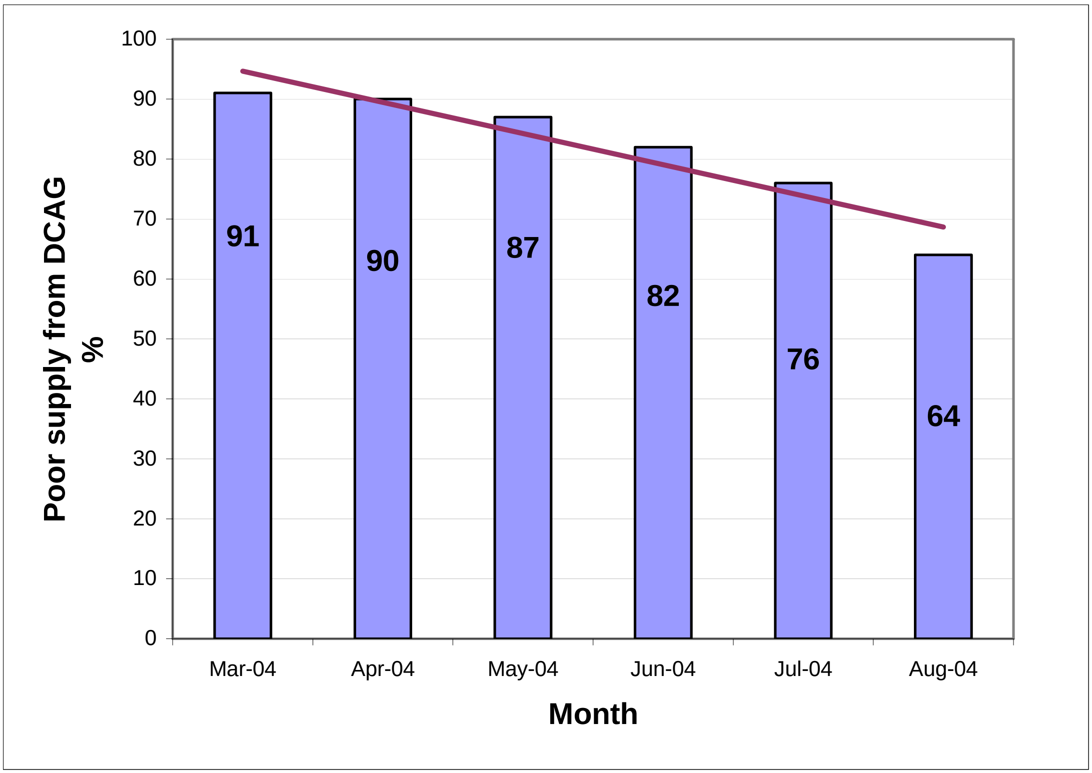


Table 5.8 –the poor supply from DCAG

This analysis has been conducted since March 2004. However, since there is a 3 month lead time from the units being packed in Germany, to being produced in South Africa, the response time for improved results will only became apparent in May 2004.

The detailed analysis is sent to the German plant, showing the type of poor supply and the affected parts by part number. From this, DCAG could isolate the problem areas on their production system and allow for preventative measures to assist in accurate supply.

The improvement in the supply chain from DCAG, is evident in the dwell time of containers at the unboxing stage. In the past, more containers were called into ITT sooner than required, to ‘rob’ from to compensate for the poor supply from Germany. With a more accurate supply from Germany there is less need to “rob” containers for missing or defective parts and this contributes positively to the overall turnaround time of a unit and essentially reduces the risk of delays in delivery to customer.

By coding faults on the production line, these faults can be seen as internal assembly faults such as poor workmanship. Poor workmanship refers to any fault resulting directly from incomplete assembly of the unit whilst in production (e.g. parts lost in plant, parts damaged in plant). These faults are also represented as a percentage of the month's units that leave the production line with defects. Monthly reporting is conducted to inform the different department of the impact that poor workmanship contributes to the overall on-time delivery of units to the customer.

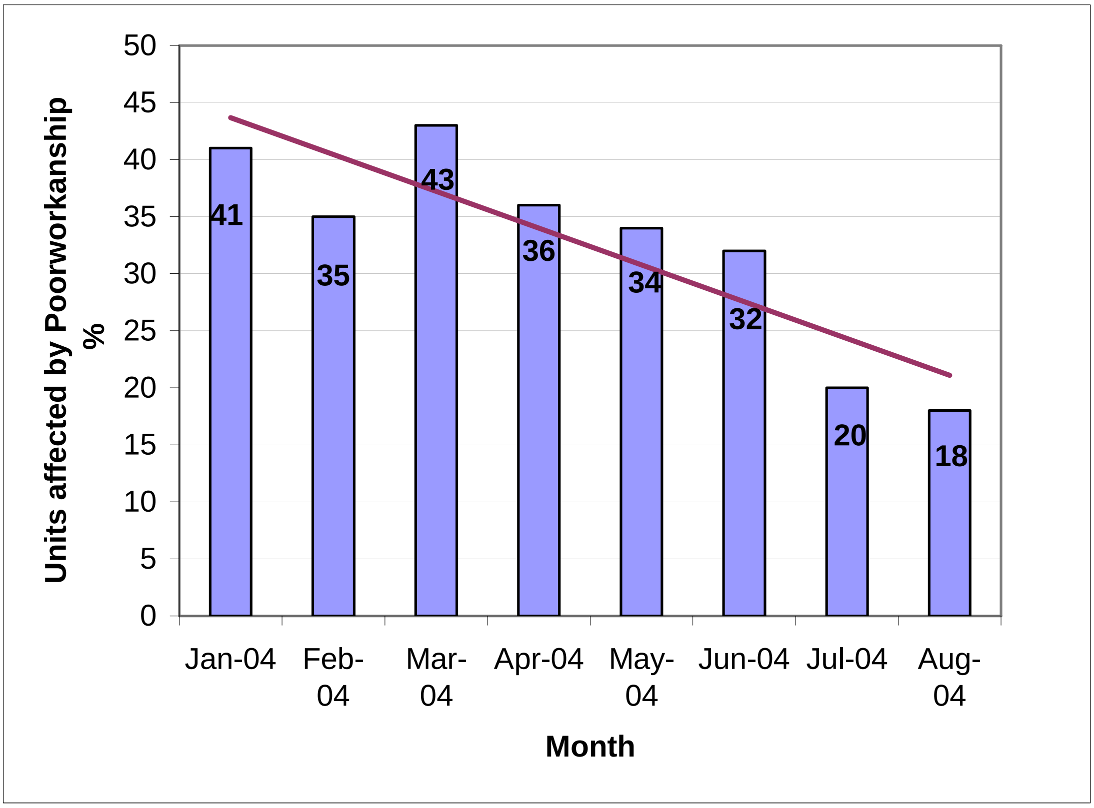


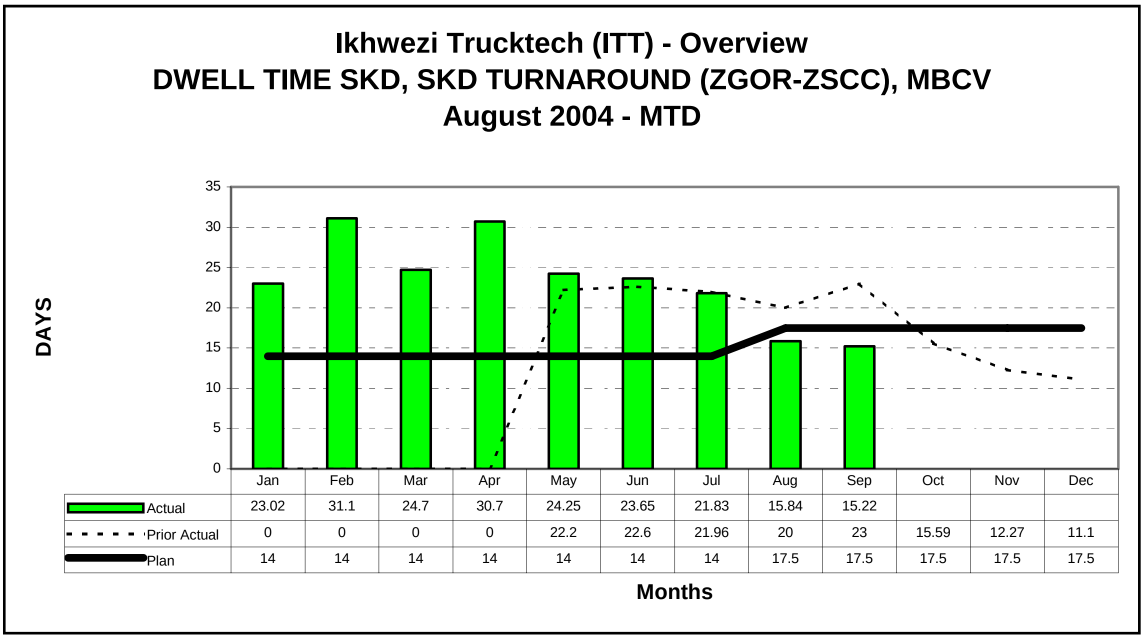
Table 5.9 – Poor Workmanship at ITT from Jan 04 – Aug 04

Table 5.9 – shows the reduction in the poor workmanship faults from March 2004 to August 2004. This decrease in faults reduces the amount of time needed to correct these internal mistakes and allows more time to meet deadlines and customer demands. The decrease to the poor workmanship is inversely related to the increase in quality of the final product being produced. This is also an obvious indicator to the improvement process and optimisation, as the poor workmanship is directly related to the increase in reworking time, which is usually preformed during overtime hour at a cost premium. Thus the decrease in poor workmanship will result in the decrease in rework time.

5.15 Dwell Time (arrival, Unboxing, Production, VPC)

Once the containers are off loaded at the local port in East London, the organizational performance of ITT is measured by DCSA. DCSA sets dwell time targets for each major phase in a unit's production cycle. The dwell time targets are measured by counting the number of days a task takes to be performed and completed.

The overall turnaround time of unit, from unboxing the semi knocked down (SKD) container to signing a unit out of plant is measured, and the dwell is calculated through each stage of the process. Table 5.10, below, indicates the improvement in the average dwell time, particularly in the last 3 months measured.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual	23.02	31.1	24.7	30.7	24.25	23.65	21.83	15.84	15.22			
Prior Actual	0	0	0	0	22.2	22.6	21.96	20	23	15.59	12.27	11.1
Plan	14	14	14	14	14	14	14	17.5	17.5	17.5	17.5	17.5

Table 5.10 – the dwell report of ITT for Jan04 – Sept 04

An increase in the volume has meant that the target of 14 days turnaround time has been increased to 17.5 days. ITT's last measurement for September showed that the units were unboxed produced and despatched to customers on an average of just fewer than 16 days.

The measurements at each stage in the cycle assist in keeping the plant informed as to where there may be delays or problem areas. By isolating each stage of the cycle, one can focus on problem areas more easily.

The turnaround achievement has noticeably reduced from over 30 days in April 2004 to 15.22 days in September, even with increased volume production. With increased flexibility on the production line and known work content levels, the production line can adjust its volume to accommodate fluctuations in the volume of units arriving on a vessel, to achieve the dwell time / overall turnaround time target.

5.16 Promise Date

The promise date is the single most important date measurement for ITT. The degree of error allowed for this target is 2 days either side of the date i.e. if the unit can be signed out 2 days earlier or 2 days later than the planned promise date, the unit can still achieve its target.

ITT does daily exception reporting to monitor units that are falling behind the plan. An action centre meeting is held daily for the team to discuss these issues. The team is aware of the monthly planned volume and any units that are overdue are an extreme priority.

To compensate for the poor supply situation from DCAG, DCSA's target of 90% on time delivery was reduced to 85% achievement for 100% reward.

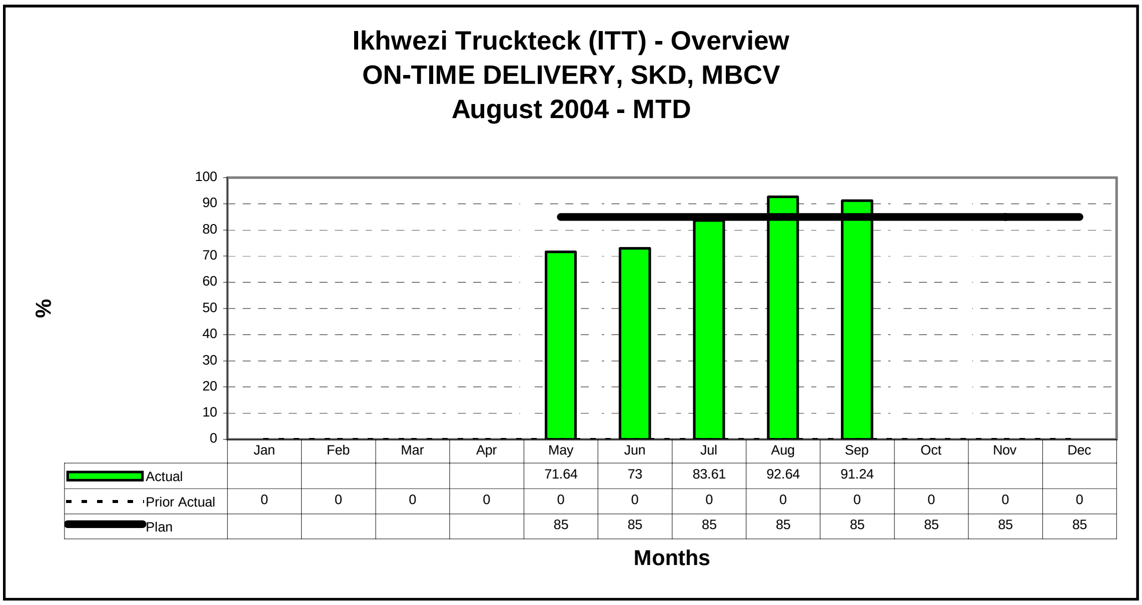


Table 5.11 – on-time delivery from May04 – Sept 04

The last measurement for September 2004 was just under 92% on-time delivery, even with the negative effect of poor supply from Germany which shows the efficiency of the plant, softening the impact of the supply problem. With an improved supply situation, the on-time delivery should be no less than 98%

There is definitely a correlation between the increased production efficiency, reduction in dwell time and the on-time delivery results. This matter is still under investigation and could be a subject of new studies, but does not form part of the scope of this research.

5.17 Summary

The results of this chapter, is an accurate reflection of the organisation from the period of January 2004 to September 2004. The increase to the production volume through systems re-engineering had allowed ITT to negotiate with DCAG for further increases to the semi-knockdown volume for 2005, as the production capacity had become the organization's strategic advantage to supply the South African market.

CHAPTER 6 – DISCUSSION OF THE RESULTS

6.1 INTRODUCTION

In this chapter, the results reflected in Chapter 5 will be discussed and the methods implemented to achieve the desired outcomes. These are to ensure that the newly designed process layout and procedural change will be sustainable for organizational growth and further development of increased capacity planning.

The realization that "people are central to the success of an organization" became the fundamental driver to secure sustainability, the process of tapping into the tacit knowledge bases held by the operators on the shop floor. The introduction of the AIDC initiative, of the Tirisano program became an enabling tool in assisting with total employee buy-in to allow for freedom to highlight concerns and suggestions for improving the plant's efficiency.

Management commitment was also tested during this period, and many agreements between the labour force and ITT management had to be settled, to guarantee the successful introduction to change. For example, before the Tirisano Shop floor Improvement Program was accepted by the trade unions, guarantees had to be signed between the two parties, reassuring employees that shop floor improvements would not lead to their dismissal. Rather, the movement of employees to strategic areas will compensate for the inefficiencies of the system.

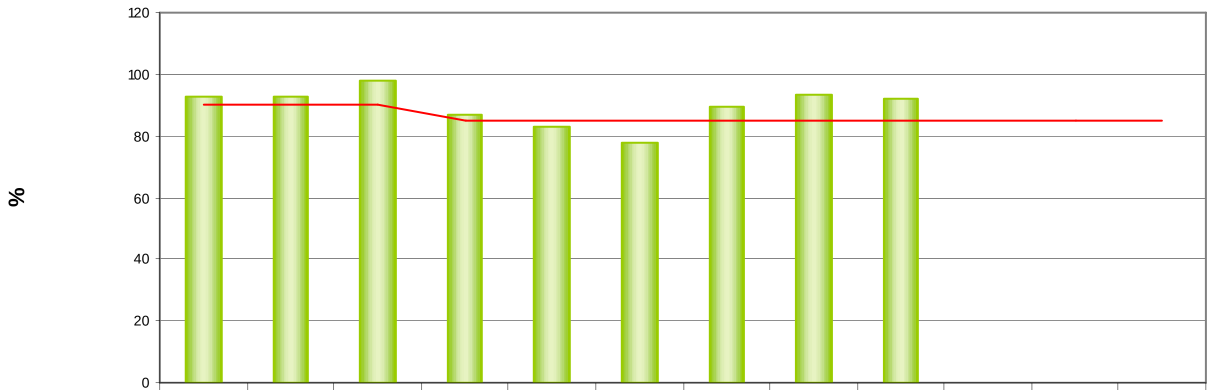
This agreement proved to be vital, at the later period of the system re-engineering. The commitment of the workforce to embrace change became more evident as people security and stability was anchored. Coupled with this change in attitudes, flexibility of the operators to assist with the process design had become increasingly active, as contributions and suggestions were flowing in "thick and fast".

In my opinion, the rapid growth in the plant efficiency and production volume that was achieved within a period of nine months can be attributed to the positive attitude of the workforce in making certain the objectives of the organization were reached. It should not be forgotten that the underlining achievement of 133% increase in production volumes within a period of nine months " is remarkable"!

6.2 Analysis of the Current Scenario

The results and achievements at ITT can only be reflected in the overall measurement of on-time delivery, cost and quality through final inspection and sign-out. It is at this stage of the process that DCSA measures the efficiency of ITT on these value drivers. The graph below will indicate the most recent figures and improvements to on-time delivery to the customer.

2004 On-Time Delivery Performance



	January	February	March	April	May	June	July	August	September	October	November	December
Actual	93	92.9	97.7	87	83.1	77.9	89.8	93.5	92.2			
Target	90	90	90	85	85	85	85	85	85	85	85	85

Table 6.0 – shows the on-time delivery from January 2004 to September 2004

The graph (table 6.0), shows a positive trend in consistently maintaining the on-time delivery to the customer. During the period from April to June 2004, the process of optimization had actively started to unfold, and for this period the on-time delivery dropped to below the allowable levels setting by the customer.

ITT management and DCSA, had to renegotiate the on-time delivery targets, as the delivery from the supplier (DCAG), was the main contributor in affecting the on-time delivery, with the increase of wrong and short supplied parts. This simply means that the units that are affected by shortages cannot be dispatched and are withheld for an interval during which their delivery dates expire. Therefore, from March 2004 the on-time delivery was set at 85%, of which 15% of the allowable production could substitute for any delays within the expected delivery window period. The on-time delivery shows a continuous improvement in sustaining levels above the target set for delivery period. The efforts of the ITT management, to address the supply chain problems, could further increase the on-time delivery status.

6.3 Supply Chain from DCAG (Germany)

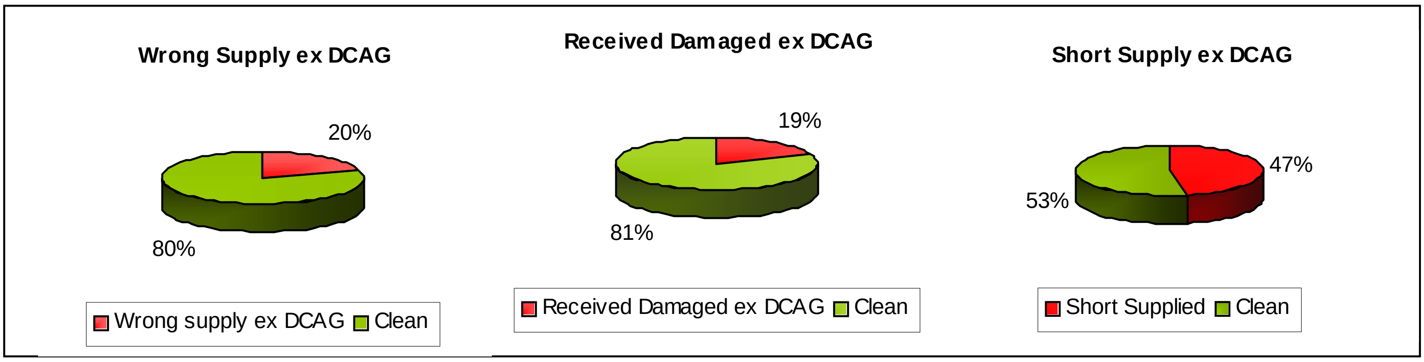


Table 6.1 – categorizes the reasons of the parts supply for Aug 2004.

6.3.1 Wrong Supply ex DCAG

The wrong supply graph in table 6.1 refers, to the actual wrong supply of parts received from Germany, which does not comply with the engineering execution of the unit. These parts are usually moved to the non-conformance area, where the notification will be received from Germany for the status of the incorrect parts.

These parts are usually scrapped, through a defined process at DCSA. It is important to note, although the parts received are incorrect for the South African vehicle execution, these parts are perfectly valid for the Germany (left hand drive units) markets and could be reusable. Therefore, the wrong supply of parts has major cost to both the German plant and South Africa environments. The German plant carries the cost to resend the correct part to South Africa, and ITT shows the impact of poor supply in areas of on-time delivery to the customer.

Depending on the urgency of the unit, overtime would be a feasible option to ensure that the promised dates or on-time delivery is met to the customer. Overtime is normally unplanned and would impact on the organizational "bottom line", therefore the cost for wrongly supplied part is at huge financial losses.

Graph 6.1 shows that 20% of the units assembled during August had wrong supply problems. In effect, 56 units from a total of 280 units may have been delayed due to wrong supply of parts from Germany.

6.3.2 Received Damaged ex DCAG

Graph 6.1 reflects, for the month of August 2004, that 18% of the units were also affected with damaged parts due to poor packaging from Germany. This calculation indicates that 51 units of a total monthly requirement at ITT; had also suffered further setbacks due to supply problems.

The lead-time for receiving parts from DCAG, is approximately four working days. The process at ITT, is to immediately order the defective parts from DCAG. If these damages are identified in the unboxing area then the possibility of the parts arriving Just-In-Time to meet the promised date of the unit is probable. Alternatively, if the parts are identified on the production line as being damaged then the on-time delivery to the customer may be jeopardized.

6.3.3 Short Supply ex DCAG

Graph 6.1 indicates that 47% of the entire production month had been affected by short supply of parts. This simply interprets as parts not being supplied in the packs or parts not received from Germany.

The first step at ITT, is to establish whether any robbing stock is available from other commission ranges expected for later assembly from the local port. If the parts are available, then the containers are requested by ITT for robbing thus impacting on the dwell time in plant. But, if no stock is available, the normal ordering process is activated

Evidently, short supply of parts from Germany is the largest contributor to the production process and on-time delivery. With 132 units of an effective 280 units scheduled for production in August reflecting supplier problems. The ramifications of these shortages have an enormous impact on the cost drivers at ITT.

6.4 Overall Measure of Supply ex Germany

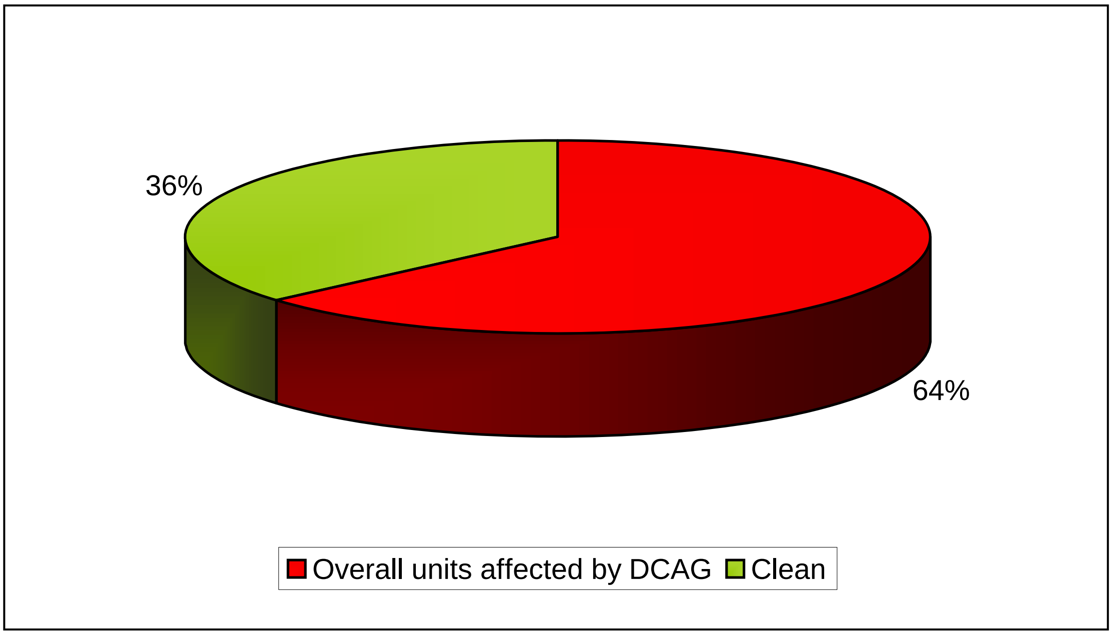


Table 6.2 – reflects the overall supply of parts to ITT for Aug 2004.

Table 6.2, reflect a total of 36% of the production month of August was affected by supplier problems. The total of the wrong, received damaged and short supply figures reflected above may not correlate with the overall calculation, as one unit can be affected by all three problems.

Currently, this matter is being addressed with DCAG, and the results at ITT will become apparent approximately two months later. Continuous feedback and improvement methods are relayed to Germany, with the necessary measurements in place to monitor the progress of the supply chain.

6.5 Cost Drivers

6.5.1 Lost in Plant (LIP) and Damaged in Plant (DIP)

2004	Damage in plant (Dip)	Lost in plant (Lip)	Wrong Supply (1)	Short Supply (3)	Received damage (4)
January	4	1	11	17	6
February	7	5	18	16	11
March	26	9	19	27	15
April	37	7	40	43	19
May	25	6	26	49	21
June	17	8	28	47	14
July	17	10	35	66	10
August	23	6	56	132	50
September	17	6	32	26	10
Total	173	58	242	317	114

Table 6.3 – shows the overall cost factors for 2004

Table 6.3 shows that the LIP and DIP at the ITT plant is stabilizing but the actual allowable cost for this factor still needs considerable reduction. LIP and DIP are costs that affect the organizational efficiency; therefore a factor of the performance bonus reward incorporates these elements in the calculation of the allowable remuneration.

The table illustrates for the month of September, considerable improvements throughout the various categories measured. In my opinion, it is too soon to determine whether a positive trend has developed, but with the constant monitoring and feedback to DCAG these improvements would add to the efficiency and productivity of the production plant at ITT.

6.6 Quality Report

6.6.1 Actros and Axor Quality

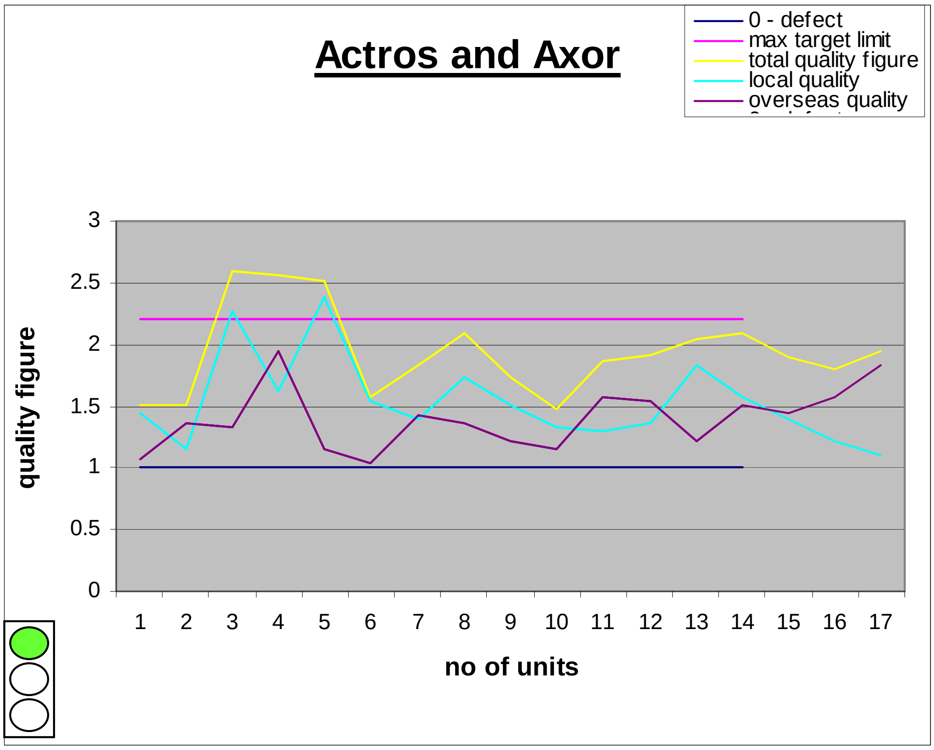


Table 6.4 – the quality graphs of the Actros and Axor for 2004

The quality graph reflects the product audit results of 1% of the total production volume. The target set for Actros and Axor is at 2.2, the total result at the audit should not exceed this measurement. The total result is divided into both “local” assembly faults and “overseas” faults.

The agreement with DCSA, allows for 1% of the total production volume at ITT to be product audited by an independent quality practitioner. DCSA has the liberty to select an audit unit at random, to ensure credibility and transparency of the quality process.

ITT views the product auditing system in the highest esteem to ensure that the quality standard meets the expectation of the customer. Stringent on-line quality inspection, guarantees that the units are built to “world class standards” as quality will not compromised.

6.6.2 Atego Quality

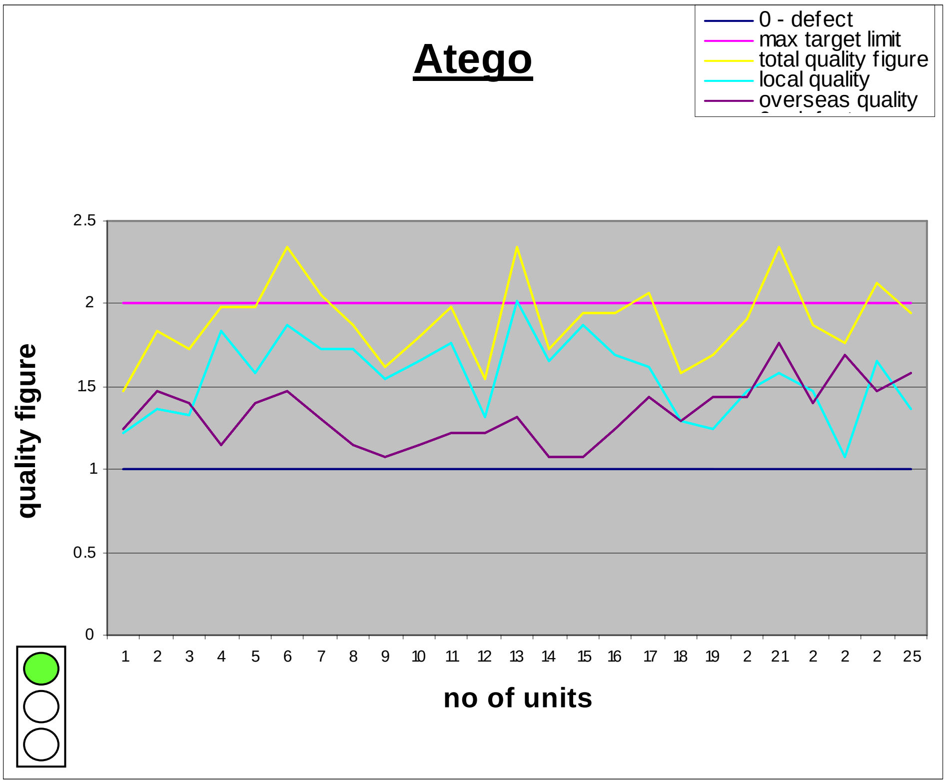


Table 6.5 - the quality graphs of the Atego for 2004

Similarly to the Actros and Axor, the Atego audit process and quality standard are vital indicators to be assembly process of the unit. Clearly, the quality audits reflect positive trends but continuous improvements will always allow for further development.

The positive spin-off from a product audits could result in the redesign of processes to improve the final quality of workmanship. Therefore, at ITT product audits serve as useful tools in eliminating procedural inefficiencies and adding invested value to the completed product.

6.7 Summary

The underlining improvement to any optimization strategy must ensure that the value drivers, critical to the organizations sustainability are maintained. ITT is consciously focusing on these indicators and continuously improving through the system of "Kaizan".

CHAPTER 7 – Recommendations for Improvement

7.1 Introduction

The contents of this chapter will indicate recommendations for further growth and profitability for Ikhwezi Trucktech (Pty) Ltd. These recommendations for improvement have been gathered through the post-test interviews and discussions with the general workforce.

The feasibility studies of these improvements are not completed, and the next process within ITT's existence is to explore the opportunity for further growth and sustainability of the organization.

The suggestions below reflect the next logical step to follow in the optimization process. The feasibility of the improvement will still need testing and only the highly structured ideas will be implemented in the future change process of ITT.

7.2 Recommended Improvements

7.2.1 The Sub- Assembly Area

Presently, the production plant is optimized to volume capacity. The system manages to achieve the daily production target with the manpower requirement of 70 employees, in a confined space. Therefore, the next stage in the progress of ITT's production process is to have an area dedicated to the sub-assembly of the parts, thus converting the production plant to purely an assembly function.

The sub-assembly area will have to work in close synchronization with the unboxing team. As the units are unboxed from containers, the parts that require sub-assembly are supplied to a special area, where the sub-assembly will be conducted. The parts are then supplied to the production line Just-In-Time and fully assembled. The function of the operators in the production plant will be to fit and secure the pre-assembled parts.
The advantages of this process:

- Will reduce the number of operations on-line, thus decreasing the cycle time of the completed unit.
- Benefit of moving part of the existing workforce off-line to develop the sub-assembly area, thus reducing the operator motion, which is considered at a wasteful activity.
- Less operators on-line, therefore allowing process improvements to be re-designed to reduce necessary non-value adding and waste.
- Leads to an increase in production volume, as the production plant will be convert to purely fitment and securing.
- Reduction in the takt and cycle time, thus improving the plant efficiency.
- Allow ITT management the tools, to negotiate for increased volumes from DCAG.

7.2.2 Debugging of the Supply Chain

The quality of the supply to South Africa requires major attention. The ramification of poor supply, impacts on the delivery period to the customer, amongst many other problems. The lead time and the guarantee of on-time delivery of the correctly ordered part needs to be improved, to ensure an improvement in the turn around time from unboxing to dispatch.

Presently, the process of a unit with shortages is destined to the “graveyard”. The “graveyard” is not the ideal process in production but ITT has no choice but to build these units and hope that the correct parts arrived in time to satisfy the customer’s promised date for delivery. If the quality of the supply is improved, then ITT will have the opportunity to shorten their supply chain to the customer and eliminate all “graveyard activity”.

7.2.3 Nuts and Bolts supply ex Germany (Sammelsendung)

The nuts and bolts (small parts), supply from Germany is received on a monthly basis. This supply includes the entire supply of small parts for the entire production month. It has become evident that before the end of a production month, specific small parts are being re-ordered. The cost of the re-ordering process forms part of a cost to ITT.

An investigation has to be conducted to ensure the following:

- The correct quantity of small parts is received from DCAG.
- 100% audit check to be conducted, to verify the quantities received at ITT.
- To determine whether the reoccurring small parts shortages are investigated to establish a misusage factor in the production process.
- A clear demarcation of small parts on the production line is essential.

7.2.4 H-Plant Process

H-Plant refers to the production department that is responsible for the chassis assembly. The concern surrounding this department is that there is no defined process flow of work-in-progress, which creates a production environment where many wasteful activities can be eliminated.

To confirm that the chassis are supplied to the production line Just In Time, it is imperative that a defined process flow is established to ensure production efficiencies and production volumes are increasingly sustained.

7.2.5 Roll-out of the Tirisano Program

Presently at ITT, the Tirisano program has been introduced to the Mercedes-Benz commercial vehicle production line. To secure sustainability and continuous improvement of the program, it is vital that the roll-out process is transferred to the various departments of ITT (i.e. American Freightliner production and Japanese Mitsubishi production).
Continuous training and educational workshops surrounding the core aspects of the Tirisano philosophy needs to be actively relayed to the operators on the shop floor in an effort to create organizational awareness and understanding.

7.2.6 Parts Allocation

This recommendation refers to the allocation of the correct parts to the correct line stations within the production assembly plant. Presently at ITT, operators often spend idle time trying to locate parts required for assembly. This normally occurs with the introduction of new models, as the parts have not been correctly assigned to the correct line stations.

Ideally, when a new unit is introduced to production, the 100% status to the unboxing schedule should be established. To ensure that this process is conducted thoroughly, a detailed verification build of all prototype units should be accurately conducted. Therefore, the time frame to ensure a problem free introduction of new models will need to be extended to eliminate later systems constraints.

7.2.7 Hand and Air tools

During the pre and post-test interviews many operators highlighted the concern surrounding the lack of the correct hand and air tools. This problem creates major production constraints within the system. At present at ITT, the tool requirements have been established for which purchase approvals have not been received.

To make certain that a high quality world-class product is produced at ITT, tooling forms a major part of the basic requirements needed to perform this function. Goldratt (1990: 26) clearly states that “many constraints can be policy driven”, it is important for ITT to review its policies concerning capital expenditures purchases to allow for a more efficient turn around time.

7.2.8 Engine Plant Assembly

This recommendation should be included in the long term planning strategies at ITT. It is the consideration of converting the engine plant assembly area into a continuous process by including a conveyer system.

Currently the engine department sub-assembles engines only for the MBCV production line. The process adopted is a “stand alone” system of assembly. Simply interpreted, each motor is assembled individually by a team of employees from start to finish. At the moment, the system is coping with production demands, but if further increases to the production volumes are experienced, then strategy optimization will be required to improve the efficiencies in that area.

The inclusion of a conveyer system would beneficial to the overall production at ITT, as the engine department could then assemble all the motors required in the total production at ITT, including Mitsubishi and Freightliner. The process will be more defined as takt and cycle time studies will assist to guarantee the continuous process improvements and supply to the various production departments.

7.2.9 Forklift Traffic

The design and demarcation of set forklift routes needs to be mapped for each vehicle supplying unboxed parts to the production areas. Defined routes would eliminate the concentration of forklift traffic through a specific area, thus unraveling potential constraints or bottlenecks.

The spaghetti diagram in chapter five clearly defines the current bottleneck area due to traffic flow at ITT. For future planning and growth, improved efficiencies from parts supply needs to be considered in maintaining improved production volumes.

7.2.10 Jigs and Fixtures

Presently at ITT, many of the existing jigs and fixtures have been in production for many years. Some of the equipment is not adequately suitable for the function it has to perform. The main reason is that new models are continuously being introduced and many of their existing equipment is still based on the old levels.

It is important to note that improved tooling results in an automatic increase to efficiency and, with inadequate structures, immediate constraints will become apparent. Therefore, for future growth and development at ITT, all major and minor constraints would need re-addressing.

7.3 Summary

It is important to note that many of the suggestions above are indicative of future growth and development for ITT. Yet these recommendations can also be implemented to improve the current situation of truck assembly in South Africa.

The ergonomics for the operators will immediately be improved thus creating an environment that is less strained and more productive. Through the system of Kaizan incremental steps of improvement can continuously add value to the systems design and process re-adaptation.

CHAPTER 8 Conclusion

What an experience! The optimization strategies at ITT, has taken the organization from an ordinary production plant of low volume, to a situation of substantial production volume increases. An effective 133% increase in the plant efficiency was experienced, whilst maintaining the key organizational value driver during this period. A definite change to the employee mind set was challenged; there was a conscious move away from just meeting the production demands, to achieving and maintaining the key value drivers – (quality, cost and delivery).

This can clearly be observed, when analysing the reduction in the poor workmanship graphs, which reflects a constant decrease in cost for the period from January 2004 to August 2004. This indication is inversely related to an improvement to quality and on-time delivery, with further planning and controlling strategies to reduced poor workmanship to an acceptable low.

The learning point that needs mentioning was one that is particular to the South Africa culture. During the optimisation process, employee resistance to change became one of the most crucial stumbling blocks to improving the plant efficiency. The understanding of academic qualifications to determining the level of control is definitely not the case in Black African Culture.

The underlining importance to the Black African Culture is not to a large degree the qualification or level of authority of an individual. But the age of the individual, allows the employee status and authority to be a key role player and influence the final outcome. When this phenomenon was disclosed the optimisation strategy found the momentum that was desperately required. The inclusion and involvement of key employees to form part of the core team become imperative, these employee played a fundamental role in convincing and motivating the changes. The task of planning improvement strategies had become less strained, and the fluency of workable suggestion had started surfacing from the shop floor.

ITT had found the break through, to ensure that the optimisation strategies would become sustainable and effective for the organization.

CHAPTER 8 – *Conclusion*

8.1 ABBREVIATIONS

1. BEE - Black Economic Empowerment
2. JSE - Johannesburg Stock Exchange
3. PDI - Previously Disadvantaged Individual
4. BMF - Black Management Forum
5. BEECom - Black Economic Empowerment Commission
6. ITT - Ikhwezi Trucktech (Pty) Ltd
7. DCSA - DaimlerChrysler South Africa
8. MIDP - Motor Industry Development Program
9. CV - Commercial Vehicles
10. CKD - Completely Knock Down
11. FBU - Fully Built Up
12. SKD - Semi Knock Down
13. DCAG - DaimlerChrysler Germany
14. TOC - Theory of Constraint
15. TQM Total Quality Management
16. MRP - Manufacturing Resource Planning
17. JIT - Just-in-Time
18. EOQ Economic Order Quantity
19. ST - Systems Thinking
20. DCOM - DaimlerChrysler Operating Model
21. AIDC - Automotive Industry Development Centre
22. MBCV - Mercedes-Benz Commercial vehicles
23. HP Horse Power
24. Hz - Hertz
25. ERR - Expected Receipts Report
26. SKD - Semi knocked down
27. POM - Production and Operations Management

CHAPTER 9 – REFERENCES

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