

**Management and production techniques in the
manufacturing and service industries and how it relates to
the construction industry**

Colin Pickering

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Supervisor: Prof. R. G. Pearl

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ABSTRACT

This dissertation is concerned with the future of the construction industry in South Africa and the ability to improve. Continuous growth is predicted through to the year 2015 and beyond, it is considered that to meet this challenge the South African construction industry must achieve substantial improvement and change.

South Africa is a developing nation with ambitious objectives to improve social development and growth through delivery of infrastructure and other areas including, municipal development, hospitals, roads, water, electricity and government facilities. It is essential that South Africa has a construction industry that can develop capability and capacity to achieve sustainable growth.

Current management thinking acknowledges that the best management and production principles are transferable. This is not a new concept or proposal, early management and production theorists and applicators such as Frederick Taylor, Frank B Gilbreth and Henry Ford all held the view that best practice techniques are transferable in application.

By researching and presenting current successful management and production practices it intends to identify principles that can be adopted for change and improvement by the South African construction industry.

A current general review of the South African construction industry has been undertaken to place it in context regarding the adoption of these best practice principles.

The research will adopt a qualitative approach; it will be subjective and contain descriptions of techniques, people interactions, observations and assumptions.

The principles addressed in this research are Benchmarking, Lean Production and Supply Chain Management; they have been selected as current best practice and as having significant use and proven continued success.

They are presented in a format to allow understanding of the principles now developed and to illustrate via existing case studies, successes in application.

Conclusions are made on individual aspects, on common core practices existing in all three principles and the current state of the South African construction industry. Recommendations are made and further areas of research suggested.

DECLARATION

I hereby declare that this dissertation, submitted in partial fulfilment of the requirement for the Master Degree in Construction Project Management, is the result of my own work and that due reference is made where necessary to the work of other researchers and authors.

I further declare that this dissertation has not already been accepted in substance for any degree and is not being submitted concurrently in candidature for any other degree.

A handwritten signature in black ink, appearing to read 'C. Pickering', with a stylized flourish at the end.

Colin Pickering

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LIST OF ABBREVIATIONS (in alphabetical order)

BAA	British Airports Authority
BPB	Best Practice Benchmarking
CBP	Current Best Practice
CIDB	Construction Industry Development Board
CIO	Chief Information Officer
CRM	Customer Relationship Management
DTI	Department of Trade and Industry (UK)
DETR	Department of the Environment, Transport and the Regions (UK)
EU	European Union
ISO	International Standards Organisation
IT	Information Technology
KPI	Key Performance Indicators
M&E	Mechanical and Electrical
MIT	Massachusetts Institute of Technology (USA)
PFI	Private Funded Initiative
QCDDM	Quality, Cost, Delivery, Design and Management
SA	South Africa
SCM	Supply Chain Management
UK	United Kingdom
USA	United States of America
US\$	United States Dollars
VP	Vice President

CHAPTER 1: INTRODUCTION

1.1 Background

The construction industry in South Africa is at a crossroads regarding its sustainability and continued growth. That an industry could be considered to need intervention of Government to improve its market performance, and ability to provide customer satisfaction clearly indicates that the industry concerned was in a very poor state and lacks capacity to implement strategies for improvement (Hindle, 2001).

South Africa is a developing nation and relies on the industry to deliver projects and provide opportunities for employment. That the industry remains in place, develops capacity and sustainable growth can be considered essential for the country as a whole.

South Africa's developing economy has not supported the industry in its current traditional form, competitive pricing and low volumes of work have left many casualties in the construction sector. Significant consolidation has taken place and more is likely. Examples of this consolidation are the merger of LTA and Grinaker in 2000 and the acquisition of Concor by Murray & Roberts in 2006.

Perceptions of the industry are poor; customers are skeptical about delivery on time, quality and budget. Literature indicates that cost, quality and time to be the traditional project performance measures (Smallwood, 2000).

It is likely that these perceptions may have also reduced the number of people coming into the industry. The ability of a business sector to continue to attract new and young talented people should be seen as crucial to its survival.

The construction environment is considered as conservative and reluctant to change, traditionally cyclical by nature the tactic has been to ride out the downturns and take advantage of the boom times. In the past these boom times in South Africa were driven by government spending, the mining sector and related industries.

It is now widely predicted that significant growth in the industry will be sustainable through to 2015 and underpinned by governments increasing levels of investments in infrastructure that is driven by its commitment to economic and social development (Pautz *et al*, 2003). The future can be considered to be one containing far more flexible and challenging market conditions. Changing client aspirations may well be very different and more demanding as the growth continues.

Other industries worldwide both in manufacturing and service providers have faced up to similar challenges. They have succeeded in changing themselves whilst going on to provide a more varied product base or service coupled with improved productivity, quality and value.

The current literature supports that the automotive and aerospace manufacturing industries have been leaders in business change and reinvention (Womack *et al*, 1990; Monden, 1998).

Specifically within motor manufacturing the scale of improvements achieved by the best are being pursued by others. Japanese car makers have led the way for others to follow, benchmarking studies in the early 1990's show a two to one gap in performance and a hundred to one gap in quality between Japanese and Western car manufacturers (Egan, 1998).

The scale of improvements are impressive, the time taken to weld, paint and assemble a car has been reduced from 40 hours to 15 hours, the time taken from design freeze on a new model to launch has been reduced from 40 months to 15 months. Similar achievements within suppliers have produced defect statistics in the components manufacture of a reduction from 3% to 5 parts per million (Egan, 1998).

Major improvements have also been made by improving the supply chain from smaller second tier suppliers. Nissans QCDDM supply chain management system is acknowledged to be among the most effective in the world. It measures all suppliers on Quality, Cost, Delivery, Design and Management against negotiated continuous improvement targets.

Competition is created across the supply chain by collating performance information every month and informing each supplier of its performance in relation to the others (Egan, 1998).

The Boeing Company, one of the world's most global multinational companies, offers an example of a company challenging itself before the external environment can do so. Enormous strides forward were made in improving efficiency, the company stated in its 2001 annual report that the labour required to assemble a Boeing 737 has fallen from 30,000 hours to under 10,000 hours (Ryan, 2001).

Tookey and Betts (1999) explain that the aerospace and construction industries face similar problems. Both these industries produce and deliver expensive products in relatively short time periods, this work is carried out under demanding variables and under extensive pressure, however only the aerospace industry is considered as a world leader.

This research is intended to identify successful business practices that have been developed or applied in the fields of manufacturing, also that common core principles exist across successful business practice.

It will present these processes and analyze the specific techniques and components of improvement. A current review of the South African construction industry has been undertaken to place it in context regarding the adoption of best practice.

1.2 Problem statement

The South African construction industry is considered to be severely challenged by the continuous growth predicted through 2015 and beyond and needs to achieve improvements in all aspects to remain a sustainable part of the economy. It is proposed the adoption of best practice techniques in widespread use in manufacturing and retailing may become the basis of the improvement process.

1.3 Relevance and justification for the research

This research is concerned with improvement and change within the construction sector. It is proposed that this improvement and change needs to take place if South Africa is to develop as a nation and a global participant. Commentary from within the industry as cited below indicates challenging times ahead for construction in South Africa.

Dr Iraj Abedian, economist and Chief Executive of Pan-African Investment and Research Services said *"that while South Africa's fundamentals are generally sound there is an urgent need to invest in the country's economic and export infrastructure, particularly the sectors of logistics, energy and tourism"* (Abedian, 2005 pp. 3).

The tide is turning to sustained investment, Brian Bruce chief executive officer of Murray & Roberts, South Africa's largest construction and engineering company says, *"in the domestic construction economy we are experiencing the early stages of what we believe is a period of sustainable growth and opportunity, maybe extending into the next twenty years or more"* (Bruce, 2006 pp.1).

1.4 Research objectives

The primary objectives of the research is to investigate the successful techniques of present day manufacturing and service providers that continue to be applied in a constantly changing environment.

Objective 1: Identify successful techniques of business improvement and the key elements of these techniques.

Objective 2: Provide a basic understanding of these techniques, their current use and successful application.

Objective 3: Analyze these different techniques for common core elements.

Objective 4: Review in general the current state of the South African construction industry and its suitability to adopt best practice.

1.5 Research methodology

1.5.1 Overview

Research methodology in simple terms is a description of principles and procedures of logical thought processes which are applied to scientific investigation (Fellows and Lui, 1997). Robson (1996) recognizes research methods that can be implemented to include interviews, one-on-one or workshop discussions, questionnaires, observation and experimentation.

Research methods can be categorized in a number of different ways such as for example, focusing on five specific categories of research namely, experiment, survey, archival analysis, history and case study (Yin, 1994).

However it is widely considered that the most common distinction between methodologies is between quantitative and qualitative research. These two research methods are discussed in the following sections.

1.5.2 Quantitative research methodology

Quantitative research concentrates on measuring phenomena, for example the gathering of numerical data and applying statistical tests. It would involve studying relationships between multiple facts and how such facts and relationships accord theories and findings of any research executed previously (Fellows and Liu, 1997).

This type research entails enquiring into a recognized problem or issue based on testing the hypothesis, measuring it numerically and analyzing the results using statistical techniques. The purpose of quantitative research is to use testing to determine whether the predictions of a pre- formed theory prove to be correct.

Quantitative research differs from qualitative research in a number of ways:

- Quantitative research can usually be replicated or repeated, given its high reliability and core sample size.
- Data usually collected using structured research instruments.
- The results tend not to focus more on subjective issues of behavior, attitudes and motivation.

- The results need larger representative sample sizes of the entire population in order to make results more dependable and convincing.
- The analysis of the results is objective rather than subjective, (Naoum,1998).

Dobbin & Gatowski (1999) suggests that the most widely used quantitative research techniques include:

1. **Experiments:** These are experiments that use random assignment of subjects to experimental conditions and the use of experimental controls (in order to ensure a non-partisan participant representative of the whole).
2. **Quasi-Experiments:** Quasi-experimental studies replicate almost all of the experimental design features, except that they engage controlled or nonrandomized assignment of subjects introduced into experimental conditions.
3. **Surveys:** Often used when sample sizes are large, and a large amount of data is to be gathered and analysed statistically. It would typically involve cross-sectional and longitudinal studies using questionnaires or interviews for the data collection phases with the aim of categorising the characteristics of a large population derived from the analysis of a smaller sample taken from that population. Quantitative research analysis is typically based on the use of statistical techniques, which lends itself to managing large and very large sample sizes which requires a great deal of data manipulation (graphs, charts, etc).

1.5.3 Qualitative research methodology

Qualitative research concentrates on understanding phenomena. It involves examining and reflecting perceptions in order to gain an understanding of social activities, such as the exploration of an unknown area, the identification of the extent of an issue, the making of assumptions and the reaching of understanding.

Qualitative research is more subjective, consisting of detailed descriptions of situations, events, people interactions and observed behavior (Patton, 1992).

The following methods of collecting data suggested by Hancock (1998);

- **Individual interviews:** The definition of an interview is a verbal interchange, usually face-to-face (though the telephone may be used), in which an interviewer proceeds to extract information, beliefs or opinions from another person (Burns, 2000).
- **Direct observation:** this method is used to observe and study individual members participating in a research study. It is often used when data collected through other means can be of limited value or is difficult to be validated (Hancock ,1998), such as with children playing when an interview would be intrusive.
- **Focus groups:** These are a form of interview for groups that profit from the interaction between multiple research participants in order to generate data (Kitzinger, 1995). Focus groups are sometimes misused as simply a quick short-cut to collect data from several people at the same time, but this overlooks the inherent benefit of group participation as a central part of the method. For example, rather than the researcher asking each individual to respond to a question in turn, the participants are encouraged to communicate with each other by questioning each other, relating personal experiences, and exchanging and debating points of view (Powell and Single, 1996). This interview method is useful for exploring peoples' experiences and views on a subject and can be used to examine not only what people think, but how they think and why they think in that way (Gibbs, 1997).
- **Case studies:** The case study approach is used to gain detailed understanding of a subject, focusing on process rather than outcome, on discovery rather than confirmation (Burns, 2000).
- **Action research:** This research usually involves active participation by the researcher in the subject under study, in order to identify, promote and evaluate problems and potential solutions, gaining empathy rather than an abstract or remote view (Fellows and Liu, 1997).

1.5.4 Deductive versus inductive approach

The Deductive approach to research is based on scientific principles, used in the development of a theory that is later thoroughly tested and a hypothesis is developed and crystallized. Traits of a Deductive approach would be the presence of a highly structured methodology, with an emphasis on measurement and quantification of the results.

The Inductive approach emphasizes theory generation which is developed in parallel to the data evolving during the research process. The researcher will be part of the research process so will have a front-line involvement in its development. The research will be a product of ongoing data collection and analysis using exploratory means to find a fresh viewpoint based on the richness of information. The data collection process will involve observation and reflection, which in turn assists the evolution of the theory.

There is no right or wrong approach on a one-size-fits-all, but rather it is the nature of the research that largely dictates the best-fit approach that should be adopted to greatest effect.

A researcher's decision of what type of strategy to follow may already be pre determined for them, as choice is largely dependent on the nature and purpose of the study, together with type and availability of the information which is required (Nauom, 1998).

1.6 Methodology adopted

This research as stated earlier in section (1.1) is intended to identify successful business practices that have been developed or applied in the fields of manufacturing and service industries, also that common core principles exist across successful business practice.

To meet the objectives of this study, the research concentrates on understanding phenomena and involves examining and reflecting perceptions in order to gain an understanding of social activities. Hence the research conforms towards a qualitative approach; it will be subjective and contain analysis of text, descriptions of techniques, people interactions, stated observations and

assumptions to formulate understanding of the subject through a holistic perspective (Hancock, 1998).

1.6.1 Data collection methods

The data collection method is termed as the secondary method, this is utilising data collected from books, papers, reports, studies, newspapers and web-sites.

Following the literature review, three specific techniques or practices have been identified for further study:

- Benchmarking.
- Supply Chain Management.
- Lean Production.

Whilst many management techniques or principles overlap considerably the three identified are considered sufficiently independent to warrant separate analysis.

Literature review:

The scope is potentially broad and for the purpose of meeting with the objectives of the research a more focused approach was adopted. The researcher has stated earlier that current literature supports that the automotive and aerospace manufacturing industries have been leaders in business change and reinvention (Womack *et al*, 1990; Egan, 1998; Monden, 1998). Although forming a significant component of the focus of the research the review has not been limited to these areas and has remained closely associated with construction, industrial production, manufacturing and retailing.

Case studies:

Relevant existing case studies and research material have been identified, examined and reviewed to establish the success factors and applications. In line with the theory of the methodology the case studies contain interviews, commentary, opinions and points of view from the people involved.

Vehicle manufacturing, aerospace, retailing and construction form the subject base of the case studies chosen. The criterion for selection was to identify case studies from the subject areas that demonstrated the techniques and successful application of techniques congruent with the objectives of the research. The selection method adopted is information oriented; the cases are selected on the basis of their information content.

The framework adopted was to identify for inclusion and analysis best practice examples within the automotive and aerospace manufacturing and retailing sectors of industry as well as example related to the construction industry. This was carried for each of the best practice methodologies of Benchmarking, Supply Chain Management and Lean Production.

The case studies are a component of the research data and are provided for reference as an annexure at the end of this dissertation. They provide detail, understanding and are evidence of success and continued in application of the subject. Commentary and content analysis are provided at the end of each topic section.

1.6.2 Data Analysis

The data analysis method of “content analysis” has been adopted broadly for this research. The method of content analysis enables the researcher to include large amounts of textual information and systematically identify its properties by detecting the more important structures of its communication content. (Hancock 1998). The procedure adopted conforms to an open analysis approach which identifies the dominant message and subject within the text (McKeone, 1995).

Quantative Data Analysis:

Specific qualitative data of the research has been analysed in a quantitative way, this is presented in Table 5-1 on page 68 .The themes and presence of the common core principles within the case studies has been analysed by content analysis to provide an interpretation of frequency and relevance. This is a general view and a simple ranking score of, 3 for high relevance, 2 for

medium relevance and 1 for low relevance has been given to each common core principle.

Qualitative Data Analysis:

The research data has been analysed by a form content analysis and was concerned with analysing text for the classification, summarisation and tabulation of data.

The content has been analysed on two levels:

1. The basic level of analysis is a descriptive account of the data.
2. The higher level of analysis is an interpretive account of the data.

The analysis in line with the problem statement and objectives is presented in a commentary of the results and within the conclusion.

1.6.3 Validity and Reliability

Validity and reliability of research methods and findings:

The process of the method used, content analysis, involves continually revisiting data and reviewing the categorisation of data until the researcher is sure that the themes and categories used to summarise and describe the findings are a truthful and accurate reflection of the data.

1.6.4 Presentation

The methodology adopted is to present each principle, its component parts and application, also citing case studies for each principle. The case studies are products of the literature review and research, commentary is provided and conclusions made. The case studies are included as annexures.

The presentation of these principles and studies form the results of the research. This methodology has been followed to document clear understanding of these principles and to illustrate their successful application across business sectors.

1.6.5 Scope and boundaries

This research is intended to identify successful business management and production practices that have been developed in the fields of manufacturing and service providers.

The focus is on specific techniques and management practices that have shown significant improvements for those concerned and are presently acknowledged as best practice .

This dissertation deals with the South African construction industry in general from the perspective of main contractors. It does not attempt to prove the application of best practice within the industry but reviews the present status of the industry and provides commentary on the capability and capacity to adopt best practice and common core principles identified.

1.6.6 Structure of dissertation

It is proposed that the dissertation is presented in a number of chapters which logically addresses the issues regarding the research subject and objectives.

Chapter one: Introduction

Describes the general problem area, the specific problem, why the topic is relevant, prior research, the approach, research methodology, limitations and contributions made by the research. Sub questions will be proposed and the structure of the work will be advised. Also literature will be utilised in the research to identify objectives and to establish known current best practices.

Chapter two: Production and Construction

This chapter reviews the evolution of production theory and practice, what sort of production is construction, the construction industries claim to be unique and highlights the Toyota Production System.

Chapter three: Results of the research

It is the intention of this chapter to present the results of the research methodology in the format of definition, explanation, case study reference and summary relevant to the objectives.

The components of this chapter are:

Benchmarking.

Supply Chain Management.

Lean Production.

Chapter four: South African Construction Industry Environment

This chapter reviews the current South African construction industry environment, including a global perspective, local review, capacity and capability within the industry, government's present role and influence, HIV Aids and Black Economic Empowerment.

Chapter five: Analysis and discussion

This section discusses the results, answers questions posed, and explains the conclusions that can be drawn from the data and the implications of the theory.

Chapter six: Conclusions and recommendations

Comments on the results of the research to determine if the objectives have been met, recommendations are made and suggestions for further research are also outlined.

CHAPTER 2: PRODUCTION and CONSTRUCTION

2.1 Introduction

This chapter reviews the evolution of production theory and practice, what sort of production is construction, the construction industries claim to be unique and highlights the Toyota Production System.

2.2 Production management

It is widely considered that F.W. Taylor was the founder of the scientific approach to management; he is also credited with the theory of organisations which altered the personalized autocracy of the time.

At the time of Taylor's work a typical manager would have very little contact with the activities of the factory. Generally a foreman would be given the total responsibility for producing goods demanded by sales. Under these conditions, workmen used what tools they had or could get and adopted methods that suited their own style.

By 1881 Taylor had published a paper that turned the cutting of sheet metal into a science. Later he turned his attentions to shovelling coal by experimenting with different designs of shovel for use with different material (from rice and coal to ore); he was able to design shovels that would permit the worker to shovel coal for the whole day. In doing so he reduced the number of people shovelling at the Bethlehem Steel Works from 500 to 140. Taylor progressed with time and motion studies and incentives.

Taylor argued that the scientific method could be applied to all problems and applied just as much to managers as to workers. Further he advises that the old fashioned dictator does not exist under scientific management, the man at the head of the business under scientific management is governed by rules and laws which have been developed through hundred of experiments just as the workman is, and that the standards developed are equitable (Taylor, 1911).

His framework for organisation was:

- Clear delineation of authority.
- Responsibility.
- Separation of the planning from workers.
- Incentive schemes for workers.
- Management by exception.
- Task specialisation.

Taylor's impact has been so great because he developed the concept of work design, work measurement, production control and other functions, that completely changed the nature of industry. Before scientific management, such departments as work study, personnel, maintenance and quality control did not exist.

Construction is one of the birthplaces of the early theories of production management with the motion studies of Gilbreth (1911), an important early pioneer in production management improvement.

As a building contractor he studied what he termed as the needless, ill directed and ineffective motions in the construction process (Gilbreth, 1911).

In his most famous study he analysed the movements of a bricklayer and reduced them from eighteen to five, this doubled the productivity without any increase in the bricklayer's efforts. Gilbreth believed that improvements from his observations of construction were applicable to other industries (Cheetham *et al*, 1992).

Henry Ford is credited with the introduction of mass production techniques. The assembly line for his Model T Ford was an integrated production system that emphasised quality, efficient production and the avoidance of waste (Ford, 1998).

Ford's assembly line took the ideas of Gilbreth, of process analysis and controls one step further, the content and speed of production was taken out of the hands of the workforce. The intent was that the standard of quality of the product was guaranteed by the machines, a sub standard product would not pass through the various processes because the machines were so good.

The production system that he designed allowed Ford to recruit low skill and hence low cost labour for the majority of tasks. Ford's mass production techniques allowed the motor car to become an affordable commodity, also it created a fundamental change in production management.

Prior to the assembly line a product as complicated as a motor car was built and assembled by craftsmen who would painstakingly manufacture and assemble the product. Quality was as much controlled by the skill and consciences of the craftsman involved as any inspection process. Craftsmen, managers and owners worked in close proximity and although not a classless society it was in a sense an integrated team with mutual respect for each other's roles and decision making powers.

The assembly lines changed this and individualised repetitive tasks isolated the workforce from management and in fact the human element became part of the component parts. Rigid time keeping and discipline was necessary to ensure continuous flow of the line.

As with Gilbreth, Ford believed that production techniques could apply universally (Ford, 1998). The manufacturing world adopted this and mass production assembly lines were developed across the commodities range.

After the First World War Henry Ford and Alfred Sloan of General Motors moved world manufacturing techniques from centuries of craft production led by firms in Europe to an age of mass production, as a result the United States dominated the world economy. Automobile manufacture remains the world's largest manufacturing sector.

After the Second World War automobile manufacturing was to spawn another system that moved production theory forward by a quantum leap.

Taiichi Ohno and Eiji Toyoda of the Toyota Motor Company in Japan developed the concept of the Toyota Production System (Shingo, 1989; Ohno, 1998). The companies that first took up and mastered this system all had their original base in one country, Japan (Balakrishnan, 2003).

The rise of this country as an economic powerhouse soon followed and the West is still trying to catch up with Japanese production.

Balakrishnan (2003), also states that though many western companies now fully understand the Toyota Production System, few if any have implemented it successfully.

Japanese companies have, however taken this system with them in the establishment of manufacturing bases for their product in other countries. The system combines the advantages of craft and mass production but avoids the high cost of the former and strict rigidity of the latter. This is achieved by employing teams of multi skilled workers at all levels of the organisation and using highly flexible and automated machines to produce volumes of products in enormous variety.

The Toyota Production System is also defined as Lean Production because compared to mass production it uses less of everything (Womack and Jones, 1996).

Also in comparison mass producers set limited goals, such as an acceptable level of defects or waste, lean producers in comparison set themselves up explicitly for perfection, referred to as “Zero Defect “.

Ohno (1998) as cited by Wren and Greenwood (1998) credited two concepts that were developed into the Toyota Production System. The first was Henry Ford's book, “Today and Tomorrow” published in 1926 that provided the basis of a manufacturing production system; the second was the supermarket operations in the United States observed during a visit in 1956. The supermarket concept provided the basis of a continuous supply of merchandise to store shelves.

Further the Toyota Production System is concerned with the whole process; this supports the view by Ballard and Howell (1994), that it is the whole process that must be considered.

Goals of the Toyota Production System, according to Monden (1998):

The Toyota Production System completely eliminates unnecessary elements in production for the purpose of cost reduction. The basic idea is to produce the kind of units needed, at the time needed and in the quantities needed. The system has three sub goals:

1. Quantity control, which enables the system to adapt to daily and monthly fluctuations in terms of quantities and variety.
2. Quality assurance, which assures that each process will supply only good units to subsequent processes.
3. Respect for humanity, which must be cultivated while the system utilises the human resource to attain its cost objectives.

Further views on modern production relevant to this research are:

The basic philosophy of the new production system according to the New Production System Research Association (Shinohara, 1998):

1. To seek a production technology that uses a minimum amount of equipment and labour to produce defect free goods in the shortest possible time with the least amount of unfinished goods left over.
2. To regard as waste any element that does not contribute to meeting quality, price or the delivery deadline required by the customer and to strive to eliminate all waste through concerted efforts by the administration, research and development, production, distribution, management, and all other departments of the company.

The organisational features of a lean plant according to Womack *et al*, (1990):

It transfers the maximum number of tasks and responsibilities to those workers actually adding value to the product on the line, and it has in place a system for detecting defects that quickly traces every problem, once discovered, to its ultimate cause.

First law of manufacturing, according to Plossl (1991):

In manufacturing operations, all benefits will be directly proportional to the speed of flow of materials and information.

Corollary 1: This law applies to every manufacturing business.

Corollary 2: The tightness of control of manufacturing activities will vary inversely with their cycle times.

Corollary 3: Any planning and control of manufacturing activities will be more effective with fewer problems causing slower rates of materials and information.

Corollary 4: Solving one problem which slows down or interrupts material or information flow will cost less and be more effective than efforts to cope with the problems effects.

Santos *et al*, (2002) state that definitions of the new production philosophy focus on the consolidation of just-in-time with total quality management and an array of other theories and practices such as total productive maintenance, visual management and re-engineering . Developments of these core ideas and theories have in particular been described as world class manufacturing, lean production and agile production (Womack and Jones, 1996; Shonberger, 1996).

2.3 Is construction unique?

The construction industry in South Africa has developed along the traditional management philosophy developed in the United Kingdom, which engenders

a conservative approach, tight disciplines and detailed administration procedures. Many within the construction Industry appear to consider it unique and see limited opportunity to learn from others or change its basic philosophy.

Construction, as any other industry, has its own particular mix of peculiarities; to place these peculiarities at a level where they are all determining seems however both logically and historically false. Technical change can continuously transform the physical content of any production process, making seemingly insuperable barriers either non-existent or easier to overcome (Ball, 1998).

It is argued that most of the peculiarities of construction also exist in other domains of engineering and thus, are subject to the same theoretical advancements (Koskela, 1992).

If we consider construction as a form of site production, what kind of production is construction? (Ballard and Howell, 1998a).

Koskela, (1992) lists the differentiating characteristics as: one of a kind nature of projects, site production, and temporary multi-organisation. They are expanded by Koskela (1992) as follows:

1. **One of a kind nature of projects:** The sheer uniqueness of a project is relative, the end user, client or owner will receive a product no one else has. Manufacturing and particularly motor car manufacturing is increasingly grasping this characteristic as it moves to producing instantaneously customer specified products (although variations on a theme).
2. **Site production:** Indicates a different geographical location per unit, this shares similar characteristics with extractive industry like forestry, deep sea fishing and mining. Also it differentiates construction from other members of the fixed position manufacturing category such as shipbuilding and airplane manufacture.

3. **Temporary multi-organisation:** In construction, temporary multi organisations are not unique. In fact the definition of a project now has no industry boundaries, “projects” now exist in all fields.

Koskela (1992) further argues that construction is not unique and suggests actions to reduce this uniqueness such as modular construction, prefabrication and the use of enduring teams.

Ballard and Howell (1998a) suggest that construction projects possess only two characteristics that define them:

1. **They belong to the category of fixed position manufacturing.**
2. **They are rooted in place.**

In summation construction is the design and assembly of objects fixed in place and possess the characteristics of site production, unique product and temporary teams (Ballard and Howell, 1998a).

Site production is merely part of the process and should be seen as such. To limit comparison between a fixed product manufacturing process such as the factory and a construction site would be limiting opportunities of improvement. It is advocated that the products whole development process be reviewed for inspiration and analogies to the construction process (Ballard and Howell, 1994).

Schmenner (1993) cited by Ballard (2005) considers projects as a type of production system locating them on one extreme (Figure 2-1). The products are unique and process pattern flows are “very jumbled”, challenges for management are indicated as scheduling and materials handling. It can be argued that all of the aforementioned characteristics are typical of a construction project.

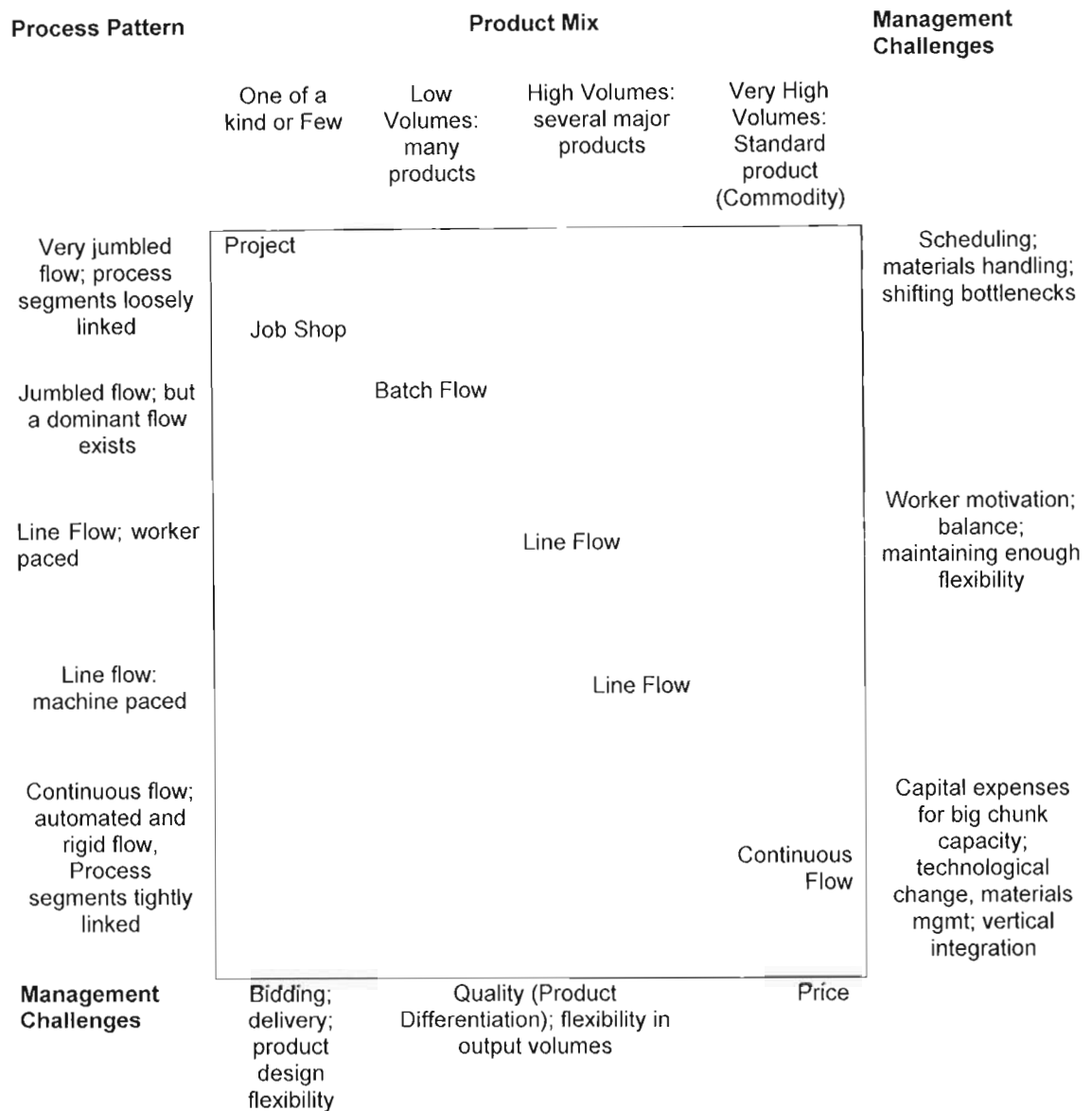


Figure 2-1: Types of Production Systems (Schmenner, 1993).

2.4 Summary

The research supports that the development of the scientific approach to production produced rigid structures typified by the assembly lines of Ford. In this form, production lost its human element and championed the process success based on the machines in use, low skilled and hence low cost labour was the order of the day. This rigid system dictated the customer's product

choice. Fords statement (Ford 1998) that “the customer can have any colour as long as it’s black” typifies this approach.

The Toyota Production System broke this mould providing product in enormous variety by utilising multi skilled teams of workers. This system combines the advantages of craft and mass production.

Construction fits into craft production and relies on skilled workers to carry out the difficult task on site as and when the process dictates.

It does not easily fit or has capability to adopt mass production but is a process that can accommodate multi skilled teams. As a project, construction cannot claim to be unique; projects now exist in all fields. It is a form of production and is considered justifiably linked to production management theory and practice.

CHAPTER 3: RESULTS OF THE RESEARCH

3.1 Introduction

It is the intention of this chapter to present the results of the research methodology in the format of definition, explanation, and summary relevant to the problem statement and objectives. The components of this chapter are:

Benchmarking.

Supply Chain Management.

Lean Production.

3.2 Benchmarking

Benchmark: "a standard or point of reference" (Concise Oxford Dictionary, 1995).

Benchmarking is a method of improving performance by a systematic process of comparing and measuring the performance of your key business activities against others, and using lessons learned from the best to make targeted improvements. It is a continuous activity of identifying, understanding and adapting best practice and processes that will lead to superior performance (KPIZone, 2003).

It involves answering three questions:

1. Who is better?
2. Why are they better?
3. What actions do we need to take in order to improve our performance?

The aim then is using this information to make changes that will lead to improvements in performance.

The best performance achieved in class is the benchmark. It is the best in class level of performance for a specific business process or activity, and is used as a reference for comparison and target setting (KPIZone, 2003).

3.2.1 What benchmarking is and what it is not according to Camp, (1990) :

Benchmarking is not a mechanism for determining reductions in resources, although this may occur. It could also be that the results of benchmarking require additional resources and expenditure due to correctly determined customer focus.

It is not a short term program to produce a result; it must be an ongoing management process that requires constant updating.

It is not a tick list of events to bring about success; it is a learning experience and a process of discovery.

Benchmarking is not a quick fix; it is a winning business strategy that can be continually adapted to achieve superior performance.

Benchmarking is a new way of doing business; it forces an external view to ensure correctness of the objective setting.

It is a new management approach; it forces constant testing of internal actions against external standards of industry practices.

It promotes teamwork by directing attention on business practices to remain competitive rather than personal, individual interest. It removes the subjectivity from decision making.

3.2.2 Objectives

Benchmarking when applied to a critical process is a powerful improvement tool for continuous improvement. Organisations from all sectors of industry have found that benchmarking can lead to significant improvements to performance and competitiveness (CBP, 2004).

Examples are:

- Increased customer satisfaction.
- Greatly improved productivity.
- The knowledge that your organisation compares against acknowledged world leaders.

3.2.3 Practice

Benchmarking is best applied to critical issues. Before starting to benchmark, it should be established what the mission or objectives are as an organization and the factors that determine success (KPIZone, 2003).

This analysis is used to identify the critical activities which must be performed at the very highest level and benchmark them.

3.2.4 Types of benchmarking

The construction best practice organisation (CBP) in the United Kingdom defines three types of benchmarking.

1. **Internal:** by comparison of internal process or systems operations, within the same organisation (Bendell *et al*, 1998). Internal benchmarking is relatively easy to carry out but may not yield high levels of innovation, although it can yield significant cost savings.
2. **Competitive:** a comparison against a specific competitor for the product, service or function of interest. Information obtained from competitors or large organisations can be misleading (Bendell *et al*, 1998). This form of benchmarking is difficult as access to data is often not easy to obtain (Fisher, 1996). Success relies on open cooperation and mutual respect.
3. **Generic:** a comparison of business functions or processes that are the same regardless of the industry or location, it is most accurately described as Best in Class (Fisher, 1996). Generic benchmarking can reveal high levels of innovation, but the ideas may be difficult to implement in a new environment.

In addition to the above, Fisher (1996) also identifies functional benchmarking.

Functional: (non competitive) involves comparing unrelated industries or organisations that exercise similar functions.

Benchmark Method	Relevance	Ease of Data Collection	Likely Innovation
Functional	Medium	High	High
Internal	Medium	High	Low
Competitive	High	Low	Medium
Generic	Medium	Medium	High

Table 3-1: Types of benchmarking.

In Table 3-1, the researcher indicates and compares the types of benchmarking, there is no best method and the route an organisation takes in many cases is determined by the information it decides to collect.

Benchmark information can be obtained from a variety of sources:

- Desk research can provide data industry reports and publications.
- Existing contacts within supplier's customers and other contacts may be willing to participate in a benchmarking exercise.
- Sector performance reports are often published by trade associations.
- Benchmarking partners, someone who perceives a mutual benefit from participation in a benchmarking exercise.

3.2.5 Five steps to successful benchmarking, (CBP, 2004) :

1. **Plan:** clearly establish what is to be improved, make sure it is important to you and your customers also determine the data collection methodology to be used.
2. **Analyze:** Gather information and determine the current performance gap against a competitor, the industry or internally, identify the reason for the difference.
3. **Act:** Set performances targets, and then develop and implement improvement plans to meet them.
4. **Review:** monitor performance against the performance targets.
5. **Repeat:** Repeat the whole process, benchmarking needs to become a habit if you are serious about improving performance.

3.2.6 Key performance indicators

A key performance indicator (KPI) is the measure of performance of an activity that is critical to an organisation. KPI's will differ depending on the nature and objective of the organisation. Regular measurements using appropriate KPI's can enable an organisation to communicate its performance targets and measure if it is achieving them (KPIZone, 2003).

Successful benchmarking requires management commitment to make tough decisions to base operational strategy and goals on a concentrated view of external environments. A company's management has to accept that internal operations cannot always have the best answer for every problem (Camp, 1990).

Ultimately it is not the process selected that determines the success of benchmarking. Benchmarking works best when organisations are willing to look outside their company and their industry for those ideas that, once adapted to fit their organisation and values can leapfrog them ahead of the competition.

3.2.7 Case studies

Table 3-2: Benchmarking Case Studies

Annexure	Title	Industry	Country	Format	Interviewee
1 (Page No.82)	Benchmarking Case Study 1: Galloway Group	Construction	UK	Study	
2 (Page No.87)	Benchmarking Case Study 2: Rover Body Pressings	Vehicle Manufacturing	UK	Study & interview	Chris Millard, Logistics Director
3 (Page No.89)	Benchmarking Case Study 3: Rank Xerox	Retail Services	UK	Study & interview	John Welch, Quality Manager

The case studies as listed above have been chosen to provide an overview on benchmarking applied in practice to the different industries of construction, vehicle manufacturing and retail services. They are congruent with the focus of the literature review, demonstrate the successful application of technique in different environments and establish common core principles.

Commentary on case studies:

Galloway Group:

Keywords: change, survey, customer satisfaction, communication, continuous improvement, training.

Galloway's initial data from benchmarking highlighted room for improvement in staff development and communication. They fully understood that change was needed and desired a structured approach which they felt benchmarking offered. The experience of working with Mace and client Glaxo SmithKline became the benchmark model and fuelled the change in the business.

The research indicates that predominately Galloway carried out a Generic type of benchmarking process as described by Fisher (1996) as Best in Class. This form of benchmarking can reveal high levels of innovation, but implementation of new ideas may be difficult to implement.

To start the process they approached a CBP advisor to help with the re-engineering of company. The whole of the company's staff take part in the process with the real investment in the time applied being championed by senior management of the company. Representatives from all levels of the workforce attend meetings with the management team on a regular basis.

Training and the focus on customer satisfaction is seen as areas for major improvement via investment of time and money and this is considered as a continuous improvement process.

Rover Body Pressings:

Key words: comparing, best practice, overall operation, process groupings, value, understanding.

One of the factors for Rover Group's decision to look outside at best practice was the introduction of Japanese car plants across Europe. They looked at organisations best at the key processes, inside or outside the motor industry.

Rover considered that you cannot benchmark the operation in total terms, but emphasis to be given to specific key processes which are the drivers of the enterprise. From his close involvement Chris Millard, Logistics Director advises that *"if you only benchmark an operation in total terms you will miss. You must examine and establish benchmarks for the processes which are the drivers in achieving the targets set for the overall operation. Also the absolute value of the benchmark is relatively insignificant compared to understanding how it is achieved"*.

This study is similar the Galloway Group study , as the research indicates that Rover undertook a Generic form of benchmarking, comparing business functions or processes that are the same regardless of the industry.

From the benchmarking process self directed teams have been established to improve their own processes.

Rank Xerox:

Key words: competitors, quality, customer satisfaction, improvement, performance.

Rank Xerox have shown that best practice companies to benchmark against must be considered from a wide range of industries as evidenced in the study of distribution. Their approach is considered a mix of Competitor, Generic and Functional Benchmarking that can result in high levels of innovation.

John Welch, Quality Manager explained *"we compared our distribution against 3M in Düsseldorf, Ford in Cologne, Sainsbury's regional depot in Hertfordshire, Volvo's parts distribution warehouse in Gothenburg and IBM's international warehouse in France"*.

As in the case of Galloway & Rover, part of Rank Xerox's solution was to benchmark the separate aspects of the business, they did this with competitors and against anyone else from which it could learn.

3.2.8 Conclusions of Benchmarking

Benchmarking can be applied to almost any business process either focussed or holistically. All industries can use benchmarking to improve performance (Bendell *et al*, 1998). The research indicates that it is best applied to all the functional aspects of a business; it is not a quick fix activity or a blitz technique to solve specific problems.

Embarking on the benchmarking process is a serious decision by the leadership of a business; it should be championed by senior management and have the cooperation and buy in of all employees. The success of the latter is not a given in the process, employees will be concerned about their positions and employment.

Programmes that drive change are often viewed with suspicion from employees who feel that they will become a cost cutting exercise and will lead to job cuts. Whilst it is possible that benchmarking and its results will highlight

redundant practices it should be stressed that the intent is to improve the business as a whole and ensure its sustainability and future growth.

This is a significant challenge for the senior management of the business and communication and transparency of all goals and objectives are required. Within a conservative business this will be a paradigm shift from the divide and rule principles that may be embedded in management style.

Without this shift in attitude the process is likely to fail, in fact the actual realisation and acceptance of full and participative communication can be argued as initial success factor in the process.

This point on communication cannot be over emphasised, and the climate must be created that it is a two way process between the senior managers, champions of the process and the general employees.

In certain circumstances it may be of benefit for leadership teams to seek outside advice on this element of the process, this is not to abdicate the responsibility of communication but to help get it right first time around .

Also the time frame should correctly reflect what is trying to be achieved, many businesses are driven by the calendar, yearly, half yearly, quarterly, monthly. It is suggested from the research that the time frame for successful implementation of the full benchmarking process will in fact take several years and that it also becomes a continual process within the business activity. It is in fact a continuous journey.

Benchmarking is based on comparing work systems (Fisher, 1996). The research shows that it is the whole process that counts, the A-Z practice and application is what brings about success. Ample time and senior management resources must be allowed to implement strategic and management changes.

The relevance of Key Performance Indicators is high; KPI's allow the measurement of the critical activities within an organisation. Also they are a clear communication of targets for the business to aim for. It is proposed that the utilization of benchmarking within the construction industry would produce

clear key performance indicators (KPI) that could become cornerstones in driving change and improvement.

3.3 Supply chain management

Supply Chain Management (SCM) is a concept that originated and flourished in the manufacturing industry. The first visible signs of SCM were in the Just-In-Time delivery system as part of the Toyota Production System (Shingo, 1989). This system aimed to regulate supplies to the Toyota factory just in the right amount, just in the right time (Vrijhoef and Koskela, 1999).

As cited by Vrijhoef and Koskela (1999) as early as 1950 in an address to Japanese industrial leaders Deming (1986) suggested that working with the supplier as a partner in a long term relationship of loyalty and trust would improve the quality and decrease the cost of production.

3.3.1 SCM defined

Supply chain management is an integrative philosophy to manage total flow of a distribution channel from the supplier to the ultimate user (Cooper and Ellram, 1990). Gattorna and Walters (1996) advocate supply chain management as evolving from distribution management followed by logistics management.

The supply chain has been deemed as the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer (Christopher, 1992).

Further definition by Gattorna and Walters (1996) concludes that in a very short space of time physical distribution management became logistics management and now in the more forward thinking companies this developed into supply chain management.

3.3.2 Objectives

An integrated supply chain focuses on the processes associated with the reduction of the total cost of the supply chain, including but not limited to design, procurement, inventory management and product installation. A totally

integrated supply-chain enables an end user to more effectively and cost efficiently manage manufacturing, inventory and manufacturing costs.

It is essential to get strategy right first. Managers can be unclear about which supply chain improvements can drive real advantage, which service enhancements customers will value and how to link their operations into suppliers and customers so that the whole supply chain is complete.

Cooper and Ellram (1993), as cited by Vrijhoef and Koskela (1999) advocate that SCM looks across the entire supply chain(refer Figure 3-1) rather than just at the next entity or level and aims to increase transparency and alignment of the supply chain's coordination and configuration, regardless of functional or corporate boundaries.

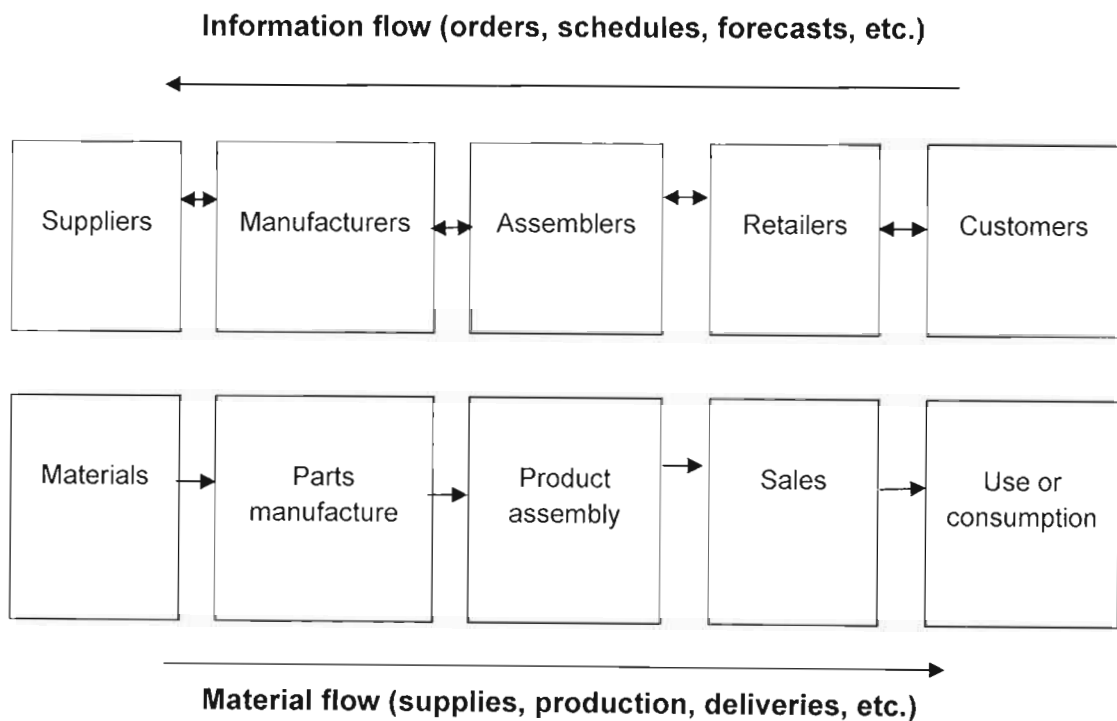


Figure 3-1: Generic configuration of a supply chain in manufacturing.

Vrijhoef and Koskela (1999).

In a true integrated supply relationship, the customer and the integrated supply partner analyse every aspect of the supply chain process, (acquisition, storage, logistics, installation, post shipment support, information systems,

etc.) and then streamline each component, eliminating redundancy of effort and cost, and improving service levels (Morris and Hough, 1987).

Approaches differ but a key method of supplier management is to reduce the number of suppliers bidding or pricing contracts. It has been effective in reducing the time periods to put out and assess bids, hence providing opportunities for cost savings. This has been referred to as supply chain pruning and is common in the United Kingdom and tends to be driven primarily by lowest cost (Tookey and Betts, 1999).

The threat of losing the contract to a lower cost producer can be the driving factor for a supplier. This is not ideal, the ability to develop partnerships with a manufacturer will be the key factor in a supplier being maintained; quality, delivery and cost are merely entry tickets to the process (Tookey and Betts, 1999).

Element	Traditional management	Supply chain management
Inventory management approach	Independent efforts	Joint reduction of channel inventories
Total cost approach	Minimize firm costs	Channel-wide cost efficiencies
Time horizon	Short term	Long term
Amount of information sharing and monitoring	Limited to needs of current transaction	As required for planning and monitoring processes
Amount of coordination of multiple levels in the channel	Single contact for the transaction between channel pairs	Multiple contacts between levels in firms and levels of channel
Joint Planning	Transaction – based	Ongoing
Comparability of corporate philosophies	Not relevant	Compatibility at least for key relationships
Breadth of supplier base	Large to increase competition and spread risks	Small to increase coordination
Channel leadership	Not needed	Needed for coordination focus
Amount of sharing risks and rewards	Each on its own	Risks and rewards shared over the long term
Speed of operations, information and inventory levels	“Warehouse” orientation (storage, safety stock) interrupted by barriers to flows; localized to channel pairs	“distribution centre” orientation (inventory velocity) interconnecting flows; JIT, quick response across the channel

Table 3-3: Characteristic differences between traditional ways of managing the supply chain and supply chain management (Cooper and Ellram 1993).

Referring to Table 3-3 above, the traditional way of managing is essentially based on a conversion or transformation view on production, whereas SCM is based on the flow view of production (Vrijhoef and Koskela, 1999).

Koskela (1992), cited by Vrijhoef and Koskela, (1999) states that the conversion view suggests that each stage of production is controlled

independently whereas the flow view focuses on the control of the total flow of production.

3.3.3 Leading practice

Supply chain is rarely viewed as a glamour job, but supply chain management leaders such as Wal-Mart prize the role. They recruit top people who can save millions of dollars with better forecasts, vendor strategies and execution (Cook and Jackson, 2002).

Best practice means managing multiple supply chains; Wal-Mart uses direct deliveries for products with rapid obsolescence and time to market pressure, putting other products through traditional distribution centres when velocity matters less than cost.

Wal-Mart is renowned for its ability to combine information from companies across their supply chain with demand and inventory data from its stores to minimize operating cost and reduce prices. This requires a lot from its suppliers and Nestlé USA for example, have created a Vice-President level position exclusively to manage business with Wal-Mart (Worthen, 2002).

Nissan's QCDDM supply chain management system is one of the most effective in the world. Suppliers are measured on Quality, Cost, Delivery, Development and Management against negotiated continuous improvement targets. For each element the supplier is marked on a range of product and process items which are aggregated on a weighted basis to give a performance percentage for that element. Competition is created across the supply chain by collating the performance information every month and informing each supplier of its performance in relation to the others. Constant improvement is an expectation of Nissan and its suppliers (Egan, 1998).

3.3.4 Case studies

Table 3-4: Supply Chain Management Case Studies.

Annexure	Title	Industry	Country	Format	Interviewee
4 (Page No.91)	Supply Chain Management Case Study 1: ChevronTexaco	Retail Oil industry	USA	Study & interview	Louie Ehrlich, CIO, Global Downstream
5 (Page No.96)	Supply Chain Management Case Study 2 : British Airports Authority	Construction	UK	Interview	Tony Douglas Group Technical Director

The case studies as listed above have been chosen to provide a view on supply chain management applied in practice. The industries chosen are oil & gas (fuel retail) and construction.

The ChevronTexaco case study provides a review and report of SCM from the standpoint of customer demand data and the use of this real time data as the driving force of the whole business strategy and day to day actions within the production and delivery segments of the operation. The process is customer driven and reinforces the core principle of customer driven decision making. The BAA interview is considered by the researcher as an excellent example of SCM in practice on a major project within the traditional construction environment.

Both studies are congruent with the focus of the literature review, demonstrate the successful application of technique in different environments and establish common core principles.

Commentary on case studies.

ChevronTexaco:

Key Words: cost-effective, sharing, technology, information, customer view, continuous improvement.

ChevronTexaco have taken their partnering philosophy further than most by understanding their customer demands and using this demand data to dictate its operations. Taking this customer focussed view has lead to driving cost from the supply chain, in a staged application the end user demand has now become the driver of all aspects of the ChevronTexaco business.

Louie Ehrlich, CIO for global downstream says that *"every time you make too much or too little of whatever it is, you're introducing cost into your supply chain"*. ChevronTexaco has used detailed consumer demand data to all but eliminate run-outs and retains (the industry term for a delivery aborted because a tank is too full) the Industry's twin evils.

ChevronTexaco's investment into the process and the long term view has paid off, the investment in technology and sharing data within the operation are key success factors. Such investment is a direct action from the philosophy of continuous improvement.

British Airports Authority:

Key words: framework, continuous improvement, respect, trust, value, commitment.

The BAA interview is clearly aligned to construction and demonstrates the fundamentals of traditional supplier management moving to supplier partnering with mutual benefits. Key issues demonstrated are that framework agreements have been developed for 10 year periods, this shows commitment and trust and such periods allow certainty in planning and investment of time and capital into the process. The management of relationships and the climate of teamwork and partnering for mutual benefit are crucial to the planned successes that, if achieved, will breed further success in the future.

Systems' thinking is also present in the process, an example is BAA and their analysis that under traditional conditions a 40 ft truck would pass through the gate every 40 seconds for 4 years in the construction of Heathrow Terminal 5.

A traditional problem solution approach could be considered as follows:

- Have more gates.
- Have more on site storage.
- Deliver 24hours 7days a week.
- Employ more material handling resource.

BAA systems thinking approach is to design solutions of pre assembled products, this will not only cut down deliveries but also the level of personnel required dealing with the final assembly into position on site. This concept could arguably be exportable to any construction environment.

This case study highlights the importance of the involvement of people in the process and that trust and respect are important components of success.

3.3.5 Conclusions of SCM

Supply chain management is an activity that is applied upstream of a process, through a process and downstream of a process.

The motor manufacturing industry has developed sophisticated models of supply chain management with component part manufacturers and established strong partnerships. These partnerships are based on mutual trust and respect and in some instances no formal contract exists. Just- in- time principles rule, as does quality and cost effectiveness, continual monitoring is present on measured deliverables.

Also within the motor manufacturing industry supply chain management is present through the production process itself.

On the downstream side companies like Wal-Mart have revolutionised how a product gets to and stays as short as possible in their stores by prioritising delivery and storage processes. Key to this activity is up to date demand data and information technology has played a major role in this regard.

A significant point evidenced in the successful supply chain management is clearly the willingness of a company to share information about itself with its supply chain partners. This is a fundamental shift from protecting your

information from suppliers or partners because they may use it against the source. Sharing information internally as demonstrated by ChevronTexaco can bring about major improvements in efficiency and cost.

Information technology has key roles to play across all aspects of supply chain management. The recurring theme of continuous improvement is possibly no more prevalent than in the application of IT and its impact on real time data collection and communication demonstrated by Wal-Mart and Chevron Texaco.

It can be said that in construction the supply chain is re invented with each project and hence difficult to advance. The researcher considers this to be only partly correct and that it is the enterprise and not the project that should be considered the partner in the supply chain. Further, this can be compared to the motor manufacturing industry and its demand for new models, hence each new model can be considered as a new project.

Many components or elements will fundamentally remain unchanged, so will the assembly process. The elimination of waste and hence associated cost are key issues in SCM, supply chains are fluid mechanisms and need the attention of continuous improvement to stay, leading edge.

3.4 Lean production

3.4.1 Lean defined

"The first thing you learn about lean manufacturing is that it is a journey that you set out on upon, toward a destination you'll never quite reach". (Phillips, 2000 pp. 22).

The Production System Design Laboratory (PSD), Massachusetts Institute of Technology (MIT), considers that lean production is aimed at the elimination of waste in every area of production including customer relations, product design, supplier networks and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible.

Lean manufacturing, so called because it resulted in fast assembly times, low material waste and volume outputs to suit the changing market requirements, was first recognised on the automobile manufacturing line at Toyota in Japan. The extension of these ideas to the business environment was termed lean thinking; its central theme is value (Womack *et al*, 1990).

An organisation must understand the real value it delivers to its customers and do so in the most effective way making best use of world resources and its people. According to Womack *et al*, (1990), the organizational features of a lean plant transfer the maximum number of tasks and responsibilities to those workers actually adding value to the product on the line, and it has in place a system for detecting defects that quickly traces every problem, once discovered to its ultimate cause.

3.4.2 Objectives

The main objectives of lean manufacturing are presented as follows (Womack *et al*, 1990):

- Increase capacity.
- Improve lead times.
- Improve quality.
- Increase productivity.
- Reduce cycle times.
- Reduce inventory.
- Reduce changeover time.
- Reduce costs.

3.4.3 Practice

In practice this means subjecting an organisation, its processes and people, to a close scrutiny aimed at identifying value, and studying existing work processes to remove the waste that causes value being effectively denied.

Adopting lean thinking can result in a highly flexible, profitable company but the process to achieve it requires radical change and takes a number of years (CBP, 2003).

The Construction Best Practice Programme (CBPP) in the United Kingdom suggests there are principles to guide the change process:

- Identifying value from the point of view of the customer.
- Understanding the value streams by which value is delivered.
- Achieving flow within work processes as waste is removed.
- Achieving pull so that nothing is made/delivered until it is needed.
- Perfection recognising that improvement needs to be constantly sought.

CBPP further suggests that these principles can be applied at a number of levels, for example in the construction environment they can be applied as follows:

- By an individual design company who recognises its clients to be both the owner of the buildings and those downstream in the design and construction process.
- By an individual component supplier who delivers value through their component products e.g. bricks, concrete, etc.
- By a PFI organisation that provides value to different clients through the provision and operation of a building product e.g. a hospital or a prison.
- By a group of companies who provide value to various clients through the provision of a building product e.g. city office space.

3.4.4 Benefits

The benefits of adopting lean thinking can be:

- Making good profit margins whilst contributing to improving the social infrastructure by protecting the environment and respecting the people who work for you.
- Creating an industry for the future that attracts young and vibrant people to carry it forward.

3.4.5 Lean production is not mass production

It is important to separate lean production from mass production. Mass production models are rigid structures that focus on exploiting economies of scale, they have organisational hierarchies that tend to condemn the workforce to do similar boring tasks day in day out. The reliance is totally on the equipment and the process facilities and not on any human innovation or capacity, the work force is usually unskilled and unmotivated.

Lean manufacturing is focused more on its customers than it is on big machines. The lean enterprise is a flat team based structure with a high degree of autonomy that has broken down organisational barriers and develops highly trained, motivated employees who identify problems and find solutions as part of their jobs.

The following Table 3-5 demonstrates the fundamental differences between mass and lean production.

AREAS AFFECTED	MASS PRODUCTION	LEAN ENTERPRISE
Business strategy	Product-out strategy focused on exploiting economies of scale of stable product designs and technologies.	Customer focused strategy focused on identifying and exploiting shifting competitive advantage.
Organizational structure	Hierarchical structures that encourage following orders and discourage the flow of vital information that highlights defects, operator errors, equipment abnormalities, and organizational deficiencies.	Flat structure that encourage initiative and encourage the flow of vital information that highlights defects, operator errors, equipment abnormalities, and organizational deficiencies.
Operational capability	Dumb tools that assume an extreme division of labour, the following of orders and no problem solving skills.	Smart tools that assume standardized work, strength in problem identification, hypothesis generation, and experimentation.

Table 3-5: Comparison of requirements for mass production and lean enterprise.

Dr. Thomas Jackson, beyond the pilot project: an essay on becoming lean. Presented at the 4th annual best of North America conference, in St. Louis Missouri, October, 1999.

3.4.6 The Toyota Production System

It is widely acknowledged that lean manufacturing was born on the production lines of automobile manufacturer Toyota, in Japan (Monden, 1998; Womack *et al*, 1990).

In order to produce world-class, quality automobiles at competitive price levels, Toyota developed an integrated approach to production which

manages equipment, materials, and people in the most efficient manner while ensuring a healthy and safe work environment.

The Toyota Production System is built on two main principles: "Just-In-Time" (JIT) production and "Jidoka", the assurance of top quality. Underlying this management philosophy and the entire Toyota production process is the concept that "Good Thinking Means Good Product".

The Toyota production system completely eliminates unnecessary elements in production for the purpose of cost reduction. The basic idea is to produce the kind of units needed, at the time needed and in quantities needed (Monden, 1998).

Terminology used within the Toyota Production System has found its way into most lean practices and is the cornerstone of successful transference into diverse field of manufacturing and production. Definitions of its two main principles are as follows:

The "**Just-In-Time**" production philosophy is the foundation of the Toyota process. This concept refers to the manufacturing and conveyance of only what is needed, when it is needed, and in the amount needed. In addition, a minimum amount of inventory is kept on hand. This enhances efficiency and allows quick response to change. It can also be argued that JIT spawned what in present day has developed as supply chain management.

The assurance of top quality for Toyota's automobiles is maintained through "**Jidoka**". This defect detection system automatically or manually stops the production operation and / or equipment whenever an abnormal or defective condition arises. Any necessary improvements can then be made by directing attention to the stopped equipment and the worker who stopped the operation. The Jidoka system shows faith in the worker as a thinker and allows all workers the right to stop the line on which they are working.

3.4.7 Case studies

Table 3-6: Lean Production Case studies

Annexure	Title	Industry	Country	Format	Interviewee
6 (Page No.99)	Lean Production Case Study 1 : Boeing Corporation	Aerospace	USA	Study	-
7 (Page No.101)	Lean Production Case Study 2 : Hathaway Roofing	Construction	UK	Study	-
8 (Page No.105)	Lean Production Case Study 3: Toyota Industrial Equipment Manufacturing	Vehicle Manufacturing	USA	Study & interview	Bruce Nolting, VP, Purchasing, Production Control & Sales

The case studies chosen cover the aerospace, construction and vehicle manufacturing industries. They are congruent with the focus of the literature review and provide evidence of success in lean production and lean thinking. Collectively they demonstrate common core principles in action in industries that are considered different and hence evidence that best practice is transferable and usable in diverse business applications.

Commentary on case studies.

Boeing Corporation:

Key words: self directed teams, best practice, benchmark, continuous improvement, flow.

Boeing's new successful missile manufacturing facility illustrates the involvement of self directed work teams who take part in every process from unloading raw goods deliveries, through manufacturing to packing the finished products. To these employees the whole system is visible because they operate in all areas.

The company is following a continuous improvement philosophy and before they set out to create a lean assembly plant benchmarked against other

facilities and studied best practices to follow and incorporate. They have followed the principles of flow of the line and its philosophy of multi-skilled workers responsible for the whole product including packing and shipping.

Hathaway Roofing:

Key words; benchmarking, improvement, continuous improvement, transformation.

Hathaway roofing have also started with a benchmarking process by comparison with the automotive industry. Further it is seen that the whole process has been addressed including packaging, an area that Boeing also targeted for improvement. Customer liaison and consolidation of relationships with customers brought Hathaway into the customers supply chain as a partner. The implementation of "lean" within the business was recognized as a long term goal with a four year period set as a timetable for transformation .

Outside facilitators were utilised to help managers and training was introduced at all levels .Continuous improvement was a major theme within the new lean organisation , this resulting in the lean steering group at the outset of the process being transformed into a continuous improvement group.

Toyota Industrial Manufacturing Equipment:

Key words: kanbans, flow, training, teamwork, quality, customer.

TIEM have the Toyota Production System as the foundation of its manufacturing facility. Getting the components in the right place at the right time is key and this application of supply chain management is a strong theme running through this plant. It is initiated by kanban cards and keeps the flow of the line.

Bruce Nolting, Vice President for Purchasing, Production Control and Sales says *"we have a pull system; we receive raw materials on one end and pull the product through final assembly and on to the customer"*.

Also evident are multi skilled self directive work teams and continuous improvement driven by TIEM improvement groups made up of volunteers.

To help assure that there are quality products each and every time, the people at TIEM are well trained. During an associate's first week with the company, all 40 hours are spent in training. This training and the focus on quality are crucial elements of the plants success, so is teamwork, everyone is involved in getting the job done correctly.

3.4.8 Conclusions of Lean Production

The lean production model aligns action or tasks to produce value for the customer. The people involved in this process fully support this value proposition and are committed to continued improvement.

In the context of construction, Ballard and Howard (1998b) advocate that implementing lean production does not require making construction into manufacturing by standardising products, rather the implementation starts by accepting the ideal of perfection offered by lean principles and understanding the application of each principle and technique to construction.

The key to success is the involvement of people in the whole process and customer pull. Trust of the employee to "stop the line" and for their decision to prevent defective work moving downstream indicates a fundamental respect for humanity which has origins in the east.

Transparency prevails, which means that the whole system is visible to employees so that their decisions taken in isolation support the objectives of the whole system.

CHAPTER 4: THE SOUTH AFRICAN CONSTRUCTION INDUSTRY ENVIRONMENT

4.1 Introduction

This chapter reviews the current South African construction industry environment, including a global perspective, local review, capacity and capability within the industry, government's present role and influence, HIV Aids and Black Economic Empowerment.

4.2 Global perspective

Construction constitutes more than half the total national capital investment in most countries, and construction can amount to as much as 10% of GDP. It is estimated that the industry employs 111 million people globally and accounting for almost 28 percent of all industrial employment, is the largest industrial employer worldwide (Van Wyk, 2003).

Construction accounts for 7 percent of total employment with 75 percent of all construction workers found in developing countries (Van Wyk, 2003).

In most developing countries the broad strategic aim of construction industry development is the creation of an enabling environment, in which sustainable domestic capacity is expanded to meet demand, to promote national economic and social objectives, improved efficiency, competitiveness and value to clients and society (CIDB, 2004).

Growth is one of the most effective ways of reducing poverty, and infrastructure development is one of the key pillars of economic growth (CIDB, 2004).

Providing a developing country with good infrastructure along with other drivers of growth, better health and education services, a positive investment climate and good governance that respects property rights and is corruption free, is central to the mission of reducing poverty (World Bank, 2003).

4.3 South Africa

The construction industry in South Africa has faced some serious challenges, decline in skills, poor delivery, poor quality and low profit margins.

Compounding these challenges has been the rapid globalisation of the South African economy. Large South African contractors in particular have increasingly expanded into offshore markets to grow revenues and to survive economic recession. This has meant that South African contractors had to be more competitive to match the level of performance of their counterparts operating in international markets (Dlungwana *et al*, 2002).

Also a number of major foreign contractors that have attempted to establish a foothold in South Africa have left after facing the tough local competition and conditions (Amod *et al*, 2002).

The recent accelerated expansion of the South African business enterprise into global markets underscores the inherent capability and potential of the country. This includes the ownership, extraction and beneficiation of natural resources; the manufacture and distribution of consumer products; the provision of financial and technical services; the export of sophisticated engineered and manufactured machinery, equipment and products; and engineering and construction services (Bruce, 2003).

South Africa is fortunate to have a well established contracting sector as part of its construction industry, notwithstanding this fact, there are many serious challenges still facing contractors (Dlungwana *et al*, 2002).

The following Table 4-1 illustrates the formation of the contracting structure in South Africa and highlights the challenges in management and skill levels.

CATEGORY	ECONOMIC SECTOR	ANNUAL TURNOVER	MANAGEMENT SKILLS LEVEL
SMALL	FORMAL INFORMAL	LESS THAN R10M	VERY POOR & FAIR
MEDIUM	FORMAL INFORMAL	R10M-R50M	POOR, FAIR, GOOD & VERY GOOD
LARGE	FORMAL	ABOVE R50M	FAIR, GOOD & VERY GOOD

Table 4-1: Structure of the Contractors in South Africa, (Dlungwana *et al*, 2002).

In 2002 the amount spent on construction related activities amounted to 5.1% of GDP up from 4.9% in 2001 (CIDB, 2004). The construction industry is the third largest employer in South Africa providing work for over 500,000 people; it will potentially have to double over the next ten years to meet investment demand (Sigcau, 2004). This indicates a turning point for the industry which is set to continue underpinned by a strategic increase in government spending and the 2010 soccer world cup.

The Construction Industry Development Board (CIDB) (2006) state that the construction economy in South Africa is now set for a decade and more of sustained growth and hence there is an urgent need to develop quality contracting capacity and skills to achieve the following:

- Growing capacity to deliver South Africa's infrastructure.
- Improved performance of contractors to deliver South Africa's infrastructure.
- Sustainable empowerment and sustainable enterprises as the basis for improved employment and skills development.

4.4 Capacity and capability.

The South African construction industry embodies features of both the developed and developing economies. The challenge is to narrow the gap and to raise overall performance.

Declining investment of the past 25 years has led to a depletion of contracting capacity and, technical, supervisory and artisan skills, requiring a renewed focus to boost construction capability (CIDB, 2006).

South Africa's productivity remains low, Van Wyk (2003) advises that a survey undertaken by Proudfoot Consulting in 2003 found that South African businesses used only 59% of their time productively, reasons were identified as:

- Poor planning and inadequate management (46%).
- Inadequate supervision (26%).
- Low morale (11%).
- Inappropriately qualified people (9%).
- Information technology problems (7%).
- Poor communication (6%).

The sustained growth predicted indicates that South Africa's construction output will need to double within the next 10 years.

Leading South African construction companies compete with the world's best. Eight listed companies account for about 23 percent of South Africa's total output; approximately 50 percent of their work is undertaken cross-border, reflecting their global competitiveness. Off-shore work on major projects enables these companies to consolidate specialist expertise that is then readily available to the South African market (CIDB, 2004).

Materials can constitute as much as 60 percent of the total project costs, South Africa produces virtually all of its strategic materials, with manufacturers generally only supplying direct to very large projects with the rest of the market serviced via retail companies.

This local production and supply capability provides a cornerstone to the growth aspirations of the industry as a whole. This local capacity can provide excellent opportunities for the development of a more sophisticated link to the supply chain, long term supplier relationships and improved efficiency.

4.5 Government

The South African Government has clearly recognised the importance of the construction industry and a number of programmes are underway to facilitate development (Amod *et al*, 2002).

In his State of the Nation address of 2003 President Thabo Mbeki highlighted the significance of infrastructure delivery to social development and growth of the South African economy;

“Further improvement in the quality of lives of our people also requires that we take new measures to increase the volume and quality of our investment in social infrastructure.

This includes such areas as housing and municipal infrastructure, hospitals and clinics, schools, roads, water, electricity and government facilities. In all areas we must improve our performance relative to the previous year.

Accordingly, additional resources will be set aside to meet this obligation. We will ensure that these resources are actually used, consistent with what we have said about the need to ensure that we have the necessary mechanisms to implement our policies and decisions”.

Finance Minister, Trevor Manuel’s Budget Speech, (National Treasury, 2004) further reinforced governments commitment to infrastructure investment;

“We recognise that the pace of economic growth has to be accelerated, investment in industry and infrastructure and an expansion of job opportunities are critical challenges for the decade ahead”.

This research considers that the most influential document expressing government policy towards the construction industry is to be found in its White Paper for construction.

The, Department of Public Works (1999), White Paper sets out government's vision for an enabling strategy aimed at enhanced delivery, greater stability, improved industry performance, value for money and the growth of the emerging sector. Government states:

"Our vision is of a construction industry and strategy that:

- *Promotes stability within the industry.*
- *Fosters economic growth and international competitiveness.*
- *Creates sustainable employment.*
- *Addresses the historic imbalances as it generates new industry capacity for industry development".*

The White Paper identifies the lack of best practice standards within the construction industry as a key constraint to industry performance and as cited by Smallwood (2002) highlights the following as the key approaches towards enhancing industry performance.

- A partnering approach.
- Participative management and workplace forums.
- Alternative dispute resolution.
- Quality and productivity improvement programmes.
- Procurement – related measures to promote health and safety.
- Environmental protection.
- Human resource development.
- The integration of the design and construction processes.

- The establishment of best practice performance standards and participative management techniques.

The South African construction industry has the advantage that government views the industry as a national asset to be developed, maintained and transformed (Van Wyk, 2003; MBSA, 2004; CIDB, 2006).

South Africa is witnessing increasing levels of investments in infrastructure driven by its commitment to economic and social development. All spheres of government and state owned enterprises are challenged to increase the pace and efficiency of construction delivery (Pautz et al, 2003). In this context the Construction Industry Development Board believe that the introduction of supply chain management principles will support improved procurement efficiency and predictability to the benefit of both the client and the industry. It is believed that the introduction of supply chain management will provide huge benefits (CIDB, 2004).

It is clearly evidenced that government is proactive in facilitating change in the industry and supports this by legislation. The following are the main acts passed by government that have a positive influence on the development and growth of the South African construction industry which has also been underpinned by the Government White Paper (1999).

Government legislation impacting on the industry:

- Labour Relations Act, No 66. 1995.
- Employment Equity Act, 1998.
- Department of Public Works (1999), White Paper: Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry.
- Preferential Procurement Policy Framework Act, 2000.
- Council for the Built Environment Act, 2000.
- Construction Industry Development Board Act, 2000.

- 2003 regulations in terms of the Occupational Health and Safety Act, 1993.
- Broad – based Black Economic Empowerment Act, 2004.

4.6 HIV/Aids

A review of the construction industry in South Africa cannot ignore HIV/Aids.

The highest levels of new infection are reported as occurring on the African continent, the fight against HIV and Aids in the workplace has become an African priority (Haupt *et al*, 2005).

The HIV/Aids epidemic in South Africa represents a serious threat to the skills base of the construction industry (Gymah *et al*, 2002).

Aids deaths lead directly to the reduction in the number of workers available, these deaths occur to workers in their most productive years. As younger less experienced workers replace these experienced workers productivity is reduced (Bollinger and Stover, 1999). Given the predicted growth in the sector any threat to an already depleted skills base cannot be ignored and must be given the highest priority.

Government legislation in 2002 and 2003 in terms of the Occupational Health and Safety Act, 1993 that regulate the construction industry has helped raise awareness, however recent studies by Haupt *et al*, (2005) indicate much is still to be done.

Responsibility lies within the employer organisation and HIV/Aids awareness and education programmes must form part of best practice within the industry.

4.7 BEE: Black Economic Empowerment.

Empowerment in the South African construction industry has been largely driven by the affirmative procurement process.

Empowerment in the JSE listed construction sector is a key challenge. BEE wealth in this sector represents 9% of the entire sector, amounting to R1.3.bn. Of the 16 listed entities, 14 are non-BEE companies and two are BEE-influenced companies (CIDB, 2004).

Three companies, PPC, Murray & Roberts Holdings and Aveng represent over 70 percent of the total market capitalisation and generate over 60% of market revenue.

BEE ownership of total share capital in the 3 largest construction and engineering companies is indicated as follows:

Murray and Roberts Holdings 10%

Wilson Bailey Homes Ovcon 15%

Aveng subsidiary Grinaker – LTA 25%

Although the industry's major players continue to address BEE targets it is understood that government considers that the industry as a whole has a long way to go to achieve full transformation (CIDB, 2004).

Review of the literature indicates current initiatives by government are to reach agreement with industry on targets that will promote growth of sustainable broad based empowerment and skills development and it is considered that industry has a positive outlook on future opportunities for BEE.

4.8 Conclusions of the South African construction industry.

The South African construction industry faces possibly the most significant challenge of its history with a predicted decade or more of sustained growth. The review indicates that the industry recognises this challenge to grow capability and capacity as well as addressing Black Economic Empowerment and the HIV/Aids pandemic. This growth is seen as sustainable well beyond 2010 and the delivery of high profile projects associated with the soccer world cup such as stadiums and the Johannesburg Light Rail project.

South Africa is a rapidly developing nation driven by a commitment to economic and social development and as such demands continued growth of infrastructure, services, commercial developments and housing. Most important for the industry is the recognition by government that it is an essential national asset and hence it is strongly supported to achieve these objectives.

CHAPTER 5: ANALYSIS and DISCUSSION

5.1 Introduction

The International Motor Vehicle programme with its headquarters at the Massachusetts Institute of Technology (MIT) carried out a worldwide benchmarking study in the nineteen eighties, investigating companies from Europe, Japan and North America as well as South Africa, Australia, Brazil and Korea.

One of their main findings was that best plants worldwide had common characteristics and practices. These companies were able to produce more products with higher quality but with fewer resources (Womack *et al*, 1990).

It is the intent of this section of the dissertation to review the literature and case studies presented in a format that highlights core elements, common characteristics and best practice, discusses them in line with questions posed and conclusions that can be drawn.

5.2 Common core principles

The following are considered common core principles and characteristics across the three subjects of the research, Benchmarking, Supply Chain Management and Lean Production

5.2.1 Close scrutiny of existing structures and performance.

Early production theorists and practitioners F.W. Taylor and F.B. Gilbreth commenced their work with studies of existing practices and used this analysis as a basis for improvement. In Gilbreth's (1911) most famous study he analysed the movements of a bricklayer and reduced them from 18 to 5.

Scrutiny of existing structures and performance is a starting point of self examination and will be a difficult process for the people involved but considered essential for improvement. A company's management has to accept that internal operations cannot always have the best answer for every problem (Camp, 1990).

Hathaway Roofing (annexure 7) had their steering group review the value stream of the organisation to identify “blockages”, i.e. areas where people felt hindered in their work. These blockages were analysed and prioritised into project topics with project leaders assigned to each topic.

In the process everyone involved will be tested and there may well be redundancies, this is the difficult first step on the way to improvement.

Revaluation takes time and input from all involved, for success it needs the drive of executive management and champions of the process. It also needs positive involvement from all levels within the business, communication is a key factor.

5.2.2 People involvement

Tony Douglas of BAA (annexure 5) states that *“this is not a soft option, everyone has to invest time and effort and positive commitment to understanding each other’s cultures, structures, systems, processes, strengths and weaknesses. Tangible benefits come from the bond of people having a mutual desire to do things differently.”*

It is essential to obtain the commitment of senior management who need to instigate and champion new initiatives. Authority should be given to department managers to encourage their teams to put forward their ideas on improvements, to review ideas generated and implement those with potential.

Flat structures encourage initiative and encourage the flow of vital information that highlights defects, operator errors, equipment abnormalities and organisational difficulties. The introduction of a mechanism for staff consultation and feedback from all areas of the organisation is a key success factor. For example, Hathaway Roofing (annexure 7) set up a steering group of middle managers and representatives from all parts of the company including the factory floor. Great progress was made in resolving problems which were mainly due to flow and a positive attitude towards continuous improvement became evident in all departments.

To communicate the aims of all initiatives of all staff, and emphasis that all suggestions for improvements will be taken seriously. Galloway Group (annexure 1) introduced a memo explaining the process and objectives of the benchmarking process and the staff reacted positively to the benchmarking exercise

Respect for all participants in the process is prerequisite as is a learning environment and a no blame culture based on interdependence and trust. The process of benchmarking underscores this by promoting teamwork and by directing attention on business practices to remain competitive rather than personal individual interest.

The successes of individuals does not compare with successes of integrated teams, nowhere is this more credible than within the Toyota Production System. Employees become knowledge workers regardless of the tasks they perform, it is critical to promote this ideal and continually reinforce it.

5.2.3 Respect for humanity

Involvement and trust of people to add value to the system via the sharing of responsibility for improvement with employees is one of the core heuristic implementation approaches advocated in the research. One of the three sub goals of the Toyota Production System is respect for humanity, which must be cultivated while the system utilises the human resource to attain its cost objectives. The Jidoka system shows faith in the worker as a thinker and allows all workers the right to stop the line on which they are working (Monden, 1998).

This sharing of responsibility and indolent is a key thread within the theory of the learning organisation and is a core initiative within top best practice companies worldwide.

5.2.4 Training

It is better to retain and retrain than to recruit, the research shows that successful organisations create an enterprise wide "learning organisation environment" that fosters personal development.

In times of economic squeeze training budgets are usually hit hard, for a sustainable business continued investment in training is essential. Best practice studies show that enterprises that continually train and develop their people are the leaders that others will always have to follow.

Rank Xerox (annexure 3) had a very low training expenditure and this reflected the low priority given to staff development by the previous management, with limited training on the job and very little externally sourced instruction. As part of the improvement process Rank Xerox introduced targeted budgets for broad based training initiatives.

At the Boeing Corporation (annexure 6) each mechanic does every job, from unloading raw goods, to assembly, to packing the finished product in collapsible and reusable bar-coded containers for shipping. Members of integrated teams are multi skilled and hence multi-task, they help each other to improve and therefore improve the process.

Workers at Toyota Industrial Equipment Manufacturing (annexure 8) are cross-trained in order to maintain flexibility; the approach is for the individual to first learn the jobs of the people who work on either side of them, the supplier or the customer in the manufacturing sequence.

Training does not always have to be formalised chalk and talk lectures or courses that are “time out activities” In many instances it can be one member of the integrated team showing another member a particular task or skill. What is clear is that training has to become a continuous process that involves all individuals.

5.2.5 Change and change management.

Many long established businesses may appear to have a built-in conservatism. The reason for this state of affairs is to be found in a typical characteristic of organisational life; regularised patterns of behaviour resulting in acting in an organised manner. Often these patterns of behaviour lead to the view that stability is a necessary condition for survival. Change or transformation on the other hand is regarded as the destruction of regular patterns of behaviour.

Moerdyk and Fone (1987) advise change that interferes with normal patterns of work, will generally be resisted as old habits and routines have to be unlearned and new ones acquired. CBP (2003) advocate that adopting lean thinking can result in a highly flexible, profitable company, but the process to achieve it requires radical change and takes a number of years .

Organisations should not be reluctant to get help with the process, external facilitators and consultants can help this process in many ways to achieve the goals and objectives in a cost efficient manner.

Within a change process there can be a tendency for the need to demonstrate short term gains, this may in some cases be at the expense of long term improvement. However, early positive results even minor in nature are necessary to fuel the process, and should be broadcast loudly.

Short term solutions may not be sustainable, it is necessary to adopt a realistic time frame to implement change and keep it as the only constant. The time frames to be considered are to be measured in several years; also once fundamentals have been determined the process has to become continuous. Hathaway Roofing (annexure 7) began their lean transformation process by accepting that it could take up to four years.

The acceptance of change by the industry is a major hurdle, Senge *et al*, (1994) state that there are four levels of change: events, behaviour, system and the mental model.

Industry has traditionally continued to operate and put energy into changes in system and behaviour, there is a problem, and it is solved by a change in the procedure (activity).

Change needs to be driven and understood at all levels, as well as internally within established business, tertiary education feeding industry must take up this challenge and the industry must support it.

The manufacturing industries and service providers highlighted in this research have addresses change at the mental model level and achieved a shift from activity to system thinking.

5.2.6 Customer focus

Henry Ford's mass production techniques allowed the motor car to become an affordable commodity to meet customer demand. Customer focus is seen as fundamental to success; it is the pull in the system of leading businesses concerns.

A customer focused organisation defines work in terms of responsibility for complete processes that serve customer needs. It is implicit within most advanced production concepts that the customer should be in charge of the production line.

What does not add value for the customer is waste; it is a fundamental shift to take the customer view and let the customers' requirements dictate actions and processes.

Customer focus is a strong theme amongst best practice theorists and practitioners; Womack *et al*, (1990) consider that an organisation must understand the real value that it delivers to its customers. Nestle, for example have created a vice president position exclusively to manage its business with their customer, Wal- Mart, (Worthen, 2002).

Chevron Texaco's (annexure 4) business is totally driven by customer demand. Louie Ehrlich, Chief Information Officer, for Global Downstream says *"It was a fundamental shift to take the customer view, before the shift we acted like a manufacturing company just trying to make products when really the market was customer driven"*.

Employees of organisations need to be able to understand who their customers are and what their customer's requirements consist of, they should be involved in efforts to improve their process to meet customer's needs.

5.2.7 Value

Everything that is done should add value for the benefit of the customer; activities which do not add value from a customer's viewpoint are classified as waste and should be eliminated.

The Construction Best Practice Programme in the United Kingdom suggests that identifying value from the point of view of the customer is a major principle in change to business improvement (CBP, 2004).

Further Womack *et al.*, (1990) consider that the organisational features of a lean plant transfer the maximum number of tasks to those workers actually adding value to the product on the line and that the central theme of lean thinking is value.

Boeing Corporation (annexure 6) has patterned their lean missile plant after the Massachusetts Institute of Technology's Lean Aerospace Initiative and the Toyota Production System. The key principles are value flow, pull, value stream and perfection.

The proposition of value is a key component of business best practice.

5.2.8 Communication

The research indicates that communication is a vital part of success in business practice.

Galloway Group's (annexure 1). Benchmarking process showed that communications within the company were poor and had a knock-on effect in employee satisfaction levels. Internal communications have since been improved across the business with regular timely announcements on notice boards, a bi-annual newsletter which creates healthy competition for coverage and suggestion boxes on the shop floor.

Meetings are critically important to the success at Toyota Industrial Equipment Manufacturing (annexure 8). Bruce Nolting, Vice President, Purchasing, Production Control and Sales says *"that every week there is an Associates' Meeting, each area of the plant sends a representative to a one-hour meeting with the executive staff. They can voice complaints, recommendations, ideas,*

suggestions, and so on. This lets us find out what's going on and what we need to be doing in order to improve".

Information technology and systems play a major role in today's world. ChevronTexaco (annexure 4) utilises information systems for up to the minute demand information and monitoring. Schedulers use the demand data and the terminal inventory to create a tank-refilling plan that optimizes the use of the pipeline for all the terminals a refinery serves.

The subject of communication cannot be over emphasised, and the climate must be created to encourage communication, time has to be invested in this process and all mediums utilised to carry this out.

5.2.9 Continuous improvement

The quest for "Zero Defect " is contrary to the common belief that it is acceptable to make errors, that an acceptable failure or scrap rate can be tolerated. Nissan's QCDDM supply chain management system is one of the most effective in the world; suppliers are measured on Quality, Cost, Delivery, Development and Management against negotiated continuous improvement targets.

Continuous improvement is driven by knowledge and problem solving activities (Schroeder and Robinson, 1993), thus it depends on people's ownership of problems in order to maintain the flux of improvements. Indeed, experiences in practice have shown that when people actually have control of continuous improvement activities the consolidation of the process is more likely to be successful.

It is also more natural and likely that they will achieve a durable self driven improvement process when their actions are taken step by step and gradually introduced as a collective system for the entire company (Sjoholt, 1998).

Successful businesses have taken quality as part of an overall system, as a process of continuous improvement, an ideal of zero defects. Nothing less is acceptable, ownership of the process must be given to everyone and the

responsibility to stop the line when something is wrong shows faith in the worker's ability and contributes to improving the process.

The particular production practice of the use of a "stop button", allows people to stop the entire process when an error has been detected. In this case the responsibility for correcting the error is collective since any deviations have to be corrected in order to move the process forward (Shingo, 1989).

The case studies (annexure 1-8) all underscore the theme of continuous improvement and this core principle appears as the strongest driver in business change, it is a process that has no ending.

5.2.10 Elimination of waste

Waste is any element that does not contribute to meeting quality, price or the delivery deadline required by the customer (Shinohara, 1998).

Chevron Texaco's (annexure 4) Louie Ehrlich says *"every time you make too much or too little of whatever it is, you are introducing cost into your supply chain"*.

Henry Ford's assembly line for his Model T ford was an integrated production system that emphasised quality, efficient production and the avoidance of waste (Ford, 1998). The Boeing Corporation (annexure 6) see the key features of their new plant as, self directed work teams, reduced cycle time, continuous flow, waste elimination, set-up reductions and kanbans.

The elimination of waste in the whole process is defined as a winning strategy that could be adopted by any process in any industry.

5.3 Case study analysis of common core principles

Table 5-1 below, illustrates analysis of the relevance of the common core principles appearing in the case studies referred to in annexure 1 to 8.

A ranking for each core principle is determined as 3 for high relevance, 2 for medium relevance and 1 for low relevance.

Common Core Principles	Benchmarking Case study number:			SCM Case study number:		Lean Production Case study number:			Total	Rank
	1	2	3	4	5	6	7	8		
Continuous improvement	3	3	3	3	1	3	3	3	22	1
Close Scrutiny of Existing Structures and Performance	3	3	3	3	2	3	2	2	21	=2
Customer Focus	3	2	3	3	2	3	2	3	21	=2
Change and Change management	3	2	2	2	3	3	3	2	20	4
Communication	3	2	2	2	2	2	3	3	19	=5
Elimination of Waste	1	2	3	3	3	3	2	2	19	=5
People Involvement	2	2	2	2	2	3	2	3	18	=7
Respect for Humanity	2	2	2	2	3	2	2	3	18	=7
Value	1	2	2	3	2	2	3	3	18	=7
Training	3	2	1	1	1	1	2	3	14	10

Table 5-1: Ranking of the relevance of the common core principles in the case studies.

5.4 South African construction industry

Review of the literature indicates strong support for the adoption of best practice and supply chain management initiatives. Also that the support from government and increased investment in all sectors of the South African economy creates a positive environment that can only assist in bringing positive change and sustained improvement in the Industry.

Research by Smallwood (2002) within the South African Contracting fraternity ranked the adoption of best practice programmes which include benchmarking as the number one intervention for improvement. This research by Smallwood

also recommends the industry should endeavour to benchmark all performance areas.

Best practice is applicable in all fields , it is relevant to note that world class manufacturing facilities such as Toyota and VW are established in South Africa and serving the world demand for quality motor vehicles .They are drawing from the same resource pool available to construction, and they have succeeded in negotiating the barriers to improvement.

In construction key developments have been led by government and are seen as the, White Paper (1999): Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry and the establishment in terms of the CIDB Act, 2000 of the Construction Industry Development Board (CIDB) to provide strategic leadership for growth, reform and improvement in the construction industry.

Change and South Africa is not a new concept, the country has gone through enormous change in the last 15 years. The acceptance of change as being the only constant is now considered part of the psyche of the nation.

The drivers of this change have been internal and external, within construction it is suggested that it will be similar. Internally markets have been poor and externally markets are considered to have been better. However requirements in external markets are all round higher and continually rising, to compete in this arena continuous improvement is essential.

Companies that are successfully competing in the global market can arguably experience transfer within the organisation. This will generate further transfer through the system and hence facilitate transformation to meet the challenges of the next 10 years and beyond.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This dissertation is concerned with the improvement and change within the South African construction industry. Conclusions of the objectives of the research are given, recommendations based on the research are made and further areas of research suggested.

6.2 Overview of the Research

Problem statement

The South African construction industry is considered to be severely challenged by the continuous growth predicted through 2015 and beyond and needs to achieve improvements in all aspects to remain a sustainable part of the economy. It is proposed the adoption of best practice techniques in widespread use in manufacturing and retailing may become the basis of the improvement process.

The research has addressed the problem statement by investigating and presenting best practice in use in by market leaders in the manufacturing and retail sectors of industry. Common core principles in use in these sectors have been indentified and commented upon.

A current review of the present status of the South African construction industry has been carried out and commentary provided on the capability and capacity to adopt best practice and common the core principles identified.

The methodology adopted has been to present each principle, its component parts and application, also citing case studies for each principle. This methodology has been followed to document clear understanding of these principles and to illustrate their successful application across business sectors. A qualitative approach has been carried out; it is subjective and contains descriptions of techniques, people interactions, stated observations and assumptions to formulate understanding of the subject.

Research objectives have been established and are reviewed in the following section.

6.3 Review of the objectives

- 1. Identify successful techniques of business improvement and the key elements of these techniques.**

The research has presented Benchmarking, Supply Chain Management and Lean Production as successful techniques used in the business sectors of aerospace production, retail, vehicle manufacture and construction.

- 2. Provide a basic understanding of these techniques, their current use and successful application.**

A basic understanding of these techniques has been provided in chapter 3 covering, definition, objectives, practice and benefits. Also the case studies demonstrating the success and further understanding of these techniques have been commented on and are provided as annexures for reference purposes.

- 3. Analyze these different techniques for common core elements.**

Analysis of the literature and cross analysis of the case studies has revealed that common core principles across the three areas of Benchmarking, Supply Chain Management and Lean Production. These common core principles have been identified and commented on individually in chapter 5. The perceived ranking of these common core principles is demonstrated in table 5-1, page 68, with the highest ranking belonging to continuous improvement.

- 4. Review in general the current state of the South African Construction Industry and its suitability to adopt best practice.**

The researcher concludes that there is sufficient evidence to suggest that the core principles of best practice are applicable in all areas of

business activity. Current thinking and research supports that best practice is transferable.

South African construction Industry can be considered ready to embrace improvement by adopting best practice principles. This is underpinned by the stated intentions and actions of government, the aims and objectives of the Construction Industry Development Board, experience gained by local contractors in the international arena and the tremendous opportunities predicted for growth within the construction sector.

6.4 Recommendations

1. Benchmarking initiatives should be introduced and key performance indicators (KPI's) established across each sector of the industry with key process reviews within individual business units. These continuous improvement initiatives require support and coordination from established and structured organisations such as the Construction Industry Development Board, South African Association of Consulting Engineers and the Association of South African Quantity Surveyors. The involvement of people from all levels of the process is considered essential to bring about real improvement as well as significant investment in training.
2. Client procurement in the government and private sectors and construction procurement via sub contractors and suppliers should embrace principles of supply chain management. Framework agreements based on trust and mutual respect and understanding should be developed and introduced across the industry.
3. The integration of procurement, design and construction is identified as a process to be developed and championed by leadership across the industry. Customer focus, the elimination of waste and the creation of value are key objectives of this approach; it is the application of lean thinking. The research underpins that in all cases it is the whole process

that is to be considered, this may be the greatest challenge to the industry but could bring about the greatest improvement.

6.5 Further areas of research :

Suggested areas for further research on this subject are:

- The role of the professions and the integration of design and construction.
- Procurement methods in construction and comparison with other industries.
- Transfer of methodology and how this can be achieved effectively.

6.6 Concluding remarks

This dissertation has remained within the boundaries of the approach to the subject, which is to focus on best practice business processes and identify core principles of best practice. Discussion comparison and points of view relevant to the construction industry have been made in line with the problem and questions posed. The best practice processes identified are currently considered to be leading business reform, efficiency and continuous improvement.

The opportunities for major growth within the South African construction industry is now current and government is clearly aligned to supporting the industry, hence timing for implementation of improvement processes could not be better.

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ANNEXURES

Case Studies

The case studies are provided as annexures to the main text.

Annexure 1:

Benchmarking Case Study 1: Galloway Group, United Kingdom

The following case study is reproduced accurately and unchanged in content:

Department of Trade and Industry, Construction Best Practice Case Study. Ref CB204, April 2003.

Benchmarks boost the bottom line:

Galloway Group, the nationwide ductwork manufacturer and contractor, worked with a Construction Best Practice advisor, to benchmark its business processes and performance. Some initial findings were encouraging, but Galloway also discovered that it was not doing enough to develop its people, communicate its goals and strategies to staff or manage remote labour effectively. Once identified, these problems were successfully tackled with specific initiatives.

Why change was needed:

In the face of increased competition, new competitors in new regional markets and growing awareness of some inefficiency within the company, Galloway wanted to improve. It also wanted a structured process to monitor the effect of changes in practice over time and manage progress towards set goals.

Background:

From a history in sheet metalwork, Galloway has been at the forefront of the ductwork industry for decades. With modest, steady growth in its core business of ductwork manufacture and installation, the company is dependent on the fortunes of the wider construction industry.

Operations were extended in 1997 to increase the workload in the London market. The company has since secured several major projects, fuelling additional growth in the south.

The size of these major projects provides a considerable workload and reduces the volume of sales required. Traditionally ductwork companies in the UK are small and operate in a local market.

Galloway, with a turnover exceeding 30million Pounds Sterling, sits among the top three in the sector. Under the direction of a new Managing Director, appointed in 2001, Galloway is using the Benchmark Index to improve profitability and to build a fitter company.

Identify a model for change

Galloway saw the industry's desire to change through initiatives such as 'Rethinking Construction' (Egan, 1998) and had already identified some issues that required attention.

Working with Mace on the Glaxo SmithKline headquarters at Brentwood, Galloway staff experienced a completely new approach, with the client and the whole team working together for the good of the project. With this as its template for best practice, Galloway approached a CBP advisor at the end of the project for help in re-engineering its own business to the same standards.

Survey the territory

The data collection exercise, the first step in the Benchmark Index process, was not entirely new to Galloway. The company already prepared very detailed management information for its monthly management meetings, but

benchmarking was much more focused, imposing its own rigour on the collection and presentation of data.

The management team initially thought that the process would be similar to when it implemented ISO5750, in that many of the components of benchmarking are already in place. Again the process introduced more structure, assembling various data sources into a cohesive view of the business.

After an introductory memo to explain the how and why of benchmarking, survey questionnaires were distributed to a cross-section of staff within the company. Meanwhile commercial and management data was collected and fed into the Benchmark index for comparison with other companies.

The investment of time was considerable with the central team (Managing Director, Commercial Director and nominated Benchmarking Coordinator) devoting three person-weeks to the collection exercise and over thirty hours to the Conclusions Workshop.

Most staff reacted positively to the benchmarking exercise and the team received several comments commending the effort to take positive action to raise performance in the face of difficult market conditions.

Drawing the map from results

Ignoring positive results, which were comfortably familiar to the management team, the problem areas and the remedial actions identified were:

Customer satisfaction

Management and staff alike felt that most customer care was carried out on an ad hoc basis. 'No complaints' was thought to equal 'no problems' and repeat orders were read as the proof of good performance. This passive approach was missing real opportunities for improving customer relations and only extremes of performance were eliciting customer feedback. Post-project reviews had been used for some time, but these were not formalised and some clients were reluctant to contribute comments.

An investment in customer care skills reflects Galloway's work to improve customer satisfaction and retention. As part of the benchmarked training initiative, the Marketing Manager is attending a Customer Relationship Management (CRM) course to learn about best practice in other industries. Already a customer survey has been conceived, borrowing Key Performance Indicators from the building services section of the CBP Knowledge Bank, tailored to the ductwork sector.

Communications

Wide differences of opinion between management and staff emerged from the survey questionnaires. This showed that communications within the company were poor and had a knock-on effect in people satisfaction levels. It was clear that many staff did not understand company goals nor appreciate the part every employee played in the overall team. Internal communications have since been improved across the business with regular timely announcements on notice boards, a bi-annual newsletter which creates healthy competition for coverage and suggestion boxes on the shop floor.

A new quarterly Employee Liaison Group, with representatives drawn from all levels, is also creating some valuable feedback and helping the management team to develop inclusive company-wide values and vision.

Training

Very low training expenditure reflected the low priority given to staff development by the previous management, with limited training on the job and very little externally sourced instruction.

Targeted budgets for training have now been introduced, raising annual expenditure from roughly five thousand Pounds to over seventy thousand Pounds. In addition to the CRM work, young graduates are learning project management techniques and office and shop floor staff are gaining from broad-based training initiatives including the EU IT Driving Licence (the new European computer competence standard) and best practice in safety.

Outlook

Galloway recognised most of the issues that emerged from the benchmarking process, but were surprised by some of the figures that emerged from clear objective measurement, especially in terms of financial impact on the company. Cooperation among middle managers and engineers has also been improved.

With obvious gains from reducing absenteeism and charting the path for the growth of the organisation, Galloway is now committed to measurement in its business. Galloway intends to repeat the process one year on, to get a full picture of what this new effort and investment have achieved.

Annexure 2

Benchmarking Case Study 2: Rover Body Pressings, United Kingdom

The following case study is reproduced accurately and unchanged in content:

Department of Trade and Industry (UK) Best Practice Benchmarking (1998).

The Rover Group recognises the opportunities gained by looking outside at world class practices in all fields to expand the organisation's vision of what is possible.

The need for benchmarking, prevalent throughout Rover, has been highlighted by a number of factors, including the increasingly competitive world market and the introduction of Japanese car plants across Europe.

All of Rover's business units have a requirement to benchmark their key processes written into their business plans. Management involvement is crucial in pushing for action on any measurements revealing improvement opportunities, and in removing blockages to improvement.

Rover Body Pressings were chosen to pilot the process, and from their experience trainers have been developed to cascade the technique into the other business units.

Chris Millard, Logistics Director at the plant recognises that having a clear focus is vital:

"If you only benchmark an operation in total terms, you will miss. You must examine and establish benchmarks for the processes which are the drivers in achieving the targets set for the overall operation. Also, the absolute value of the benchmark is relatively insignificant compared to understanding how it was achieved". Examining their internal processes, Rover split these into Prime Process Groupings, such as pre and post-manufacturing logistics. These are then related to Critical Success Factors, the key areas that will have to be improved to achieve Rover's company objectives.

This analysis reveals areas of concern to be prioritised, for example:

- Material utilisation.
- Days of supply of raw material.
- Days of supply of finished goods.
- Tool design lead times.
- Tool manufacturing lead times.

This research is used as the basis for looking for the organisations best at the key processes, inside or outside the motor industry. The knowledge of best practice will be used to help Rover's Quality Action Teams who have developed their own detailed process maps to improve their own processes.

Rover's close association with Honda provides a useful route for comparison, for example in benchmarking Change Over Times. Sigma Associates, an American consulting group, have been called in to identify similar press shops in USA and Japan.

Annexure 3

Benchmarking Case Study 3: Rank Xerox, United Kingdom

The following case study is reproduced accurately and unchanged in context:

Department of Trade and Industry Best Practice Benchmarking (1998).

Part of Xerox Corp, a multinational company that found itself in deep trouble in the late 1970s. From the mid-1960s to the mid-1970s its profits rose 20 per cent a year, not least because it had a near-monopoly on photocopier technology. By 1980 it saw its market share halve, as aggressive competitors moved in and beat them on price, quality and other important measures.

Xerox's solution was to benchmark the way its photocopiers were built, the cost of each stage of production, the costs of selling, the quality of the servicing it offered, and many other aspects of its business against its competitors and against anyone else from whom it could learn. Whenever it found something that someone else did better, it insisted that the level of performance became the new base standard in its own operations.

BPB has now become an everyday activity for every department in Xerox and Rank Xerox. The guiding principle is: 'Anything anyone else can do better, we should aim to at least equally well'. It is closely tied into the company's quality management programme; because BPB is one of the most important ways of identifying where quality improvements are needed. Not only has Xerox worldwide improved its financial position and stabilised its market share, but it has increased customer satisfaction by 40 per cent in the past four years.

Typical of the way Rank Xerox uses BPB is a recent study of distribution, as explained by John Welch, Quality Manager.

We compared our distribution against 3M in Düsseldorf, Ford in Cologne, Sainsbury's regional depot in Hertfordshire, Volvo's parts distribution warehouse in Gothenburg and IBM's international warehouse in France.

"We found, for example, by comparing with the best that:

- We had an extra stocking echelon, which could be removed (i.e. we had international, national, regional; they had only international and regional).
- We took one extra day in information flow between the field and centre, so we need to update our systems.
- They had transport logistics as a board level function.
- Warehouses became efficient not through a high level of automation but through efficient manual routines.
- First Pick' availability of parts averaged 90 per cent in the best warehouses; we made only 83 per cent.

Now we are putting those lessons to work, in upgrading our operations to be at least as good."

Annexure 4

Supply Chain Management Case Study 1: ChevronTexaco, USA.

The following case study is reproduced accurately and unchanged in content:

CIO Magazine June 1 2002. Drilling for Every Drop of Value, (Worthen, B. 2002).

AT 4 IN THE AFTERNOON on Feb. 25, 2002, Margo Hasselman, a 25-year-old University of California law student, pumps 13.87 gallons of regular unleaded fuel into her white 1998 Toyota Camry at the Chevron station on 145 Love Lane in Danville, Calif. The Love Lane Chevron is the very model of a modern filling station, with all the amenities the residents of this wealthy San Francisco suburb expect, eight pay at the pump lanes, a 24 hour convenience store and a car wash.

Underground, it's just as modern, the 14,250 gallon tank for super unleaded and the 19,000 gallon tank for regular (the midgrade fuel is a mixture of the two) are larger than the 10,000 gallon norm. Each tank is equipped with an electronic level monitor that conveys real-time information about its status through a cable to the station's management system and then via satellite to the main inventory management system for ChevronTexaco, the San Ramon, Calif.-based oil giant. When Hasselman tops off her Toyota, the Love Lane station's tanks hold 3,538 gallons of super and 5,877 gallons of regular.

Unless the tanks are filled soon, the station will run out of gas.

Of course, since it opened in August 2001, the Love Lane Chevron has never had a run-out.

It's the Demand, Dummy

During the past 10 years, ChevronTexaco, the nation's eighth largest company, with revenue of \$104 billion, has used detailed consumer demand data to all but eliminate run-outs and retains (the industry term for a delivery aborted because a tank is too full) the Industry's twin evils.

That data and the integration work that allowed it to be shared across the company improved the decision at every point in what the industry calls the downstream, or customer-facing supply chain that begins once the oil is

earmarked for the refinery (as opposed to the upstream chain, which includes hunting, drilling for and pumping oil). In 1997, Chevron's confidence in the reliability of its demand data had reached the point where the company for the first time used demand-forecasting to determine how much oil it would refine on a monthly basis, with weekly and daily checks, thereby transitioning the company from a supply-driven to a demand-driven enterprise. That first year, Chevron's downstream profits jumped from \$290 million to \$662 million on the same refining capacity and number of retail stations.

Louie Ehrlich, ChevronTexaco's Chief Information Officer for global downstream, says that while "it's difficult to isolate the exact percentage of that jump and attribute it to the business model change, as opposed to a booming economy and the increasing ability to replace human workers with technology. The move has revolutionized the business. "It was a fundamental shift to take the customer view," he says, in a slow, molasses-thick Mississippi drawl. Before the shift we acted like a manufacturing company, just trying to make products, when really the market was customer-driven".

It doesn't make sense to manufacture something simply because you can, but that's exactly what Ehrlich says thousands of companies that don't match production to customer demand are doing. A smart company, he says, "realizes that its business is not making a product, it's selling the product. Every time you make too much or too little of whatever it is, you're introducing cost into your supply chain".

And Cutting Cost Is the Name of the Game

John Cross, former CIO of ChevronTexaco rival British Petroleum, says that if you can't get cost out of your supply chain, "indeed, you are dead" and he adds that this is an area where ChevronTexaco has done particularly well. "They are heavily involved with SAP, and they have done a lot of good work with back-office systems for integrating supply and demand," he says, referring to an ongoing ChevronTexaco project to integrate the view of customer data across the company.

But in 1997, the year Chevron decided to let demand, and demand only, drive production, the company's systems station management, terminal management, transportation coordination, refinery scheduling and so on were still isolated from one another. Planners at the various points across the supply chain had to share data manually or flip between applications, introducing deadly cost. Since then, the company annually invests about \$15 million in supply chain technology in the United States alone, this figure doesn't include the \$200 million SAP project Cross mentions. With the help of those technologies, which include proprietary systems that capture real-time data and even more advanced planning systems, Chevron's 2000 profits increased by more than \$100 million to \$778 million. Ehrlich traces all the improvements back to the switch to a demand-driven business model, which, he says, "Allows you to take a bigger picture view of the operation because you have information. It allows you to turn the information into knowledge".

ChevronTexaco, along with its petroleum-producing counterparts, is in a unique position to harness the advantages of cross-supply-chain information sharing without the usual barriers of cultural or competitive resistance. The petroleum industry is the last haven of the massively vertically integrated company. ChevronTexaco controls the oil from the time the company finds it and pumps it out of the sand or out of the sea to when you fill up your car at one of its stations. And ChevronTexaco controls all the information from every pipe, tank, ship, distribution point and filling station along the way.

Why Keeping Tank 108 Filled Is Critical

Tonight, the Love Lane Chevron is scheduled to receive 3,150 gallons of super and 5,950 gallons of regular (gasoline truck tanks have three compartments and hold a total of 10,000 gallons).

Information from Love Lane's monitors is sent via satellite to ChevronTexaco's Customer Order Entry and Dispatch Centre in Concord, Calif, where load planning software minimizes the number of deliveries needed to keep a station running while avoiding run-outs or retains. The demand forecasting and

scheduling system has tentatively planned the next five deliveries as well, although they will be updated with new information. The demand planning system from Cambridge, Mass.-based Aspentech is new. After a year in development, it went live in the last quarter of 2001. It replaced an 8-year-old system designed around a proprietary algorithm developed by ChevronTexaco mathematicians. Early returns indicate that the new system will reduce transportation cost by 6 percent. Furthermore, the demand data stored in the systems will inform every decision made in the downstream supply chain.

Shortly after 11 p.m., a truck picks up the gas destined for Love Lane at the Chevron terminal in Avon, about a half hour away. The Avon terminal has eight tanks ranging in height from 43 feet to 54 feet, two truck-filling lanes and a one-story tin-roofed office building on about 10 acres of land. Tank 108, one of the terminal's largest, holds 2.5 million gallons of unleaded gasoline. It is 70 percent full right now. Trucks enter and leave, taking 9,100 gallons at a time. Like at the filling station, terminal inventory is tracked in real-time. The terminal's inventory, combined with the demand data from the stations that it serves, helps ChevronTexaco determine how often Tank 108 needs to be filled.

Avoiding terminal run-outs isn't simply a matter of waiting until a tank is two-thirds empty and then filling it back up. Tank 108 alone takes two and a half days to fill, and if the tank is low when a sudden spike in demand caused by unusually warm weather, a sudden drop in prices or a special event like the Olympics happens, the event could run it out and force delivery trucks to be rerouted from terminals farther away, adding costs up and down the supply chain. A bigger problem is the demanding pipeline schedule. There are only a limited number of pipelines from each refinery, which are reconfigured based on the target terminal. And they are constantly in use. When Tank 108 isn't receiving gas, another tank or another terminal is. Schedulers use the demand data and the terminal inventory to create a tank-refilling plan that optimizes the use of the pipeline for all the terminals a refinery serves.

Ehrlich's own experience is enough to convince him that the benefits of

sharing information outweigh any possible negatives. "Fundamentally it is all about making sure we have product where it needs to be, when it needs to be there, in the cheapest possible way we can get it there," he says. The bottom line is that using demand information is simply "the most cost-effective way of doing it".

Annexure 5

Supply Chain Management Case Study 2: British Airports Authority.

The following case study is reproduced accurately and unchanged in context: Solutions Magazine, WSP, Spring Issue, 2003. Discussion with Tony Douglas Group Technical Director, British Airports Authority.

How is a supply chain built?

BAA has a process that allows them to specify need so they can build an integrated supply chain, using a portfolio of suppliers with clearly identified capabilities.

For some time BAA has committed to the development of framework relationships. Their new second generation frameworks, covering a period of 10 years, bring a more long-term, structured approach to performance management to ensure continuous improvement.

They also allow the flexibility to go elsewhere in the unlikely event of people being unable to maintain progress or if there are fundamental changes in technology, competition or economic circumstances.

How much of the relationship is driven by suppliers?

Sufficient trust has now developed for certain parties in the supply chain to take a more proactive lead in driving the agenda. They are bringing their own, sub-tier, integrated teams of specialist consultancies and suppliers to develop the products and solutions BAA require. There are always risks when different types of people, from very different organisational cultures, working together. Relationships can break down, particularly if one party is deemed to have let the side down or reveals a weakness that compromises delivery.

This is not a soft option; everyone has to invest time, effort and positive commitment to understanding each other's cultures, structures, system, processes, strengths and weaknesses.

Why is BAA so committed to this approach?

The case is compelling and very simple. Take for example Terminal 5 at Heathrow, if they were to build it conventionally, not only would it require about 7,000 additional workers on site, but there would be a 40ft vehicle load passing through the site gate every 40 seconds or so for the next 4 years.

The only possible answer is to develop standard solutions that include pre-assembled products, manufactured off site, and then assembling at the airport with the minimum of human intervention. This also brings environmental benefits by reducing the impact of thousands of construction workers on local infrastructure, and, as everyone recognises, safety performance is infinitely better in factory conditions than on a construction site.

How has this approach added value?

Stansted Airport's new Satellite 3 was delivered last year through a successful integration of the shell and core and M&E supply chains. This resulted in a completed new pre-assembled solution for all the mechanical and electrical services, integrated into the building structure. It contributed to delivery in record lead time and well below budget.

Perhaps even more importantly, three hours after completion, Ryan Air were using the terminal in a fully operational fashion and were delighted with its capability.

How can a supplier be a successful part of the team?

They must be prepared to work as a team, leave their competitive behaviours behind and have a genuine desire to give of their best. They must display clarity of purpose and a structured approach with supporting processes and systems. Along with intellectual equity they must also have the potential to become world class manufacturers and logisticians.

What are the benefits for suppliers and BAA?

We all benefit from suppliers such as WSP and Crown House Engineering, the M&E manufacturer, pooling their collective expertise and resources to develop

the best standardised solution. This can be catalogued and added to a product portfolio for use as the starting point of every project.

Paradoxically perhaps, this way of working also allows people to be more creative. If you want to improve your success rate, you've got to be prepared to make more mistakes, and good partnerships provide an environment where it's safer to take risks without fear of retribution.

Finally, there is another, more intangible benefit that comes from the bond of having a mutual desire to do things differently. Chemistry, similar interests, passion, respect and trust – these are what makes working relationships special, over and above all the processes, structures and logic.

This is not to be underestimated; special people make a big difference.

Annexure 6

Lean Production case study 1: Boeing Corporation. USA.

The following case study is reproduced accurately and unchanged in content:

A Smarter Way to Make Smart Bombs, Advanced Manufacturing Magazine, January (Phillips, T.2000).

Boeing's new missile-making line showcases the company's commitment to lean manufacturing.

Boeing's missiles are so smart that trained soldiers can launch them from safety miles away from the heat of battle and remotely steer them to within inches of their targets. But the process for manufacturing some of those smart bombs hasn't quite kept pace with the advances in missile guidance technology.

At its St. Charles, Missouri missile plant, a 20 minute drive from downtown St. Louis, Boeing makes a variety of missiles for the U.S.A. and foreign clients. They also use a range of manufacturing methods.

Mass Production

For its older missiles, like the Harpoons, SLAMs and CALCMs, the missile assembly lines look much like traditional batch and queue operations that depend on a trained workforce using manual assembly techniques. And there's a lot to assemble, these missiles consist of about 88 percent outsourced parts, and two percent Boeing-made parts.

Seated on stools, workers pick small parts from bins, then stretch and stick their hands inside tight compartments to assemble the missile's inner brains. Ticketed work-in-progress is visible in various stages of assembly; there is little automation, and the workers work in cells and mostly in isolation from one another. Company officials say that, over the years, these employees have squeezed tremendous efficiencies out of the process, but Boeing would like to introduce more advanced manufacturing practices.

Lean Production

Inside Boeing's new production facility for its JDAM (Joint Direct Attack Munitions) line of missiles, you see a whole different world – lean manufacturing.

Starting from scratch, a group of lean manufacturing devotees within Boeing's missile division knew they had an opportunity to create the ideal lean assembly plant. They benchmarked with dozens of other facilities, studied best practices, conducted internal performance audits, attended lean manufacturing conferences, and did their homework.

The result is a simple looking, but highly-efficient production line that can produce top quality missiles at a low cost – about US\$20,000 per missile. The line now makes about 1,000 missiles a year, but the system could crank out as many as 20,000.

On the assembly line, each munitions mechanic follows clearly outlined standardized work procedures and spends the same time, 17 minutes, during each stage of the assembly process. There is no rework on the line, and parts are stored adjacent to where they are assembled. Each mechanic does every other job, from unloading raw goods from trucks, to assembly, to packing up the finished product in collapsible and reusable bar-coded containers with no packing waste for shipping.

Boeing officials advise that the lean missile plant is patterned after the Massachusetts Institute of Technology's Lean Aerospace Initiative and the Toyota Production System.

The key principles are value; flow, pull, value stream and perfection.

The key features are self-directed work teams, reduced cycle time, continuous flow, waste elimination, set-up reductions and kanbans.

Annexure 7

Lean Production Case Study 2: Hathaway Roofing, United Kingdom.

The following case study is reproduced accurately and unchanged in content:

Department of Trade and Industry, Construction Best Practice Case Study Ref CB166, April 2003.

A Lean Initiative

Hathaway Roofing Ltd. (HRL), a specialist roofing and cladding contractor with an annual turnover of 27 million pounds sterling, decided to carry out a lean awareness programme across the whole company, as part of its business strategy for the 21st century. As a result there has been a major transformation of the manufacturing facility with a reduction in inventories of 60%, product lead in times have been reduced by 25-50% and emergency work can be accommodated more easily.

Why change was needed

Having seen the benefits of 'lean' concepts within the automotive supply chain. HRL undertook the lean initiative as a means of continuous improvement in an already successful business which aspires to be the leader in its field.

Key benefits

- At full capacity productivity in the factory improved by 35%, leading to improved margins.
- A review of product packaging and improved efficiency in site delivery has helped reduce waste.
- Better quality control on factory goods has led to a reduction of rework on site.

- Better customer liaison and increased flexibility have led to the ability to adapt to changes in site schedules
- All the above have helped to consolidate relationships with existing customer as well as increase potential new clients' confidence in the company.

Adopt a realistic timescale

HRL began by accepting that the lean transformation process would take up to four years. The process began in March 1998, focusing first on the factory (phase 1). The factory is now in the continuous improvement cycle. Phase 2 of the process began in March 1999 and ended in 2002.

Training

A consultant, Rubicon Associates, with experience in the concepts of lean thinking and organizational change, was engaged to help tutor and coach managers throughout the company. Managers at all levels were then given introductory training in the subject and in the application of tools and techniques to be used.

Begin in one area of the company

The factory led the process by involving all staff and carrying out 'value stream mapping' with a detailed analysis of every factory operation.

The results included:

- A new factory layout.

Over a twelve month period the factory was totally modified and re-designed by the factory teams and factory operations were organized.

- The retaining of factory workers.

Most of the factory workers were re-trained to be multi-skilled and able to carry out operational production / maintenance requirements.

- Ongoing improvement teams.
- Ongoing improvement teams within the factory are using the lean process to attain higher levels of quality, efficiency and productivity.

Set up the lean steering group

Steering group of middle managers and representatives from all parts of the company, including the factory, was created, with one member appointed lean transformation leader and chairman. This person was the point of contact with the consultant and generally led the process. These duties were carried out in addition to his managerial role in the company.

The transformation leader reported to the contracts director who also attended the lean meetings. The contract director was the champion of the initiative, primarily because it was intended that the contracts department should be the penultimate benefactor of any change, the ultimate benefactor being the client.

The steering group had clear objectives from the board, i.e.

- 1) Improve customer service.
- 2) Complete projects to estimate.
- 3) End projects with no outstanding issues.
- 4) Improve profitability.

The steering group reviewed the value stream of the organization to identify “blockages”, i.e. areas where people felt hindered in their work. These blockages were analysed and prioritized into project topics, with project leaders assigned to each topic. The project leaders involved staff members considered key to the development and implementation of necessary changes.

Great progress has been made in resolving problems which were mainly due to poor information flow. As with the factory, a positive attitude towards continuous improvement is now evident in all departments.

Restructure the company

A continuous improvement policy has been implemented to determine the best pre-site and on-site management structure to suit the type and scale of the project. Flexibility is the key.

More time has been invested in site staff meetings to explain what HRL wants to achieve and why.

Overcome problems

Finding time to carry out change at the same time as undertaking normal activity was initially a struggle for the factory and for the rest of the organization. It was therefore imperative for senior managers to be committed to the initiative, so that they might lead by example and create the time to make change whatever the pressures of day-to-day business.

Taking the principle of improvements made in the factory out into the site was not a simple task. Depending on the project, this may involve a total re-orientation of a site crew's thinking and practices and for HRL this was a big step.

In mid-year 2002 HRL transformed its lean steering group into a continuous improvement group, comprised of senior managers and directors who meet regularly to review projects and devise new initiatives.

One such initiative is known as the "Success on Site Scheme", whereby the contracts department talks to clients' site teams to explain what needs to be in place before HRL arrives on site. As a result HRL's time on site is productive and not wasted.

Outcomes

The company has begun to see itself as a continuous stream of value adding activities rather than isolated groups of connected functions. Communications has improved radically and staff are willing to take joint responsibility for the outcome of their activities.

Annexure 8

Lean Production Case Study 3: Toyota Industrial Equipment Manufacturing, (TIEM) USA.

The following case study is reproduced accurately and unchanged in content:

The Toyota Production System, TIEM Case Study. www.autofieldguide.com, (Vasilsah, G.S., 1998).

Although they're producing vehicles with four tires, a gasoline engine, and a steering wheel, the folks at Toyota Industrial Equipment Manufacturing in Indiana aren't making cars, but material handling equipment. And unlike the folks in Kentucky, they're also building units with three tires and electric motors.

When most people think of the Toyota Production System, they undoubtedly and understandably think of Camrys and Corollas, but forklifts?

In fact, 95% of the forklifts that Toyota Industrial Equipment which is, interesting enough, a division of Toyota Motor Sales, the same organization that markets the Camrys built in Georgetown, Kentucky, and the Corollas produced in Ontario and in California sells in the United States are built by Toyota Industrial Equipment Manufacturing (TIEM) in Columbus, Indiana. Production began in the Indiana plant in 1990.

TIEM operates with some 450 people who work in a facility that measures just under a half-million square feet. In the plant they produce four different product models: three-wheel electric trucks, four-wheel electric trucks, and two different ranges of internal combustion (gasoline, LPG, diesel) forklifts. This equipment is produced on three different lines in the plant, with the majority about 75% being built on the internal combustion engine line. The main processes performed in the plant are welding, painting and assembly.

Although the majority of units built by TIEM have internal combustion engines, they do build electric-powered forklifts, such as this, which has a 6,000-lb. capacity.

"Specials" are Common

Not only does the line produce an array of forklifts that range in capacity (one may have a 7,000lb. capacity and another a 10,000lb.capacity), but, according to Bruce Nolting, vice president of Purchasing, Production Control & Sales at TIEM, as many as 25% of the units built, or every fourth truck, could be a special unit. As Nolting explains "We feel we're rather unique in that our competitors may make a vanilla truck and take it off line and to a separate line, building or town and add what it takes to make it a special unit." This could mean special seating, lighting, or a variety of other elements. "We do it in line." He adds, with what would seem like a huge understatement with regard to most companies but not Toyota, "As you can well imagine, it takes a significant amount of coordination and planning—getting the right components in the right place at the right time".

The manufacturing strategy at TIEM—which, of course, utilizes the Toyota Production System is one-piece production. "We have a pull system," Nolting says. "We receive raw materials on one end and 'pull' product through final assembly and on to the customer." Facilitating this is the use of kanban cards. When one of the associates on the line takes the first part out of a container, he or she pulls the kanban card from the box, which is a signal that more parts need to be delivered. The cards are collected five times a day; part deliveries are made five times a day. Many of the larger components are kitted and delivered sequentially.

Assuring that parts are ordered and ready is only one part of having the ability to produce the required forklifts, having the capability to do it is another. In order to assure that at the end of the day (they run one shift at TIEM) the necessary number of forklifts has been built, takt time is calculated. By way of example: there are 20 processes on the main line. So, given the number of processes, the number of forklifts that need to be built, the number of people to do the work, and the number of hours available to do the job, the takt time is calculated for the work that needs to be done. Each process has a takt time. This is the number of minutes that is available for the job to be done, whether this is a standard unit or a Toyota Special Design vehicle.

The ability to flex with increases in demand can be accomplished in two ways: either work more hours or add more people. They do work overtime at TIEM. And they do hire people. Nolting observes that it is a fine balance that must be struck: on the one hand, they absolutely do not want to overwork the associates; on the other hand, they don't want to add people so that should the market drop there are more people than are needed to perform the work.

Training for Quality

To help assure that there are quality builds each and every time, the people at TIEM are well trained. During an associate's first week with the company, all 40 hours are spent in training, both in the classroom and at the actual work site (a practice that's called "assimilation"). The training starts with safety, which is the number-one concern, then moves to achieving quality through the Toyota Production System. Then there is on-going training of associates at all levels of the organization either with internal classes or at nearby educational institutions.

Although the work isn't performed by teams of workers per se, the supervisory structure is organized so that there are groups of associates that are managed by an assistant team leader. Whats more, there are groups of volunteers who are called "TIEM Improvement Groups," which set out to identify and resolve problems and to make overall improvements to the plant.

Workers are cross trained in order to maintain flexibility. The approach is for an individual to first learn the jobs of the people who work on either side of him or her, the supplier and the customer in the sequence. Assistant team leaders must be capable of filling in for any of the people who are within that particular grouping.

A hard schedule is set eight days in advance of production. What this means is that given an order, changes can be made to it up to the eighth day before it will be produced. This doesn't mean that everything can be changed, but literally several hundred things can be modified. (And Nolting admits that they'll even accommodate late changes, but this would undoubtedly require having to move the vehicle off the line to handle it.) The reason why it is eight days and not seven or nine is simply based on being able to provide the

suppliers with a sufficient time frame in which they can meet the orders. They are working on reducing that amount of time.

Crucial Elements

Once a vehicle is to be built, all of the items (with the exception, of course, of things like nuts and bolts) that go in to making that vehicle are numbered. There is one-piece production in the sense that all of those items are going to come together to make the indicated unit. Which means that (1) equipment uptime, (2) the availability of people, and (3) quality are crucial.

According to Bruce Nolting, the painted items on the forklifts built by TIEM, especially the counterweights (the back end, which keeps the vehicle stable when the front is loaded) have what he describes as "an automotive finish." In order to assure the quality of the paint, there are more counterweights in the system at any given time than there are frames, which can be produced more readily.

Although there is a preventive maintenance (PM) program in place, with each piece of machinery having its own schedule for PM, let's face it: things break. When this happens, things don't come to a complete halt. In fact, when there are problems it should be that the next process in the sequence doesn't even notice the stoppage. Nolting explains that it is a matter of keeping track of what happens in the various processes: how much downtime has there been; how much time has it taken to repair? Given that historical information about process capability, things are scheduled accordingly.

For example, in the case of the mast assembly line (the unit on the front of the forklift), given the takt time, the amount of time required to produce a mast, and the time that repairs have taken in the past when things have gone, they'll keep 40 to 45 minutes of finished products ahead of final assembly. Consequently, if something goes wrong on the mast line, the final assembly line wouldn't notice it unless the amount of time needed to repair the broken equipment exceeded the number of finished masts on hand (which is statistically unlikely). This is not buffer in the traditional sense, because, as mentioned, each major element that goes into the assembly of a vehicle is

numbered one particular mast is to be mated with one particular frame and so on.

The availability of people issue is addressed through the cross training of the associates, the abilities of the assistant team leaders to take on tasks of any of the associates, and by a restriction of the number of people within a given area who can take vacation at any one time.

As for quality, it is paramount. Each vehicle produced undergoes a comprehensive inspection. Each and every flaw is identified, listed, and repaired. The issues are collected on a Completed Vehicle Inspection (CVI) board. Where a problem occurred is determined. The assistant team leader responsible for the process where it came from must talk to the person responsible for the defect no later than by the start of work the day after the issue gets on the CVI board. There are daily meetings at the start of work each day to review the previous day's work and to plan what will happen that day so interactions between people are a matter of course

In fact, meetings are critically important to the success at TIEM. Nolting says that every week there is an Associates' Meeting. Each area of the plant sends a representative to a one-hour meeting with the executive staff. They can voice complaints, recommendations, ideas, suggestions, and so on. "This lets us find out what's going on what we need to be doing in order to improve", Nolting says.

In a lean organization like TIEM, everyone has to be involved in getting the job done right.

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