THE INTEGRATION OF LEAN THINKING AND MANUFACTURING BUSINESS IMPROVEMENT METHODS WITHIN THE AEROSPACE SUPPLY CHAIN

SAMANTHA BERKHAUER-SMITH

PHD

THE UNIVERSITY OF GREENWICH

BAE SYSTEMS

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ABSTRACT

Business environments need to react efficiently and quickly to demand today's global markets. The manufacturing industry is an environment that has become more competitive due to greater demands from the customer. Technology is evolving faster, and this impacts on the accelerating changing market. Customers no longer require mass customised goods but want individual high quality products, at reduced costs. Businesses then feel that in order to remain competitive, they have to cut costs wherever possible to meet these demands.

This research was initiated by carrying out an extensive literature survey on the current inter-relationships between Manufacturing Business Improvement Methods (MBIMs). The chosen subjects have many areas and theories that can be used to assist in the development of improvement programs. The review highlighted that one particular improvement concept is lean manufacture. This review carried out an investigation into the lean environment and assessed many applications of the concept. The literature survey also highlighted some restrictions to lean thinking. It is been proposed how some of these limitations can be alleviated by introducing other MBIMs into an integrated methodology.

The research assesses currently practised MBIMs and reveals that these methodologies have differentiating relationships, thus producing many types of implementation strategies. The research resulted in studying the inter-relationships between these MBIMs including cultural issues surrounding process improvement initiatives, so they can be unified into an integrated methodology creating a unique strategy that can be correctly tailored to a chosen environment.

This research outlines a proposed design methodology that involves ten stages of change including the planning, creating, data collection, analysis and strategic implementation to apply. The approach flows through the change process systematically highlighting how to achieve the best outcome. Feedback into the system is also visible. The proposed design methodology incorporates significant findings from the research, as it highlights the originality of the amalgamation of both the technical and cultural transformations, which are two very different aspects, but highly important factors of

change. This research highlights the issues surrounding technical and cultural factors of change that are the main cause of process improvement failure.

By considering the two factors, a more harmonious approach in implementing the MBIMs within a company is achieved, therefore resulting in a higher success rate of change. A number of case studies illustrating the implementation of the proposed design methodology is also presented to highlight the significance to the manufacturing industry. Each application has different requirements and gives examples of how the proposed design methodology is tailored specifically to the application.

The initial case study (interrelationship between the supplier and customer) highlighted that in order to achieve the ultimate goal lower level projects within the individual companies would be beneficial in order to succeed across the supply chain.

The second case study (the supplier) concluded that the improvement would be within the organisation of the work within the cell, the capacity of the production line was adequate although the demand through the cell was variable and thus impeded the production rate. To reduce this variation, it was suggested that improvements could be made by having a multi skilled and flexible team operational within the cell.

The final case study (the customer) had the aim to improve information flow to alleviate a silo mentality and to improve the whole internal supply chain. This again demonstrated differing results due to differing requirements but through tailoring of the proposed design methodology.

The extensive literature review has shown that currently there is no integrated improvement concept that assesses the current unique business situation and uses a number of differing subject areas. This proposed design methodology creates a path of transformation which alleviates cultural issues and resistance to change, it gives the project team assurance that the right changes are being made in the most efficient manner, therefore allowing a smoother acceptance to a change initiative program. The saved time can be better spent on training and culture programs to ensure greater implementation success. All of these factors aid to reducing the lead-time of a traditional change improvement program making the manufacturing environment a more competitive industry.

This unified approach has ensured that a number of strategies that are not currently synchronised can be implemented successfully. The proposed design methodology will automatically reduce factors associated to cost and time; as it also portrays as a confident view for success. The literature review also highlights that the failure rate of improvement initiative programs is quite high, due to the lack of planning of the cultural aspects and because technical issues are easier to implement. This proposed design methodology satisfies two main objectives;

1) An integrated business improvement system that analyses many improvement concepts
2) Implementing this theoretical design through analysing and evolving cultural aspects

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AUTHOR'S NOTE

The information presented in this document is the sole and original work of the author, except where stated by acknowledgement or reference.

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NOMENCLATURE

5s	Sort, Straighten, Sweeping, Standardising, Sustaining Methodology
62 Series	Product production line at Amphenol UK
7w	Seven Wastes, Transportation, Inspection, Motion, Over Production, Over Processing, Defects and Waiting
ACE	Achieving Competition Excellence
AOV	Analysis Of Variance
AP	Agile Production
AVE	Agile Virtual Enterprise Reference Model
BOM	Bill Of Materials
BPR	Business Process Reengineering
CAD	Computer Aided Design
C/T	Cycle Time
DES	Discrete Event Simulation
DMADV	Design, Measure, Analyse, Design and Verify
DMAIC	Design, Measure, Analyse, Improve and Control
DOE	Design Of Experiments
ERP	Enterprise Resource Planning
FAO	For the Attention Of
FIFO	First In First Out
hrs	Hours
IM	Implementation Management
IN	Inspection
JIT	Just In Time
k	Thousand
LAI	Lean Aircraft Initiative
LM	Lean Manufacture
m	Million
M/A	Machine Availability
MBIMs	Manufacturing Business Improvements
min	Minute
mins	Minutes
MRP	Material Requirements Planning

OP	Operation
OTD	On Time Delivery
PAM	Process Activity Mapping
pcs	Pieces
PDCA	Plan, DO, Check, Act Cycle
Q	Queue Time
R	Reliability
RTV	Return To Vendor
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SIPOC	Suppliers, Inputs, Processes, Outputs, Customers, Requirements
SS	Six Sigma
ST	Storage
SWOT	Strengths, Weaknesses, Opportunities and Threat Analysis
TPM	Total Productive Maintenance
TQM	Total Quality Management
TR	Transport
U/T	Uptime
VSM	Value Stream Mapping
WIP	Work In Process
w/o	Work Order
WW	World Wide

CHAPTER 1 : INTRODUCTION

1.1 Chapter Introduction

This chapter outlines the reasoning and the scope for the research, as well as justification for the case studies to underpin the academic theory. Within this chapter background information on the research area is also given.

1.2 Literature Background

Over the past few years a great deal of literature has been produced discussing the way in which manufacturing has undergone many evolutionary stages, mainly from mass production to a leaner more customised environment. Crute et al., (2003) discuss this concept of lean and why such an approach is needed within manufacturing. They argue that with changes in the competitive market, customers are requiring a more 'made to order' approach, which is having a major impact on the producing companies. Sharp et al., (1999) similarly identify how;

> ...."There is a continuing fragmentation of mass markets into niche markets as customers are becoming more demanding with increasing expectations. Also, there is a spread of collaborative product manufacture with suppliers and customers, joining together to add value within the supply chain. In order to cope with these changes, companies are striving to improve their manufacturing performance."

Business improvement techniques such as lean manufacture are described as the current era. Work published by Womack et al., 1991 and Womack and Jones, 1996 initiated the interest in this technique. Improvement theories such as agile production (Sharp et al., (1999)) and (Zhang et al.,(1999)), also have defined analyse and implementation techniques. These methods are logically structured and concerned with physical rearrangement of process flows, material flow, information flows. It is thought that these ideas that can only be applied to specific systems.

As research develops within these subject areas it highlights the importance of more philosophical approaches that are needed in the real industrial work place. Other factors such as human intervention, cultural changes and the leadership styles are required to complete the task successfully. A paper written by Heracleous and Langham (1996) identifies the importance of organisational culture change in strategic change processes.

This research study looks into the implementation styles of different business improvement concepts within manufacturing systems. Particular areas of interest are lean manufacture, agile production, supply chain management, six sigma and discrete event simulation. The implementation relationship between these ideas will be discussed within the design methodology (Chapter 3). Currently all of these topics have theoretical correlation; however they are practised as stand alone concepts. By researching these interrelationships, an integrated implementation application has been derived in Chapter 3. The fundamental contribution gained from this research is how to manage this integration; this is demonstrated in the application of the design methodology (Chapters 4, 5 and 6) and discussed in Chapter 7. The niche research field highlighted within the literature review will be fulfilled with the proposed design methodology outlined in this thesis.

1.3 Industrial Background

The collaborating establishment for this research project is BAE Systems, Rochester, UK. From industrial experience within this manufacturing environment, business improvement projects are seen as a continual procedure. Whilst these stand alone improvement projects evolve, there is a lack of improvement assessment to the suitability of the improvement techniques to the environment. **Figure 1.1** highlights how the research has evolved and how a specific area for investigation has been developed for this research. The figure demonstrates how the research was initiated by investigating the evolution of lean manufacturing, as well as researching the associated tools and techniques. From this the research progressed to understand how the theory was being applied, including how the theory was expanding beyond the manufacturing industry. This research highlighted some application opinions and views, which required investigating possible implementation restrictions. The research study became more focused to understand these restrictions and investigate possible solutions through the application of other manufacturing business improvement methods. Particular methods were researched and therefore identified as suitable candidates to diminish these restrictions.

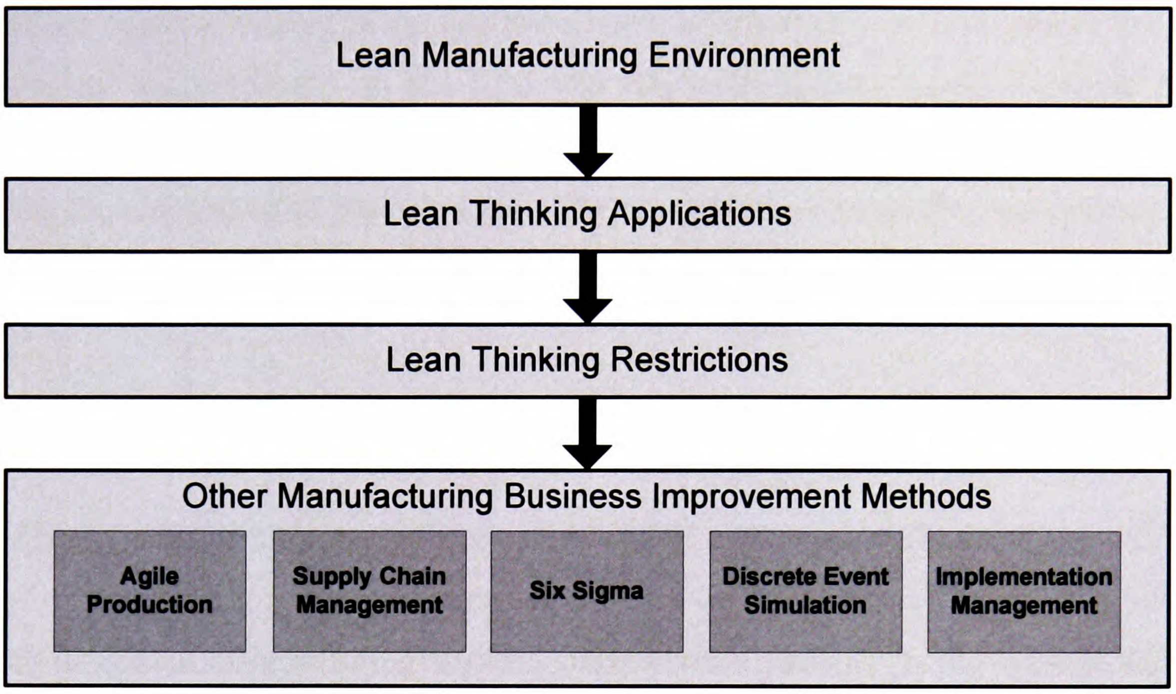


Figure 1.1: A diagram of the research progression

BAE systems within procurement and operations currently have a business improvement team that oversee all improvement projects within these functions. The scale of these tasks are isolated from other business areas and tend to be of a adhoc nature. It was also noticed that as well as working the projects individually, there appears to be very little standardisation across the projects. This was due to a number of reasons;

- The changing of job roles,
- The improvement team consists mainly of graduates,
- The lack of coherent knowledge and structured design of business improvement,
- The suitability of the project requirements to the improvement technique.

It was thought that the company would benefit from a structured design methodology. This would initiate and continually create standardisation through design to implementation of an improvement project. It was also anticipated that this research and methodology creation, would benefit the company by introducing many improvement techniques that would analyse the suitability of a technique to the project needs.

Having this structure would not limit the improvement project to one technique, but would introduce a number of proven techniques, which would work in unison and suit the project requirements. It was seen that this investigation would eliminate these observations and would allow standardisation, the analysis of technique suitability as well as the elimination of silo mentally. This would drive change beyond the initiating functions and set to improve across the supply chain in unity.

1.4 Research Scope

The chosen subjects have many theories that can be used to assist the development of an improvement program, however extensive research by the author has shown that there is not an integrated manufacturing business improvement roadmap in a sequential format, using a number of strategies, in differing subject areas. The topics that have been chosen are due to experience with business improvement initiatives both academically and industrially.

1.5 Research Objectives

The main objectives of this research are to:

- Review and investigate the lean environment and applications
- To assess the inter-relationships of MBIM applications as they are currently practised
- To create an integrated methodology which supports many facets of these concepts, including technical and cultural issues
- To create a user friendly roadmap of change that enables proposed design methodology applications to a number of case studies
- To highlight the flexibility of the proposed design methodology through testing and enable specific tailoring to the application requirements

- To discuss the outcomes of the case study applications to verify the proposed design methodology creation
- To conclude and highlight the research contribution
- To discuss further work that is a result of this investigation

1.6 Research Aims

The aim of this research work is to contribute to knowledge by creating a design methodology that solves the research objectives. In this particular study the literature requirement that has been identified is to integrate a number of specific MBIM's alongside the fundamentals of lean manufacturing. With this integration a clear roadmap will be created to highlight the importance of structured design and implementation, along with analysis of method suitability given to the particular environment. This research also aims to study the cultural aspects of MBIM's to understand the relationship between technical and cultural business improvements.

1.7 Research Philosophy

The subjects discussed and the objectives stated are defined throughout the thesis. All of the subject areas are fully researched from varying sources of information. This enabled an understanding of previous research and allowed it to be developed further within this study. Having completed the research, a detailed methodology of the approach was written and justified through case studies. The results found were demonstrated in graphs, tables or drawings, depending upon the requirement. The results were discussed and analysed enabling future research to be identified.

1.8 Chapter Summary

This chapter has identified how the research will be undertaken and completed. This chapter has discussed the literature background and highlighted the theoretical requirement for this study. The industrial contribution for the investigation has also been discussed and outlined the benefits that were achieved. Having discussed the project scope the next stage was to study the current literature available.

CHAPTER 2 : LITERATURE REVIEW OF MANUFACTURING BUSINESS IMPROVEMENTS METHODS

2.1 Chapter Introduction

This chapter investigates and studies previous research within manufacturing business improvement methods (MBIM's). The main focal concept is lean manufacture as it is currently the most discussed and practised application. This chapter discusses the evolution of the technique along with the application of lean within manufacturing, including the restrictions of the concept. Other MBIM's are investigated and their association with lean are studied, to assess eliminating these lean limitations through subject integration.

2.2 An Overview of Manufacturing Business Improvements Methods

The manufacturing industry is an environment that has become more competitive due to greater demands from the customer. Technology is evolving faster, and this impacts on the accelerating changing market. Customers no longer require mass customised goods but want individual products, at reduced costs. Businesses then feel that they have to cut costs wherever possible to meet these demands to remain competitive. Manufacturing as a whole requires a change in the way merchandise is produced (Berkhauer and Pepper, 2003). Products quickly become outdated, therefore there is a need to quickly develop and change items. This increases costs and overheads. However, there is also the pressure to deliver the items to the customer at a competitive rate. It has been documented for a number of years that this has been the case, but companies are unsure how to regain competitive advantage. Bayraktar et al (2007) discuss the evolution of operations management and highlights the main trends in each era. The paper demonstrates how the current era consists of built-to-order supply chains that are flexible and responsive to customer demand and market requirement.

Ultimately all MBIM's aim to enhance the business for a number of advantages;

- Reduced lead time
- To be more cost effective

- Reduced inventory
- More efficient estimating process
- More communication throughout the supply chain
- Reduced supplier base
- Reduced over heads

Many different MBIM's are applied at any given time within a supply chain and the success of the outcome is dependent upon the suitability of the technique to the environment.

A great deal of literature exists explaining a number of different concepts and techniques that are available within logistics and manufacturing systems, some more defined than others. Particular areas of study are lean manufacture, agile manufacture, supply chain management, six sigma and discrete event simulation. All of these subjects have previously been researched and studied, with some having in depth detail whilst others are at different development phases. These topic areas have been investigated and comparisons between them have been generated in this thesis. However, there is a shortage of literature on the study of 'Business Improvement Techniques' integrated together. This literature review chapter will describe, analyse and create a deeper understanding of these concepts by discussing their interrelationship and identify other topics that will enhance the application.

Manufacturing has been defined as "the making of goods and articles by hand, or especially by machinery, often on a large scale and with the division of labour" (Schey, J.A. 1977). Manufacturing techniques have developed over the years. The type of manufacturing process required is very dependant upon the types of materials that are being processed. There are a number of ways to classify manufacturing systems, however generally there are three types: mass production, batch production and job-lot/make to order production the differing systems. These systems are highly documented, including approaches of improvement method. It is highlighted (Rother and Shook, 1999) that these manufacturing systems require documentation and benchmarking prior to improvement. A review was carried out by Aguilar-Savén (2004) that classified techniques associated with Business Process Reengineering (BPR). The authors created this classification for their own research purposes and it indicates a structured framework for BPR methods.

Business improvement concepts are always evolving. These ideas have been influenced and driven by Japanese manufacturing processes. **Figure 2.1** highlights the trend in the automotive industry over the last twenty years. The diagram mainly identifies how Japanese manufacturing techniques were being practised a decade later, by the Western manufacturing industries. It also demonstrates the power the Japanese industries have over Western companies competing for the same customers. Continuous improvement methods within manufacturing and the evolution of this has been discussed by Bhuiyan and Baghel (2005). The paper highlight that today more sophisticated methodologies can be used in any organisation, however continuous improvement today is quite challenging as it requires organisational change on many levels.

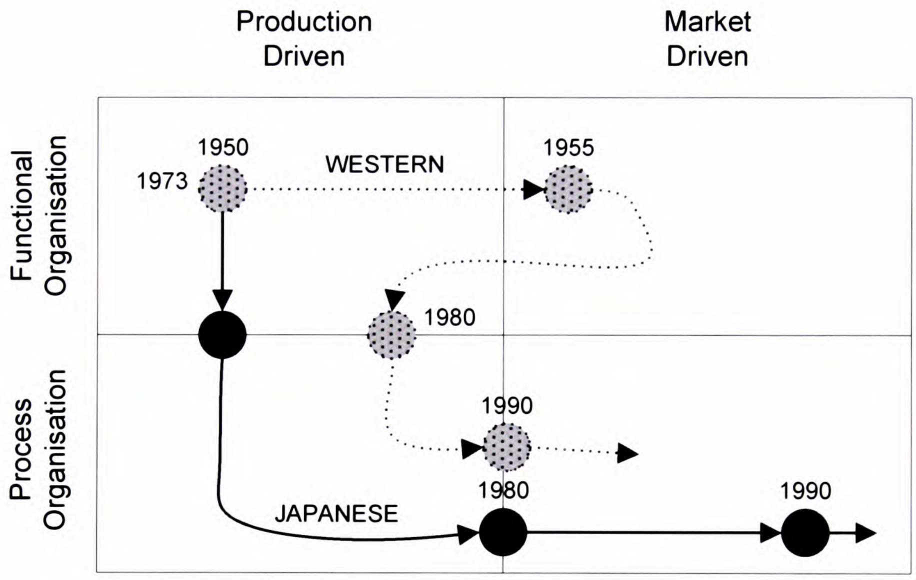


Figure 2.1: The process orientation drive

(Johansson et al, 1993, cited (Naim et al, 2002))

Looking at these concepts that have originated from Japan, Katayama and Bennett, (1999) discuss how the Western manufacturing industry is following the Japanese techniques and identify their reasons for doing this. The literature also studies the concepts of lean, agility and adaptability. It was discovered through research and surveys that companies are trying to understand the cost of adaptability through agile initiatives, even though agile manufacturing strategies opposes some lean procedures. These Japanese methods are advertised as lean manufacturing techniques to the Western global sector and it is these concepts that are seen as the latest business improvement methods to apply.

2.3 Lean Manufacturing

2.3.1 The Evolution of Lean Manufacture

It was Deming (1900-1993) who emphasised waste reduction in Japan in the 1950's; however the elimination of Muda (Waste) which is associated with the theory of the Seven Wastes, was introduced by Taiichi Ohno (1912-1990). The removal of waste is a central theme of lean thinking. Deming revolutionised industry by developing better ways for people to work together, by creating quality and management techniques which continually improve and redefine mistakes as opportunities for improvement. Taiichi Ohno who was the assembly manager for Toyota, developed many improvements that eventually became the Toyota Production System. Through the work with Toyota he began to assist several U.S and European firms with implementation of these techniques.

Hines et al (2004) gives a brief history on the concept of lean and highlights the evolution from the origins of Japanese manufacturing right up to the concept as it is perceived and applied today. A functional model created by Hicks et al (2004) also classifies the strategic issues of waste. The model is applied within a case study which researches the models used within the supply chain. It was thought that this model could be used to,

> ...."Facilitate communications internally within a company and externally between companies." (Hicks et al, (2004))

Womack et al (1999) and Womack and Jones (1996) have renewed the same theories and consolidated the ideas into a methodology. In the past decade the knowledge and use of lean manufacture has increased, the concepts are more worldwide and the literature of successful implementation has been enhanced. This has contributed to improving the efficiency, flexibility and the need to respond to demands in many manufacturing environments. This study will demonstrate that the evolution of lean manufacture is expanding to other environments and industries, proving that the principles of lean manufacturing can be applied to many environments as well as all levels of the supply chain. These techniques are now often referred to as 'lean' or 'lean thinking'.

2.3.2 The Lean Environment

The main concept of lean is to eliminate waste and from this 'Five Lean Principles' have been devised (Rother and Shook, 1999). These principles start by specifying value from the customer's perception, instead of giving the customer what is convenient for the manufacturer. These principles are seen as a journey of continuous improvement. 'Learning to See' (Womack and Jones, 1996) is a clear method of benchmarking through mapping the current and future state of a process as it indicates the flow of both information and material. More recently the concepts of 'Continuous Flow' (Rother and Harris, 2002) and 'Seeing the Whole' (Womack and Jones, 2002) have been introduced. These are the implementation procedures above and below the supply chain in the 'single plant' method explained in 'Learning to See' (Womack and Jones, 1996). It is suggested (Womack and Jones, 1996) that the ideal environment is the manufacture of product family that has low variability, high volume, and adequate quality. The techniques are best applied in a standardised environment. This concept also applies better to a product family of the same technology but more importantly that same process flow through the products production life cycle.

The references previously mentioned (Hicks et al, 2004, Rother and Shook, 1999, Rother and Harris, 2002, Womack and Jones, 2002) highlight that lean thinking can easily be conducted in many different levels of the supply chain, **figure 2.2**.

Throughout these methodologies there is the basic mapping method; however each level has a different variation. Martinez Schanez and Perez Perez (2001), introduces the main concepts, by highlighting manufacturing strategies and types of lean indicators. As the understanding and use of lean thinking increases, the greater the research expands into more in depth detail on implementation. Smalley (2004) and Harris et al, (2003) actually discuss and identify methods of more in depth implementation.

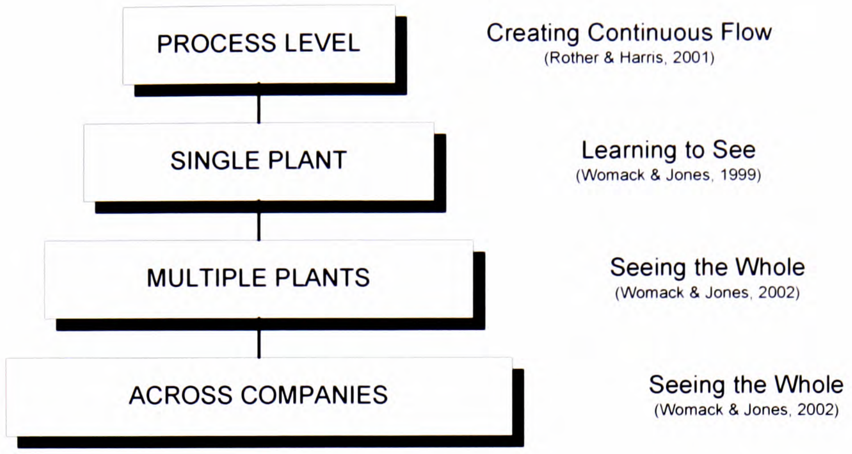


Figure 2.2: The different levels of mapping through lean thinking

(Womack and Jones, 2002)

Throughout these methodologies there is the basic mapping method; however each level has a different variation. Martinez Schanez and Perez Perez (2001), introduces the main concepts, by highlighting manufacturing strategies and types of lean indicators. As the understanding and use of lean thinking increases, the greater the research expands into more in depth detail on implementation. Smalley (2004) and Harris et al, (2003) actually discuss and identify methods of more in depth implementation.

2.3.3 Applications of Lean Thinking

As the lean philosophy is associated with a high volume, low variety environment, it is thought that the application of lean is mostly limited in a 'job shop' environment (Karlsson and Ahlstrom, 1996). There is a great deal of literature on the understanding of the concepts (Martinez Schanez and Perez Perez, 2001) and how they can be applied (Soriano-Meier and Forrester, 2001 and Kojima and Kaplinsky, 2004). The understanding of lean thinking to date has been widely implemented within the manufacturing industry (Achanga et al, 2006, Seth and Gupta, 2005, Herron and Braiden, 2006 and Naim and Barlow, 2003). Lee-Mortimer (2006a) applies lean initiatives to electronic product manufacturing operations and discusses the design and implementation of the application.

Mabry and Morrison (1996) discuss the need to develop a production system for automotive components applications, with the paper following through the use of a lean process tool that is used to evaluate the flow. This type of detailed implementation that is covered by the Mabry and Morrison (1996) is hard to extract from literature. Time studies have been created in order to generate a leaner environment through the use of Just In Time (JIT) and Kanban, (Abdul-Nour et al, 1998). However, in the era of lean and agile systems, these ideas can seem very basic when used in a complex manufacturing organisation.

The most concentrated industrial environment associated with lean thinking is the automotive industry. A great deal has been written on the success and implementation of lean manufacturing systems within this business (Hines et al, 2002). It has also been documented that the aerospace industry has many similarities to the automotive trade (Mathaisel and Comm, 2000).

The automotive industry is the largest manufacturing business and lean practises originated from this industry. The most significant business improvement to the car industry was the transformation of Toyota. Since then all other automotive manufacturers have aspired to follow these techniques to remain competitive, these ideas created from Toyota are the fundamentals of lean principles. Hines et al (2002) investigated the use of lean techniques within the automotive industry. The literature describes how the concepts of lean and project management have been used to map the current system over a six months period and suggested improvements. The authors applied strategic management ideas and cost analysis, one particular useful technique was to create a strategic change programme (**figure 2.3**).

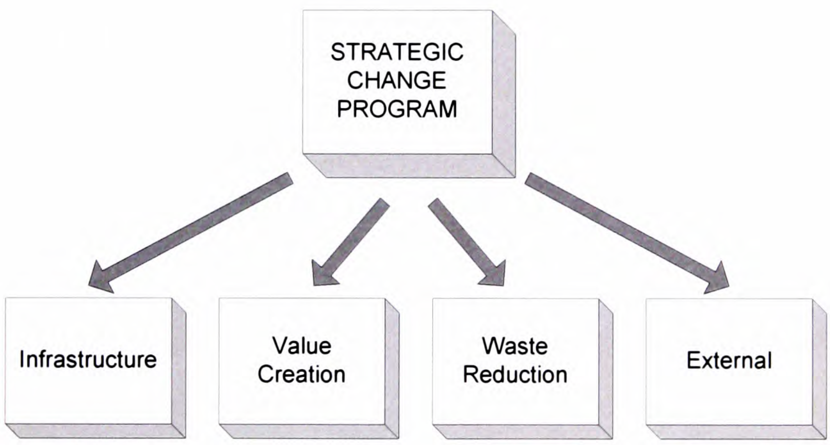


Figure 2.3: The Strategic Change Program

(Hines et al, 2002)

A framework was developed that could be used to implement lean thinking, strategic cost management, marketing and policy deployment, and to apply this to an automotive dealership. The study was very top level but on balance the study proved to be successful. A particular drawback was the time consuming nature of collecting the data required. In conclusion the following method (**figure 2.4**) was established to create a framework.

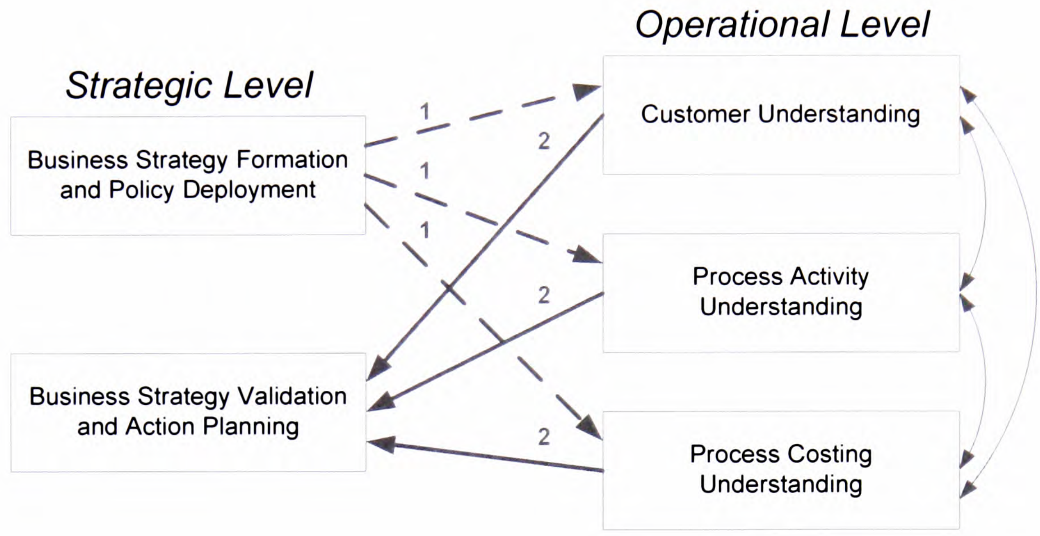


Figure 2.4: A framework for integration

(Hines et al, 2002)

By applying this framework to a case study it enabled the authors to break down departmental barriers. However the study was very labour intensive for all concerned and so it was difficult to obtain reliable data as some of the areas within the organisation, were not being measured.

Cooney (2002) also writes about categorisation of vehicles in the automotive industry, but the case study looks into a component manufacturing for automotive vehicles. This paper investigates the use of batch production along with the constraints of lean production. It was found that although the technique in principle is unique, the implementation and the applicability to different types of environments was more demanding. It was also thought that,

> …."Lean manufacture provides only a partial model of manufacturing systems, if they cannot account for the range of circumstances faced by companies." (Cooney, 2002)

Constraint management and lean thinking has been integrated (Taj and Berro, 2006) to identify bottlenecks and waste within the automotive industry. Using these methods in tandem created better throughput in the plant.

Lean thinking has also been established in the aerospace sector. Mathaisel and Comm (2000) discussed a study that was initiated in 1993 to see if lean principles were applicable to the military aircraft industry. From this the Lean Aircraft Initiative (LAI) was created whose aim was "to create and implement road maps for change in the US defence aircraft industry and the broader industrial base supporting it." A strategy for implementation was similar to that shown in **figure 2.5.** This strategy however is "very top level" and is more of a management strategy.

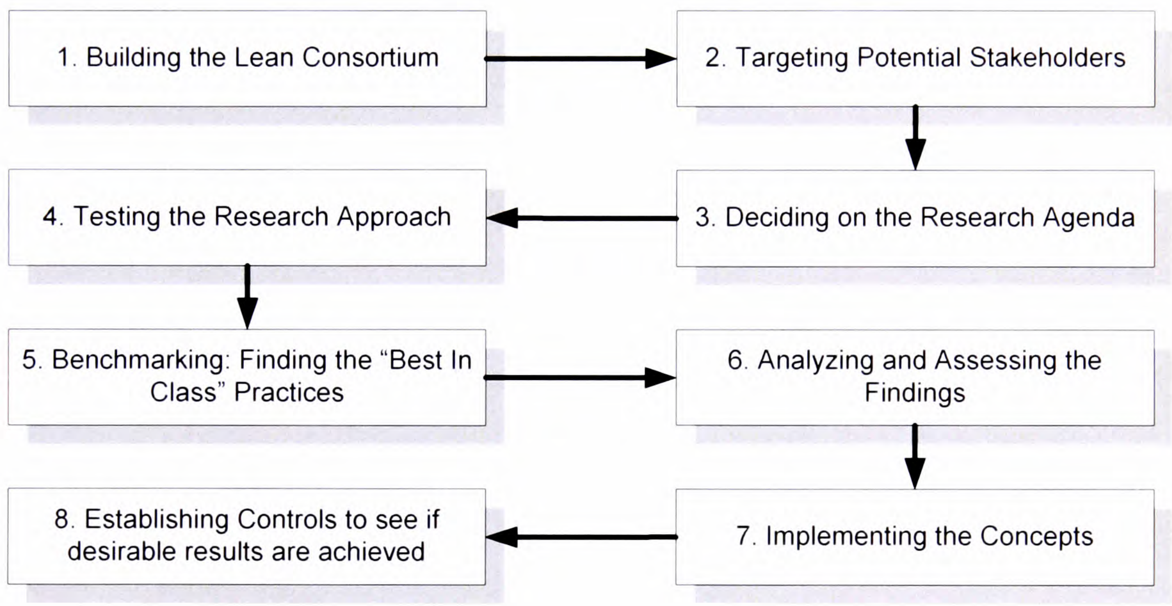


Figure 2.5: An eight step strategy for implementation

(Mathaisel and Comm, 2000)

Other authors (Haque and Moore, 2004) have researched the performance measures of lean thinking within the aerospace industry, whilst others (Bhuiyan et al, 2006) looked at creating a continuous improvement methodology that uses lean sigma and Achieving Competition Excellence (ACE) and concluding by stating "people make continuous improvement successful".

One particular paper that is interesting is by Phillips (1999) and whose basis is the use of agile manufacturing in the aerospace industry. It was particularly interesting because of the association between the aerospace and automotive industry.

> ...."The two products marketed by two respective industries are technically poles apart both in volumes produced and application. The respective markets are served by basic families of products, each family having a product aimed at a particular sub-sector."

A fascinating analogy (which can be seen in **figure 2.6**) was derived to summarise the similarities between the aerospace and automotive industry.

Volume Producers

- *Both are dominated by volume producers*
- *Automotive = Specialist catering for local markets*
- *Aerospace = Serving the sub 100 seats market*

Unique Sectors

- *Both have unique sectors requiring different variants of a product*
- *In both industries components are shared across the respective family*

Impacted by Economy

- *Both are impacted by world economy and financial events with the world economy*

Respond to Business Cycles

- *Both respond to business cycles and economical phase transitions by upsizing or downsizing their operation in line with market demand*

Figure 2.6: Similarities between the automotive and aerospace industries

(Phillips, 1999)

The author explains the paradox, that the world-wide output of automotive vehicles is millions per annum, but the aerospace only has an output of a few thousand per annum. However, the true comparison should be between manufacturing systems employed to produce the volume for their respective markets. It was thought that the aerospace industry is currently facing market conditions similar to that of the automotive environment of the early 1980's and so therefore the businesses are forced to change.

In order to manage the slowdown it has been identified that some of the major aerospace companies such as Boeing and Airbus Industrie are now adopting the lean production philosophies of the automotive industry, having proved that this concept can be applicable to the aerospace business in a similar way that it was introduced to the automotive environment.

Haque (2003) explains the use of lean thinking concepts and applies these to three aerospace companies. The investigation looks into Kaizen on a design process, single piece flow on a new product and off-line development to speed time to market. From the work carried out it was found that the lead-time was significantly reduced on all three accounts. The information appeared to be very in depth and it would have been interesting to see how these improvements had an effect of the rest of the supply chain. Other useful literature that has been written (Haque and Moore, 2004) is the measurement of the performance of introducing lean to a new product within the aerospace sector. This was because it was found that the collection of metrics was the most time consuming task, and so the authors created formulae that could be used to gather a quick perception of the company.

Literature was created by another aerospace component manufacturer, BAE Systems. The company has a dedicated business excellence team which is used to "manage change and monitor business improvement in the organisation". **Figure 2.7** highlights the business improvement strategy created for business improvements.

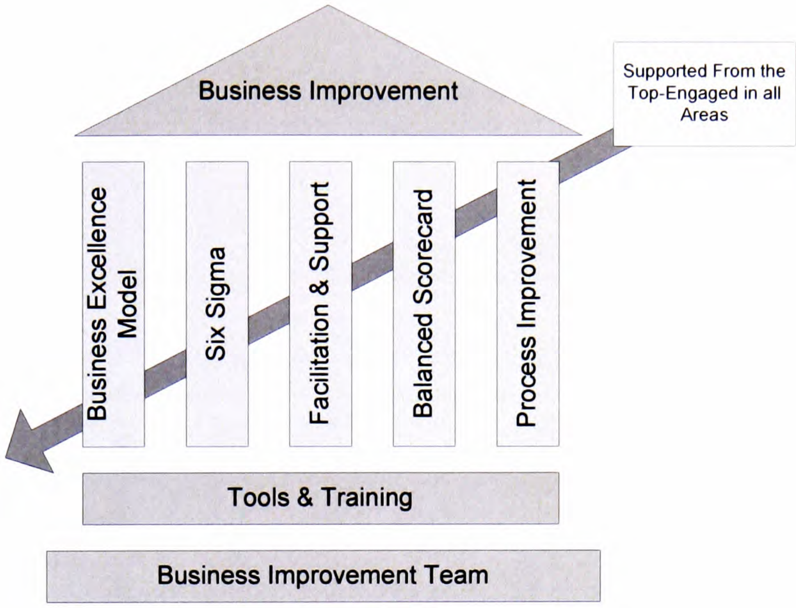


Figure 2.7: The business improvement house from BAE Systems

It can be seen from this literature research that business improvement initiatives are being implemented in the aerospace sector. It has also been noticed that these are comparable techniques to those being used by the automotive industry.

Crute et al (2003) discuss the use of lean practises within the aerospace industry. They state that the largest problem is the difference in volume, which contradicts what has been written by Phillips (1999). It can be deduced from these ideas (Crute et al, 2003 and Phillips, 1999) that discussion around benchmarking activities are dependant upon where the customer is seen in the supply chain. If it is perceived that the end customer is the owner, then there is a difference in volume between automotive and aerospace industry, but if the end customer is the user, then the difference in volume of the end customer requirements is not to dissimilar. The theory raises debate about how the end customer is defined in any given situation.

The concept of lean thinking is expanding from the production functions into the design and development of the product (Berkhauer, 2006). Alford et al (2000) argue that one philosophy is that the customer should be involved in the conceptual stage of the product to determine the design features of the product to best meet their needs. This solution allows customers to design products which they are able to change as opposed to just pushing variety into the current market. Within the automotive industry it is said that three strategies can be derived from mass customisation and are explained in **figure 2.8**. These three strategies reflect the integration of the customer with the value chain.

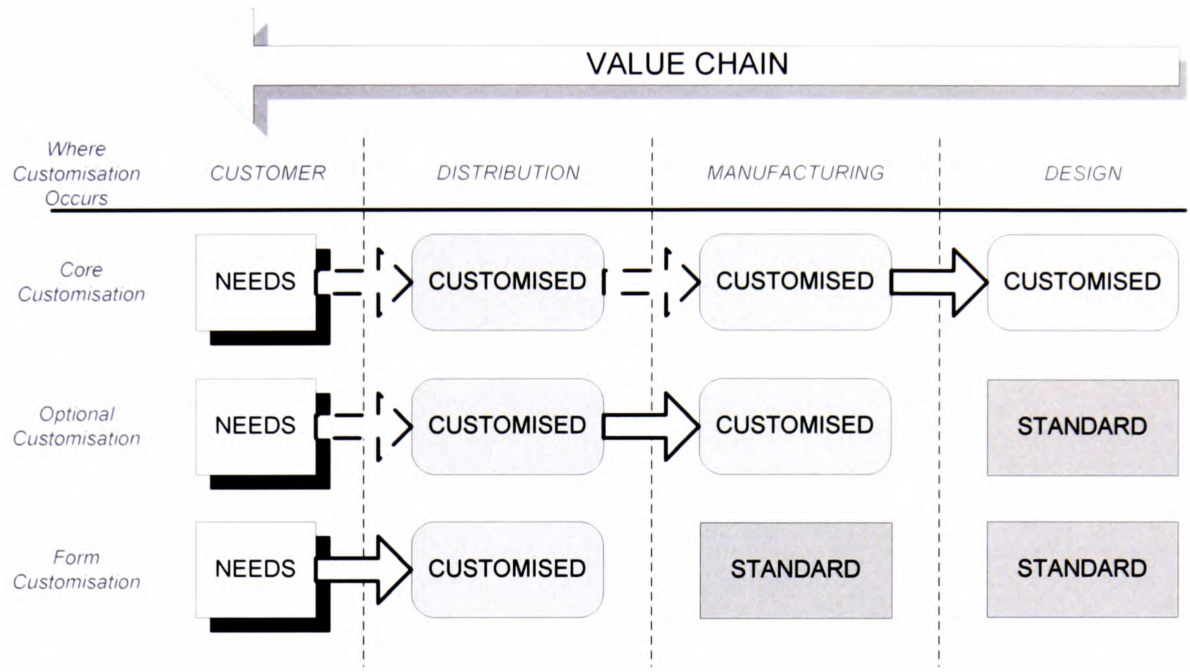


Figure 2.8: Automotive customisation

(Alford et al, 2000)

Haque and James-Moore (2004) also researched into implementing lean techniques with the design of new products and gives two examples. The authors implemented lean at 'New Product Introduction' project management level and they used a macro-level approach and identified that a sustainable approach was missing. However, this is applicable within other businesses such as the service industry and more information based companies (Papadopoulou and Izbayrak, 2005 and Hicks, 2007).

As the concept of lean thinking has developed the application of the concept has expanded enormously. An industry that has applied lean initiatives is the healthcare industry (Fairbanks, 2007 and King et al, 2006). Kollberg et al (2007) creates a framework to place lean thinking in healthcare services. Lean thinking has also been applied within universities (Comm and Mathaisel, 2005 and Billington, 2004), Comm and Mathaisel (2003) show how the "intent is to provide a paradigm of how a lean sustainability could be developed and implemented by colleges and universities". The "Lean Iceberg Model" (**figure 2.9**) was created (Adapted from Hines and Lethbridge, 2008, cited (Hines and Lethbridge, 2008)) to show that as lean initiatives are applied, the more enabling attributes of lean thinking and change become visible. What the model demonstrates that is of particular interest, is the order of enabling attributes. For example the application of lean initiatives are easiest with 'Processes' and hardest with 'Behaviour and Engagement'.

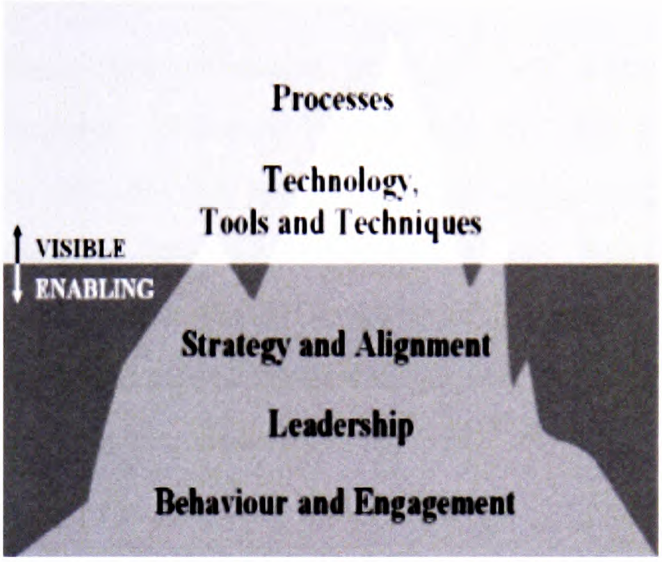


Figure 2.9: The lean iceberg model

(Adapted from Hines et al, 2008, cited (Hines and Lethbridge, 2008))

Another author who chooses the use of lean applications is Arbós (2002). This work is particularly interesting as it demonstrates how the same concepts and ideas can be used within the services industry as well as manufacturing. This highlights that the system of lean thinking is well structured, but very versatile and simplistic to comprehend. It also demonstrates how the application of lean manufacture is not necessarily limited to the manufacturing environment. Other industries are applying the principles (Pepper and Spedding, 2006a) by eliminating waste, creating value and making the same radical improvements as seen previously in the automotive industry.

A great deal of research has been carried out within the construction industry (Kempton, 2006, Green and May, 2002 and Salem et al, 2006). Green and May (2005) discuss how lean thinking was applicable to the construction industry. However, the main issue which is concurrent across many industries will be the implementation and acceptance to change, "The likeliest outcome is that managers give lip-service to the language of lean" (Green and May, 2005). Other industries where the concept is being implemented within its initial stages, is the food industry (Person et al, 2005 and Simons and Zokaei, 2005) and within the marketing and retail industries (Found and Rich, 2007 and Sharma and LaPlace, 2005).

2.3.4 Restrictions of Lean Manufacturing

The literature survey has looked and studied the application of lean thinking and its true success has been discussed. However this survey has also highlighted that some manufacturing environments are more researched with lean techniques than others whilst highlighting some significant limitations of lean thinking. Fearne and Folwer (2006) discuss the limitations of lean in isolation. In those environments that are more job shop orientated these become boundaries to the extent that lean can be applied. In some cases there can be many restrictions that hinder the lean transformation.

It can be found that in large manufacturing organisations the implementation of lean manufacture consists of pull systems and some waste removal. This is due to applying this concept to one particular area of a large organisation and having to retain a traditional supply chain around the system. Therefore, judgement is required in the intermediate change process to alter from push to a pull systems throughout the supply chain and the business functions. There are many factors that hinder the transition between the traditional system and the new lean procedure (**figure 2.10**).

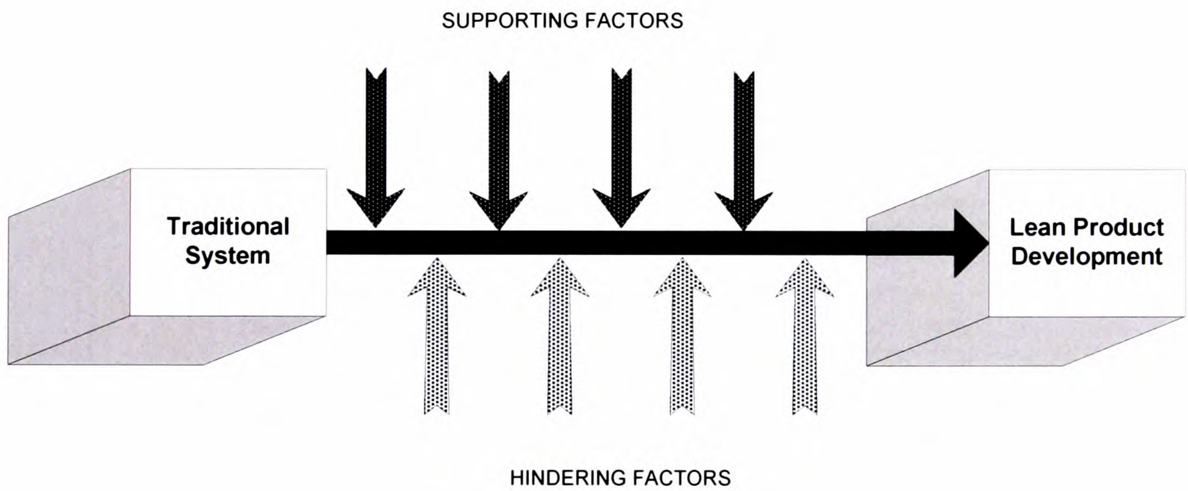


Figure 2.10: How lean manufacture is not always applicable to all manufacturing Industries

(Karlsson and Ahlstrom, 1996)

The main issue that Karlsson and Ahlstrom (1996) consider is how some aspects of lean development hinder the implementation of change from the traditional system to the new lean product development. Some of these factors are;

...."1. Difficulties in creating a cross-functional focus in the organisation.
2. Simultaneous engineering being an inherent paradox.
3. Managing the project through visions is an intricate matter.
4. Strains in the relationship with suppliers involved in the development process."

It can be argued that these issues are not due to lean manufacture but could be generic through all manufacturing business improvement concepts. However, it does indicate the issues that need to be considered when making changes.

Melton (2005) has created a diagram, **figure 2.11** that shows the benefits and advantages of implementing lean initiatives. More importantly it highlights the "forces resisting lean". These typically are natural resistances as well as production and functional culture.

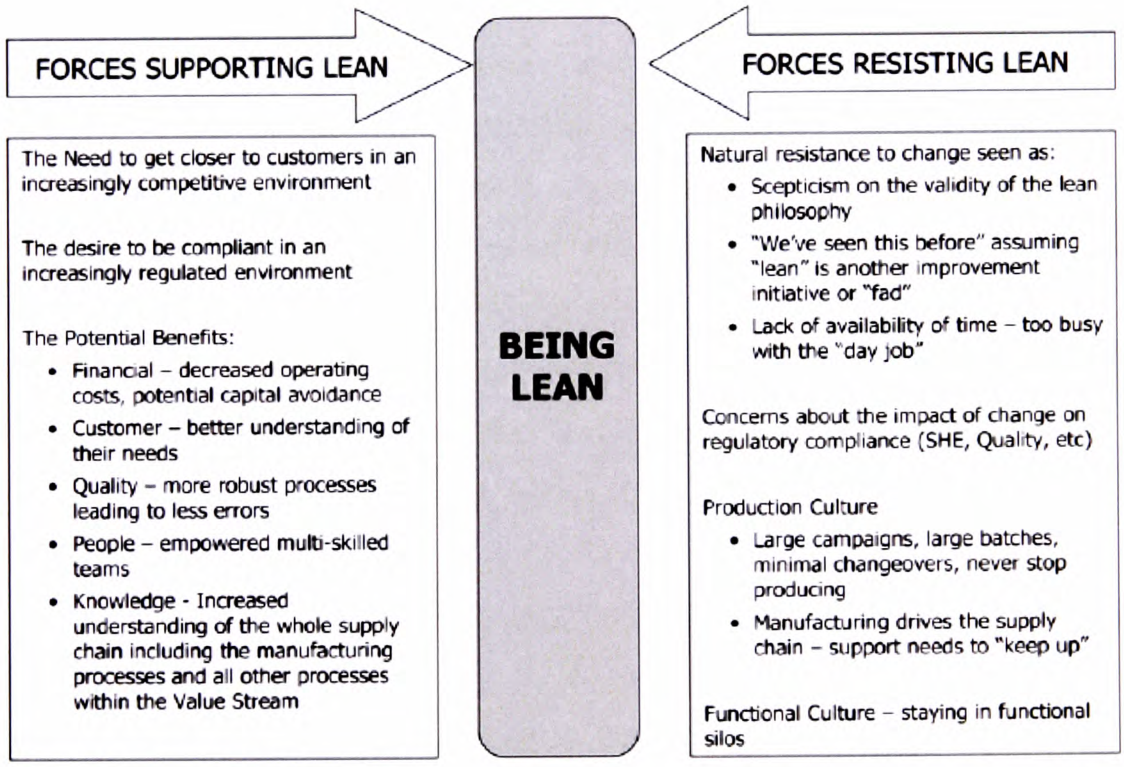


Figure 2.11: The forces opposing and driving a change to 'lean'

(Melton, 2005)

A large contributing factor can be the resistance to change from employees. Being able to collect detailed and relevant information is essential. Lean thinking also requires a stable, repetitive system with limited flexibility, requiring varying kanban sizes which all hinders the data collection process. Lean thinking techniques can lack a holistic view that considers its neighbouring supply chain. Understanding the supply chain is necessary to enable a successful implementation process, for example investigating the true single level process that happens up and downstream in the supply chain.

Cagliano et al (2006) discuss how lean integrates information and physical flows and that Enterprise Resource Planning (ERP) systems only look at information flow. The authors states that;

> ...."Manufacturing companies are today facing the problem of integrating supply chain and manufacturing strategies to optimise operations throughout the value chain."

This indicates that initiatives such as lean manufacture require a holistic outlook across a value chain.

A limitation with lean is the need for zero defects with the highest quality possible is required in a production system to ensure successful implementation and continuous improvement. There are some environments where lean is not ideal and the use of features from other MBIM's may provide a better solution. Bendall (2005) argue that "lean maybe criticised for potential naïve simplisticity". Six sigma is a business improvement tool that looks to improve the quality within systems and research work has been carried out to study lean sigma initiatives. By combining these ideas of a lean with those associated with six sigma, the "Work becomes more focused and time scale for implantation is shorter." (Markarian, 2004).

Research undertaken by Cox and Chicksand (2005) identified how concepts of lean lack flexibility. The studies looked at how these limitations could be addressed with concepts of agile production; **figure 2.12** shows the profiles of each technique. They argue that "the lean approach is not always the most appropriate way to manage internal processes and external relationships". This paper discusses some of the limits of lean management thinking.

Distinguishing Attributes	Lean Supply	Agile Supply
Typical products	Functional products	Innovative products
Marketplace demand	Predictable	Volatile
Product variety	Low	High
Product life cycle	Long	Short
Customer drivers	Cost	Availability
Profit margin	Low	High
Dominant costs	Physical costs	Marketability costs
Stockout penalties	Long-term contractual	Immediate and volatile
Purchasing policy	Buy materials	Assign capacity
Informatioin enrichment	Highly desirable	Obligatory
Forecasting mechanism	Algorithmic	Consultative

Figure 2.12: Lean and agile product profiles

(Cox and Chicksand, 2005)

Lean thinking is a concept that is simple to design and thus very theoretical. The concept does not consider the practicalities of implementation into a real system and this hinders the route of improvement. These requirements was highlighted by Worley and Doolen (2006) who quoted that "the importance of studying organisational phenomenon within real-world settings".

Implementation plans are also inadequate, normally through designing a lean system the changes are so significant from traditional manufacture that the implementation strategy needs to be of a continual design and improvement. Lean thinking lacks implementation direction. Thomas et al (2003) discussed the same issues and stated that focusing "more on workforce management strategies to improve". This statement justified the need for implementation strategies through cultural change methods to enable ad assist a lean transformation.

2.3.5 Lean Manufacturing Summary

Lean manufacturing is a philosophy that can be successfully used in high volume, low variety environments, to reduce waste and inventory. Ultimately to reduce lead times it is necessary to increase on-time delivery and respectively costs. It has been discussed how lean manufacture can be applied at any given point within the supply chain; however the functioning processes around this needs to be considered.

It has also been shown that there are some environments where lean manufacture is not ideal and it is thought that by using features of the other techniques, this may enhance the transition. Agile production is seen as a concept which in some cases is more applicable to those situations where lean manufacture is not always compatible. With a combination of the two, a leagile system can be introduced.

Lean manufacturing gives little consideration to the quality of the products; some of these limitations could be addressed through six sigma strategies. By understanding the supply chain this shall give lean a holistic view and management techniques can enhance the implementation of the lean design. Realistic scenarios could be created in simulation models to test the future state. Lean manufacture is described as an improvement system that can be used in any industry. It has been discussed how lean was created within the automotive industry and as the knowledge expands, the industries of applications broaden and one particular example is the aerospace industry.

2.4 Eliminating Lean Limitations

2.4.1 Agile Production

There are many papers that discuss agile manufacture and the practicalities of the concept, (Van Assen et al, (2000), Yu and Krishnan, (2004), Meredith and Francis, (2000) and Gunasekaran et al, (2002)).

> …."Agility means using the market knowledge and virtual corporation to exploit profitable opportunities in a volatile market place" (Naylor et al, (1999))

Figure 2.13 highlights the authors (Jin-Hai et al, 2003) perception of agile production, and how this compares to other business improvement concepts. Agile production is really driven by competition and must be incorporated in the organisation's development. Depending on the company there will be different levels of the implementation of agility throughout the supply chain.

...."Agile production embodies the ability to cope with change by the application of partners' core competencies to supply customised products. It requires the synthesis of diverse technologies within an integrated system." (Jin-Hai et al, 2003)

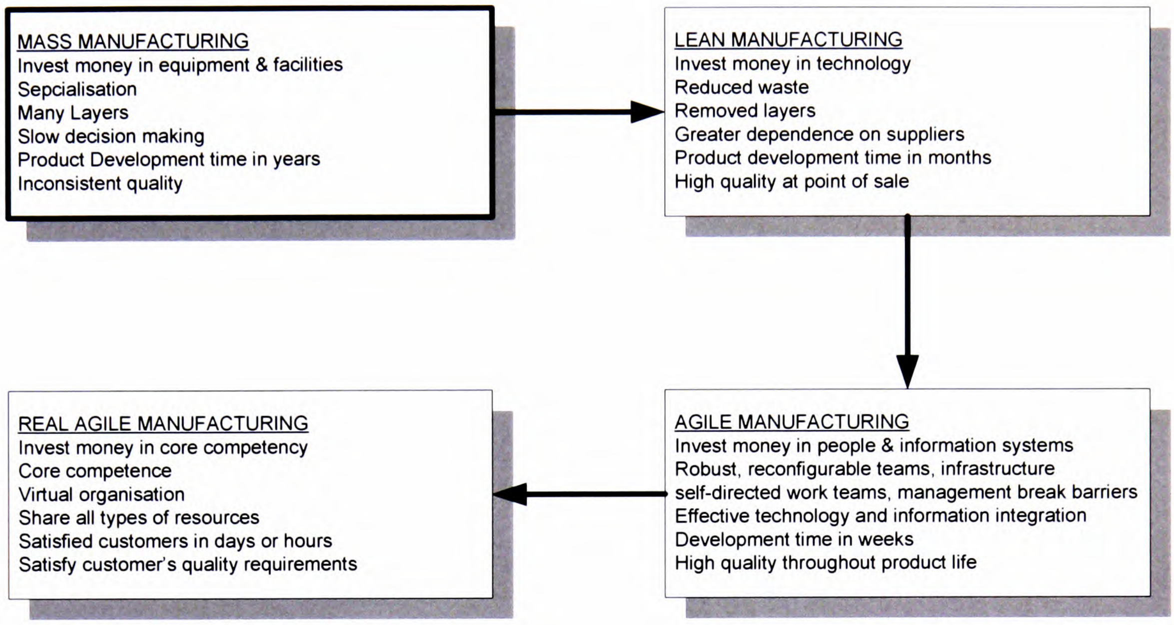


Figure 2.13: Categorical differences in mass, lean, agile and real agile manufacturing

(Jin-Hai et al, 2003)

Lin et al (2006) evaluate the use of agility through the use of fuzzy logic, as with most business agile improvement concepts, it is thought that, "the main driving force behind agility is change".

A methodology was created by Meredith and Francis (2000), to understand the agility of a company by deriving an agile wheel which is divided into four categories. This explores agility through strategy, process, people and linkages. This theory was created to transform a company into an agile organisation with "the ability to respond proactively, to changes within increasingly competitive global markets."

The concept of agile production is increasing but the theory is less regimented than lean thinking and the definitions including the implementation procedures are not as well structured. However, similarly to lean the main procedure is to synchronise the system and understand the production flow. Yao and Carlson (2003) investigate a case study that highlights all of these issues and the problems that occur through the implementation phase. Yusuf et al (1999) explain an implementation procedure and gives a detailed definition of the capabilities of agile manufacturing. The main points of the definitions are:

...."• High quality and highly customised products.
• Products and services with high information and value-adding content.
• Mobilisation of core competencies.
• Responsiveness to social and environmental issues
• Synthesis to social and environmental issues.
• Response to change and uncertainty.
• Intra-enterprise and inter-enterprise integration"

Figure 2.14 highlights the key factors that are associated with the implementation of agile production.

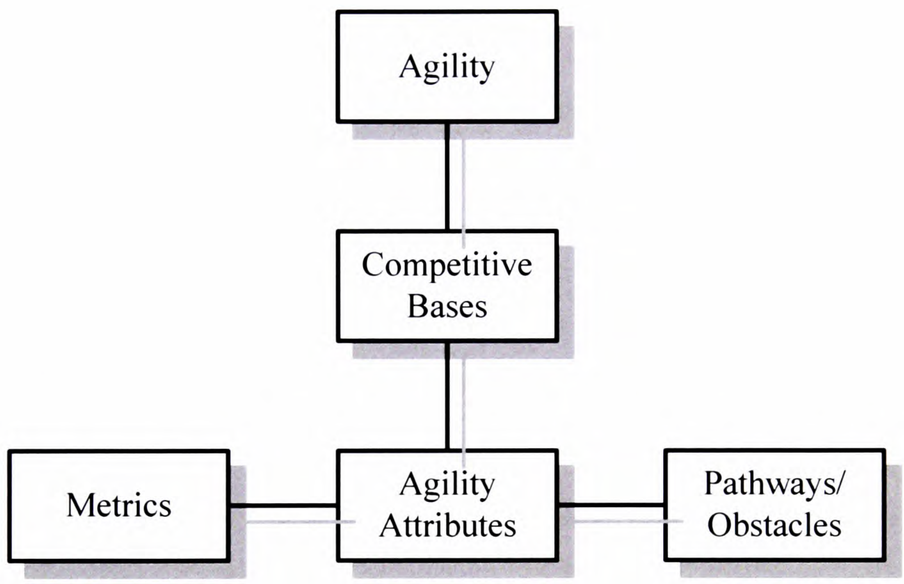


Figure 2.14: A framework for achieving agility

(Yusuf et al, 1999)

A limitation of agile production is that in most environments, products are not unified throughout the whole production process and so the techniques of lean can be applied up stream within a more stabilised environment. Many writers have investigated the use of lean manufacture and agile production (Narasimhan et al, 2006), and found that in those manufacturing environments where neither concept is totally suitable, the methodologies can be integrated to produce a leagile system.

Bicheno (2004) argues that there is a lot of literature that discusses both lean manufacture and agile production. The writer believes that,

> ...."There has been a large amount of frankly incorrect, misleading waste written attempting to compare lean with agile and to identify market segments for each or claiming 'distinct differences by using selective quotation'."

The outcome from this theoretical conflict is to combine the two techniques in a leagile system. From the research currently undertaken by the author it can be summarised that both lean manufacture and agile production can easily be applied throughout the supply chain and at different levels of the supply chain, independently. From this it can be assumed that it is possible to integrate the concepts of the two techniques to produce a leagile system. However, it is important to investigate how well this philosophy is documented and its applicability within the supply chain.

A significant finding from this literature research is the understanding of creating a "Leagile" supply chain (Prince and Kay, (2003), Naim and Barlow, (2003) and Sharp et al, (1999)). Leagile systems allow the advantages from both lean and agile concepts to be used as the theories have different attributes. Integrating the lean and agile techniques within the supply chain provides a very powerful tool. However, the critical issue is the positioning of the decoupling point (Mason-Jones et al, (2000)).

> ..."Leagility is the combination of the lean and agile paradigm within a total supply chain strategy by positioning the decoupling point so as best to suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the decoupling point." (Naylor et al, (1997) cited in (Mason-Jones et al, (2000))).

Characteristics those both lean and agile manufacturing aspire to be are: the removal of waste, reducing the necessary waste and compressing the lead-time in both the material and information flow. However a particular dissimilarity is that lean production pulls material through the supply chain, but in an agile environment the material is still pushed through the system. It is thought that a system where standardised products are produced (upstream) the material can be pulled through the supply chain, but when the products become more specific (downstream) an agile system is more beneficial. This is when the decoupling point in the chain is required and it is important to ensure that the decoupling point is placed in the correct point in the supply chain. The decoupling point acts as a buffer between the two paradigms because of the change in demand. **Figure 2.15** highlights the most suitable point for a decoupling point in different supply chains.

The effects of a decoupling point reduce the 'bullwhip' effect of demand up the value stream. The demand upstream has less variability as it is forecast driven whereas beyond the decoupling point the demand is customer driven and so the variability is greater. The decoupling point acts as a buffer between the two paradigms because of the change in demand.

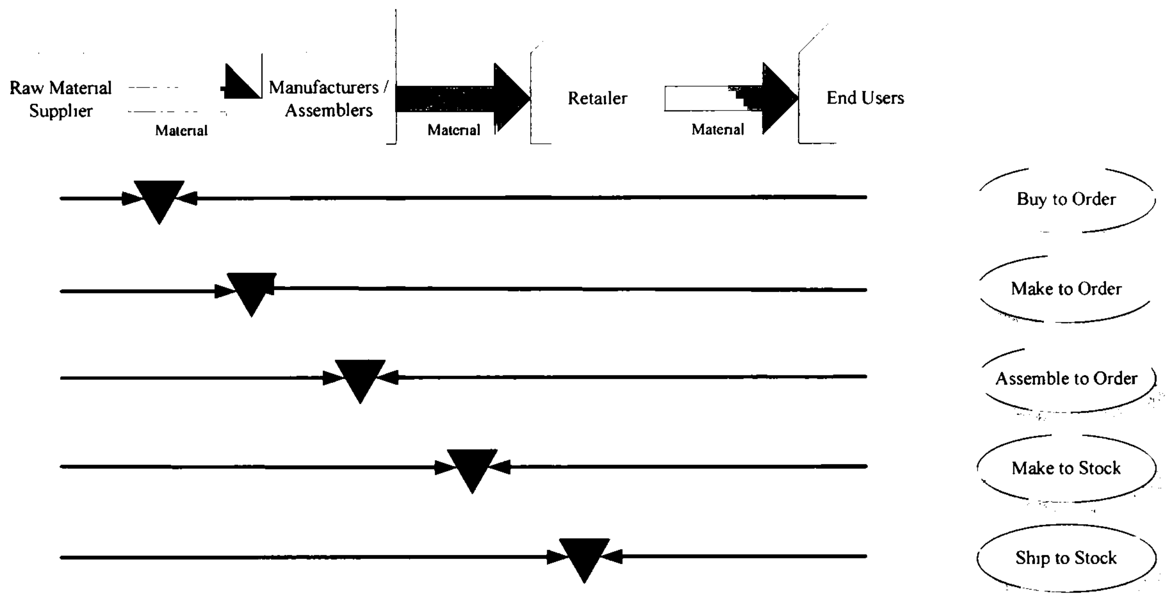


Figure 2.15: Supply chain strategies with a stockholding decoupling point

(Hoekstra et al, (1992) cited (Naylor et al, (1999)))

A survey created and discussed by Power et al (2001) look at results which were carried out by Australian manufacturing companies. The companies were assessed using critical success factors in agile supply chain management. This research also highlighted that the concepts of agile production can be implemented across the supply chain. Together with methodologies created by Womack and Jones (2002) on applying lean manufacture within the supply chain, it was proven that theoretically a leagile system could be introduced into a supply chain.

2.4.2 Supply Chain Management

Some researchers portray supply chain management as a macro mapping tool across companies (Womack and Jones, 2002), while others see it as a subject based around the logistics, distribution and transportation of products throughout the process (Mason et al, 2003 and Naim et al, 2002). Supply chain management is managing the supply chain, the processes and procedures from the raw material through, in many companies, to the end customer.

Value Stream Mapping (VSM) is associated as a lean tool used to improve the existing system. However, it is important to look carefully at the variability in the order and material flows. Mapping throughout the external supply chain is harder because mapping is required through all company boundaries. It also requires the cooperation of all department and divisions within the company, as well as the companies up and downstream. Because of this supply and demand throughout the chain, the variability will increase making the system less stable. In order to control this inconsistency there needs to be a relationship between the company and the supplier, a 'partnership aims at zero receiving inspection and at delivery directly to point of use' (Bicheno, 2000). It is also necessary to agree to on-time delivery from the supplier and structured demands from the customer.

Ultimately more frequent small deliveries are required to create a stable and lean environment and the supplier base will have to be reduced in order to create this relationship with the more important suppliers. Bicheno (2000) demonstrates (**figure 2.16**) the reduction in cost to the customer if there are better relationships with the supplier.

There are many techniques by which to improve the relationships within the supply chain with Towill et al, (2000) and Naim et al (2002) discussing and investigating a method of 'Quick Scanning'. This method is used to evaluate how well the process and procedures within the supply chain meet the end customers requirements. This idea was carried out on a case study and highlighted paradigms such as, lean thinking, business process re-engineering and agile production. Other methods are used to reduce the supplier base in order to create a better relationship with the supplier and the buyer:

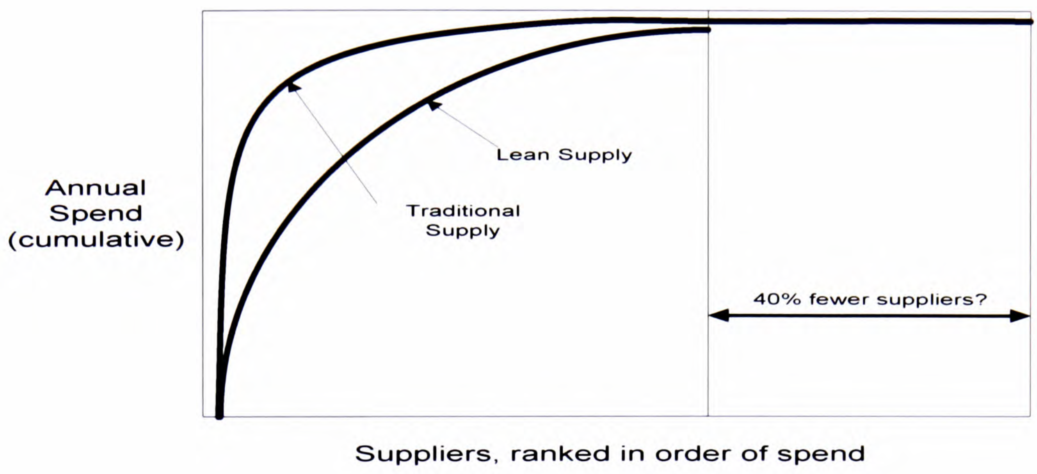


Figure 2.16: Rationalising the Supplier Base

(Bicheno, 2000)

> ...."By single sourcing the suppliers provides easy control of the procurement for achieving the lean supply objectives beside some important advantages." (Barla, 2003)

Work carried out by Bredström et al (2004) discusses the use of models to improve the supply chain. To organise the supply chain, models can be created to understand the current state or to test new programs, the models can be created either mathematically or through simulation software packages. Work carried out by Bredström et al (2004) discusses the use of models to improve the supply chain.

A book written by Bolstorff and Rosenbaum (2003) discusses the use of supply chain council, a non-profit organisation formed in 1996, to develop a Supply Chain Operations Reference (SCOR) methodology, **figure 2.17**. This SCOR model is used by a number of organisations such as Compaq, Lockheed Martin, Rockwell Semiconductor, 3M and many more. The model is based on a number of processes.

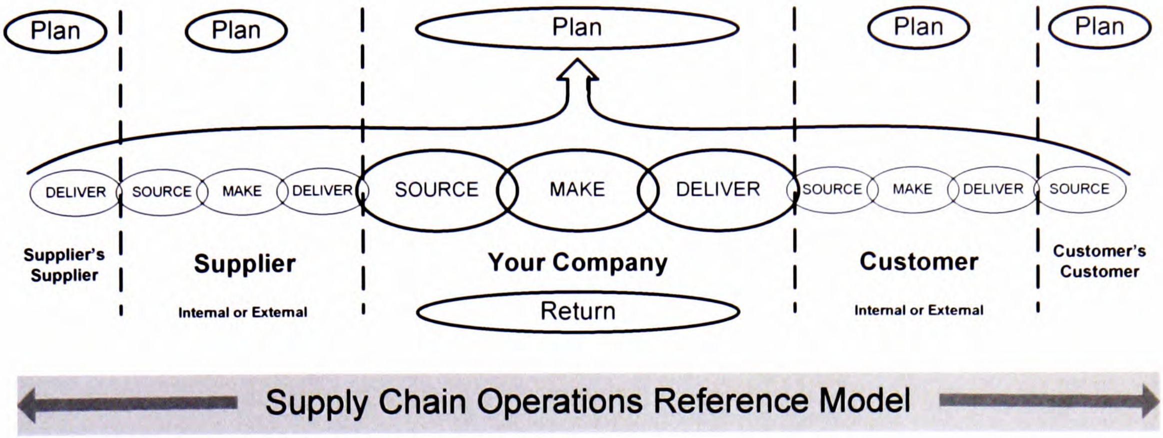


Figure 2.17: The SCOR model

(Supply-Chain Council, Inc, 2001(cited in Bolstorff and Rosenbaum, 2003))

The SCOR methodology appears to be very powerful with Bolstorff and Rosenbaum, (2003) discussing the use of the technique in a case study and indicating why and how decisions are made as the methodology progresses. The authors have highlighted a roadmap on how to implement the reference model, shown in **figure 2.18**.

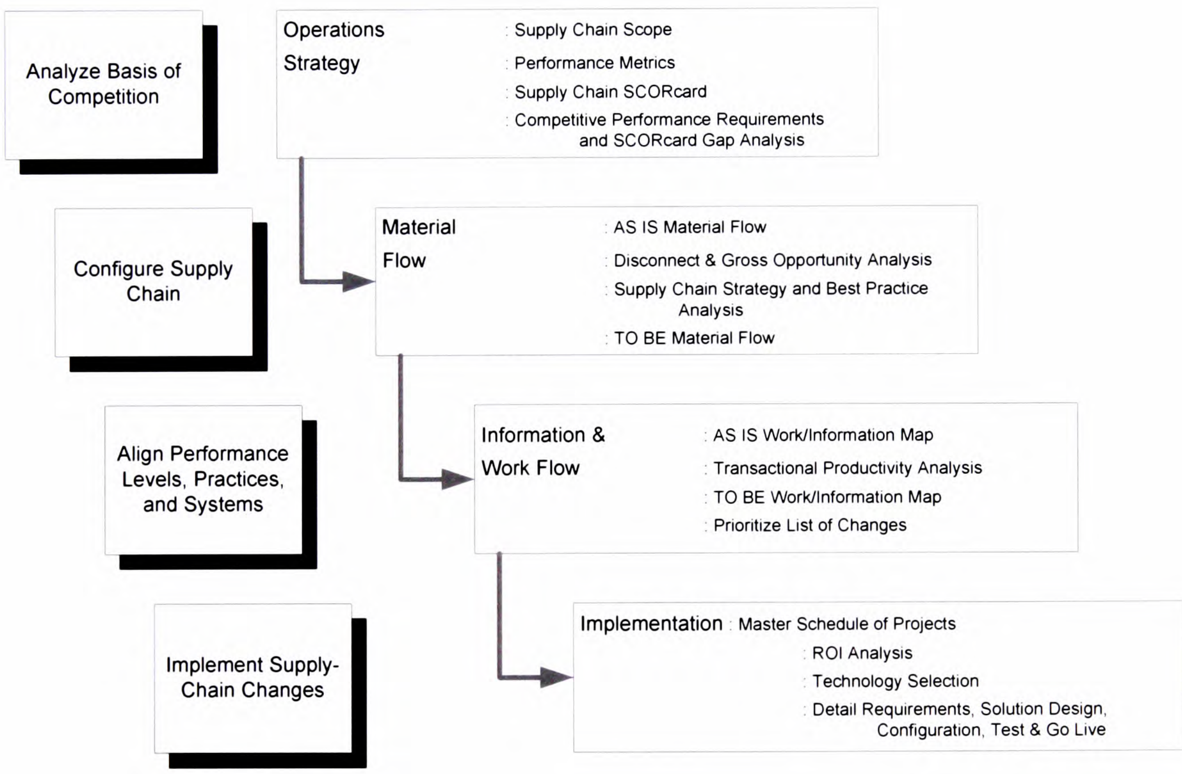


Figure 2.18: The SCOR roadmap

(Supply-Chain Council, Inc, 2001(cited in Bolstorff and Rosenbaum, 2003))

A paper by Mason et al (2003) assesses warehouse and transportation management systems and how the two can be integrated to reduce supply chain costs. The results proved that the key to integrating warehouse and transportation management systems is that a virtual warehouse can contain information on the past, present and projected location of each supply chain through time. The simulation study highlighted that virtual warehousing can be used to reduce lead-time variability, improve efficiencies and reduce costs. However, these ideas are only conceptual and costs that would be associated with such integration have to be considered.

Supply change management relies mainly on the organisation of the logistics, as well as structured planning schedules, forecasting techniques, and inventory control. However, the concept depends upon the type of the system (Caridi and Sianesi, 2000). One view that is being introduced is the idea of virtual logistics, by using the same principle as banks transferring money and with the use of the internet, materials and products can be transferred virtually through inventories, buffers and warehouses (Clarke, 1998). Advantages indicate the reduction of costs associated with holding stock, along with obsolescence costs and ideally stock turnover would increase.

This literature survey on supply chain management has identified how this manufacturing business improvement concept is a very broad topic. Previously it was discussed how lean manufacture can be applied within a supply chain as well as the overall supply chain (Womack and Jones, 2002). Supply chain management enables a holistic view within the transformation of a lean business improvement. By integrating the theory of supply chain management and lean this would eliminate issues related to dysfunctional improvement projects (Pepper and Spedding, 2006b), lack of communication and isolated improvement projects.

2.4.3 Six Sigma

Six Sigma is a quality improvement technique that has been successfully implemented in industry.

> ...."Six sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical

methods and the scientific method to make dramatic reductions in customer defined defect rates." (Linderman et al, 2003)

An article written by Ingle and Roe (2001) is a discussion of the methodology and is based upon their previous work. The article also explains how "Six sigma employs a range of tools to eliminate the causes of variation". This variation is the cumulative variations created by a small variation within processes, either through production conditions or human error.

The initiative of six sigma implementation is through in house training of greenbelts, black belts and master black belts. Master black belts are trained externally and then train others internally through the green and black belt processes. Master black belts also over see the projects that are created from the training, which are undertaken by greenbelts and black belts. Different companies (e.g. Motorola and GE) perceive the implementation process differently; however the principle is the same, (the case study used in Ingle and Roe, 2001). The main process for improvement is the Define, Measure, Analyse, Improve and Control (DMAIC) (**figure 2.19**).

DMAIC	**Define**	• Define the project goals and customer (internal and external) deliverables
	Measure	• Measure the process to determine current performance
	Analyse	• Analyse and determine the root cause(s) of the defects
	Improve	• Improve the process by eliminating defects
	Control	• Control future process performance

Figure 2.19: The definition of the DMAIC process

(URL1)

However, it has been discussed that a more advanced technique may be used in some cases, this is known as the Design, Measure, Analyse, Design and Verify (DMADV) process (**figure 2.20**),

DMADV	**Define**	• Define the project goals and customer (internal and external) deliverables
	Measure	• Measure and determine customer needs and specifications
	Analyse	• Analyze the process options to meet the customer needs
	Design	• Design (detailed) the process to meet the customer needs
	Verify	• Verify the design performance and ability to meet customer needs

Figure 2.20: The definition of the DMADV process

(URL1)

this is used when;

> ....."• A product or process is not in existence at your company and one needs to be developed.
> • The existing product or process exists and has been optimised (using either DMAIC or not) and still fails to meet the level of customer specification or six sigma level." (URL1)

This reference was explaining how different techniques are required for different environments. It was thought by Simon (2005, URL1) that the DMADV theory was better used in an environment where the product was new or where DMAIC was not best suited.

However, these ideas can be related to other ideas and concepts to understand business improvements in general. Other publications describe the need to reduce variability in a manufacturing environment. Li, (2003) looks at the need to control production through reducing variability, but still within the lean constraints of demand-pull production. Aase et al (2004) discuss the use of quality techniques such as 'design of experiments (DOE)' and 'analysis of variance (AOV)' to improve labour productivity. Cua et al (2001) studied the relationship between 'JIT', 'total productive maintenance (TPM)' and 'total quality management (TQM)' to increase manufacturing performance.

Six sigma includes quality improvement techniques (Kwak and Anbari, 2006) and in each project the concepts and improvement ideas will vary depending upon the nature of the project. Quality techniques are then required when transforming the state of a system and so the cycle between the two systems is continually evolving.

Many companies are using the concept of lean because of the need to reduce lead-times and to reduce inventory. Lean thinking assumes that the quality of the product is of a high standard and leaves little flexibility for the faulty products. **Figure 2.21** (created by the author) highlights how the integrated use of lean manufacture and six sigma will continually evolve through the design and implementation.

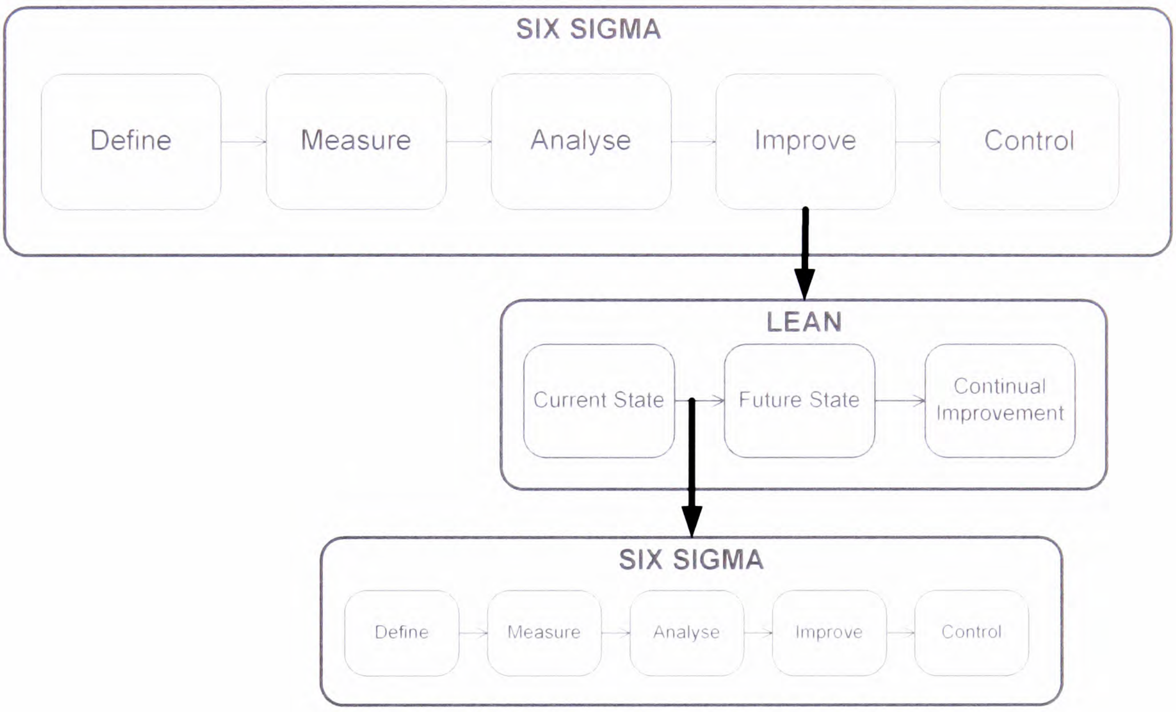


Figure 2.21: The interaction of six sigma and lean thinking

By combining these ideas of a lean thinking with those associated with six sigma, the "Work becomes more focused and time scale for implantation is shorter." (Markarian, 2004). It is widely known that six sigma has been used extensively with lean thinking. Bicheno (2004) writes about lean manufacture and six sigma, stating that,

> …"Lean is better at the big picture, at establishing the foundation through activities such as 5S and standard operations, whilst six sigma offers a powerful problem solving methodology through DMAIC."

An article written by Markarian (2004) highlights the importance of using these tools together to achieve better results rather than using any single concept. This article discusses how six sigma can improve first time yield and reduces some waste in manufacturing processes. However, lean thinking tools generate a more significant breakthrough in waste elimination.

Research has developed and the concepts of lean and six sigma have been integrated, introducing lean sigma initiatives (Furterer and Eishennawy, 2005, Byrne et al, 2007, Fairbanks, 2007, Andersson et al, 2006 and Bendell, 2006). Proudlove et al, (2008) make comparisons between the implementation of lean and six sigma. The research highlights how:

> ...."Implementation is a bigger issue and perhaps where attention should be focused, rather than on the techniques themselves".

However, Lee-Mortimer (2006b) discusses how six sigma programs deal with deep rooted quality issues within manufacturing and suggests that even initiatives such as lean manufacture can be eliminated. Whilst Kumar et al (2006) quote;

> ...."Lean sigma combines the variability reduction tools and techniques from six sigma with the waste and non value elimination tools and techniques from lean manufacture, to generate savings to the bottom-line of an organisation."

The paper proposes a lean sigma framework where lean tools were used within the six sigma DMAIC process to reduce defects occurring in the final product.

2.4.4 Simulation Modelling

Simulation is a time-based model of a real-world process or event. Simulation provides a means to create an artificial state of a system in order to analyse and study its operational characteristics. Yazici (2006) discuss how simulation modelling can be used to teach facility layouts in either job shop or cellular manufacturing to under graduates. This work highlights how simulation modelling can be used along with continuous improvement techniques.

Whether designing new systems or asking questions about existing systems, simulation is a powerful tool to provide answers to complex problems that fall outside the realm of analytic methods. Simulation models are produced in a number of different formats, either through mathematical analysis or software creation. It is believed that;

> .... "The new generation of simulation tools should support not only the traditional tasks (statistical data analysis, model building and verification, etc.), but also the decisions concerning situation analysis and the defining of the project objectives, the generation of solution variants and their evaluation" (Košturiak and Gregor, 1999)

Košturiak and Gregor, (1999) indicate the problems associated with change in process and manufacturing environments, without the use of simulation models prior to the transformation. Two typical mistakes are over capacity and under capacity. Very few papers actually write about the application procedure of models to systems. However Liu et al (2005) describe the use of simulation software for scheduling a bell-type batch annealing shop. The paper actually looks at the application of this study and identifies a structured method for creating a discrete event model in which the constraints are highlighted as well as the handling of the shared resources.

A great deal of literature involves simulation model analysis through the mathematical analysis approach (Chen and Chen, (1996), Hendry et al, (1998), Cheng and Duran, (2004) and Lin and Fu, (2001)). Work carried out by Chen et al (2002) looks at a simulation study of logistics activities in a chemical plant and the main advantage from creating simulation models on an existing system by carrying out 'What if' scenarios. A study carried out by Lyons et al (2000) conducts a comparative study of alternative approaches to modelling the operations of a small enterprise. The simulation tools selected are WITNESS, SIMET II and OME. WITNESS is a visual and interactive piece of software which is capable of modelling both discrete and continuous systems and uses a standard Windows interface. It was found that:

> ...."WITNESS provided the most consistent results, both in terms of deviation of results from the observed values and the reproducibility of the results through repeated replications of the model." Lyons et al (2000)

WITNESS was also the only tool that was able to sample from empirical data. Parola and Sciomachen (2005) use WITNESS (2004) to create a port system network. The paper highlights how the model was applied to the network and the actual logic that was used. Again the tool was used to create a number of suitable scenarios for optimisation.

Other published work examined was from the creators of WITNESS, 'Lanner'. They provide case studies that have been carried out using the simulation software tool. The studies used BAE Systems as the industrial environment. The case studies demonstrated how WITNESS was an integral part to business improvement programmes and cycle times were halved and capacity was increased, in some instances by more than fifty percent. In another case study WITNESS was used to design a new plant layout using Computer Aided Design (CAD) which can be integrated into WITNESS. Fontanili et al, (2000) also used WITNESS to replicate a flow system to calculate optimisation methods through the use of algorithms.

Another limitation of lean thinking is the realism of the designed system, as lean thinking is very theoretical in its design and it has been shown how the implementation of the future state is harder to achieve (Ballé and Ballé, 2007). Schroer (2004) have shown how simulation modelling could be used to model the theoretical model for realism.

One particular disadvantage of lean thinking is the lack of human intervention, for example the inability to assess and make a judgement on the process. This therefore increases the variability into the system. Variability can be modelled in simulation modelling through the use of distribution and complexity factors to make the model as realistic as possible. However, by using simulation alongside lean thinking this variability can be reduced and ideas can be generated to produce improvements from these. Factors that aren't always easily considered are:

- The different skills of workers
- Factors such as days off through sickness, holidays, training development
- Different shift patterns of work
- Machine reliability and capacity
- Defective products and rework

Schroer (2004) indicates there is a correlation between simulation and lean manufacture. So ideas and suggestions that are created from lean manufacturing developments can be tested through simulation models, to understand the outcome of these ideas and to measure their suitability.

> ...."Simulation is ideally suited to understand the concepts of lean manufacturing, such as the following;
>
> - Line balancing against takt time
> - Pull versus push manufacturing
> - Batch versus one-piece flow
> - Kanban inventory control
> - Process variability reduction." (Schroer, 2004)

Schroer (2004) gives a detailed discussion and provides a simple case study of a manufacturing cell. The simulation model uses the concepts of lean manufacturing to optimise the model and the model then allows the user to make the changes derived from the lean manufacture ideas to suggest a suitable outcome.

Lian and Van Landegham (2007) discuss the use of simulation modelling with VSM, which is a tool associated with lean thinking. Abdulmalek and Rajgopal (2007) uses simulation modelling to test the 'before and after' scenarios created to contrast with that created from VSM. The model was used to illustrate to managers the potential benefits such as reduced production lead-time and lower work-in-process inventory.

2.4.5 Implementation Management

To ensure that any business improvement is planned and implemented successfully, certain management methodologies can be used. Having researched manufacturing techniques, concerned with transforming a traditional manufacturing system to a lean environment, it was discovered that aspects of implementation management were required to assist the transformation to increase the rate of success.

As previously discussed there are many writers that have stated that implementation of a theoretical design is harder to achieve (Proudlove et al, 2008, Hines and Lethbridge, 2008, Balle and Balle, 2006, Bhuiyan et al, 2006, Green and May, 2005, Smart et al, 2003, Thomas et al, 2003 and Baines et al, 2006). It is believed that the success of implementation is the strategy management and people behind the theoretical design. It was found by Caron and Fiore (1995), that these issues are the main reasons for late deliveries, excess work-in-progress and large warehousing. All this was due to weak management tools and techniques that are either incorrectly implemented or are not used robustly.

Abdul-Nour et al (1998) introduce how the use of the kanban techniques and the JIT philosophy can be used in a project management style to improve a small manufacturing business. The achievement was that the lead-time was reduced from six months down to less than two months. This involved standardising the parts, modularising the Bill of Materials (BOM), understanding the critical path, creating a time study and looking into the plant layout with the final stages being to investigate the production planning and improving the system and implementing the outcomes. This finally cohered with the basic and simplest principles of lean (introducing a pull system through the use of kanban techniques), however project management concepts were used to capture the traditional systems and to test the new model.

To ensure the success of any change in the organisation of a company, a structured implementation plan is required and the process and procedures are fully understood (Berkhauer-Smith, 2007). In **figure 2.22** a route map has been created for integrating leanness and agility. This implementation plan highlights how material and information flows should be integrated to minimise stocks, demand and lead-time but also to increase profit. By introducing a leagile supply chain, the system can then be cost-effective upstream of the decoupling point and achieve high service levels down stream.

There is also a great deal of research about strategy management. However, within this study it was important to understand the association of lean thinking with strategy management to give the lean theoretical design implementation structure. Knowles et al (2005) created a model that associates continuous improvement with strategy management, **figure 2.23**. The model shows how to integrate six sigma with lean tools to ensure strategic goals.

Market Knowledge	Supply Chain Design	Optimise for Leanness Agility	Result	
• Identify product demand variability	• Integrate Supply Chain material flow	• Eliminate all waste	• Maximise profits with minimum costs and sufficient service to satisfy a level schedule	LEAN
• Identify product variety	• Integrate Supply Chain information flow	• Maximise flexibility without incurring additional waste		
• Identify point of differentiation	• Strategic positioning of the decoupling point	• Design for total flexibility	• Maximise profits with maximum service and lowest possible cost to satisfy a volatile market place	AGILE
• Identify lead-time requirements	• Lead-time compression	• Minimise waste without restricting flexibility		

Figure 2.22: A route map for integrating leanness and agility

(Mason-Jones et al, 2000)

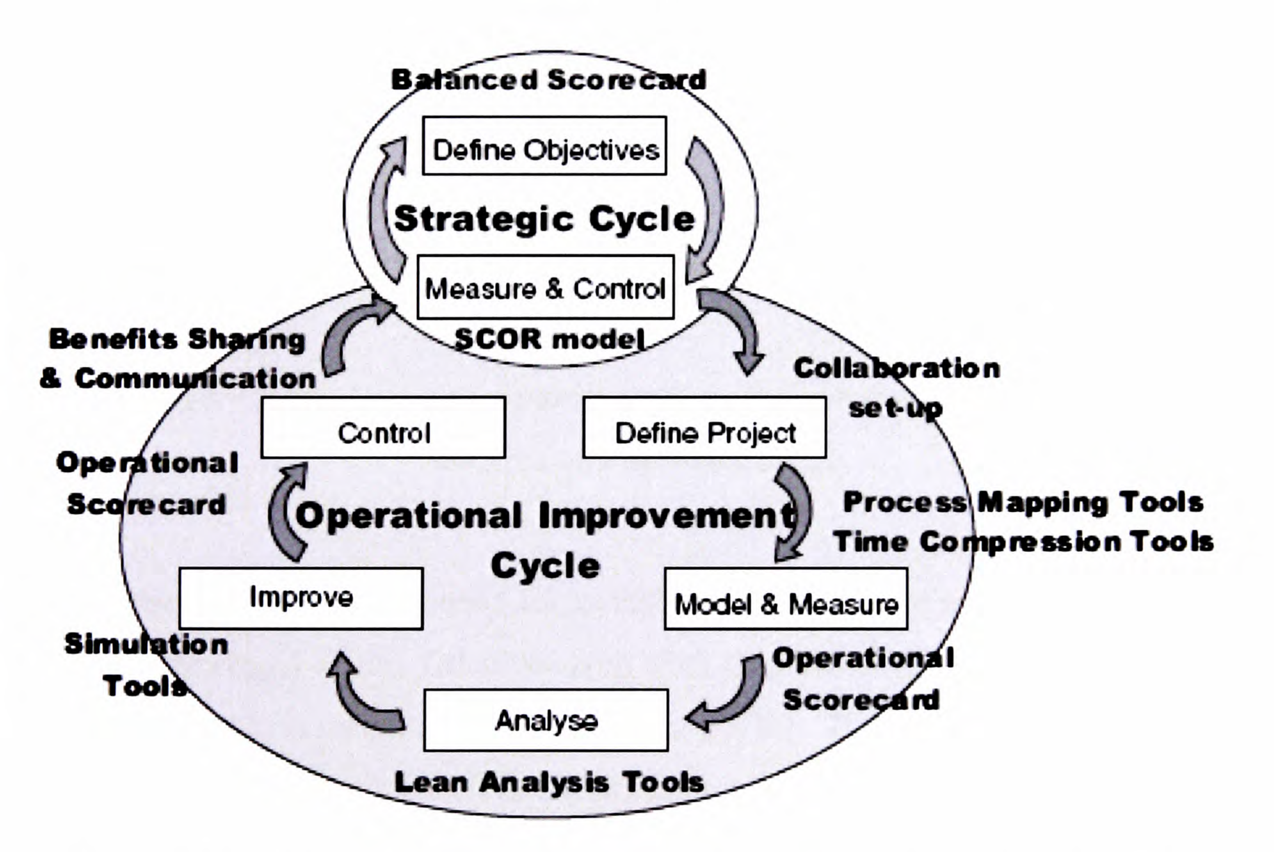


Figure 2.23: Additional tools, techniques and activities to be used in the model

(Knowles et al, 2005)

Other work has entailed the use of VSM to "determine the belief, behaviour and competences processed by business leaders". This work carried out by Emiliani and Stec (2004) also highlighted that maps alone are not enough to change the mindset of the business leaders and change their fundamental belief in leadership. This work also highlighted the need for cultural and mindset change, when transforming a traditional manufacturing environment.

De Toni and Tonchia (2002) identified the "missing links between the literature concerning new production models on one side and that concerning corporate and manufacturing strategies on the other", this is shown in **figure 2.24.**

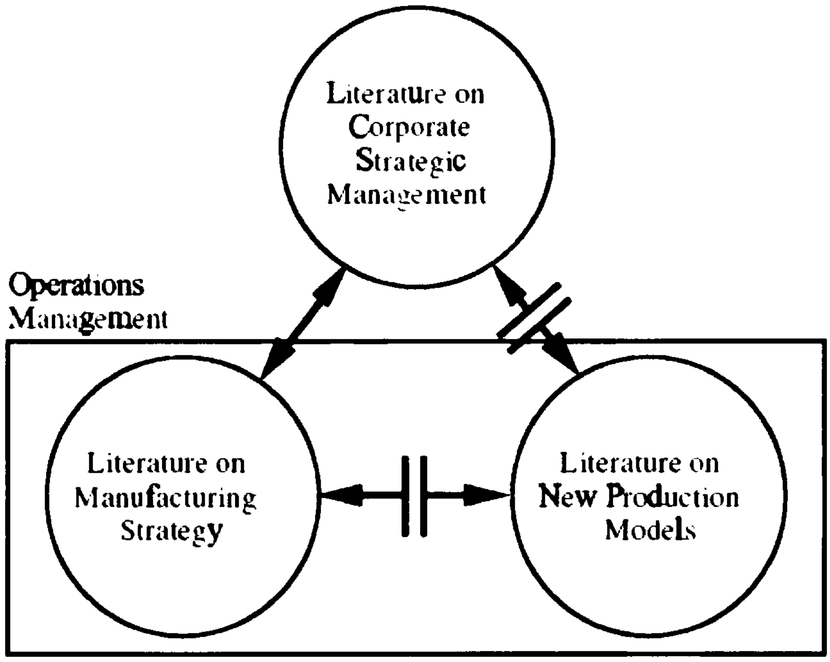


Figure 2.24: Driving corporate strategy through the supply chain
(De Toni and Tonchia, 2002)

This diagram highlighted the need for overall corporate strategy to drive the changes throughout the supply chain. Other research work that studied the integration of strategy management and lean manufacture is by Tagore (2007). This work discusses the use of 'a roadmap that integrates the technical transitions with managerial transitions to create a 'High Performance Process Plant' which are referenced to 'World Class' and 'Lean Management' plants.

Abdul-Nour et al, (1998) identified that the design of a lean system is easy to create but that implementation is harder to achieve. The resistance to change is the hardest factor to accomplish when implementing business improvements (Trompenaars and Hampden-Turner cited in Finlay, (2000)). This approach can be seen as the "forgotten" strategy when introducing change since the more technical concepts are seen as the most important due to the time frame given or the easier approach to take. Educating employees in these ideas, although costly, is effective, but usually the most complex part is to actually implementing these ideas. Having the management and work teams involved and interested is important for successfully implementation.

Reijers and Liman Mansar, (2005) reiterate again how BPR is seen as a "twofold challenge" and it highlights the use of different practises to reorganise the structure. Typical techniques are:

- Centralisation – treating geographical dispersed resources as if they are centralised.
- Empowerment – giving workers most of the decision making authority, reducing middle management and techniques such as outsourcing or task automation.

Other writers who indicate that there are problems with changes are Huang and Mak (1999) who by conducting a survey noticed that problems such as 'poor communications', 'problems being discovered too late' and 'internal departments not being co-operative', hindered these changes. Even though these problems were noticed they were not really addressed in the research and there was no indication on how to confront these issues and transform the ideas into reality.

Alsène (1998), Link and Marxt (2004) and Tavcar and Duhovnik (2005) present ideas on social-cultural change management. These authors' highlighted factors such as the risks associated with change, but also highlighted the implications of technical changes to the design and development phases of a process. They also discussed how these issues would effect the changes in the manufacture of a product. But it is particular hard to find documentation on the implications and implementation procedures of change management within a manufacturing business. However, Balogun and Jenkins (2003) discuss how organisations have to understand change as a process of knowledge generation.

> ...."For organisational transformation to occur, an organisation's members need to evolve new tacit knowledge about the way they interact both with each other and external stakeholders, and how they co-ordinate their activities."

Balogun and Jenkins, (2003) identifies case studies, particularly an engineering company that has been expanding and required changes to the structure. The case study highlights the resistance to change and how these resistances are overcome. One concern that was raised was the type of knowledge concepts that were applied to the change management philosophy as some of these ideas conflict with the principles of lean. However, the paper emphasised sharing knowledge, having better teambuilding skills and having better relationships with the customers. The authors describe change management as a form of knowledge creation, as most organisations understand change as something for individuals.

Obviously these concerns are not just relevant to manufacturing industries as Savage (2000) writes, but how these problems of socio-cultural development are relevant in all industries, including the service industries. Similarly Driscoll and Morris (2001) define these problems within the civil service industry. Power and Sohal (1997) investigated the human variables in just-in-time environments, but concluded that more research is needed to study to understand the "development of models to predict more accurately the organisational conditions required to facilitate successful implementation and operation".

Research work carried out by Hong et al (1995) examined the impact of employee benefits on work motivation and productivity. They found that monetary benefit programmes were the most highly valued by both executives and workers. It was found in a review (The Economist (1994) cited in Chu (2003)) that 85% of change projects failed. Two major reasons were identified. One reason was due to the impact of the change process on other areas of the organisation and the other was human resources management. One significant quotation from this was about a change process;

...." That many such initiatives failed because they had concentrated on purposes and ignored the people who made them work."

It is felt that this quotation summarises the whole concept of the 'socio-cultural challenge'. In this literature review it was discovered that many writers conclude that the cornerstone to change management to improve quality, was empowerment. It is also thought that management must consistently show a high commitment to encourage the changes to take place.

From this research it can be seen that there is a need to address the problem of the 'socio-cultural challenge' and though it has been noticed that this issue exists, the real problem is how to solve it.

It is understood that change management tools will have to be used to ensure the success of implementation of business improvements (Vidal, 2007). There will be conflict between some tools and the principles of lean thinking with the main issue being with the principle of 'Pull'. **Figure 2.25** demonstrates a model that can be used to assist the use of change management techniques with organisational culture being at the centre of all of the other factors.

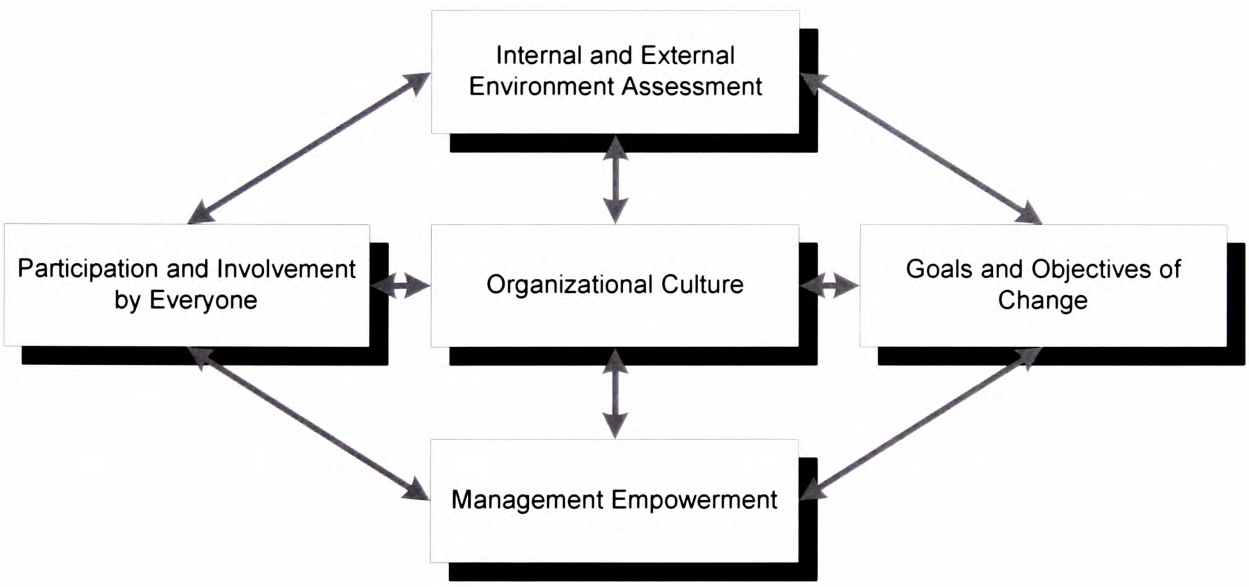


Figure 2.25: A model of organizational culture and empowerment on change management

(Chu, 2003)

Smith (2003) discusses how a transformation from "an expert-based ergonomics system to a culture-based one can be beneficial". The author highlights the concept of ergonomics culture and implies "that all member of a work organisation are informed and empowered to make improvements appropriate to their level of assigned responsibility."

From this literature research it can be summarised that the benchmarking of change management within manufacturing is very important in order to increase the success rate of implementation. Such changes can be of a technical nature such as customer demand, suppliers, design redevelopments or due to new technology including business improvements, or due to cultural issues. However the cultural issues that arise from the technical improvements need careful consideration as well. This review has highlighted that technical changes cause cultural changes however the effects of these cultural changes are not considered successfully in most cases of business improvements (Reijers and Liman Mansar, 2005 and Chu, 2003).

Implementation management is a particularly broad subject area. The two main focal aspects researched within this scope have been strategic and change management, as it was seen that these two factors would enhance the implementation of lean concepts.

2.4.6 Cultural Change

As studied in the previous section cultural change is a subject that is less apparent when discussing business improvement techniques and implementation theories (Trompenaars and Hampden-Turner cited in Finlay, (2000), Alsène (1998), Link and Marxt (2004) and Tavcar and Duhovnik (2005), Balogun and Jenkins, (2003), Savage (2000), Driscoll and Morris (2001), Power and Sohal (1997), Hong et al (1995), The Economist (1994) cited in Chu (2003), Smith (2003) and Reijers and Liman Mansar, (2005)).

The findings of Trompenaars and Hampden-Turner (cited in Finlay (2000)) highlighted that the differences between cultures were grouped under three main headings: relationships with people, attitudes to time and attitudes to nature. **Figure 2.26** highlights these findings in the form of a table below.

Relationships with other people

Trompenaars and Hampden-Turner subdivided these relationships into five 'tensions':

Rules versus relationship

Some cultures take the view that universal laws should apply. This view tends to the use of tight contracts rather than relying on relationships between people when engaged in business. Others take the view that, instead of believing that there is only one right way, the person should act in a way that fits the particular, often exceptional, circumstances. A person's obligations of friendship, for example, may easily override a concern for universality. One consequence for international business is that reward systems imposed on affiliates from head office may well be counter-productive.

The group versus the individual

This was one of the explanatory dimensions found by Hofstede and Bond – the extent to which the ties between individuals were loose or strong. The relative emphasis on individuality and on the community is a tension that exists in the EU between the UK, the Netherlands and Scandinavian countries, which tend to stress individuality, and most of the rest of the EU, which puts more emphasis on a communitarian approach. In cultures that put an emphasis on the group, it would see themselves as delegates, bound by the wishes of their group. In more individually inclined cultures, single decision makers in group-oriented cultures tends to take longer, but implementation of the decision tends to be quicker.

Lack of emotion versus show of emotion

In some cultures it is expected that emotion be expressed, in others the showing of emotions is considered 'uncultured'. Where the expression of emotion is frowned on, the use of humour, understatement and irony should be severely restricted.

Specific relationships versus diffuse relationships

In some cultures the relationships between people are narrowly defined to fit a specific context: no business talk at the golf course, no religiousness in business. This can be contrasted with other, more inclusive cultures, where all aspects of the relationship have to be enquired about before 'getting down to business'. Where specific relationships dominate, the expectation is for specific target

setting, a striving for efficiency and for meetings structured in terms of agendas and time management.
Status through achievement versus status through ascription In some societies status is accorded to a person's track record – to what have they achieved – with little or no concern with qualifications or family background. In other cultures what a person is, rather than what they can do, is important: have they been to the right university, the Haute Ecole Polytechnique or INSEAD, or are they part of a well-known family? In achievement-orientated businesses it would be expected that managers would be of differing ages and gender and for decisions to be challenged on technical and functional grounds.
Attitudes to time In some cultures, what has been achieved in the past isn't of much importance: the focus is on the future and making future plans. Other cultures place more importance on history and the past. To quote Trompaneers and Hampden-Turner: ....'With respect to time, the American Dream is the French Nightmare, Americans generally start from zero and what matters is their present performance and theory plan to 'make it' in the future. This is *nouveau riche* for the French, who prefer the *ancien pauvre*; they have an enormous sense of the past and relatively less focus on the present and future than Americans. Some cultures view time as linear, as a sequence of events. Other cultures view time more as circular, linking the past, present and future. The sequential-time thinker will tend to separate means clearly from ends and plan each link in the chain. The circular thinker won't work with intertwined means and ends. One view of time is that the immediate future is achievable through personal effort yet the longer-term isn't, since too many things can happen. In this view, short-term planning is in order, with the future taken care of through a succession of short-term activities.
Attitudes to the environment Two broad attitudes to the environment can be discerned. One is to see it as something to be controlled and exploited; in business this leads to the entrepreneur who overcomes environmental forces to succeed with the product or service that they are offering. The other view of the environment is to see it as

something that must be adapted to; in business this leads to taking notice of customers continually and appraising the business environment.

Figure 2.26: Findings for Trompaneers and Hampden-Turner cited in Finlay (2000)

2.4.7 Summary

It has been shown that although lean manufacturing is a revolutionary concept, the technique has some limitations. These main limitations can be addressed by integrating factors of other MBIM's. The relationship between these other concepts and lean has been discussed and it has been shown how individually these concepts have had some integration with lean. This integration differs depending upon the knowledge of research of the other concepts. Some integration methods are more advanced than others and are practised in depth, for example leagile systems and lean sigma. However, some methods still require further development and enhancement.

2.5 Literature Review Summary

A number of MBIM's were researched. However lean manufacturing has been the focal concept. The history and background of all concepts has been discussed as well as the application. This literature review has discussed the evolution of lean as well as the application in many different environments. The concepts of lean manufacture are well documented and implemented, however this extensive review has highlighted a number of limitations concerning the concept:

- The concept is a radical change; the concept however lacks a holistic view to relate all concerned supply chain functions.
- The concept requires a standardised environment for optimum transformation, therefore has little flexibility.
- The concept relies on high quality for transformation, therefore lacks methods for quality improvements.
- The concept creates theoretical design but it does not consider the practicality of the implementation process, and therefore lacks testing of the design.

- In practise the implementation of the design is hard to achieve successfully, and so lacks implementation structure.

This chapter has highlighted and discussed MBIM's to try and satisfy these restrictions. However, though these MBIM's currently integrate and some practised with lean manufacture provide a clear method of integration or direction as well as lack the assessment of method suitability to a given situation or environment. It was thought possible that this research could create a roadmap of change through the integration of specific MBIM's.

Figure 2.27 (Berkhauer-Smith and Spedding, 2007) shows the results of the survey and indicates the association between these widely used methodologies as they are currently practised. The similarities and differentiating characteristics of the strategies are compounded to produce many types of implementation strategies.

The findings of this research demonstrate that lean manufacturing and agile production can apply to all levels of the supply chain. Due to variability, lean manufacturing techniques are hard to apply at plant level as well as across companies. Lean thinking is most applicable in high volume, low variety manufacturing environments. This is easier to apply as the variants in kanban sizes fluctuate to a lesser extent and the system is easier to control. However, when in an environment such as a job shop, make to order situation, flexibility is needed to control the system. Lean will not react efficiently to significant changes in the process or system, a complex and less stable system and so the ideas of agile production are more applicable. It is suggested that the better systems are those that incorporate both lean manufacturing ideas and agile production methods, with the use of a decoupling point (a leagile system). This is when most of the upstream part of the chain is standardised and can be controlled better through lean techniques. However, after decoupling agile production means are more applicable as product requires more customisation. There is not a great deal of literature on how to apply the theories on using lean and how agile production can be applied in a supply chain environment. However, it is felt that these three methodologies can be still be developed together to provide improved performance.

	Lean Manufacture	Agile Production	Supply Chain Management	Six Sigma	Discrete Event Computer Simulation	Implementation Management
Lean Manufacture		⬤	⬤	⬤	•	•
Agile Production	⬤		•	X	X	X
Supply Chain Management	⬤	•		•	•	●
Six Sigma	⬤	X	•		●	⬤
Discrete Event Computer Simulation	•	X	•	●		X
Implementation Management	•	X	●	⬤	X	

Key: No Known Relationship = X, Small Association = • , Intermediate Link = ● , Large Correlation = ⬤ .

Figure 2.27: Summary of the inter-relationships between the MBIMs

(Berkhauer-Smith and Spedding, 2007)

Six sigma techniques can be used to influence better optimisation and successful implementation due to lean manufacturing limitations by working on the quality of the manufacture of the product. Lean manufacturing assumes that at the time of transformation there are a few problems related to quality. Realistically this is not true. Lean sigma initiatives are created to reduce this limitation.

Simulation modelling can be used along with lean techniques to test the theoretical design within a real time model. This integration will enhance the rate of success as the design will be tested and issues resolve prior to the real transformation. Discrete event simulation can be used to optimise a theoretical system through validating and verifying the suggested future state theoretical models. Discrete event simulation also introduces factors related to human error through distributions.

Another area of interest that could be considered is the use of the internet with Attaran (2001) discussing the internet's use in the supply chain through online procurement. This process can give a quicker response to the supplier and can be used further downstream in the manufacturing department to reduce lead times and inventory. Information such as stock levels can easily be sent and introducing the use of the internet in the supply chain would reduce information distortion such as the bullwhip effect. It is felt that the internet will have a large impact on MBIM's in the future by reducing transactions.

Studying the inter-relationships between these Manufacturing Business Improvement Concepts resulted in the creation of the following statements;

1. (LM + AP) = Leagile System
2. (LM + SCM) + (AP + SCM) = Leagile Supply Chain System
3. (LM + SS) + (SCM + SS) = Quality Improved Leagile Supply Chain System
4. (LM + IM) + (SCM + IM) + (SCM + IM) = Quality Improved Leagile Supply Chain System with Implementation Structure
5. (LM + DES) + (SS + DES) + (SCM + DES) = Discrete Event Simulation with Operational Strategies

Where;

LM = Lean Manufacture

AP = Agile Production

SCM = Supply Chain Management

SS = Six Sigma

IM = Implementation Management

DES = Discrete Event Simulation

With statements 1 and 2 involving agile production, a unified system can be produced by integrating all Manufacturing Business Improvement Methods to create a unique strategy that can be accurately tailored to a chosen environment.

Baker (2002) and O'Corrbui (1999) cited in Bhasin and Burcher (2006) state that;

> ...."Less than 10 per cent of UK organisations have accomplished successful lean implementation."

This quotation was discussed in depth and for this reason, it was thought that change and strategy management, were to be investigated in particular the understanding of the environmental culture (Berkhauer-Smith and Bhatti, 2007a). The findings from this literature review show all techniques studied have some correlation with lean manufacturing. **Figure 2.28** was created by the author and indicates this association.

Figure 2.28 shows the integration with lean thinking and other MBIM's as they are currently practised today. The main findings in the research were that lean manufacture is a successful MBIM, however it has certain limitations. These limitations are reduced through individual integration with lean manufacture, which all have differing development phases. Based on the findings within this research, it has been concluded that these concepts can be integrated together to give a methodology of application to enhance the success rate.

What this research has also identified is that whilst these restrictions are solved individually there is not any research concerned with the integration of all of these methods that enable a user to design and implement a change business improvement program.

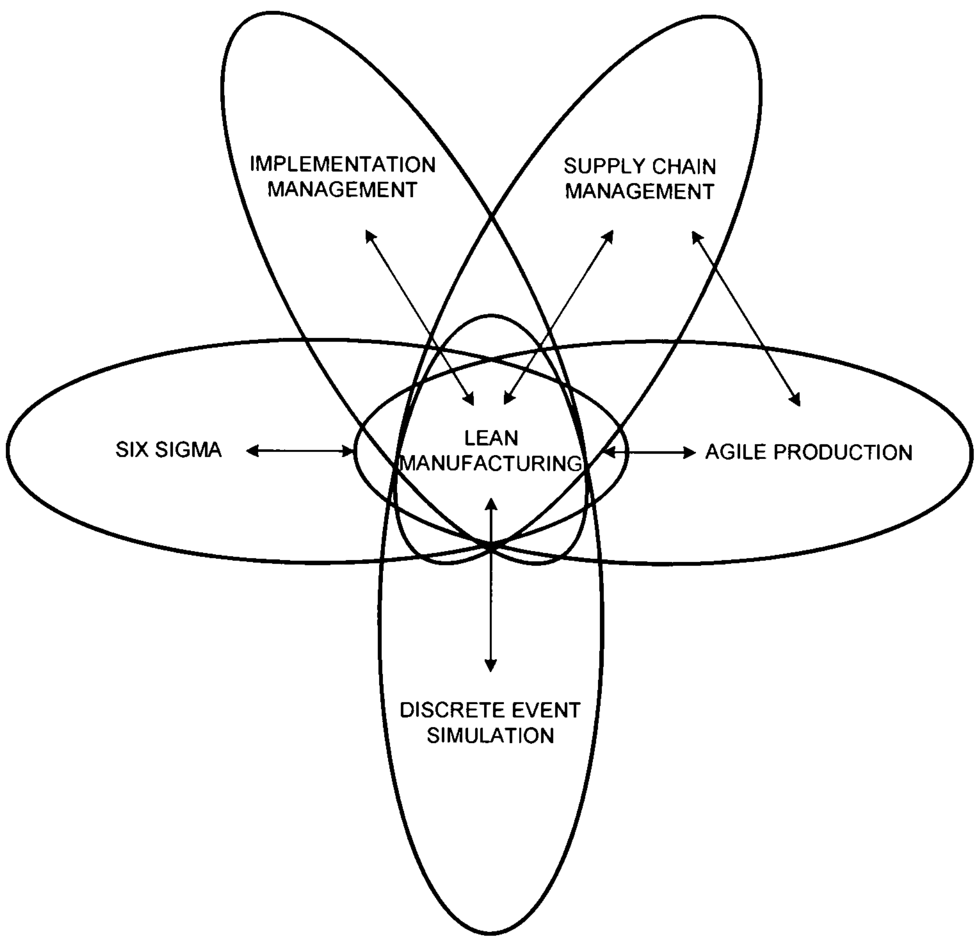


Figure 2.28: The Interaction of manufacturing business improvement methods

2.6 Thesis Layout

The structure of this thesis is of a logical and consistent nature. Chapter 1 introduced the research by describing the research area and the importance to BAE Systems of this research subject. Chapter 2 highlighted the extensive research undertaken in the chosen topics and also shows the sources information, as well as the justification, relevance and suitability to the research area. Within this chapter the implementation relationships between the subject areas are discussed and the results highlighted introduce the niche within the literature review.

In Chapter 3, the methodology and approach taken to adopt the theories will be outlined. The design methodology justifies the research requirement by discussing the integration strategy of the business improvement implementation concepts. This generates a roadmap for change introducing the user to these techniques in an integrated sequential format. The design methodology is defended and analysed through the use of case studies within Chapters 4, 5 and 6. These chapters demonstrate how the manufacturing business improvement roadmap is tailored accordingly to meet the needs of the differing case study environments. The critical justifications made are also highlighted to show the decisions making process throughout the integrated topics.

The structures of the case studies are defined to show the versatility of the roadmap, by applying the methodology to differing areas within the supply chain. The case study in Chapter 4 investigates and sets to improve the relationship and lead times between a supplier and a buyer. From this the case study in Chapter 5 researches into more depth the processes at the end of this internal supply chain of the supplier to instigate the material and information flow across the external supply chain. Similarly the third case study (Chapter 6) investigates the initial processes within the buyers internal supply chain to practise better material and information flow internally and externally.

Chapter 7 discusses the findings and results of the research study and whether the initial objectives have been successfully completed. This chapter concludes the research material.

The Chapter 8 discusses further work that could be investigated from opportunities derived from this research study. Chapter 9 identifies the references and sources of information required to conduct this study. The thesis Bibliography is also included as well as the Appendices in a logical sequence, according to the Harvard System.

2.7 Chapter Summary

This chapter has discussed many research areas through a literature review and it has highlighted the current practised MBIM's. The main subject area was lean manufacture, the relationships between this concept and other MBIM's were investigated to identify any significant integrated methods. This chapter has discussed these integrated methods and has highlighted a requirement for an integrated method of application. This chapter has also represented the case for the research work and discusses how the thesis has been approached.

CHAPTER 3 : PROPOSED DESIGN METHODOLOGY

3.1 Chapter Introduction

This chapter discusses the development of a design methodology that sets out to fulfil the requirements outlined in the literature survey in Chapter 2. The literature review highlighted that there were limitations with the philosophy of lean thinking. These were related to limited flexibility, distorted views as the supply chain increased the assumption of high quality, the lack of human variability and that the designs are hard to implement successfully, this lead to the research of many MBIMs. Also in this chapter the integration of the researched MBIMs is discussed by highlighting how the proposed methodology is developed. The specifics and scope of the proposed methodology are discussed and it is assessed against other MBIM frameworks with comparisons being made and justified.

3.2 Conceptual Integration

In the literature review it was discussed how the focal MBIM researched was lean manufacturing. It was highlighted how lean manufacturing has certain limitations. The literature review concluded that lean manufacturing has been currently integrated with some other MBIMs, however there is scope to integrate further to (**figure 2.26**, page 69 create a roadmap of change to improve the route of success. **Figure 2.26** (page 69) can be reiterated further and the MBIMs can be classified into method types. **Figure 3.1** displays the classification of the MBIMs, as classified by the author. It can be seen that lean manufacturing, agile production, supply chain management, six sigma and discrete event simulation are classified as operational methods (Bayrakar et al, 2007). From the literature survey it is clear that implementation management falls into two categories, either cultural change management, dealing with cultural change issues related to implementing MBIMs (Balogun and Jenkins, 2003) or strategy management tools on how to move through the change process (Tagore, 2007).

Strategic concepts involve issues related to project management, project definition, project alignment as well as project implementation plans. All operational concepts occur in parallel throughout transformation of the system. Similarly cultural management theories are also required through the change process to assist with the physical design to aid the management of the implementation and to improve the project. It has been shown in published literature that by using cultural management ideas the project success rate increases (Smith, 2003, Vidal, 2007 and Thomas et al, 2003).

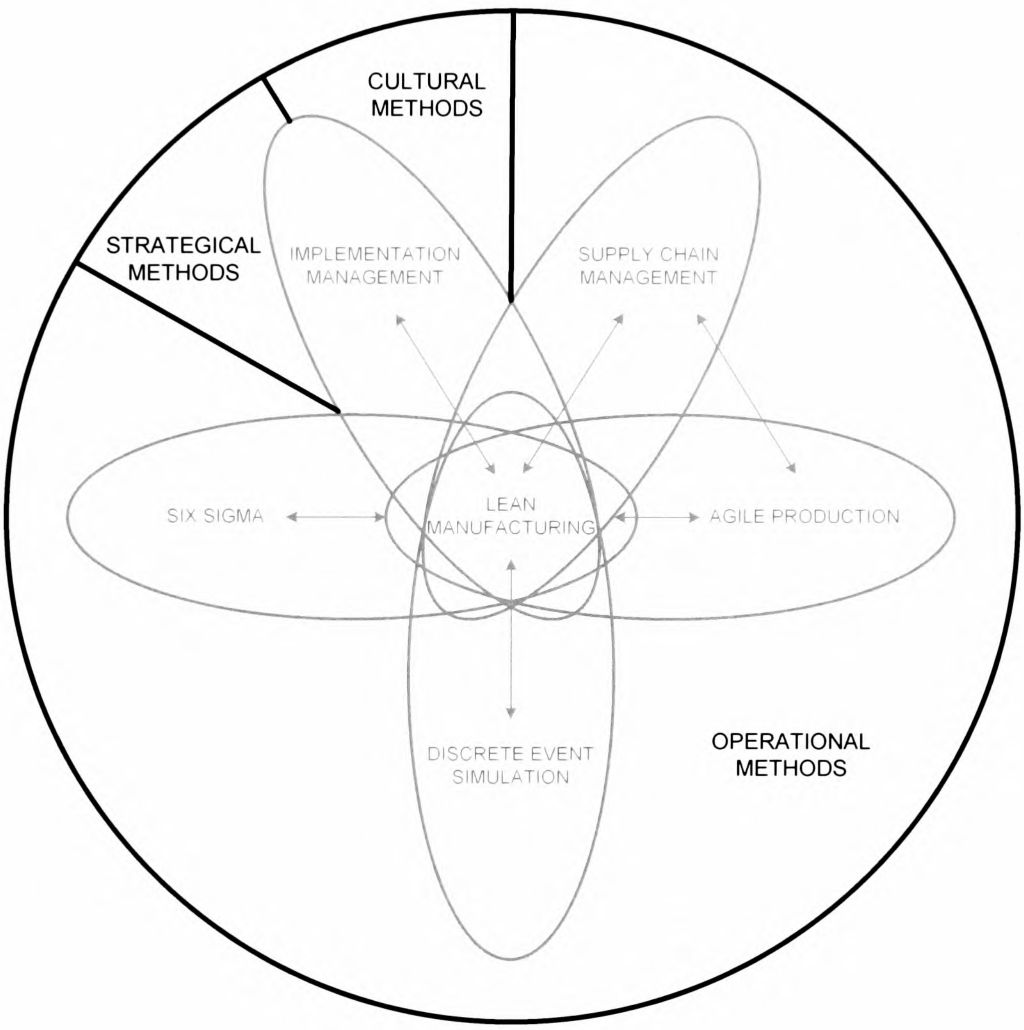


Figure 3.1: MBIM Classification

The proposed methodology developed within this chapter uses this conceptual integration and initiates triggers between the three classifications. The proposed methodology has been designed so that these triggers initiate the movement through the stages to create a parallel continuum of concepts. **Figure 3.2** developed by the author, highlights how in this proposed methodology these strategies will work in parallel throughout the concept, design and implementation of an improvement project.

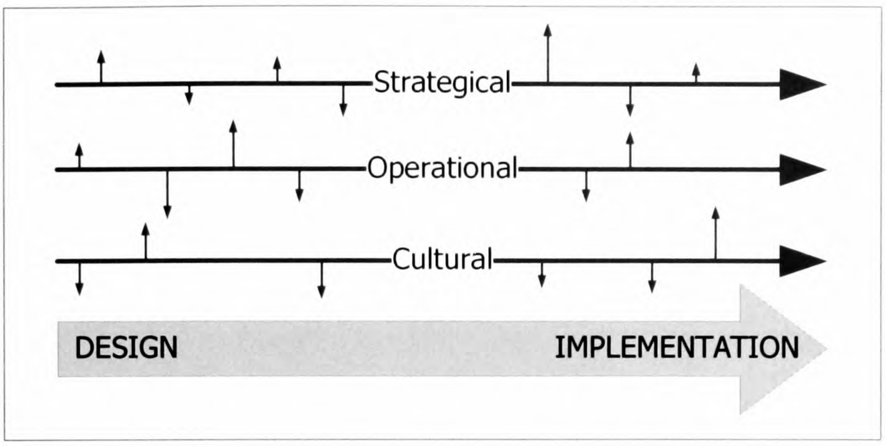


Figure 3.2: The parallel continuum of concepts.

These findings were taken and **figure 3.3** was created by the author to highlight the integration and inter-relationships between the MBIM as well as to demonstrate the classification type of the MBIM. **Figure 3.3** shows how lean manufacturing is the focal MBIM and that by using agile production techniques reduces standardisation and creates flexibility, producing a 'leagile system'. This system can be integrated into the supply chain to give a holistic approach. Integrating six sigma with lean thinking methods gives a 'lean sigma system'. Using this theory alongside a leagile system with supply chain management, would give a leagile sigma supply chain. Simultaneously integrating discrete event simulation with lean, ultimately gives a 'leagile sigma supply chain simulation models', within an operational framework. Forces enabling this operational systems transformation are those of strategical and cultural change requirements.

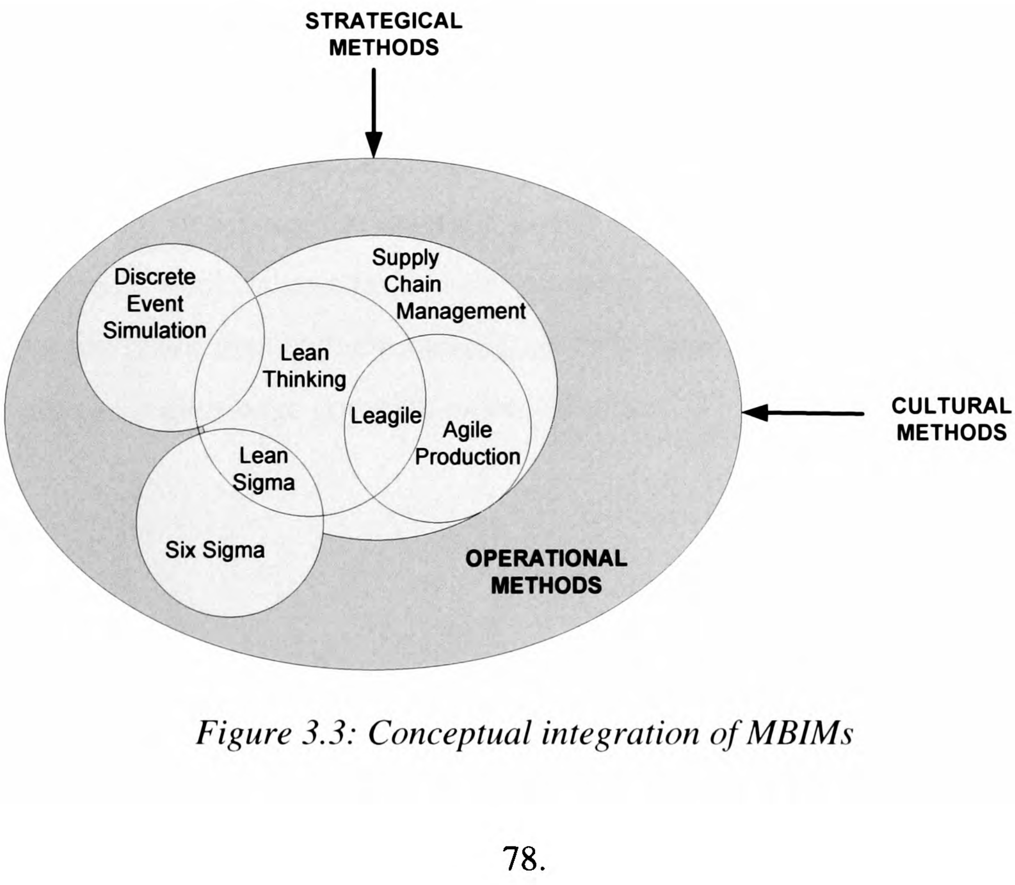


Figure 3.3: Conceptual integration of MBIMs

This top level integration was expanded further to demonstrate detailed integration. This displayed the specific strengths and benefits of lean thinking as well as how aspects of other MBIM would fill the 'gap' of the limitations identified in lean manufacturing tools. **Figure 3.4** created by the author shows how these concepts have been expanded to demonstrate the strengths and abilities of each MBIM listed. It also highlights the impact of the use of these concepts on each other and what the benefits of integrating these are, as shown in the diagram. This diagram is an overview of many MBIMs and engages many tools and aligns them together. The literature review discussed the strongly proven concept of lean manufacturing. It also demonstrated how this is a concept best applied in a low variety, high volume production environment. The lean approach requires a stable environment and creates standardisation through continuous flow and pull systems. It has been argued that lean may not necessarily be the best technique to use in an environment such as the aerospace industry, which is a lower volume producing bespoke environment (Phillips, 1999).

However, the principles can be applied and adapted to improve a system. VSM is a micro-mapping tool used in lean thinking that has transformed many systems (Rother and Shook, 1999). However the aerospace business requires greater flexibility and agile production creates this flexibility (Maskell, 1994).

These micro-mapping tools provide the in depth improvements usually associated with a production line or departments units within a site (Rother and Shook, 1999). In some instances, to provide improvements across the whole company a holistic approach would be required to not only link together the smaller micro-mapping projects (Scholtes, 1998), but to understand the logistics including the movement of material either throughout a plant or among the external supply chain (Womack and Jones, 2002). A holistic approach would also consider the business as a whole and not just individual efforts. Supply chain management techniques help focus and provide an initial starting point for change within large complex organisations.

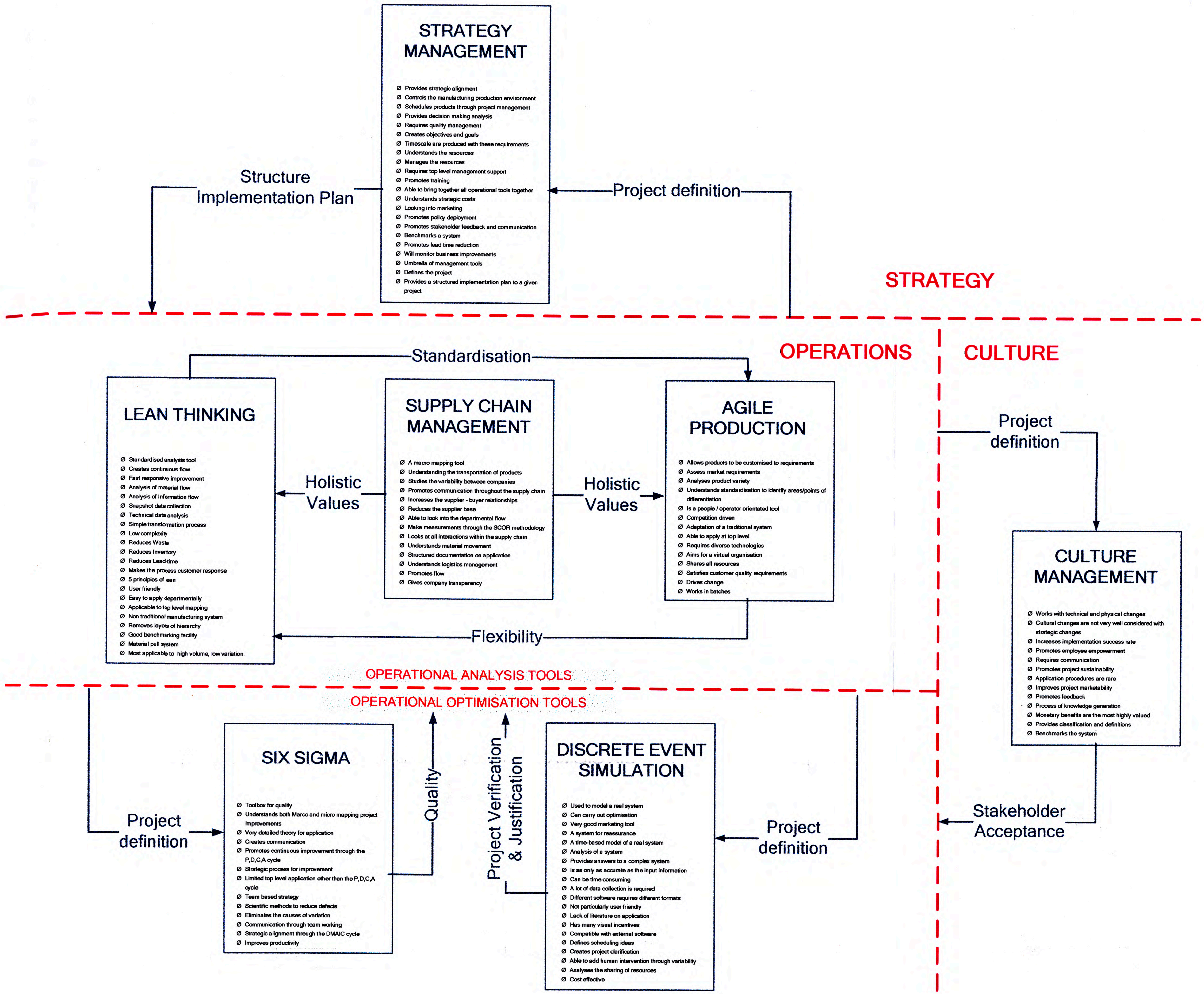


Figure 3.4: Concept integration triggers

By introducing a holistic approach for micro-mapped systems, creates an optimum future state 'blue sky vision'. To implement this theoretical system straight into a real environment could have disadvantageous affects in a large complex business. Operational optimisation tools can be applied before actual implementation. These optimisation tools will provide project definition and will highlight areas that may cause concern before implementation, but can also aid in the verification of concerning areas highlighted from the operational analysis tools. Six sigma is an example of this. Six sigma is a methodology of quality improvement tools which can aid the mapped project and improve the future state (Pande, 2000). Likewise, discrete event simulation can be used in a specific area of the proposed system. One particular disadvantage of discrete event simulation is the time taken to create the model as well as it being costly. If discrete event simulation is seen as a tool that could be used to assist the proposed system either through validation, verification or justification of a particular area, defined by applying the operational analysis tools, then this would reduce the modelling time and cost.

Discrete event simulation can also introduce the factors associated with human variability which will enhance the proposed system before implementation. This will potentially reduce implementation lead time as well as increasing employee acceptance through a smoother implementation process and introducing employee empowerment. By using these operational optimisation tools, important factors such as quality and time are not normally considered in operational analysis tools. VSM has no consideration for real time and assumes that the quality of the system is of a high standard. All of this analysis is represented in **figure 3.4.**

The design of the proposed methodology consists of a structured roadmap to ensure that all concepts are suitably assessed before application. This works against the principles of lean thinking and the concepts of kaizen, however a deeper understanding is required for such a corporate complex industry as systems thinking concepts are required to create an enterprise view. Without a structured framework the application becomes dysfunctional and creates 'pockets' of improvement initiatives in isolation (Scholtes, 1998) through the structured design.

The proposed methodology has been created for a large worldwide aerospace company and therefore requires an in depth change analysis system utilising many techniques and concepts, in an effort to justify change by financial gain and employee acceptance. A methodology of this complexity is required to create an enterprise view through systems thinking and so requires a high level of analysis. Without detailed analysis of the concept, design and implementation of any change improvement project, the effects could be costly and create a negative impact. An environment such as the aerospace industry experiences long manufacturing lead times due to the use of high technology in the product design, as well as issues related to customer requirements such as high product quality, product traceability and limited supplier sourcing among other factors. The aerospace industry in comparison to the automotive industry is an environment that is considered to have a low product volume along with a high product variety (Philips, 1999). Products designed and manufactured in this environment tend to be specialist in nature with bespoke design for a number of reasons, requiring a large expert supplier base, with holding stock, planning and purchasing of obsolete items and long life cycles, which can all be costly. These are the main considerations when creating the proposed methodology as well as filling in the gaps that currently exist. Having a complex industry requires a structured and well defined methodology. The proposed methodology is a roadmap and allows the user to tailor the framework to the project requirements, giving a clear path of direction. It has been colour coded throughout to highlight the difference between the concepts, so it is possible to eliminate certain aspects of the proposed methodology depending upon the improvement project requirement. Therefore, the roadmap is scaled down as the project progresses and becomes more defined and simpler, thus highlighting the pathway of change.

The literature review highlighted the requirement for a structured change program. This proposed methodology has accommodated all of the restrictions of lean thinking stipulated in the literature review and achieved this hypothesis of conceptual integration, from design to implementation of an improvement project.

3.3 Proposed methodology development

All businesses undertake improvement projects to remain in an ever changing and competitive market. Businesses wishing to make changes require a roadmap of business improvement tools which provides them with a structured guide, thus eliminating the need for expert advice or theoretical misuse and attaining the skill base within the organisation. From undertaking the research demonstrated in the literature review, it was concluded that an integrated business improvement methodology was required that incorporates tools of lean thinking and eliminates the restrictions identified, as well as providing conceptual integration of all researched MBIMs. **Figure 3.5** developed by the author highlights the stages of change necessary: planning, creating, data collection, analysis and strategic implementation. The initial development of the proposed methodology was based upon Deming's Plan, Do, Check, Act, cycle along with the six sigma DMAIC process..

The three main concepts of strategy, operations and cultural management (**figure 3.2,** page 78), integrated along with these cyclic processes can be applied to all improvement projects at all levels of the supply chain. This concept integrates continuous improvements holistically as well as detailed improvements internally.

The overall framework was generated from the six sigma DMAIC procedure; Stage 1 being the 'define' process. Stages 2 and 3 utilising the 'measure' function, however integrating the current state benchmarking facilities of lean thinking and VSM as an outcome. Stages 4 and 5 are the use of 'analyse' section of the DMAIC process to generate the future state of the VSM tool of lean thinking. In more detail these stages would use operational analysis tools to create the stages outcomes. Thus integrating discrete event simulation and six sigma within lean thinking tools within the DMAIC cycle (as outlined in **figure 2.19,** page 53) and thus creating the design of the proposed system.

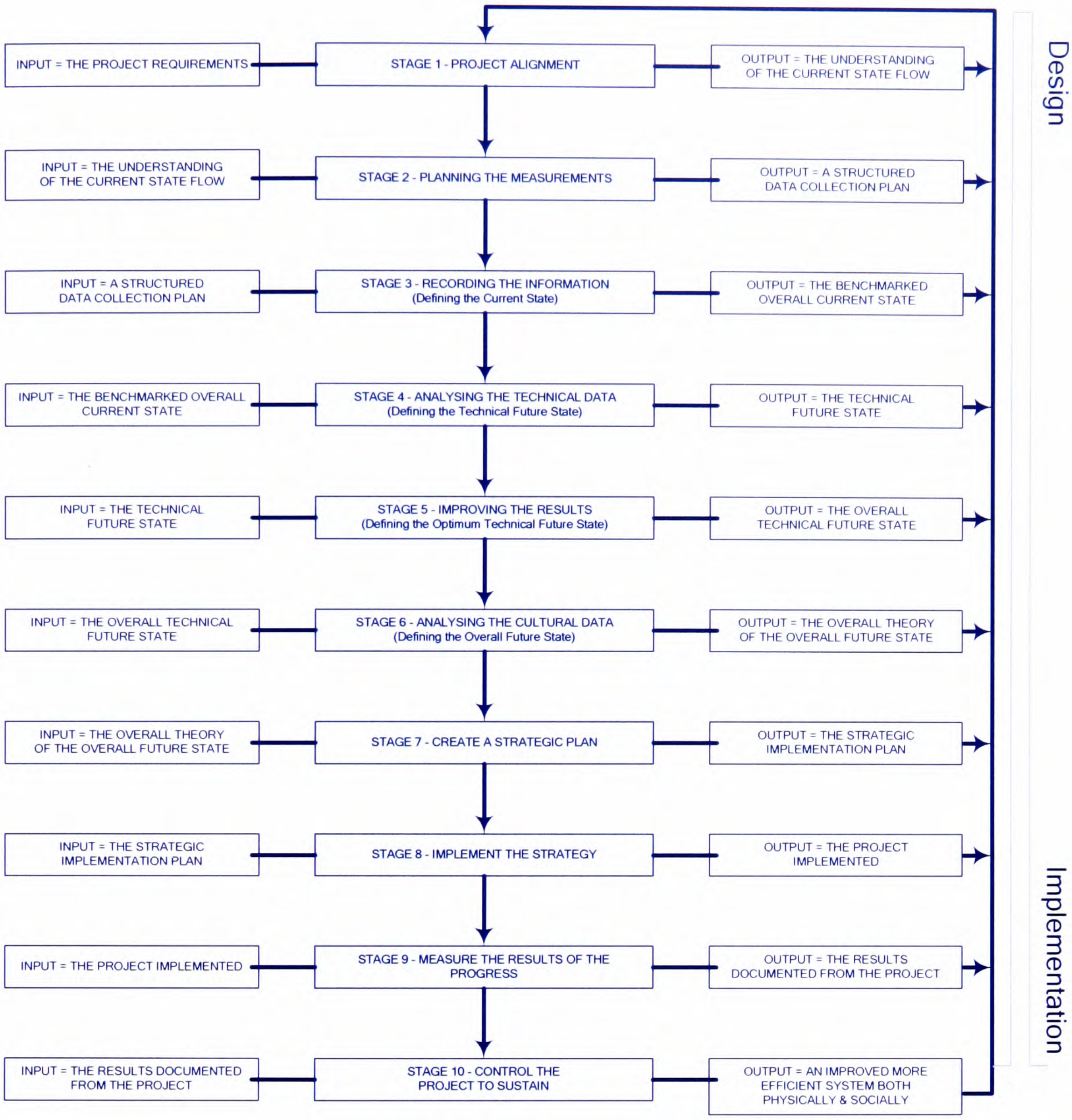


Figure 3.5: A structured framework of the conceptual integration of MBIMs

(Berkhauer-Smith and Bhatti, 2007b)

Throughout these initial stages the cultural change has been benchmarked in Stage 3 and 6 for analysis, as without technical and physical changes the cultural transformation is negligible. However, between the design and implementation the cultural effects have to be addressed. At this point cultural behaviour is analysed and controlled in the similar form of the 'analysis' and 'control' stages in the DMAIC cycle, as well as consulting the plan, do, act and check cycle of TQM (Liker, 2004). Furthermore the TQM cycle requires the improvement program to 'check' the design. This is done by 'defining' a strategic plan and so the DMAIC cycle is an initiative again through the design of the implementation. Stage 7 introduces the definitions design of the implementation and so aspects of strategic management are integrated with TQM and six sigma to create the strategic implementation plan. Implementing the system integrates the use of cultural management with strategy management alongside six sigma and TQM.

Stage 8 takes the strategic plan developed in Stage 7 and works through implementing this plan. This stage considers a number of cultural aspects that have been analysed throughout the methodology and this is highlighted more significantly in Stages 3 and 6.

Stage 9 similarly 'acts' upon the implementation of the system by 'analysing' the progression and measurement of metrics. Finally Stage 10 'controls' the system by introducing continuous improvement for the project to sustain, thus using elements of lean thinking through kaizen bursts of continuous improvement as well as strategy management tools such as project management including change management.

Figure 3.5 displays the process flow and shows how to achieve the best outcome. The feedback into the system is also visible thus demonstrating its importance at each stage and this will ensure the project definition remains true to the project brief. These stages have been developed further to create a number of sections to enable ease of use. Each stage is designed so that there are a number of sections to follow and then within these sections there are guidelines on how to best achieve the requirements. It is important to understand that the guidelines within each section are to be carried out simultaneously and that the order stipulated in each section has no regard to order or importance. Within each stage the conceptual integration continues and provides depth and justification to the proposed methodology.

The proposed methodology has been created in a flow chart form which is not only user friendly but also enables the user to tailor it to the particular project. It also allows the user to use it as a checklist facility to make decisions whether to proceed or whether to investigate specifics further. **Figure 3.6** highlights the feedback and communication key that has been created and is continually referenced at every stage in the proposed methodology and this has been extracted from the flowchart to reduce the visual complexity. The key mainly asks the user to understand issues related to cultural management and include project management attributes. The key in **figure 3.6** is developed to understand the current culture and perception of change at the point in time and it also considers the completion of the guidelines as well as the project timescale. However, the management of cultural change is assessed overall in Stage 6 of the proposed methodology, taking into consideration the cultural information gathered within the communication key.

The flow diagram of the integrated proposed methodology is shown in **figures 3.7 - 3.16**. The design of the flow chart methodology has been created in a generic format. Throughout, there is direction from project inputs and outputs within the stages, including what the stage aims to achieve. Generic feedback loops have been included that allow the user to feedback into the system as necessary within any stage. The feedback and communication key is considered at every stage to encourage change. The proposed methodology also allows flexibility by enabling the user to make the decisions concerning the completion of each stage, again allowing the proposed methodology to be tailored to the project requirements.

The initial stages were created to guide the proposed methodology through the design of the project. This included the true interpretation of the project, the desired outcome of the project and the key metrics required for the transformation of the project. These stages were also derived to highlight the importance of an integrated approach and how different scenarios require different aspects of the concepts. In a large organisation it cannot be assumed that one technique is applicable to all systems and so the purpose of this proposed methodology is to select what is suitable, given the users specific knowledge of the system.

KEY

DISCRETE EVENT SIMULATION – PURPLE
LEAN MANUFACTURE – RED
AGILE PRODUCTION – ORANGE
SIX SIGMA – YELLOW
CULTURE MANAGEMENT- GREEN
SUPPLY CHAIN MANAGEMENT – TEAL
STRATEGY MANAGEMENT – BLUE

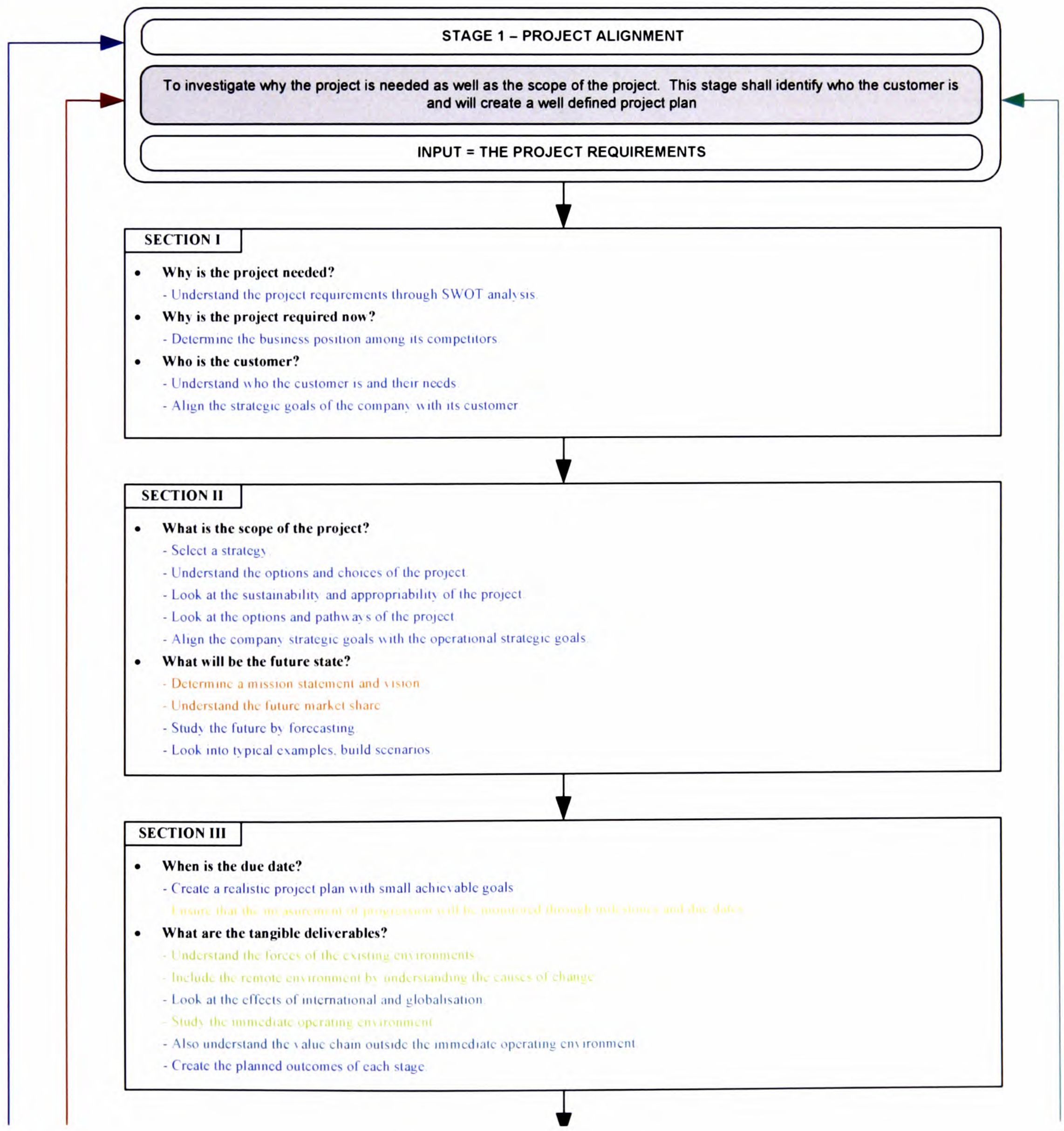
FEEDBACK & COMMUNICATION

- Have all the necessary guidelines been met?
- Have changes been periodically reported and documented?
- Has the progression been checked with the stockholders?
- Has the project been reassessed due to changes?
- Does the project need changing?
- Verify the progression with the original project plan.
- Work through unfreezing the current culture
  - Explain the need for change and its feasibility.
  - Highlight how these improvements need a new method of thinking.
  - Show how these improvements are linked to goals & objectives.
  - Highlight the "psychological safety" - the need for everyone in the change.
  - Highlight how a new form of knowledge will be created.
  - The people creating this knowledge however must have a purpose - this purpose has to be highlighted very carefully.
  - Be aware that people will be in denial & will deny the validity of new ideas
  - Consider the magnitude of change.
  - What is the effect of culture change on the business improvements?
  - `- Investigate the thoughts and emotions of the people the change effects.
  - Introduce employee empowerment & self motivation.
  - What is the perception of the project?
  - Study why the people have reacted the way they have.
  - Maybe the reasons are though security, patterns or commands, status, authority, power or relationships.
  - Understand the needs of those effected, i.e. self esteem, social needs as well as safety and physical needs.
  - Need to consider what things are said and how they are said.
  - Investigate the cause & effect on employees reactions to certain change.
  - Understand the communication needed to feed the changes through the project team members.

Figure 3.6: The feedback and communication key used in the proposed methodology

3.3.1 Stage 1 – Project Alignment

The first stage of the proposed methodology uses the 'Define' stage in the six sigma DMAIC process. The main objective of this stage is to investigate why the project is needed as well as the scope of the project. This stage will identify who the customer is and will create a well defined project plan. It also aims to strategically align the project between the company's strategic goals, its customer whilst aligning these objectives with the operational strategic goals. These strategic alignment techniques are fundamental structures to project improvements programs, **figure 3.7**. It was highlighted in the literature review that a restriction of lean thinking hindered tools associated with implementation management (Karlsson and Ahlstrom, 1996) and thus project definition. Here, strategy management and six sigma tools will be integrated to eliminate the limitations (De Toni and Tonchia, 2002).



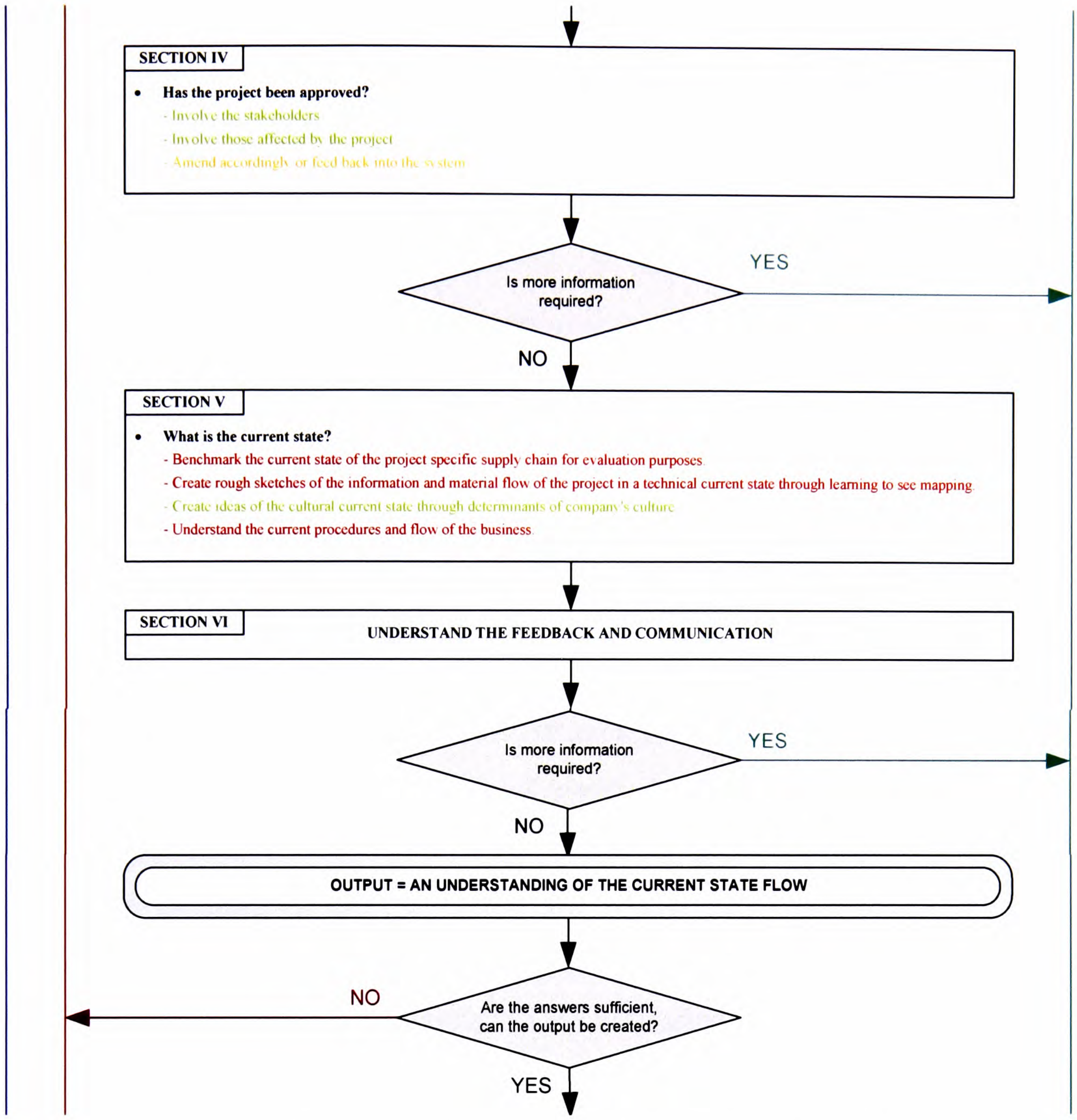


Figure 3.7: Stage 1 of the proposed methodology

The first feature of this stage is to understand the project requirements in greater detail. Objectives as to why the project is needed will be clarified through Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis which in turn will define the project position within the business. Using these guidelines will highlight why the project is needed and why it is required now. This section is based on strategic management techniques (Finlay, 2000) as indicated by the corresponding colour (Blue). It is also necessary to understand the project strategy. However, here principles of lean thinking are also applied by defining the customer, who they are and what their needs are, which are all fundamental characteristics of lean thinking (Womack and Jones, 1996)

Defining the project strategy would necessitate to the user to investigate the options and pathways of the project, along with gain retention and appropriateness. These facets of project strategy creation are defined as strategy management concepts. However, sustainability is a concept associated to lean thinking and the application of 5S (Bicheno, 2004). This part in Stage 1 also considers the future market and studies the future through forecasting as both measurements are considered to be associated with the integration of strategic concepts (Slack et al, 2007) along with operational analysis ideas through agile production (Maskell, 1994).

The future state definition is probably best associated with lean thinking (Field, 2001) which executes VSM and similarly simulation modelling can be carried out for scenario testing (Lian and Van Landeghem, 2007). It is anticipated at this stage in the project creation, the content through mapping and modelling will be of very little detail. Project management theories are practised alongside cultural and operation strategies such as six sigma and supply chain management. This part of the methodology defines the scope of the project by creating deliverables, defining milestones and due dates. It is also necessary to understand the external constraints and the influences impacting the project and how this will affect the transition. Understanding the project acceptance is an important factor of effective cultural management (Bolstorff and Rosenbaum, 2003). Within Stage 1, Section II, aspects of the 'measure' function of the six sigma DMAIC process, are used along with environment assessment related to culture change management (Paton and McCalman, 2003). When assessing the tangible deliverables a holistic view is required so that improvement projects are not isolated and this involves theories behind supply chain management (Handfield and Ernest, 1999). The plans of the deliverables need to be benchmarked to monitor progression which again uses lean thinking principles.

Another part within this stage assess the project approval and ownership, which uses the features of strategy management (Finlay, 2000), however it integrates with six sigma initiatives which heavily rely on champions to oversee greenbelt projects (Coulter, 2005). At this point in the proposed methodology there is a feedback loop incorporated to enable further gathering of information as project acceptance by all stakeholders is the key to moving forward.

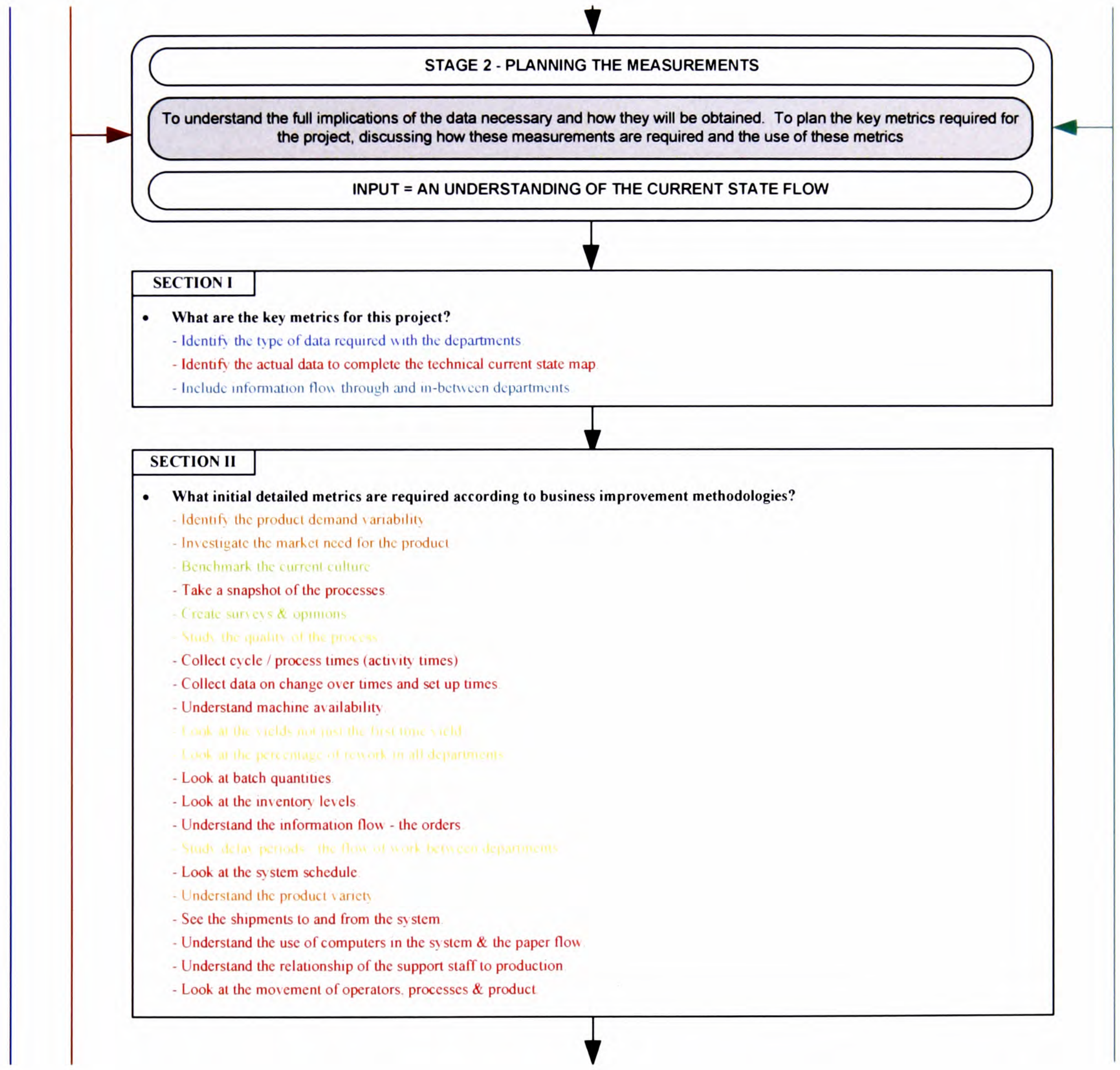
From the knowledge gained in this initial stage, the current process flows of the business can be determined and benchmarked through lean thinking methods of VSM. However, it is also important to create ideas and benchmark the current culture to enable a continuation of benchmarking to measure the cultural changes through strategical and operational changes (**figure 3.2,** page 78).

It is at this stage that the feedback and communication key (**figure 3.6,** page 87) is consulted as well as incorporating another feedback loop into the system. The key works through typical questions that are required within every stage, the feedback and communication key assess the cultural changes as well as project management style guidelines. As a feedback loop into the system it is essential to ensure that the project remains true to the brief (Scholtes, 1998). It also ensures that the stakeholders are in agreement with the monitored progress. It is at this point that the user can make the decision that the guidelines have been used efficiently depending on the project requirements. It is extremely important to ensure that the progress of the project is measured at every stage in the proposed methodology, to ensure that the features of lean thinking are adhered through benchmarking.

This loop will ensure that the selected project is within the time frame, but more importantly the project will be reassessed for changes that will be documented and thus ensure the project will meet the initial definition and strategy. The output of this stage is the project definition and this is so that throughout the stages it can be compared to the original brief. The ultimate outcome from Stage 1 is an understanding of the current state flow in the form of a VSM with strategic opinion as well as cultural current state analysis. Once the output has been created and all of the stage requirements are met the flow chart moves through into Stage 2 of the proposed methodology.

3.3.2 Stage 2 – Planning the Measurements

The second stage of the improvement process is to plan the measurements that will be required for the project transition. Similar to the 'measure' function of the DMAIC process, it is this stage in the proposed methodology that is of significant size as the planning of a project is the key to better implementation accuracy, **figure 3.8**. As the project is aligned and the scope of the project analysed, a plan of the data to be measured is devised. This should include the method of collection, by whom and in what format, so that the results can easily be analysed. An important factor of this stage is the integration of the operational techniques used in many businesses and that the concepts will be evaluated for their suitability to the project. It is expected that in most cases not all techniques will be applicable. However, it is necessary to understand what theories are available to create the transition. Within this proposed methodology the roadmap of transition is created and it consults a number of currently researched MBIM's. This research eliminates any issues related to needing prior knowledge of the techniques.



SECTION III

- **What further metrics are required according to business improvement methodologies on reflection of that planned above?**
  - Identify the point of differentiation
  - Look at placing the decoupling point nearest to the customer as possible
  - Investigate in suitable methodologies into standardising products
  - Study the standardisation of the product
  - Study the quality of the support - paper and computer systems
  - Research into the departmental flow
  - Understand the quality of the flow
  - Look at the materials supplied
  - Carry out statistical process control measurements where necessary
  - Know the supplier base
  - Look at lead-time requirements
  - Make measurements through the SCOR methodology (drill down)
  - Look at the distribution of products
  - Investigate through the people involved - the stakeholders
  - Document the current state culture through classification
  - Look at the associated costs- the costs of change
  - Create risk analysis reports for change
  - Document any changes to the plan
  - Adapt the main project plan by drilling down and expanding

SECTION IV

- **What holistic metrics are required according to business improvement methodologies?**
  - Create a regimented plan to collect the planned measurements
  - Adapt the lean and agile ideas into all department not just specifically into Production
  - Look at achieving a leagile system across the departments in the supply chain not just in sub groups
  - Understand how change is effecting the culture
  - Investigate the organisation structure
  - Continually involve the stakeholders
  - Understand the supplier logistics
  - Study the relationship between the business and the product suppliers
  - Refer back to the project plan
  - Reassess the time scale

SECTION V

- **Are the metrics valid and reliable?**
  - Highlight a number of methods for data collection to validate the data
  - Evaluate those methods for reliability
  - Measure the material value added to non value added activity through the processes
  - Understand the processes of the project to fully understand which improvement techniques maybe applicable in the analyse stage
- **Is there adequate data on this project?**
  - Measure the routing of product through tagging
  - Collect the data manually if necessary
  - Feed back into the system if necessary

Is more information required?

YES

NO

SECTION VI

- **What resources maybe required for data collection?**
  - Study the scale of the project
  - Understand the timings
  - Expand the project plan in greater detail to understand resource requirements throughout the recording data stage
- **Do the resources need training?**
  - Investigate the skills and act accordingly

SECTION VII

- **Have all company rules and regulations been adhered to (unions)?**
  - Understand these requirements and comply

SECTION VIII

UNDERSTAND THE FEEDBACK AND COMMUNICATION

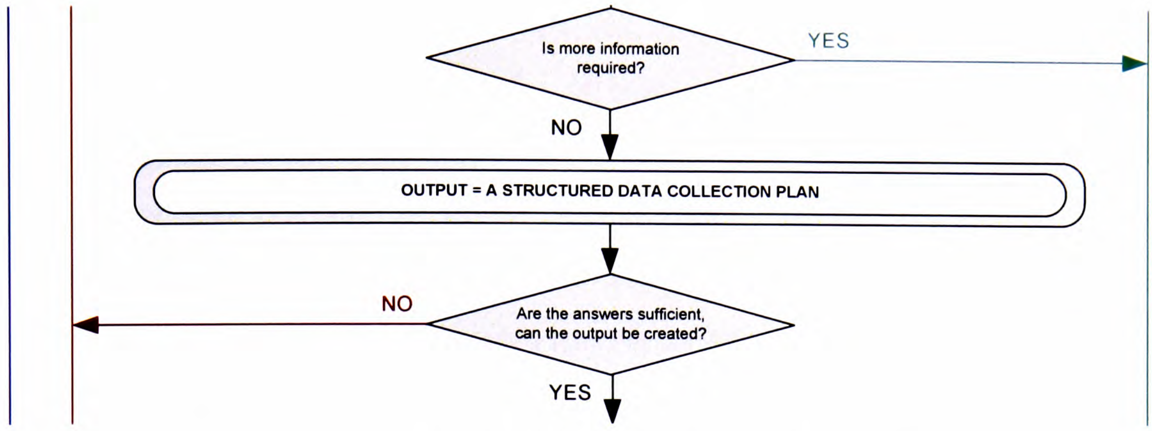


Figure 3.8: Stage 2 of the proposed methodology.

This stage integrates all concepts and provides a systematic approach to supply chain analysis. The stage starts by defining the overall key metrics required to complete the benchmarking process through the current state maps. Key metrics are a major aspect of six sigma methodology (Bicheno, 2004). This however is integrating lean thinking tools to benchmark the current state and allows the use of six sigma concepts through the collection of the key metrics. This integration also allows the analysis of a given situation at any point in the form of a 'snapshot'. This section (Section II) requires integrating a number of operational methods through agile production, lean thinking and six sigma as well as cultural concepts. It is anticipated that a set of captured data could fulfil a number of the required metrics.

Integrating lean and sigma was investigated in the literature review. It was highlighted how tools associated with quality improvement would enhance lean thinking methods (Markarian, 2004). The second part of Stage 2 is integrating a number of techniques from agile production, six sigma, supply chain management, strategy management to culture management. At this point more detailed planning measurements are created to give clearer definition of the measurements required. Typical elements that are necessary are assessing system dynamics throughout a supply chain (Scholtes, 1998). As the user moves through supply chain dynamics not only are agile production aspects considered to record the customer/market demand, but also measure the material and information flow around the system. This is based upon the guidelines of the 'learning to see tool' associated with lean thinking (Rother and Shook, 1999).

It was discussed within the literature review that lean thinking concepts could restrict the system, should it not be standardised. It was concluded that flexibility would be provided by agile production tools to reduce this limitation (Cox and Chicksand, 2005). The following part of the proposed methodology defines the need for further requirements and initiates a second phase of data collection given that the results of the previous 'measure' are limited to project specific requirements. An enterprise approach is considered in the next section (Section IV), outlining how to expand the micro mapped system to other departments. This requires investigating the logistics functions as well as the suppliers and aims to improve them.

This stage of the proposed methodology assesses the realism of the project through the collection of metrics for validity and reliability. These specifics are centred more on external supply chain topics to create the holistic view identified in the literature review. This part of the proposed methodology takes the fundamentals of the operational methods and measures the requirements amongst the external supply chain, to elevate issues considered with isolated improvement projects (Scholtes, 1998). This was another aspect that was studied within the literature review. Lean thinking methods are best applied to plant level implementation, by introducing supply chain management with tools lean thinking concepts these restrictions would be reduced (Cagliano et al, 2006).

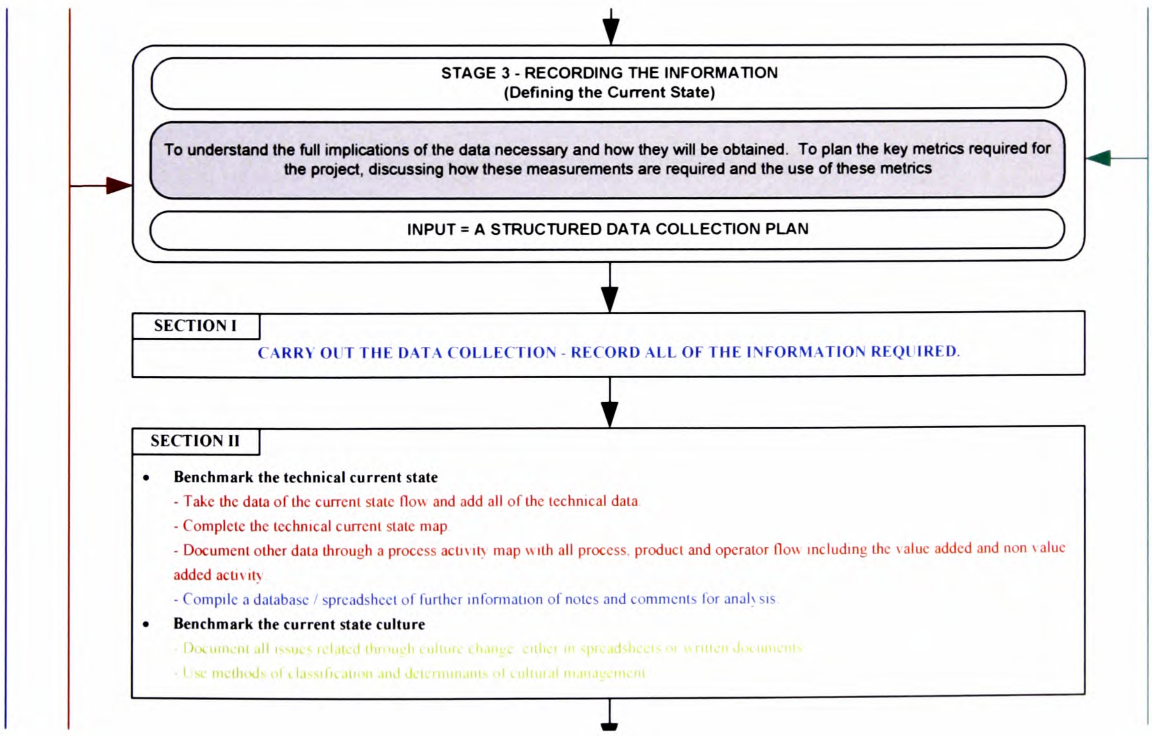
The planned measures are considered for validity and accuracy, as inaccurate information is of little value. Strategy management tools are used to assess the requirement alongside lean thinking and six sigma tools such as Process Activity Mapping (Bicheno, 2000) to measure the value added activity to non-value added activity. A feedback loop has been incorporated to assess the need for further information before proceeding onto the next stage since a great deal of decision making has already been made up to this stage.

By planning the metrics, it is not just the numeric, technical and physical data that is required but also the capacity and resources required need to be taken into account. Capacity and resource planning are attributes of strategy and project management (Russell and Taylor, 2000). However, the roadmap also considers any training that may possibly be required. This identifies cultural methods as there is the need for knowledge sharing and creating employee empowerment (Paton and McCalmon, 2003 and Scholtes, 1998). Other cultural aspects considered are in the consultations with the employee unions. Again acceptance to change is better received if the correct procedures are implemented. In the same method as Stage 1 the feedback and communication key are considered in conjunction with the checklist method at the end for decision analysis by the user.

From this stage, a detailed data collection plan will be created. It is here that the proposed methodology will be tailored to the scope of the user's project, as the project definition is analysed and the metrics considered. Not all attributes of the proposed methodology will be used, and it is here that the transition pathway will be derived from the roadmap proposed methodology.

3.3.3 Stage 3 - Recording the Information and Defining the Current State

This stage is when the planned data is collected and recorded through the structured data collection plan that was derived from Stage 2 of the proposed methodology. This information will be benchmarked through VSM the current state. However, unlike lean thinking both technical and cultural analysis will be made to ensure better implementation success. **Figure 3.9** outlines Stage 3.



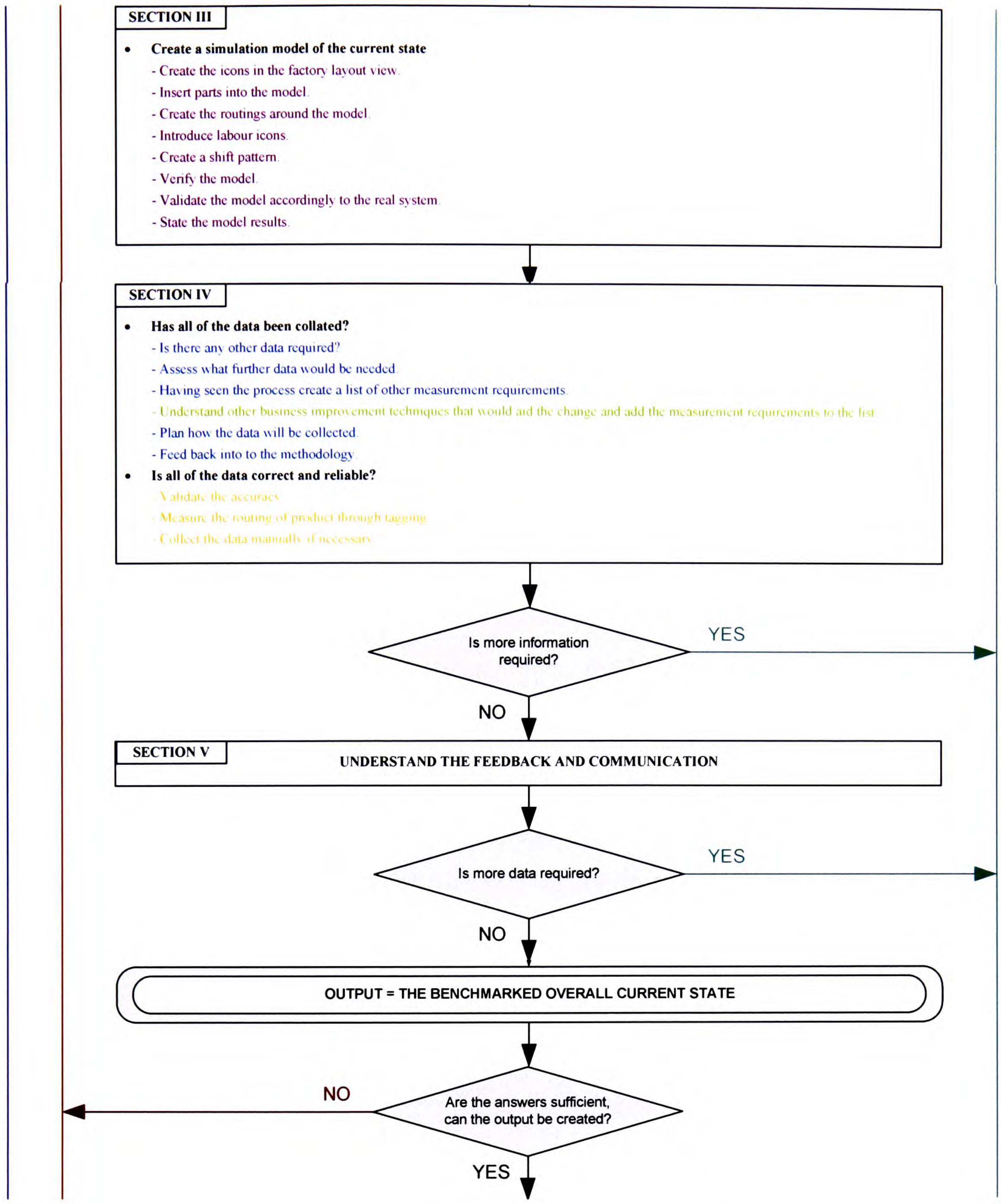


Figure 3.9: Stage 3 of the proposed methodology

Once all of the planned data is recorded, the benchmarking of the current state can be completed. Current state mapping through the lean thinking method of learning to see is used for the technical data, as well as PAM which is a tool associated with lean thinking (Rother and Harris, 2001). PAM is particularly useful as the information recorded is detailed but is also transferable into other tools, such as VSM simulation models and quality analysis. However, the cultural current state data will be defined through questionnaires and surveys adopted from strategy management styles (Finlay, 2000).

Here (Stage 3, Section III) discrete event simulation can be used to highlight obvious issues related to the project. It is most likely that these will be current problems that are obvious without any analysis, that requires immediate attention by validating, verify or justifying the concerns. Such issues are likely to highlight bottlenecks. These models are needed to confirm initial suspicions, and are used as a tool to demonstrate the importance of these problems to others.

Demonstrated here is the benefit of tailoring an improvement program through a number of methods and the use of discrete event simulation to highlight issues, which in turn will improve the acceptance of the project through reassurance. A conscious decision was made by the author, to only highlight the use of discrete event simulation with the physical system. If the cultural model was created the research parameters would increase and this would extend the project timescale. This methodology does not use discrete event simulation to model the current state culture and is seen as extended research work beyond this study and it is felt that there is little benefit to be gained with the length of time spent. Extensive knowledge is required about the system as well as the modelling techniques to model cultural transitions. When creating the physical current state simulation model the data collected for the PAM is used to define the model. If further information is required beyond that of the PAM the factors of time versus benefit have to be considered. Typical steps of simulation modelling creation are used within the proposed design methodology (Banks et al, 1994).

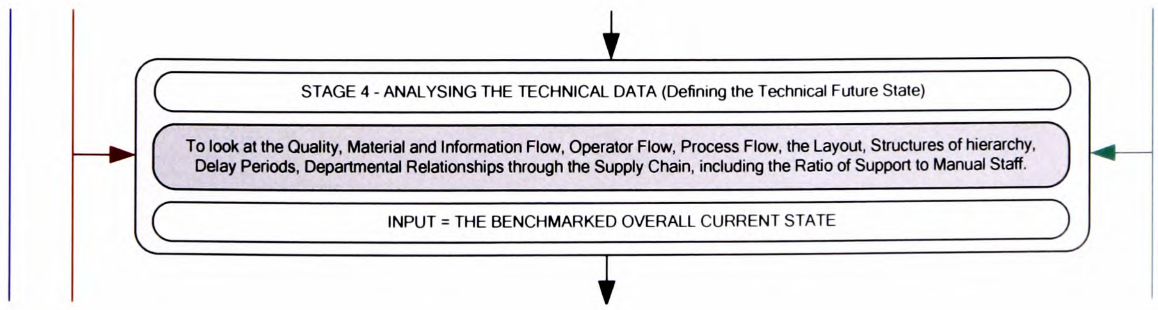
The current state culture will be analysed through a matrix (Finlay, 2000). As the project changes, so will the culture content within this matrix thus enabling the user to monitor the change throughout and before the overall culture analysis in Stage 6. As the data is being collected and recorded, it will be evident whether any further information is required and if this is so, what this it is. Depending on the scale of further information the user can use the feedback loop to feedback into Stage 2 and redefine all of the necessary measurements to be taken.

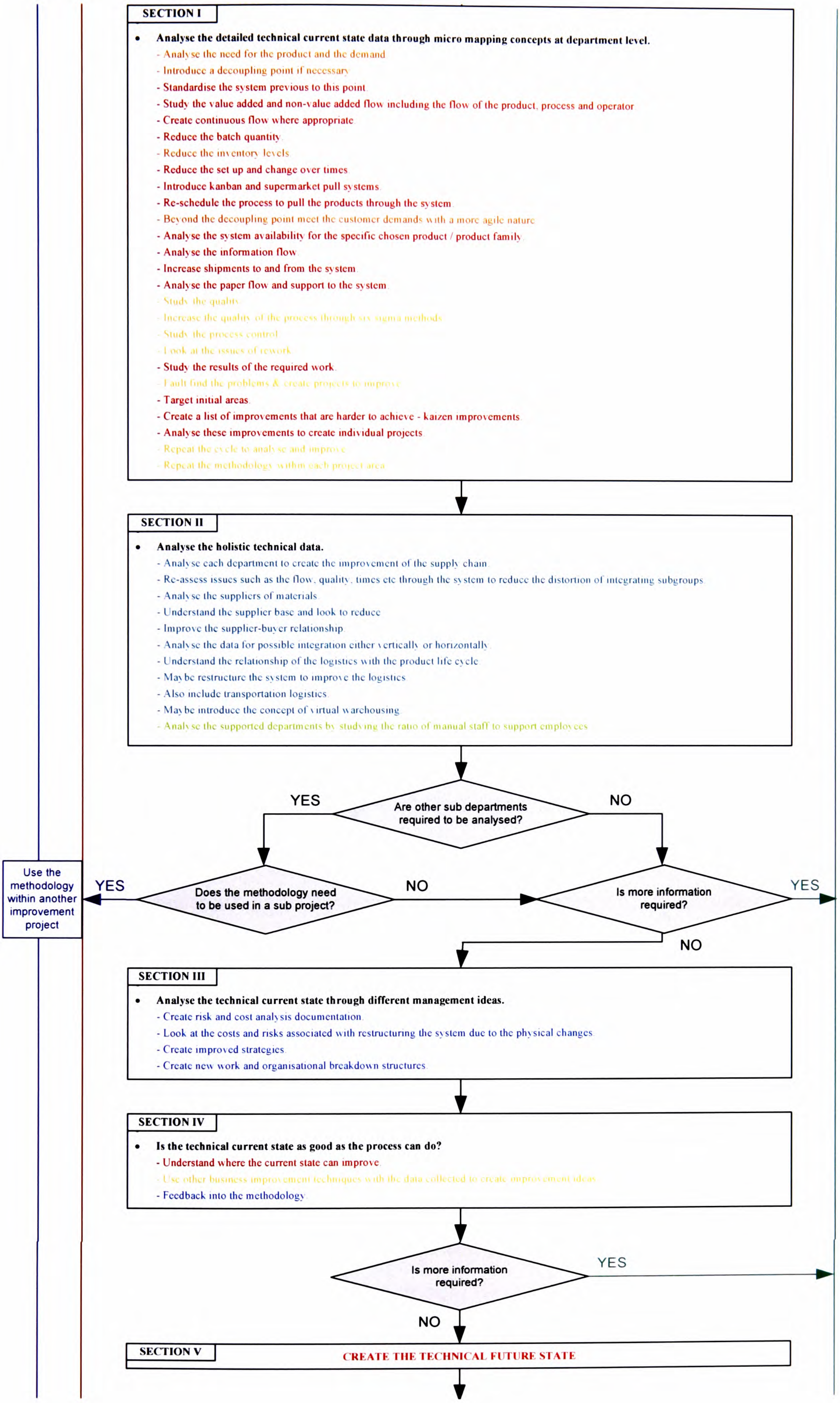
At this juncture of the methodology, the accuracy and reliability of the data can be assessed as this may be a point of returning back to Stage 2 if quality of data is deemed to be poor. These are typical aspects of project management (Slack et al, 1998) and six sigma methods through the DMAIC function (Pandes, 2000). Again the feedback and communication key is consulted to measure the cultural gains and to ensure correct completion of all of the guidelines. This key gives a general overall understanding of the project methodology. This stage introduces queries to instigate feedback, promotes the correct analysis and enhances the project direction.

The outcome from this third stage will be the overall current state of the organisation. It is here that the proposed methodology prioritises the design and physical changes over the cultural changes. The cultural issues are enhanced with the technical changes taking form. In the proposed methodology the technical advances will be documented theoretically and then analysed first. However, the cultural issues will be monitored throughout via the feedback loop and communication key. Allowing these technical aspects to be involved when deriving the cultural future state allows greater change of successful implementation (Chu, 2003). After technical issues have been assessed, the concepts that influence the cultural changes are required. Both features are then united and will be introduced as one structure when transforming the system from current to future state if all requirements are achieved and set. The user can then move onto the fourth stage.

3.3.4 Stage 4 – Analysing the Technical Data and Defining the Technical Future State

The fourth stage uses only the technical data for analysis, by collecting and analysing the data as planned and required in Stage 2 and thus recorded in Stage 3. Initially the current state of the technical data is benchmarked theoretically, the techniques described are applied and this current state is re-evaluated, analysed and transformed. The first section within this stage, **figure 3.10,** looks at the operational micro-mapping concepts defined in **figure 3.4** (page 80) and are referred to as 'operational analysis tools'. All of the concepts are evaluated by departmental level in this first Stage (Stage 4, Section I).





SECTION I
Analyse the detailed technical current state data through micro mapping concepts at department level.
- Analyse the need for the product and the demand
- Introduce a decoupling point if necessary
- Standardise the system previous to this point
- Study the value added and non-value added flow including the flow of the product, process and operator
- Create continuous flow where appropriate
- Reduce the batch quantity
- Reduce the inventory levels
- Reduce the set up and change over times
- Introduce kanban and supermarket pull systems
- Re-schedule the process to pull the products through the system
- Beyond the decoupling point meet the customer demands with a more agile nature
- Analyse the system availability for the specific chosen product / product family
- Analyse the information flow
- Increase shipments to and from the system
- Analyse the paper flow and support to the system
- Study the quality
- Increase the quality of the process through six sigma methods
- Study the process control
- Look at the issues of rework
- Study the results of the required work
- Fault find the problems & create projects to improve
- Target initial areas
- Create a list of improvements that are harder to achieve - kaizen improvements
- Analyse these improvements to create individual projects
- Repeat the cycle to analyse and improve
- Repeat the methodology within each project area
SECTION II
Analyse the holistic technical data.
- Analyse each department to create the improvement of the supply chain
- Re-assess issues such as the flow, quality, times etc through the system to reduce the distortion of integrating subgroups
- Analyse the suppliers of materials
- Understand the supplier base and look to reduce
- Improve the supplier-buyer relationship
- Analyse the data for possible integration either vertically or horizontally
- Understand the relationship of the logistics with the product life cycle
- Maybe restructure the system to improve the logistics
- Also include transportation logistics
- Maybe introduce the concept of virtual warehousing
- Analyse the supported departments by studying the ratio of manual staff to support employees
YES
Are other sub departments required to be analysed?
NO
Use the methodology within another improvement project
YES
Does the methodology need to be used in a sub project?
NO
Is more information required?
YES
NO
SECTION III
Analyse the technical current state through different management ideas.
- Create risk and cost analysis documentation
- Look at the costs and risks associated with restructuring the system due to the physical changes
- Create improved strategies
- Create new work and organisational breakdown structures
SECTION IV
Is the technical current state as good as the process can do?
- Understand where the current state can improve
- Use other business improvement techniques with the data collected to create improvement ideas
- Feedback into the methodology
Is more information required?
YES
NO
SECTION V
CREATE THE TECHNICAL FUTURE STATE

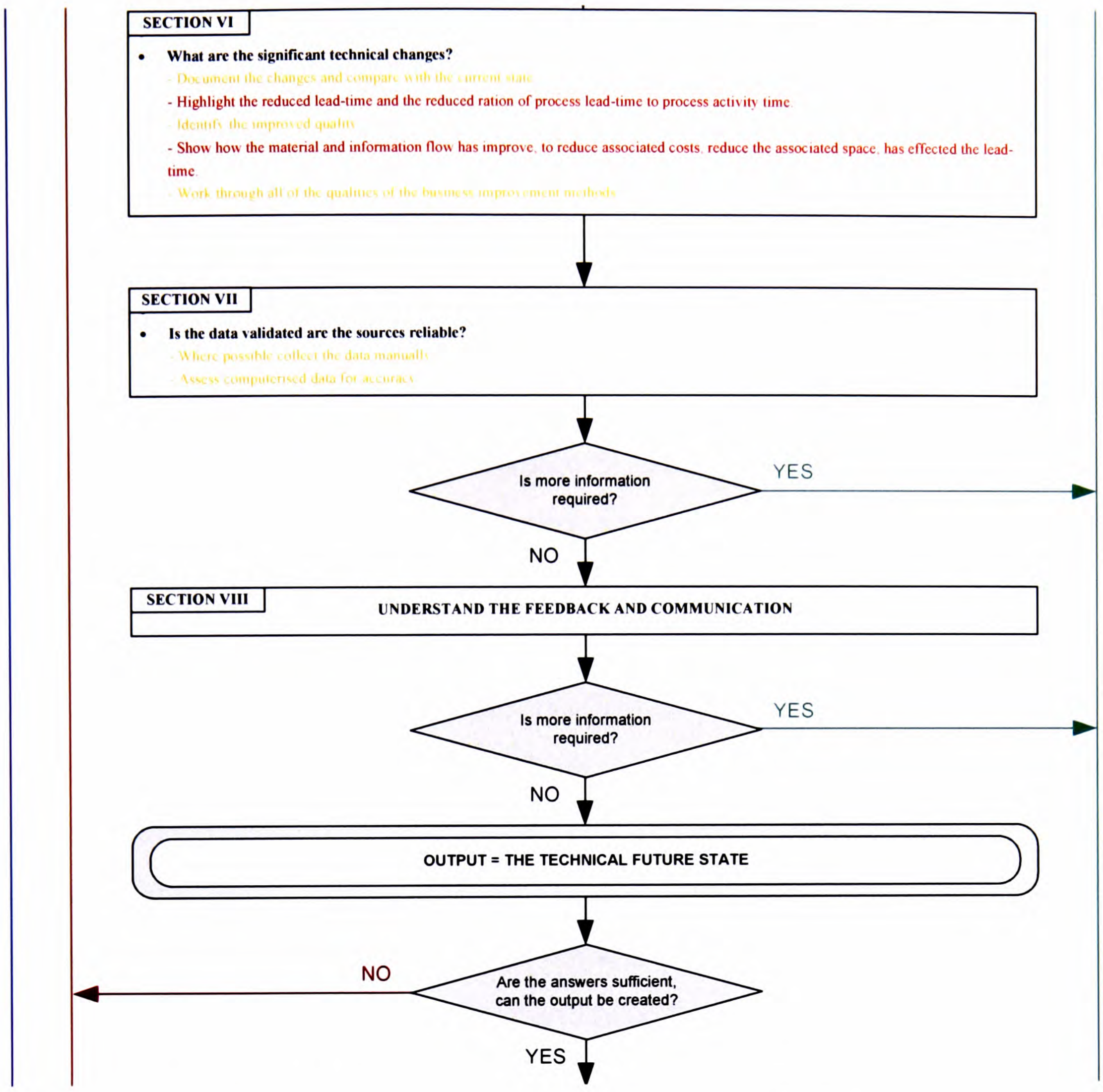


Figure 3.10: Stage 4 of the proposed methodology

This stage uses lean thinking tools such as the eight guidelines for transition. Rother and Shook, 1999, Rother and Harris, 2001, Harris, Harris and Wilson, 2003, Smalley, 2004 and Liker, 2004 all use methods associated with lean thinking mainly at plant and production process level. Agile production methods as well as six sigma methods are used to create flexibility into a system to increase quality. All issues raised within the literature review assessed the limitations of lean thinking and discussed the lack of flexibility in the systems thinking, as well as the assumption of high quality manufacture. This stage moves through the guidelines allowing the transition to develop according to the relevance of the concept to the project. By assessing at this level the results will produce a more achievable outcome since the actual people of the system are involved and their view, opinions and experience are also used to help gain insight into the project (Paton and McCalman, 2003).

The following stage takes a holistic approach and assesses the project requirements for overall measurements. From the project definition the proposed design methodology will be simpler to implement, due to scaling down the roadmap depending on the project needs as not all sections or guidelines will be necessary. This stage also considers logistics as well as departmental integration.

As the scale of the project could be reasonably quite large, it is felt that at this point in the project it may be necessary to reduce it into sub groups and the proposed methodology allows for this decision making process. This then guarantees that the project remains united between the departments/factories and that projects are not carried out in isolation. The supply chain will be analysed to reassess issues such as material and information flow, quality and lead times. The overall picture can be fused together through systems thinking methods (Scholtes, 1998), ensuring that the information in the lower levels is accurate and reliable. At this point in the stage, feedback is sought regarding the need for the decision of the project into sub-groups. This allows the integration of sub groups or departmental projects to be fed back into the proposed methodology to create a top level and holistic view of the business.

It is important to remember that the project also requires a degree of management skills to stabilise the system through the management of other projects and assess the overall project with regard to cost and risk. There may possibly also be a need for structural changes to the company as well as new organisational and work breakdown structures. As another feedback loop, the proposed methodology realises that it is important to consider the situation further and assess whether technical current state is as good as the process can do. This can be achieved through implementing lean thinking through kaizen events, six sigma through data analysis and strategy management through project management. So, this stage of the proposed methodology provides an understanding not only where the process can be improved through theory but also through experience.

If only operational tools are used to change the project then the success will not be very high (Reijers and Liman Mansar, 2005). Therefore, strategy management tools also need to be considered (Knowles et al, 2005) to manage the transition either through cost analysis organisational structural changes, communication plans, resource planes, timescales and objectives to name a few. Lean thinking alone does not consider the planning and management involved with the implementation of a system. It was necessary at this stage to question the results produced, as a great deal of information has been addressed and processed and it was felt that it was essential to question what has been achieved thus far. Should any faults or mistakes occur the project could feedback into the system.

From this it is then expected that the technical future state can be generated. In turn these technical changes should be documented for investigation, by highlighting the significant technical changes and this benchmarking processes allows the user to consider concepts of lean thinking and six sigma through mapping and data analysis.

By analysing the significant differences between the current and future states, the documentation can be referred back to highlight the milestones and transitional accomplishments. This strategy complies with continuous improvement initiates associated with lean thinking and six sigma. These considerable changes should measure lead times and the reduction in inventory through waste elimination as well as strategy management issues such as costs and quality. Like the previous stages the data is assessed for reliability as well as the feedback and communication key. The final outcome from the fourth stage is the technical future state. Within the literature review it was highlighted that one particular limitation of lean thinking was the consideration of 'real time' events. It was thought within the literature review that simulation modelling could benefit 'operational analysis tools' by testing in a simulated system of the theoretical model. Stage 5 takes the data analysis and evaluates the limitation highlighted within the literature review.

3.3.5 Stage 5 – Improving the Results and Defining the Optimum Technical Future State

The fifth stage takes the results from the previous stage, the technical future state and investigates the need for further improvement. This stage identifies how the technical future state can be improved through simulation modelling including verification and that the suggested improvements from the technical future state are achievable. This stage satisfies the lean thinking limitation of implementing a theoretical future state design into a real system with **figure 3.11** showing Stage 5 of the proposed design methodology.

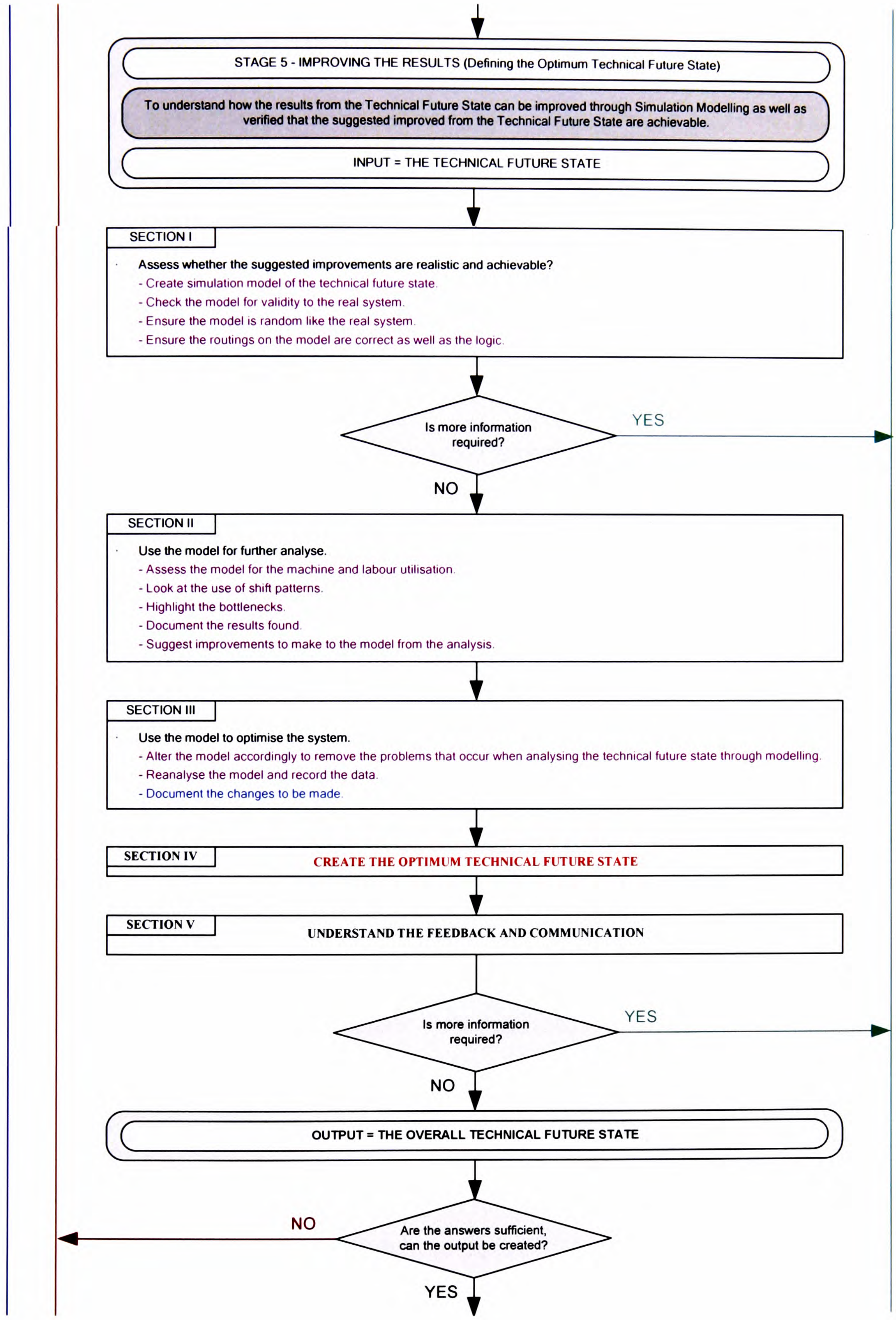


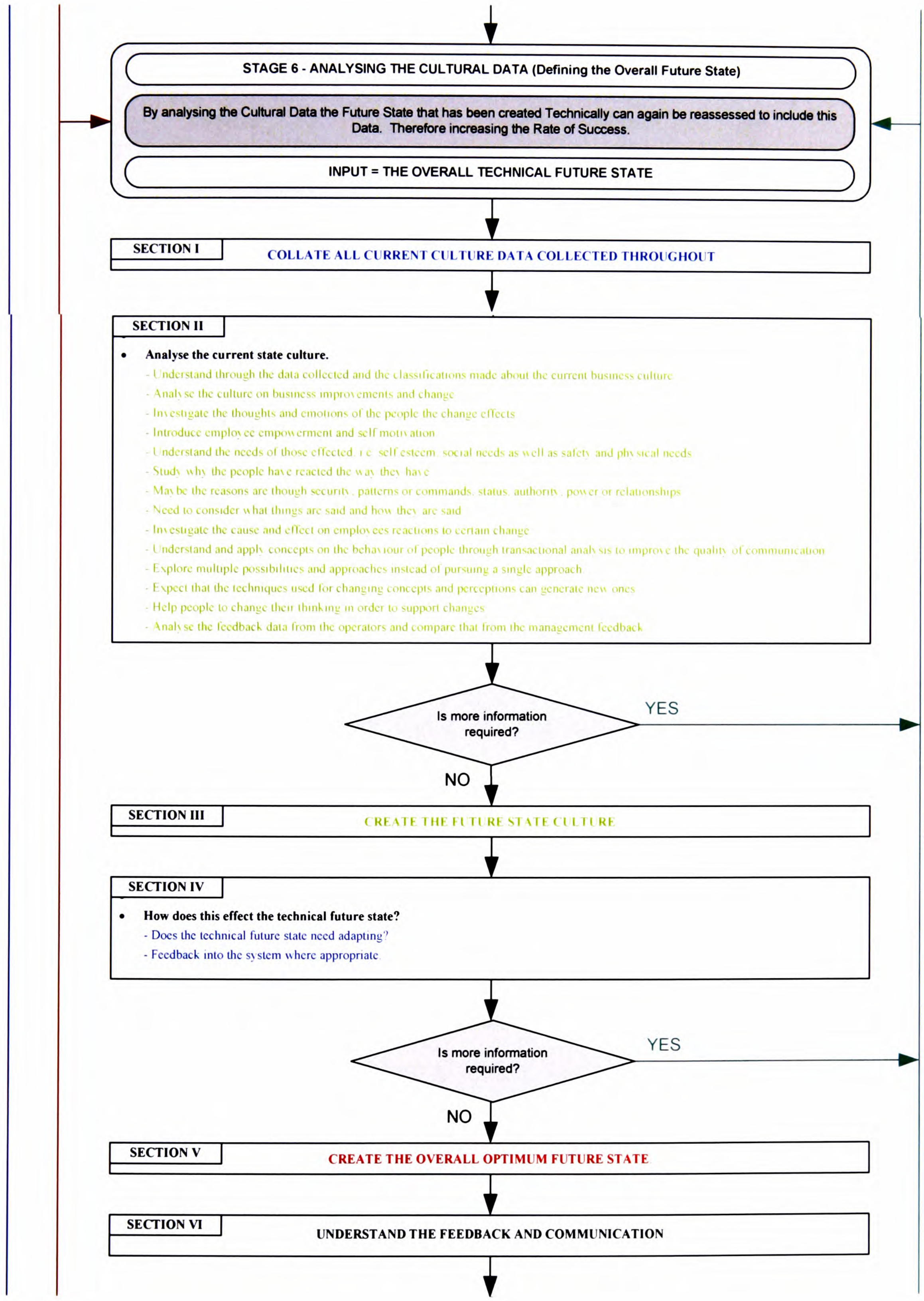
Figure 3.11: Stage 5 of the proposed methodology

From previous research these technical results can be evaluated further to check the validity in a real system. To do this the proposed methodology creates questions to be answered about the reliability and achievability of the results produced from the technical theory. The approach that the proposed methodology uses is through computer simulation modelling. This then allows the results of the system to be tested on a model before making these changes in the real system. The approach taken here to define the future state model is adopted from Banks et al, 1994 from which aspects of simulation model building were used from the 'steps in a model'. The information derived for the technical future state is used. Once more these results are likely to produce further questions that may have to be considered by feeding back into the system through the feedback loops.

This model can then be used to simulate other aspects that may not have been studied in the operational analysis tools, thus improving and justifying the results of the change process to make more realistic and achievable. 'Operational analysis tools' do not assess the effects of shift patterns and the concept of time (Worley and Doolen, 2006). Also resource and capacity planning are also not utilised in these tools (operational analysis tools) and hence this is where the use of discrete event simulation is important.
It will be necessary to investigate the project to ensure that it is meeting the initial requirements that were set and that all stakeholders involved are satisfied with the progress the project is making. As with the current state simulation model the operational analysis tool will tailor and give direction of where to apply discrete event simulation. This stage will use discrete event simulation to understand other factors where these operational analysis tools do not consider, for example machine and labour utilisation, the aspect of time to include shift patterns, to highlight bottlenecks and other related factors.

3.3.6 Stage 6 – Analysing the Cultural Data and Defining the Overall Future State

Stage 6 analyses the cultural data, shown in **figure 3.12**. The reasoning behind this stage is to reassess the overall technical future state to include the influences of the changing culture. A major concern that was discovered within the literature research study was the integration of technical data with cultural data. 'Operational analysis tools' such as lean thinking only analyse the technical information of a system (Fearne and Fowler, 2006). To ensure implementation success cultural aspect also need to be considered, which are harder to achieve (Proudlove et al, 2008). The literature review highlighted this particular aspect being a limitation of lean thinking methods. All previous cultural data collected throughout the previous stages is collated together to analyse the changing cultural environment.



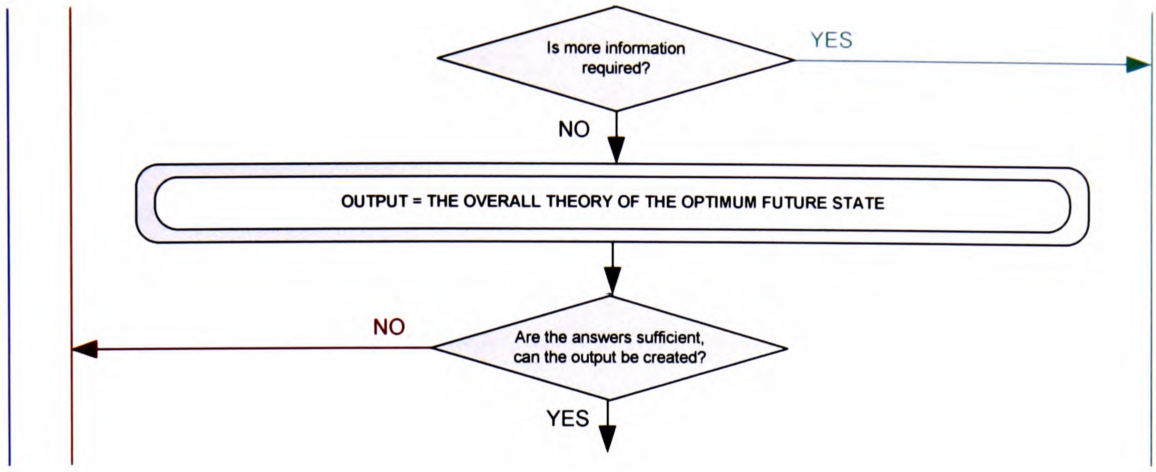


Figure 3.12: Stage 6 of the proposed methodology

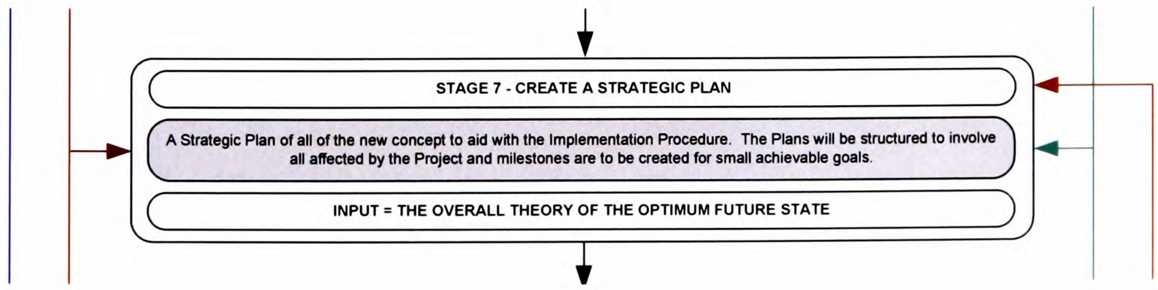
The proposed methodology analyses the current state culture, by taking the current cultural classifications and the evolving changing matrices as shown in the literature review in Section 2.4.6. This stage evaluates how change and business improvements affect the business as well as the success of the project. This section will cover a number of different aspects through investigating the thoughts and opinions of those involved and how they think these changes will affect the business (Kotter, 1996). The proposed methodology will explore the different ideas and the possible multiple approaches instead of pursuing a single approach (Scholtes, 1998). This stage also recognises and investigates the use of employee relations as well as empowerment and company ethics. This stage is used to understand the reaction to change including the willingness to change of the work force. It can be assessed through surveys of all stakeholders and also the perception between the operators and the management can be studied.

This different approach tests the hypothesis to establish how to actually take the technical processed theoretical data and use that information to also consider and investigate the cultural aspects (Paton and McCalman, 2003). It is this feature that is very often forgotten when transforming a system through a change process (Reijers and Liman Mansar, 2005). Should further cultural information be needed to be measured, recorded or analysed the proposed methodology utilises a feedback loop to allow the user to back into the previous steps. These loops are important to create project structure and justification.

At this point in the proposed methodology the ideal future state culture is documented. It is also important to bear in mind that, should there be any significant differences between what has been achieved at this stage to any previous 'creating future state' stages, the future state should move back through Stages 4, 5 and 6 to be reassessed via feedback loops. There are a number of feedback loops at this stage due to the high uncertainty of cultural change management and how this affects the physical system. It is also necessary to specify any further significant change between the technical future state and the future state culture. To continue with standardisation the feedback and communication key is evaluated, and the output created.

3.3.7 Stage 7 – Create a Strategic Plan

Stage 7 starts by re-visiting the project definition outlined within Stage 1. This is so that changes in the project strategy as defined in Stage 1 (which have been fully documented) as well as the mission statements and visions may have altered. It is from here that the creation of the strategic plan can be initiated. As highlighted in the literature review a limitation of lean thinking is the knowledge of a structured implementation plan. This stage aims to create this plan through the use of strategy management techniques, such as project planning through Gantt charts (Russell and Taylor, 1999) but also using the model of the system created from the operational techniques. An important factor of the proposed methodology is that those affected by the changes are involved at every stage of the plan. Also as discussed in the literature review the lack of cultural analysis in lean thinking methods (Thomas et al, 2003) is overcome in this stage by considering the 'people' aspect in the plan definition. This stage is an example of the parallel continuum of operational, cultural and strategical management methods, shown **figure 3.2,** page 78. The flow chart of Stage 7 in the proposed methodology is shown in **figure 3.13**.



SECTION I

- **Refer back to the project definition.**
  - How has the project changed?
  - Analyse the changes
  - Document these changes
  - Define the mission statement.
  - Define the vision.
- **Have an input from the internal stakeholders.**
  - Meet these those involved.
  - Discuss issues with the design phase
  - Make changes if necessary.
  - Create the strategic plan of implementation with the stakeholders.
- **What is the relationship with the external stakeholders on the improvements.**
  - Assess the financial relationships.
  - Assess the relationships with the suppliers and the customers.
- **Highlight the goals and objectives of the strategy.**
  - Take the theory and divide into manageable sizes.
  - Create loops in the theory - sections.
  - For each section list the improvements required.
  - Place a goal / objective for that improvement.
  - Put a time constraint to the objectives.

Is more information required? YES / NO

SECTION II DOCUMENT THE STRATEGIC PLAN.

SECTION III

- **Analyse the plan.**
  - Assess the risk factors on each improvement.
  - Calculate the associated cost.
  - Assess the factors of cost compared to the effect of the impact of the implementation and the benefits.
  - Create a work breakdown structure.
  - Inform the teams of the implementation of the work breakdown structure
  - Also create the organisation breakdown structure.
  - Discuss who will be the change agents - people who will drive the change
  - Can the business profit from these project improvements?
  - Assess the durability of the improvement.
  - Will the advantages sustain.
  - Analyse the transparency and replicability.
  - Can these improvements be generic and applied in other areas.

Is more information required? YES / NO

SECTION IV

- **What is the feasibility of the project?**
  - Will the culture make the improvements problematic?
  - What is the financial feasibility?
  - What is the feasibility of obtaining the resources?

SECTION V DOCUMENT THE IMPROVED STRATEGIC IMPROVEMENT PLAN.

SECTION VI UNDERSTAND THE FEEDBACK AND COMMUNICATION

Is more information required? YES / NO

Does the strategic plan need adapting? YES / NO

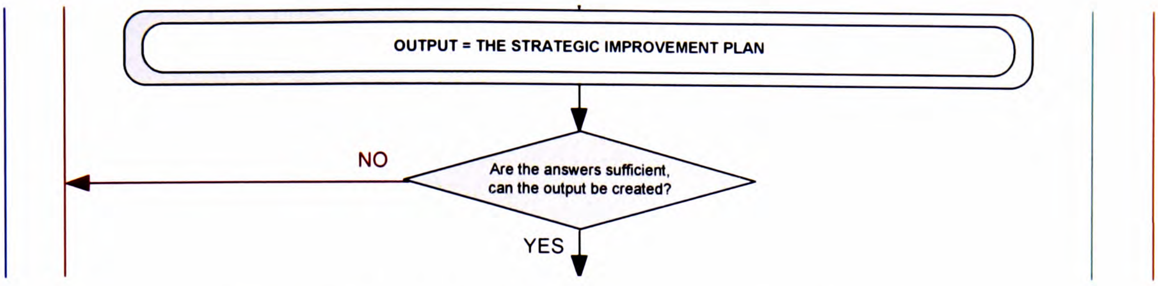


Figure 3.13: Stage 7 of the proposed methodology

Internal stakeholders have an input into the creation of the strategic plan by discussing the success of the design, whether it has met the needs of the company and whether further adjustments are to be made. Here it can be seen the integration of a number of concepts. The flowchart of Stage 7 demonstrates the use of strategy management, six sigma, culture management, supply chain management and lean thinking tools to define the plan. Concepts of lean thinking are used to break the plan into manageable size through implementation loops as demonstrated in the learning to see analysis (Rother and Shock, 1999). These manageable loops have goals and objectives assigned which uses concepts of six sigma in the define stage of the DMAIC process (Pande, 2000). Stakeholders are involved at the onset which elevates cultural issues related to project involvement and communication (Kotter, 1996). Similarly logistics planning is measured and defined, so supply chain management ideas are established to ensure a total project overview (Bolstorff and Rosenbaum, 2003).

Once these initiating steps are complete the strategic plan will be created and documented. The next step is to analyse this plan to assess the financial situation of the change as it will be necessary to understand the associated financial risks involved and the associated costs. These are measures of strategy management and this is an example of concepts and considerations that lean thinking does not evaluate as shown in the literature review. The relationships of the suppliers will also have to be investigated to ensure successful implementation of the methodology. In this step of the proposed methodology theories of strategy management, supply chain management and cultural management are being used simultaneously to improve the plan and implementation. As with all stages of the proposed methodology feedback loops are present and so further information can be collected and analysed to allow continuous improvement on the project design and implementation plans.

Goals and targets are set within the proposed methodology to guarantee that all aspects of the theoretical design are met, by creating feedback loops to verify that the implementation design is in line with the theoretical design of the future state. Most importantly time constraints are added to these objectives to ensure the sustainability whereas lean thinking tools place very generic time restraints on the implementation of the design as discussed in the literature review. It is intended that in this proposed methodology structured and achievable time constraints will be set to ensure greater implementation success through strategic management tools such as project management. The strategic plan will then be documented ready for analysis. The strategic implementation plan will be the most customised part of the proposed methodology while the other stages are however tailored and will still remain very generic.

Once the strategic plan has been documented it is analysed on topics such as costs, profits, durability, work breakdown structures and organisational work breakdown structures. The change agents, those people directly linked to the project and drive the changes will be involved in the plan. The transparency and reliability of the project will also be considered to ensure that the improvements are generic for other areas. At this point in the stage the feasibility of the project is questioned in terms of financial, resource and structural. These are all areas of implementation management that lean thinking does not consider when transforming a system. The feedback and communication key is analysed and a number of questions are placed before the output to ensure that all aspects are considered. The output from this stage will be an improved strategic plan.

3.3.8 Stage 8 – Implement the Strategy

Figure 3.14 displays the steps of Stage 8 of the proposed methodology, which is to "Implement the Strategy". This module will concentrate more on the monitoring of the cultural environment the physical changes as these have been defined and are less fluid then cultural issues and constraints. It is this stage that is the most significant with regard to the success of the project implementation. This stage is based upon the 'Do' function of the TQM cycle previously discussed as the Plan, Do, Check, Act (PDCA) cycle (Liker, 2004).

STAGE 8 - IMPLEMENT THE STRATEGY

Using the Strategic Plan the theory of the Future State will be implemented, assessing the Cultural Behaviour throughout the Implementation Phase. The Changes as with all Stages will be studied & documented.

INPUT = THE STRATEGIC IMPROVEMENT PLAN

SECTION I

IMPLEMENT THE CHANGES IN INCREMENTS ACCORDINGLY TO THE STRATEGIC IMPLEMENTATION PLAN.

SECTION II

- **Consider the following points when Implementing the Improvements.**
  - The greater the change, the greater the impact on the culture, the more lasting and fundamental the change will be
  - For the change to sustain without coercion mental models have to be changed
  - Thus creating knowledge and a purpose
  - Reiterate the purpose of change
  - Empathise with people and assist to manage their self-esteem through the implementation process
  - People will defend themselves
  - Their self esteem and skills will suffer
  - Understand people's reaction to change - denial, defence, discarding, adaptation and internalising
  - Explain the need for change and its feasibility
  - Highlight how these improvements need a new method of thinking
  - Show how these improvements are linked to goals and objectives
  - Highlight the "psychological safety" - the need for everyone in the change
  - Highlight how a new form of knowledge will be created
  - The people creating this knowledge however must have a purpose - this purpose has to be highlighted very carefully
  - Be aware that people will be in denial and will deny the validity of new ideas
  - Consider the magnitude of the change
  - Assess the type of change - incremental or transactional
  - Understand the time available on the project, as well as the discussion time
  - The support for change within the organisation
  - Discuss the outcomes and select a change management style
  - A typical style would be 'forced evolution' - this would be introduced in incremental steps but the majority of people oppose the change
  - The style could change throughout the implementation process. (participate evolution, forced evolution, charismatic transformation, dictational transformation.)

Does the strategic plan need adapting?

YES

NO

SECTION III

- **Ensure that the change agent performs certain roles.**
  - That the change agent relates to the objectives
  - Is aware of the politics throughout change
  - Is sensitive to those involved
  - Carries out continual communication and negotiation
  - Has the ability to build teams and takes a leadership role
  - Understands tactics for and against change
- **Involve both the internal and external stakeholders.**
  - Listen to the opinions of the stakeholders
  - Analyse the information
  - Document this data.

SECTION IV

- **Are changes required in the strategic implementation plan.**
  - Does the plan give the desired effect?
  - Gather the information from the teams involved in the plan
  - Gather the data documented from the stakeholders

Does the strategic plan need adapting?

YES

NO

SECTION V

UNDERSTAND THE FEEDBACK AND COMMUNICATION

Is more information required?

YES

NO

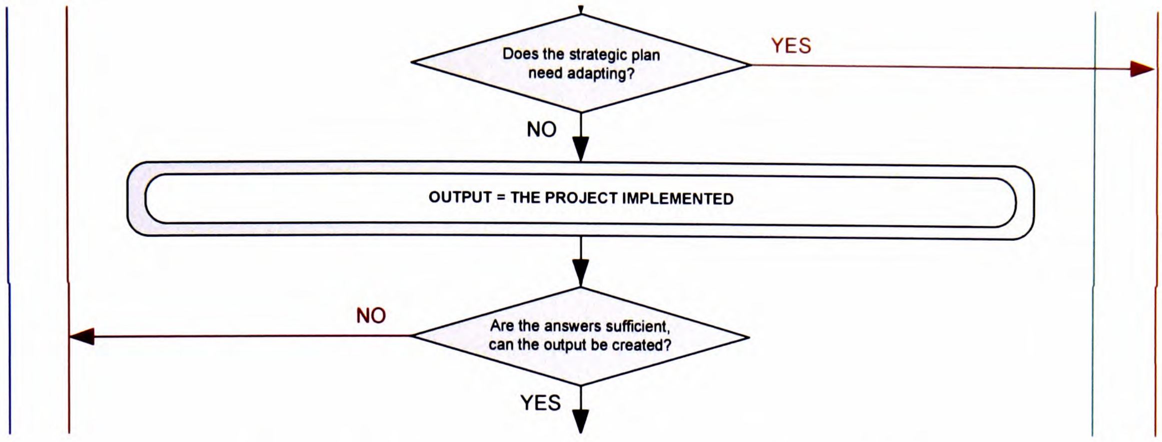


Figure 3.14: Stage 8 of the proposed methodology

At this stage the concept displayed in **figure 3.6** (page 87) is utilised the most. This stage involved using all previous cultural data collected through the transition either from the feedback and communication key, the documented changes, Stage 6 and the implementation plan. This stage aims at not only using the cultural unfreezing process achieved throughout the previous stages and implements the planned improvements but also considers the culture management points in the first section in Stage 8.

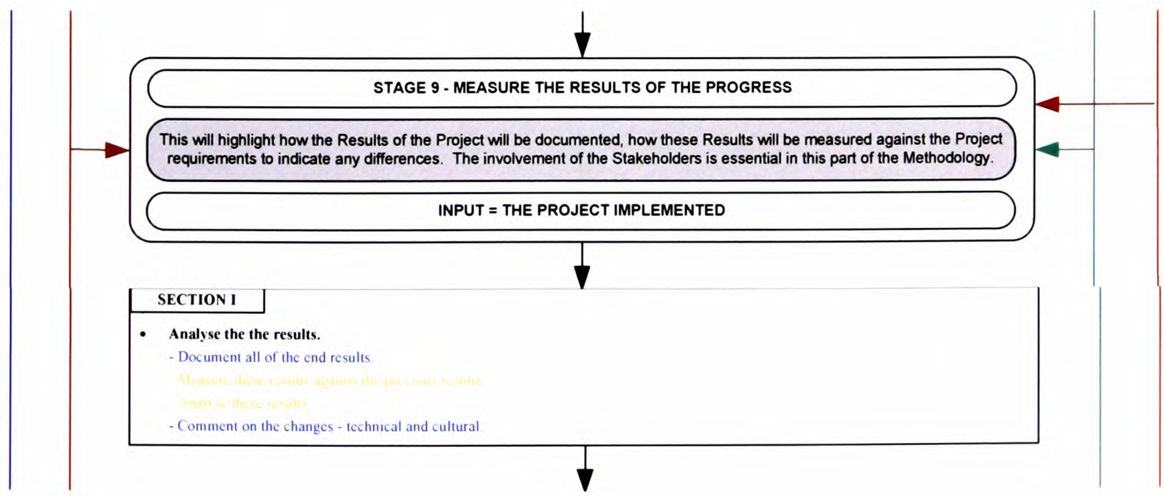
Ideas such as considering the types of change management styles and ensuring that the change agents perform certain roles are also necessary to consider here. The proposed methodology concurrently uses aspects of culture management through people management, but uses six sigma tools to manage the data analysis that is produced from implementing the improvements. The information analysed in this section highlight attributes of soft systems through the uses of cultural, strategical and people management. All of these aspects are restricted in lean thinking tools. Soft systems thinking results with less distinct answers (Fullan, 2004) and at this point in the proposed methodology the implementation approach could be dramatically changed and so a feedback loop has been identified to allow changes to the implementation and plan.

Whilst the implementation process is taking place there are certain aspects that need to be monitored throughout. Clear roles, responsibilities and change agents should be defined so that the transformation needs are promoted and that any concerns and issues by any stakeholders are addressed. These again involve all stakeholders, internal and external, possible changes that may be required to the plan and creating a progress report detailing how this is monitored. This can be taught through strategy management tools

(Coulter, 2005) and lean thinking tools through benchmarking (Feld, 2001). This stage also allows adaptations to the plan due to real life implementation and using the feedback and communication key. The final outcome of the eighth stage, feeding into the next stage, is the project implementation. The main usage of this stage is to follow the structured operational changes and to monitor the cultural changes simultaneously.

3.3.9 Stage 9 – Measure the Results of the Progress

In this stage Deming's Plan, Do, Check and Act cycle is reiterated further. This stage is a formation of this cycle and is based on the analysis of the actual results against the planned and estimated results. Stage 9 is seen as a revision section, **figure 3.15**, and it was felt that this stage should analyse the results from the implementation phase. The main achievement from Stage 9 would be to highlight the documented results and how these answers compare against the project requirements to indicate any differences. Initially all results from the implementation of the design would be acknowledged and analysed using techniques from strategy management by project documentation and six sigma through the 'measure' and 'analyse' function of the DMAIC process. From this all previous documented stages in the proposed methodology will be referred to. By referencing the current state (technical and cultural) the user can use six sigma through data analysis (Pande, 2000) and lean thinking by benchmarking the change. VSM (Rother and Shook, 1999) can be applied to understand the accuracy of the measurements taken to investigate discrepancies. These issues can be used for continuous improvement with the use of the planned future state.



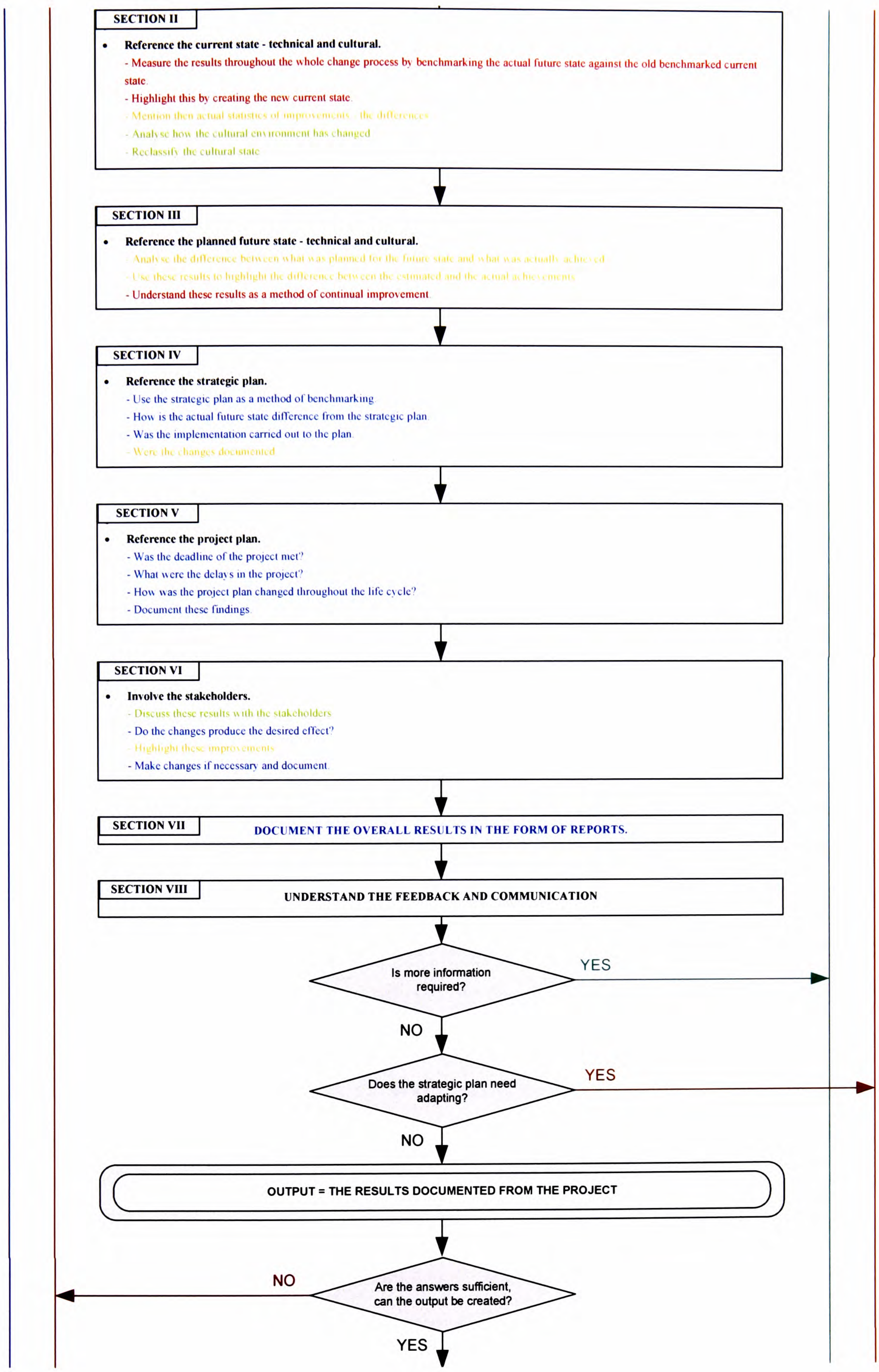


Figure 3.15: Stage 9 of the proposed methodology

By using theories of strategy management, as a form of benchmarking, the user can analyse any future state differences between the strategic improvement plan and what was actually carried out. Finally the initial project plan can be assessed to investigate the project as a whole and to challenge any discrepancies with regard to meeting the goals and objectives as well as the timescales. These issues should be kept to a minimum due to the continual assessment carried out throughout the proposed methodology via the feedback loops, including the feedback and communication key. All of these sections will involve the input from the stakeholders by incorporating theories from culture management. This is through discussions and communication plans, as well as strategy management by questioning the actual results.

From the analysis in these steps within Stage 9 will be documented in the form of reports and it is here that the proposed methodology has further feedback loops for improvement. This stage will also calculate the usual measurements, for example looking at the progress measured throughout the project as well as the views and culture barriers that may have occurred. The outcome for Stage 9 will be the overall investigated and assessed results from the entire project which will be fully documented.

3.3.10 Stage 10 – Control the Project to Sustain

The final Stage 10 is considered to be the most important as this will determine the success of the whole project. This stage is concerned with finalising the continuum of the operations, strategy and culture cycle. This stage is about controlling the project to sustain the improvements made, as utilised by the 'control' function of the DMAIC six sigma process. **Figure 3.16** shows the flow diagram of Stage 10 of the proposed methodology. The first point is to understand how to control the physical system, ensuring that the designed system remains within it limits and constraints. This can be achieved through six sigma tools. However, the system is also required to be reactive to the customer demand as well control of the structure is also necessary. Therefore the proposed methodology needs to be cautiously balanced. Variances in this system need to be understood and so the actual to required measurements of the improved system have also to be monitored and adjusted accordingly.

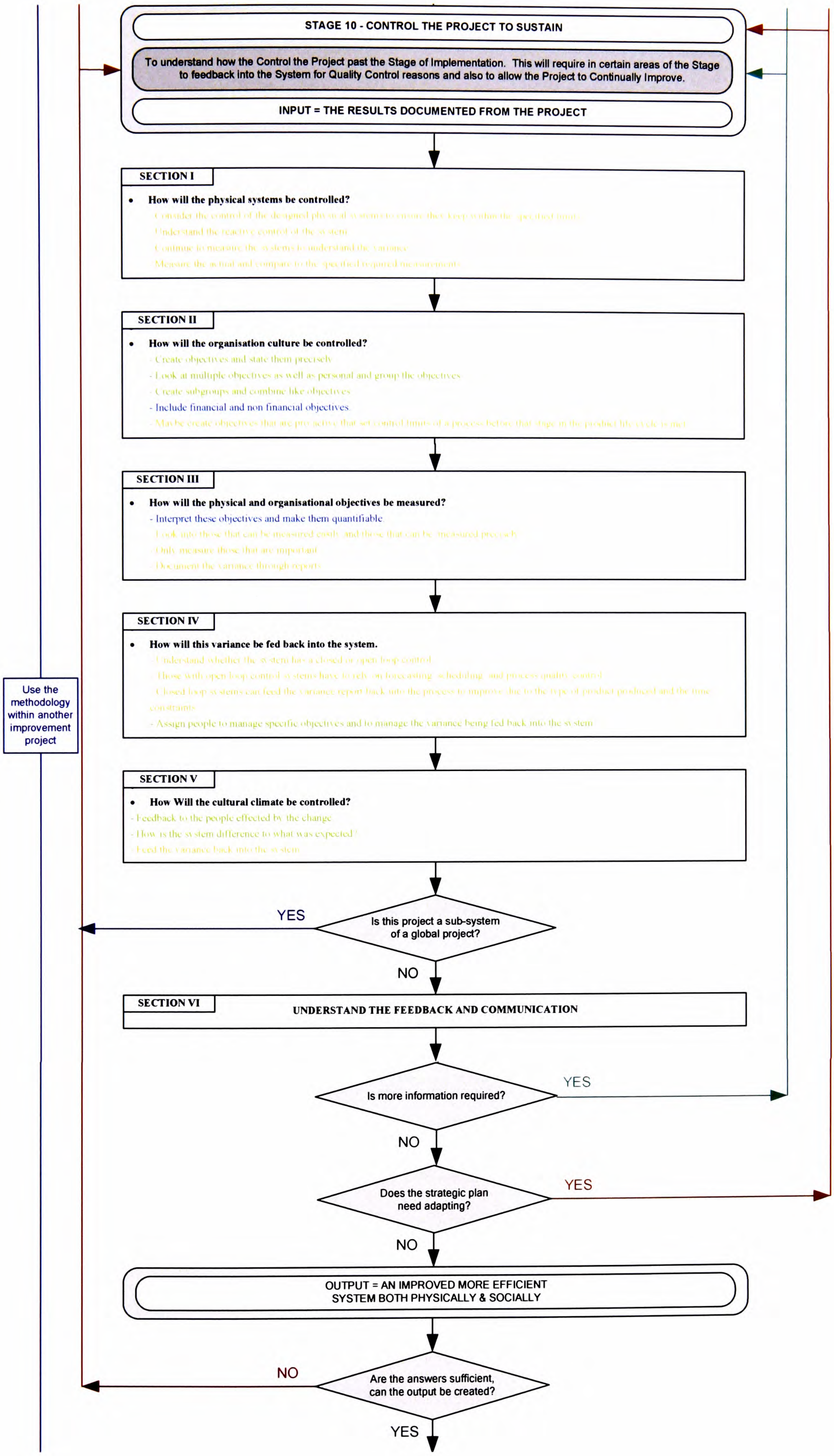

STAGE 10 - CONTROL THE PROJECT TO SUSTAIN
To understand how the Control the Project past the Stage of Implementation. This will require in certain areas of the Stage to feedback into the System for Quality Control reasons and also to allow the Project to Continually Improve.
INPUT = THE RESULTS DOCUMENTED FROM THE PROJECT
SECTION I
How will the physical systems be controlled?
Consider the control of the designed physical systems to ensure they keep within the specified limits
Understand the reactive control of the system
Continue to measure the systems to understand the variance
Measure the actual and compare to the specified required measurements
SECTION II
How will the organisation culture be controlled?
- Create objectives and state them precisely
- Look at multiple objectives as well as personal and group the objectives
- Create subgroups and combine like objectives
- Include financial and non financial objectives
- Maybe create objectives that are pro active that set control limits of a process before that stage in the product life cycle is met
SECTION III
How will the physical and organisational objectives be measured?
- Interpret these objectives and make them quantifiable
- Look into those that can be measured easily and those that can be measured precisely
- Only measure those that are important
- Document the variance through reports
SECTION IV
How will this variance be fed back into the system.
- Understand whether the system has a closed or open loop control
- Those with open loop control systems have to rely on forecasting, scheduling and process quality control
- Closed loop systems can feed the variance report back into the process to improve due to the type of product produced and the time constraints
- Assign people to manage specific objectives and to manage the variance being fed back into the system
SECTION V
How Will the cultural climate be controlled?
- Feedback to the people effected by the change
- How is the system difference to what was expected?
- Feed the variance back into the system
Use the methodology within another improvement project
YES
Is this project a sub-system of a global project?
NO
SECTION VI
UNDERSTAND THE FEEDBACK AND COMMUNICATION
YES
Is more information required?
NO
YES
Does the strategic plan need adapting?
NO
OUTPUT = AN IMPROVED MORE EFFICIENT SYSTEM BOTH PHYSICALLY & SOCIALLY
NO
Are the answers sufficient, can the output be created?
YES

Figure 3.16: Stage 10 of the proposed methodology

Not only does the physical system need to be controlled but the cultural system needs to also be carefully observed. This will be carried out by creating objectives to control the cultural environment. These objectives need to be created by all of the stakeholders directly involved in the project. These objectives may contain sub categories, but need to include financial and non-financial gains (Finlay, 2000) and then they need to be combined through similarity; these are concepts of project management. This will then create objectives that are more pro-active that have a set of control limits within the physical process. In this stage of the proposed methodology the use of all three classifications of operational, strategical and cultural methods have been highlighted.

Once the physical and organisational systems have processes in control through the use of statistical process control methods and the limitations are set, the next step is to understand how these controlled systems can be measured through six sigma tools. This will be undertaken by making the objectives created quantifiable using strategy management methods (Scholtes, 1999). It will be important to guarantee that only those measurements that are important to the controlled system are considered. Once again, any variance will have to be measured and reduced.

Measuring variance is only useful if the information is fed back into the system and this is determined by the type of control the system has, that is whether it is open or closed loop control. By feeding the variance back into the system the improvements that have been strategically controlled and measured will be sustained. For example this could be changes within the customer demand or variance within the supply of products to the controlled system.

The last step in Stage 10 is to discuss with the stakeholders how the change has affected those involved and how the new system is different from what was expected. Again these variances need to be fed back into the system to highlight the need for changes to be continually fed into a structure to ensure absolute success and the feedback and communication key is finally used to highlight any differences. Then the entire project needs to be periodically restarted as a form of continuous improvement and to emphasize sustainability and control. Creating the output of an improved more efficient system physically and socially.

3.4 Research Justification

Particular frameworks that are associated with MBIM's are shown in **figure 3.17.** This diagram highlights existing improvement concepts that have been utilised within this research study and where they have been integrated within the proposed methodology. The figure highlights the features of the tools and their association with the proposed methodology. It can be seen how the features of these existing frameworks only consider certain aspects of the integrated from this research.

When analysing the diagram it can be seen that lean manufacturing tools focus particularly at recording data and analysing the technical information. Lean thinking tools are also associated with continuous improvement by measuring the progress and sustaining the improvements. Agile production tools concentrate on planning, recording and analysing a system to synchronise the project, which are different attributes to lean thinking. The figure shows many tools of supply chain management, which have a range of features. Whilst some specialise in project design through measurement planning data recording and analysis, other tools feature aspects of implementation tools, such as implementation strategy plans as well as progress measurement and sustainment.

Discrete event simulation tools have purely been executed to optimise a given system. These tools also have methods to plan the measurements requirements, however the primary functions is to verify and validate the system in a real time form. Tools that have broad aspects which fit closest to this proposed methodology are features of six sigma methods. The diagram shows how six sigma and quality associated tools have functions across all aspects of the proposed methodology apart from cultural techniques. The DMAIC cycle is very versatile and can be applied in any given system, however the PDCA cycle can be reiterated through project design as well as project implementation.

	Existing Methodologies \ Integrated Methodology	Stage 1 Project Alignment	Stage 2 Planning the Measurement	Stage 3 Recording the Information	Stage 4 Analysing the Technical Data	Stage 5 Improving the Results	Stage 6 Analysing the Cultural Data	Stage 7 Create a Strategic Plan	Stage 8 Implementing the Strategy	Stage 9 Measure the Results of the Progress	Stage 10 Control the Project to Sustain
OPERATIONAL	**Lean Thinking**										
	Learning to See - VSM Tool			X	X			X		X	X
	Policy Deployment	X	X								
	Benchmarking Flow			X	X	X				X	X
	5s				X						X
	7W				X						X
	PAM			X	X						
	Agile Production										
	System Synchronisation			X	X						
	AVE Reference Model	X	X	X	X	X			X		
	Supply Chain										
	Macro Mapping	X		X	X						
	Bull Whip Analysis				X						
	SIPOC Model	X	X	X	X						
	SCOR Model	X	X	X	X			X	X	X	X
	Transaction Management				X						
	Balance Scorecard		X	X	X						
	Logistics Management	X	X		X						
	Discrete Event Simulation										
	Real Time Testing			X		X					
	System Optimisation Tools			X		X					
	Six Sigma										
	DMAIC process	X	X	X	X	X					X
	PDCA Cycle	X		X	X	X		X	X	X	X
	TQM				X					X	X
STRATEGICAL	**Strategy Management**										
	Project Alignment	X	X								
	SWOT Analysis	X									
	Project Management	X	X					X	X	X	X
	Leadership Management	X						X	X	X	X
	Systems Thinking	X	X	X	X	X		X		X	X
CULTURAL	**Culture Management**										
	People Management			X			X		X	X	X
	Training and Education		X					X			
	Relationship Building	X	X				X	X	X	X	X
	Knowledge Sharing	X	X				X	X	X	X	X

Figure 3.17: Matrix of existing frameworks against the design proposed methodology

Strategy management tools that are utilised are kept to a minimum to reduce the proposed methodology complexity. The existing frameworks applied are associated with project alignment and planning techniques but also strategic planning and data analysis. The tools researched to assist system transitions specialise in cultural analysis one particular feature utilised, is people management including training and education tools.

What is apparent from this diagram is that no existing framework considers all three main strategies of operations, strategy and cultural, unlike the proposed methodology created within this research study.

This unified approach created in the proposed design methodology has ensured that a number of strategies that are not currently synchronised can be implemented successfully. The literature review also highlights that the failure rate of improvement initiative programs is quite high, due to the lack of planning of the cultural aspects and because technical issues are easier to implement. This methodology satisfies two main objectives (Berkhauer-Smith and Spedding, 2007);

1) An Integrated Business Improvement system that analyses many improvement concepts.
2) Implementing this theoretical design through analysing and evolving cultural aspects.

The main significant advantage gained from the methodology is the development of a specific development path to follow. This automatically reduces factors associated with cost, time, resources and increases success rates. Having this path of transformation alleviates cultural issues and resistance to change, it gives the project team assurance that the right changes are being made in the most efficient manner, therefore allowing a smoother acceptance of a change initiative program. This time can be better spent on training and culture programs to ensure greater implementation success. All of these factors will aid the reduction of the lead-time of a traditional change improvement program.

3.5 Proposed methodology Summary

Having identified the limitations of lean manufacturing within the literature review, it was also highlighted how other MBIM's could be integrated to elevate these restrictions. The literature review also identified the need for a structured design and implementation guide for business improvements.

This chapter has discussed how the overall design of the proposed methodology was created by outlining 10 stages through quality initiatives. The chapter has also explained in detail the content of each stage and how the MBIM's are used and the reasoning behind the structure. The scope has moved through all three main concepts of business improvements and has allowed concepts of each method to create movement through the proposed methodology. The main focus of the integrated techniques were around the limitations of lean manufacturing.

The specific beneficial and most influential factors of these theories have been defined in **figure 3.2** (page 78), along with impacting issues from one concept to another. This chapter has also described in detail the proposed methodology structure providing profound knowledge of this conceptual integration through the use of simultaneous guidelines within sections of a flow chart.

Existing frameworks that have been researched and studied within this research work have been represented in a table **figure 3.17** (page 120). The aspects of these frameworks have been discussed and compared to the proposed methodology created within this investigation. This justified the proposed methodology against currently practised methods and demonstrated that there does not existence a methodology that integrates main MBIMs through classifications of operations, strategy and cultural methods. The proposed methodology considers many theories and concepts, as well as allowing the user to tailor the proposed methodology to the suitability of the project.

3.6 Chapter Summary

This chapter presented a comprehensive proposed methodology for continual transition from design to the implementation of business improvement techniques for the aerospace industry. The proposed methodology is presented in 10 stages that consider and integrate a number of operational theories along with strategy concepts, including cultural investigation. The results of the literature review have been accomplished within the methodology proving the research justification and contribution to knowledge. Having created a unified concept the next phase is to test the proposed methodology by applying to case studies within the aerospace industry.

CHAPTER 4 : CASE STUDY 1

APPLICATION OF THE PROPOSED DESIGN METHODOLOGY TO IMPROVE SUPPLIER - BUYER COMMUNICATION

4.1 Chapter Introduction

The application of the proposed methodology is demonstrated within this chapter. This first case study aims to improve the communication between the supplier and buyer. This proposed methodology application is seen as a top level study. It is anticipated that this study will generate internal sub projects with each discussed company, with the foresight to reduce the product lead time throughout the supply chain.

4.2 Methodology Approach

The flow diagram highlighted in Chapter 3 (**figure 3.7 – 3.16,** pages 89 to 118) was used and applied to a top level improvement program. This project was initiated by the buyer to improve the relationship and communication with the supplier. By working with their suppliers and initiating lower level improvement programs, the two companies could work together to create a number of product supply chain improvements such as:

- Better quality products
- Shorter lead-times
- Improved transit times
- Better designed products
- Reduce inventory
- Lower costs

The aim of this case study is to work with the company to find appropriate ways to quantity these measures. All of these benefits would be passed onto the end customer; making both companies more competitive. It is thought that this first case study will be used to guide the lower level internal case studies within each company, thus ensuring continuity and communication between the companies. The methodology is applied through the use of the flow diagram (**figure 3.7 – 3.16,** pages 89 to 118); the sections are applied sequentially however the guidelines are applied as required. This chapter discusses how the proposed methodology has been applied, as well as a reasoned explanation to justify the tailoring of the design methodology to the project.

4.3 Company Overview

4.3.1 The supplier – Amphenol UK Operations,

Amphenol are a world-wide company and has a seventy year history and are global leaders in inter-connector technology. They have been present in the UK since 1957 and the UK plant at Whitstable produces connectors, as well as inter-connector systems. Amphenol UK have a manufacturing plant covering 14,000 m^2 and use a range of technologies and processes of connector and cable assembly manufacture. The company has £30 million in revenue and 366 employees (June 2006). Their complete product ranges are used within the military/aerospace sector as well as broadband, mobile and wireless communications. Amphenol UK are a typical manufacturing company that has tried many improvement programs with little success. The company has realised that improvements and changes need to take place and in 2003 the company implemented aspects of lean manufacture by understanding the flow and kanban initiatives.

4.3.2 The buyer – BAE Systems, Rochester

BAE systems are the world's third largest defence contractor, the largest in Europe and a commercial aerospace manufacturer. BAE Systems is the premier global defence and aerospace company delivering a full range of products and services for air, land and naval forces, as well as advanced electronics, information technology solutions and customer support services. Annual sales exceed £15bn and overall they employ 96,000 highly skilled people (June 2006). Like Amphenol, BAE Systems, have also implemented many improvement initiatives with limited success due to the lack of an enterprise view and lack of supply chain integration. The company has carried out many training programs with a high percentage of the employees being trained in varying six sigma levels. Many awards have been won due to the success of their improvement projects. The company now want to roll some of these ideas among their suppliers to gain further competitive advantage.

4.4 Methodology Application

4.4.1 Stage 1 – Project Alignment

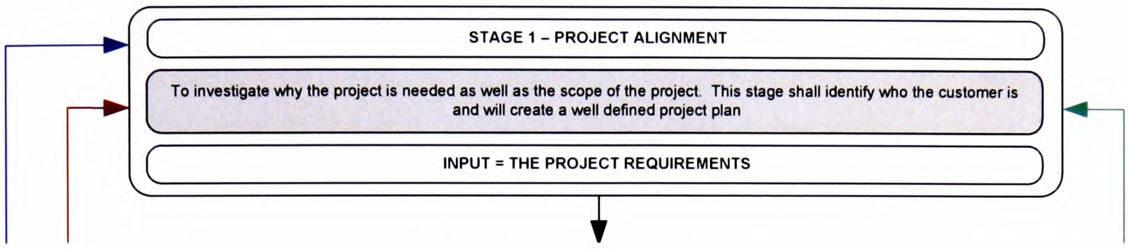


Figure 4.1: Stage 1 heading of the proposed methodology

The main project requirement is to understand and improve the communication between the buyer, BAE Systems and the supplier, Amphenol Operations UK. This is to enable the two companies to work together better within the supply chain to compete for future business. The buyer has identified future business and believes that the chosen supplier can assist and work with them; however improvements will be required internally.

The objectives to be achieved are to:

- Improve the communication and relationship between the supplier and buyer
- Reduce product lead time and cost by improving communication
- Increase the product quality and productivity
- Pass the advantages gained through these improvements onto the end customer

The aim is that by improving throughout the supply chain and by creating agreements between the two businesses, both companies can work better together and pass these benefits on to the end customer. This particular supplier was chosen as the main case study for a number of reasons: one due to previous history such as quality and On Time Delivery (OTD) issues that have arisen, as well as the physical site locations. The supplier site is 30 miles from the buyer location with all other suppliers being either located in other parts of the UK or abroad. It was thought that the ease of access to the site creates better communication and enhances the customer/supplier relationship.

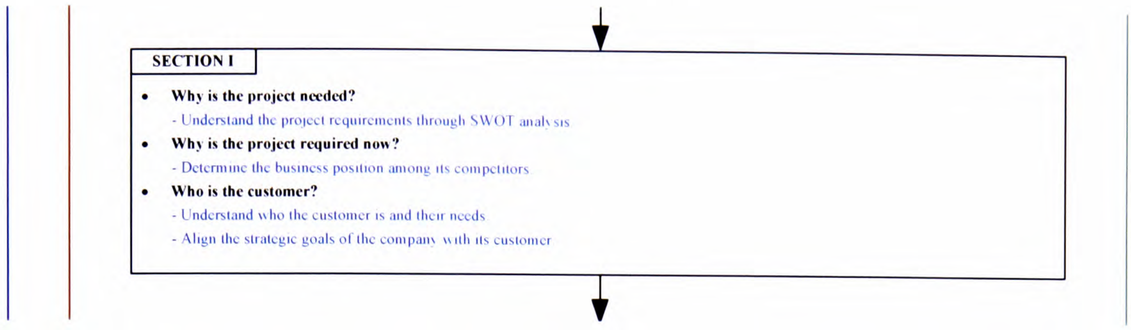


Figure 4.2: Stage 1, Section I of the proposed methodology

Taking the project requirements a SWOT analysis was used to initiate the project. **Figure 4.3** highlights the results of this analysis and it shows that there are many future opportunities that apply to both companies. Likewise, there are many current weaknesses that need to be improved upon such as, OTD quality issues, process flows and lack of communication. This analysis enables the creation of the project objectives.

The strategic goals of the companies have been discussed and the objectives highlighted. These will be addressed by creating further lower level and more detailed internal case studies. These case studies within each company will deal with the operational strategic goals and will carry out more detailed analysis. These will also address how the individual operational goals will align with the strategic goals and objectives.

The scope of the project is to understand the current supplier-buyer relationship and how to physically improve this supply chain across two companies. The options are to instigate improvements within the end of the supplier's internal supply chain and at the beginning of the buyers internal supply chain. The scope of the project is to create a top level guide between the two companies to ensure communication through the individual project improvements. This overarching project will ensure alignment between the two companies as well as alignment with the overall end customer.

Strengths	Weaknesses
• Leading edge manufacturers • High technology products • Specialist market	• OTD • Product quality • Material and process flow • Long lead times • Lack of communication • Difference in business sizes
Opportunities	**Threats**
• To expand the business • To generate new products • To improve the supplier – buyer relationship • To reduce cost, lead times, inventory etc • Increase communication • Increase knowledge	• Competitors • Losing the anticipated business • Trust between companies • The hold the buyer has on the supplier

Figure 4.3: SWOT analysis for case study 1

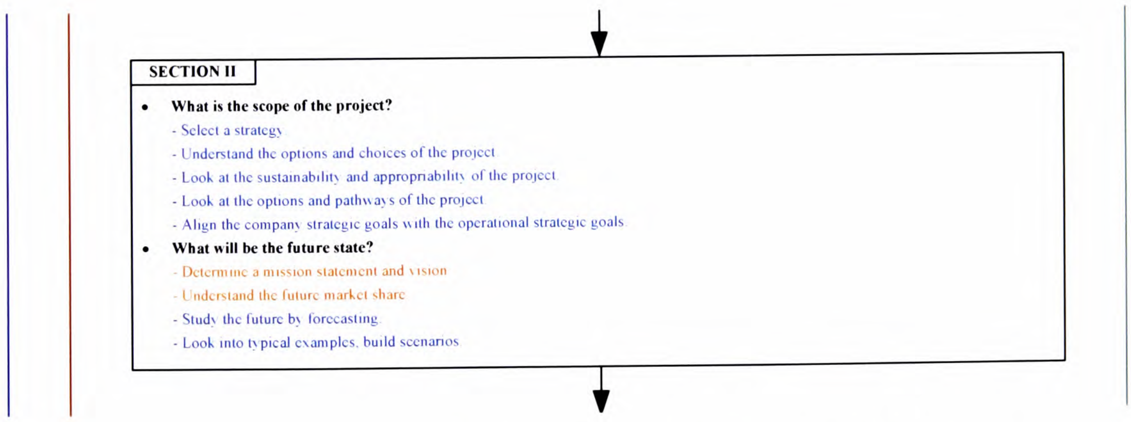


Figure 4.4: Stage 1, Section II of the proposed methodology

The mission statement and vision is to promote better communication between the supplier and buyer. This in turn will create better production lead-times as well as purchasing lead-times, thus reducing cost which will be passed onto the customer. This relationship will also increase product quality as well as product transition times. By improving their relationship through better communication, the businesses can compete to a better degree with rivals. Minimal information has been collected and analysed regarding the forecasted future, however for this project the actual details are irrelevant as forecasting examples and scenarios are not required in this top level case study.

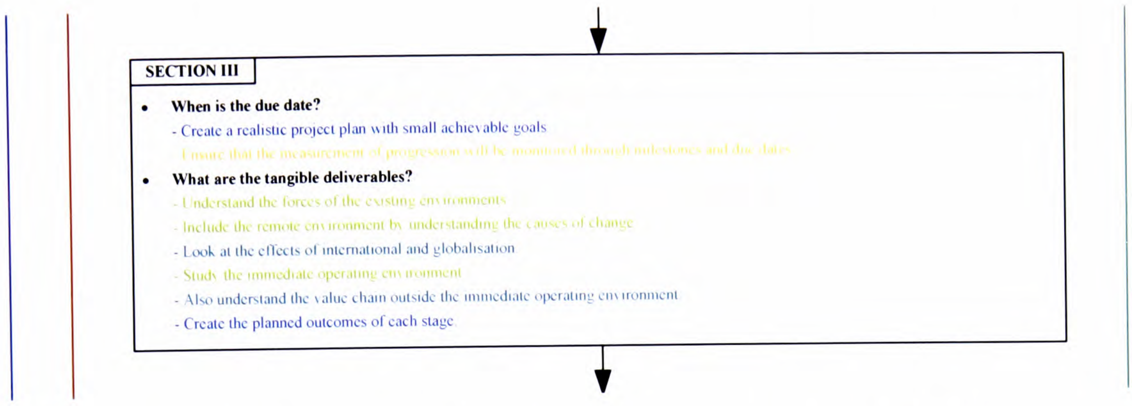


Figure 4.5: Stage 1, Section III of the proposed methodology

It is felt that only an estimated project plan can be created, because all of the case studies will instigate, overlap and begin at different stages.

A strategic project plan is shown in **figure 4.6.** This plan is however limited and demonstrates how the other case studies will unfold from this one and the interactions between them. The project plan shows the timescales allowed for all of the case studies. It was felt that the first methodology application would work through the first three stages independently. This project definition of case study 1 will instigate further applications. So project specification for this first application (created in Stage 3) will continue for a longer period of time than those subsequent applications. **Figure 4.6** highlights the proposed structure of the methodology application. This shows the more in depth applications of case studies 2 and 3. It also demonstrates how case study 1 instigates the creation of applications 2 and 3 but is also the bridging application between the two.

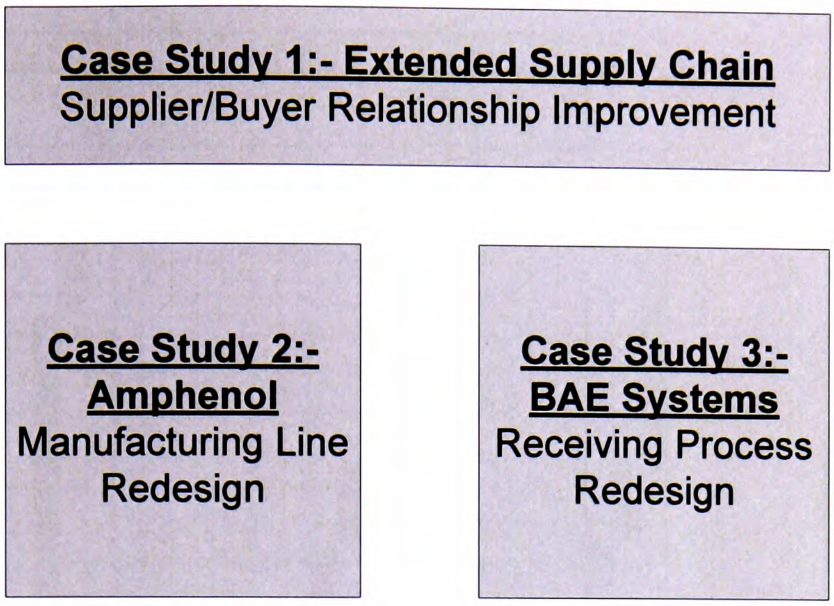


Figure 4.6: The assumed proposed methodology structure

It was estimated that both the internal case study projects (applications 2 and 3) would follow a similar timescale pattern. It was felt that the second case study would be instigated in the third stage of the first application, as the recording stage of the first methodology application would involve the designing of the second and third case studies. It would be too complex to start both the second and third studies at the same time, so the decision was made to start the third after the design of the second. From this time plan it can also be seen that all of the studies have Stage 7 overlapping as this is the planning of the implementation of the designed improvement. The planning of the implementation and the actual implementation itself are more time consuming stages. It was hard to define a timescale for these stages as they are project specific and dependent upon the project requirements. **Figure 4.7** highlights the case study set up.

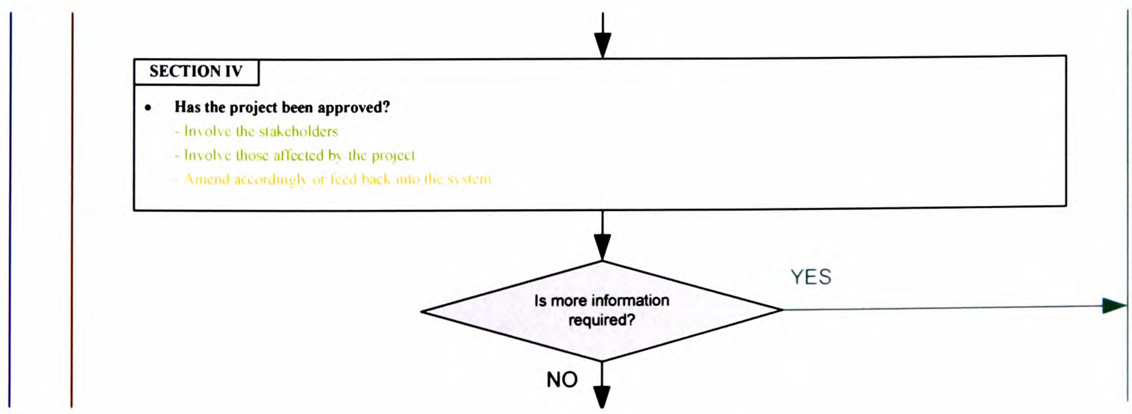


Figure 4.7: Stage 1, Section IV of the proposed methodology

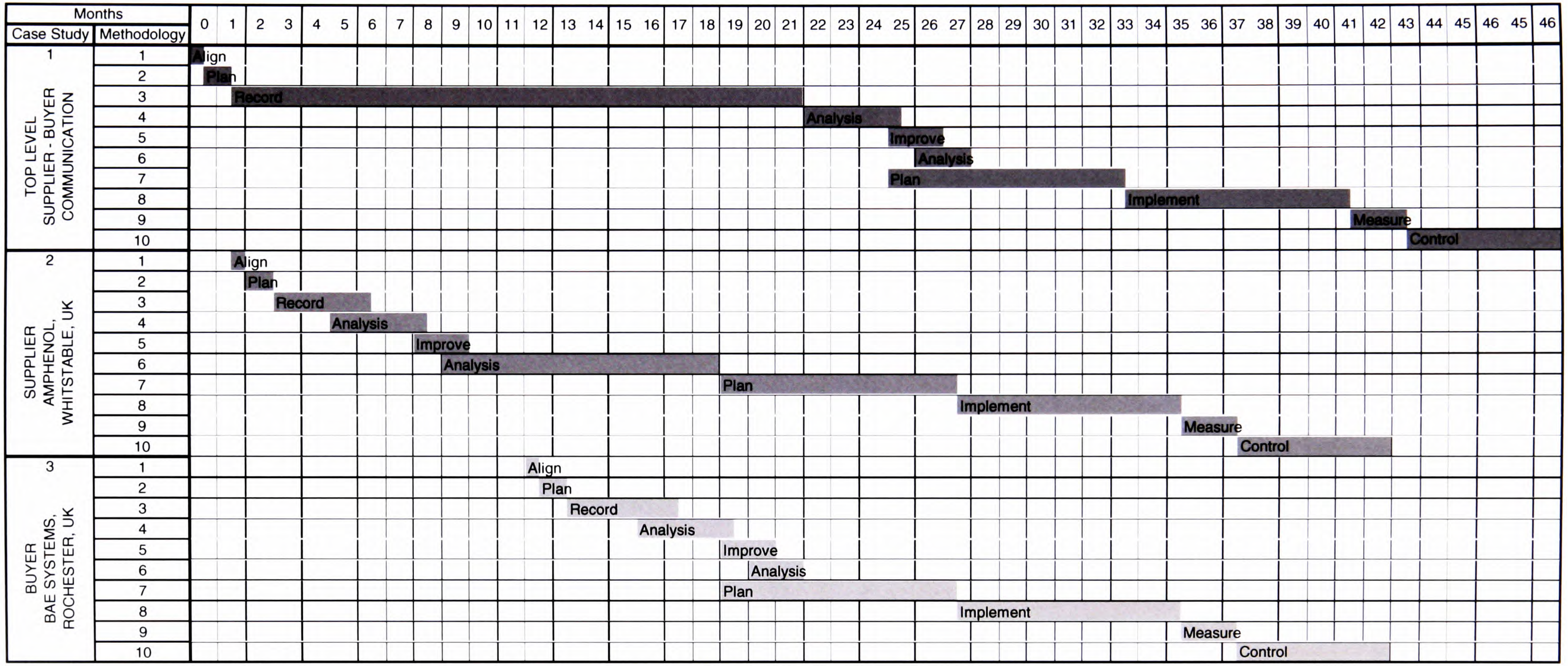


Figure 4.8: The top level project plan of the methodology application across all case studies.

This top level project is to guide and understand the creation of the further two case studies to ensure the continuity of communication. All stakeholders are management teams in both companies and are aware of the projects. As the project becomes better defined and the more people are involved, they will be informed through meetings, awareness sessions, training, surveys and questionnaires. As no further information is required the application continues to the next section.

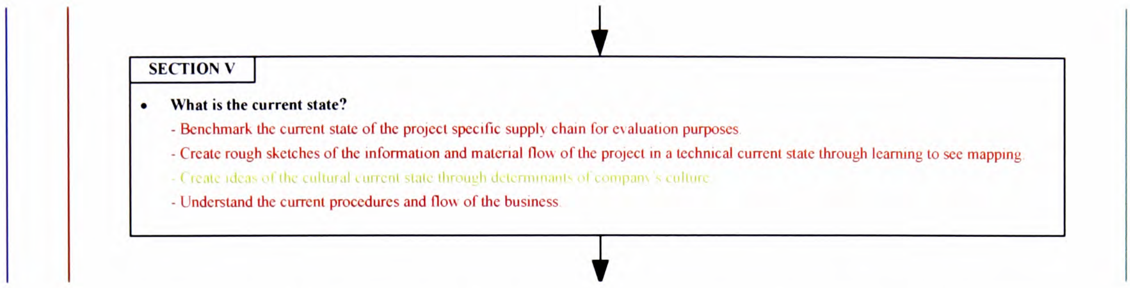


Figure 4.9: Stage 1, Section V of the proposed methodology

Due to the nature of this case study being created as a driver for more detailed analysis as well as a 'bridging' method to ensure standardisation across case studies 2 and 3, detailed information is not required. Detailed analysis through lean thinking methods have been eliminated as here the analysis is on the cultural aspects through communication and current relationships.

The current culture is based upon the idea that the buyer is instigating this project. It has been noticed that this puts considerable pressure on the supplier to comply with these requirements as the future business with the buyer and end customer is at risk. Cultural, operational and strategic changes are required internally within the supplier to the anticipated level expected by the buyer, which were seen as a threat within the SWOT analysis.

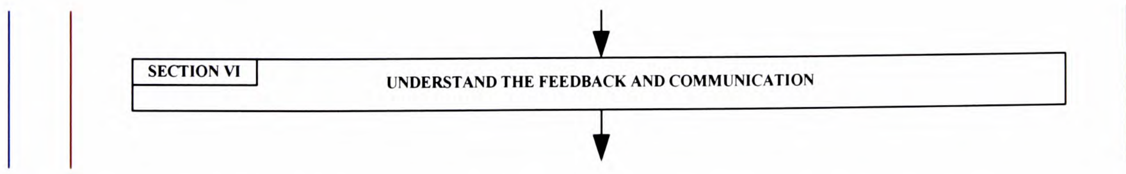


Figure 4.10: Stage 1, Section VI of the proposed methodology

Due to the early progression of the application a lot of guidelines are not necessary. Most of the cultural guidelines are based on the need of acceptance for change throughout the work force. This case study involves the management teams that are initiating the change projects and so issues related to acceptance of change are minimal at this point of the improvement project.

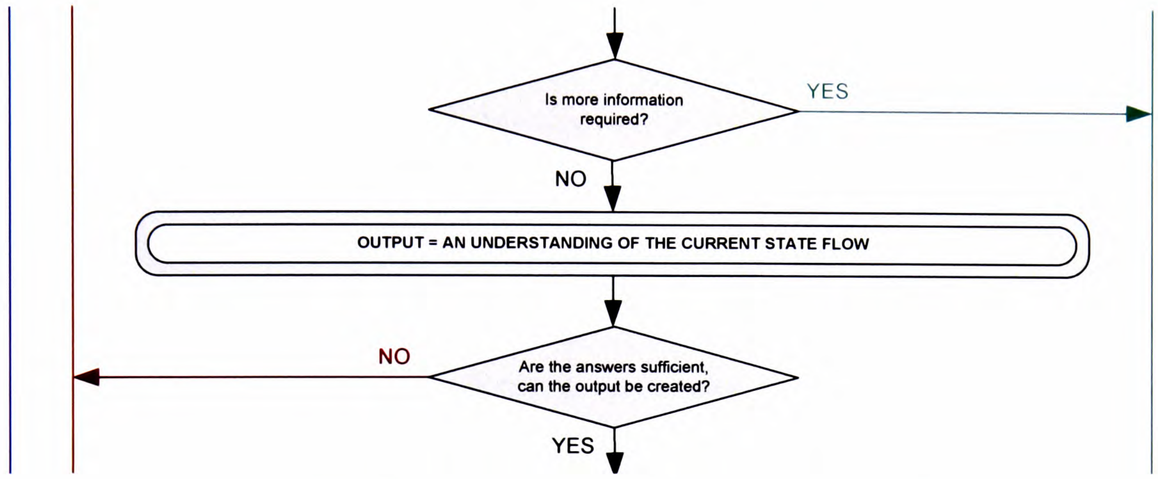


Figure 4.11: Stage 1 output of the proposed methodology.

The output can be created based on the current information and so further information is not required. The supply chain lead time can be estimated, however the true value added to non value added will be derived in case studies 2 and 3. In this first methodology application the internal non value added activity is not being established due to the holistic approach being driven.

4.4.2 Stage 2 - Planning the Measurements

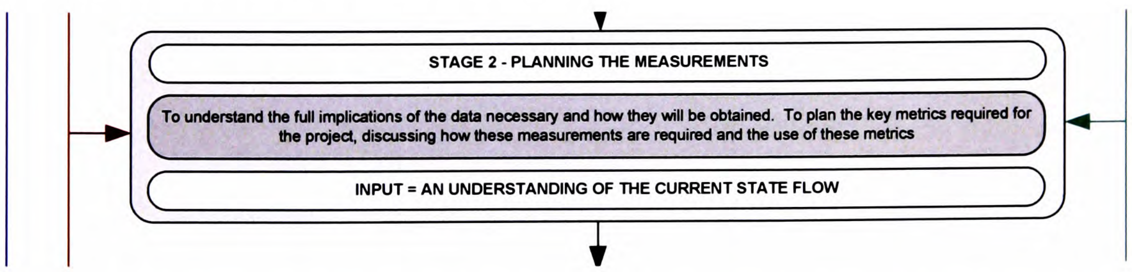


Figure 4.12: Stage 2 heading of the proposed methodology

The second stage was to understand what measurements were required as well as the type of measurements. From the previous stage the project requirements and scope are fully understood, including an understanding of the current state flow. The current state is of a supply chain of two world-wide companies requiring internal improvements, to increase operational continuity as well as better communication.

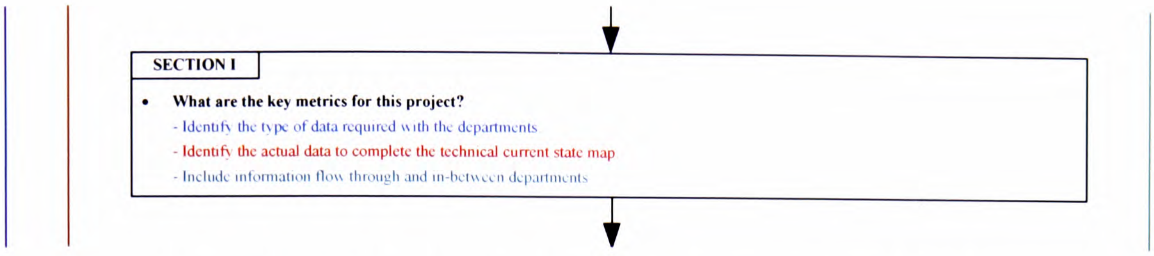


Figure 4.13: Stage 2, Section I of the proposed methodology

The key metrics for this project are top level and departmental understanding will be carried out in studies 2 and 3. The main key metrics to define here is the project requirements for studies 2 and 3. It has been decided that the case study in Amphenol will undertake and investigate the final stages internally. Case study 2 will research the final manufacturing production lines particularly focusing on a product manufactured for BAE Systems. In this study improvements can be made with the production lines and the dispatching departments.

The third case study will follow the products manufactured and supplied by Amphenol into BAE Systems. This study will investigate and carry out improvements within the receiving of these products. These studies will then create the detailed information required within this study to improve the relationship through better communication and logistics.

The guidelines covered in this Section II and III understand and define the requirements for detailed metrics. These are irrelevant for this study as the detailed information required here will be highlighted in studies 2 and 3. Operational micro mapped tools are not needed in this study; however the current culture can be classified through analysing the stakeholders involved. Within Stage 3 cultural classifications related to the relationship between the supplier and the buyer will be determined. The associated risks and costs will be assessed independently within each company. It is possible that the associated risks within each company will have an effect on the other; however this will have to be assessed after the in depth independent applications of case studies 2 and 3.

SECTION II

- **What initial detailed metrics are required according to business improvement methodologies?**
  - Identify the product demand variability
  - Investigate the market need for the product
  - Benchmark the current culture
  - Take a snapshot of the processes
  - Create surveys & opinions
  - Study the quality of the process
  - Collect cycle / process times (activity times)
  - Collect data on change over times and set up times
  - Understand machine availability
  - Look at the yields not just the first time yield
  - Look at the percentage of rework in all departments
  - Look at batch quantities
  - Look at the inventory levels
  - Understand the information flow - the orders
  - Study delay periods - the flow of work between departments
  - Look at the system schedule
  - Understand the product variety
  - See the shipments to and from the system
  - Understand the use of computers in the system & the paper flow
  - Understand the relationship of the support staff to production
  - Look at the movement of operators, processes & product

SECTION III

- **What further metrics are required according to business improvement methodologies on reflection of that planned above?**
  - Identify the point of differentiation
  - Look at placing the decoupling point nearest to the customer as possible
  - Investigate in suitable methodologies into standardising products
  - Study the standardisation of the product
  - Study the quality of the support - paper and computer systems
  - Research into the departmental flow
  - Understand the quality of the flow
  - Look at the materials supplied
  - Carry out statistical process control measurements where necessary
  - Know the supplier base
  - Look at lead-time requirements
  - Make measurements through the SCOR methodology (drill down)
  - Look at the distribution of products
  - Investigate through the people involved - the stakeholders
  - Document the current state culture through classification
  - Look at the associated costs- the costs of change
  - Create risk analysis reports for change
  - Document any changes to the plan
  - Adapt the main project plan by drilling down and expanding

Figure 4.14: Stage 2, Sections II and III of the proposed methodology

The project plan that was created in **figure 4.6** (page 129) highlighted how the key metrics will be collected through the timescale defined within the other studies. It was decided that is was at this point in the methodology that the detailed information generated from the other case studies would be required to continue this top level application.

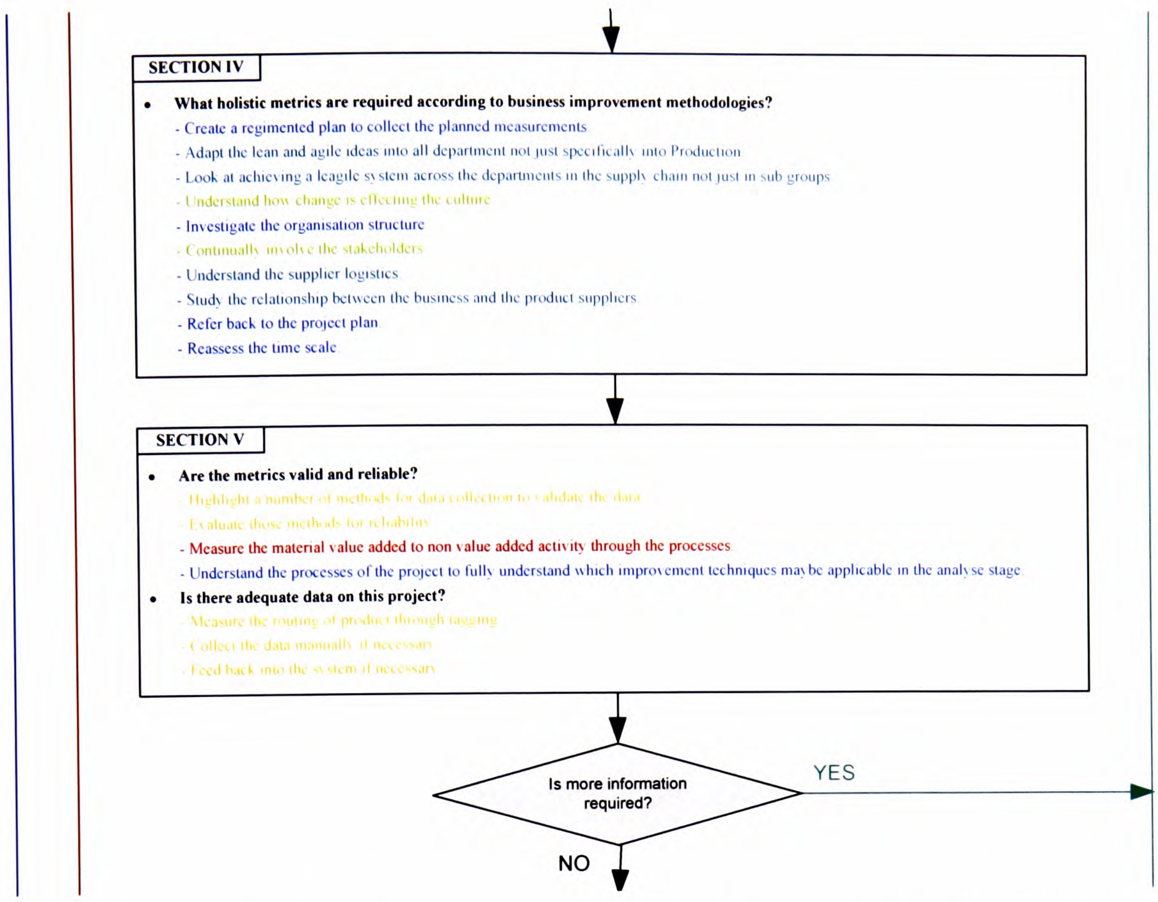


Figure 4.15: Stage 2, Sections IV and V of the proposed methodology

4.5 Methodology Application Discussion

The outcome from this initial application was that in order to proceed, the detailed information that would be created from the two internal case studies was required. This study was required to improve the communication and relationships between a supplier (case study 2) and buyer (case study 3) as well as act as a 'bridging' application (**figure 4.7**, page 130) to ensure continuity and communication. The communication and relationship cannot be improved without either businesses assessing their own company individually and addressing any issues that the other may have. This therefore requires an analysis of the internal supply chains.

Once the application of the proposed methodology is complete for case studies 2 and 3 and the future states are designed. The baseline improvements can be fed back into this first application. It is impossible to improve the objectives set without obtaining more detailed information on the internal analysis, in this instance it is operational information. The cultural nature of this project is not only to monitor and guide the change but to ensure continuity and communication through these operational changes.

4.6 Methodology Justification through Application

The proposed methodology has been justified through the completion of the guidelines within the sections of the stages created in the methodology. This example has been used to highlight the application of a strategic and cultural based improvement project. Factors due to environmental changes and the relevance of communication and continuity should be monitored to achieve sustainability within lower level projects, as well as creating strategic direction for internal improvement analysis. This application example has allowed methodology justification by highlighting differing objectives and achievements that can be obtained through this versatile integrated methodology.

4.7 Chapter Summary

This chapter has discussed the initial use of the methodology within a top level improvement project. This case study example was created to ensure that the internal operational studies were continually monitored and that the initial objectives were met. In order for this methodology application to be completed, studies 2 and 3 need to be started and the methodology applied. This will provide the detail for this cultural change. Within the next two chapters these studies will be discussed and the methodology application will be demonstrated allowing the completion of case study 1.

CHAPTER 5 : CASE STUDY 2

APPLICATION OF THE PROPOSED DESIGN METHODOLOGY TO IMPROVE THE SUPPLIER'S MANUFACTURING PROCESS

5.1 Chapter Introduction

This chapter uses the design methodology and applies the theory to a supplier of BAE Systems. This case study uses the proposed methodology and tailors the design to a production line to improve the internal processes with the ultimate aim of improving the efficiency of manufacturing processes to make the company more competitive.

5.2 Methodology Approach

As with the previous methodology application, the flow chart of the design methodology (**figure 3.7 – 3.16,** pages 89 to 118) is applied to Amphenol UK. This proposed methodology application investigates a production process at the end of the supplier's internal supply chain. It was felt that this methodology application would enable a third methodology application to follow the product through into the initial processes of the buyer's internal supply chain.

The goals and objectives were to meet the overall requirements outlined in the first methodology application (Chapter 4), which were;

- Better quality products
- Shorter lead-times
- Improved transit times
- Better designed products
- Reduce inventory
- Lower costs

The aim of this study was to carry out a more detailed improvement project and so there were other specific objectives within this application. They were to investigate the production line, understand how the company planned to relocate this line to encourage process flow and to apply the methodology to improve the processes within this line. This was so that the production line would function more effectively by reducing the lead time and become more responsive to the customer demand.

5.3 Company Overview

The company used in this second application is referred to as the supplier, Amphenol UK Operations. The company background was given in Chapter 4.

5.4 Methodology Application

5.4.1 Stage 1 – Project Alignment

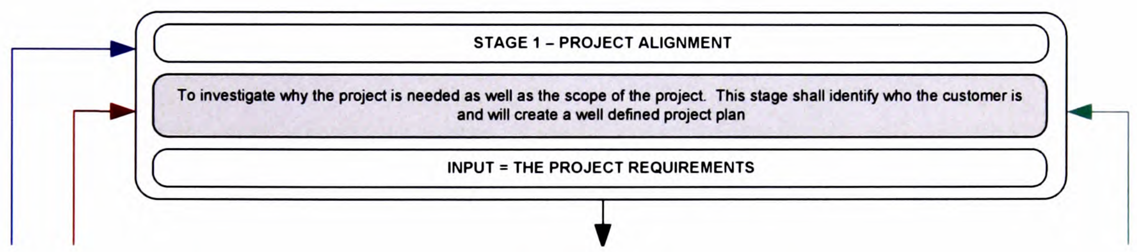


Figure 5.1: Stage 1 heading of the proposed methodology

Within this initial stage a basic knowledge of the company background was gathered and information of other business improvement programs that had previously been tried and tested was understood. The project requirements were to improve the manufacturing process within the supplier, in line with the buyer's requirements.

Previously to this project a presentation was made by the Managing Director (carried out in the first quarter of 2006) to the workforce to encourage business improvements, continuous improvements and change (**appendix 5.1 – 5.10** (on CD)). The presentation spoke about the current positioning of the company globally as well as the product range that is manufactured. The presentation also highlighted the problems related to change,

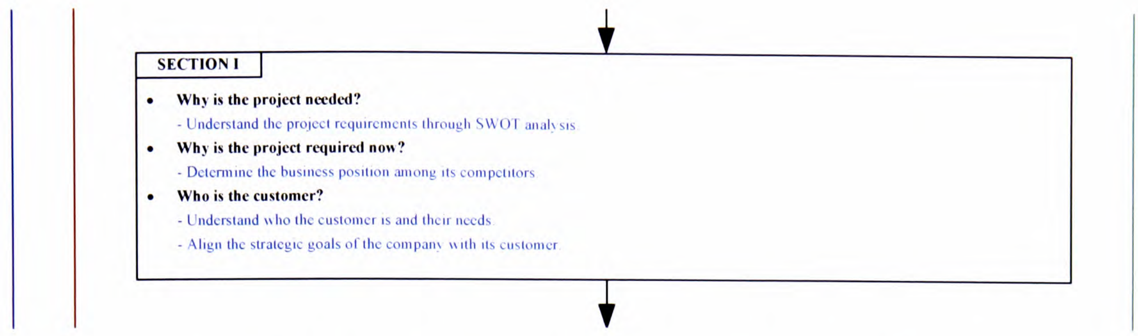


Figure 5.2: Stage 1, Section I of the proposed methodology.

...."We have in the last 10 years tried almost every continuous improvements initiative going without any of them sticking. We had a dept dedicated to the subject." (**appendix 5.6** (on CD))

The presentation also highlighted how concepts of lean thinking and process orientated flow have been applied and that "the results were stunning" (**appendix 5.6** (on CD)). It was chosen by the company to roll out these ideas across the site.

These slides highlighted the need for business improvement initiatives within the company to gain competitive advantage amongst the company's competitors. It demonstrated how over previous years, a number of techniques and strategies have been applied without any sustaining. Recently, the company have initiated improvement programs centred around the concepts of lean thinking; however this now needs to be readdressed to understand how to achieve sustainability (**appendix 5.9** (on CD)).

The presentation also mentioned issues related to the acceptance of change and improvement programs, it also discussed the issues related to employee resistance to change. These are again typical issues which are also assessed within the design methodology.

Further work from this had not been sustained and so it was felt that this was a typical manufacturing company and the methodology needed to be applied to this example. The company had initiated aspects of lean thinking and implemented line side stock; however, the concept was not discussed any further. This level of commitment of MBIM implementation is a typical example of lean implementation of a current practising manufacturing company. It was realised that the application of this methodology would enable such a company to assess their current situation and to instigate the process of continuous improvement. This methodology allows the company to create a pathway of improvement from a given roadmap, which will encourage the changes and allow continuous improvement initiatives, sustaining in a user friendly and simple flow chart format.

The information in (**appendix 5.1 – 5.10** (on CD)) was used to create the SWOT analysis table (**figure 5.3**) to gain project definition and to understand which areas to target within the company. This SWOT analysis table was also created to confirm some thoughts on initial visits to the company. The weaknesses outlined in the main project objectives were set; this highlighted the first areas for improvement. These weaknesses would be improved through the methodology application. The strengths were created from the presentation given by the managing director. The opportunities for the company were to expand the business and this was established from meetings between the two companies initiating the change of this improvement program.

Strengths	**Weaknesses**
• Leading edge manufacturer for connectors and inter-connector systems • High technology process lines	• OTD • Product quality • Material and process flow
Opportunities	**Threats**
• To expand business with BAE Systems • To generate new products	• Competitors • Losing the anticipated business • The influence the buyer has on the improvements made

Figure 5.3: The SWOT analysis of Amphenol, UK

From the initial visits to the site and previous meetings prior to this project held, it was noted that the manufacturing assembly consists of three production groups that are independent. The company originally thought to integrate the management of these groups, however it was thought that it was physically unfeasible to merge the three production lines together due their differing nature in volume, process flow and requirement machinery. The aim of this project was to study one particular production line that produces some products for BAE Systems. The aim was to reduce product lead time and increase product quality as well as achieve better OTD.

It was seen that both companies were strategically aligning their goals to achieve similar outcomes. Both companies are assisting each other through communication to improve the assembly manufacture within Amphenol and to build a better supplier-buyer relationship. This is seen as an opportunity to improve the quality of the products as well as to improve the OTD, enabling the supplier to be more receptive to the customer's requirements.

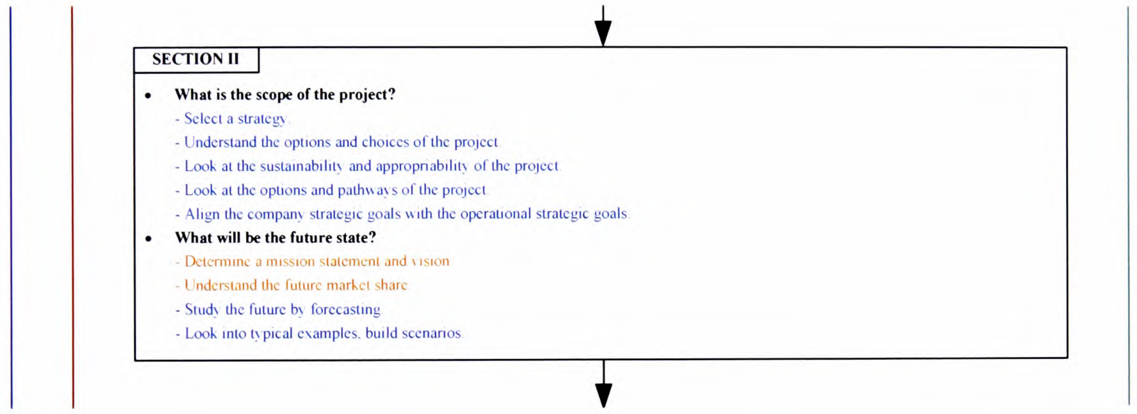


Figure 5.4: Stage 1, Section II of the proposed methodology

It was thought that this specific project will assist with this relocation plan the company had already defined through introducing process improvements within the chosen production line. The project scope was to understand the production line and include this within the relocation project timescale including the project feasibility.

The sustainability of the project was a major concern; this was because of the limited timescale of this research project. However, as the structure of the methodology became more defined, it improved the project sustainability. Concurrent to the application of this methodology a re-layout of the production floor was being carried out. The employees were acceptable of change as all were aware of the layout relocation project; this made the acceptance of this process improvement project easier. The suitability of this project was dependent upon the suitability of the techniques; the approach of how to design and apply them was demonstrated through the integrated methodology. The selected production line was the ‘62 series’ of connectors which is high volume and low variety production mix and so there were a number of business improvement opportunities due to the nature of the line. This particular line was chosen as this is the first to move within the relocation project and consisted of BAE products.

The aim of the company is to improve OTD, quality and achieve better process flow, which can be created by relocating the factory equipment. Justification of this layout will be through process improvements guided by the integrated methodology. It is thought that the expansion of the customer into other related fields will introduce further demand into the supplying company. This is an opportunity for them to expand their business; by improving the current system this will ensure that the production lines can withhold the extra capacity.

The operational goals of the company were aligned with the strategic goals, by investigating the production line and improving the current system in line to the customer demands to be more reactive to planned and forecasted business. The scope of this methodology application does not include initiating improvements within the company forecasting, due to the timeframe set.

The process improvement plan of this project (**figure 4.2,** page 126) fits into the scope of the relocation project plan defined by the company and it has been ensured that the measurement of progression is monitored through milestones and due dates. The effects of globalisation are not necessary, the company are a worldwide manufacturer but the main area of focus for this project is the UK plant.

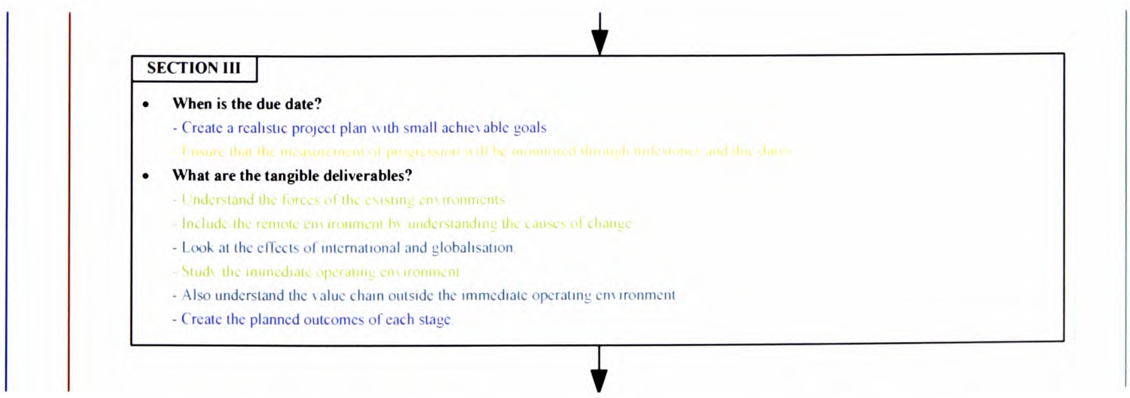


Figure 5.5: Stage 1, Section III of the proposed methodology

The value chain outside the immediate operating environment was assessed by analysing; (**appendix 5.11 – 5.23** (on CD)). **Appendix 5.11 – 5.23** (on CD) contains information about improvement work that has already been carried out by the company. VSM has been undertaken at the company and this was used to assess the immediate operating environment. This figure shows how improvements have been made within areas such as logistics; production and quality and current states have been benchmarked to enable true figures.

These slides gave the specifics of actual improvement projects; they identified problem areas and ways in which to improve these issues. Many advantages were gained from this exercise; mainly understanding that focusing on specific issues gave results rather than physically intervening and investing money.

This project aimed to roll out the exercise across many departments including external customers. These figures gave background knowledge on what continuous improvement projects had been previously tried and tested, as well as to understand how to further this work through this methodology application.

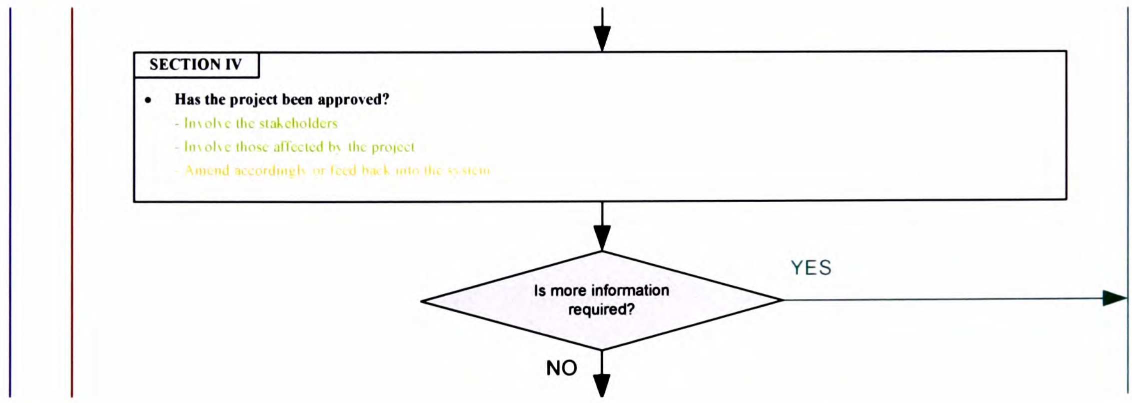


Figure 5.6: Stage 1, Section IV of the proposed methodology

The major stakeholders in this project are the management and all stakeholders were aware of the project; however those that were more directly affected by the changes were informed more on actual details through meetings. Those directly affected approved the project through carrying out questionnaires and surveys. All project ideas and determinates were agreed by Amphenol and it was thought that more information was not required at this stage of the application as the project was still being outlined and so feeding back into the methodology is not necessary.

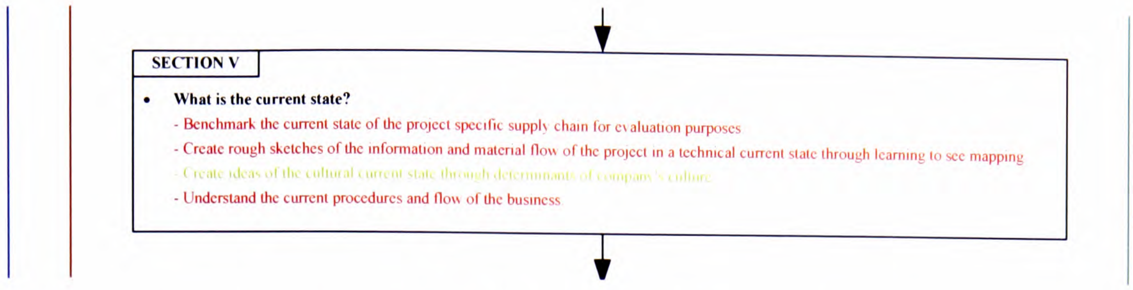


Figure 5.7: Stage 1, Section V of the proposed methodology

The supply chain of the assembly manufacture has been discussed with the company, due to the timescale and the previous research the decision was made by the company to only carry out the relocation plan of the assembly manufacture at this stage. This application was seen as the next level of mapping as it was a process improvement study within the production line. Rough sketches of the information and material flow of the current state (**figure 5.8**) were generated from the data given from previous mapping activities the company had carried out. Due to the small amount of data and information collected at this point in the application, the current state was benchmarked on the mapping that the company had carried out.

Figure 5.8 displays the current state map of the production line as seen by the company. Numeric data were not collected due to the small amount of data already obtained; however it enables an understanding of the production flow and created an initial baseline for improvement.

It was noticed that there are many processes that are in parallel and that further investigation was required to understand the process flow. The cultural current state was determined by defining the culture into four aspects, relationships to other people, attitude to the environment and to time, power and control and finally to innovation and learning. The cultural current state is defined below in **figure 5.9**, it was decided by the author to use the findings of Trompennaars and Hampden-Turner's to assist with the definition of the cultural current state.

The company was assessed with a holistic view across the company to highlight the employee relationships across the site. This current state culture was based on the author's view from brief initial visits.

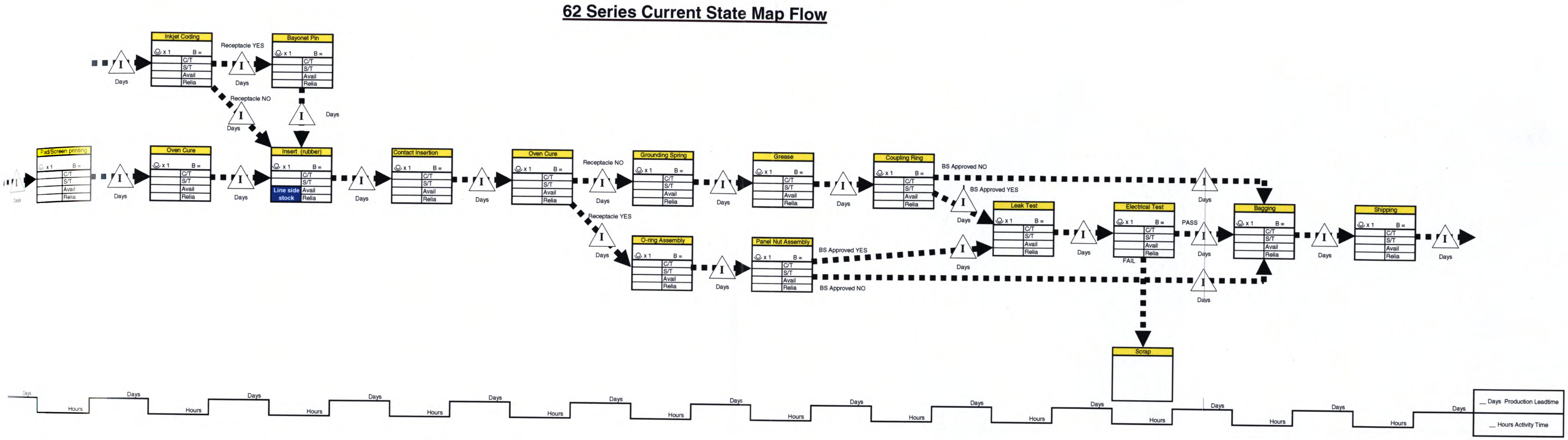


Figure 5.8: The current state flow of the '62 Series'

Relationships to other people	There appears to be a good relationship between the management and the production line workers. The line seems to be very dependent upon the production line manager and so a lot of the decision making is made by the operators. The production line workers physically work independently; on operations throughout the production line. However they work as a team to produce the end product, by being multi skilled the team work together to meet deadlines.
Attitude to the environment and to time	The environment is sufficiently controlled but can also be adapted to new systems as the company appear to focus on the future plans. The company's instructions initiate from the top of the hierarchy and work down. The planned Material Requirements Planning (MRP) system is adapted to meet the customer's requirements; the company appear to be particularly busy at the end of each month trying to make the shipping requests, which highlights the need to be more responsive to change.
Power and control	The company has many levels of hierarchy and recently these have been reduced within the manufacturing departments. Improvements are agreed by management and a budget set to improve the layout of the production department.
Innovation and learning	It is believed that learning programs for individuals are existent; however it is thought that this facility is not used. A company social club is also present and again this is not used. The attitude to risk is dissimilar on different levels of the hierarchy scale; production workers generally oppose a change in the system as this could mean changing their lifestyle. However these people are very proactive regarding the data collection program. It is thought that management are agreeing to the change.

Figure 5.9: The cultural current state at Amphenol

Figures 5.8 and **5.9** created the benchmark for the current state of the site allowing a baseline to measure improvements upon.

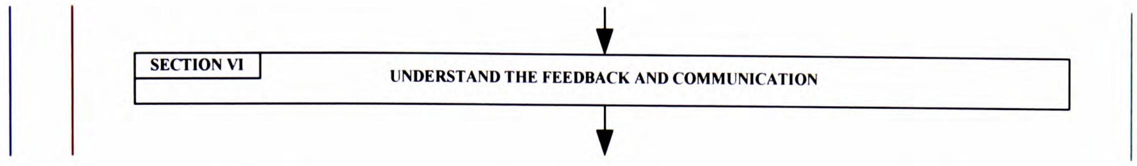


Figure 5.10: Stage 1, Section VI of the proposed methodology

At this initial stage of the methodology the feedback and communication key was not used in full detail. All of the necessary guidelines were met within the stage and the progression was discussed with the stakeholders and so no changes were made to the project definition. It was thought that due to the early progression of the project, unfreezing the current culture was a little premature within the application, all stakeholders were notified of the ideas and cultural issues had not arisen due to the insufficient involvement with the production line to date.

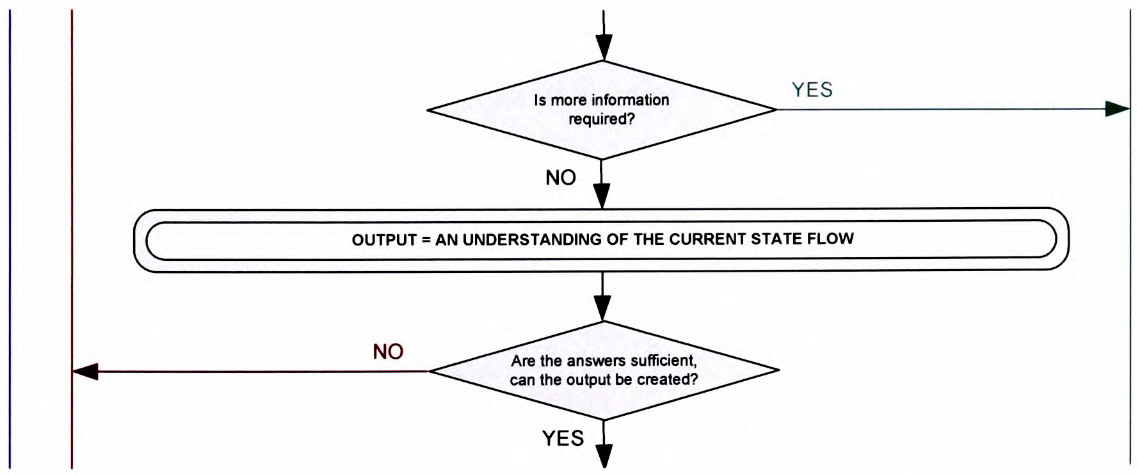


Figure 5.11: Stage 1 output of the proposed methodology

The output created from this stage can be seen in **figures 5.8** and **figure 5.9** and so further information was not required as the answers were sufficient. Therefore it was acceptable to move onto the application of Stage 2.

5.4.2 Stage 2 - Planning the Measurements

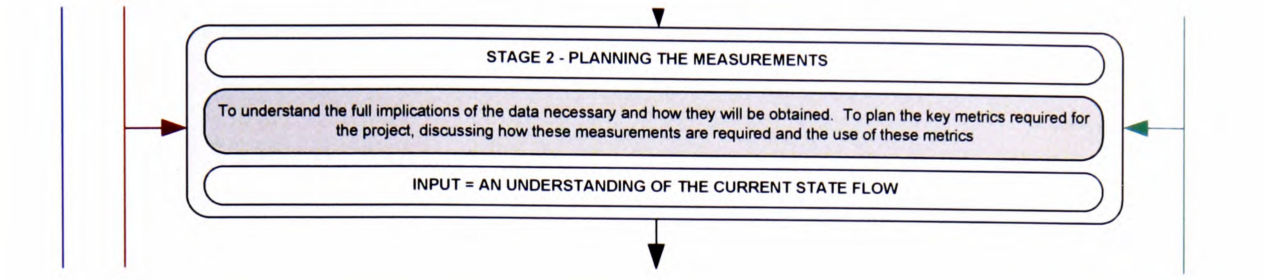


Figure 5.12: Stage 2 heading of the proposed methodology

With the current state flow defined in Stage 1 the definition of the measurements that are to be created are defined in Stage 2. The operational (**figure 5.8**) and cultural (**figure 5.9**) current state information will be used as the input for Stage 2.

The improvements within the company at the time of this project were referred to as the 'relocation layout'. The initial production line being relocated was the '62 series' of the product variety, this line shared some equipment with another line but the process flows were dissimilar and so it was thought the two lines would not be amalgamated. The current state flow produced in Stage 1 is that of the '62 series' production line. It was thought that in order to complete the technical current state, detailed information was required to gain knowledge of lead times, inventory quantities, and activity times to give a true interpretation of the actual current state.

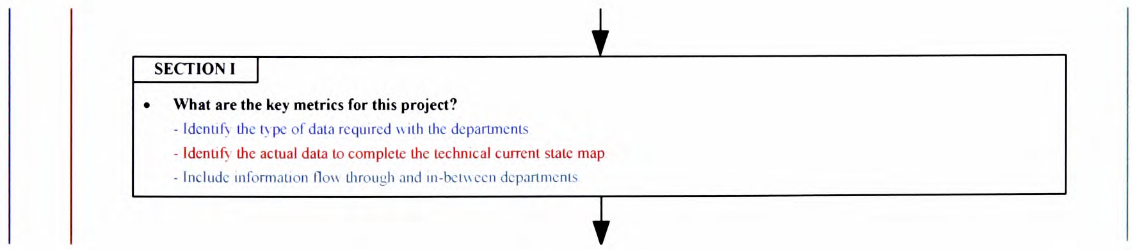


Figure 5. 13: Stage 2, Section I of the proposed methodology.

Due to the project scale the decision was made that the key metrics required were to be production process level specific and metrics involving departmental level or plant level were not required. The following three sections were used as a checklist to define the particular areas that were applicable to the project.

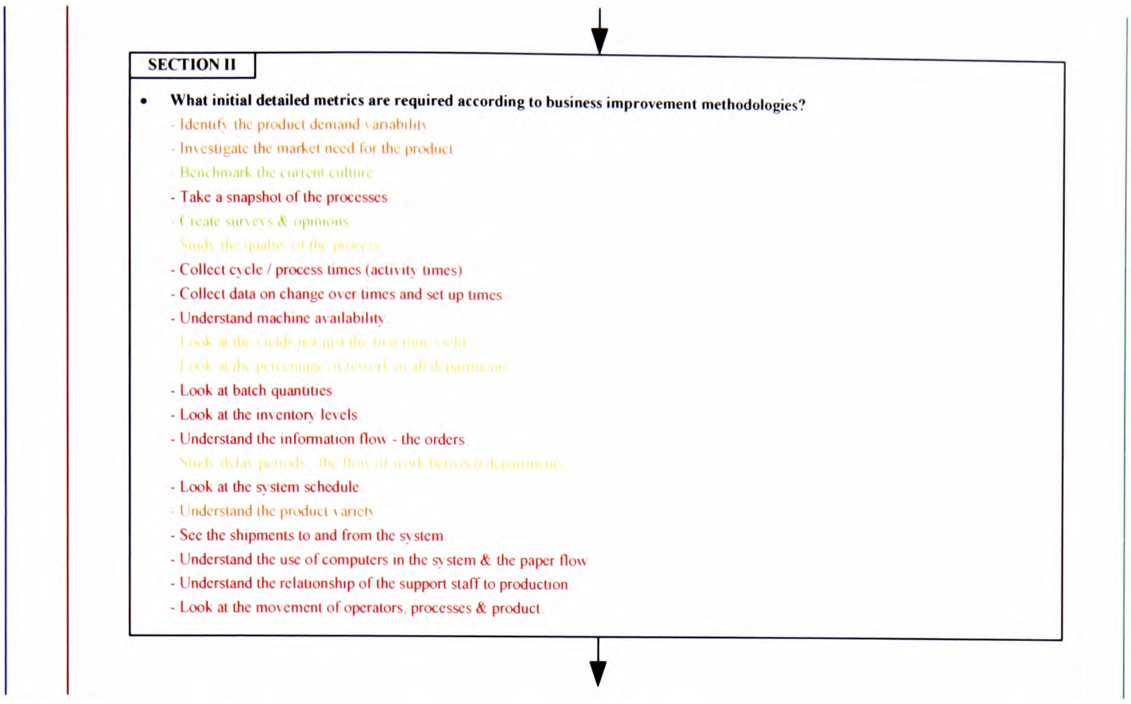


Figure 5. 14: Stage 2, Section II of the proposed methodology

This first section was to define the extent of the application of the operational analysis methods for this study; **figure 5.15** displays the table created to decide the suitability of the techniques for the project. Justifications for these ideas were made at the point of application. From the table it was concluded that the use of detailed metrics were required in order to meet the project specification. Areas that were not required were holistic techniques that were to determine metrics outside of the production line.

- Identify the product demand variability.	✓
- Investigate the market need for the product	X
- Benchmark the current culture.	✓
- Take a snapshot of the processes.	✓
- Create surveys and opinions.	✓
- Study the quality of the process.	✓
- Collect cycle / process times (activity times)	✓
- Collect data on change over times and set up times.	✓
- Understand machine availability.	✓
- Look at the yields not just the first time yield.	✓
- Look at the percentage of rework in all departments.	✓
- Look at batch quantities.	✓

- Look at the inventory levels.	✓
- Understand the information flow - the orders.	✓
- Study delay periods - the flow of work between departments.	X
- Look at the system schedule.	✓
- Understand the product variety.	✓
- See the shipments to and from the system.	✓
- Understand the use of computers in the system and the paper flow.	✓
- Understand the relationship of the support staff to production.	✓
- Look at the movement of operators, processes and product.	✓

Figure 5. 15: The checklist of the applicability of the initial detailed metric requirements

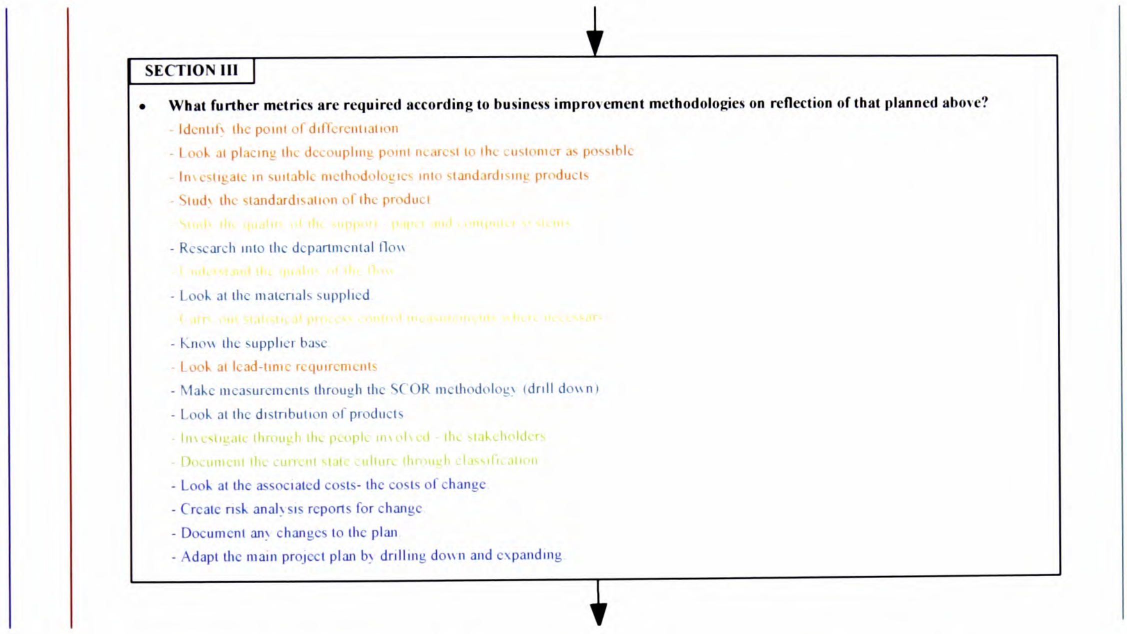


Figure 5. 16: Stage 2, Section III of the proposed methodology

This section aimed to clarify any further measurements that are required upon reflection of the previous section, **figure 5.17** displays the table created from and shows the measurements that were applicable to this project.

It was planned that all detailed measurements were required, however due to the project scale, understanding departmental flow was not necessary along with theories designed to understand the distribution of the products. The risk and cost associated with this project were minimal as the planned changes were to be made with the existing system, but with a better process, product and operator flow.

This final section was created to understand the holistic metrics required for the project. It was expected that many aspects would not be applicable as the main objective of this particular project was to improve within a production line, investigating the process flow for improvement within the lead time, inventory quantities and quality.

- Identify the point of differentiation.	✓
- Look at placing the decoupling point nearest to the customer as possible.	✓
- Investigate in suitable methodologies into standardising products.	✓
- Study the standardisation of the product.	✓
- Study the quality of the support - paper and computer systems.	✓
- Research into the departmental flow.	X
- Understand the quality of the flow.	✓
- Look at the materials supplied.	✓
- Carry out statistical process control measurements where necessary.	✓
- Know the supplier base.	✓
- Look at lead-time requirements.	✓
- Make measurements through the SCOR methodology (drill down)	✓
- Look at the distribution of products.	X
- Investigate through the people involved - the Stakeholders.	✓
- Document the current state culture through classification.	✓
- Look at the associated costs- the costs of change.	X
- Create risk analysis reports for change.	X
- Document any changes to the plan.	✓
- Adapt the main project plan by drilling down and expanding.	✓

Figure 5. 17: The checklist of the applicability of the further detailed metric requirements

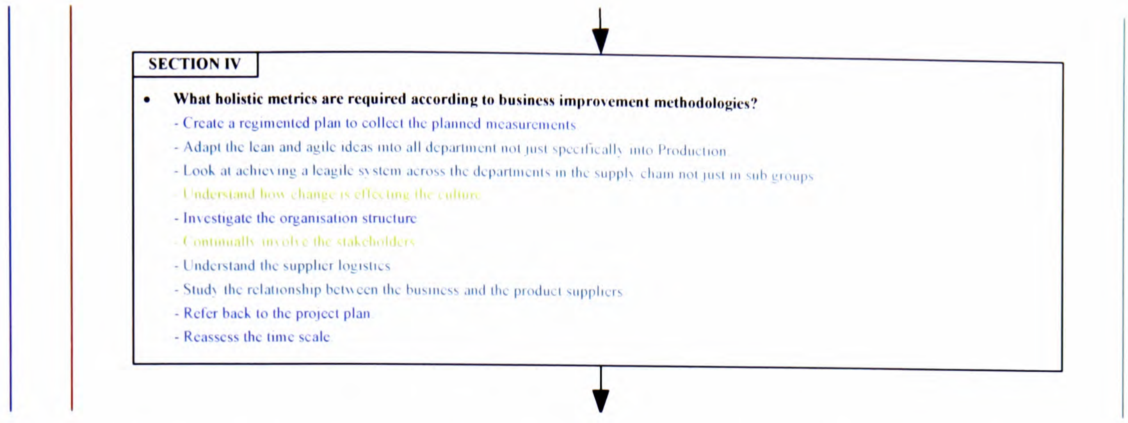


Figure 5. 18: Stage 2, Section IV of the proposed methodology

Figure 5.19 displays the decisions made on the applicability of the holistic metrics that would be suitable for this project.

- Create a regimented plan to collect the planned measurements.	X
- Adapt the lean and agile ideas into all departments not just specifically into production.	X
- Look at achieving a leagile system across the departments in the supply chain not just in sub groups.	X
- Understand how change is affecting the culture.	✓
- Investigate the organisation structure	X
- Continually involve the stakeholders.	✓
- Understand the supplier logistics.	✓
- Study the relationship between the business and the product suppliers.	✓
- Refer back to the project plan.	✓
- Reassess the time scale.	✓

Figure 5. 19: The checklist of the applicability of the holistic metric requirements

All aspects concerning departmental data collection were not applicable as the project specification was to improve the finalising areas within the supplier, not across the company. It was felt that a detailed data collection plan would not be necessary as the project scope was minimal and a large comprehensive data collection plan would impede upon the progression of the project. As the project was investigating a production, the need for investigating the organisation structure was also too great a task for a project of this scale.

Other aspects such as ‘understanding supplier logistics’ and ‘studying the relationship between the business and the product suppliers’ were not within the scope of the project assuming that the ‘supplier’ was the process upstream from the production line being investigated. In the case of this project, the process upstream would be the main stores area supplying the material to the line. Initiative within the main stores area could be carried out but not within this project scope.

For this project, the data were initially collected through questionnaires; **appendix 5.26** (on CD) gives a general overall questionnaire given to the management as well as the results to gain background knowledge to initiate the application. However the main questionnaire carried out by the production line team is exhibited in **appendix 5.27** (on CD). It was only possible to measure the value added to non value added activity through the processes once all of the data were collected.

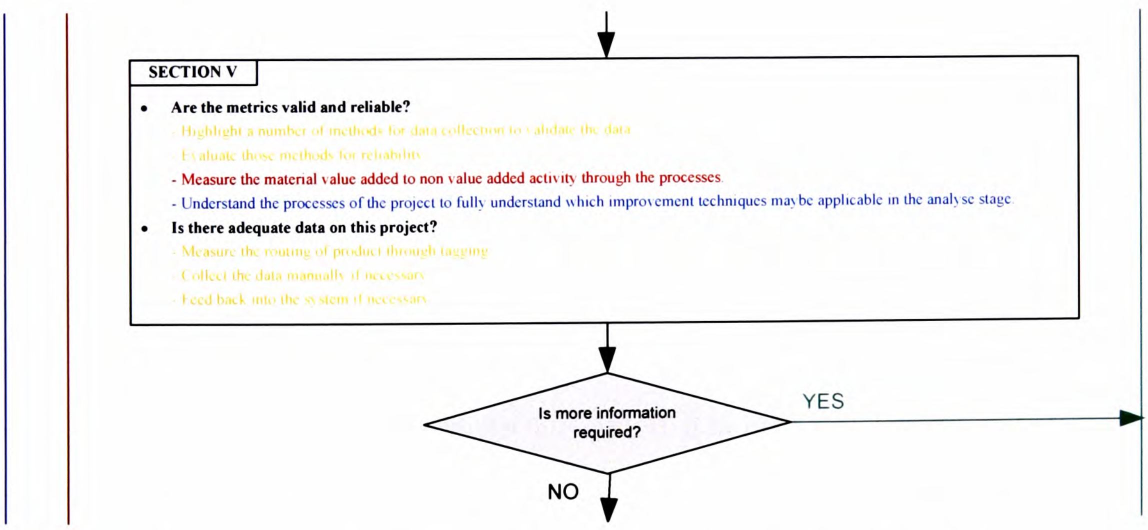


Figure 5.20: Stage 2, Section V of the proposed methodology

The decision was made to ask the team to carry out the completion of the questionnaire instead of the author collecting the data, to eliminate detailed analysis of each process and product flow. The questionnaire was used because the data required were not easily collectable, as the systems were not in place to collect the type of information that was required. It was thought that the time taken to collate this information might possibly take longer than to collect the information manually through the questionnaires and observations. This method created a degree of trust within the team, as when the data were gathered, it was noticed that this method allowed a wider scope of data collection and that the method was easily accepted, amongst the employees. It was also thought that it would be more beneficial to have slightly less specific information, in return for data with greater variation and randomness.

This survey also allowed for comments from each team member, it allowed each member to anonymously discuss issues or concerns within the processes, products, tools and machinery. Generally the results were very informative, however it highlighted that there were issues related to the availability of the coding machine. The availability of the coding machine was particularly limited and the process had to be scheduled around it's availability as it was shared with other production lines. Other issues were related to jig changes for ease of use. The survey also highlighted the culture within the team and concerns were raised as required by part of the questionnaire. It was noticed that the same issues were raised in the final sections of the survey and that after the initial completion these sections were left blank on the survey.

It was found that is was harder to clarify the production process from the survey and so the decision was made to observe the processes as well, by working within the team it helped to clarify the numeric data collected. This helped to understand the production processes but also to observe the tools and equipment that were used as well as any issues that may have arisen.

It was thought that as the project scale was small this manual method of data collection was preferred as it was less time consuming. It was a respective method that did not rely on other people to analyse the previous information or collect it. It was thought that as a method of precaution the product would be tagged as well to confirm and verify the information collected manually.

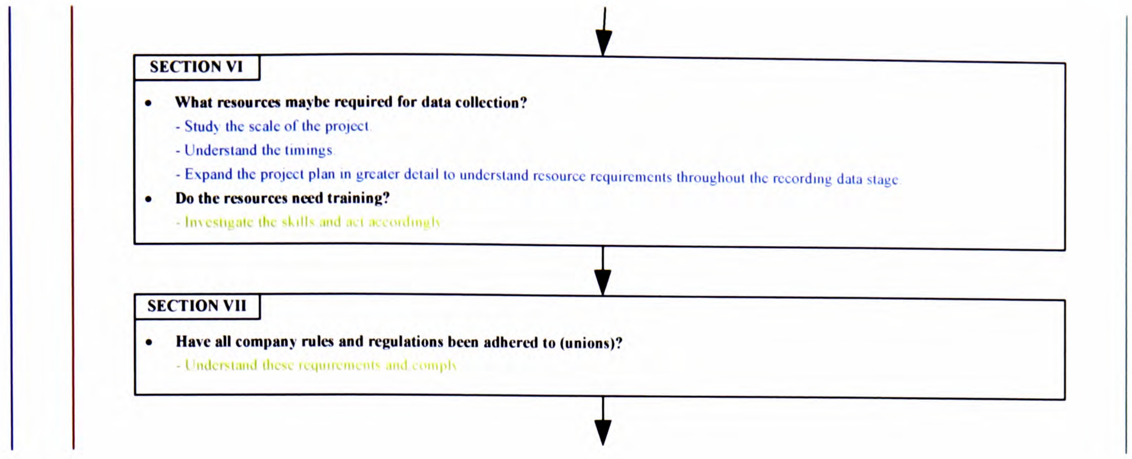


Figure 5.21: Stage 2, Sections VI and VII of the proposed methodology

The people that carry out the processes were needed for answering the questions and observations, however meeting times and data collection were verbally agreed with the team due to the project scale. It was decided that other resources were not required for data collection as the resources needed were the people within the team. It was the knowledge of the team that was required, therefore, assessment of the skills and whether the resources needed training were not applicable, likewise understanding company rules and regulations were not applicable to this project as there were minimal resources.

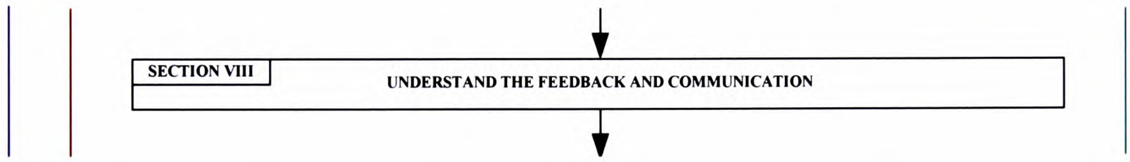


Figure 5.22: Stage 2, Section VIII of the proposed methodology

Here the feedback and communication key was used, all of the necessary guidelines were met and reasons were given to the extent of the application for this project. The measurements that were planned to be collected within this stage are in line with the project requirements and so no changes were made. The project progression was verified against the original project plan (**figure 4.5**, page 128) and according to the plan; this project was to be in the second month. This project was still within these requirements.

At this stage, no further contact was made with other people from the company as the design of the project was still being defined, due to this, there were no changes in the current state culture. Unfreezing the culture was not necessary as the project was not clearly defined and so it was difficult to work on changing a system when the definition of this system was not clear.

The magnitude and scale of acceptance was considered when creating the surveys and questionnaires, these were created in a user friendly format for ease of use and so that a high percentage would be completed. The thoughts and emotions of the employees including the measurements of the perception of change was planned to be monitored through the use of the observations and surveys. All of the reactive guidelines suggested in this key would be considered once the data had been collected.

No further information was required as all of the applicable guidelines were fulfilled and the feedback and communication key had been considered. From this, all of the answers created in Stage 2 were sufficient and so the output of a structured data collection plan was created.

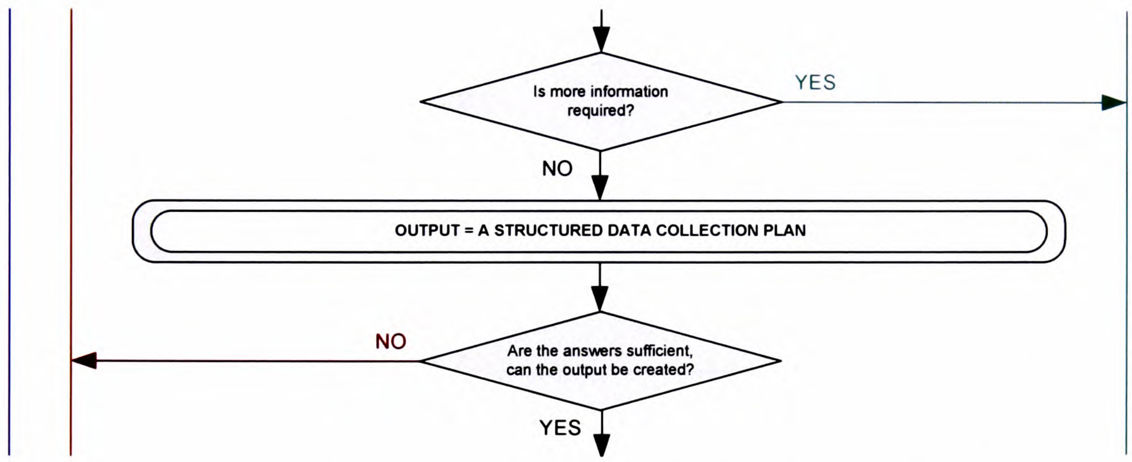


Figure 5.23: Stage 2 output of the proposed methodology

This data collection plan can be seen in **figure 5.24.** The surveys created were the main source of data collection. This method relied upon the operators to complete the surveys so there was an element of trust with them to complete them accurately and it was thought that this method would gain acceptance. A more accurate method of data collection would be for the author to time the processes individually, however the reception given by the team would be more hostile and the project and author acceptance would be less successful. It was felt that data collection by the operators through surveys would build employee trust and that the accuracy was sufficient.

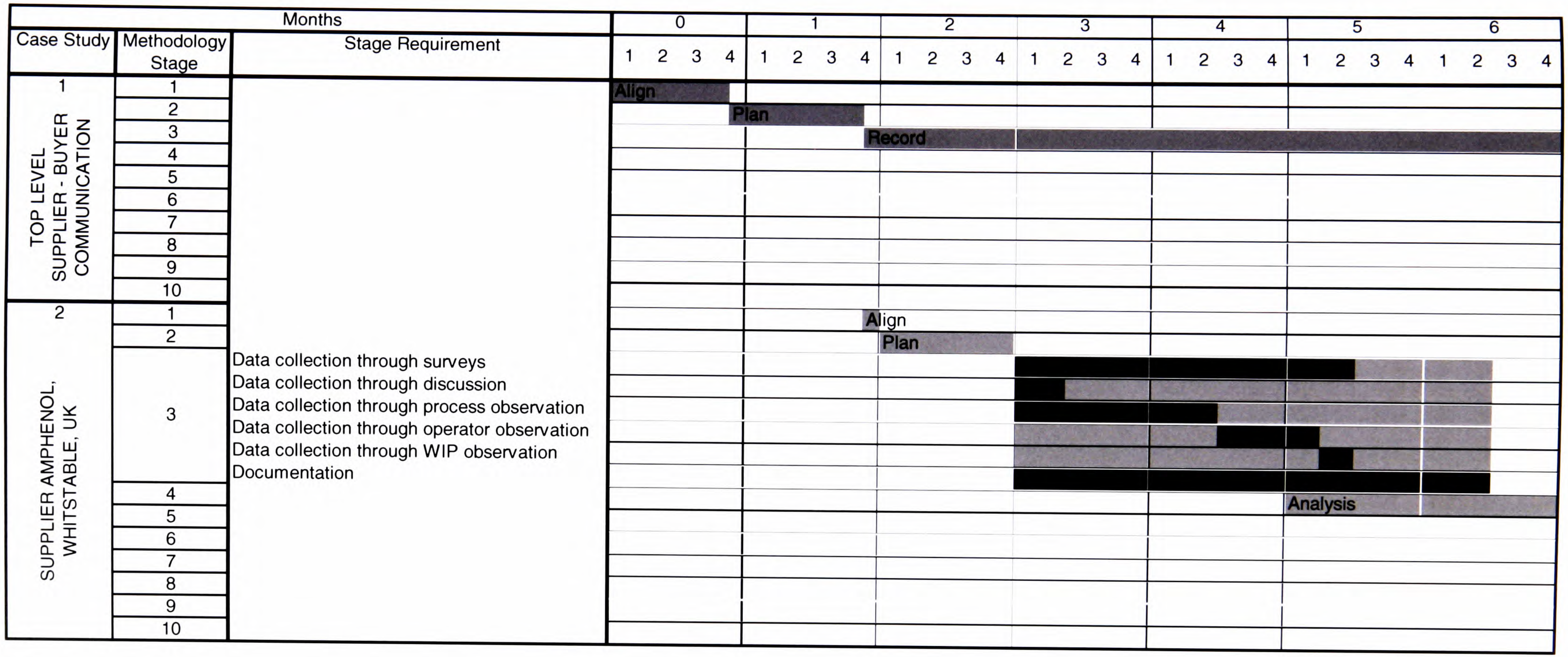


Figure 5. 24: The timescale of the data collection plan

Figure 5.24 highlights the project plan and also demonstrates the focus carried out with the data collection process. The lighter shaded area shows the overall general time dedicated to the data collection process. The darker shaded area within shows the specific times dedicated to each task.

To justify the data collected through surveys, less structure methods were used to collect data through observations. Observations were carried out to understand a number of areas;

- The process
- The process flows
- The material supply
- The operator skills
- The team culture
- The production scheduling system
- The team leader involvement
- To justify the core data collected in the surveys

5.4.3 Stage 3 – Recording the Information and Defining the Current State

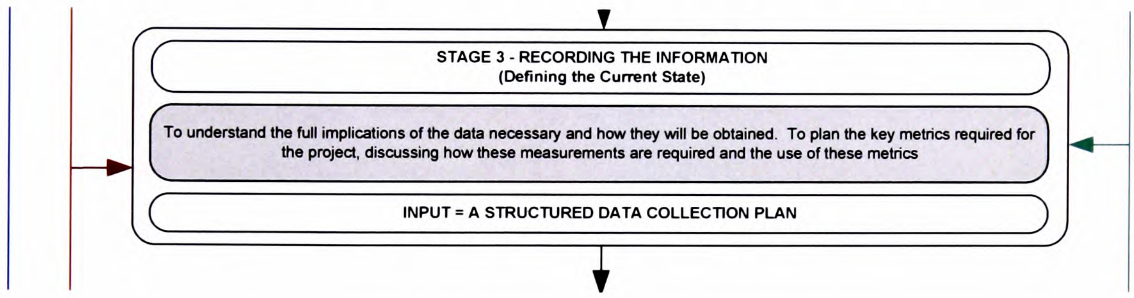


Figure 5. 25: Stage 3 heading of the proposed methodology

The plan created in Stage 2 (**figure 5.24**) was used to conduct the recording of the data collection.

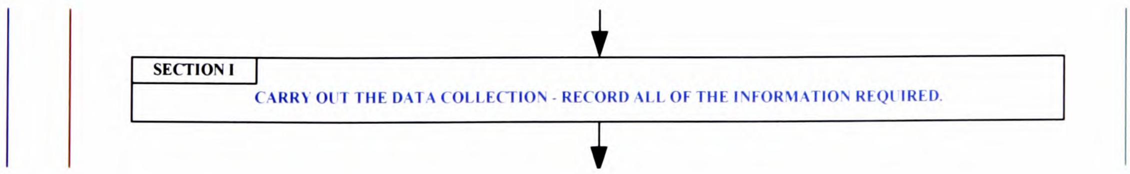


Figure 5. 26: Stage 3, Section I of the proposed methodology

Prior to working with the team directly involved, a survey was created for the management to enable an understanding of the process without involving the operational team members (**appendix 5.26** (on CD)). This was to ensure a basic understanding of technical and information flow of the system. The results from this highlighted not only the complex structure of the production line but also demonstrated the possible reaction of the members involved in the production process. Queries regarding the previous improvement initiatives were also answered, including information about worksheets, production aids and materials ordering systems. This included answers to the timeframe and the presentations that were given by management. Cultural issues were also mentioned with regard to direct employee perception and employee incentive schemes.

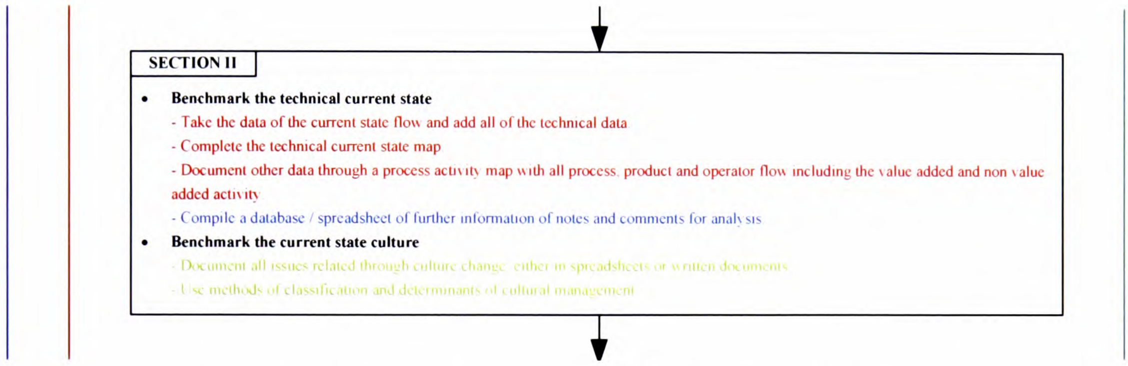


Figure 5. 27: Stage 3, Section II of the proposed methodology

As defined previously, it was decided to work with the team and collect the information through surveys and observations. All of the data were collected over the timescale planned and this information can be seen in **appendix 5.28** (on CD). The most effective method was through the operator surveys, this allowed the data to be collected over a longer period without the need for micro managing the process. The trust was placed with the operator which resulted in successful data collection. This method also enabled many calculations for one operation but with different operators and different variants of the product, which would give a truer interpretation of the operation. This methodical system also meant that the data collection process was self sufficient, however would have not been as possible without co-operative of the team members. The information collected from this questionnaire to date can be seen in **appendix 5.28** (on CD).

From all of the further information that was collected, the current state mapping adjusted and a true current state map of the process was created. It was discovered that the initial current state map (**figure 5.8**, page 145) was not a true interpretation; this map was based upon the physical and documented product flow and not based upon the process flow. **Figure 5.28** displays the process orientated current state map. This information was then validated by observing the team and asking further questions when observing the individual operations.

As the questionnaires were issued prior to the observation, the team members were aware of the type of information that was required and that judgements were not made about the individual team member but about the operation. All observation data were collected and written in a log book which assisted in the understanding of the processes.

Some observation data were written up as PAMs and stored electronically, however it was decided that this was very time consuming and as long as the information collected in the surveys was verified, it was unnecessary to process all of the observation data. The observation data that were written were analysed and the two following examples of the processes (**figures 5.29** and **5.30**) of the production line highlight this information

Figure 5.29 displays one operation completed but with one set of data (therefore without variation) which was the 'Coding' operation. It became apparent that although the process are seen as independent by the company, the 'Coding', 'Oven Cure' and 'Air Cure' operations were seen as one operation through mapping techniques. The figure shows the PAM that was created for this operation and how the value added and non value added activity was assessed. This information is represented graphically (**figure 5.29**). General notes were also mentioned as well as possible simple process improvements. It was thought that all the information gathered about an operation would be processed in a similar manner so that all of the information gathered would be easily visible. The same information is held for the 'Staking' operation and this can be seen in **figure 5.30**.

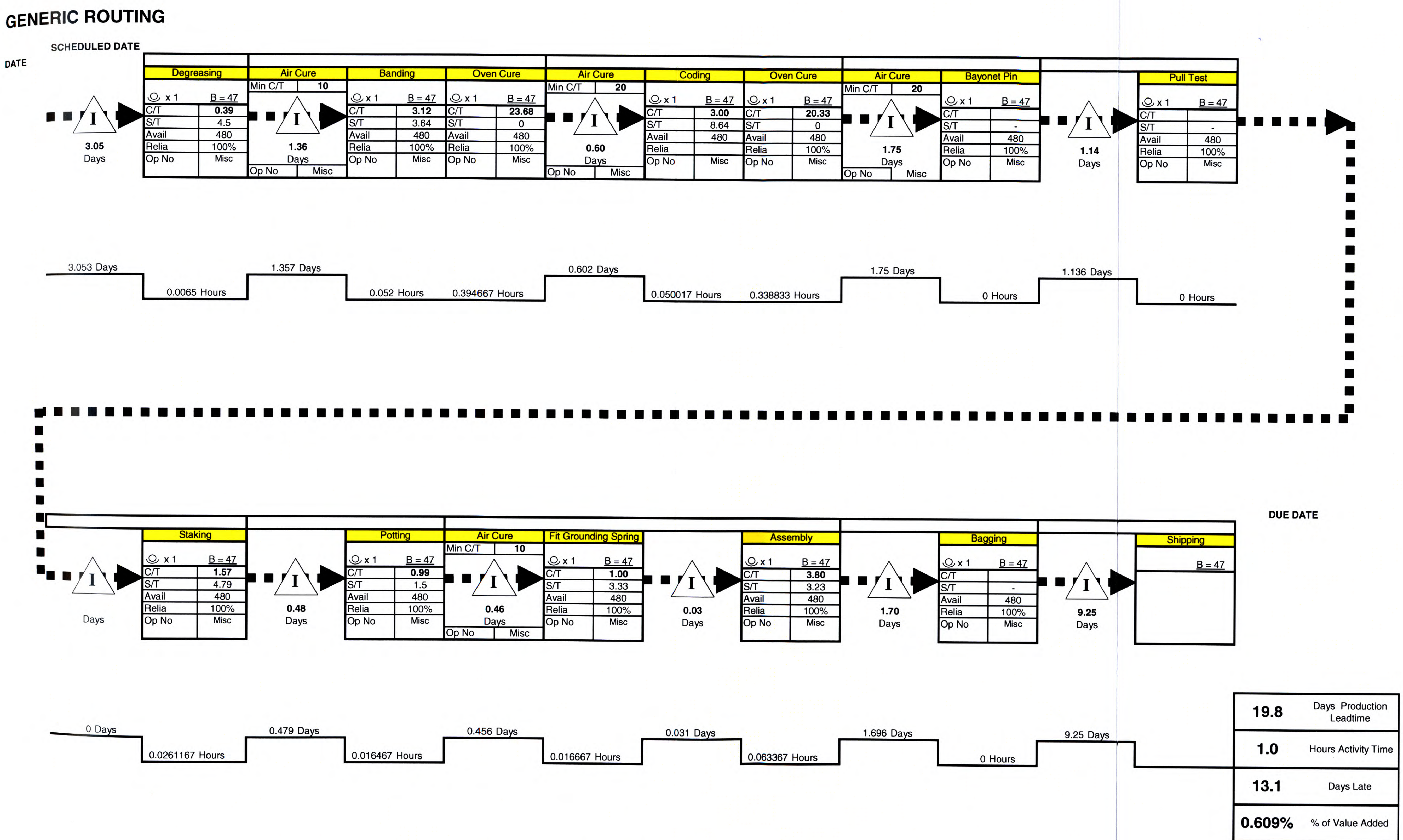
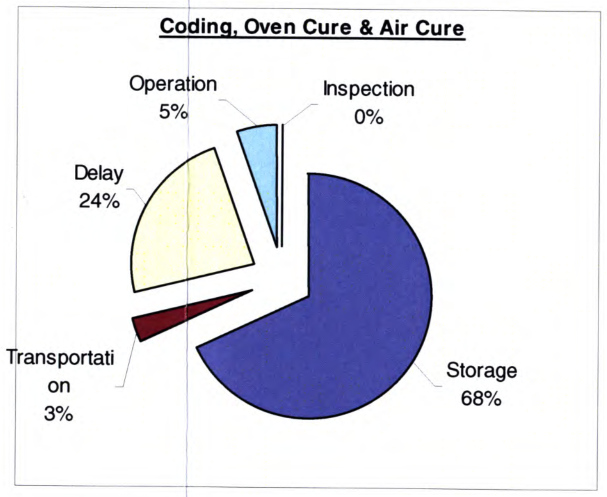


Figure 5. 28: The current state map after some data has been collected

Coding

Step	Description	Time (Mins)	Distance (Paces)	WIP	Batch Quantity	Notes	Symbol	Procedure Breakdown	Time Breakdown
1	**STOCK**			500		Pre-banded products from India	S	WIP	
2	Collect from shelf	5.00	6				T		
3	Look up item number to get the code	0.08					D		
4	Adjust the Jig for the Product	0.25					D		
5	Number doesn't exsist on the printer selection need to look the drawing up	4.00	20				D		
6	Put the coding description into the computer system	6.00					O		
7	Download code	1.00					O	Set-Up	16.92
8	Place the ring on the jig	0.08					O		
9	Print the code	0.08					O		
10	Check the code is correct	0.08					I		
11	Check the alignment of the code	0.08					I		
12	Alter the alignment on the jig	0.17		15	15		D		
13	Check the alignment on the coding again	0.08					I		
14	Place the ring on the jig	0.08					O		
15	Print the code on the ring	0.08					O		
16	Place the ring on the tray	0.08					O		
17	Repeat steps 14, 15 & 16 for another 14 rings	2.00					O	Coding Operation	3.33
18	Walk the tray to the oven	1.00	7				T		
19	Place the rings in the oven	0.08					O		
20	Rings are in the oven (Oven Cure)	20.00				Sometimes left longer if the batch is bigger - Brass ring have to be 20 mins exactly	D	Oven Cure	20
21	**STOCK**	20.00		50	50	Already in the oven	S	WIP	
22	Take the rings out of the oven and leave to cool (Air Cure)	20.00		15	15		D	Air Cure	20
23	**STOCK**	20.00		100	50	Already cooling	S		
24	Put to shelf			15	15		T	WIP	
25	**STOCK**	87.00		0	0	On shelf	S		
	TOTAL	**60.25**	**33**	**665**					**60.25**

Symbol	Time
Storage	127.00
Transportation	6.00
Delay	44.50
Operation	9.50
Inspection	0.25
Total	**60.25**



Improvement Notes
- To have a faster computer
- Drawings aren't always easy to find
- it is assumed that a new coding machine is being bought for the line.

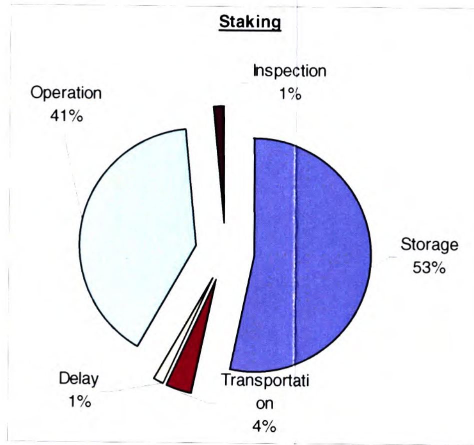
General Notes
- Previous process is Banding
- Sometimes they are bought in from india and so they do not need Banding.
- Process after is Baynot Pinning if required
- If not the process after is Skating

Figure 5. 29: The coding, oven cure and air cure processes analysed after observation

Staking

Step	Description	Time (Mins)	Distance (Paces)	WIP	Batch Quantity	Notes	Symbol	Procedure Breakdown	Time Breakdown
1	**STOCK**			1000			S	WIP	
2	Collect from shelf	3.00	10				T		
3	Collect other materials for the job	3.00	3			There is a lineside stcok that withholds the staking rings, seals & inserts	T		
4	Check for special requirements	0.08					I		
5	Put the required tooling into the machine	1.00					D		
6	Take the inserts from the packaging	0.33					D		
7	Take the seals from the packaging	0.33					D		
8	Take the stake rings from the packaging	0.33					D		
9	Dip the seal into the methalated spirit	0.02					O		
10	Put the seal into the connector	0.08					O		
11	Place the connector on the tray	0.02					O		
12	Repeat steps 9, 10 & 11 for another 82 rings	9.57					O		
13	Degrease the socket	0.02					O		
14	Put the socket in the machine	0.08					O	Set-Up	20.87
15	Locate the strip on the socket in the machine	0.25		83	83		O		
16	Locate the main keyway on the connector & place on socket	0.08					O		
17	Check the air pressure on the machine	0.08				Certain air pressure for different size rings	I		
18	Arrange the tooling	0.03					D		
19	Push the socket within the connector	0.08					O		
20	Remove the connector	0.08					O		
21	Pressure test the connector	0.08	3				I		
22	Check that the socket does not fall out of the connector	0.03					I		
23	Remove the connector	0.08					O		
24	Walk the connector to the shadow graph machine	0.05	10				T		
25	Check the alignment	2.00					I		
26	Walk back	0.05	10				T		
27	Place the connector on the tray	0.08					D		
28	Repeat steps 13, 14, 15, 16, 19, 20 & 27 for another 82 rings	56.03					O	Staking Operation	56.03
29	Put to shelf		10	83	83		T	WIP	
30	**STOCK**	87.00		99	33	On shelf	S		
	TOTAL	**76.90**	**46**	**1235**					76.90

Symbol	Time
Storage	87.00
Transportation	6.03
Delay	2.12
Operation	66.40
Inspection	2.28
Total	**76.83**



Improvement Notes
- The new tooling could be improved - the old machine is better
- Could make the tooling better for shell plug size 11 - is too long and part of the jig has to be removed.

General Notes
- Previous process is Coding / Baynet Pinning
- Process after is Fitting the Contacts (Pre - Potting)

Figure 5. 30: The staking process analysed after observation.

The level of detail that was required within the PAM was unnecessary because it was too specific for a large production line producing a number of different products. The processes varied depending upon the product type, the batch quantity, the customer requirements and the skill of the operator. It was decided that as long as these specific limits of the variation were noted it was sufficient to proceed.

Other data that were collected from the observation, was the flow of the process (**figure 5.31**), product (**figure 5.32**) and operator (**figure 5.33**). This enabled the creation of the spaghetti diagram to monitor this movement and act as a benchmark for future changes.

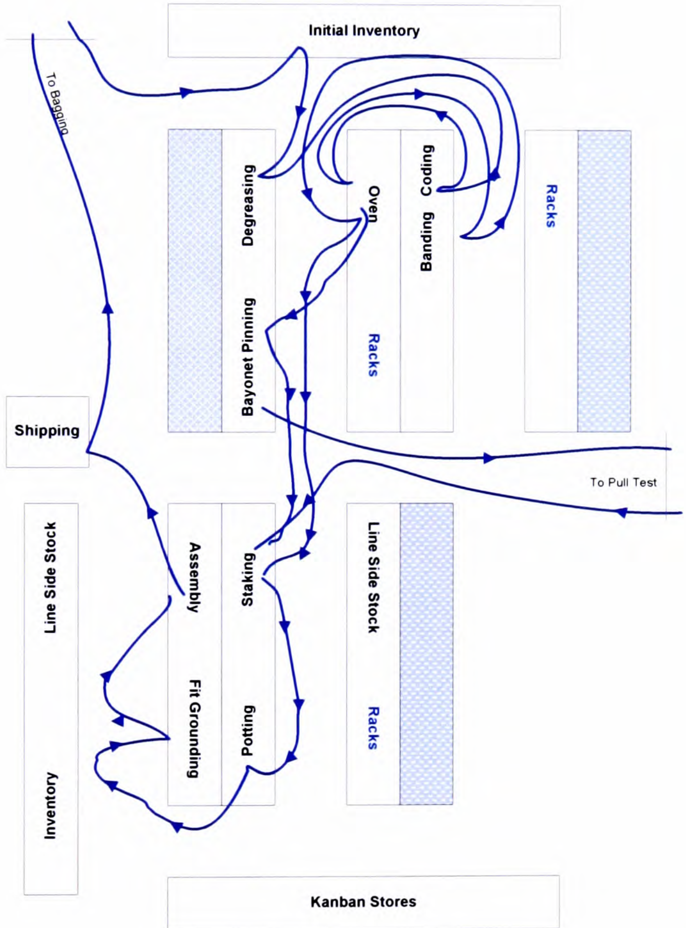


Figure 5. 31: The spaghetti diagram of the process flow.

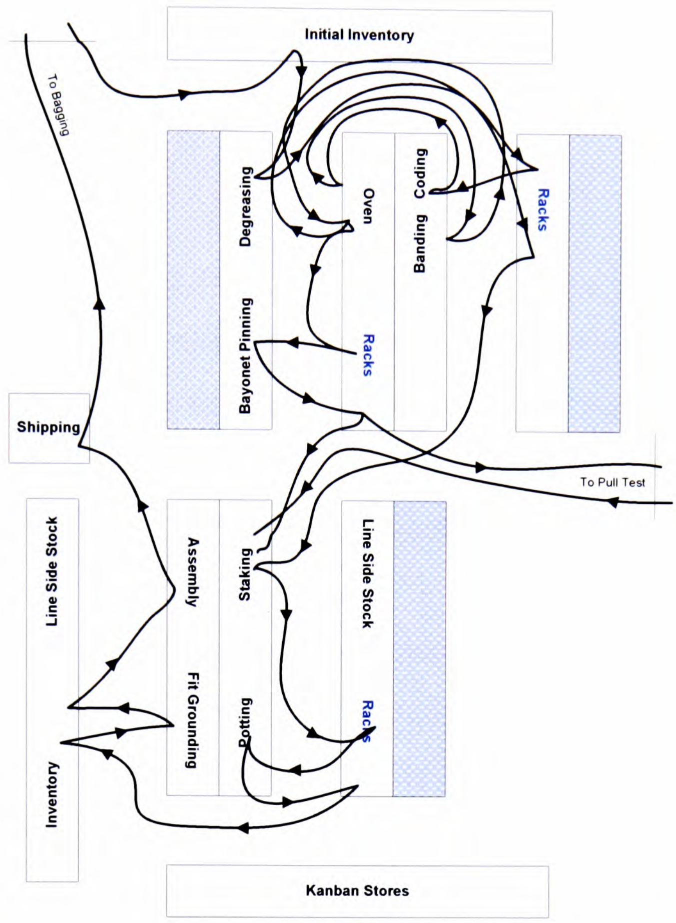


Figure 5. 32: The spaghetti diagram of the product flow.

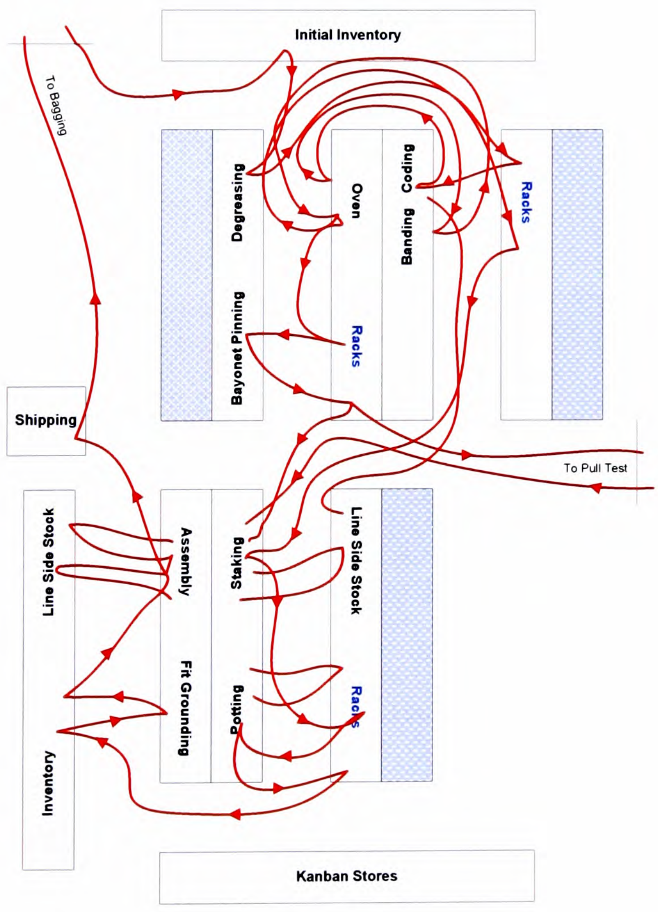


Figure 5. 33: The spaghetti diagram of the operator flow.

It can be seen how there are marginal differences between the three diagrams. What the diagrams do highlight is that the movement of the process, product and operator flow are unorganised around the cell.

Within this section the current state culture was determined, by scaling the questions in **figure 5.34** and classifying the relevancy of the statements to the current state culture. **Figure 5.34** displays this information and shows the company culture classification. This information was created mainly from surveys that the operators used to record process information and when making observations.

This table generally highlighted that the team operating this production line were within tight operational contracts due to customer requirements. The team were very group orientated and work well with the team leader. The operators also communicated amongst each other creating a more relaxed working environment. Furthermore, past achievement and record keeping were very important attributes of the operating environment.

With regard to the environment, the production was very linear and the team were solely concerned about this particular line; this was the company culture as a whole. It was thought that the company cultural environment needed to be considered as one entity instead of a number of production lines.

Current State Culture Definition	Agree = 5 Disagree = 1				
	1	2	3	4	5
- Relationships to Other People					
- Rules versus relationships – The organisation uses tight contracts when engaged in business				✓	
- There is not only one right way; the person should act in a way that fits the particular requirement				✓	
- Group versus the individual – it would be expected that several people would attend meetings and make group decisions			✓		

- Single decision makers are common and decision are made quickly			✓		
- Lack of emotion versus show of emotion – it is considered uncultured to show emotion		✓			
- Specific relationships versus diffuse relationships – Are relationships defined to fit a specific context				✓	
- All aspects of a relationship are discussed and intertwined		✓			
- Organisational status is according to past record achievement					✓
- Organisational status is satisfied through ascription					✓

- Attitude to the Environment and to Time

- The environment can be controlled and exploited				✓	
- The environment is something that can be adapted too				✓	
- The organisational focus is on the future and making future plans			✓		
- The organisation places importance on the history and the past			✓		
- Time is seen as a linear, sequence of events				✓	
- Time is seen as circular, linking the past, present and future		✓			
- The immediate future is achievable through personal effort		✓			
- Long term is not as achievable, as too many things can happen				✓	

- Individual – Organisational Relationships

- Individuals can come together in an organisation because it furthers their own ambitions			✓		
- Individuals have little loyalty to the organisation				✓	
- The organisation instructions initiate from the top and work down					✓
- The role of every individual is well defined					✓
- Members have come together due to shared values or			✓		

goals					
- Power and Control					
- The organisation has several levels of hierarchy and relies on a committee for decision making					✓
- The Organisation focuses on successfully completing well defined projects / tasks				✓	
- Influence is based on expert power and is widely dispersed			✓		
- Innovation and Learning					
- The managers are experts in their organisations limited area of operation			✓		
- Management tend not to search outside their current areas for new equipment				✓	
- The company narrowly defines the market segments				✓	
- The organisation continually searches the market opportunities		✓			
- Regularly experiments with responses to environmental trends			✓		
- Attitude to Risk				✓	
- The organisation operators through the use of formalised structures and processes				✓	
- Management are reluctant to change		✓			
- Management only react when they are forced to do so			✓		

Figure 5. 34: The current state culture classification

Within the site there appeared to be little self ambition within the operations department, but essentially these team members were the most functional employees of the company. Due to the production line cultural environment, the members remained loyal to the team and the operation of the production line, as well as the team leader. Within this environment, direction is given from the top downwards and every individual has a defined role.

With regard to power and control at the top level, the organisation has many levels of hierarchy and relies on a committee to make decisions. Within the production line, the control is with the team leader who is liked and respected within the team; hence the team operates successfully together.

Innovation and learning was considered across the company as it was hard to define classification to these statements at production line level. Innovation at production line level is non existent, however learning happens daily to acquire new skills, but this is only with new employees. Those individuals that have greater skills tend to stay with one or two processes and carry out the same operations and processes daily.

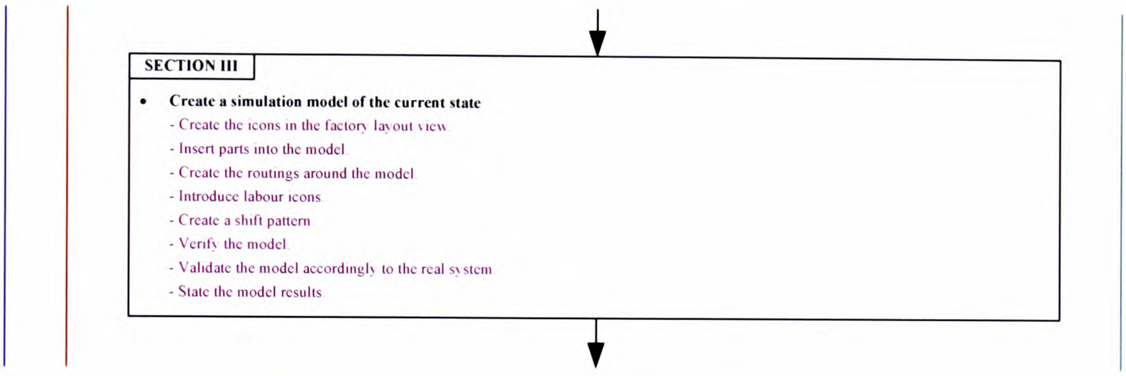


Figure 5. 35: Stage 3, Section III of the proposed methodology

It was decided to produce a current state simulation model to highlight immediate bottlenecks and to identify the need for greater availability of the coding machine. The icons and attributes were created within the software program and the model layout was created to represent the actual system. **Figure 5.36** displays the model view; it also highlights the process flow and the products entering storage around the production line.

The decision was made to produce a rough interpretation of the actual system to justify the need of a new coding machine, as this was an issue highlighted by the team operators. A model of this standard allowed the justification to be made without consuming too much time and to highlight the major bottlenecks.

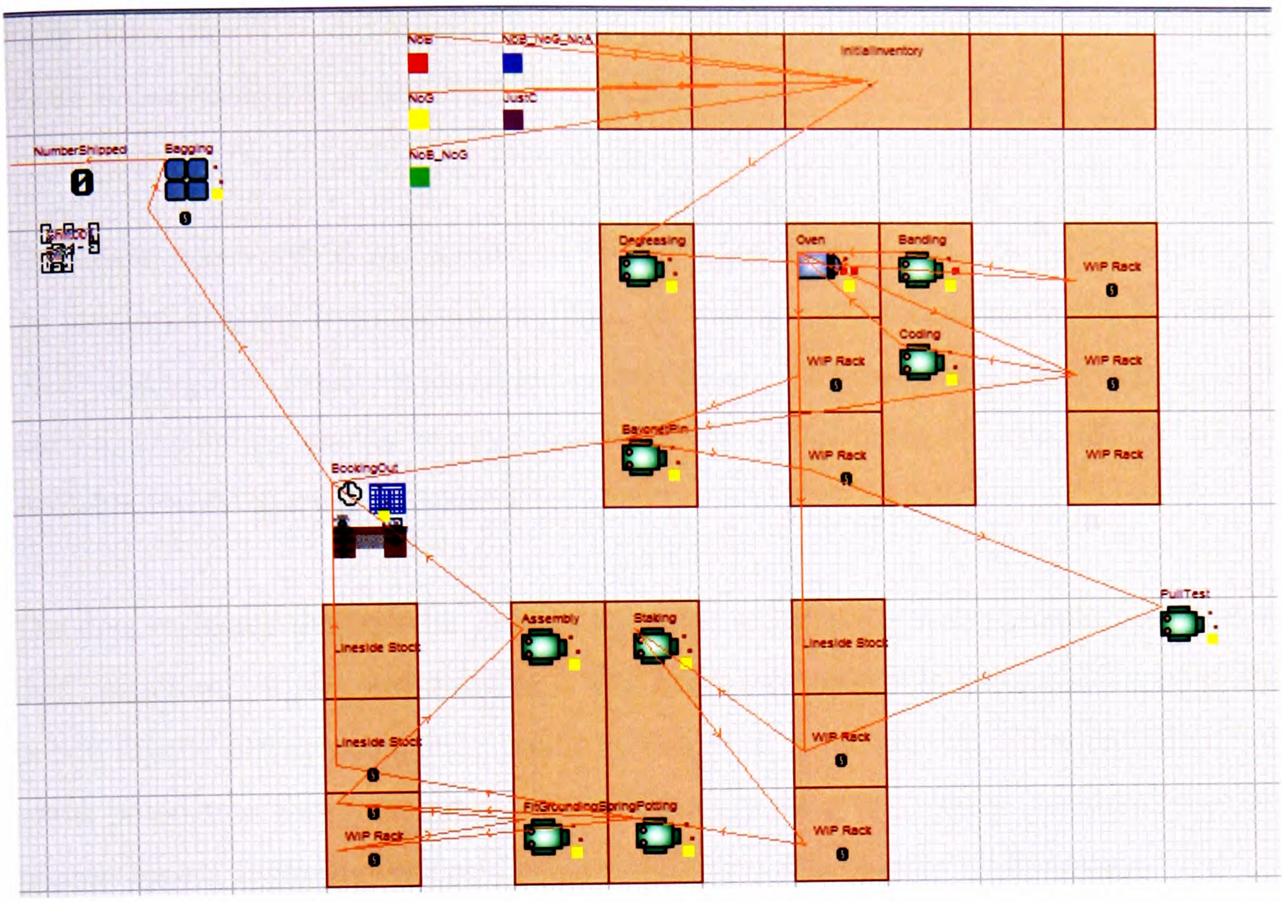


Figure 5. 36: The screen of the simulation model

From the data the products were grouped into five variant types; these were grouped according to similarly process flows. These product types were colour coded to enable the visibility around the model and for highlighting variation in product routing. Due to the vast amounts of data collected, the decision was made to create distributions for the process cycle time and batch quantities depending upon the product type and routing. To simplify the model further the model machine cycle times (operation times) were a multiplication of varying the product type cycle time against the varying batch size and this information was referenced in the spreadsheet is shown in **appendix 5.29** (on CD).

Labour was introduced and defined by setting up the individual skills used depending upon the operator and the process, this allowed the model to utilise the labour fully. It also allowed the simulation model to measure and investigates the labour capacity around the production line. Shift patterns were also introduced to allow the labour to operate within a normal working week but to also allow for overtime. Shift patterns also allowed the labour to operate according to the differing shift patterns per individual, some team members did regular overtime. All of the data gathered for this model creation can be seen in **appendix 5.29** (on CD).

The model was verified and validated through comparison to the real system including the tagging of parts from the survey data, as well as calculating the Work In Process (WIP) through the system with regard to lead times. The model met these requirements and the simulation results were in line with the actual times recorded in the survey available for the analysis in Stage 4.

The data collected through the surveys appeared to be the best and simplest method of data collection. It was decided that whilst the information was being documented, the period for the survey completion could be extended, to ensure that a true understanding of the production was gathered as well as better sampling to produce the variation of the process times. It was thought no further information was required at this stage.

As previously mentioned, the data were verified for accuracy through different techniques, however they were mainly verified through surveys and observation of the production line processes, operations, system scheduling and discussion. A product was also tagged to justify the overall lead time.

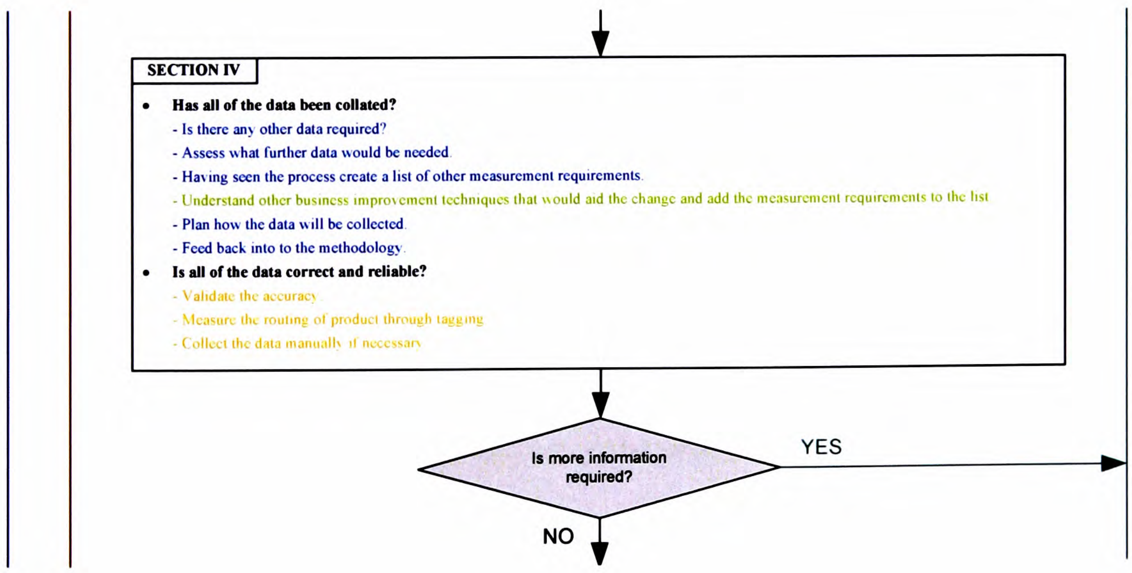


Figure 5. 37: Stage 3, Section IV of the proposed methodology

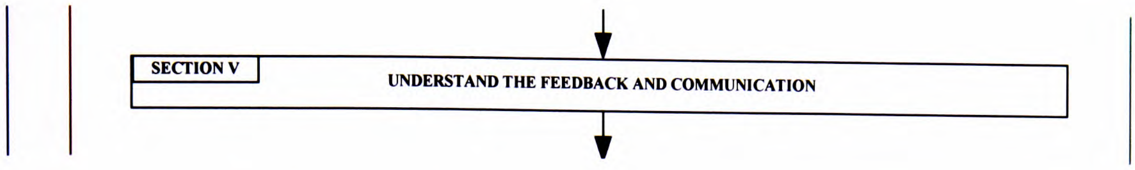


Figure 5. 38: Stage 3, Section V of the proposed methodology

All of the guidelines that were necessary were applied and justified. The data collection stage actually involved participation from the stakeholders and so communication was carried out throughout the team. This did not create any problems or delays within the project and remained true to the project brief and time scale. What was also observed whilst carrying out the data collection was the level of project acceptance. As time continued and data were still being collected, the culture was changing and the willingness to help increased.

No further data were required and the stage was completed. **Figure 5.28** (page 161) displayed the current state map with the numeric data and demonstrated that production lead time was on average 19.8 days whilst the average activity time was only 1 hour. The results also highlighted that in some cases the products were up to thirteen days late, this confirmed ideas highlighted in the SWOT analysis table, **figure 5.3** (page 140).

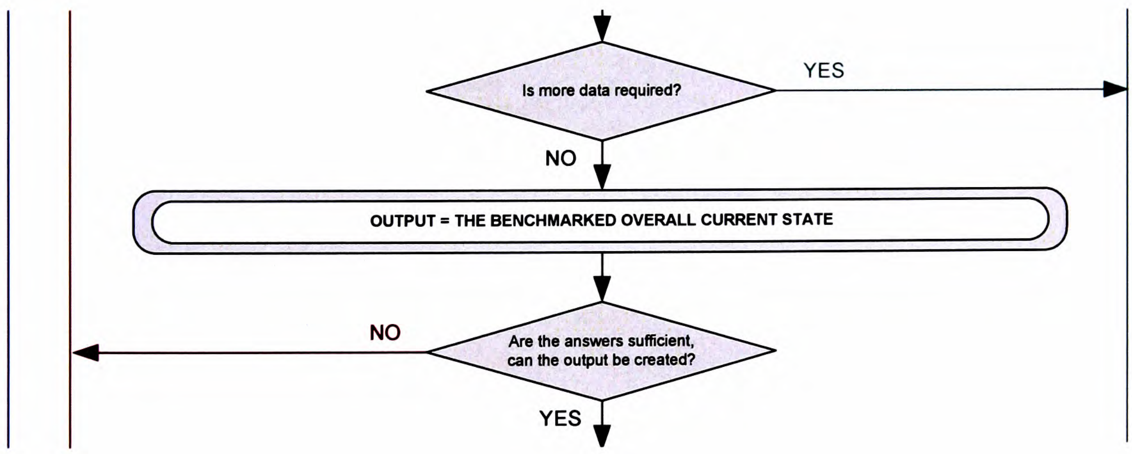


Figure 5. 39: Stage 3 output of the proposed methodology

The current state model operated in line with the actual system and highlighted that the coding machine was the main bottleneck in the system, this would then allow the system to be tested and analysed in Stage 4. The current state culture was benchmarked (**figure 5.34,** page 168) this allowed measurement against subsequent states and thus concluded the application of Stage 3.

5.4.4 Stage 4 – Analysing the Technical Data and Defining the Technical Future State

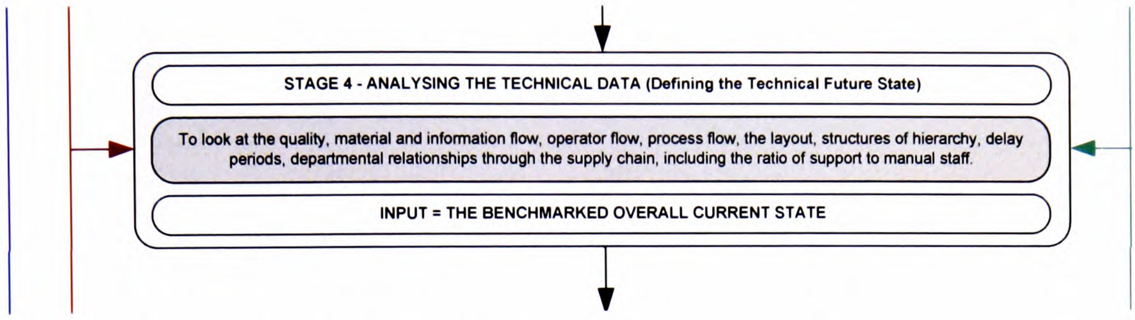


Figure 5. 40: Stage 4 heading of the proposed methodology

The benchmarked overall current state was highlighted in **figure 5.28** (page 161) **5.34** (page 168) and extensively discussed in Section 5.4.3. This information was used and analysed with this stage.

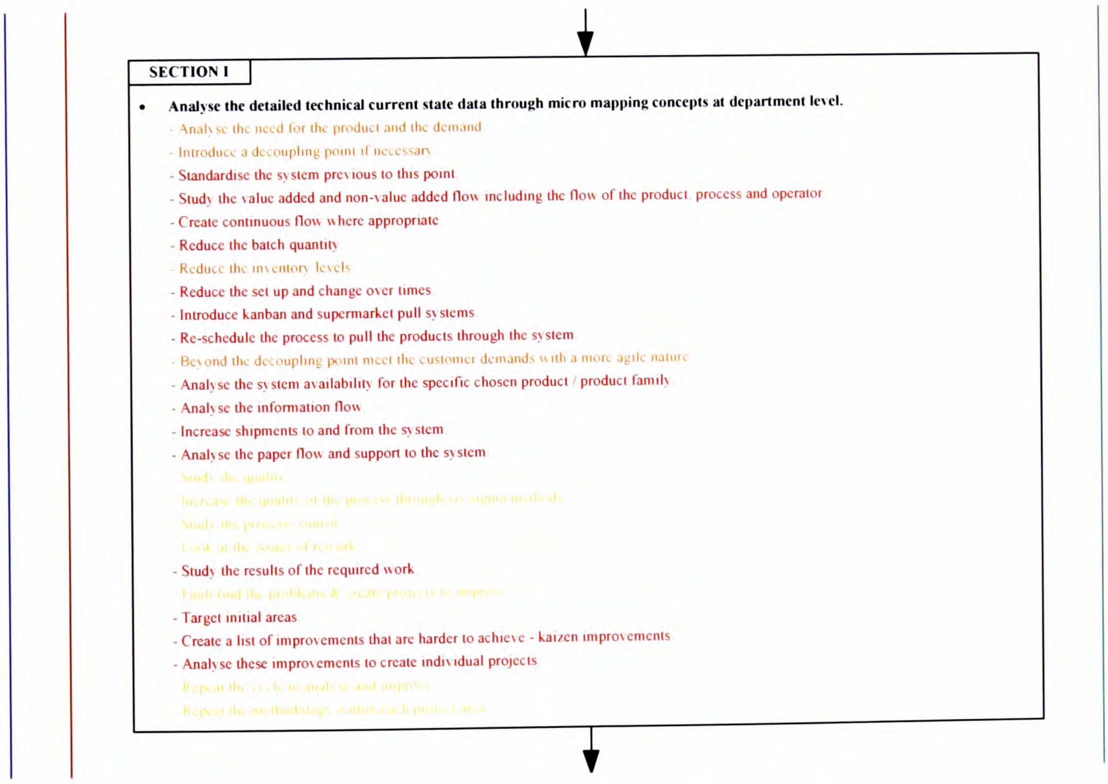


Figure 5. 41: Stage 4, Section I of the proposed methodology

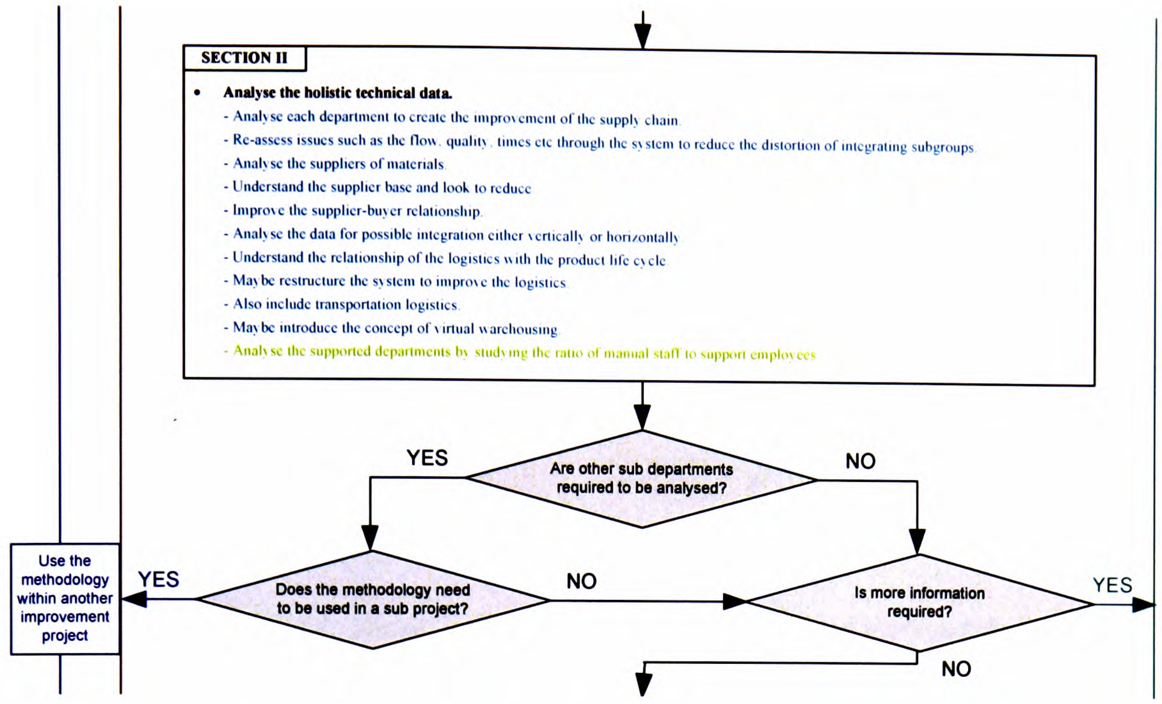


Figure 5. 42: Stage 4, Section II of the proposed methodology

When working through the methodology application it was discovered that further information was required with regard to analysing the details within the production line. Information such as the customer demand was not gathered as well as the sharing of other resources other than the coding machine. It was decided that by carrying out these sections in the methodology that more holistic data were required. It was decided that the feedback loop and feedback into Stage 3 would be used in order to determine what further information was required to enable the completion of Stage 4.

5.4.5 Stage 3 – Recording the Information and Defining the Current State

This stage was used to re-evaluate the data that were required in order to analyse the case study. To determine the specifics of this information, the feedback loop was used to move from Stage 4 and feed back into Stage 3 to determine what data are actually required.

It was decided that further information was required; these were in the form of questions to establish how this information would be gathered. The other information that was required was;

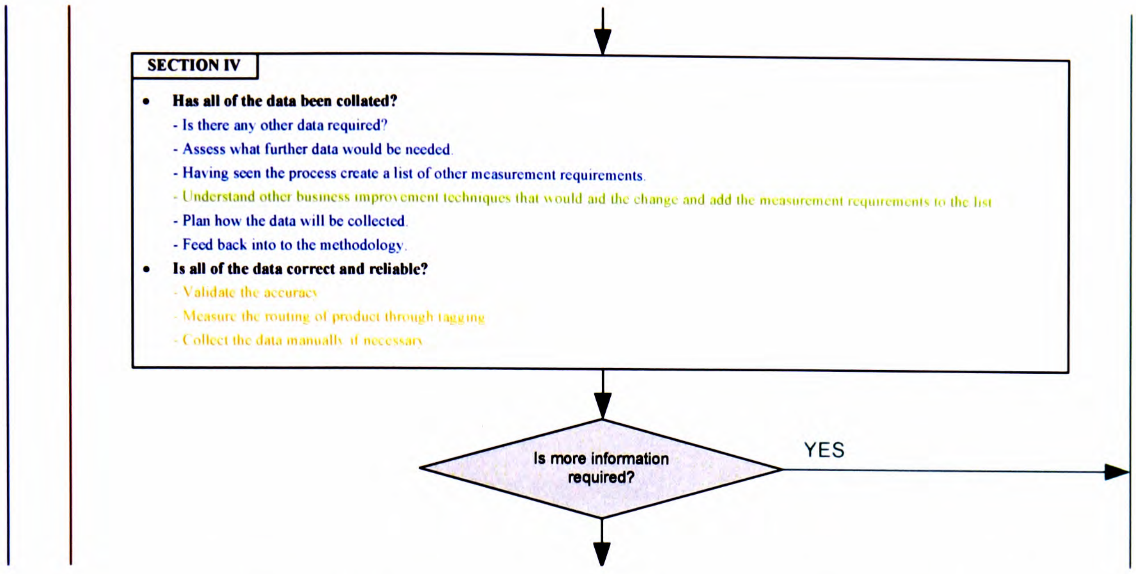


Figure 5. 43: Stage 3, Section IV of the proposed methodology

- Customer demand
    - For all of the products and for the BAE products define the percentage split of the line.
- Customer deliveries
    - How frequent are the deliveries from the production line?
    - Does the line build in batches?
    - What are the batches to the customer?
- Supplier deliveries
    - How frequently are parts pushed onto the system?
    - What are the batch sizes?
    - How are the supplied to the line?
    - Does the line build in batches?
- Information flow data
    - The estimated time given to produce the products?
    - How often orders are required from the customer?
- WIP on the shop floor
    - Need to calculate the WIP at each production station for the mapping purposes.
- OTD information
    - How are the products fed off the production line?

    - What are the time scales?
    - What is the OTD to the customer?
- Sharing of equipment
    - What is the availability of the coding system?
    - Are the ovens are shared?
    - What is the percentage of the time usage?
- Material availability
    - Is the material there when required?
- Operators
    - What is the total number of operators?
    - How are their skills shared among the production line?
    - What are the dedicated shift patterns?
    - Is the over time and when?

It was decided that the data collection process to obtain this information would be less formal. The information required is to enable the current state analysis to begin as well as to develop the current state simulation model. It was established that the information could be collected from the production line leader, the team members or the computer system.

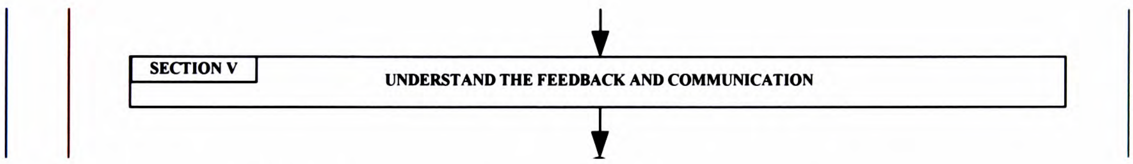


Figure 5. 44: Stage 3, Section V of the proposed methodology

This stage was demonstrating a feedback loop and so the completion of this section was unnecessary as it was already addressed previously.

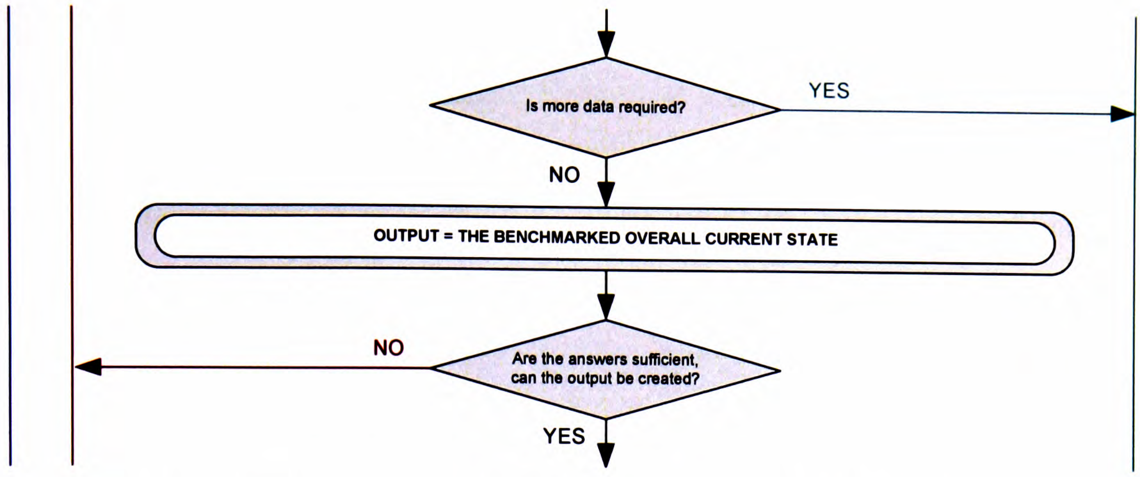


Figure 5. 45: Stage 3 output of the proposed methodology

The current state was still the same as that in **figures 5.28** (page 161) **and 5.34** (page 168), however, further information was required. The specification as to what was required was determined including how it was to be collected. The actions now needed were to actually record the information and so the application was fed back into the beginning of Stage 3.

5.4.6 Stage 3 – Recording the Information and Defining the Current State

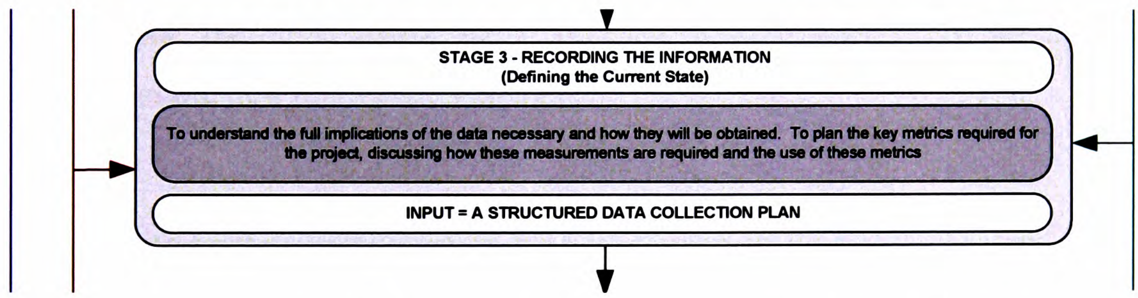


Figure 5. 46: Stage 3 heading of the proposed methodology

In this instance, the data collection plan was less formal and so the data were planned to be collected through informal meetings and discussions.

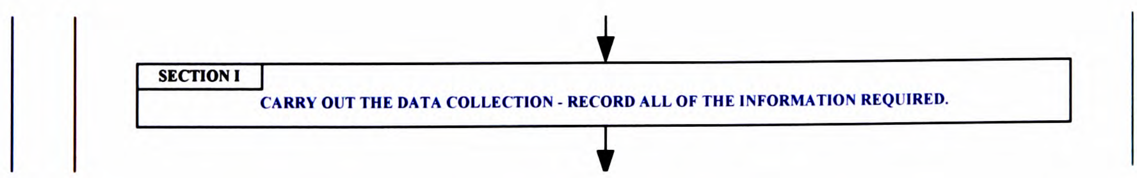


Figure 5. 47: Stage 3, Section I of the proposed methodology

Further information was collected over a session of visits which entailed speaking to the team leader, the team members and gathering numeric data whether from the computer system or observation. Within this period of time, the company had made some changes; the company had restructured the production line to a straight line production line.

The previous information still remained the same, however the 'Grounding Springs' assembly has moved further upstream due to financial reasons. This was the most costly process, as by moving the operation upstream to the customer meant that any quality errors would be noticed prior to the operation, therefore scrapping the product earlier. Not only did this mean allowing any quality issues to be resolved earlier, but also that prior to this operation, all products are standardised.

The WIP for the production remains the same; however the new racking system is more visual being directly behind the production line, with the most urgent work being at the top of the rack and other work on the middle or bottom shelf depending upon the due date. This enabled the team leader to allow the other teams members to understand the priority of work, therefore taking the scheduling pressure away from the team leader allowing the production line to self manage.

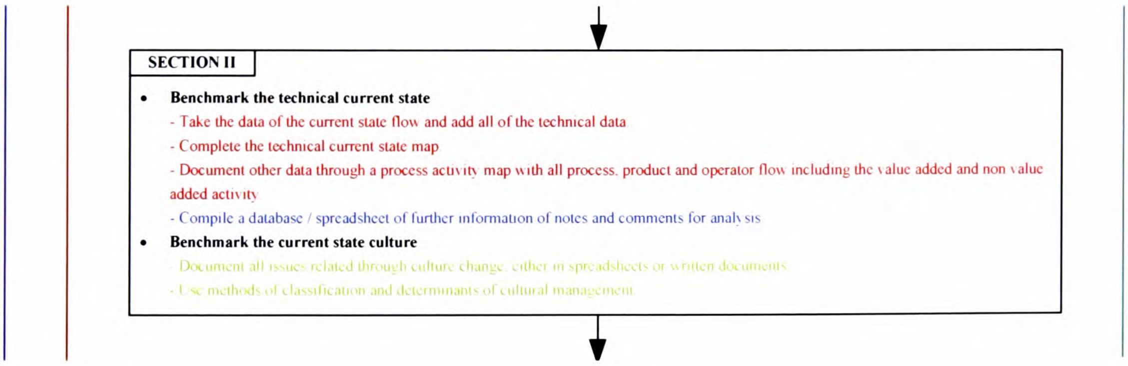


Figure 5. 48: Stage 3, Section II of the proposed methodology.

New information was gathered; **figure 5.49** displays the new routing of the current state map taking into consideration the new layout. To give a more accurate interpretation of the system more data were collected on the OTD (see **appendix 5.30** (on CD)). This information allowed the OTD of the cell to be assessed.

It was felt that the data recorded on the OTD was misinterpreted as the production line collected data on the OTD, which on average was found to be thirteen days late. This information included the bagging process, which it was thought should have been seen as a separate process to the production line. The bagging department bagged all of the products on site and were not just dedicated to one production line. By reanalysing this information, it was found that the production lead time, without the bagging department considered, would be reduced by 55% to only 8.87 days late. This meant that the true OTD of the cell was 94%, as the team could complete a work order within the allotted 5 days.

The production quantity was also researched as this would broaden the understanding of the customer demand and how the team meet this demand. **Appendix 5.31** (on CD) displays this information. It was discovered that the team on average complete twenty-one work orders per shift, with an average of forty-five connectors per work order. This totalled that the team per shift produced on average 945 connectors per day.

Other information that was gathered was regarding the WIP inventory around the newly relocated line (**appendix 5.32** (on CD)). This information displayed that at one point in time 3009 connectors were currently in the system, which totalled to just over 3 days inventory. From further information gathered, it was seen that the numeric data of the current state map were marginally different. The production lead time was previously based on the lead time of a work order and the activity time was based on the assumption of per connector. So, from revaluating the line, it was apparent that the production lead time equalled 10.55 days (eliminating the bagging process from the map). However, the average activity time per work order was 5.115 hours. The average number of days late was reduced to 8.87 days, so the percentage of value added time (based on an 8 hour day) was 6.1% which was not ideal, but was an improvement and more realistic than previously determined. **Figure 5.49** displays the updated current state map.

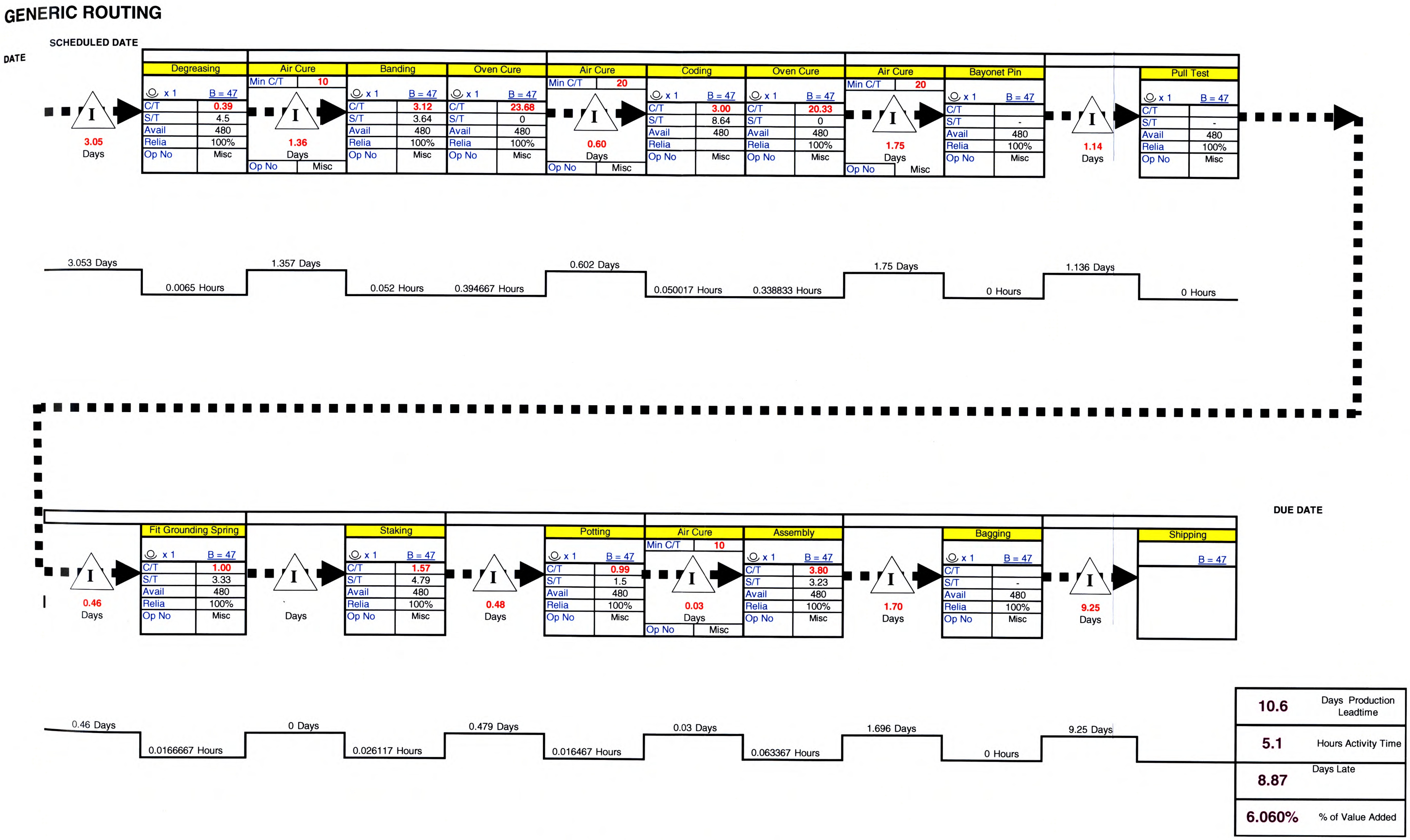


Figure 5. 49: The updated current state map

From the data collected a list of the production line specifics were created. The technical current state of the production line is that;

- There are 7 operators for 9 operations
- Most operators work beyond the core hours
- out of 7 operators worked weekends
- The operators are quite highly skilled within the line and are multi skilled so it would be easy to train all team members for all operations
- The products generally follow 5 different routing throughout the system
- There are many mixed models within the production line
- Customer demand is of a high volume
- Product quality is high within the production line. Quality issues are supplier related, and this is due to uncompleted plating from other on site company operations
- The production line is within a straight line arrangement
- The production line is highly dependant on the team leader for cell organisation and scheduling
- The production line is scheduled by due date
- The production line is allowed 5 working days lead time per product. This is met on average 94% of the time; however the real figure is lower due to external quality reasons

The current state culture remained the same as that created in **figure 5.34** (page 168); this was due to the positive attitude of the team members. This cell was seen as the example of success that the other lines would follow.

The current state simulation model was reassessed to ensure that the further data collected were used within the model to create greater accuracy. As the production line had changed its layout in the time frame, the icons within the model were laid out in the same structure as the production line, however not to scale. **Figure 5.51** displays the simulation model screen view.

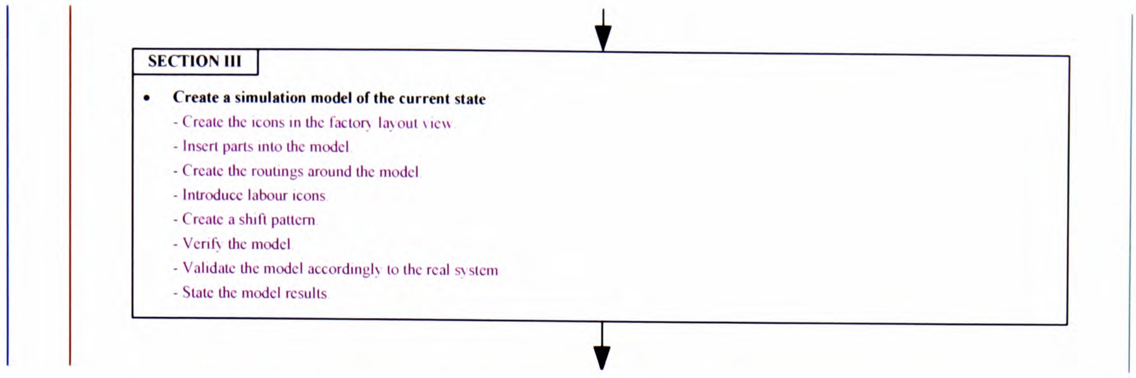


Figure 5. 50: Stage 3, Section III of the proposed methodology

The parts were designed as before and entered into the model; the model has five routings which are defined by the parts and were represented by differing colours in the model. Each part had an inter arrival time of (24 x 60) = 1440 minutes everyday, this was to ensure that each routing type had a number of parts arriving everyday. The model was designed so that the parts operated on a normal shift pattern without any over time. The lot sizes of the parts arriving to the simulation were determined by the number of actual work orders arriving to the cell and the part routing type. In the simulation model each part has a 'Name' attribute to act parts are pushed onto the real system.

The routings around the model can be seen in **appendix 5.33** (on CD). All routing passed through the same first four processes: Degreasing, Banding, Oven Cure and Air Cure. From this point, all the routings are different through the line depending upon the product type. The process routings could be categorised in to five flows around the simulation model. For ease of use, the model was simplified by using this categorisation to reduce logic complexity within the model. This production line is also a mixture of high volume and high variation with the same production process. The most complex logic is centred on the oven process due to variations in the routings; this was accomplished by using the 'NameNo' attribute. Products were pushed around the system depending on the process it had just completed and the type of routing that the part was assigned too. Some buffers had delay periods; the buffer after the oven operation had a 20 minute delay to allow the parts to cool. The buffers after the degreasing, staking and potting operations had a 10 minute air cure delay. The model was designed so that the oven could hold 5 work orders worth of inventory at any one time to highlight the multi use of the oven in the production line with many shelves and trays.

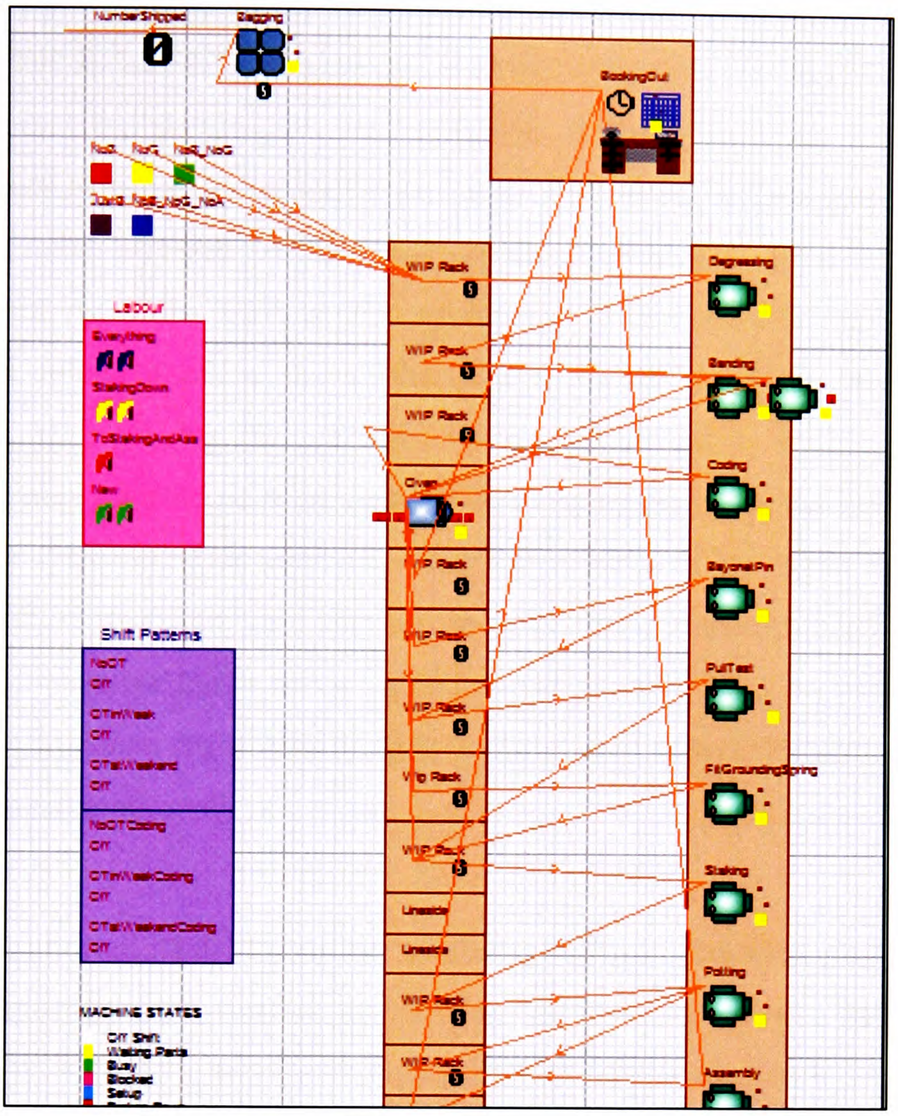


Figure 5. 51: The simulation model screen of the current state

The labour was the main function in the simulation model; the processes would only be carried out if the appropriate labour was there to operate the process. This enabled full visualisation on the capacity of the labour and the model machines, which could not be tested using any other techniques. In the system there were seven operators, operating a nine process system. The system was set up so that there were two team members who were skilled to operate all processes of the production line; one team member was able to work on the production line from degreasing down to staking and could also undertake the assembly process. Another two team members could work within the staking process and sequent downstream processes. The last two team members were new to the production line and were only able to work within the assembly processes.

Shift patterns were created to assign the labour to different shifts depending on the time that they worked. Furthermore, the parts and the processes had to be assigned shift patterns to give a true interpretation of the production line. Three different types of shifts were created; there is one shift for a normal working week with core hours between 8am and 4pm; however the production line work was generally between 6am and 5pm, enabling the team to meet the customer demand. The model assumed that there were rest periods for lunch and two 10 min breaks in the morning and afternoon and at peak times three team members work at the weekends. There are also designated shift patterns for the coding machine due to the limited availability of the machine. The model operates by assigning the machines to the labour and so seven operators are shared between nine production processes and so to cover the set up the labour was then assigned to the different shift patterns. The batch sizes of the work orders varied through distributions and were only used in the cycle times of the machines (production processes). All machine cycle times were varied by multiplying by the 'Batchsize' variable and all products regardless of their routing were moved through the booking system and onto bagging.

The system was verified whilst the model was being built. All routings were built one at time and the routings were verified by slowing the processes down, through colour, cycle counts within buffers and by changing certain factors to ensure the model was correct (see **appendix 5.34** (on CD)). The model was also verified by using the reporting system within the software (see **appendix 5.35** (on CD)).

The model was then validated against the real system WIP. A snapshot picture at this level of WIP was confirmed in the model, as well as the WIP levels recorded by the production team (see **appendix 5.36** (on CD))

The simulation worked accordingly to the real system. After running the model with a warm up period and then a true production year, the model highlighted that the main bottlenecks were the banding and coding. Inventory previous to the banding operations was 601 products and before the coding operation the inventory quantity was 394. The highest utilised machine was the coding machine at 99.7% and the banding machine was also highly utilised at 96.7%, however the majority of the time (63.2%) was awaiting labour. The highest utilised labour was 'ToStakingAndAss' at 98.9%, whilst the oven operation had one of the lowest utilisations at 2.85%. From these results it was noted that the following action had to be taken, which was to increase the banding operation, however it was felt that by increasing the operation, the bottleneck would just move further downstream. The model therefore required analysing in Stage 4.

More general results were also highlighted, the model showed that it was very complex to organise seven operators between nine operations, due to the different routings and skills. As most of the team members were skilled of the downstream processes, the largest bottleneck was at the front of the production line. The upstream processes where the bottle neck was the greatest is around banding and coding, this is where the operations are also machine reliant. For the coding machine only having 50% availability is a large constraint on the system. The only concern was that if the bottleneck operations were relieved the bottlenecks would occur around the staking, potting and assembly processes because the cycle times are slightly longer than the upstream processes.

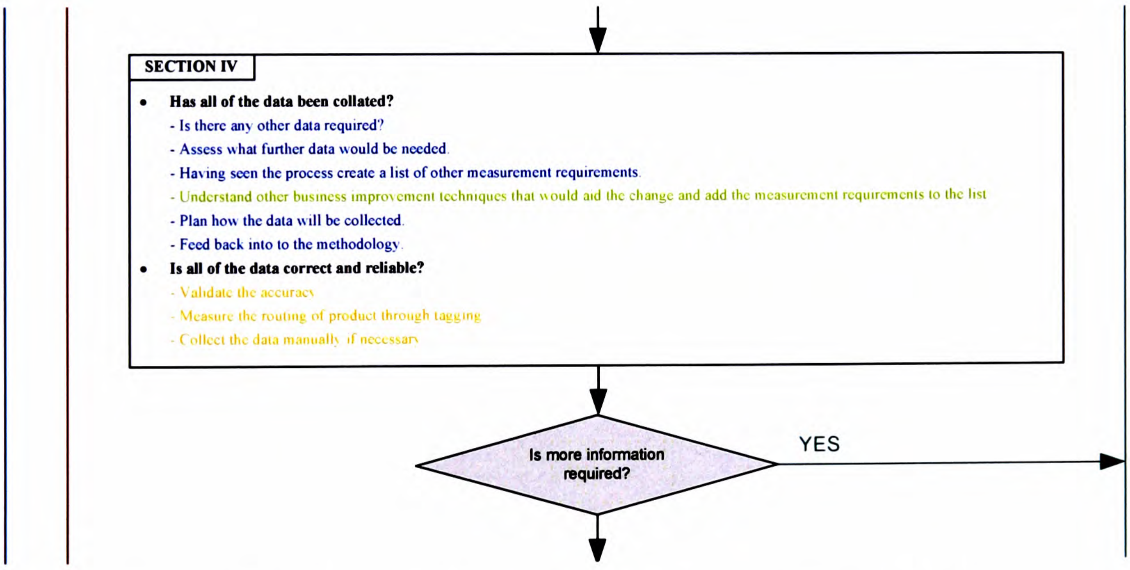


Figure 5. 52: Stage 3, Section IV of the proposed methodology

All of the data that have been collected have been used within the PAMs, the VSM and the simulation models. It was thought that no further information would be required as the information was best analysed and the system transformed.

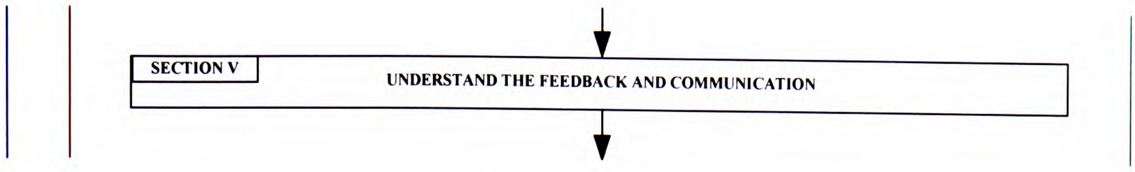


Figure 5. 53: Stage 3, Section IV of the proposed methodology

The production line team and team leader were very accommodating and the data were easily collocated, again the information was collected manually through observations and meetings. However, this time the data collection process was more informal due to the familiarity and the understanding of the project requirements. All guidelines were completed, in some cases very detailed.

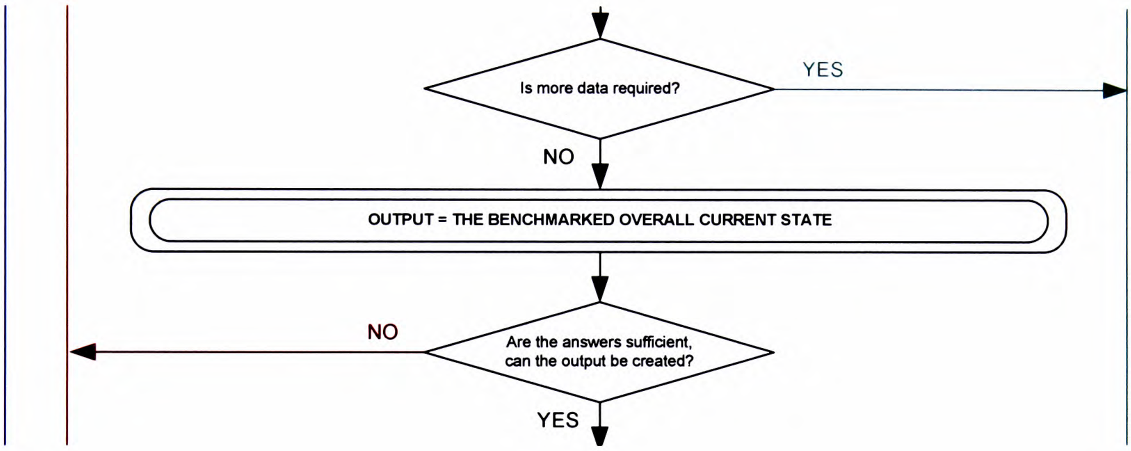


Figure 5. 54: Stage 3 output of the proposed methodology

No further information was required and the necessary outcomes were achieved, allowing the application to move onto Stage 4.

5.4.7 Stage 4 – Analysing the Technical Data and Defining the Technical Future State

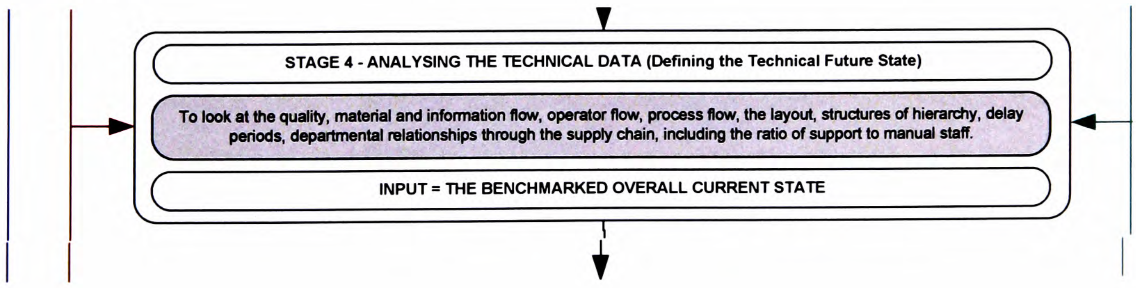


Figure 5. 55: Stage 4 heading of the proposed methodology

The newly benchmarked current state was mapped in **figure 5.49** (page 180), the cultural classification remained the same as that in **figure 5.34** (page 168) and the simulation model had been thoroughly validated. As second data collection took place, there was a great urgency to ensure that all of the information that was required for the analysis was obtained and this stage allows for this to take place.

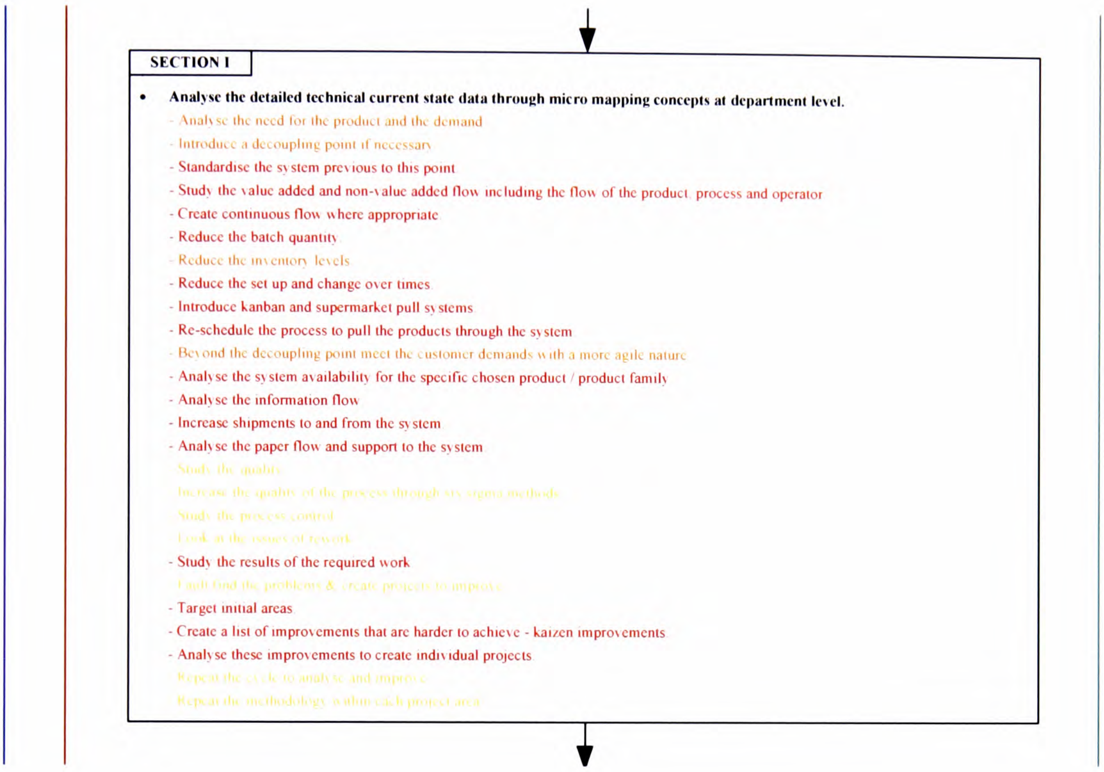


Figure 5. 56: Stage 4, Section I of the proposed methodology

The data collected on the customer demand of the production line across all products can be seen in **appendix 5.31** (on CD). On average, the customer demand is 21 work orders a day, which equates to an average of 945 connectors.

It is thought that the production line was standardised with regard to process flow and product routing, although there is a small routing variation, this really is negligible with regard to the product volume. The better improvement would be to rearrange the product and operator flow through the standardised production process and allow the production line manage itself with pull systems and more efficient line side stock. Standardising the system prior to this point would work within the existing standardised physical production procedure. The product flow would have small variation due to the existing product routing, however the process improvement would be mainly within the operator flow.

The value added and non valued added flow was studied within the VSM and can be seen in **figure 5.49** (page 180), this was created from the survey and observation data. The flow of the product around the production was discussed in Section 5.4.3 and can be seen in **figures 5.31** (page 164), **5.32** (page 165) **and 5.33** (page 165). This data collected confirmed that the process improvement would be best within the product and operator flow. There is little improvement to be made within the process flow and organisation as the company had undergone a relocation improvement plan, however, there remains room for improvement within the product and operator flow.

The takt time had been calculated for both a normal working week without any over time and a working week with some work on Saturdays (calculated from previous data **appendix 5.31** (on CD)).

Takt Time (Normal working week)

$$= \frac{\text{Available work time / shift}}{\text{Customer demand rate / shift}}$$

$$= \frac{\text{8am till 4pm minus breaks per shift}}{\text{21 w/o per shift}}$$

$$= \frac{(8\text{x}60) - (30+10+10) \text{ minutes per shift}}{\text{21 w/o per shift}}$$

$$= \frac{\text{430 minutes per shift}}{\text{21 w/o per shift}}$$

= 20.5 minutes a w/o is to be completed

Takt Time (Working week with overtime)

$$= \frac{\text{Available work time / shift}}{\text{Customer demand rate / shift}}$$

$$= \frac{\text{6am till 5pm minus breaks per shift}}{\text{25 w/o per shift}}$$

$$= \frac{(5\text{x}60) - (30+10+10) \text{ minutes per shift}}{\text{25 w/o per shift}}$$

$$= \frac{\text{610 minutes per shift}}{\text{25 w/o per shift}}$$

= 24.4 minutes a w/o is to be completed

The cell already works directly to shipping onto the bagging process; however the bagging lead-time could be studied. The bagging process on average 9.25 days, which in turns equates to 46.7% of the whole overall production lead-time.

Eliminating bagging from the loop, the production lead-time = 19.8 – 9.25 = 10.55 days. The average number of hours activity time per w/o = 5.115 hrs. Currently with bagging included in the production line the % of value added;

$$= \frac{(5.115/60)}{(5.115/60) + 19.8} \times 100\% = \frac{0.08525}{19.88525} \times 100\% = 0.4287\ \%$$

0.4% of value added activity within the overall lead-time. With bagging not included in the production line the percentage of value added;

$$= \frac{(5.115/60)}{(5.115/60) + 10.55} \times 100\% = \frac{0.08525}{10.63525} \times 100\% = 0.8016\ \%$$

0.8% of value added activity; therefore there is still room for improvement.

In this case study, the production line has a high volume as well as high variety, it is thought that the production line could work on a continuous loop with little WIP apart from air cure times and cooling from the oven. First In First Out (FIFO) lanes can be used here. As the team members are highly skilled amongst the line and the training for the production line is inexpensive and not particularly time consuming, it was thought that the product can be produced with very little operator variation, if at all any. The line would be one continuous system with the operator following the product from the beginning to the end of the production line. The variations of size and consequently time would need to be considered to allow the products to flow easily down the production line, but this should not be much of an issue as the variation in cycle times of the individual connectors is minimal if non existent. The main consideration would have to be the splitting of batches, to reduce the batch size to a more average figure (ideally down to one). The routings, even though it is hard to analyse through this mapping method have been examined, the percentage of the products that flow through the process had been noted on the map, this information had then been used to analyse the continuous flow and the FIFO lanes through the line.

It was found in the data collection process that a number of customer's products are placed into one batch if the requirements are the same, thus also increasing the batch size. This project will reduce the batch size down to a more level loaded figure to reduce variation. Reducing this to zero to introduce one piece flow would be too unrealistic. Air curing times after degreasing and potting is a minimum of ten minutes, if we assume that on average it takes one minute at any point within the production line to manufacture a connector, we can assume a batch size of ten to compensate this drying time. This will then balance the line almost evenly along the process. This allows immediate flexibility to the customer and also levels the demand to the supplier, therefore keeping the cost of inventory to a minimum.

It is felt that some of the non valued activity could be reduced to zero; air cure times are part of the process and therefore are necessary. However in some processes where the items are air cured, the rest of the batch could be worked on whilst the items are drying. The batch size on the production line varies significantly as well as the item type. It was felt that this production line can be a continual pull system from start to finish as this is due to highly skilled staff, the ability to train staff easily, as well as a fast moving production line including the high standard of the product produced by the line. Team members can use their skills to be able to move through the system automatically and FIFO lanes are only necessary in this system (air cure times after the oven process).

All tooling that is required is close to the operation. However there are set up and change over times, they have been reduced to the minimum and do not affect the output of the line. This reduction of setup and changeover times could be a future improvement project; this is a lower priority. It is thought that a continuous system could be put in place as the cell quality is 94%, so that when the customer requires the product it will move through the production line when needed. A supermarket pull system will work at the beginning and end of the production line to allow safety stock and resolve issues elsewhere around the production line as an interim measure. This improvement will cause the finished goods supermarket to fluctuate, however the WIP and inventory store will level, causing less demand fluctuation to the suppliers.

With regard to rescheduling the process and pulling, it is possible to pull the products through the system, using the straight production line, with minimal WIP.

As the system is to be considered as a continuous pull system, the production line will be scheduled at the most upstream process, which is degreasing. The pacemaker process will be degreasing as the production line. When the product is required, the signal will be sent to degreasing, the product will move non stop with the operator until the final process is complete. The production line is relying on skilled staff to move with the product down the production line. Utilising the production line capacity is the key to scheduling the system.

The line has been evenly balanced to incorporate the different labour skills as well as the batch size; the amount of labour at any given point in the production line has also been balanced accordingly to these requirements. The system will be one continual pulled loop, what is required by the customer is produced and can be completed in just over 1½ hours including oven cure and air cure times within FIFO lanes. For the interim, it will be decided by the materials handler to level the products at the pacemaker process because the percentage split of the product variety is known.

When the system availability was analysed, it was found that the coding machine is shared within another production line and so the studied production line has an availability of 50% of the working time. This was been seen as the greatest bottleneck within the team and the simulation models also clarify this. An independent coding machine would be required to enable an improvement in the production flow.

The information flow around the system is scheduled through the company's scheduling system. The indication to the production line that work is required is from a combination of either when the materials appear from the stores or when the production schedules the requirement and the material is located. The production line team leader then schedules the line from the due date requirement, which is also a new system that has been put in place since the relocation. The older system allowed the production line to have 5 days to manufacture the item. The relocation project introduced the new racking system to identify the more urgent products. Material from stores is placed on a set of shelves at the beginning of the production line. When a team member walks past the shelves, the material is placed on the new racking system in order of urgency.

Shipments from the system are booked out of the production line as soon as the product is complete; however products then sitting within the bagging area and those products that are to be exported are held for specific shipment dates.

The system could be improved by moving the products straight from stores to the production line; however it then means that the people in stores have to be aware of which products are for what production line. Better still, the materials could be placed from the dock to the shop floor, eliminating the stores transactions completely. Shipments are made immediately from the cell however, there has to be consideration of exported products. The pitch, the increment of work released to the system has been calculated and as the production line produces directly to shipping the pitch time is actually zero, so in this case the pitch at which the work is released to the production line is according to the takt time. This is the responsibility of the material handler.

When analysing the information flow and support to the system, it was found that work orders are a paper system support the products within the production line. This allowed the team members to identify the stage of production, as there are other facets around information flow which are not scoped within this investigation. Further project work could include investigating the information around the production line. It is possible to initiate the work from triggering the consumption of finished goods; however this is dependent upon the planning system and the specific limits set around this. This investigation is also beyond the scope of this project.

The quality was studied within the production line (see **appendix 5.28** (on CD)). It was found that the quality within the production cell is very close to 100%. The quality within the production cell is sufficient enough to implement process improvement tools and it is thought that improvements within the product flow and operator flow would have a greater impact on improving the lead time of the cell. There are many quality issues that are imposed upon the production line, these issues are mainly related to the plating of the components from the in house machine shop. The quality within the cell is to a high standard there would be greater gain by improving the flow of the product and operator. Improvements would include better scheduling within the cell, as this would make the cell is less reliant on the team leader. As the quality of the production line is of a high standard, it was discovered that the main reason for rejection came from the plating of the shells from the on site machine shop, but this problem is only noticed on the production line, it was therefore decided that it would be better to inspect the quality at the plating processes.

Occasionally products are sent back to the company from the customers; however this is not the fault of the production cell but is usually due to the manufacture of the components and is therefore a problem for the company's supplier.

The results of the investigation show that the main area of improvement is the flow of the product through the cell. This can be achieved by not only regulating the flow of the work throughout the cell by reducing the fluctuation of the arrival of products and levelling the demand, but also through the availability of the machinery. The organisation of the labour, introducing training of the whole assembly line to all team members would create flexibility within the cell by producing a skills matrix. This will allow the labour to move with the product, having a complete pull system throughout the cell and will relieve any WIP within the cell, reducing the lead time further.

Initial areas to target would be to train the staff over the whole production line as much as possible to enable process standardisation. As quality within the cell is high, the set up times and change over times are low and so these are seen as insignificant to the rest of the system. The materials handler will have the responsibility for scheduling the system daily and so this may require training and understanding of the new system. To ensure the levelling of the cell, 100% availability of the coding machine would be required and batch sizes would also need to be reduced again to level the production line better.

The production is one of three lines and so further initial projects would be to expand these ideas vertically through the company production lines, and integrate both the internal and external supply chain. This would include focusing on the customer demand but also understanding the supplier limitations. This project has involved investigating a small production line within a supplying company. The supplier to this production line is the main stores of the company and the customer is the bagging and dispatching processes. All of these areas would benefit from improvements, especially along the same guidelines and methodology presented in this project in order for this project to succeed overall.

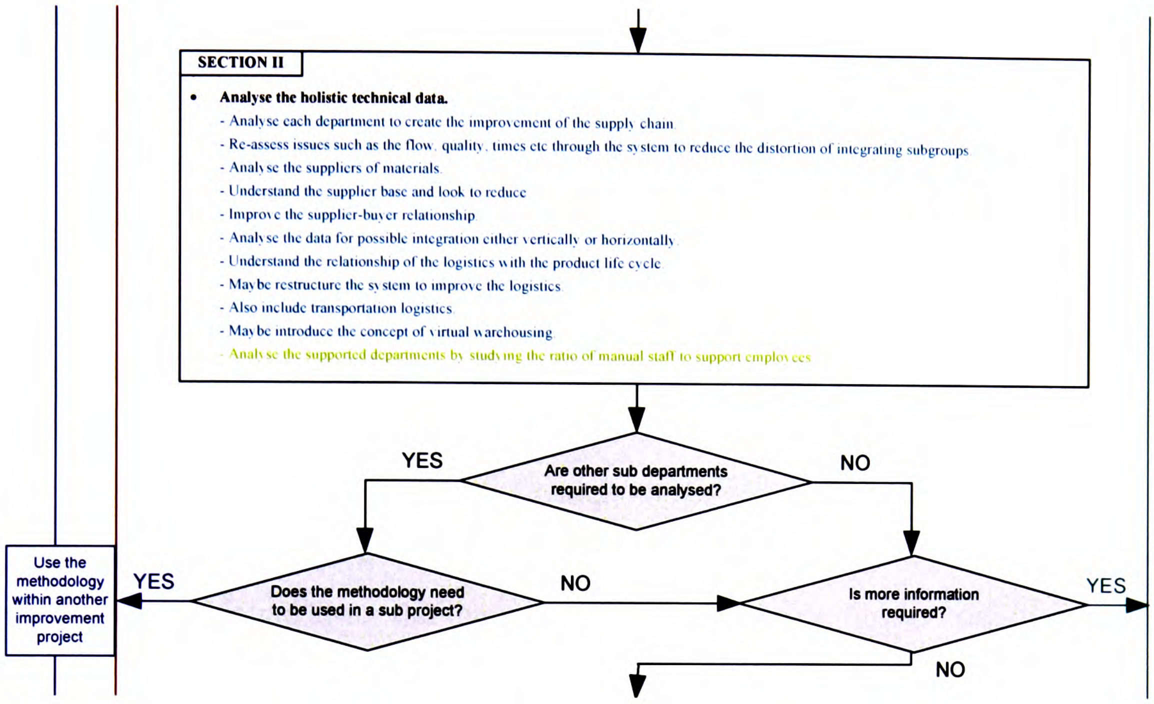


Figure 5. 57: Stage 4, Section II of the proposed methodology

With regard to creating improvements throughout the supply chain, the main focus in this study is the production line; another project could be to follow the products through to the customer production line. Reassessing issues such as the flow, quality and times through the system to reduce the distortion of integrated subgroups is a large task that is not required for this small project, an improvement can be made without working through the supply chain in this instance. Within another project, the supply chain could be assessed and the first initial stages could be to use the same theory and techniques through the company's supply chain and to understand the enterprise issues.

The supplier of the material in this case is the main stores on site, the system has been designed so that there are supermarket buffers before the production line to allow for flexibility between the push and pull systems. However, the methodology suggests the external material suppliers and this is out of the scope of this project. This first case study for this research work is to understand the supplier-buyer relationship and so this has been carried out externally to this case study application. This first case study application is measuring the relationship by initiating further projects to improve within both companies. The other guidelines in this methodology are to generate work within the departments of the company which is outside the scope of this project.

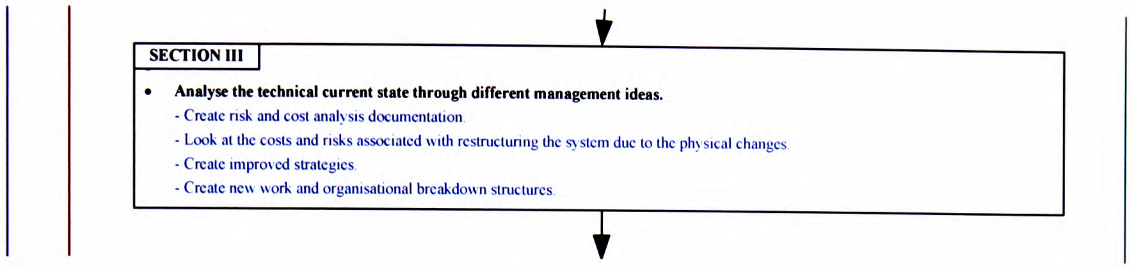


Figure 5. 58: Stage 4, Section III of the proposed methodology

Cost implications are minimal as the company are realigning the production area to improve the product and process flow throughout the site. This project is aimed to assist the production line through process improvements by assessing the product and operator flow. The results found from the theory need to be analysed further and justified before implications of cost are considered in detail. This project involves training the staff in all processes as well as to the new system; however the percentage of productivity can be increased by 102% of value added.

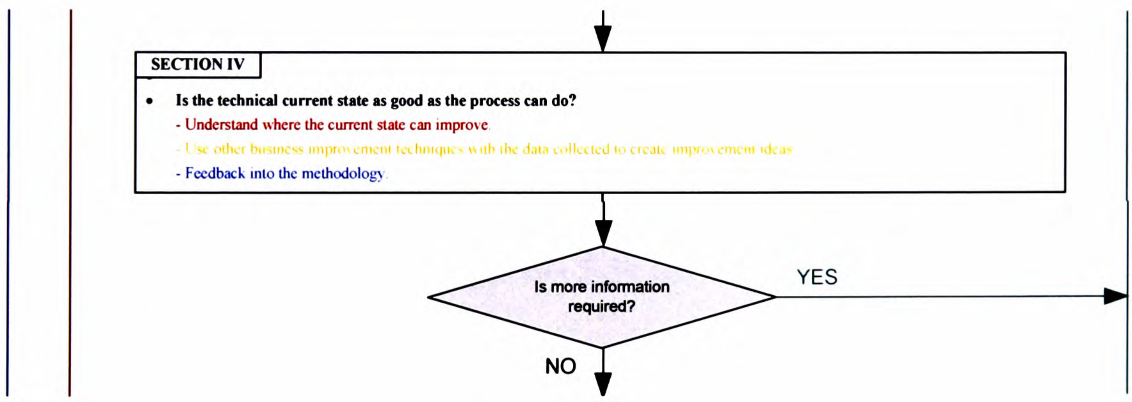


Figure 5. 59: Stage 4, Section IV of the proposed methodology

Simulation modelling was used to analyse the current system, from these results (**appendix 5.36** (on CD)) it was highlighted that by increasing the banding, the bottleneck moved onto the coding operation. The buffer before the coding process held 554 products which was 57% of the total of the WIP in the model. The coding utilisation was also 98.98% so it was working at its highest capacity. The highest utilisation for the labour was "ToStakingAndAss" which is the labour that operates the coding process; the results also highlighted the start of a bottleneck at the staking operation.

It was decided that the coding machine limitations were to be removed and so the coding machine would have unlimited availability. This indicated the need for a dedicated machine and highlights the thoughts of the team. The overall results were (**appendix 5.37** (on CD));

- The cell output increased from 978 to 1025 products and so this was an increase of 4.8%
- The coding bottleneck had moved to the staking operation
- The staking operation results are that the simulation machine representing the operation is 100% busy, however 65% of this time the simulation machine has to wait for assigned labour
- The labour for the staking process, which used the "Everything" and "SteakingDown" employees in the simulation model, the utilisation was 70% and 81.7% respectively

From these results, it was decided that it would be cheaper for the company to introduce another staking operation as there is the potential for up to four staking operations. Another staking process was introduced into the line but with the same amount of labour. The results were that (see **appendix 5.38** (on CD));

- The overall output increased a further 16.8% from 1025 to 1197
- The bottleneck had now moved further downstream and was now before the potting and assembly processes
- The utilisation of the assembly process was that the process was actually busy 99.9% of the time, however again there was a large amount of time (66/6%) that the machine was waiting for labour
- The potting process had similar figures, 99.8% of the time the process was busy but 69.2% of the time the process was awaiting labour

- For the labour that operated these operations, "Everything" and "StakingDown" the percentage of utilisation was 95% and 97% respectively

Again from these results it was seen that the bottleneck was the availability of the operation, not the labour. The third analysis looked at increasing the assembly and potting operations from one operation station to two. The detailed results can be seen in **appendix 5.39** (on CD), the overall results were;

- The overall output increased further by 27.3% from 1197 to 1524.
- So the overall output across all of the analysis had increased by 55.8% from 978 to 1524.
- In this case there were not any bottlenecks; however the overall labour utilisation was high.

Everything	=	95.5%
New	=	66.8%
StakingDown	=	95.5%
ToStakingAndAss	=	98.2%

The cell met the requirements of the customer, however the utilisation was high. This required the output to be lower and the utilisation thus reducing.

From analysis of the current state using simulation modelling, the production could remain in the same environment with the same method of manufacture, on a normal shift pattern with the same scheduling system, with a dedicated coding machine, two staking operations, two potting processes and two assembly processes, with the same amount labour and same skills. However, with this system, there is little capacity to increase the workload to the system. With future business the system does not have any greater flexibility to meet customer requirements with a shorter lead time, even though greater output has been achieved.

The changes that have been used to transform the technical future state map are heavily reliant upon reorganising how the system operates through adding the process quantities and reorganising the labouring schedule to suit this, as well as to schedule material to and from the system. This requires the team to be trained within all production processes, so that the operator can move with the product. The improvements also require the system to reduce the batch size to ten. No further information was required and the technical future state map could be produced.

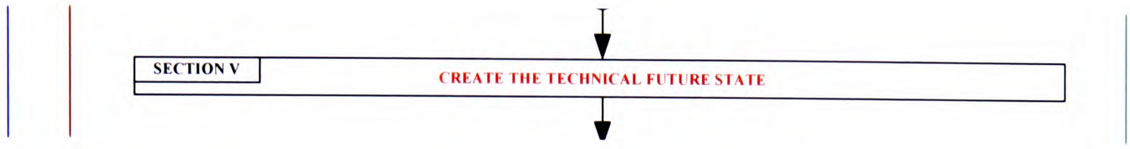


Figure 5. 60: Stage 4, Section V of the proposed methodology

Figure 5.62 highlights the technical future state map.

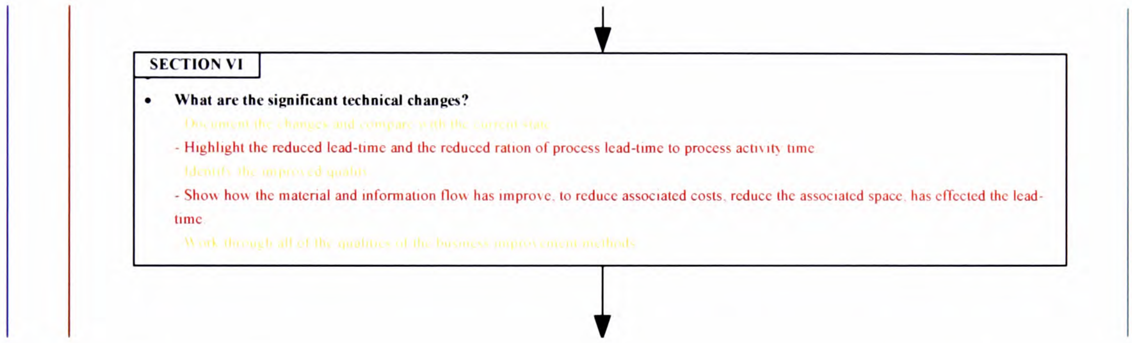


Figure 5. 61: Stage 4, Section VI of the proposed methodology

It can been seen from **figure 5.62** that if a system such as this is created, the overall lead time has been significantly reduced from 10.6 days down to 4.2 days. This has increased the value added percentage figure from 2% to 44%, this is a 22 times increase or 2200%. It can be seen that the activity time has also reduced from just over 5 hours to just less than 1 hour; however this is mainly due to the reduction in batch size to compensate for the air cure times. Initially, the batch size was 47 with an activity time of 5.1 hours which was reduced to a batch size of 10 with an activity time of 57.2 minutes.

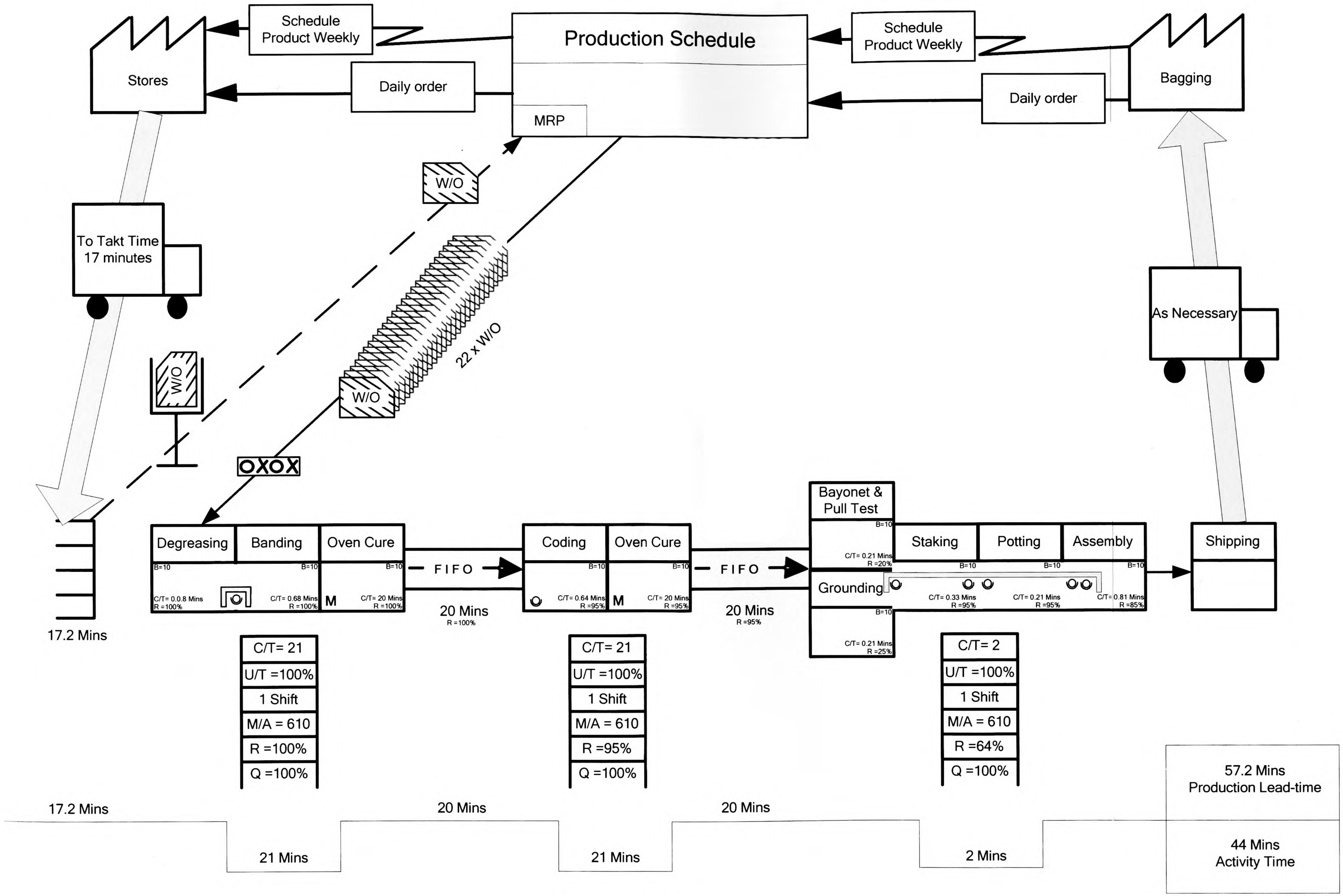


Figure 5. 62: The technical future state map

Quality issues have not been raised in the project, for previously explained reasons. There are quality issues surrounding the production which can be initiated in further projects and further research.

The material flow through the system will greatly improve as well as the material flow to and from the system. The information flow still has room for improvement, however there are many external forces that effect the information flow and so initiating change within the information flow including the production schedule, the ERP and MRP system would require further project work and research, which in turn will effect other production lines and processes that are yet to be studied and improved.

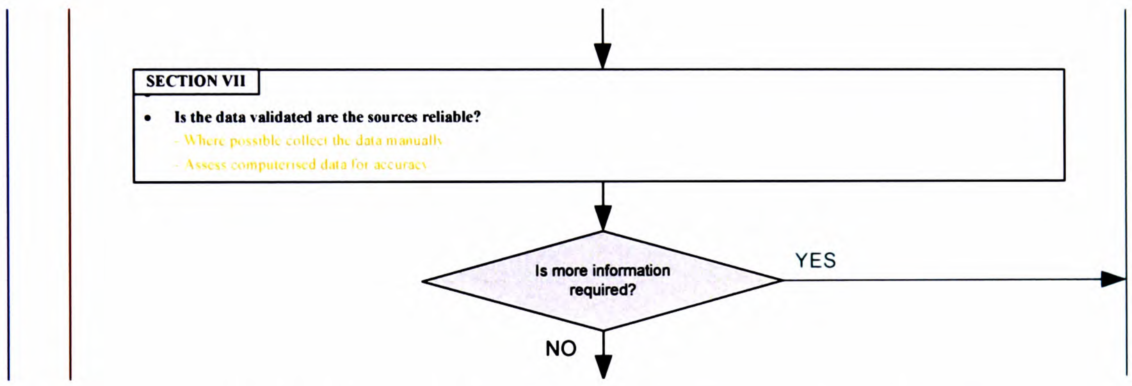


Figure 5. 63: Stage 4, Section VII of the proposed methodology

All information that was required was collected previously and the sources of data collection were assessed at that point in the application process.

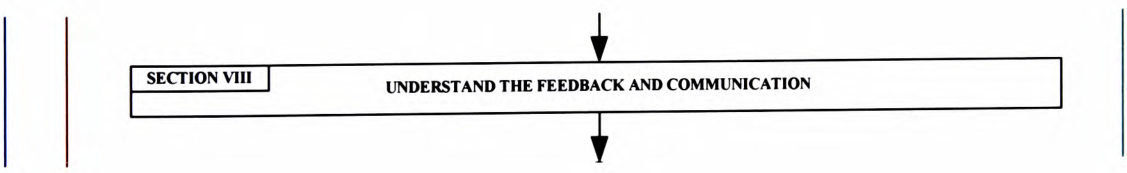


Figure 5. 64: Stage 4, Section VIII of the proposed methodology

All guidelines were met and justified at the time of application, no other changes have been made to the project and no further information is required. With regard to the project progression, due to the need to calculate some further information the project was a little behind the project plan, however it was felt that there was no need to make adjustments to the plan to compensate for this as it is felt that the project will still remain within the target time. As this stage involved analysing the data collected no external people were used to apply the theories and so the concepts of cultural management were not required.

No further information was required and the answers were sufficient in the stage to proceed to the methodology application. The technical future state was shown in **figure 5.62** (page 199) and the reasons and justification of this change was discussed. A comparison between the current state and future state was made and the differences benchmarked.

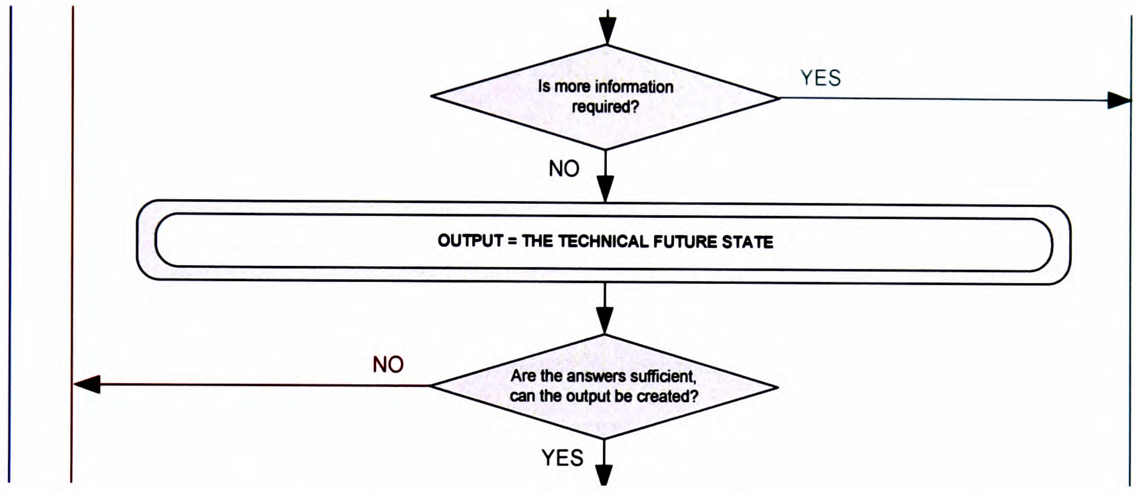


Figure 5. 65: Stage 4 output of the proposed methodology

5.4.8 Stage 5 – Improving the Results and Defining the Optimum Technical Future State

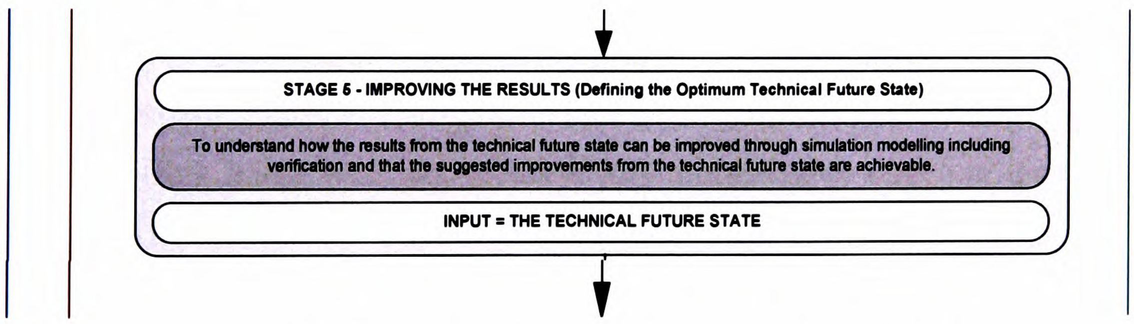


Figure 5. 66: Stage 5 heading of the proposed methodology

Taking all previously collected current state data along with the analysis of these data, it was decided that the optimum could be achieved by analysing the future state through simulation modelling.

Taking the results of the technical future state design, simulation modelling was used to analyse this further. The current simulation model was taken and adjustments and assumptions were made, these were;

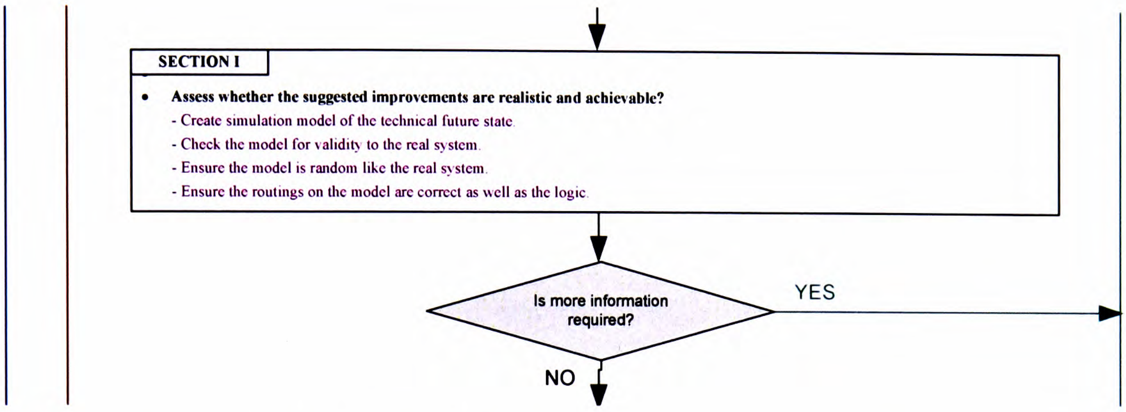


Figure 5. 67: Stage 5, Section I of the proposed methodology

- The process flow was levelled
- The shift pattern was reduced to a normal working week
- All operators were skilled in all areas
- The operating batch size for all products was reduced to 10, therefore the part inter arrival time was increased
- Re-analysis of the process times according to the future state map which required averaging the cycle times used as the batch sizes did not vary
- Created pull systems to limit the WIP around the oven operation and so FIFO lanes were used for air cure times
- All delay times were removed within the buffers except for after the oven process
- Staffing levels were not reduced, just re-evaluated; therefore there were no job losses

The new future state routing for the model can be seen in **figure 5.68**. This diagram highlighted the continuous flow around the production line as well as the FIFO lanes required around the oven process for air curing times. The model screen was not any different from the existing view; however the logic and routings were changed to produce the technical future state model.

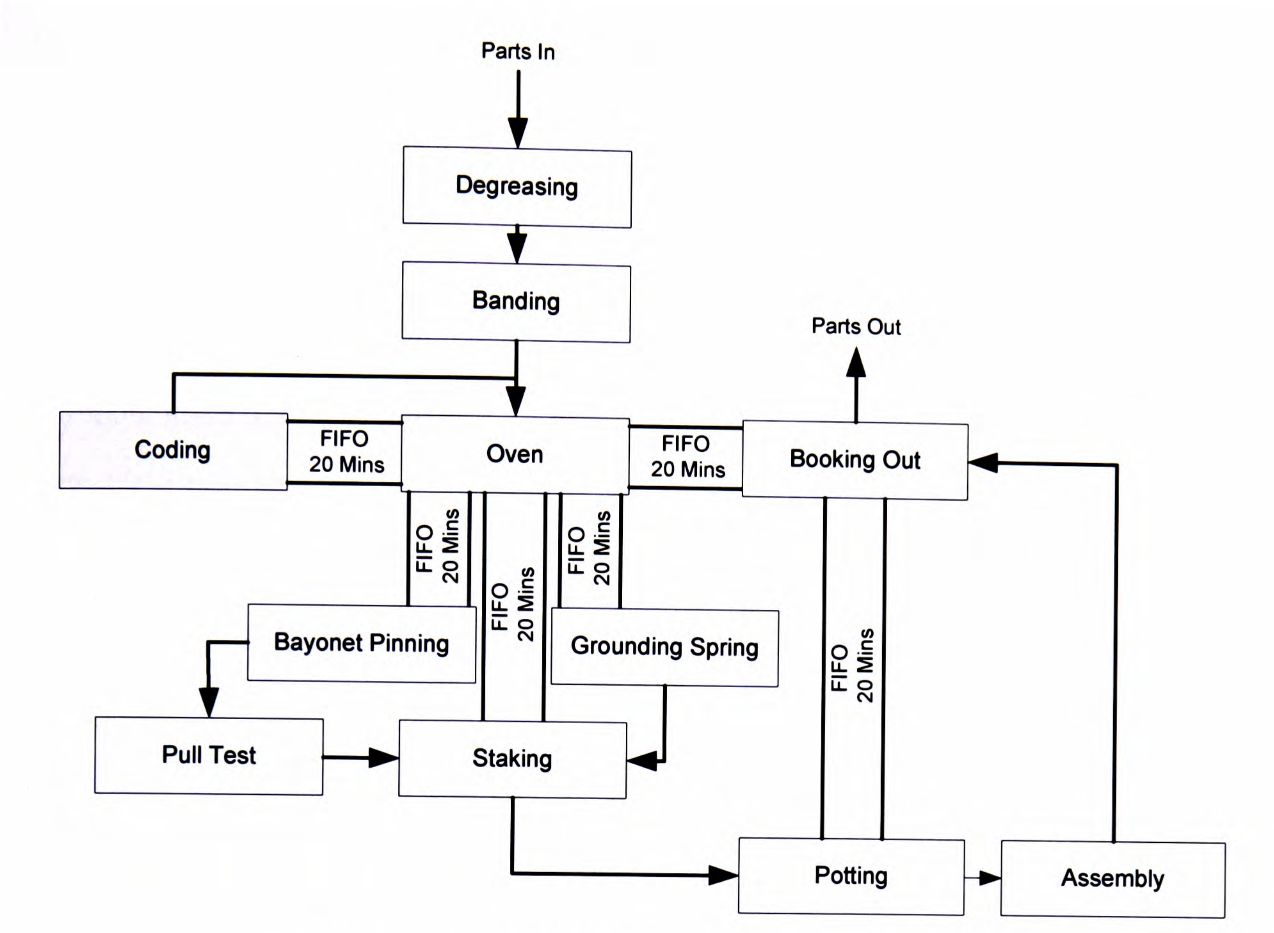


Figure 5. 68: The future state simulation mode routing

The variation and validity of the models were tested again, through the reporting function in the software. The results of this system can be seen in **appendix 5.40** (on CD). It was noticed that with the processes on different shift patterns inaccurate times for the percentage of time that a process had to wait for labour were being given. The solution was to put the machines and labour on the same shift pattern, the results of these changes can be seen in **appendix 5.41** (on CD). Parts were validated within the model by checking the routing through final buffer counts and queues as well as the logic around the model.

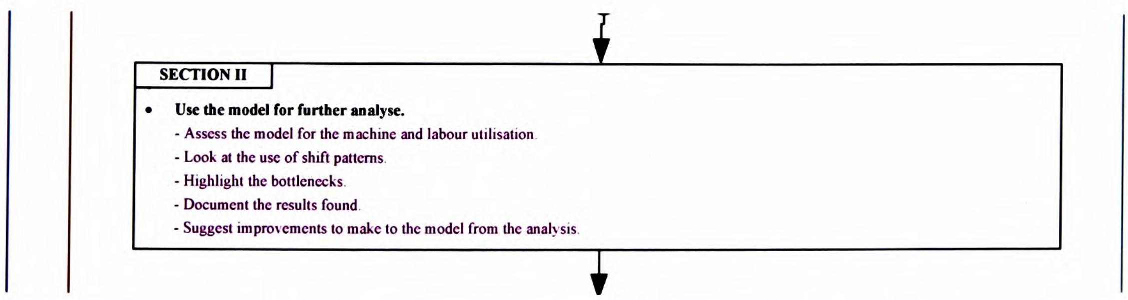


Figure 5. 69: Stage 5, Section II of the proposed methodology

The model was run for a year and the results produced highlighted that 2869 work orders were run through the system in comparison to the original current state model of 978 work orders. This produced an increase of 193%. It was calculated that the model was still 341 work orders short of meeting the customer requirements. However there were another 920 within the system waiting to be processed and were caught within the bottlenecks of the system. It was also noticed within the results that the labour overall is only 45% busy which is better than the current analysed system; however there is still room for improvement. The largest bottle neck was the degreasing and banding operation, where the percentage of utilisation was 93%.

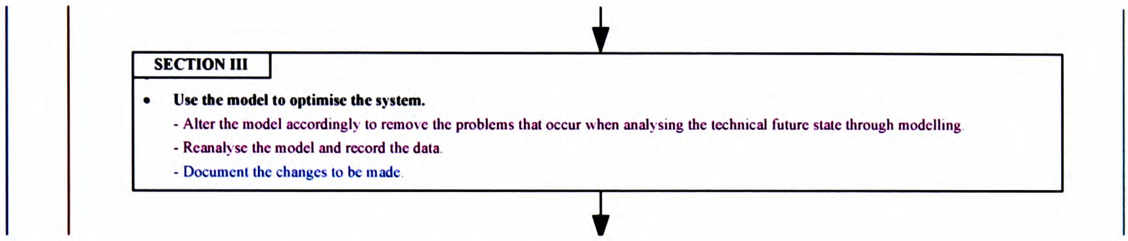


Figure 5. 70: Stage 5, Section III of the proposed methodology

The model was optimised through analysis, and the removal of any bottlenecks. To do this, the process capacity had to be increased and so another process was added for the degreasing and banding operation as well as for the coding machine. The results produced from the model having been run for a year and can be seen in **appendix 5.42** (on CD). It was discovered that;

- The output increased from 2869 to 3136
- The bottleneck previous to the degreasing and banding operation had reduced from 4140 to 3865
- The utilisation of the labour across the production line was only 49.3% busy
- There were large blockages around the oven, the processes before the oven had an average blockage of 49.3% and the processes after the oven had an average blockage of 61.3%

This resulted in requiring more capacity around the oven and it was thought that more trays could be used to utilise the capacity of the oven better or another oven would have to be purchased.

The model was analysed with another oven, increasing the oven process to two machines. The results created from the modelling software package can be seen in **appendix 5.43** (on CD), the overall results were that;

- The output increased from 3136 to 5235
- The blockage before the degreasing and banding operation had decreased from 3865 to 1762, with a maximum blockage of 1807 at any one time
- The labour utilisation had increased and everyone was better utilised at 82.2%
- There were still blockages in the system; however the line was producing more than the customer requirement

All of the extra capacity required is currently available to the system. The only investment from the company would be another coding machine so that the production line does not have limited availability. Another investment would be the oven as this becomes a bottleneck; however the production created with this extra oven exceeds the customer requirement.

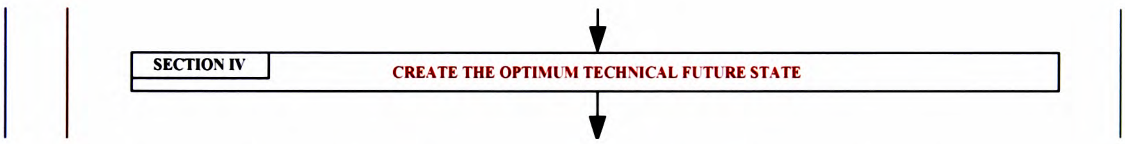


Figure 5. 71: Stage 5, Section IV of the proposed methodology

The optimum future state visually looks exactly the same as the technical future state; however organisation of the line has been evaluated. Within this line, there is one coding machine, two combined degreasing and banding operations and either with one oven with more trays or two ovens. The labour is multi skilled and there is no over time required in the system.

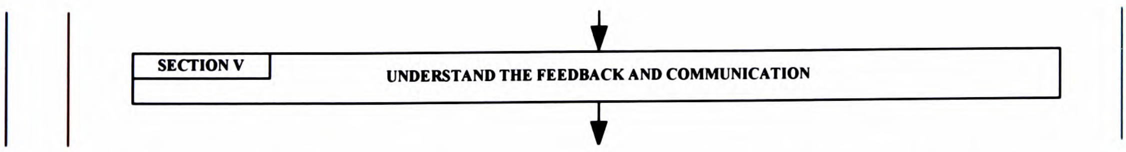


Figure 5. 72: Stage 5, Section V of the proposed methodology

No further information was required as all of the guidelines were met. What was thought to be necessary was a comparison of the changes throughout the application **figure 5.74**. Issues related to current state culture and cultural changes are recognised in the next stage and so it was thought appropriate to proceed.

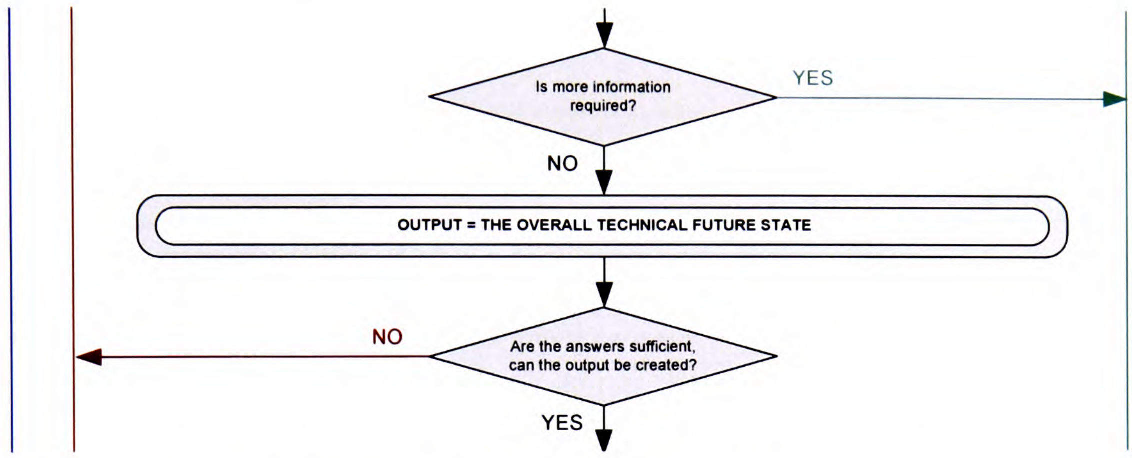


Figure 5. 73: Stage 5 output of the proposed methodology

No further information was required and **figure 5.74** displays the benchmarked stages throughout the methodology application. The specifics in each milestone have been extensively discussed at the point of application, however it can be seen that the production output has increased by 81%. The labour utilisation has increased however at the lower utilisation levels; there are large amounts of inventory around the bottleneck processes. Overtime has been eliminated in the technical mapping analysis, however the same amount of staff are still required.

The number of processes has increased to two, however this is at no extra cost because the operations are manual; therefore, there is only need of extra capacity.

		Current System	Current System Simulated	Technical Future State	Technical Future State Simulated
No. of Operations	Degreasing	1	1	1	2
	Banding	1	2		
	Coding	0.5	1	1	1
	Bayonet Pining	1	1	1	1
	Pull Test	1	1		
	Grounding Spring	1	1	1	1
	Staking	1	2	2	2
	Potting	1	2		
	Assembly	1	2	1	2
No. of Machines	Oven	1	1	2	2
	Shift Type	Overtime	Overtime	Normal	Normal
	Labour Skills	Different	Different	Same	Same
	Statistical Output	978	1524	2869	5235
	Statistical Labour Utilisation	65.3%	89.7%	45.0%	82.2%
	No. of Operators	7	7	7	7
	Production Leadtime	19.8 Days	19.8 Days	236.8 Mins	236.8 Mins
	Activity Time	1 hour / per connector	1 hour / per connector	179.6 Mins	179.6 Mins
	Days Late	13	13	0	0
	% of Value Added	0.61%	0.61%	75.8%	75.8%
	Notes	Contains WIP	Contains WIP	Continuous Flow	Continuous Flow
		Contains bottlenecks		Contains bottlenecks	

Figure 5. 74: A table of the data benchmarked throughout the application

5.4.9 Stage 6 – Analysing the cultural data and Defining the Overall Future State

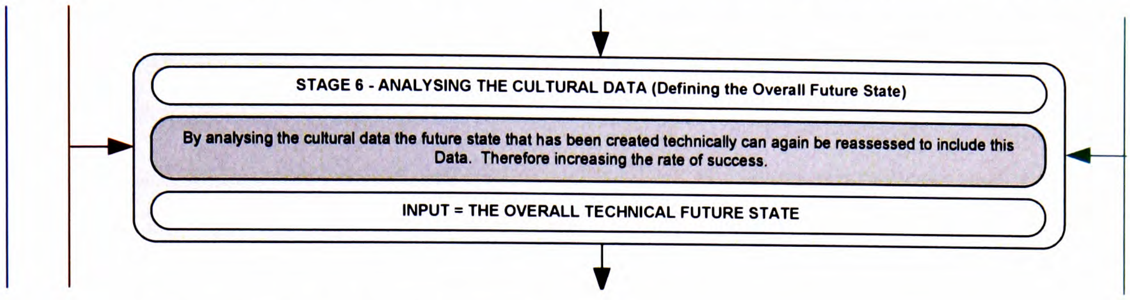


Figure 5. 75: Stage 6 heading of the proposed methodology

All technical data that has been processed can be seen in **figures 5.61** (page 199) **and 5.74** (page 207). It was noticed in the previous stage that many transformations have occurred, increasing the output and utilising the operations and labour more efficiently.

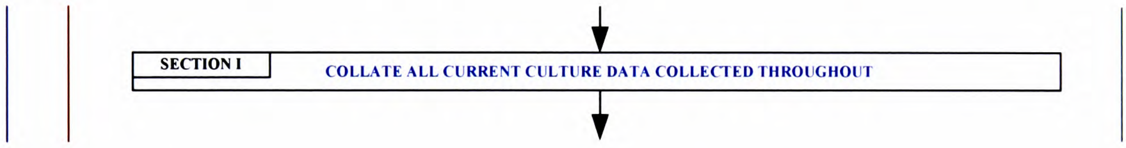


Figure 5. 76: Stage 6, Section I of the proposed methodology

The cultural data that has been collected throughout the methodology application and can be seen in **figures 5.10** (page 147) **and 5.34** (page 168). The communication and feedback key has been used to determine any changes in the cultural environment.

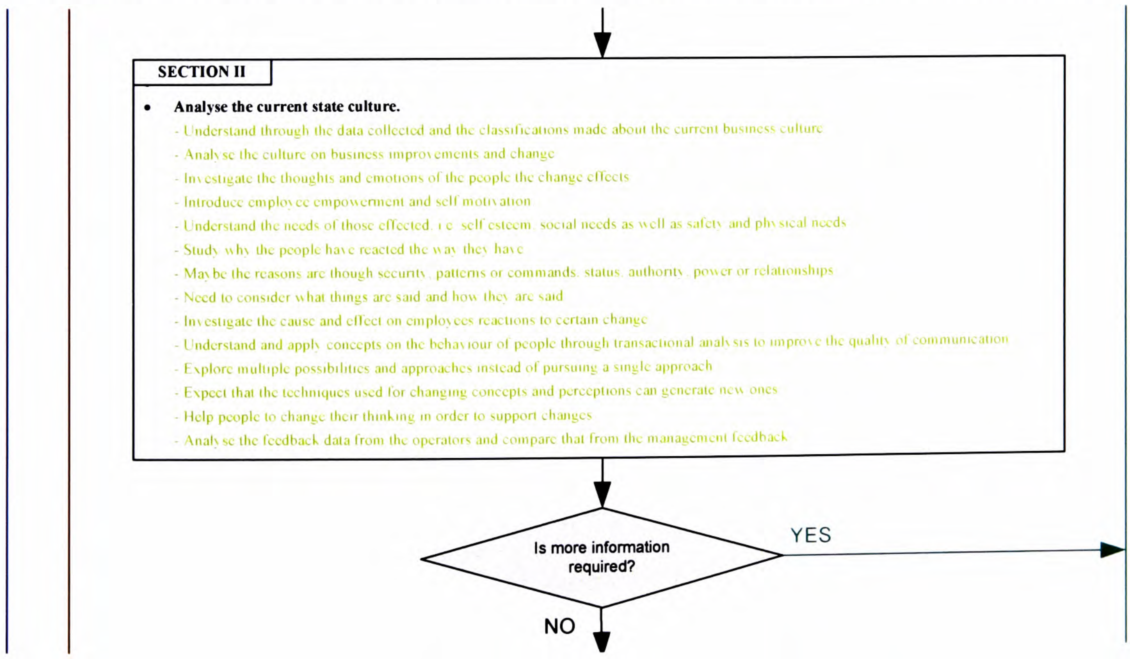


Figure 5. 77: Stage 6, Section II of the proposed methodology

It was felt that there were little concerns related to the culture within the production line. The operators and team members were aware of the relocation project that the company were putting in place before the start of this application. So the usual obstacles such as resistance to change and issues associated with improvement projects were not present. The management team that were enforcing the change were respected and so there was no resistance to change. This methodology application was advertised as an improvement project within the relocation plan to highlight any related problems and future potential improvements.

The manner in which the data collection was carried out reduced factors of resistance. This method allowed the operators to calculate the operation times and complete the surveys independently of the author or team leader. These types of studies usually include measuring time throughout using stop watches, which tend to let the operators think that is a measurement of their capability and skill and not on their operation and process. This methodology enables a less formal approach which does not encroach upon personal achievement. Throughout this methodology application all employees of Amphenol remained anonymous.

Understanding the current culture was achieved through the completion of the survey data (**appendix 5.28** (on CD)), and it was found that the team were satisfied with their jobs. The data highlighted the requirements for better tools and equipment to aid with the completion of the operations. However, this was seen as a technical point, the team were happy with the reliability of the equipment and with the quality of the products, except for the plating of the products.

Unlike the technical data that were collected, the cultural data did not vary between each product. The information was operator specific towards the end of the data collection period and this part of the survey was not being completed as it was repetitive information.

Outside of the company, the core team socialise with one another occasionally indicating the culture within the team. One concern is the turn over of agency staff within the production line, which causes issues regarding training and staff flexibility. The future culture will aim to reduce the issues related to agency staff and will encourage team building through work shops and learning.

The largest change that will affect the culture is by introducing more training to multi-skilled staff, thereby promoting cell flexibility. This will be achieved by carrying out learning work shops and awareness courses prior to the training. This also includes communicating and informing the team of the changes. Efforts will be made to encourage team building through social events and communication. The greatest resistance will be through the implementation period, the greater the awareness, training and communication the lower will be the resistance to change.

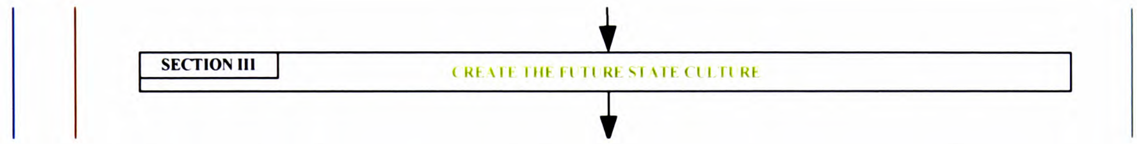


Figure 5. 78: Stage 6, Section III of the proposed methodology

The future state culture will include integrating the small divide between core employees and agency team members. It will also encourage members to voice opinions on operational tool requirements in order to make the operations easier for the operator to carry out. **Figure 5.79** displays the future culture classification; this will be the aim of the company.

Current State Culture Definition	The future aspirations of the company				
	-				+
- Relationships to Other People					
- Rules versus relationships – The organisation uses tight contracts when engaged in business				✓ ✗	
- There is not only one right way; the person should act in a way that fits the particular requirement				✓ →	
- Group versus the individual – it would be expected that several people would attend meetings and make group decisions			✓ →		

- Single decision makers are common and decision are made quickly		←	✓		
- Lack of emotion versus show of emotion – it is considered uncultured to show emotion		✓	→		
- Specific relationships versus diffuse relationships – Are relationships defined to fit a specific context				✓ x	
- All aspects of a relationship are discussed and intertwined		✓	→		
- Organisational status is according to past record achievement					✓ x
- Organisational status is satisfied through ascription					✓ x
<u>- Attitude to the Environment and to Time</u>					
- The environment can be controlled and exploited				✓ x	
- The environment is something that can be adapted too				✓	→
- The organisational focus is on the future and making future plans			✓		→
- The organisation places importance on the history and the past			✓ x		
- Time is seen as a linear, sequence of events		←	✓		
- Time is seen as circular, linking the past, present and future		✓			→
- The immediate future is achievable through personal effort		✓ x			
- Long term is not as achievable, as too many things can happen		←		✓	
<u>- Individual – Organisational Relationships</u>					
- Individuals can come together in an organisation because it furthers their own ambitions		←	✓		

- Individuals have little loyalty to the organisation				✓	
- The organisation instructions initiate from the top and work down					✓
- The role of every individual is well defined					✓ x
- Members have come together due to shared values or goals			✓		
- Power and Control					
- The organisation has several levels of hierarchy and relies on a committee for decision making					✓
- The Organisation focuses on successfully completing well defined projects / tasks				✓ x	
- Influence is based on expert power and is widely dispersed			✓		
- Innovation and Learning					
- The managers are experts in their organisations limited area of operation			✓ x		
- Management tend not to search outside their current areas for new equipment				✓	
- The company narrowly defines the market segments				✓ x	
- The organisation continually searches the market opportunities		✓			
- Regularly experiments with responses to environmental trends			✓		
- Attitude to Risk				✓ x	
- The organisation operators through the use of formalised structures and processes				✓ x	
- Management are reluctant to change		✓			
- Management only react when they are forced to do so			✓		

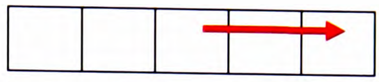


Figure 5. 79: The current cultural environment and the future cultural aims

This figure indicates the current cultural classification and highlights what the company aim should be and what will be defined in the strategic plan. Within this figure, it can bee seen that the company needs to promote communication and group decision making to create constructive discussion to propose a number of solutions. It also highlights the need to support the ideas of an adapting environment responsive to change that focuses on making plans for the future, focusing on aspects and continuous improvement by linking past and present experiences.

The future culture aims to encourage learning and knowledge sharing to create a multi skilled environment, which will enable flexibility. It is also thought that the perception of management acceptance and approval are key to acceptance among the work force.

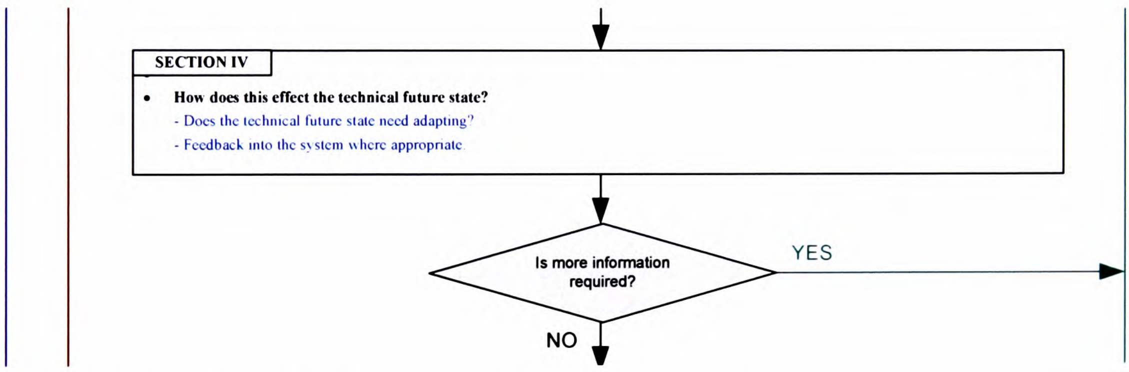


Figure 5. 80: Stage 6, Section IV of the proposed methodology

The technical future state does not need adapting as the future cultural environment supports these ideas and is based upon this knowledge.

All guidelines have been satisfied and completed with this stage. The cultural factors have been extensively discussed in this particular stage.

Further information is not required as all sections and guidelines have been met. The theory of the optimum future state is displayed in **figures 5.62** (page 199), **5.79** (page

213) **and 5.82** (page 215). The summarised points of the optimum future state can be seen below in **figure 5.82**.

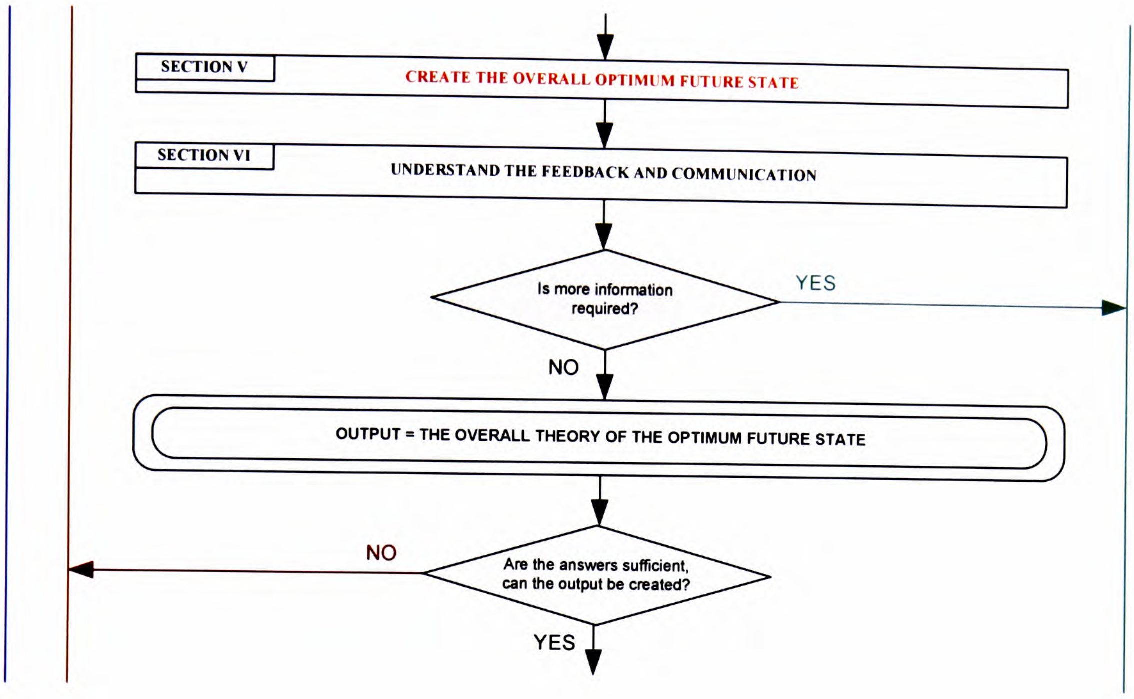


Figure 5. 81: Stage 6, Sections V, VI and the output of the proposed methodology

• Maximum availability of processes required;
• 2 degreasing and banding operations,
• 1 coding operation,
• 1 bayonet pinning and pull test operation,
• 1 grounding spring operation,
• 2 staking and potting operations,
• FIFO lanes around the oven operation.
• Production within normal working time.
• Better utilisation of machines, operations and labour.
• Continuous levelled production process.
• Very little WIP.
• Group decision making to create constructive discussion.
• To encourage learning and innovation to work towards multi skilled staff.

• 7 multi-skilled operators.
• Fully integrated team members.
• Displaying management acceptance through interactive management involvement to enable a responsive environment.
• To support continuous improvement from past and present experiences.
• A more responsive environment to encourage change.
• Change initiatives to be created from within the team.
• Better communication internally and externally.
• Shipments to the line are as required.
• Shipments from the line are as required.

Figure 5. 82: The optimum future state theory

5.4.10 Stage 7 – Create a strategic plan

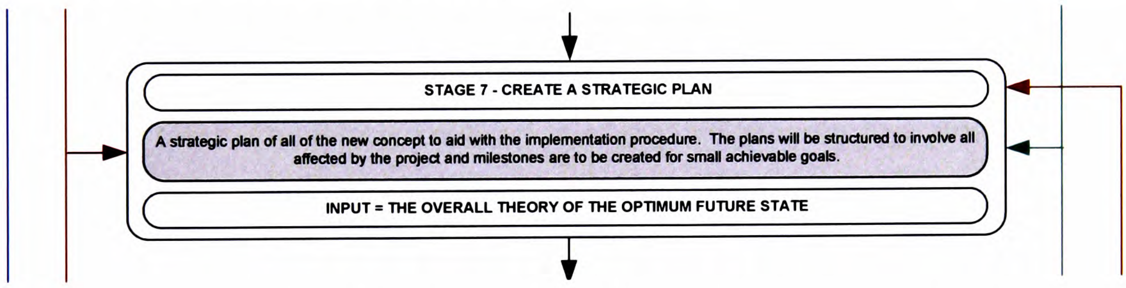


Figure 5. 83: Stage 7 heading of the proposed methodology

The system that had been created through the previous stages was to be used to create the strategic plan for implementation.

The project objectives that were defined at the on set have remained the same throughout the methodology application. Changes have been made to the system accordingly to the application requirements and the significant changes to the production line are displayed in **figures 5.74** (page 207) **and 5.82** (page 215).

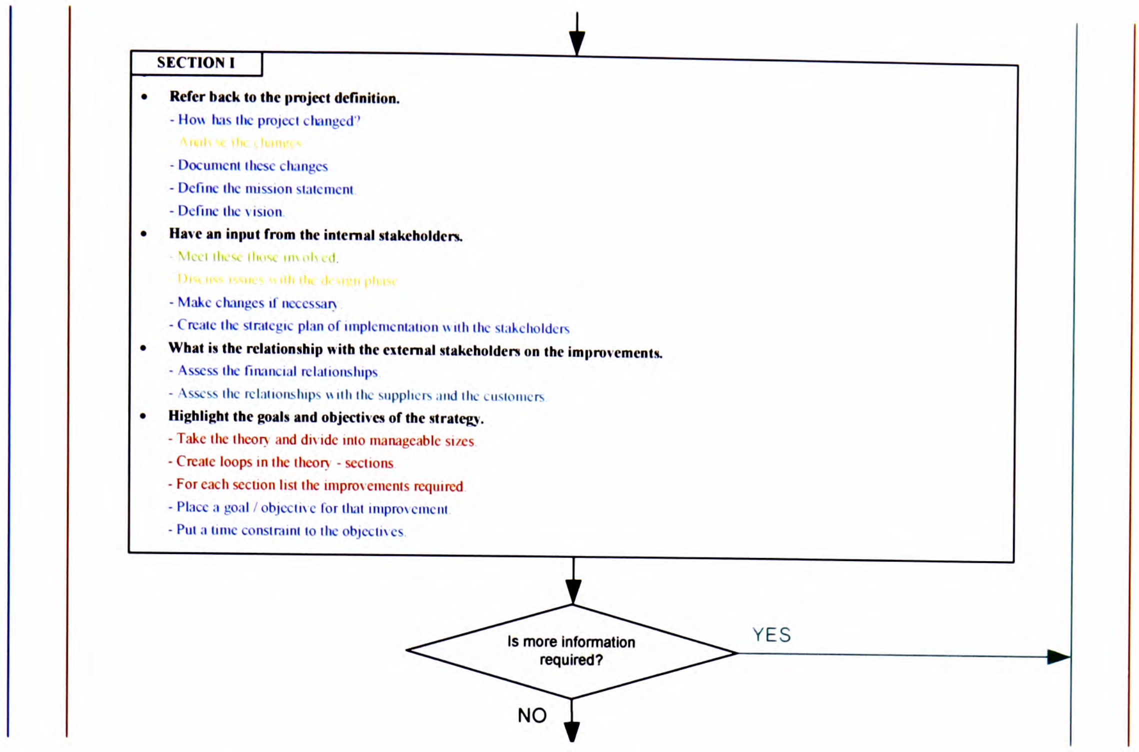


Figure 5. 84: Stage 7, Section I of the proposed methodology

It was felt that before any project implementation was carried out, it was best to understand the project objectives and aims of the customer. The changes that were to be made with the customer would have an impact on the supplying processes; it was thought that the two processes could work together simultaneously. So the decision was made to initiate the methodology application of the downstream case study to ensure the communication between the two companies and encourage concurrent improvement.

5.5 Methodology Application Discussion

This chapter has applied the design methodology to a case study; this was initiated from the application discussed in the previous chapter. The aim of this second methodology application was to gather more detailed operational data and look to improve a downstream process within the supplier. The information from this application could be fed back into the top level case study to improve the supplier-buyer relationship.

The results of this methodology application were discussed throughout the stages in this chapter and the main results that were benchmarked were highlighted in **figure 5.74** (page 207). The table created in **figure 5.82** (page 215) gave information on the final outcome which was described as the optimum future state.

The optimum future state determined the capacity of the process operations. Initially, there is the availability for one of each operation. The process within the line is very manual, where the process capability has increased this is with no extra investment, it allows the space to perform the operation if required. Currently the process capacity was one; however the coding machine had limited availability 50% of the time. The optimum future state was that due to creating continuous flow those processes with similar operation times. Currently there were ten operations, all with a capacity of one, which equates to ten work centres. The optimum future state required seven operations; some with a maximum capacity of two, which equated to a total of 11 work centres. The technical content of the existing system remains the same but is re-organised and re-scheduled in a more utilised format with a significant reduction in WIP.

The system output increased by 435%, which was nearly 5½ times more than the current system. Utilisation also increased however in this case there was continuous flow and no bottlenecks were present in the system. Originally, when operating on a normal shift, the products were on average 13 days late, but with extensive over time the future system can achieve this output on a normal shift pattern. However, this required training with the team to create a multi-skilled and flexible team. The team were very approving and supportive of the project and the data collection was very successful because of this, it was also due to the method of collection as cultural issues were considered.

From the application through current bench marking and analysis, the results concerning cultural issues consisted of encouraging learning and innovation to create a flexible and multi-skilled team. Promoting communication internally within the line, as well as externally. It was also felt that the team should be encouraged to initiate continuous improvement from past and present experiences by creating a more responsive environment. This would require management displaying acceptance through interactive involvement.

5.6 Methodology Justification through Application

The application of a case study through the use of the integrated methodology has allowed it to be reasoned and justified. The completion of the necessary guidelines within the sections of the methodology has encouraged the progression of the case study objectives. Those guidelines that are not necessarily relevant to the project have been discussed at the point of application and the reasoning of the decisions justified.

The feed back loops created in the methodology have been used, this was mainly due to insufficient information. In these instances when feedback was required, the methodology allowed the project to feedback and flow into the necessary stages and sections as required.

This application has highlighted how the methodology has been tailored to the case study requirements and therefore has created a pathway of change though a given roadmap. The author has given recommendations to Amphenol UK as a result of this study and they have employed new staff to carry out these suggestions.

5.7 Chapter Summary

This chapter has applied the methodology to a given case study. This application has seen considerable improvements within the supplier. The decision was made to initiate the improvement program within the customer before implementation of the changes within the supplier, to ensure clarity between the two companies with the top level case study in mind.

CHAPTER 6 : CASE STUDY 3

APPLICATION OF THE PROPOSED DESIGN METHODOLOGY TO IMPROVE THE BUYER'S RECEIVING PROCESS

6.1 Chapter Introduction

This chapter uses the proposed design methodology (Chapter 3) and applies the theory to receiving processes at BAE Systems. This application investigates and defines improvements within these processes. This study will aid the improvements created and implemented in this previous application with the supplier (Chapter 5). These investigations will assist the holistic view of the overall supply chain (Chapter 4). This application requirement differs slightly as the approach of this application studies in detail the movement of material flow and assess the inventory management techniques. In Chapter 5 the significances was within the process, production orientated environment.

6.2 Methodology Approach

The flow chart of the proposed design methodology (**figures 3.7 to 3.16,** pages 89 to 118) is applied and the application follows on from Chapter 5, this methodology completes a third application which is linked back to the first application (Chapter 4).

The goals and objectives were to meet the overall requirements outlined in the first methodology application (Chapter 4), which were;

- Better quality products
- Shorter lead-times
- Improved transit times
- Better designed products
- Reduce inventory
- Lower costs

The aim of this case study, like the previous case studies was to work with the company to find appropriate ways to quantity these measures. This application was associated with understanding the holistic supply chain and the aim of this study was to carry out a more detailed improvement project, which would influence the outcome of the first case study. This study is focusing on transactional processes rather than production build assemblies and assesses inventory control methods. Specific advantages will be;

- Better responsiveness to production
- Shorter lead times
- Reduction in inventory
- Less material handling
- Less system transactions
- Better communication internally and externally
- Better supplier chain relationship
- More efficient processes
- Reduction in waste

All of these objectives will reduce the material receiving process and reduce the dock to shop lead times.

6.3 Company Overview

The company used in this third application is referred to as the buyer, BAE Systems. The company background was given in Chapter 4.

6.4 Methodology Application

6.4.1 Stage 1 – Project Alignment

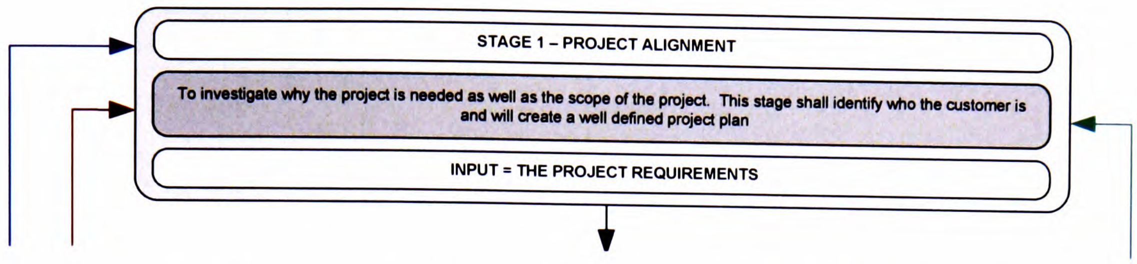


Figure 6.1: Stage 1 heading of the proposed methodology

The project requirements were discussed in Chapter 4, which highlighted the requirement for internal analysis within the buyer to improve the relationship with the supplier. The present case study will look at how the material supplied will be processed through the receiving areas.

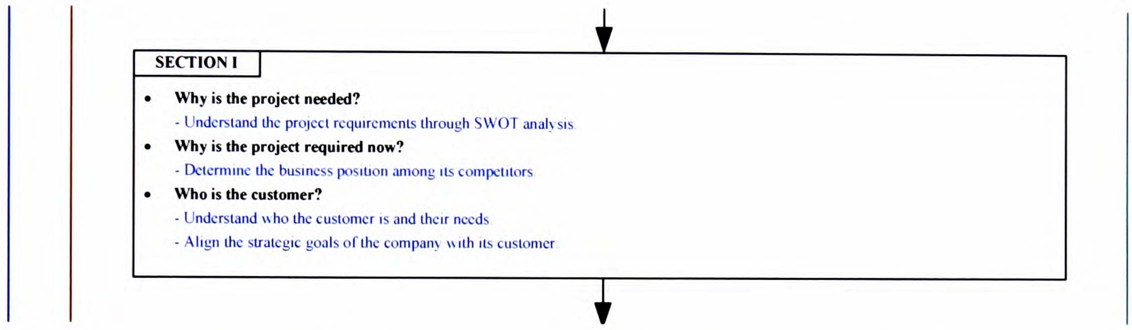


Figure 6.2: Stage 1, Section I of the proposed methodology

This study was required to analyse how products were supplied to BAE systems and this would enable the company to be more receptive to the production process requirements. This would also benefit the company by lead time reduction as well as reductions in transactions between material delivery and product build. This ultimately allows better communication and feedback to the supplier. Reasoning for this project is highlighted in **figure 6.3** through SWOT analysis.

This SWOT analysis highlighted that from this project there are many opportunities to reduce internal supply lead times and processes, which in turn would also promote better external supply chains. This would also introduce better responsiveness to the customer by reducing the transactions. One particular strength is the introduction of a new ERP system, as this requires in depth investigation around all the company processes. The new ERP system will enhance this project application as all processes need to be questioned.

Strengths	Weaknesses
• Large worldwide company • Unique market • Advanced technology • New planning system being put in place	• Long internal supply chain lead time • Large amounts of inventory held • Material planning system reliant • Large supply base • Unique component requirement • Long receiving processes • Less receptacle to supplied material
Opportunities	**Threats**
• To reduce internal supply chain lead times • Reduce material handling • Have quicker responding material receiving processes • To reduce transactions • Improving the operations around the planning system • Reducing the supply base	• Competitors • Movement of production to another location • Reducing supplier base and lead time without reducing the internal supply chain lead time

Figure 6.3: The SWOT analysis of BAE Systems

There appear to be many weaknesses at the current state; however these will be reduced through the application of the proposed design methodology.

The customer in this scope of the project is production. Physically on site there is one central receiving area with many stores and many production areas. Due to this reason and the project timescale, only the receiving areas and the main stores area will be studied.

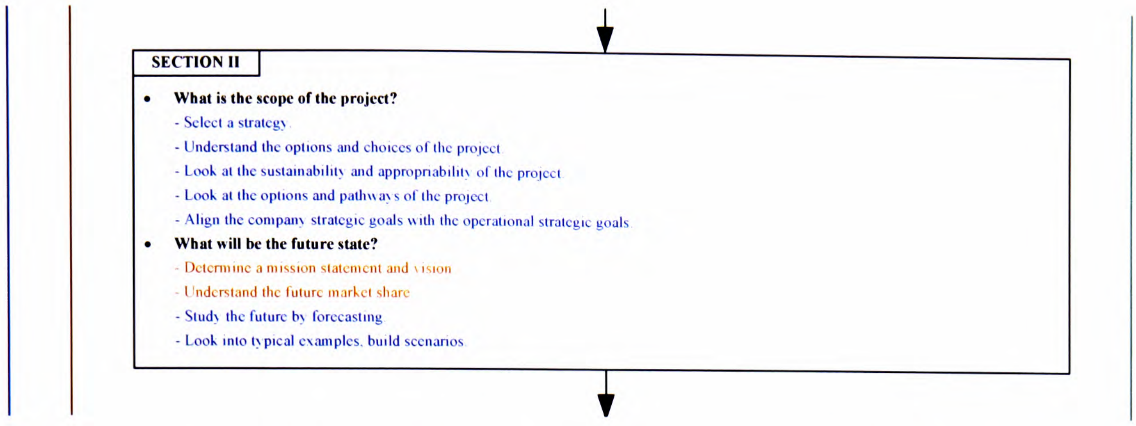


Figure 6.4: Stage 1, Section II of the proposed methodology

This project's strategy is to understand and identify the current system for receiving and inspecting material supplied and how this material is moved and received into stores. As the project scope is quite specific the options and pathways are limited. It is anticipated that transactions will be reduced as well as material handling and that supplied material will be more readily available to the production team. Without further detailed analysis it is hard to determine and identify the future state on a specific project. It is thought that the future state will encourage better communication with the suppliers, as the internal receiving processes will react better to the demands of the internal customer, thereby producing greater, more controlled and more reactive stock turns.

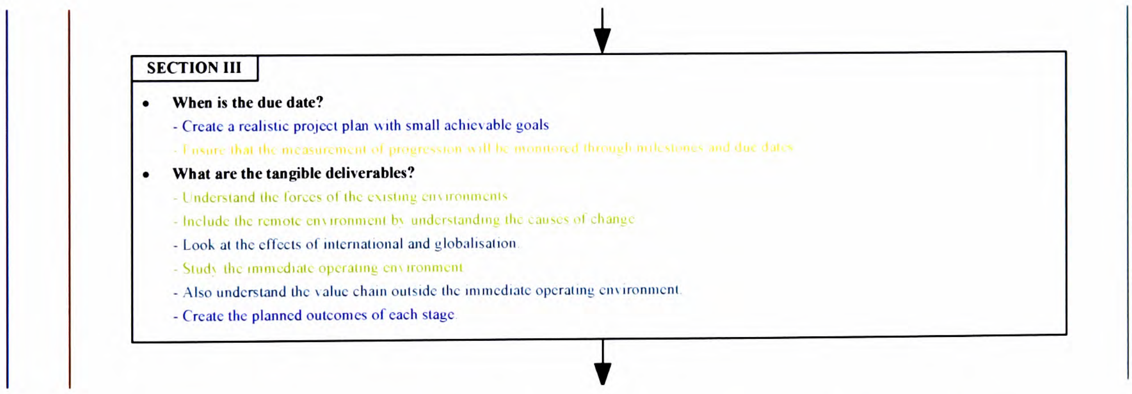


Figure 6.5: Stage 1, Section III of the proposed methodology

The due date of this project is to be kept in line with the project plan created in Chapter 4 (**figure 4.2**, page 126). It is thought that this third case study will allow the continuation of the previous two. This project progression will be monitored throughout and any issues will be highlighted in feedback loops.

One of the current forces that affect the existing environment is that many products are inspected intensely. The site has three stores depending upon the production environment and so the goods are transported to the necessary stores. Currently, not all material is received into the planning system and due to receiving lead times the items are not booked onto the planning system in time. Employees would chase the suppliers for the items when the items were actually in house and not visible on the planning system. To overcome this problem, the material is now booked onto a separate system to highlight the receipt from the courier and then placed onto the actual system once certain processes have been performed. This now enables visibility of receipt; however it is not globally communicated.

The movement of material currently is received through goods in and the receiving areas. It is held here until it is physically moved over to stores. The material is placed into specific locations, in stores, ready for picking into kits ready for production as required by the ERP system. Foreseeable causes of change could be job definition; currently people have specific job roles that do not allow flexibility. These are the type of issues that maybe of some concern through this change process.

Understanding the effects of international and globalisation are too generic for the scope of the project. The value chain outside of this immediate operating environment has previously been discussed (Chapter 4) and investigated (Chapter 5).

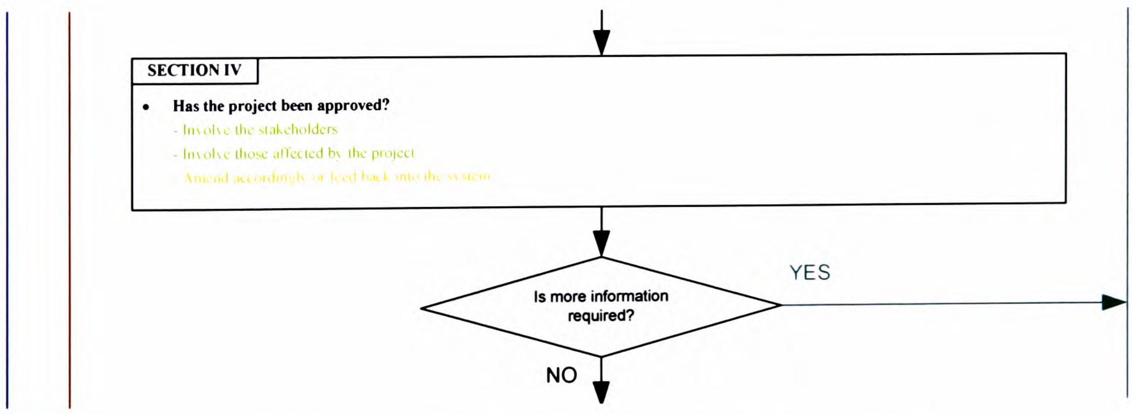


Figure 6.6: Stage 1, Section IV of the proposed methodology

All stakeholders are aware of change and are supportive of this case study investigation. No further information is thought to be required and so the current state was created.

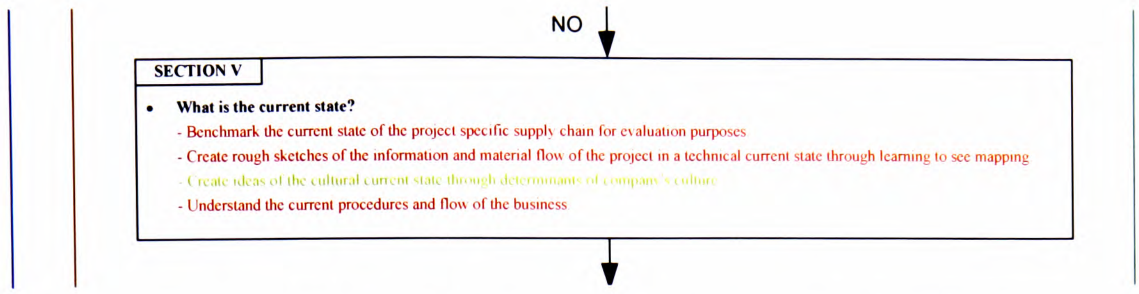


Figure 6.7: Stage 1, Section V of the proposed methodology

The current state of the process was benchmarked through VSM tools and can be seen in **figure 6.8**. This figure highlights how the material is received in, processed through goods in and pushed through into stores. The material in stores is kitted as required, however it is left in the holding area until it is collected. This map gives a rough indication of lead time, however this methodology will enable the creation of a more detailed evaluation of the system as required, highlighting the internal processes below the top level given.

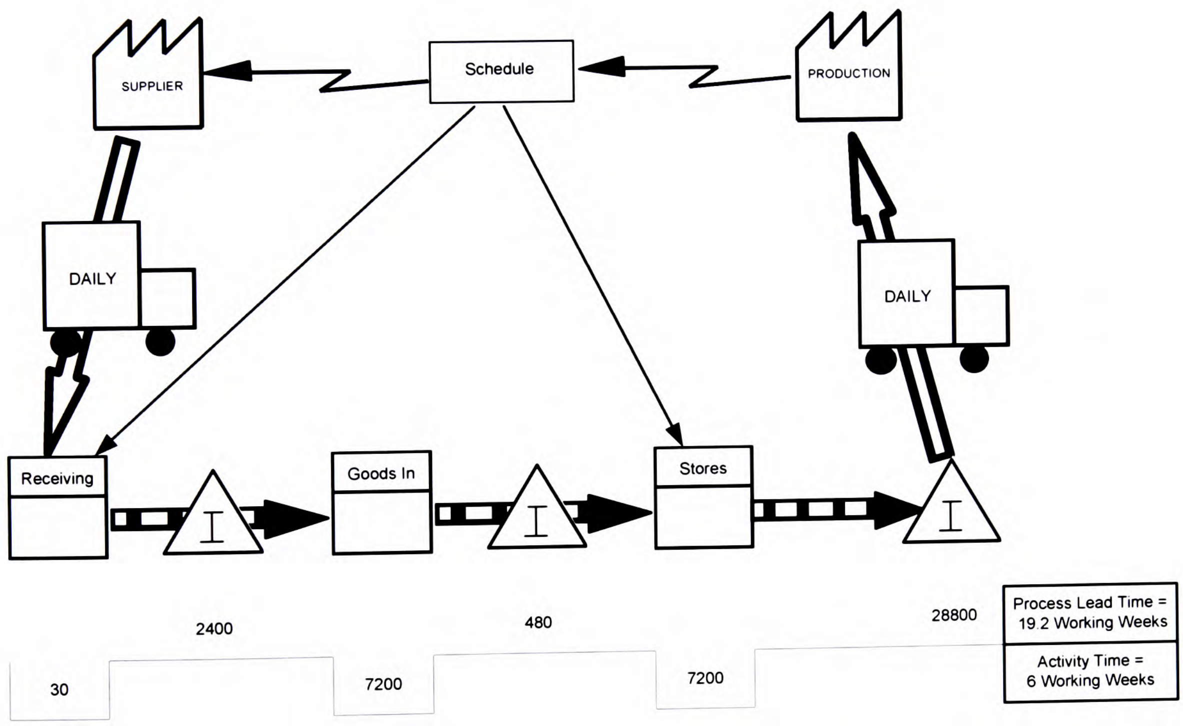


Figure 6.8: The current state map of the receiving process

This figure highlighted that the process lead time was over 19 working weeks and that the activity times associated with this are 6 working weeks, however it was noticed that further improvement was required with the activities and that there are many wasted opportunities within. These data were obtained through initial observations and meetings. The cultural environment was analysed in the same form as the previous case study and current culture has been determined in **figure 6.11.** This current state culture was based on the view of the author on the brief visits.

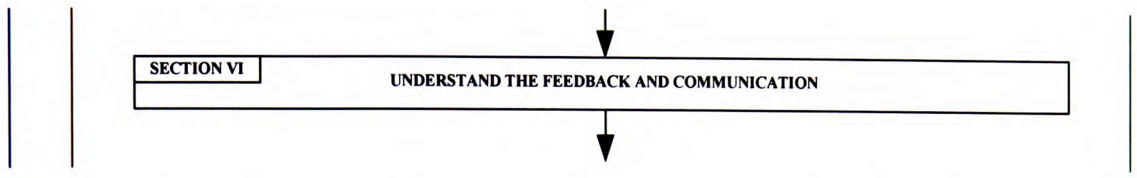


Figure 6.9: Stage 1, Section VI of the proposed methodology

The feedback and communication key was used to test the requirements of the scope against the current data collected. All of the necessary guidelines were met and the information was recorded and documented as required, it highlighted that the project remains true to the scope. Cultural analysis has been determined; however it appears unnecessary to start changes before more data are collected.

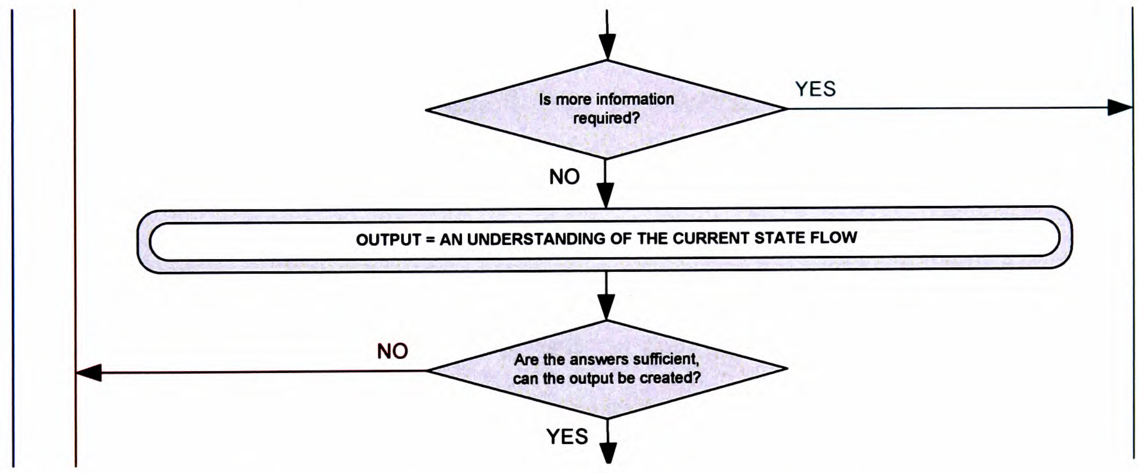


Figure 6.10: Stage 1 output of the proposed methodology

The output created from this stage can be seen in **figure 6.8 and figure 6.11** and so further information was not required as the answers were sufficient, therefore it was acceptable to move onto the application of Stage 2.

Relationships to other people	The team of people involved within the activity processes all appear to work well within a team. However, across the functions there is little communication, across the site there appears to be divides between functions and processes. The receiving processes are lengthy and this effects the perception of the function externally.
Attitude to the environment and to time	A new planning system is being implemented across the site. This will effect the environment and the way the processes are currently operated. The items are delivered to the site as agreed with the supplier and the buyer. The receiving processes are unable to meet the deliveries made to the site and so another database was created to receive the material before it was entered into the system. Time is a factor that is particularly limited in this environment; this has effects on how the system is operated.
Power and control	Like the previous case study, the company has many levels of hierarchy. The areas are organised by managers and this includes scheduling the functions as well as managing the people. There have been past efforts to improve these areas to reduce the lead times and to be more reactive.
Innovation and learning	It is believed that learning programs for individuals are existent and is left to the individual to utilise this facility. Like the previous case study, the attitude to risk is dissimilar on different levels of the hierarchy scale; production workers generally oppose a change in the system due to changing their lifestyle. However these people are very proactive regarding the data collection program.

Figure 6.11: The current cultural state within the receiving processes

6.4.2 Stage 2 - Planning the Measurements

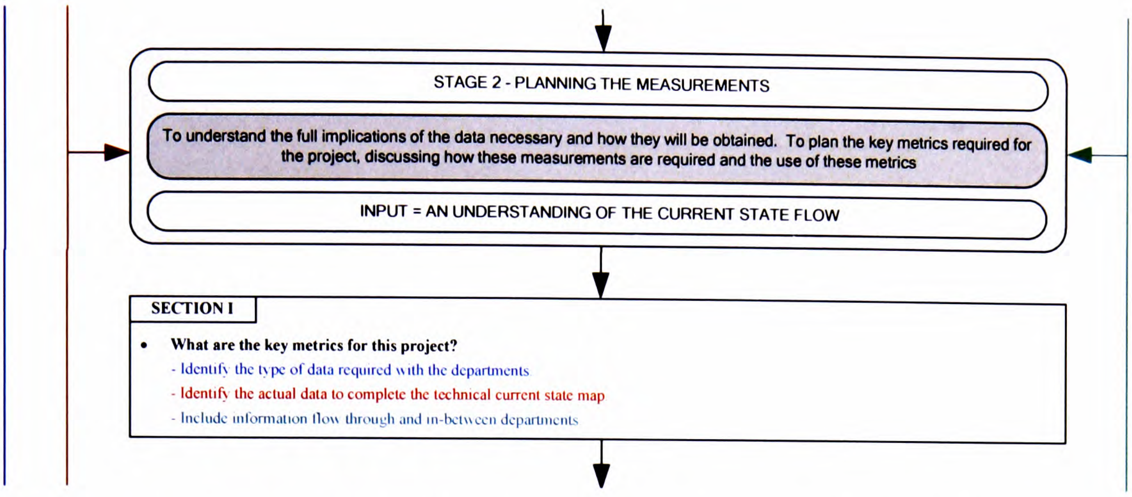


Figure 6.12: Stage 2 heading and Section I of the proposed methodology

The type of data required within this project is detailed information on activity times, cycle times and lead time to process these transactions around the receiving area. This project is similar to Chapter 5 and is of a specific nature around an internal process. This case study understands and improves the current material receiving transactions rather than production related improvements.

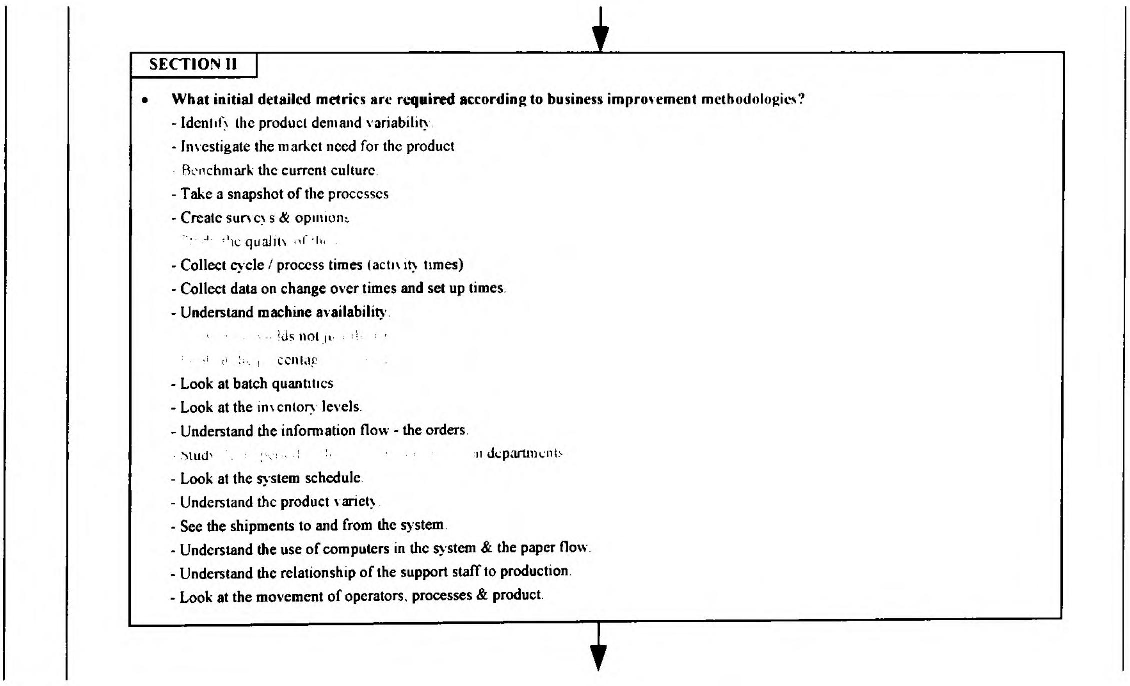


Figure 6.13: Stage 2, Section II of the proposed methodology

This section understands the detailed specific requirements. Many of the attributes in this section are not applicable as they are product related. However, aspects such as current culture benchmarking are a function of the case study, as well as understanding the material and information flow through these process transactions. The initial areas of the plan can be seen in **figure 6.14**.

- Identify the product demand variability.	X
- Investigate the market need for the product	X
- Benchmark the current culture.	✓
- Take a snapshot of the processes.	✓
- Create surveys and opinions.	✓
- Study the quality of the process.	X
- Collect cycle / process times (activity times)	✓
- Collect data on change over times and set up times.	✓
- Understand machine availability.	X
- Look at the yields not just the first time yield.	X
- Look at the percentage of rework in all departments.	X
- Look at batch quantities.	X
- Look at the inventory levels.	✓
- Understand the information flow - the orders.	✓
- Study delay periods - the flow of work between departments.	✓
- Look at the system schedule.	X
- Understand the product variety.	X
- See the shipments to and from the system.	✓
- Understand the use of computers in the system and the paper flow.	X
- Understand the relationship of the support staff to production.	X
- Look at the movement of operators, processes and product.	✓

Figure 6.14: The checklist of the applicability of the initial detailed metric requirements

The quality issues are related to the quality of the received material, rather than the quality of assembled products and so issues are more straight forward, as the error lies with the supplier.

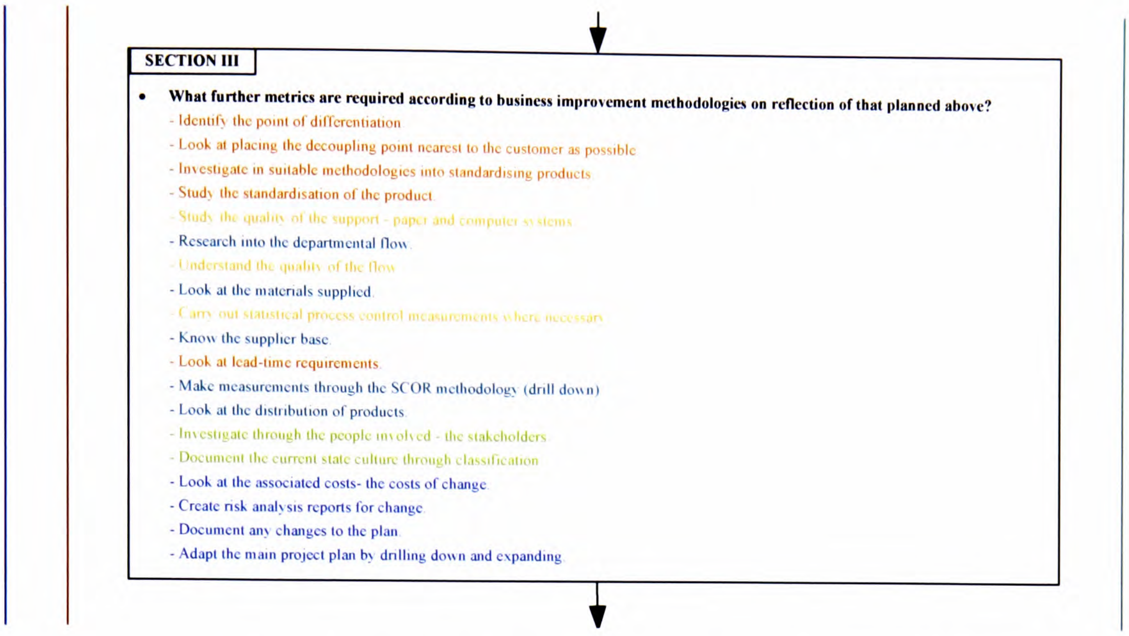


Figure 6.15: Stage 2, Section III of the proposed methodology

Any further metrics that were required (**figure 6.15**) related to extending the supply chain were analysed in **figure 6.16**. For this case study, current state culture definition was required as well as strategy management concepts such as cost and risk analysis including project planning.

- Identify the point of differentiation.	X
- Look at placing the decoupling point nearest to the customer as possible.	X
- Investigate in suitable methodologies into standardising products.	X
- Study the standardisation of the product.	X
- Study the quality of the support - paper and computer systems.	✓
- Research into the departmental flow.	✓
- Understand the quality of the flow.	✓
- Look at the materials supplied.	✓
- Carry out statistical process control measurements where necessary.	X
- Know the supplier base.	X
- Look at lead-time requirements.	✓
- Make measurements through the SCOR methodology (drill down)	X
- Look at the distribution of products.	X
- Investigate through the people involved - the Stakeholders.	✓
- Document the current state culture through classification.	✓

- Look at the associated costs- the costs of change.	X
- Create risk analysis reports for change.	✓
- Document any changes to the plan.	✓
- Adapt the main project plan by drilling down and expanding.	✓

Figure 6.16: The checklist of the applicability of the further detailed metric requirements

The following section (**figure 6.17**) relates to holistic measures and investigates the external supply chain. This project is very specific and these holistic measures are assessed in Chapter 4 with the overall assessment of the supplier-buyer relationship. The association between the proposed design methodology applications are highlighted in **figure 4.7** (page 130).

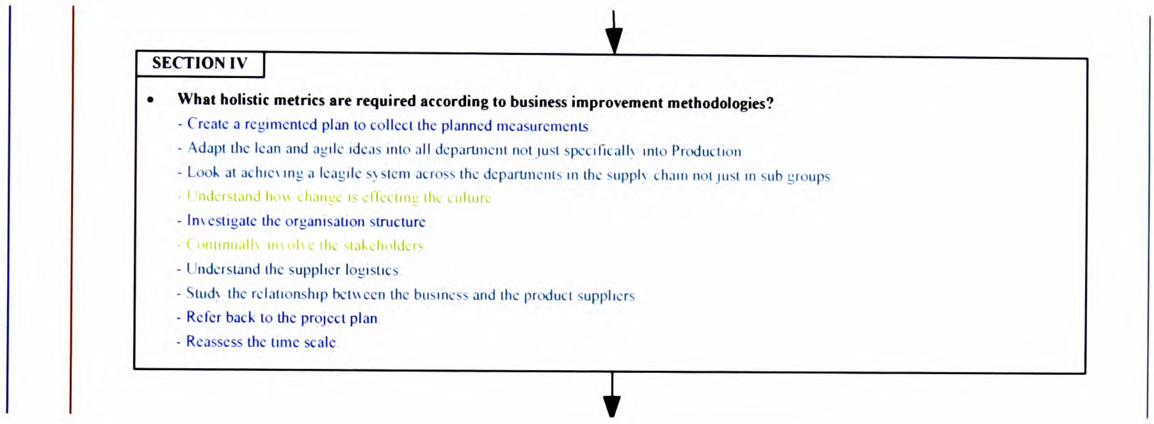


Figure 6.17: Stage 2, Section IV of the proposed methodology

The following table (**figure 6.18**) displays the decisions made on the applicability of the holistic metrics that would be suitable for this project. It was thought that facets of this section were applicable to project planning and stakeholder involvement.

- Create a regimented plan to collect the planned measurements.	✓
- Adapt the lean and agile ideas into all departments not just specifically into production.	X
- Look at achieving a leagile system across the departments in the supply chain not just in sub groups.	X
- Understand how change is affecting the culture.	✓

- Investigate the organisation structure.	✓
- Continually involve the stakeholders.	✓
- Understand the supplier logistics.	X
- Study the relationship between the business and the product suppliers.	X
- Refer back to the project plan.	✓
- Reassess the time scale.	✓

Figure 6.18: The checklist of the applicability of the holistic metric requirements

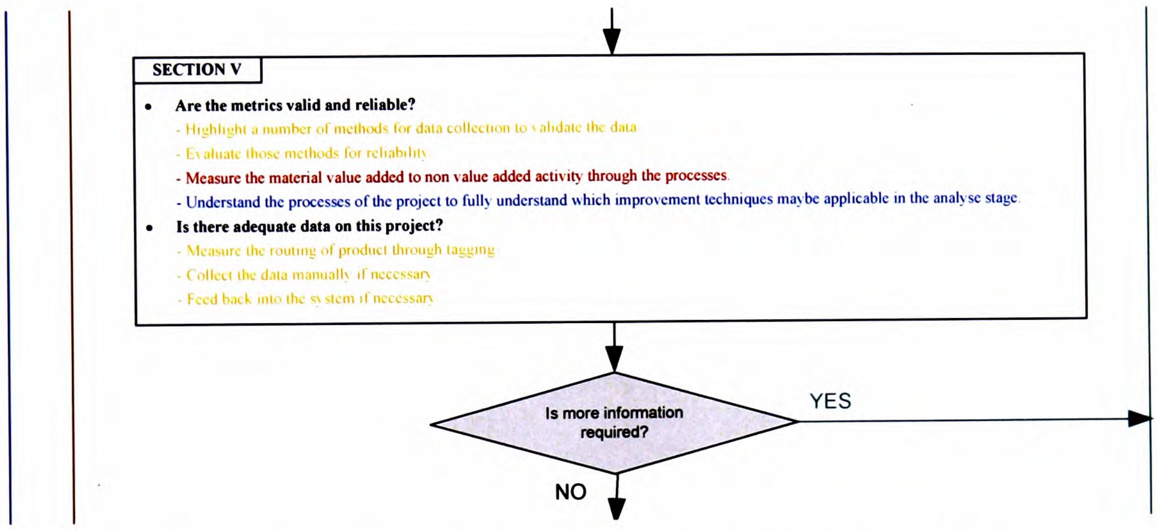


Figure 6.19: Stage 2, Section V of the proposed methodology

The data will be collected through observations by walking throughout the area. These observations are completed with estimated times from the processors. The aim of this study is to analyse the processes and transactions, not the specifics of time and complex data analysis. Non value activity can be seen for receiving items that are not specific to production build but are for the attention of specific people; however this could be for development programs. Also some investigations can be carried out to understand the principles of inspection. It was thought at this stage that no further information was required.

As this project is of a similar scale to that in Chapter 5, the resources necessary will be very minimal; those people required will be directly related to the process. This study will be in line with the overall original project plan.

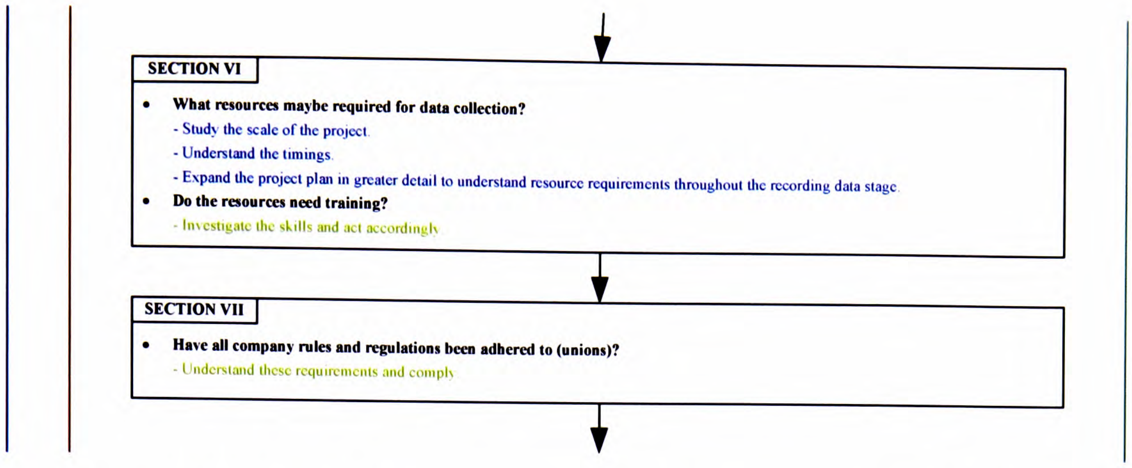


Figure 6.20: Stage 2, Sections VI and VII of the proposed methodology

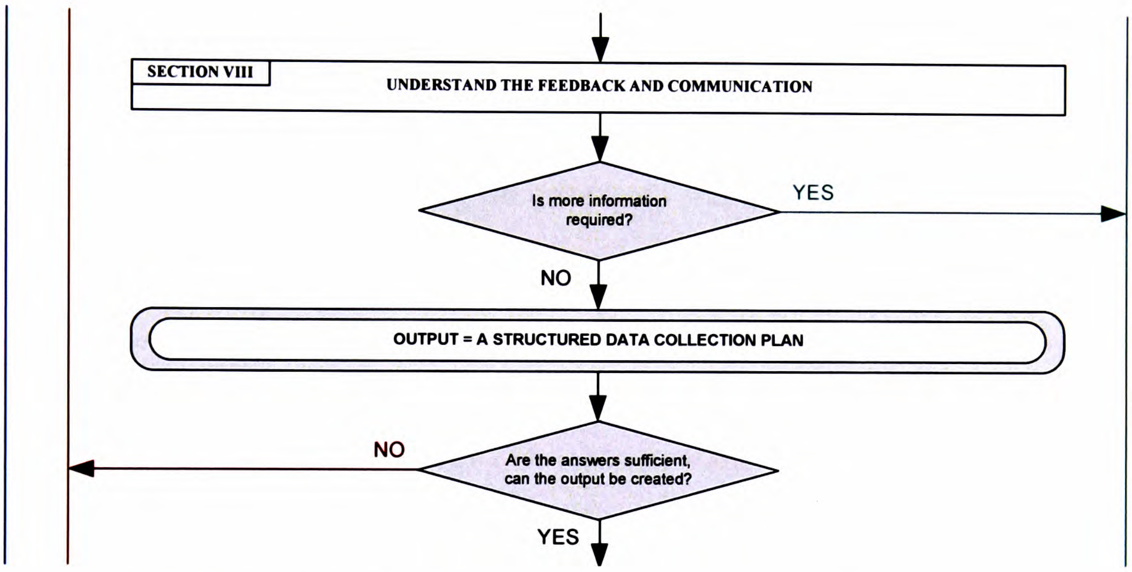


Figure 6.21: Stage 2, Section VIII and the output of the proposed methodology

All of the required guidelines have been met and no further changes have been made. The project is still in line with the project plan (Chapter 4, **figure 4.2**, page 126). The cultural involvement at this stage has only been a benchmarking exercise, so changing the cultural environment has not been a priority at this stage.

It was seen at this stage no further information was required and so the structured data collection plan was generated, **figures 6.14** (page 229)**, 6.16** (page 231) and **6.18** (page 232). The time it took to collect the data was planned to be over a short period through visual observations and training within the area. By observing the processes within the department allowed a true understanding of the processes and transactions through material and information flow analysis.

6.4.3 Stage 3 – Recording the Information and Defining the Current State

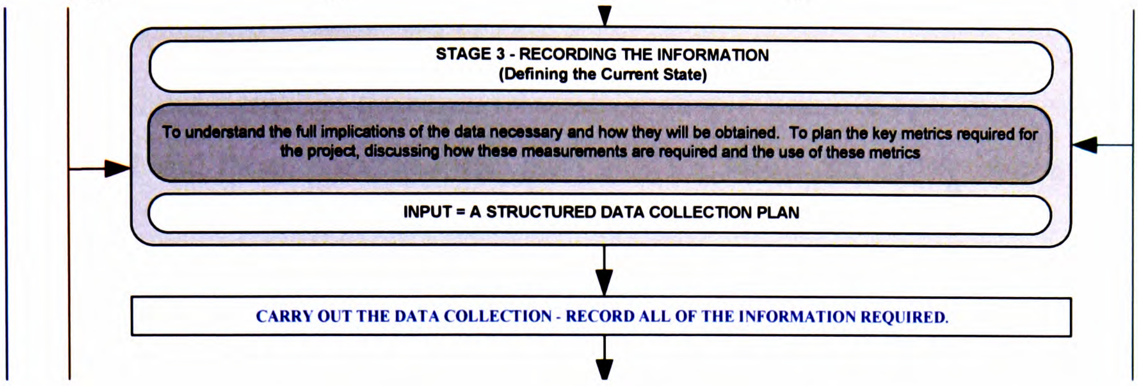


Figure 6.22: Stage 3 heading and Section I of the proposed methodology

All of the data were collected over the period defined in the project plan. The information was recorded through observation and questions. The timings were not accurate as the importance was focused on the material handling, transactions, the number of people involved, including the processes and the overall lead time.

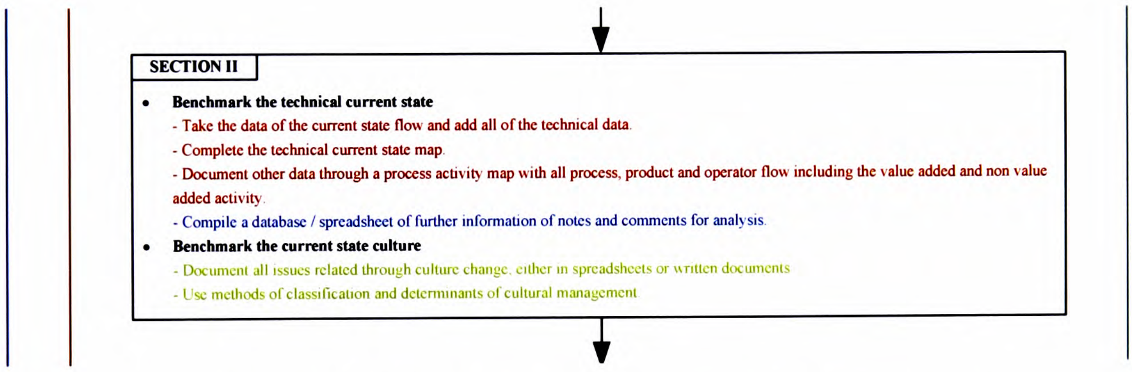


Figure 6.23: Stage 3, Section II of the proposed methodology

The current state flow created in Stage 1 through the data collection was adapted and more in depth information was obtained. A flow diagram was created to highlight the step changes of the receiving transactions and storage methods used at the company; **figures 6.24 to figure 6.30** shows these flow diagrams. These flow diagrams were obtained from BAE Systems and display different levels of transactions. The overall processes to acquire materials are displayed in **figure 6.24**, these range from requiring material through to production assembling the items. **Figure 6.25** highlights the overall receiving processes at a very top level view. The following figure (**figure 6.26**) looks at the initial receiving processes, from receiving the material from the courier through to the waiting for unpacking and processing. From here the receiving of the items differ depending on their final location. Those items for production can be seen in **figure 6.27**.

Figure 6.28 displays the main stores receiving processes once the goods in receiving processes are complete. This figure shows how the team are completely ready for production. Those items for attention of specific people (the FAO process) can be seen in **figure 6.29** and those packages that are items for repair are demonstrated in **figure 6.30**.

It can be seen that the material is held at many instances waiting for the next process, it also highlights the different routes each item can move given the requirements. It was noticed throughout the observations that there were just as many received items for production as there were for 'FAO'. It was also noticed that many items were inspected as per company requirements.

It was thought that to analyse this further a PAM could be created to quantify the inspection processes and those non company specific items. **Figure 6.32** shows the PAM.

The activities on the map were divided into the type of processes and a key was created to segregate the processes for analysis. The data were taken from the flow diagrams and the PAM was created around the same functions. Times were only measured roughly through observations and again it was necessary to consider the cultural impact should accurate information be taken.

The map from the initial investigation contains many inspection processes through to the receiving processes, however the time constraint seemed to be around storing the inventory. It was also assumed that all operations were an actual process, however not necessarily a valued added process. It was thought that this type of analysis was already discussed within Stage 4, and it highlighted the need to move on through to Stage 4 to analyse some of the information gathered.

The current state culture was also benchmarked and is shown in **figure 6.33** which demonstrates the table created to determine the cultural state. This table was used to classify statements according to the relevancy of the current state culture. This information was generated from process observations.

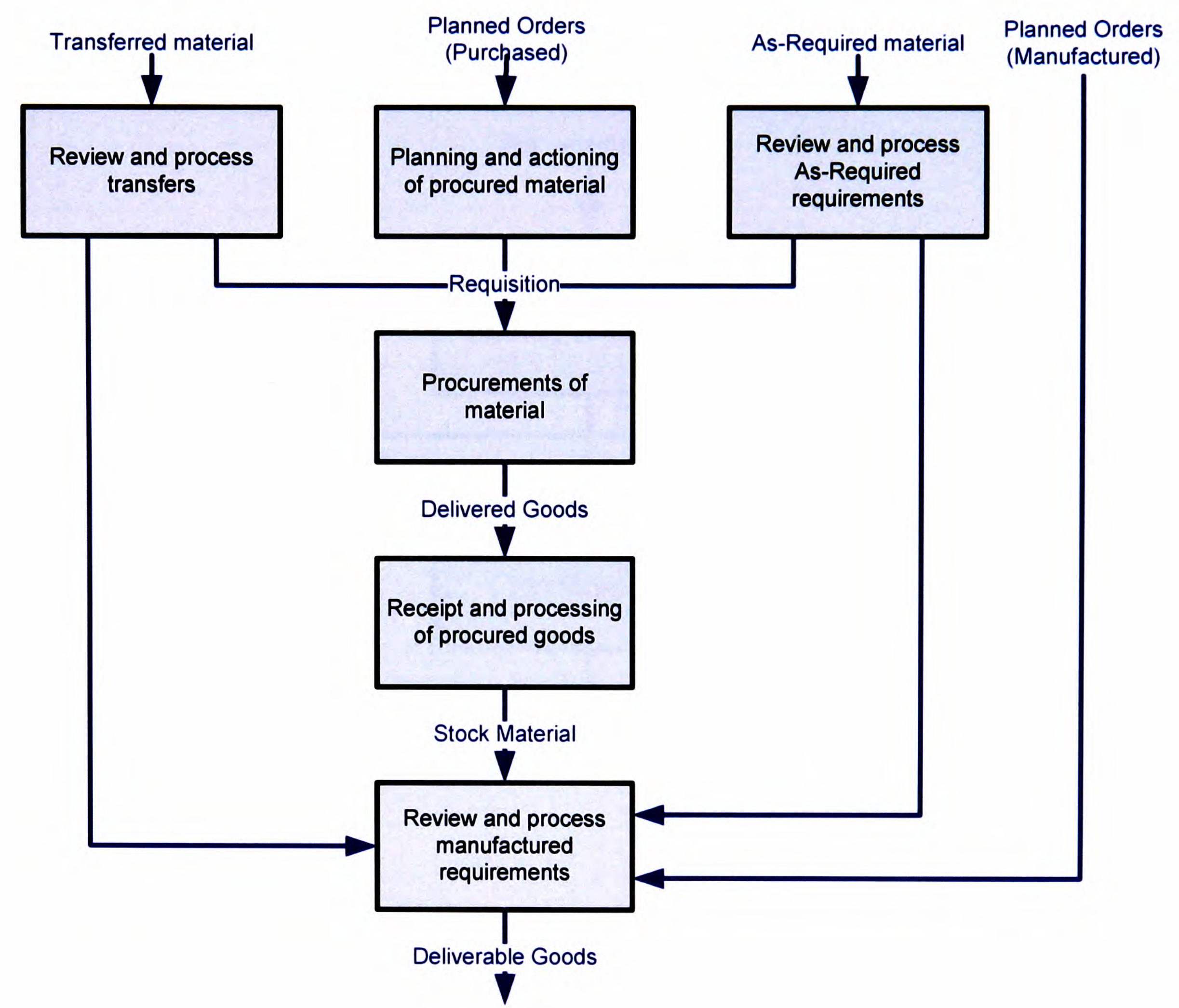


Figure 6.24: Acquiring material required for production

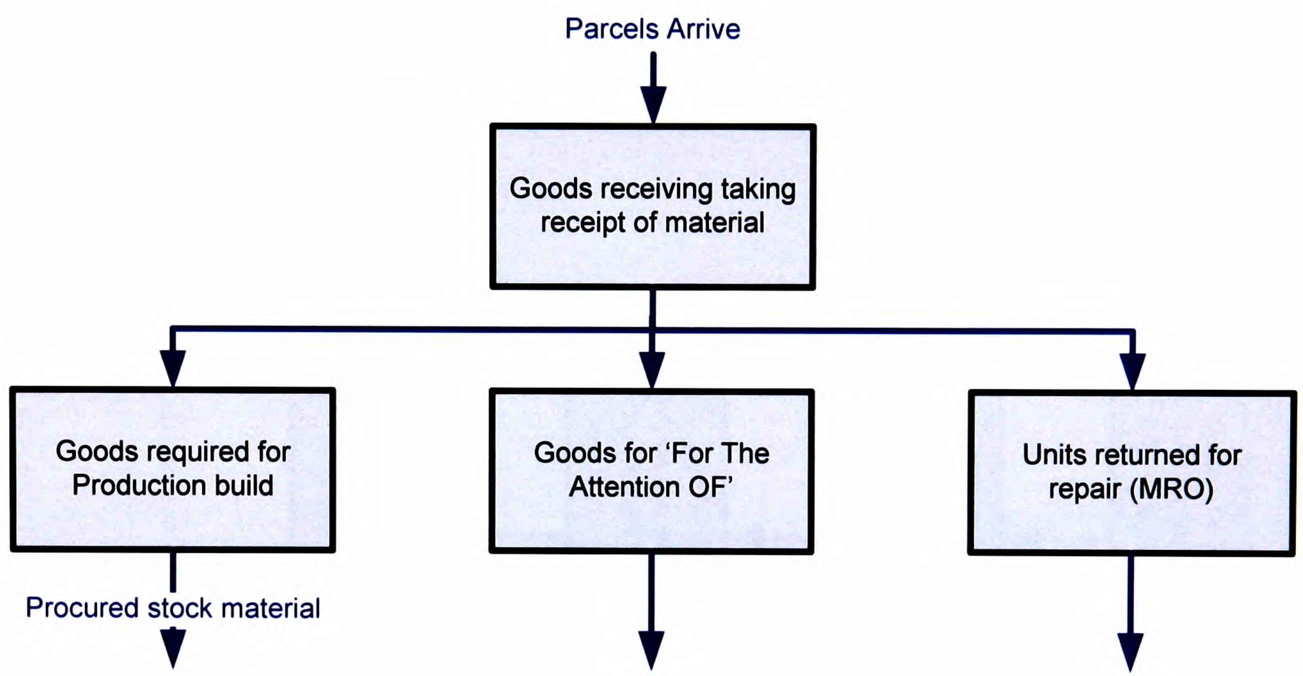


Figure 6.25: Receipt and processing of procured goods

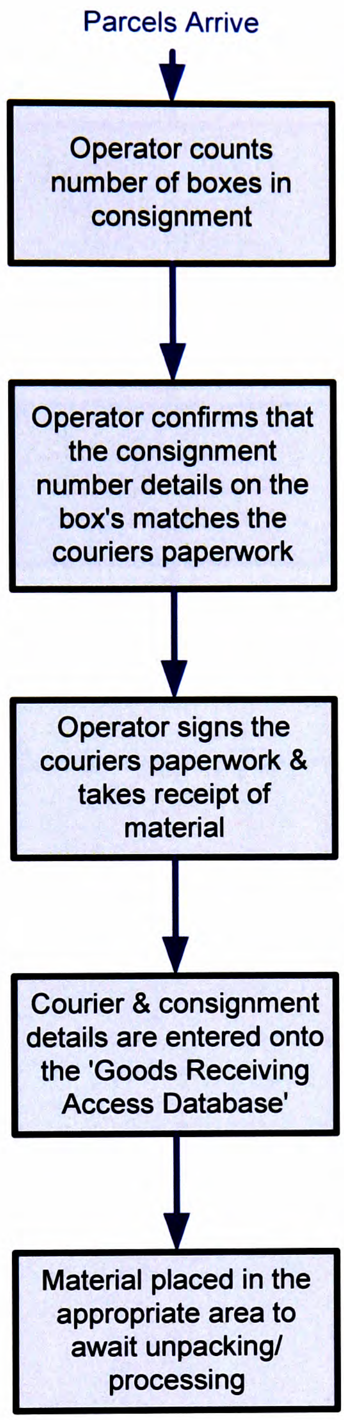


Figure 6.26: Goods receiving take receipt of material

Figure 6.27: Goods required for production build

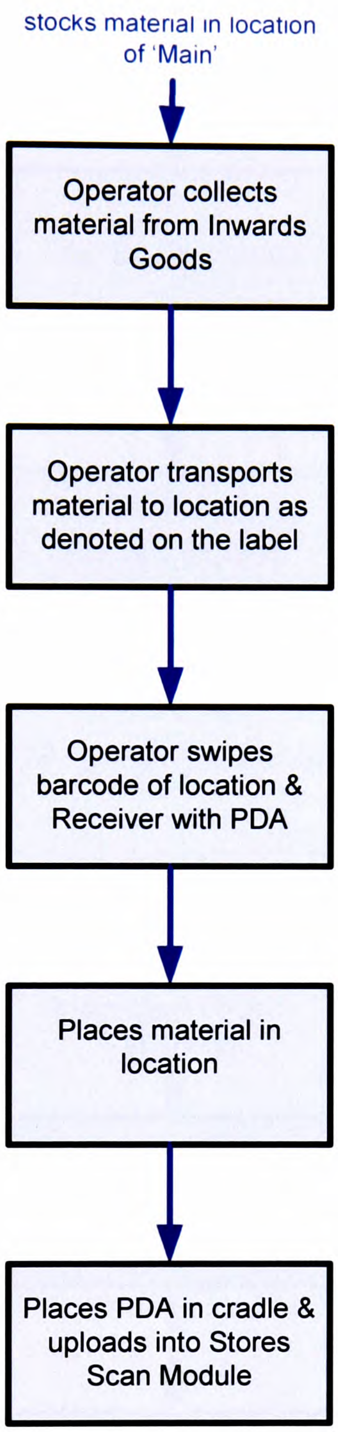


Figure 6.28: Goods passed to appropriate warehouse store

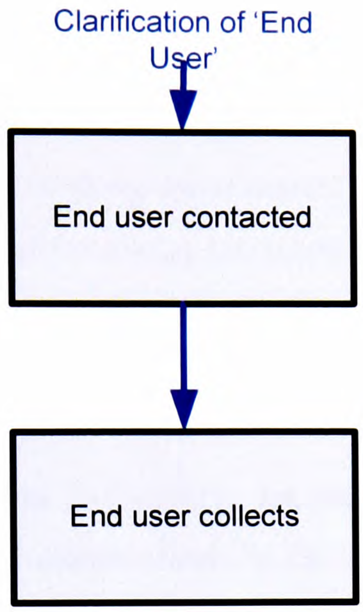


Figure 6.29: Goods 'for the attention of'

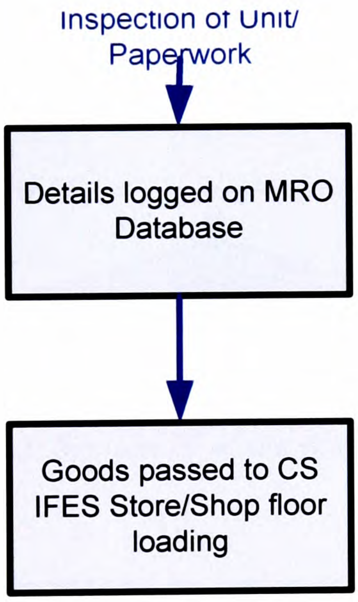


Figure 6.30: Units returned for repair

By completing the table in **figure 6.33**, it was highlighted that the company rely heavily on organisational status being defined by past record achievement. It is also apparent that it is considered uncultured to show emotion. It was also thought from the completion of the table that the working environment can be controlled and exploited and the long term vision is not achievable as too many company changes could happen. It was also thought that the short term future plans are unlikely to be achieved through personal effort but by team effort.

The culture seen by the individual is that there are many efforts to promote individual personal development and this is demonstrated by the loyalty the employees have to the company. However, lack of radical change programs leave the company with a very dated cultural background, especially within operations.

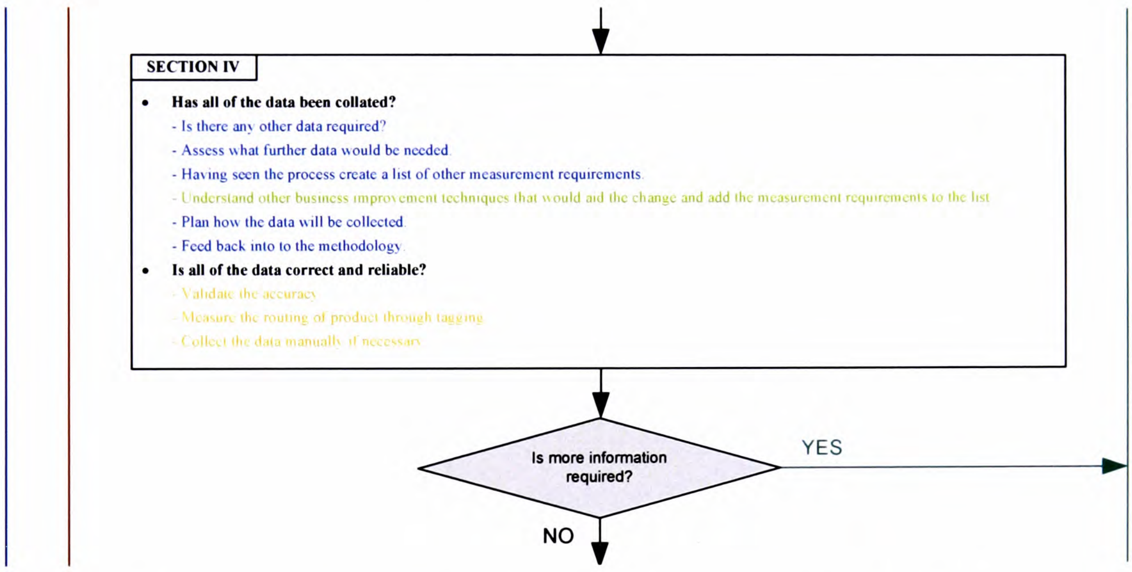


Figure 6.31: Stage 3, Section IV of the proposed methodology

All of the data required were collected and no further information was needed. This case study did not involve complex data analysis, it was required to understand transactional and process waste and so the data collated were sufficient. Data accuracy was of some concern; however at this level of interaction it was not necessary to need detailed information.

Sequence	Generic Process	Physical Location	Description	Operation	Time (Mins)	Total Process Time (Mins)
10	Material Receiving Process	Goods In	Material arrives at receiving dock	TR	10	87
20			Check the handling requirements	IN	5	
30			Check aviation security requirements	IN	5	
40			Operator counts number of box's in consignment	OP	10	
50			Check for a consignment shortage	IN	5	
60			Check for consignment damage	IN	5	
70			Check that the consignment details correct	IN	15	
80			Operator confirms that the consignment number details on the box's matches the couriers paperwork	IN	10	
90			Operator signs the couriers paperwork & takes receipt of material	OP	2	
100			Courier & consigment details are entered onto the 'goods receivng access database'	OP	15	
110			Material is placed in the appropriate area to await unpacking/ processing	TR	5	
120	Production Ready Process	Goods In	Goods required for production build are held in the appropriate area	ST	960	34187
130			Check inspection / paperwork requirements	IN	10	
140			Material that requires inspection is held	ST	960	
150			Inspect production build product if required	IN	480	
160			Goods confirmed to order / inspection requirements	OP	15	
170			Unacceptable material is held to await the CAP	ST	2400	
180			Confirm inspection acceptance	OP	15	
190			Material is received into the company planning system	OP	10	
200			Accepted material is held to pass to appropriate warehouse store	TR	5	
210			Material is held ready for storage	ST	480	
220		Main Stores	Operator from stores collects the material from inwards goods	TR	5	
230			Assess the label requirement from the 'stock ticket' report	OP	10	
240			Check the handling requirements	IN	5	
250			Operator transports material to location as denoted on the label	TR	10	
260			Operator swipes barcode of location and receiver with PDA	OP	2	
270			Places material in location	TR	5	
280			Check whether a altenative location is required	IN	10	
290			Places PDA in cradle and uploads into Stores Scan Module	OP	5	
300			Material is held ready for production	ST	28800	
310	End User Specific Process	Goods In	Goods 'for the attention of' are held in the appropriate area	ST	2400	2425
320			The end user is clarified	OP	10	
330			The end user is contacted	OP	10	
340			The end user collects	OP	5	
350	Units Returns Process	Goods In	Goods returned for repair (MRO) are held in the appropriate area	ST	1440	1970
360			Goods confirmed to order / inspection requirements	IN	15	
370			Check inspection / paperwork requirements	IN	10	
410			Details are logged on the MRO database	OP	20	
420			Goods are held to pass to the CS IFES stor / shop floor	TR	5	
430			Material is held ready for transportation	ST	480	

Figure 6.32: PAM created for the receiving processes of material

Current State Culture Definition

	Agree = 5 / Disagree = 1: 1	2	3	4	5
- Relationships to Other People					
- Rules versus relationships – The organisation uses tight contracts when engaged in business					✓
- There is not only one right way; the person should act in a way that fits the particular requirement			✓		
- Group versus the individual – it would be expected that several people would attend meetings and make group decisions		✓			
- Single decision makers are common and decision are made quickly			✓		
- Lack of emotion versus show of emotion – it is considered uncultured to show emotion				✓	
- Specific relationships versus diffuse relationships – Are relationships defined to fit a specific context				✓	
- All aspects of a relationship are discussed and intertwined	✓				
- Organisational status is according to past record achievement					✓
- Organisational status is satisfied through ascription					✓
- Attitude to the Environment and to Time					
- The environment can be controlled and exploited				✓	
- The environment is something that can be adapted too		✓			
- The organisational focus is on the future and making future plans			✓		
- The organisation places importance on the history and the past				✓	
- Time is seen as a linear, sequence of events				✓	
- Time is seen as circular, linking the past, present and future		✓			
- The immediate future is achievable through personal		✓			

effort					
- Long term is not as achievable, as too many things can happen				✓	

- Individual – Organisational Relationships

- Individuals can come together in an organisation because it furthers their own ambitions		✓			
- Individuals have little loyalty to the organisation				✓	
- The organisation instructions initiate from the top and work down			✓		
- The role of every individual is well defined			✓		
- Members have come together due to shared values or goals		✓			

- Power and Control

- The organisation has several levels of hierarchy and relies on a committee for decision making					✓
- The organisation focuses on successfully completing well defined projects / tasks			✓		
- Influence is based on expert power and is widely dispersed		✓			

- Innovation and Learning

- The managers are experts in their organisations limited area of operation					✓
- Management tend not to search outside their current areas for new equipment				✓	
- The company narrowly defines the market segments				✓	
- The organisation continually searches the market opportunities		✓			
- Regularly experiments with responses to environmental trends				✓	
- Attitude to Risk			✓		
- The organisation operates through the use of formalised structures and processes			✓		
- Management are reluctant to change			✓		

- Management only react when they are forced to do so			✓		

Figure 6.33: The current state culture classification

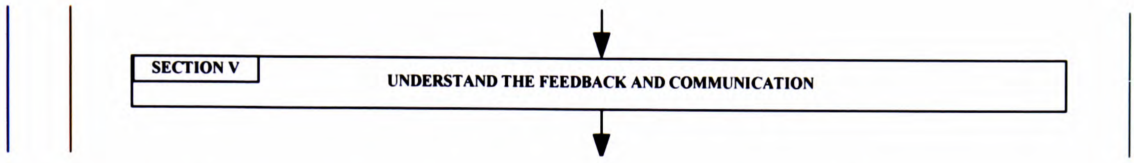


Figure 6.34: Stage 3, Section V of the proposed methodology

All guidelines and issues were met through methodology application and cultural issues were addressed through the interaction with the team. All team members were supportive of the analysis which allowed the data collection processes easier to obtain.

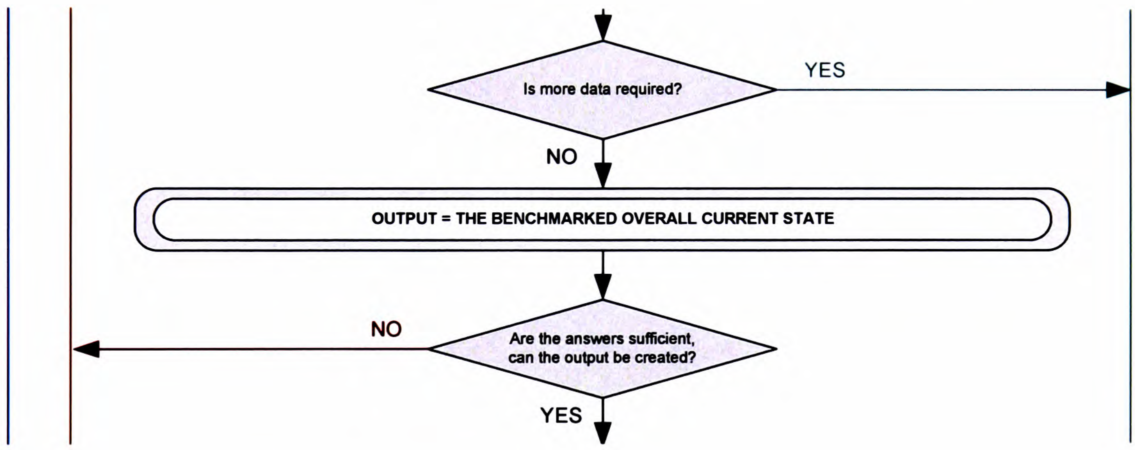


Figure 6.35: Stage 3 output of the proposed methodology

The overall current state was benchmarked (**figure 6.33**) and it could be seen that there were processes within the map created in **figure 6.36**. The greatest process bottleneck is the database receiving process, however the overall process activity was ½ a working day. This was insignificant when measuring the overall lead time which was 6.5 working weeks. This highlighted all of the wasted processes as the activity time was only 1.5% of the overall transaction.

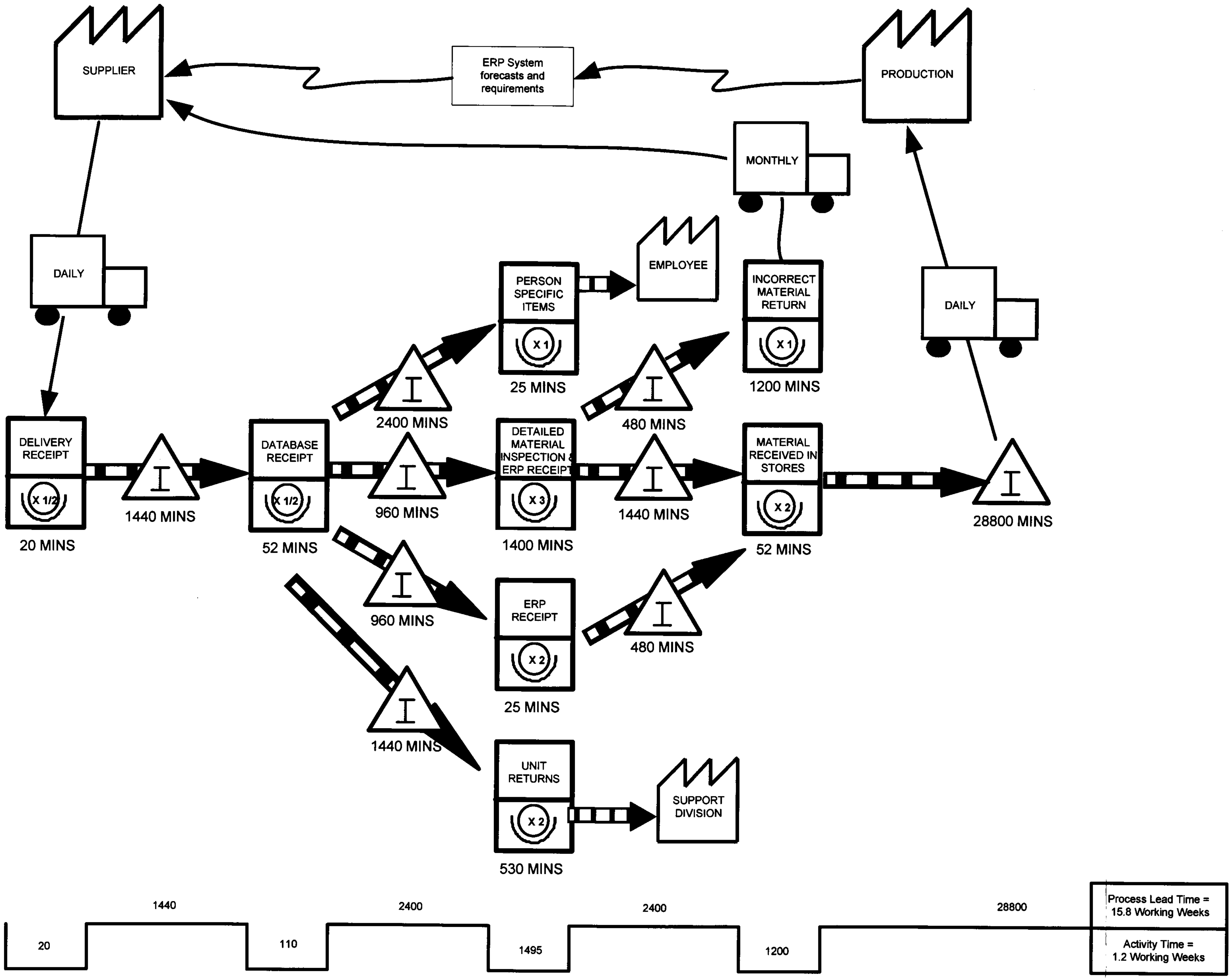


Figure 6.36: The current state map

It was also shown from the map that a large percentage of activity time was spent carrying detailed inspections on the items that were supplied by approved suppliers. It was noticed in this complex routing that a large percentage of the items packaged were for specific people, and therefore for departments other than production. This map was in a sufficient format so it would allow analysis in Stage 4. This information (**figure 6.36**) and the current culture (**figure 6.33**) which was the output of Stage 3 was sufficient to proceed.

6.4.4 Stage 4 – Analysing the Technical Data and Defining the Technical Future State

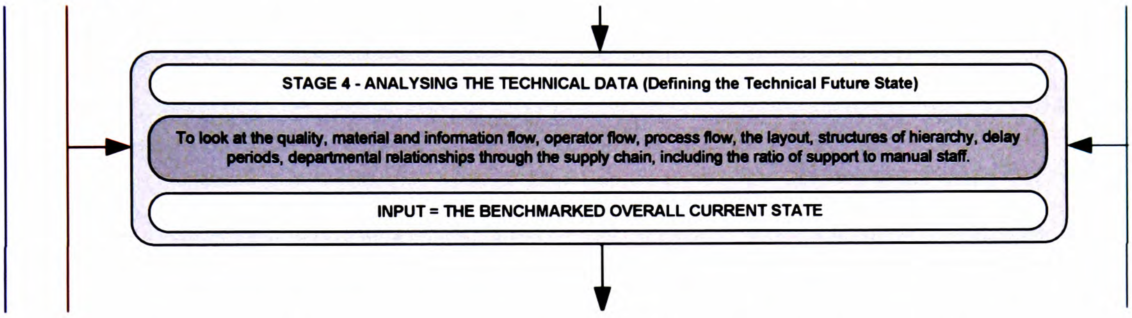


Figure 6.37: Stage 4 heading of the proposed methodology

Using the data obtained within the process maps (**figure 6.24** to **6.30,** page 236 to 241) and the PAM (**figure 6.33**, page 246) including the current state VSM (**figure 6.36**), Stage 4 of the proposed design methodology could be applied.

From the current state map it was analysed that there were many activities that were not necessary. If the company's planning system could receive material earlier in the process the need for the receiving database was not required. This possibly could be moved further upstream through reducing the number of items that require inspection. This is currently an initiative that the company are addressing through the addition of a new planning system along with the use of this methodology; **figures 6.39 to 6.43** were developed to address these issues. **Figure 6.39** show how the company plan segregated the company production areas; initially this allowed visibility of the company requirements. As the process move the delivery of the material is logged on the planning system Oracle, this gives immediate visibility to all concerned through Oracle and eliminates the current receiving database. This map shows how if inspection is not required the material is 'released' into Oracle ready for production, even though the material is not physically in stores. If required, it can be utilised once collected from goods in. Those items that require inspection are still held. The inspection process is shown in **figure 6.41** again the inspection requirements are visible in Oracle as well as the results being fed back in to Oracle, which enables the system to act as a communication tool.

Figures 6.42 and **6.43** are the same processes for returned products (**figure 6.42**) and goods for the attention of (**figure 6.42**).

The key to reducing the inspection time is to reduce the amount of items inspected. This will require investigation and analysis of historical data and to move the limits on the specifications. This can be an external project that will have a significant impact on this receiving process.

Another aspect that can be considered is the amount of time the material is held in stores. The PAM was used to analyse this issue. The information was taken from **figure 6.33** (page 246). This figure highlighted that the overall activity was 7.2 working weeks. This time is fractionally different from that produced in the VSM, as the activities are seen as sequential in a PAM and parallel in a VSM, consequently the lead time becomes shortened.

By categorising the activities according to the key (**figure 6.43**) it allows visibility to analyse the data. **Figure 6.44** was created to highlight the time categorisation. This displayed that 98.1% of the lead time was due to storage and that only 0.3% of the total lead time was dedicated to operations. This figure could be lower depending upon the definition of the operation time. It was thought that not all of the operation time maybe activity time. In order to identify where this storage time was most significant it was pertinent to identify areas to instigate improvements, the PAM was broken down to specific processes according to the process maps (**figure 6.24 to 6.30**, pages 236 to 241).

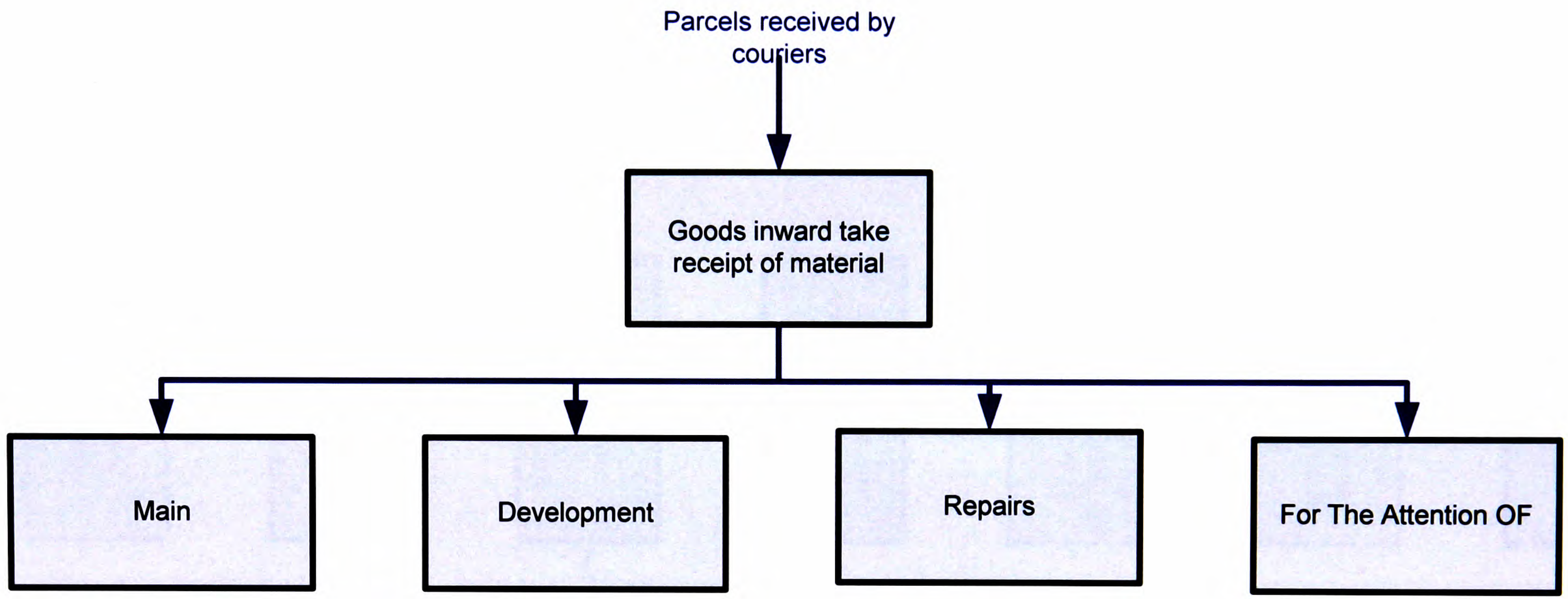


Figure 6.38: The receipt and processing of procured goods with the use of Oracle

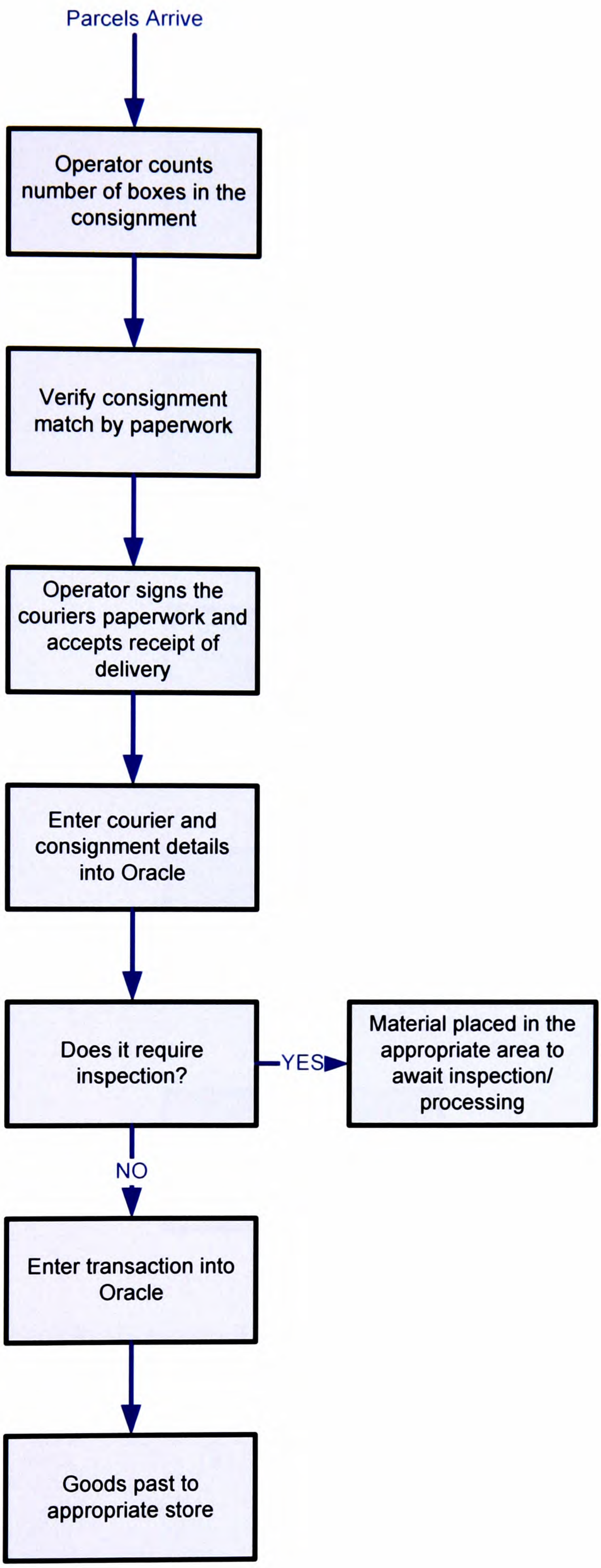


Figure 6.39: Goods receiving taking receipt of material with the use of Oracle

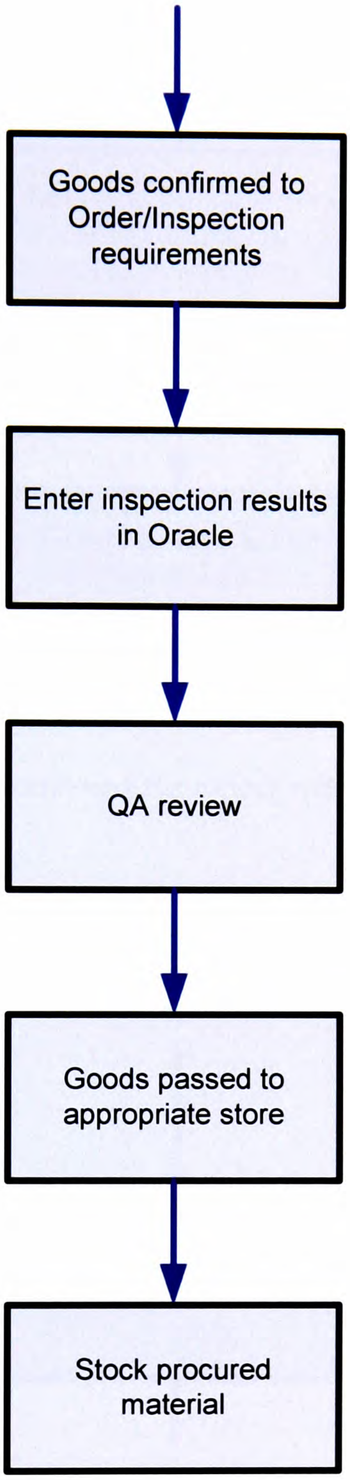


Figure 6.40: Goods required for production build the use of Oracle

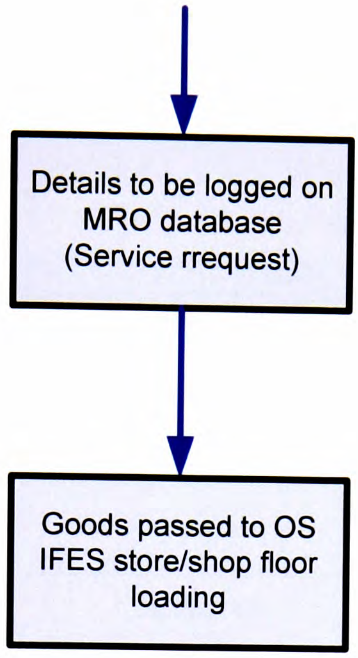


Figure 6.41: Unit returned for repair with the use of Oracle

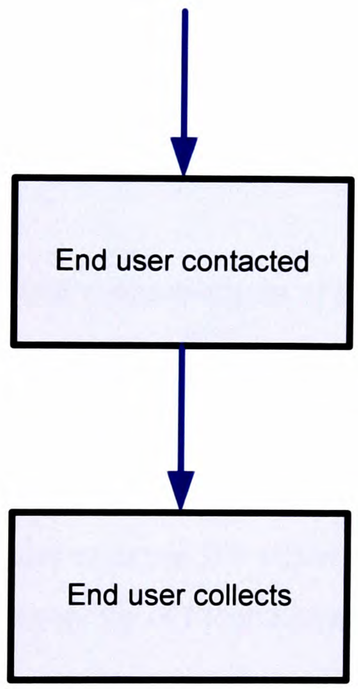


Figure 6.42: Goods for the attention with the use of Oracle

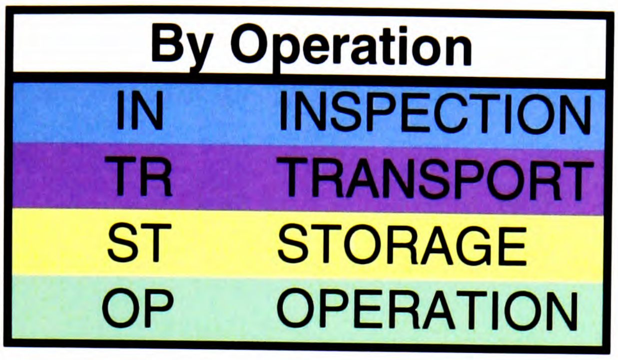


Figure 6.43: The PAM key

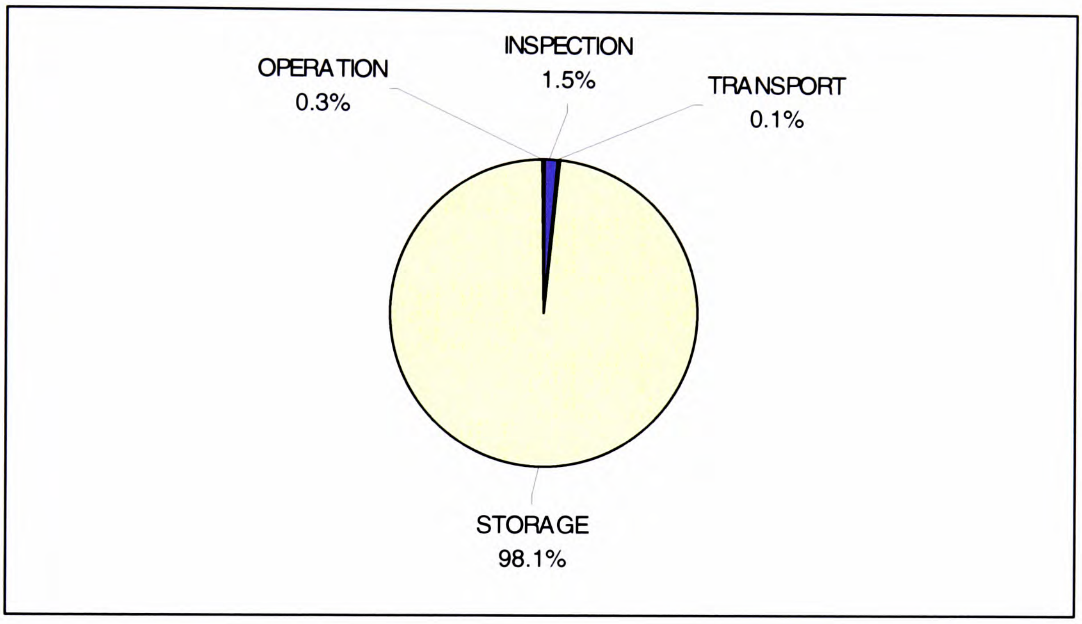


Figure 6.44: Graphical representation of the PAM by category

Figure 6.45 is a graphical representation of the material receiving process. This highlights that the greatest activity is the inspection process at 51.7%, another 31% is the operation activity. In this particular example 0% of the activity time is storage; however some of this activity time is the receiving of the material into the external database.

The following process is processing items ready for production; **figure 6.46** shows this in pie chart format. This shows that 98.3% of this specific activity time is due to storage. This process also consists of the storing of material in stores ready for production. The figure actually used here was a rough estimate, some items however can be required almost immediately, although the most common path is that items are planned to be held for as long as possible to compensate for failure and long supplier lead times. The percentage of time for operation seems insignificant compared to the amount of material stored.

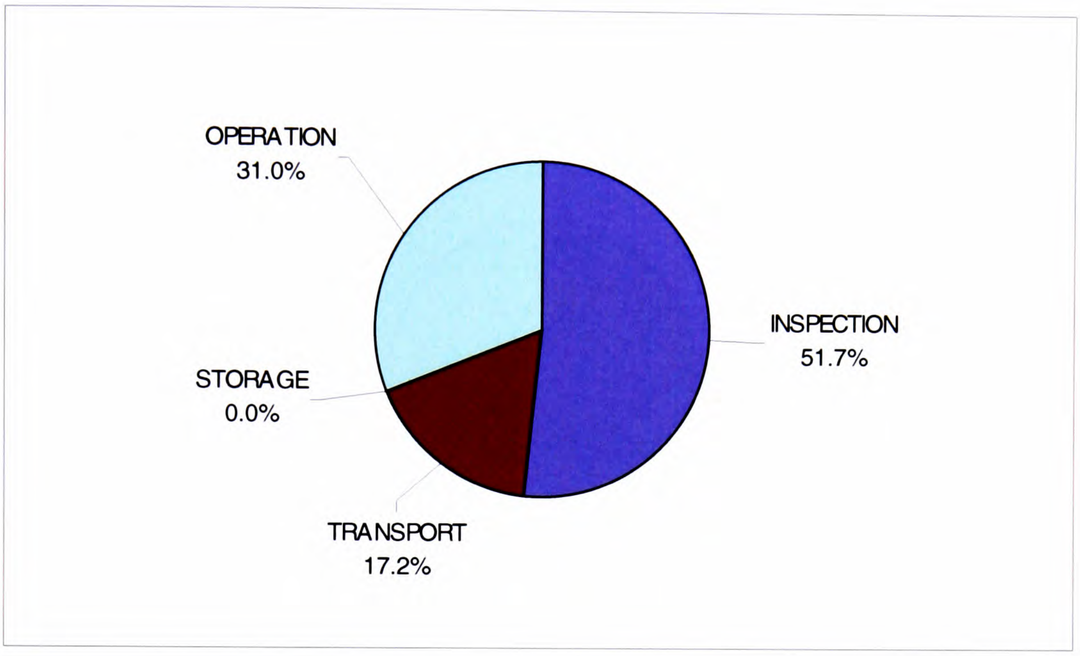


Figure 6.456: Graphical representation of the material receiving process

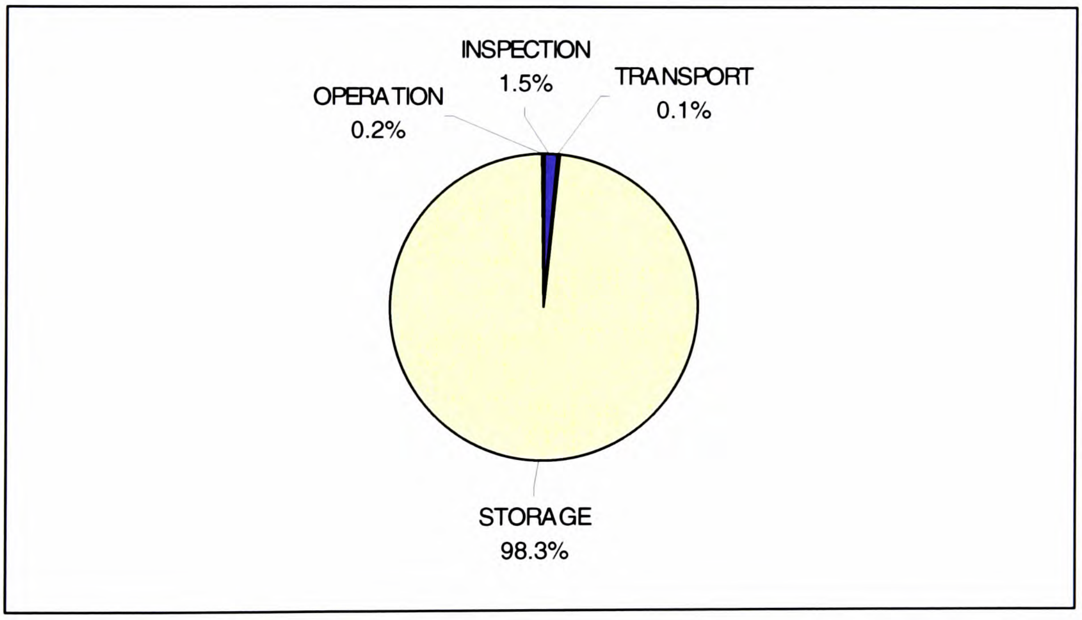


Figure 6.46: Graphical representation of the production ready process

Storage is the main activity in the 'goods for the attention of' process (**figure 6.47**) with 99% of the activity time; however this is small in comparison to the storage time in stores. Similarly, this is the same for the 'unit returns' process (**figure 6.48**). In all instances the operation time is negligible in comparison to the categories.

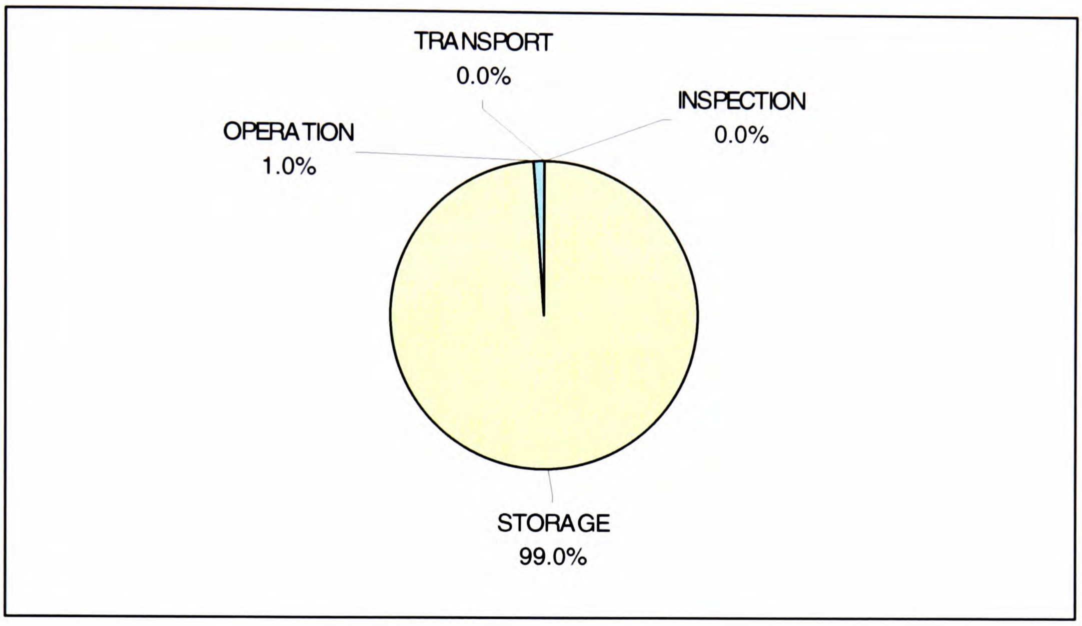


Figure 6.47: Graphical representation of the goods 'FAO' process

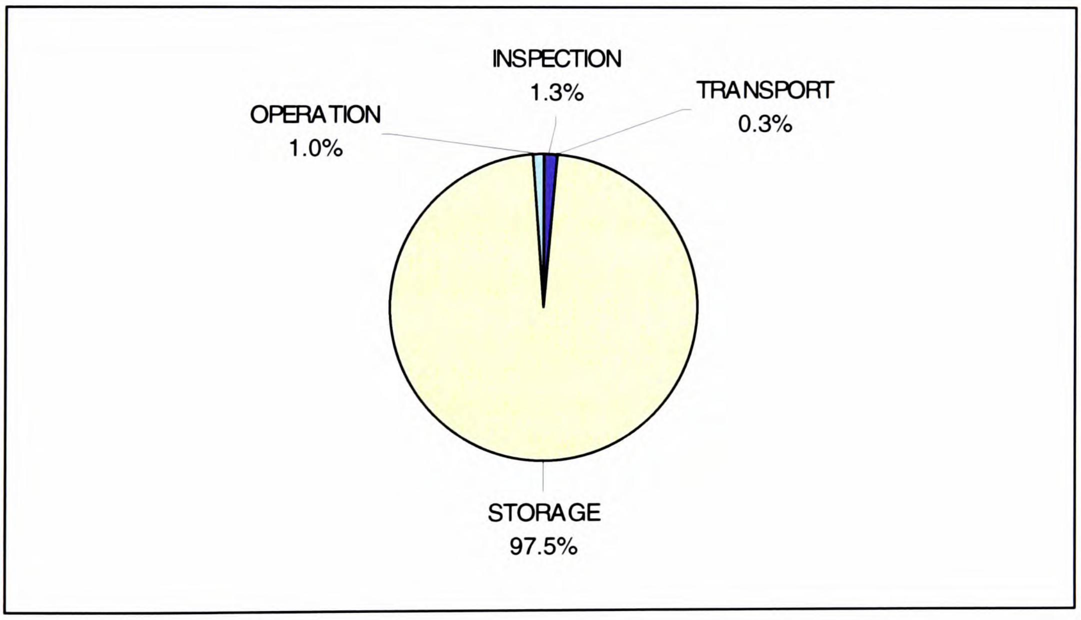


Figure 6.48: Graphical representation of the 'unit returns' processes

Figure 6.49 was created to highlight that the main issue regarding storage and the time consumption was within the production ready processes, 88.6% of the overall stage function was due to this. This was a significant issue when trying to reduce the transactions and eliminating waste within the processes.

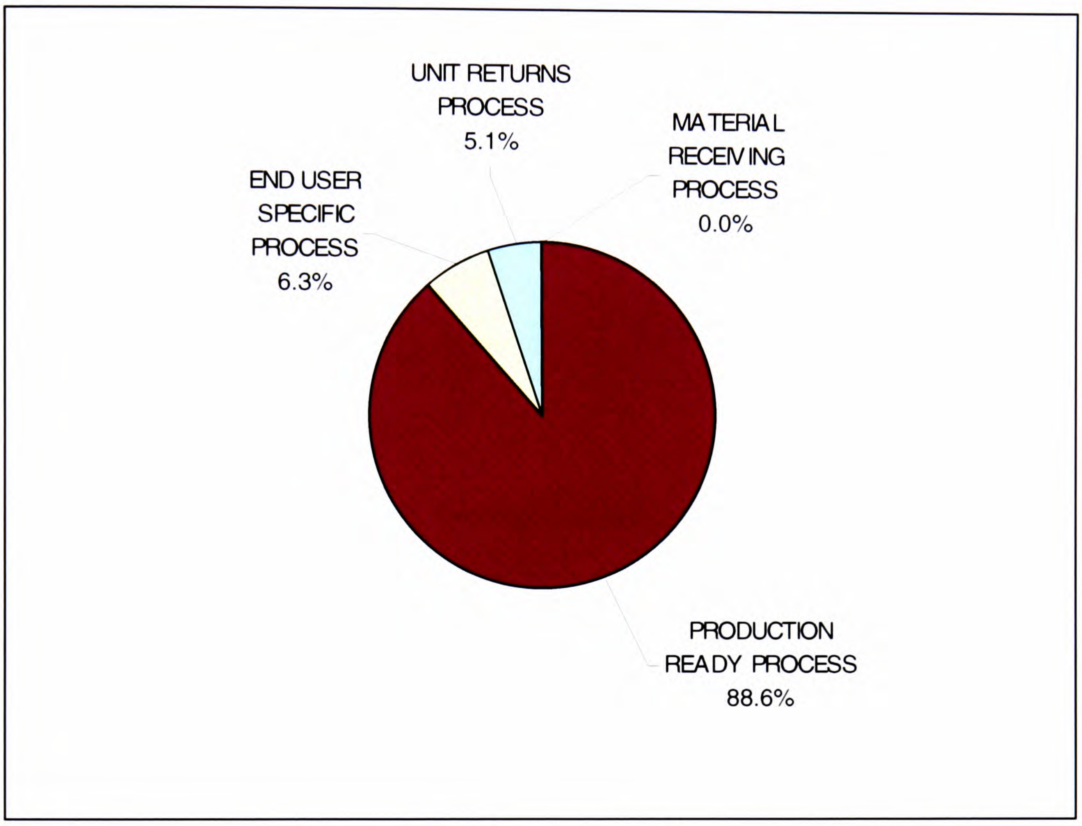


Figure 6.49: Graphical representation of the storage activity by process

Section I was used to identify significant changes within the current state map. Understanding the product demand was applicable as this process was dedicated to receiving the material as dictated by the supplier which was agreed with buyers as per the production requirement. This process was completely standardised and so the change in demand to level the process was minimal. The value added and non value added activities were analysed above with the use of the current state map, PAM and process maps, however the facets of continuous flow were yet to be fully considered. It was thought that issues of inventory could be eliminated with a two bin replenishment system. This would eliminate any long term stock holding issues, which would increase the stock turn and hence improve the issues around component life cycle warranties on faulty items.

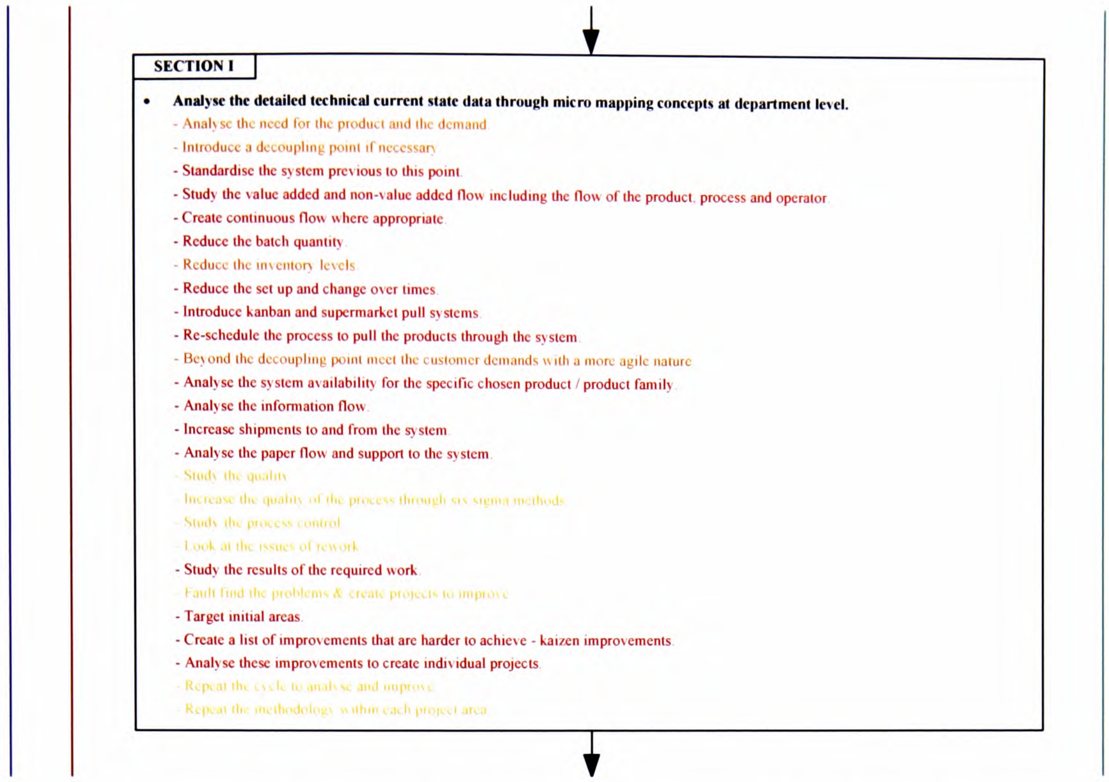


Figure 6.50: Stage 4, Section I of the proposed methodology

The items are received in packages and unpacked if necessary, so considering batches is not required. It has already been decided to use kanban and pull sequences can be used for the storage of material. The material can be triggered to the supplier when required and the material can be received as best suited. The scheduling of this process will be defined by production; however this will have to be forecast to the suppliers. They will have to be planning for this system as the suppliers have to agree to these processes.

Having a more reactive system such as a material bin replenishment system enables more shipments from the process, however it replies upon a stable system. The company's MRP system will enable information flow and a paperless workflow environment. Issues related to quality are mainly supplied faulty goods; this process is being looked into externally and is beyond the scope of this case study.

Initial areas to target will be;

- The need for inspection on items
- The elimination of the receiving database

- Producing level forecasts to suppliers and get agreements to relate to material replenishment requirements
- Initiate a bin replenishment system for production to pull the material through

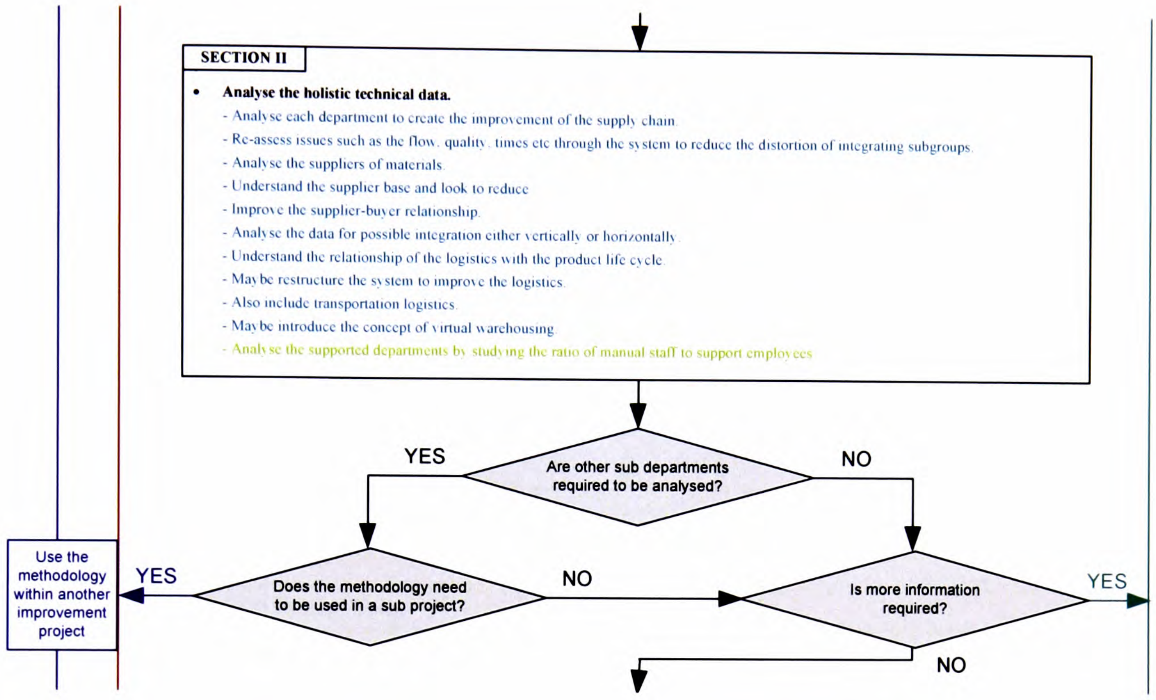


Figure 6.51: Stage 4, Section II of the proposed methodology

This section was completed to understand an enterprise view, as this project was specific understanding departmental roles this section was not applicable. Due to the nature of this study, working with the suppliers is crucial which has already been addressed prior to this section, Chapter 5. This was the case for many of the guidelines within this section. One facet that was considered was the number of staff required to support this process. A particular issue is that within the company people have very defined roles and it was thought that job flexibility may have to be addressed to ensure redeployment. It was felt that no further sub departments were required to be analysed and that no further information was required.

The associated risk and cost is again minimal in comparison to the benefits gained. The greatest risk is gained by the acceptance of those involved; the success of this project is dependant on the team involvement and acceptance. The costs will largely be associated with facility realignments with the change in process flows and material management.

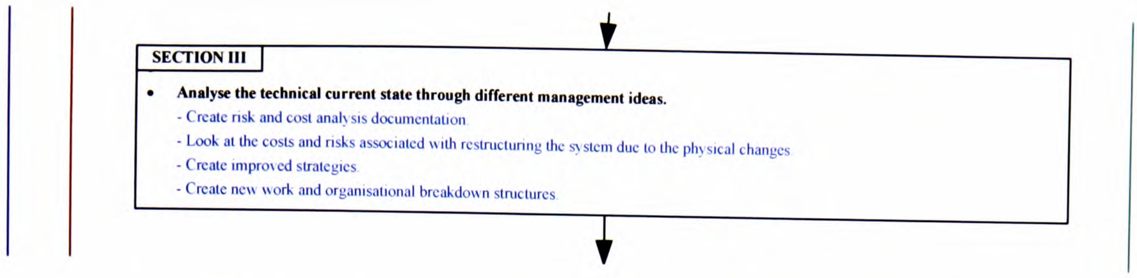


Figure 6.52: Stage 4, Section III of the proposed methodology

To minimise cultural resistance the people affected have been key stakeholders within this project. This will allow maximum acceptance but will also train the team in the new working environment. No further involvement is required and so the use of work breakdown structures appears to have minimal benefit.

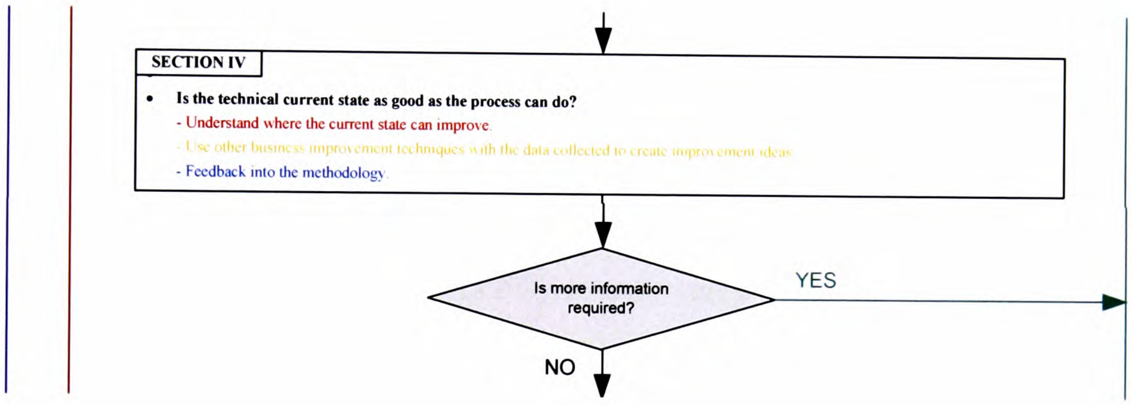


Figure 6.53: Stage 4, Section IV of the proposed methodology

Another MBIM that has been used is the 7 wastes, in this current state map there are a lot of transactions throughout the receiving department. This theory was used to reduce these transactions through analysing the wasted transportation, motion and inventory. No further information was required to create the future state map.

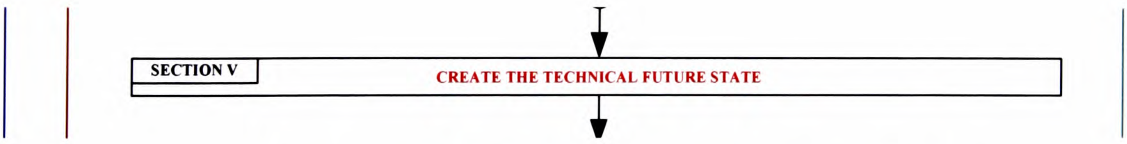


Figure 6.54: Stage 4, Section V of the proposed methodology

Figure 6.56 highlights the future state map created. It displays reduction of transactions as well as a reduction in lead time. It can also be seen how the whole process can be totally transformed enabling better communication with the suppliers, in turn this will create a more responsive system internally as well as externally.

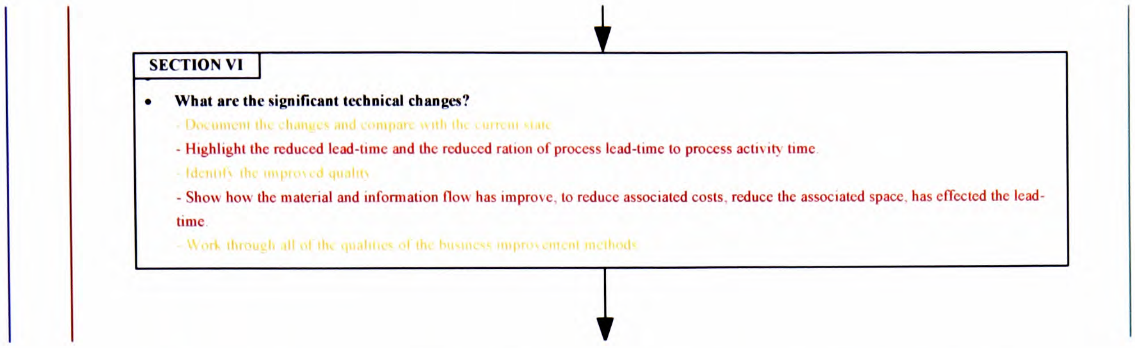


Figure 6.55: Stage 4, Section VI of the proposed methodology

One significant change on the future state is that it consists of one main transaction, this transaction receives all material. However, future improvements will have to consider not inspecting all received material; this will require setting up agreements with the supplier to increase the quality of the material. To enable this, more analysis is required on faulty material, the actual percentage of faulty material received will have to be measured and whether it would be possible to only carry out inspection on specific items with previous history problems would have to be established.

This receiving process will be significantly reduced if the items could be shipped from the supplier to the shop, but again this requires certain prerequisites. These would include the agreements made with the suppliers, along with the company regulations on suppliers being able to access the production areas, as well as the regulations on suppliers undertaking receiving transaction within the company ERP system. This system also has to assume that it can only be used on common highly used and inexpensive components, as these items can be purchased from a small select number of suppliers if not one supplier.

There will still be items that are for the attention of specific people as well as those items that are supplied faulty, which is inevitable. However, by having a better relationship with the supplier as well as better communication internally the times for those production processes will be reduced.

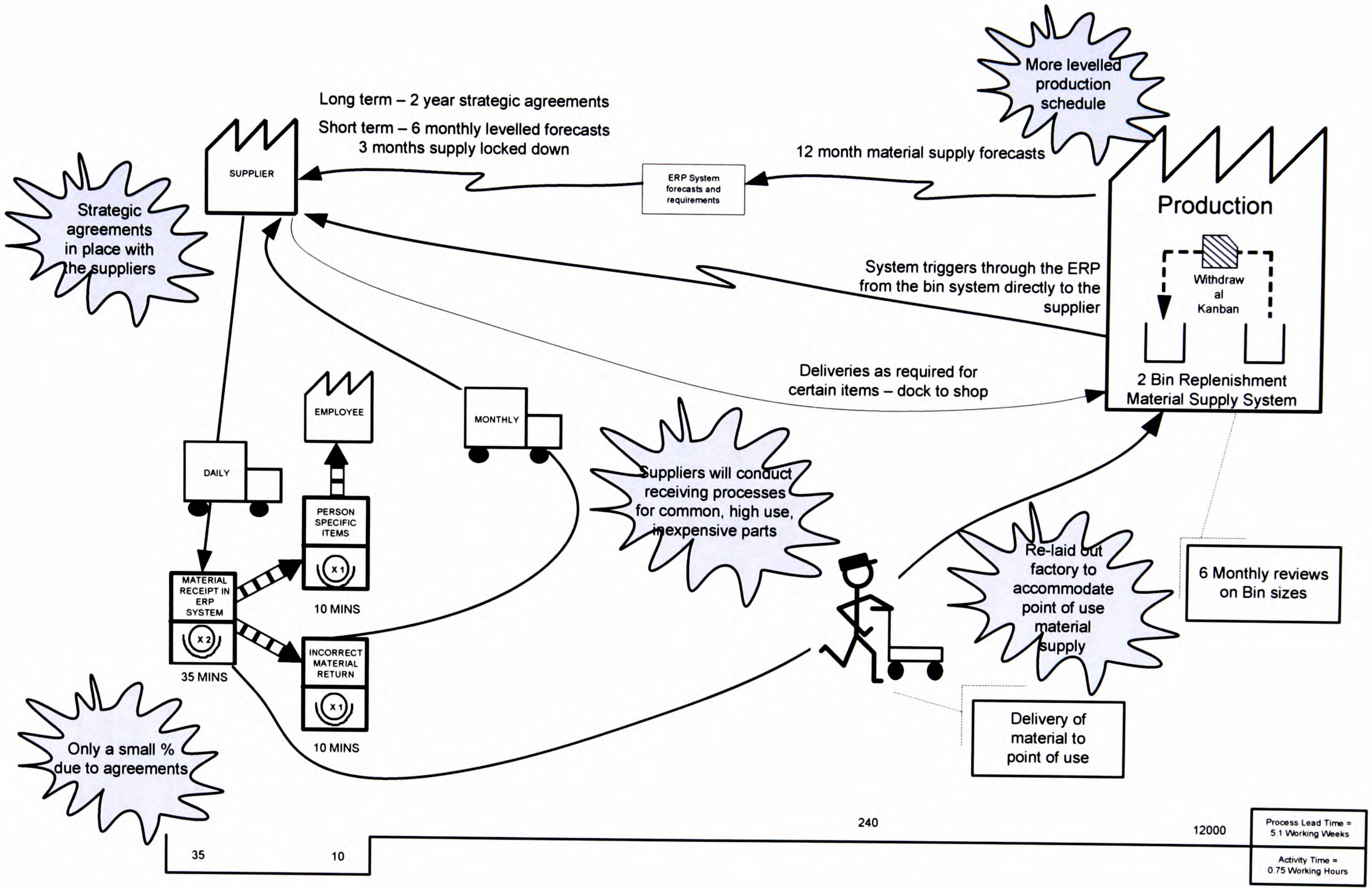


Figure 6.56: The technical future state map

The most significant change will be within the stores and production areas. Stores will be eliminated along with the processes within, such as kitting. Instead of these processes a two bin replenishment system will be introduced. This puts the material on the shop floor where it is required at the point of use. This enables the production staff to take the material when required rather than planning ahead and purchasing, storing, kitting and holding the material in advance of the planned requirement. To enable this system, there have to be a number of changes to the current system for example, the factory floor will require changes to accommodate this system, as well as the way in which production processes are planned and supported. Other considerations have to be the depletion of material within the stores area to allow this space to the shop floor.

The material in this bin system will hold an average of five weeks worth of inventory, which will be a fraction of the average time that material is currently held; this will create more stock turns. Overall the future state has enabled 63% reduction within the transaction time. The WIP has also reduced by 63% and the lead time will reduce by 64%. However, there will be a dramatic time reduction within the activity time, which will reduce by 82%. It can also be seen in **figure 6.57** how the number of operators have also reduced by 53%, these people can be deployed elsewhere within the production area managing the two bin replenishment system. The overall results and requirements can be seen in **figure 6.57**.

		Current State	Future State
No. of Operators	Delivery Receipts	0.5	-
	Database Receipt	0.5	-
	Person Specific Items	1	1
	Detailed Material Inspection & ERP Receipt	3	-
	ERP Receipt	2	2
	Unit Returns	1	1
	Incorrect Material Return	1	-
	Material Received In Stores	1	-
	Material Handlers	-	3
	Total	10	7
No. of Transactions		8	3
No. of Material Movements		8	2
Activity Time		5.86 Hours	0.75 Hours
Lead Time		15.8 Weeks	5.1 Weeks

Figure 6.57: Benchmarking data from the current to future state

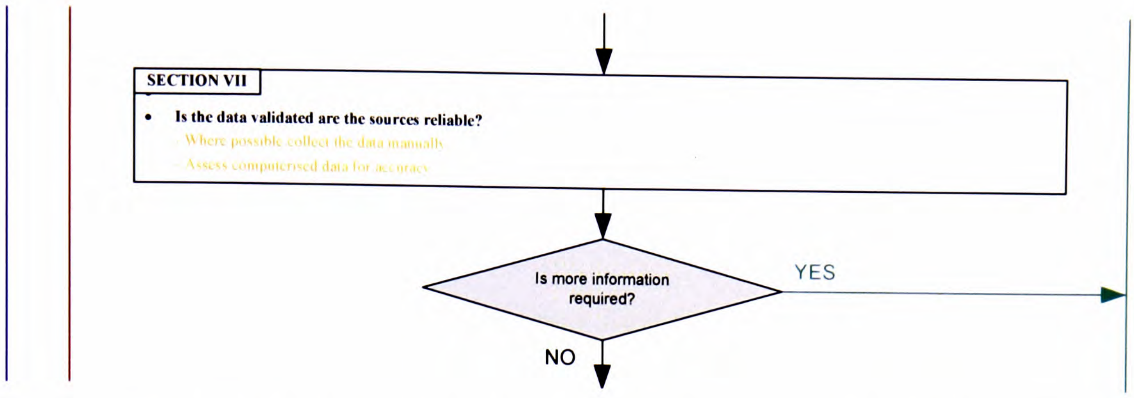


Figure 6.58: Stage 4, Section VII of the proposed methodology

All information that was required was collected previously and the sources of data collection were assessed at that point in the application process.

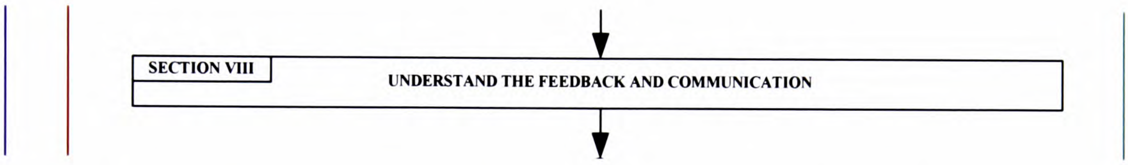


Figure 6.59: Stage 4, Section VIII of the proposed methodology

Further analysis could be carried out to investigate the number of faulty items received as well as to assess the need for inspection. However, due to time constraints this can be undertaken at a later date. The new processes remain the same, but the process time may extend to accommodate this until investigation.

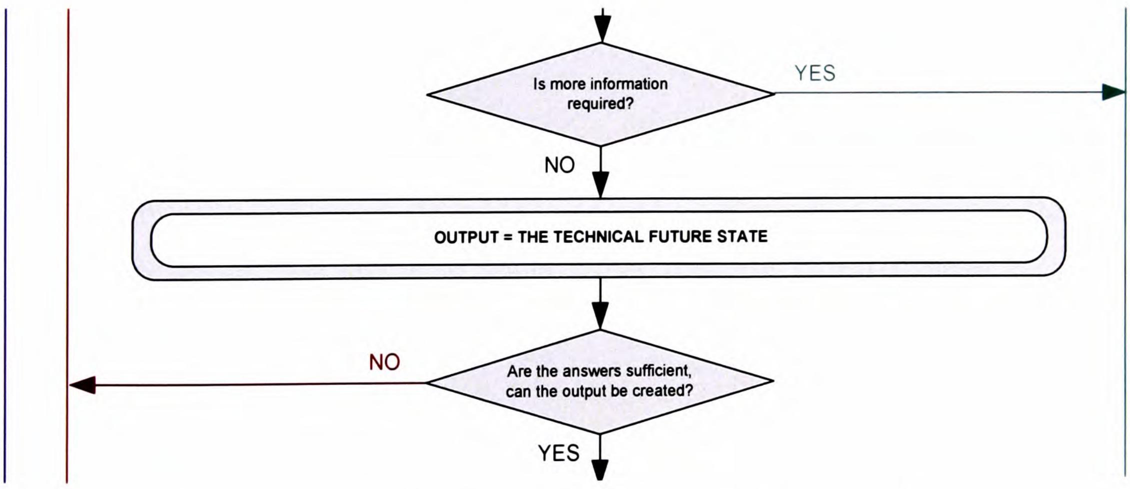


Figure 6.60: Stage 4 output of the proposed methodology

No further information was required and the answers were sufficient in the stage to proceed in the methodology application. The technical future state was shown in **figures**

6.56 and 6.57 and the reasons and justification of this change were discussed. A comparison between the current state and future state was made and the difference benchmarked.

6.4.5 Stage 5 – Improving the Results and Defining the Optimum Technical Future State

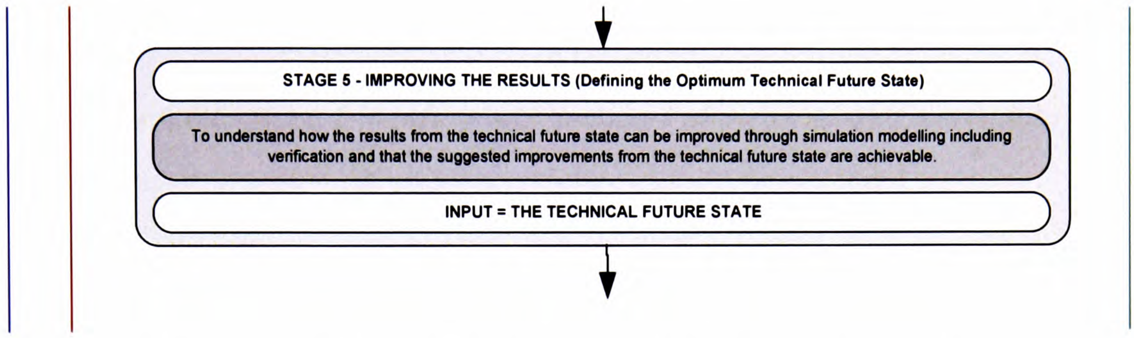


Figure 6.61: Stage 5 heading of the proposed methodology

It was decided that simulation modelling was not necessary. This case study involves investigating the process transactions and eliminating excess motion and material handling prior to production. The purposes of simulation modelling are to verify a process and validate those suggested improvements. The timings in this study are rough estimates of the process from process walks. The results from simulation modelling are only as realistic as the information placed within. Simulation modelling would have been beneficial to understand and test the future state, however creating the model would be time consuming and there are many prerequisites prior to implementation. By analysing the situation, it was decided that modelling the future state was unbeneficial due to the time and resources required.

This case study also had many dependencies and as a result it was clear that the best method was to move onto the next stage to analyse the cultural needs to enable the project strategy for implementation.

6.4.6 Stage 6 – Analysing the cultural data and Defining the Overall Future State

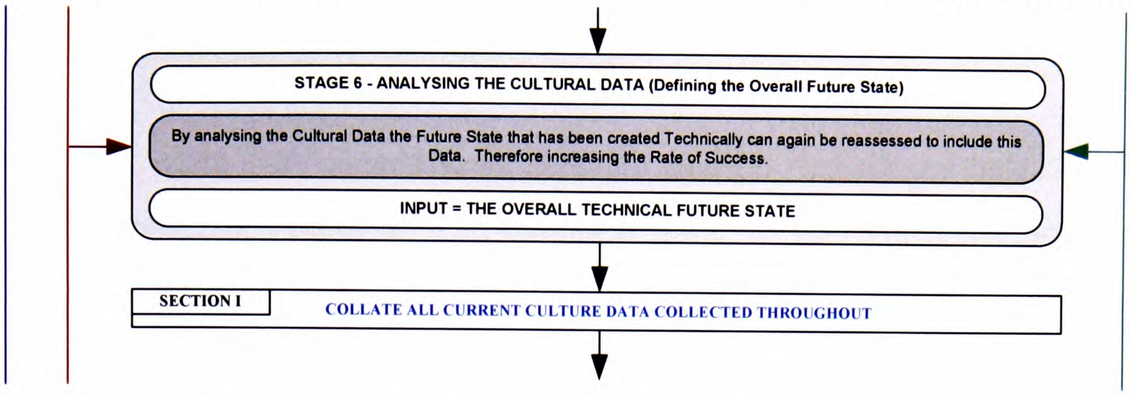


Figure 6.62: Stage 6 heading and Section I of the proposed methodology

All of the technical data were created and are shown in **figures 6.56** and **6.57**. This stage was used to analyse the cultural environment, so the data were collected throughout and **figures 6.11** (page 226) and **6.33** (page 243) were used as well as any cultural data collected throughout *via* the feedback and communication key.

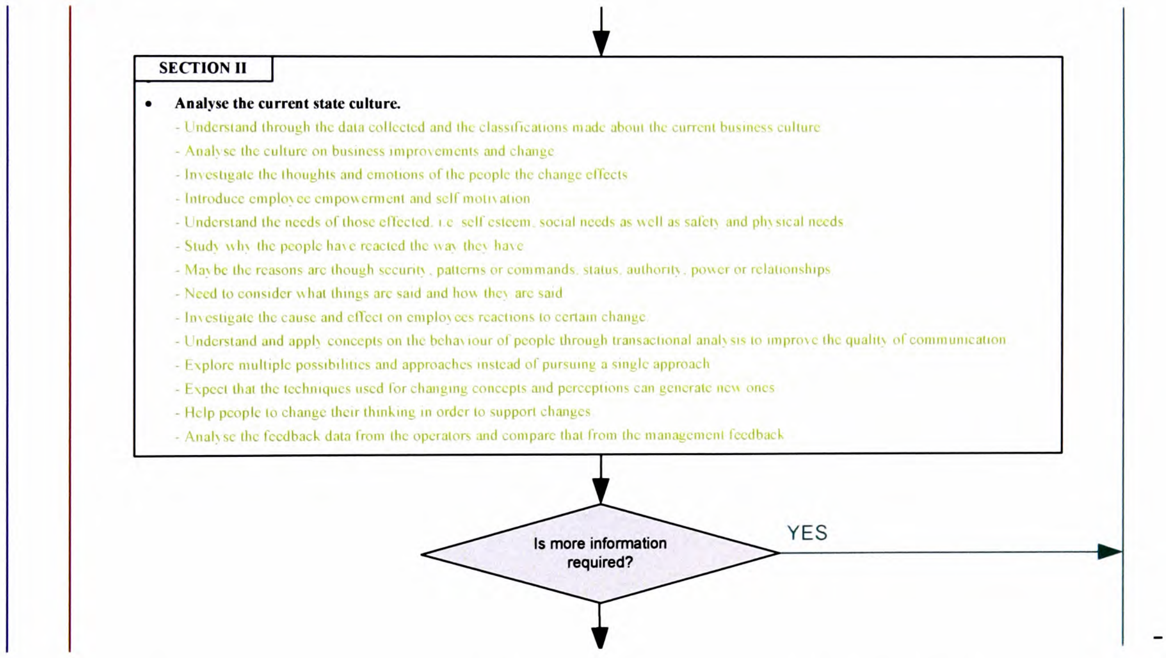


Figure 6.63: Stage 6, Section II of the proposed methodology

The cultural environment creates little concern, whilst the two main functions in this study, receiving and storing material work together. There appears to be cultural divides throughout the differing functions on site. Currently, the site operates in silos within the functions. There are also divides through job roles and tasks, roles and responsibilities are defined and so cultural unfreezing is required to enable ownership and empowerment which will in turn close this functional divide.

This technical future state created some dramatic changes that require cultural changes to enable the case study success. The change is being driven from senior management and the immediate workforces are fully supportive of the changes. This project plans to train the workforce to understand the tools available to use and to reiterate the potential gains and benefits.

It was ensured that all data that has been collected to date has been through the knowledge of all stakeholders and that hasn't been so specific that it becomes time consuming. The feedback from the team was their concern of the introduction of a new process that would run concurrently to the existing processes. Otherwise the team were unhappy with their working environment.

The main concern from the current culture that was collected in **figure 6.33** was regarding the lack of change in projects that occur within these functions. This leaves the processes being out dated and less responsive to change. These results also highlighted that the current culture is one where the work force are told about which business process will change and how. The key to the success of this project is to enable the workforce to be a part of this project and allow them to make the changes and take ownership of the new system. This has been achieved through this methodology by introducing the stakeholders into the change process and creating the new environment with them.

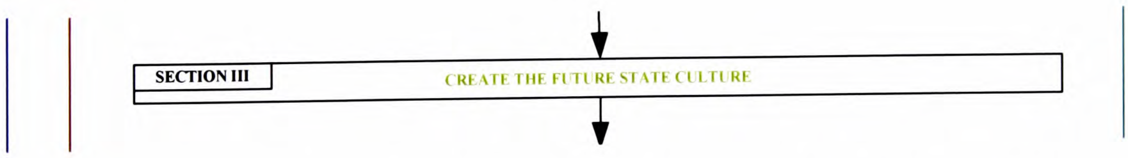


Figure 6.64: Stage 6, Section III of the proposed methodology

The future cultural environment that will be created can be seen in **figure 6.65**. This figure highlights the specific changes and sets a direction of change to work towards. These changes were based upon the workforce within the functional areas rather than a holistic site view.

Current State Culture Definition	Agree = 5 Disagree = 1				
	1	2	3	4	5
- Relationships to Other People					
- Rules versus relationships – The organisation uses tight contracts when engaged in business					✓ x
- There is not only one right way; the person should act in a way that fits the particular requirement			✓ x		
- Group versus the individual – it would be expected that several people would attend meetings and make group decisions		✓			
- Single decision makers are common and decision are made quickly			✓		
- Lack of emotion versus show of emotion – it is considered uncultured to show emotion				✓	
- Specific relationships versus diffuse relationships – Are relationships defined to fit a specific context				✓	
- All aspects of a relationship are discussed and intertwined	✓				
- Organisational status is according to past record achievement					✓
- Organisational status is satisfied through ascription					✓
- Attitude to the Environment and to Time					
- The environment can be controlled and exploited				✓	
- The environment is something that can be adapted too		✓			
- The organisational focus is on the future and making future plans			✓		
- The organisation places importance on the history and the past				✓	
- Time is seen as a linear, sequence of events				✓	

- Time is seen as circular, linking the past, present and future		✓			
- The immediate future is achievable through personal effort		✓			
- Long term is not as achievable, as too many things can happen				✓ x	

- Individual – Organisational Relationships

- Individuals can come together in an organisation because it furthers their own ambitions		✓ x			
- Individuals have little loyalty to the organisation				✓	
- The organisation instructions initiate from the top and work down			✓		
- The role of every individual is well defined			✓		
- Members have come together due to shared values or goals		✓			

- Power and Control

- The organisation has several levels of hierarchy and relies on a committee for decision making					✓
- The organisation focuses on successfully completing well defined projects / tasks			✓		
- Influence is based on expert power and is widely dispersed		✓			

- Innovation and Learning

- The managers are experts in their organisations limited area of operation					✓
- Management tend not to search outside their current areas for new equipment				✓	
- The company narrowly defines the market segments				✓	
- The organisation continually searches the market		✓			

opportunities
- Regularly experiments with responses to environmental trends
- Attitude to Risk

- The organisation operates through the use of formalised structures and processes
- Management are reluctant to change

- Management only react when they are forced to do so

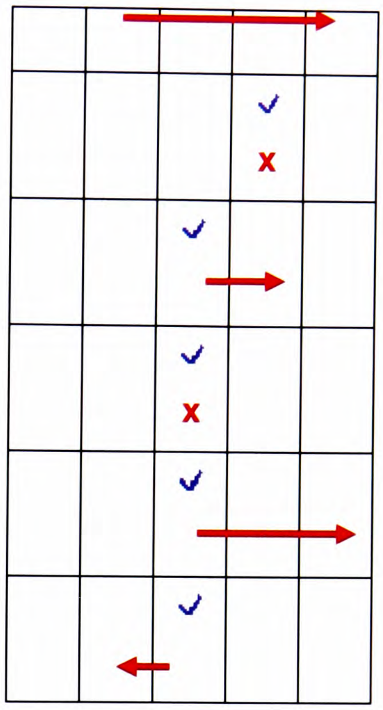


Figure 6.65: The current cultural environment and the future cultural aims

This figure highlighted that there would be many changes within the area. It was thought that the working environment should work towards having group decisions to discuss the topics. It was also considered important to move towards a more flexible environment, to encourage job rotation and to ensure the processes meet with the customer demand. This also requires the people to believe and behave in a manner, so communication and successful relationships is the key to an empowered work force. It was felt that the key to implement the changes in the current culture was to realign the business by product families, technology and processes to eliminate the functional divides.

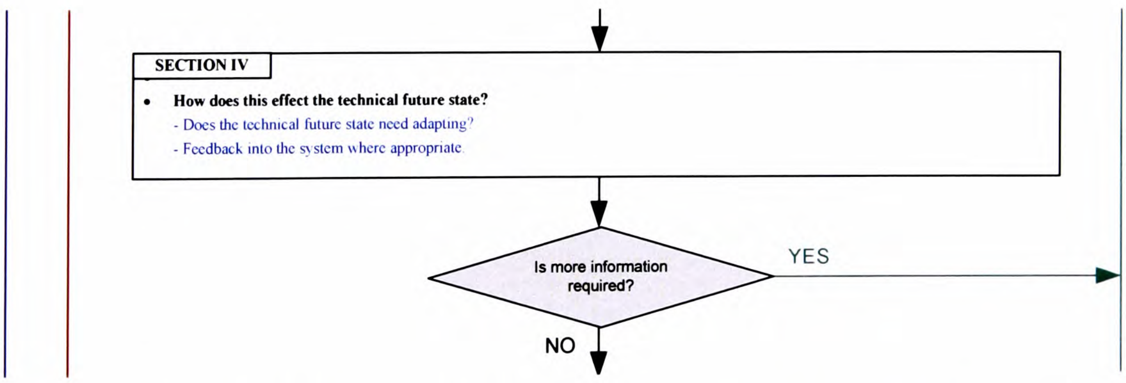


Figure 6.66: Stage 6, Section IV of the proposed methodology

The technical future state does not need adapting as the future cultural environment supports these ideas and is based upon this knowledge.

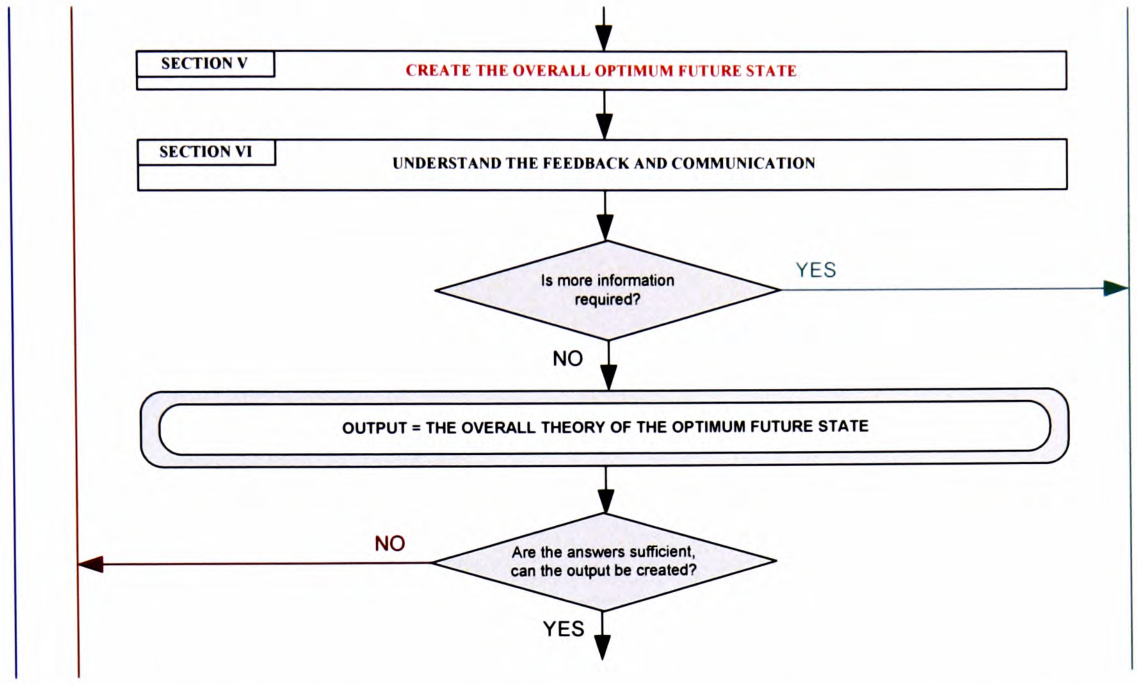


Figure 6.67: Stage 6, Sections V, VI and output of the proposed methodology

All guidelines have been satisfied and completed with this stage. The cultural factors have been extensively discussed. Further information is not required as all sections and guidelines have been met.

6.4.7 Stage 7 – Create a strategic plan

The project objectives have remained constant throughout and the design changes to the system have been reasoned and justified as required through the methodology. These documented changes can be seen throughout all of the figures in this chapter. The mission and vision that has been created can be seen in **figure 6.69**. This highlights the important factors that were required to ensure project success for a changing environment and gives an end goal.

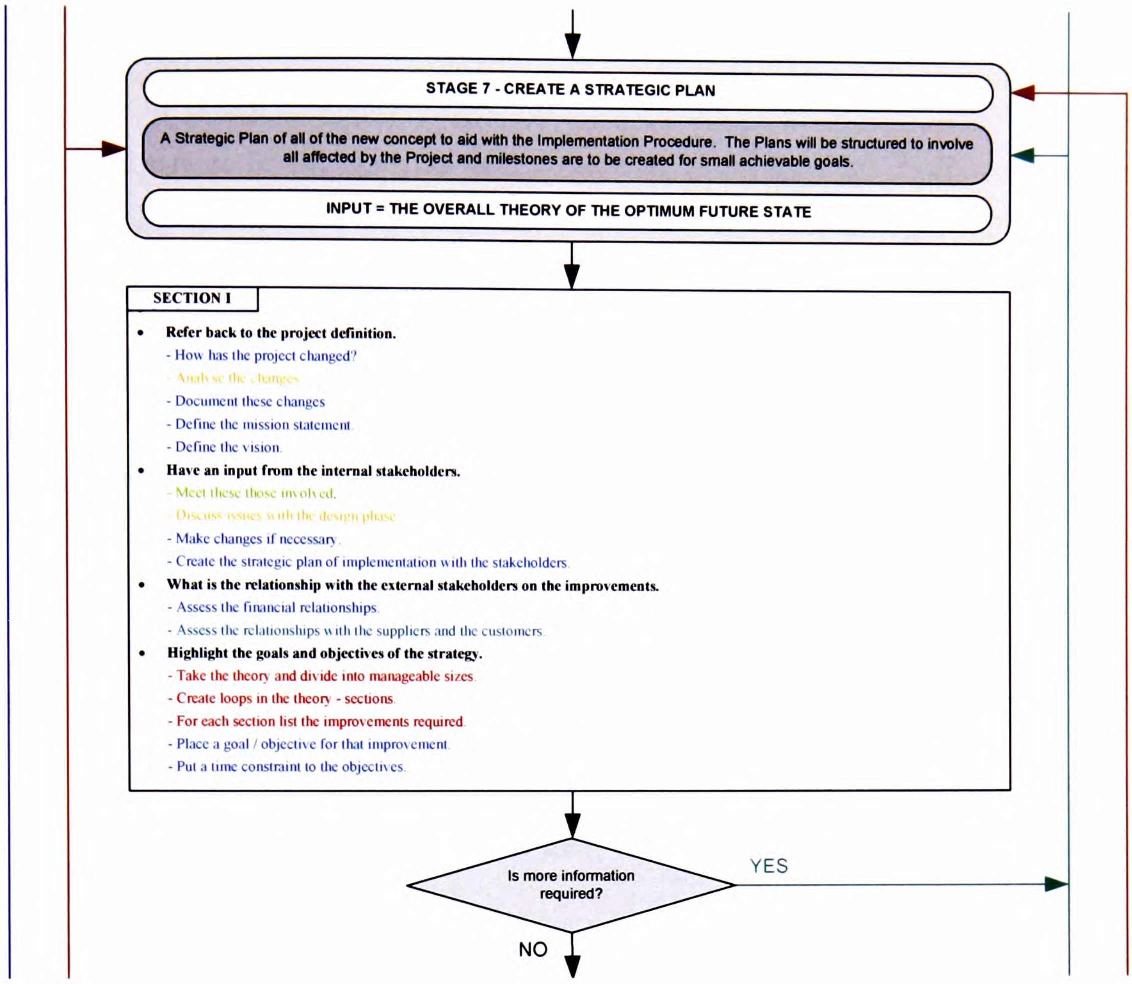


Figure 6.68: Stage 7 heading and Section I of the proposed methodology

The creation of the design has included all concerned throughout the methodology application. So no further changes are required to the final outcome and the strategic plan has been derived.

There is minimal financial concern as all changes are internal and concerned with reducing the number of processes and transactions as well as driving down stock to increase stock turns. There will be small costs associated with buying more efficient storage systems and co-locating this on the shop floor. There are greater financial costs related with the implementation of the new planning tool, however these costs are beyond the scope of this project and there are initiatives already addressing these issues, as well as the supplier base reduction,

The case study objectives and goals were created from the technical and cultural designed future states. **Figure 6.70** shows the division of the technical future state into sizeable objectives.

Mission	
BAE System is a world class leader in the Aerospace Industry. The mission of the investigation is to improve the communication and standards of supplier relationships, to create a more efficient process that will benefit the customer. This can only be accomplished if we eliminated unnecessary transactions and material handling throughout the site especially prior to production.	
Values	
People:	People are sources of strength that create the value to the processes. Empowerment and teamwork are the key to this success
Products:	These should be created with the best effort which will ultimately affect the quality provided to the end customer. The products and service are how the company are viewed.
Profits:	These are the overall measure of success; however have little purpose without people or products. Profits are required to survive and grow.

Figure 6.69: The project mission statement and values

The map was created into three loops: one for the pacemaker process, which was used to study the finalising processes of the map including the customer requirements, another loop was derived for the actual process transactions and a final loop was drawn for the supplier interaction. The divisions of these loops were used to create more specific detailed goals and objectives.

Figure 6.71 shows the map divided further to create objectives within these loops. There are nine main objectives created and **figure 6.72** displays a table of theses objectives and it discusses the requirements, enablers and dependencies.

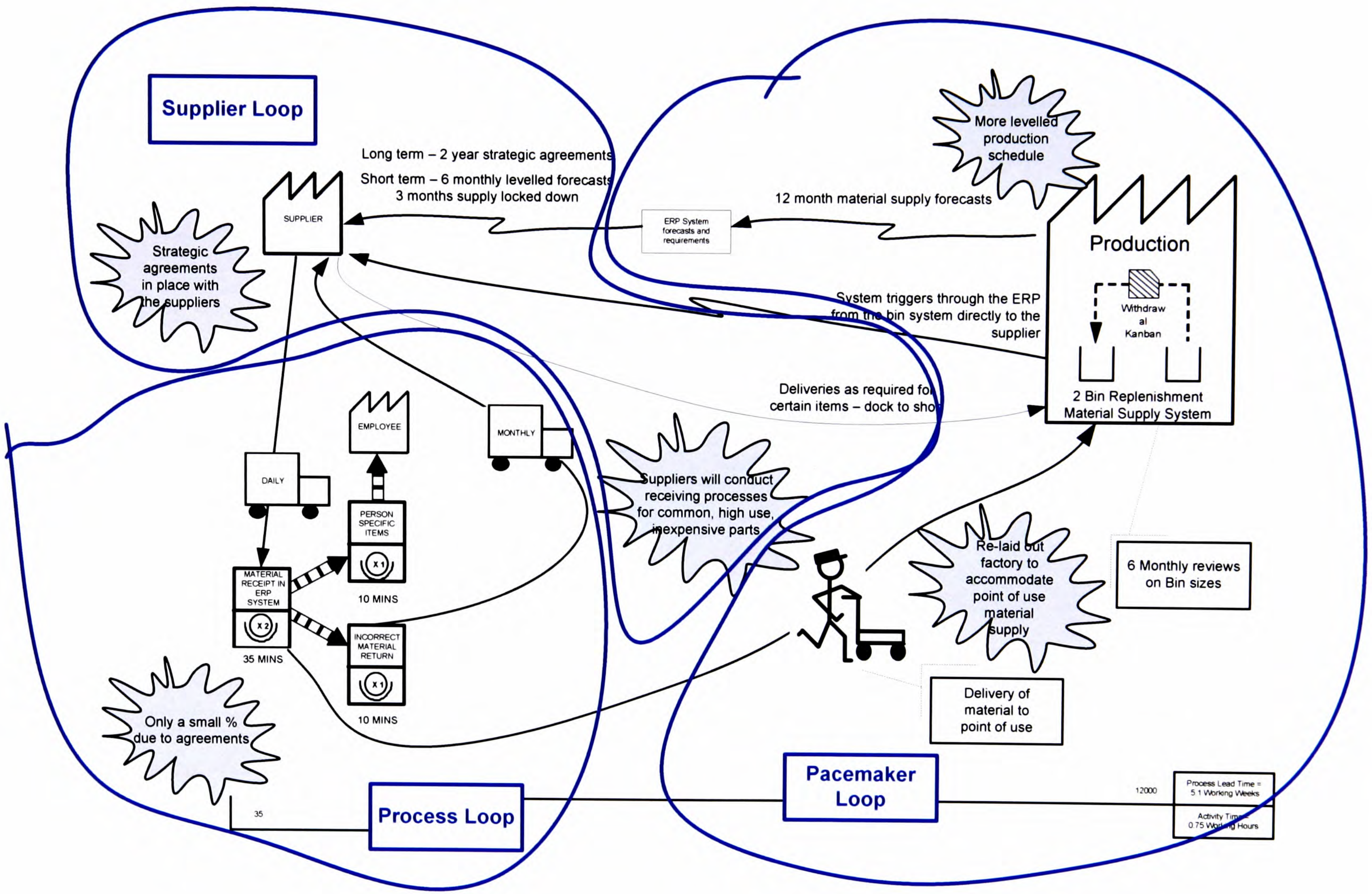


Figure 6.70: The division of the technical future state to create goals

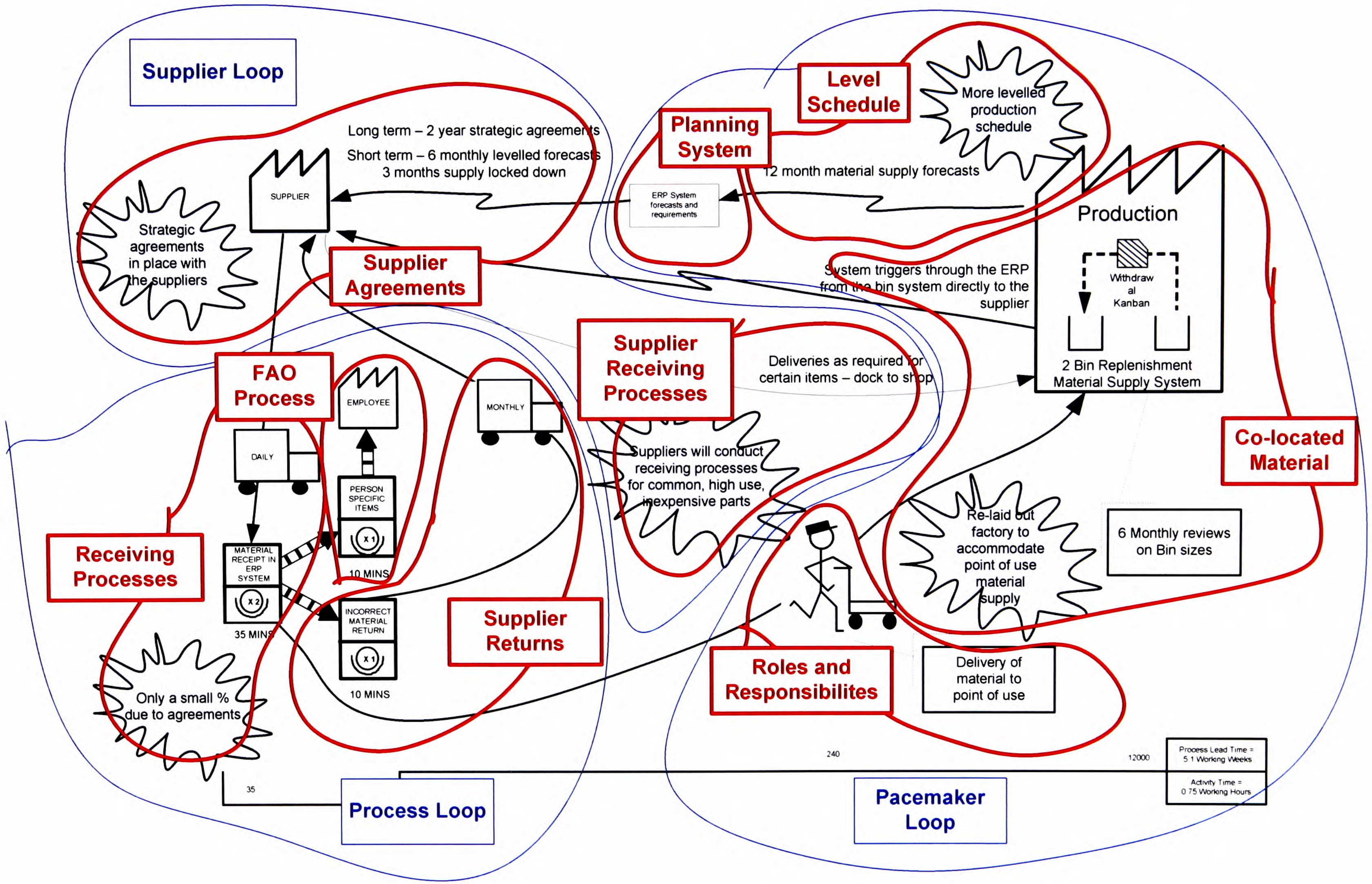


Figure 6.71: The division of the technical future state to create objectives.

Planning System	
Need	The current system is supported and out of date - External initiative
Enablers for this study	Kanban material replenishment
	Common inventory
	Supplier communication
Dependencies	-
Levelled Schedule	
Need	Understanding the end customer requirements and levelling these requirements
	Better planning of the needs with regard to resources and capacity
	Locking down those requirements and communicating these to the supplier as well internally
Enablers for this study	Kanban material replenishment
	Better understanding of the customer requirements
	Better relationship with the supplier – Supplier agreements
Dependencies	A clear planning system
	Clear customer requirements
Collocated Material	
Need	To reduce the number of material transactions prior to production as well as reduce the amount of material stored
Enablers for this study	Drives down and depletes material
	Ultimately eliminates stores
	Greater stock turns – A customer requirement
	Pulling of material when required instead of pushing the material to production through kits
	Better response to customer requirements
Dependencies	Requires facility layout changes
	Supplier strategic agreements to reduce supplier lead time
	A levelled schedule to calculate bins sizes
	Roles and responsibilities definitions for material movement processes
	On the new planning system for triggering the need to the suppliers

Supplier Receiving Processes	
Need	To allow the supplier to hold material and carry out the receiving of material on site when required accordingly to the kanban replenishment system
Enablers for this study	Moves from 'dock to stock' to 'dock to shop'
	Less inventory being held for the company
	Less transactions for the company
	Reduced inventory costs
Dependencies	Collocated material
	Better supplier relationships
	Supplier strategic agreements
	New planning system to allow the visibility of the material requirements
	Facility layout and design
Roles and Responsibilities – External Initiative	
Need	Introduction to new processes and tasks require new/different roles and responsibilities
Enablers for this study	Material movement in a kanban environment
	Supplier receiving processes
Dependencies	Collocated material process definition
	Supplier receiving process definition
	Union requirements and procedures
Supplier Returns	
Need	To reduce the lead time and processes to return faulty goods back to the supplier
Enablers for this study	Supplier receiving processes
	Better material replenishment to the shop floor
Dependencies	Re-establishing the quality constraints
	Requires a clear process definition
	Better detective techniques – better receiving processes
FAO Process	

Need	To clearly identify those items, mainly bespoke for development lines
Enablers for this study	Reduced process times
	Clear understanding of those packages for production and the kanban replenishment
Dependencies	Upon better receiving processes
	Clear labelling system
Receiving Process	
Need	To reduce the processes, transactions and material handling
	To reduce the constraints of material inspection
Enablers for this study	Reduced process lead times
	Reduced material being inspected
	Being more responsive to kanban requirements
Dependencies	Upon supplier relationships
	Upon the history of the item quality and the measurement of
	New planning system for receipting processes
Supplier Agreements– External Initiative	
Need	To communicate better to the suppliers, through agreeing long term, greater business opportunities and working with the in house material replenishment system
Enablers for this study	Reducing the supply base
	Reducing supplier lead time
	Better in house processes, receiving and material replenishment
	Kanban material replenishment

Figure 6.72: The detailed breakdown of the goals and objectives

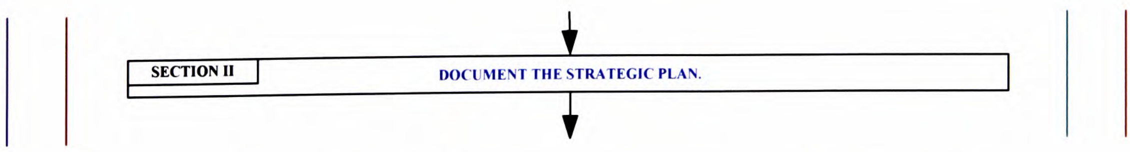


Figure 6.73: Stage 7, Section II of the proposed methodology

From **figure 6.72** the strategic plan was easily created and can be seen in **figure 6.74**.

DATE	May-08														
V.S LOOP	GOAL	VALUE STREAM OBJECTIVE	MONTHLY SCHEDULE - 1st Phase												REVIEW DATE
			1	2	3	4	5	6	7	8	9	10	11	12	
PACEMAKER LOOP	**PLANNING SYSTEM** A new planning system enhances and enables many new processes	This is an external initiative that affects this project and enables many processes.													Dec-08
	LEVELLED SCHEDULE A levelled schedule will clearly indicate the end customer requirements, the schedule can be levelled for 12 months and locked in place for 3months and then review after this period. This creates a stable inventory turnov	Understand the end customer requirements.													Aug-08
		Level these requirements.													
		Lock these needs for a set period of time.													
		Investigate better planning of these needs, capacity and resources.													
		Communicating these requirements with the suppliers.													
		Communicating these requirements internally.													
		Levelled schedule created and communicated.													
		Create plans to review continually.													
	COLLOCATED MATERIAL Collocated material will be more responsive the requirements of product	Understand material supply requirements.													Nov-08
		Understand material supply system.													
		Create facility layout changes.													
		Put in place material replenishment system.													
		Address planning changes.													
		Pull material.													
		Drive down and deplete stores.													
		Elimination of stores.													
		Reduce the number of material transactions prior to production.													
		Reduce the amount of material stored.													
		Collocated material on the shop floor being pulled from the supplier.													
	ROLES AND RESPONSIBILITIES Introducing different roles and responsibilities the workforce become more flexible to meet the manufacturing needs.	This is an external initiative that affects this project and enables many processes.													Aug-08
PROCESS LOOP	**RECEIVING PROCESS** This process aims to reduce the receiving process, the system transactions and material handling. This in turn reduces the dock to stock lead time.	Understand the current receiving processes.													Sep-08
		Reduce the number of non production specific material.													
		Reduce the number of items being inspected.													
		Reduce the number of system transactions.													
		Reduce receiving processes for low cost, high volume items.													
		Investigate and understand the supplier applications.													
		Reduced lead time for items in production.													
	FAO PROCESS Identifing those items that are bespoke for development lines separate from production elevates the lead time for the receiving of main production items.	Identify the split between development and main production items.													Jul-08
		Have clear identification for the separate items.													
		Create a system for those that are development items to received automatically and a notification sent to the relelvant person.													
		Improved system for the FAO process.													
	SUPPLIER RETURNS Better communication between the company and the suppliers will reduce the number of returns.	Having established agreements and better reciving processes, faults will be recognised earlier and the process for returns will quickier. Due to these reasons this objective is seen as a 2nd phase improvement after 'levelled schedule', 'co-located materi													Apr-09
SUPPLIER LOOP	**SUPPLIER AGREEMENTS** By reducing the supplier base and working with the suppliers, through long term agreements, there are greater business opportunities for in house material inventory designs.	This is an external initiative that affects this project and enables many processes.													Aug-08
	SUPPLIER RECEIVING PROCESSES Allowing the supplier to hold material and carry out the receving transactions	This process is dependant upon many factors such as; supplier agreements, collocated material on the shop floor, new planning system and facility layouts. Due to these reasons this objective is seen as a 2nd phase improvement.													Apr-09

Figure 6.74: The strategic plan

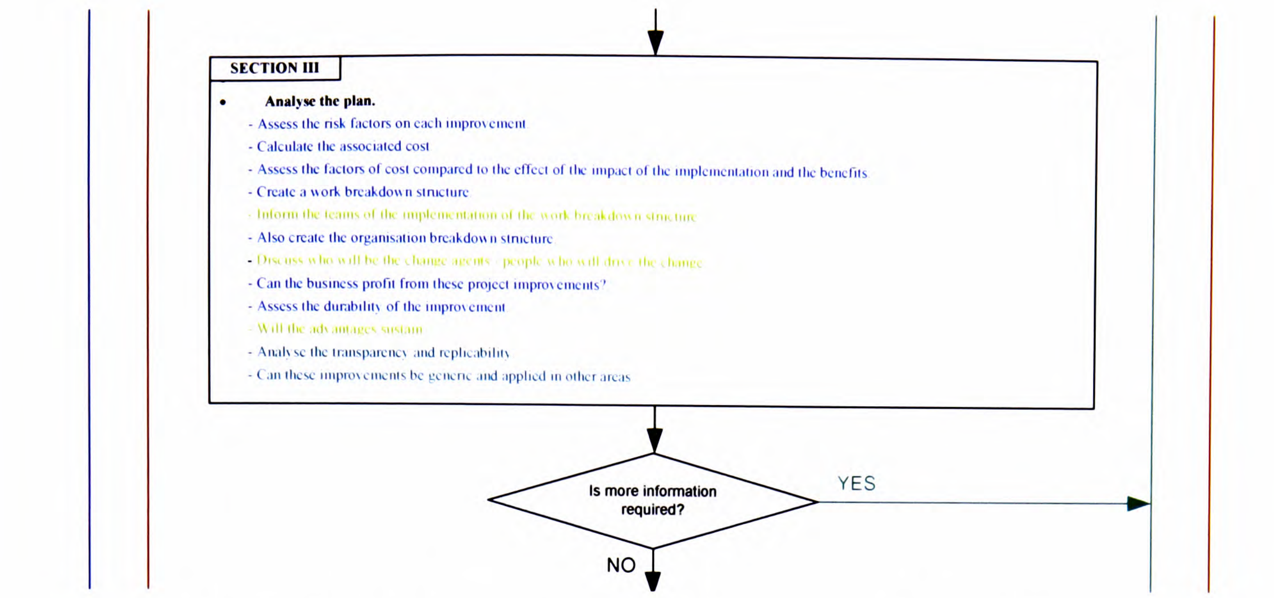


Figure 6.75: Stage 7, Section III of the proposed methodology

It can be seen from the plan that some initiatives are external to this case study such as the introductions of the materials planning system, creating new roles and responsibilities and creating the supplier agreements. These are all initiatives that affect this case study and they have high dependencies and links. However these just need to be continually reviewed to ensure how they affect the other initiatives.

There were other proposals within the loops that were second phase implementation, however they were also very dependent on other initiatives. These second phase objectives were supplier returns and supplier receiving. The supplier returns objective was dependant upon the new receiving proposal. Depending on how the receiving process was changed in turn depends on when items will be rejected, from this the procedure can be revaluated. With regard to the supplier receiving process, the supplier strategic agreements have to be in place prior to the supplier being visible on site.

The other objectives were completed in the strategic plan. It can be seen in **figure 6.74** that a timeline was created for the 'levelled schedule' objective. It was planned that over the first few months the end customer requirement would be established and understood, these requirements would be levelled. By also engaging the suppliers, the company's resources and capacity could be understood. From this, the levelled schedule could be locked down for a shorter period of time to reduce fluctuations in inventory. Once this had been established, this information could be communicated throughout the supply chain after it would be seen necessary to review the process to create plans so that they could be rolled over the following three months.

A timeline was also created for the co-location of the material on the shop floor. It was thought that the initial stage would encompass understanding the current processes and systems, as well as testing the desired replenishment system. Having investigated and planned the facility, changes in the replenishment system could be put in place given that the schedule is levelled. With the planning system conforming and some strategic agreements have been addressed with the supplier the system would be ready for implementation. The two bin replenishment system can pull the material when required; this is opposite to the traditional methods of planning and pushing material through.

As time continues, the next stages were to deplete stores and ideally eliminate. Whilst this initiative is being carried out it will be important to ensure best practise on all material handling transaction and processes to only conduct what is necessary.

Other objectives that could be carried out in this first phase were receiving and FAO processes. The receiving process would work simultaneously with the co-location of material objective. Again the first goal is to understand the current processes, from this separate goals were created to look at specific issues such as;

- Reducing the number of non production specific material
- Reducing the number of items being inspected
- Reducing the number of system transactions

From these results there would be a reduction in the receiving processes lead time. However, it would also be necessary to understand what the supplier can provide for the company. By investigating the opportunities, a more advanced receiving process will be in place to support the bin replenishment system.

The final first phase objective is the 'FAO process', the main concern here was the issue with the time spent establishing a contact for the items. A particular advantage for the development products would be the receiving transaction and personal notification for the recipient.

The associated risk for these first phase objectives are minimal. These objectives are mainly about understanding the current condition specifics and investigating the outcome. The difficulty is that all of the objectives are interlinked and dependant upon each other which makes sequential implementation hard to plan. The cost is also minimal in these first phase plans; however initiatives such as the implementation of a new planning system and agreements could be costly due to the project scale and impact.

As this project is still quite immature the project work breakdown and organisational structures have not been addressed due to timescale. It was felt at this point that more information was required regarding project delegation and communication planning. Whilst all team members were aware and participating in this project, it was felt that it was necessary to create a more formal communication plan to all external functions to gain project acceptance. This would aid the transition in the cultural environment. This also needed to be addressed in conjunction with the strategic plan.

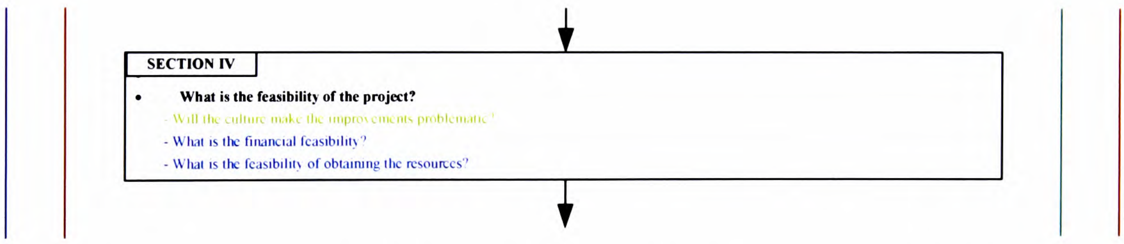


Figure 6.76: Stage 7, Section IV of the proposed methodology

The feasibility of the project with regard to cultural conflict is a concern; however it has to be ensured that this does not impede the project. The way to reduce this cultural conflict is by including the concerned people and empowering the people to make these changes.

The financial feasibility is hard to quantify as it is anticipated that there should not be any resistance of project implementation due to financial reasons. The resources already obtained will be sufficient for carrying out the project plan.

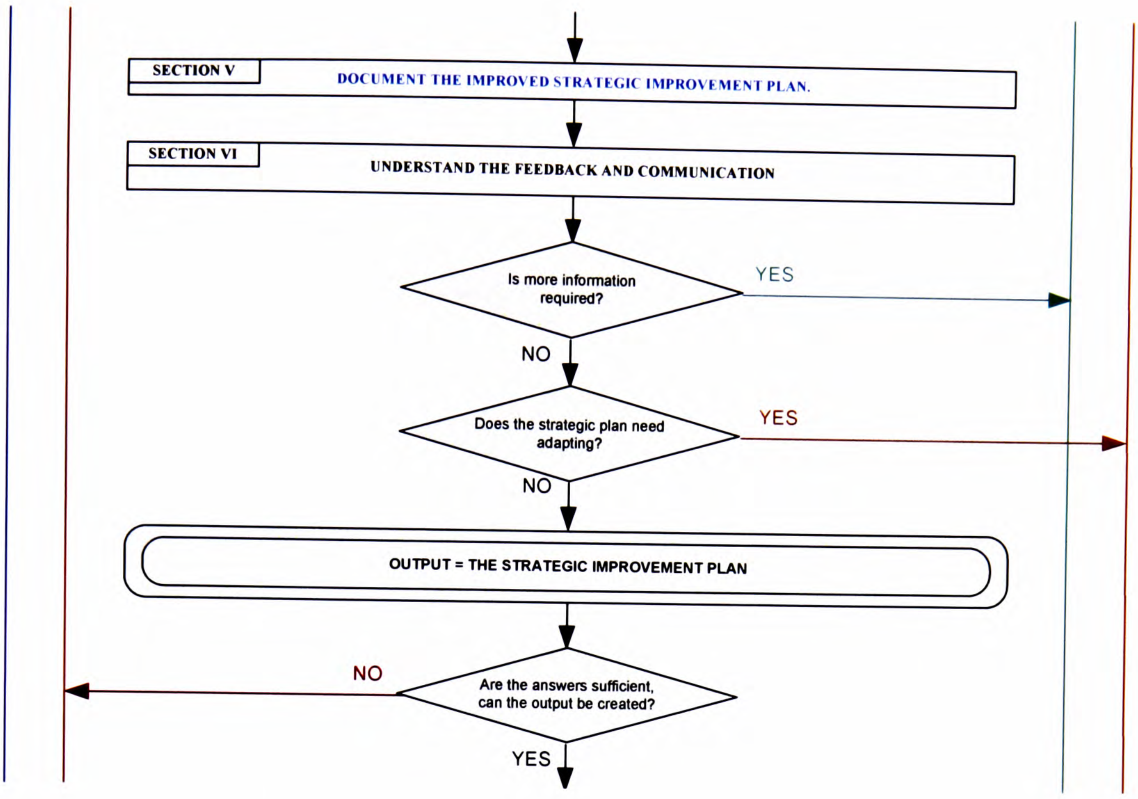
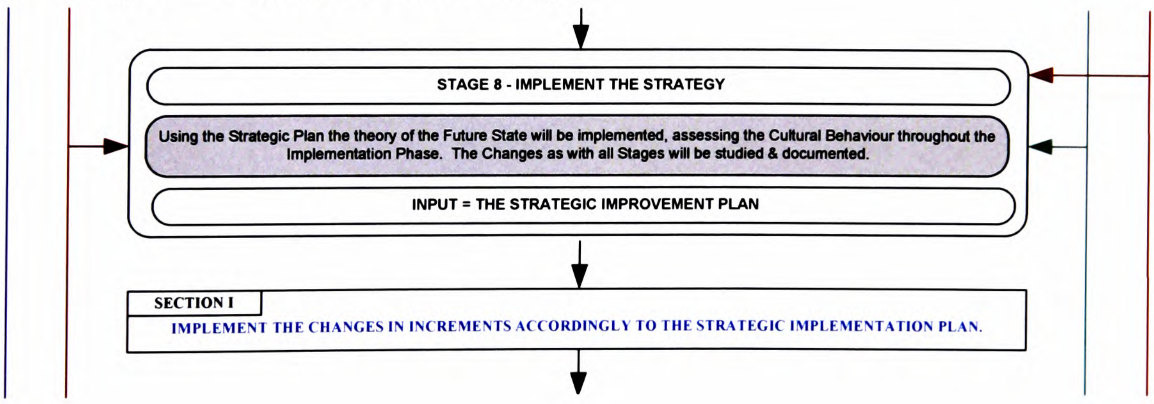


Figure 6.77: Stage 7, Sections V, VI and output of the proposed methodology

All of the necessary guidelines were met and the project remained true to the initial brief. It was felt acceptable to move onto the following stage of the methodology. No further information was required and the strategic plan did not need adapting, the plan in **figure. 6.74** were put forward for use.

6.4.8 Stage 8 – Implement the Strategy



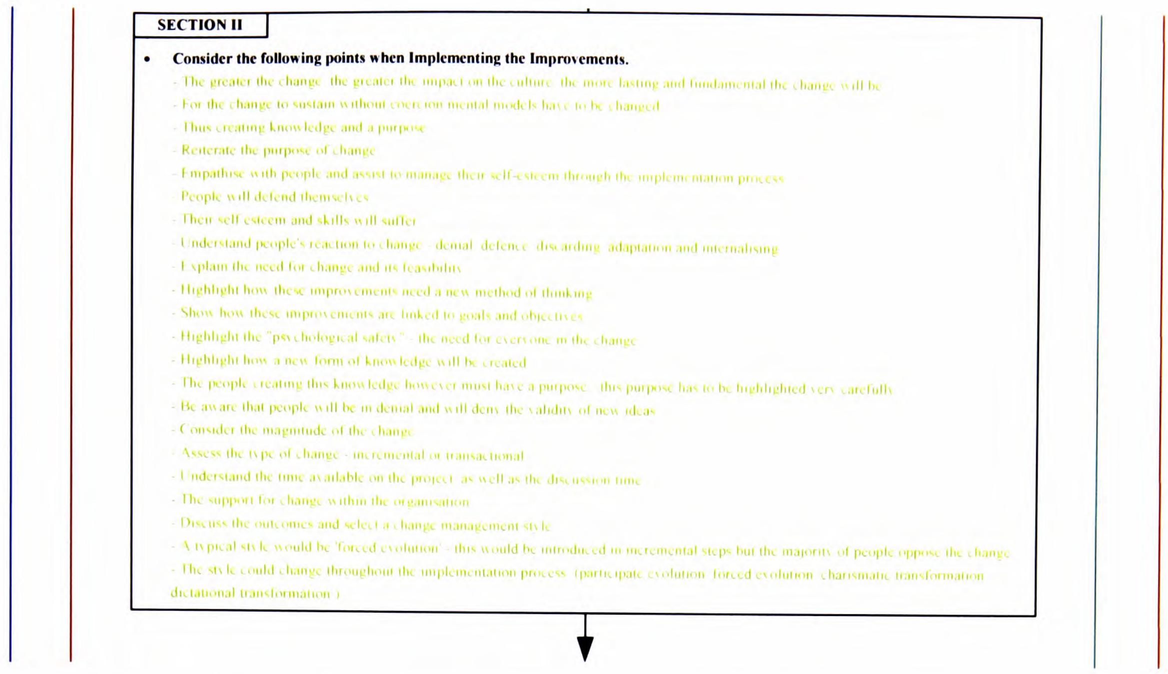


Figure 6.78: Stage 8 heading and Sections I and II of the proposed methodology

To date, work is being carried out in the implementation of the strategic project plan.

6.5 Methodology Application Discussion

This chapter has used the methodology to apply the theory to the receiving and stocking of material within the customer of the overall holistic supply chain initiated in Chapter 4. As with all of the previous chapters, the methodology and decision making has been analysed through each section. Each relevant guideline has also been justified. The project creation has some high business level objectives, however this end goal highlights the need to work and aim holistically to eliminate any smaller improvements working in silos. This holistic business supply chain vision creates these smaller improvements that work towards the overall plan.

The optimum future state has many dependencies; however the key is to continue with the project plan and be aware of these dependencies but not to let them hinder the application. The discussion and evaluation of the differences between the benchmarking has highlighted the benefits of the tool applications as well as the association of use, which is due to the methodology design.

The main benefits from the methodology application are;

- The reduction of the lead time
- The reduction of material transactions
- The redeployment of staff for new activities
- Greater inventory turns
- Better utilisation of material life cycles
- Reduction in inventory

From the benchmarking activities, the analysed improvements can be seen in **figure 6.57** (page 264), likewise the cultural changes are demonstrated in **figure 6.66** (page 270). The next phase of this study is to move through the implementation plan and start engaging the stakeholders further to carry out the finalising stages of this methodology.

6.6 Methodology Justification through Application

This application of the methodology allowed a structured progression through an improvement initiative, which required the analysis of process flow, rather than material flow on the shop floor. This specific application required the use of different tools and techniques that were apparent in the methodology; however it had different approaches due to the nature of the brief. The requirement of these tools for the application were discussed at the time of use, likewise those that were relevant were also justified. In this study, there was little use of the feedback loops due to the collection of sufficient information. Again, this third application highlighted the ability to tailor methodology decisions to the case study requirements, which again has created a pathway of change through a given roadmap which differs from case studies one and 2.

6.7 Chapter Summary

This chapter has applied a third case study to the methodology to highlight the range of differing project applications. This study, unlike the other applications investigated the application of process flows, rather than primarily material flow (case study 2) or information and communication flow (case study 1). This study has investigated the initiating areas of the buyer's processes, to reduce the lead time of material travelling from the dock to shop. This chapter has highlighted the benefits of this approach and has demonstrated how the supplier can also profit from the buyers gain.

CHAPTER 7 : DISCUSSION

7.1 Chapter Introduction

This chapter will summarise the findings of the literature review, as well as finalise the proposed design methodology. The discussions of the proposed design methodology applications will also be included as well as a reasoned justification for this research and investigation.

7.2 Discussion

The subject areas were researched given the authors previous knowledge of the aerospace industry and the use of traditional manufacturing systems that were executed. Having previously researched into new age manufacturing techniques, it became apparent that some of these techniques were being adopted in this industry. It was decided to research further into the applications and the environment known as lean manufacture. This concept has evolved quickly over the past decade, due to the recognition of the potential benefits that could be gained. This concept is no longer only applied to the manufacturing environment, as demonstrated in this research and hence the transformation to lean thinking.

The literature survey (Chapter 2) discussed particular facets of lean thinking as well as some apparent restrictions, thus limiting the detailed applicability to all environments. It was suggested from the literature survey that this concept would benefit from integrating particular features of lean thinking with other MBIMs, to broaden the spectrum of application. Some of the concepts are currently practised alongside lean thinking and at different stages of integration. The literature review studied these inter-relationships to assess the integration by comparing the concepts as they are currently practised and discussed. **Figure 7.1** demonstrates the broad theory of the integrated hypothesis.

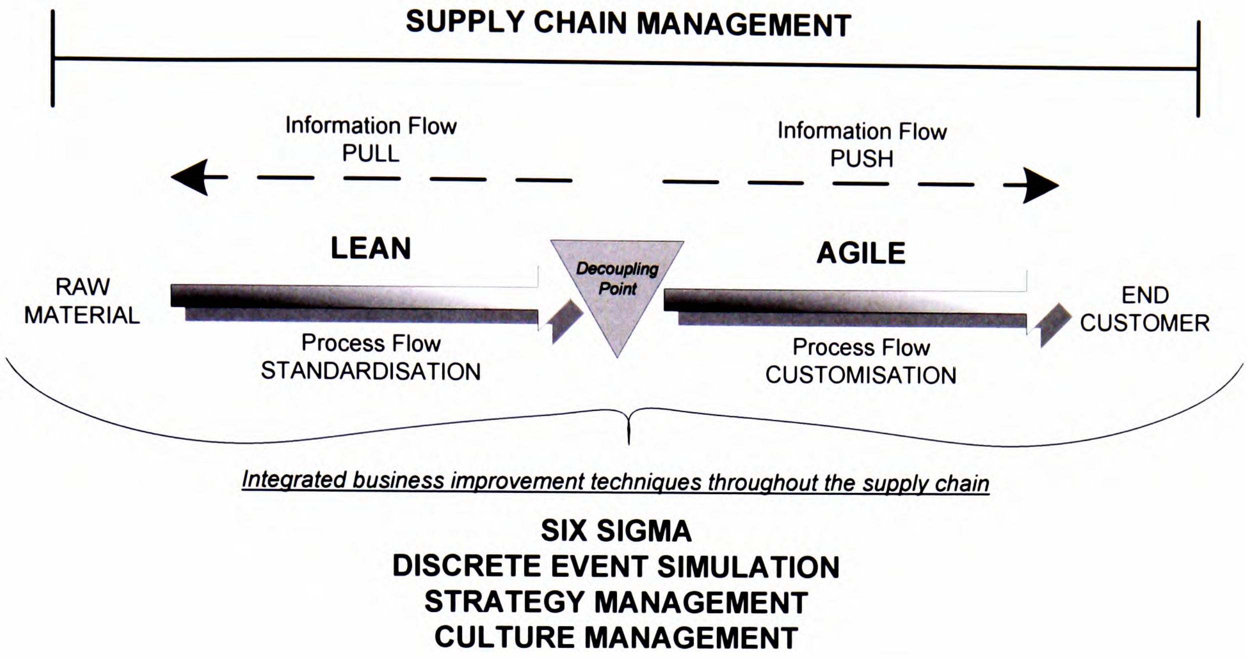


Figure 7.1: Integrated MBIMs

The outcome of the review highlighted that there was no known concept that integrated a number of MBIMs to broaden the spectrum of applicability. This was required in the aerospace industry due to complexity of the environment. The aerospace industry is a custom made industry, that manufacture bespoke complex, highly technical components for specific customers; not the ideal candidate for the applicability of lean thinking techniques. The research highlighted that particular aspects of lean thinking could be applied with the added benefit of other MBIMs to create a higher rate of success.

This investigation has showed the requirement for an integrated roadmap of change that covers a range of techniques that all improvement initiatives can be applied. The requirements of the application can tailor the proposed design methodology, thus assessing the stages, sections and guidelines to the suitability and applicability of the improvement program.

The proposed design methodology is highlighted in Chapter 3 (**figures 3.7** to **3.16**, pages 89 to 118). It involves ten stages of change including planning, creating, data collection, analysis and strategic implementation. The approach flows through the change process, systematically highlighting how to achieve the best outcomes and feedback for the system analysis. The ten stages have been developed further to create a number of guidelines to enable accuracy of application and to test the hypothesis.

The first stage of the methodology involved establishing the project needs and defining them, as well as creating the project strategy, the options and pathways of the project, the future market share, and the desired outcome of the improvement process. The second stage of the improvement process was to plan the measurements. Within Stage 2, the methodology works through a systematic approach of the individual business improvement techniques and assesses their suitability and applicability to the project requirements as well as the project environment. Completing the survey within Stage 2 results in a pathway of improvement. Given the input requirements, this highlights the best options to select and to apply to the project.

Companies that are looking to improve a system are often not equipped with the knowledge of how to apply different strategies and their true implication on the system. This unique methodology guides the user into understanding which of a number of business improvement strategies to apply. This in turn has beneficial effects on the cultural environment.

An important factor of this stage is the integration of operational business improvement techniques used in many businesses. At this stage, all of the key business improvement concepts are evaluated for their suitability to the project. This methodology has incorporated a checklist facility that enables the user to select the specifics required through a weighting method, therefore directing the pathway of the development. By using this method of analysis, the user gains a better understanding of the project requirements as well as the improvement techniques. The integrated system uniquely prioritise the amalgamated changes suggested and therefore created a direction of physical change. From this stage a detailed data collection plan is created.

All of the necessary information is collected and then the project is assessed for reliability and accuracy of the data. The third outcome is the development of the overall current state. The next two stages (Stages 4 and 5) looked at the technical data and how this is analysed and improved through quality techniques and simulation models. The sixth stage is also very significant as it highlights the originality of the amalgamation of both the technical and cultural transformations, which are two very different, but highly important factors effecting change.

The purpose of this research was not only to understand how to integrate the many business improvement techniques available to transform a system, but to test the ability to successfully implement this integrated approach. This stage created a strategic plan of implementation from the design.

The eighth stage was based on a similar format to Stage 3 and implemented the strategy. This module concentrated on the monitoring of the cultural environment. Stage 9 was seen as a revision section that analysed the results from the implementation and the final stage was considered to be the most important as it determined the success of the whole project. Not only did the physical system need to be controlled but the cultural system also required carefully observation. However, measuring variance was only useful if the information is fed back into the system.

The proposed design methodology was tested through case study applications; each case study had different project requirements to highlight the versatility and ability to tailor the proposed design methodology to the case studies needs. The initial case studies (Chapter 4) assessed the relationship between the buyer and the supplier; this application investigated the operational and cultural aspects of the proposed design methodology. The application used holistic views to assess the needs of both companies and how the communication between the two could be improved to create better OTD and quality to the end customer. The results highlighted that in order to achieve the ultimate goal lower level projects within the individual companies would be beneficial in order to succeed across the supply chain. The proposed methodology was customised to the case study requirement; however this was highlighted and enabled through the flexibility of the proposed design methodology.

The second application (Chapter 5) was carried out with the supplier site of previous application. This case study involved analysis of a final production line process. This allowed the testing of the proposed design methodology in a different format; this application consisted of operational and technical improvements. This project requirement was to improve the process line to increase the OTD and for the buyer. This had the same objectives as the first application; however, the method of use was different due to the detailed focus. This application concluded that the improvement would be within the organisation of the work within the cell, the capacity of the production line was adequate although the demand through the cell was variable and thus impeded the production rate. To reduce this variation, it was suggested that improvements could be made by having a multi skilled and flexible team operational within the cell. This study highlighted the extensive use of the feed back loops and the ability to adapt the proposed design methodology at any given point in the roadmap. The study also demonstrated the ability to create, analyse and conclude on technical information to provide statistical results. This case study was predominately applied to the supplier within the aerospace industry; however the company supplys many different companies within the telecommunications industry. Again this highlighted the versatility of the application not just within the aerospace industry, but within other manufacturing environments

The third application (Chapter 6) was within the buyer of the initial application. This particular study involved analysing the information flow through the initial process of the buyers internal supply chain. This again highlighted the ability of the proposed design methodology to undertake strategical and cultural concepts. This application studied the material received on site and assessed how the material was received, how the material was stored on site, as well as how the supplier demand was communicated back to the supplier. The aim of this investigation was to improve information flow, to alleviate a silo mentality and to aim to improve the whole internal supply chain. This again demonstrated differing results due to differing requirements but through tailoring of the proposed design methodology.

Within the literature review other industries were investigated to understand the application of lean manufacture in particular, but other MBIMs were also considered. The study highlighted that within the last decade many different industries have applied these techniques. The proposed design methodology was designed for the aerospace manufacturing environment and has been applied in these instances. However it is felt that this proposed design methodology could be applied in any continuously improving environment; but it may require manipulation to apply it to any other industry other than manufacturing. A recommendation of this kind has been suggested in Chapter 9.

This research and creation of the proposed design methodology has integrated a number of MBIMs and highlights how to apply these to a development project through weighted values of importance. The investigation has shown that a high percentage of process improvement programs fail. This approach highlights the issues surrounding technical and cultural factors of change that are the main cause of process improvement failure. The proposed design methodology aims to reduce these issues by recognising that cultural changes are as important as the technical changes. By considering these two factors of change simultaneously, a more unified approach to implementing MBIMs within a company is achieved, therefore resulting in a higher success rate of change.

This unified approach has ensured that a number of strategies that are not currently synchronised can be implemented successfully. The literature review also highlights that the failure rate of improvement initiative programs is quite high, due to the lack of planning of the cultural aspects and because technical issues are easier to implement. This methodology satisfied two main objectives;

1) An integrated business improvement system that analyses many improvement concepts.
2) Implementing this theoretical design through analysing and evolving cultural aspects.

The main significant advantage gained from the methodology is the development of a specific development path to follow. This is likely to reduce factors associated with cost, time, resources and increases success rates. Having this path of transformation alleviates cultural issues and resistance to change, it gives the project team assurance that the right changes are being made in the most efficient manner, therefore allowing a smoother acceptance of a change initiative program. This time can be better spent on training and culture programs to ensure greater implementation success. All of these factors will aid the reduction of the lead-time of a traditional change improvement program.

7.3 Chapter Summary

This chapter has discussed the reasons for the research, as well as discussing the need for the investigation. This chapter has explained how the work carried out has led to the creation of a design methodology, which has been reasoned and justified. The proposed design methodology has been displayed and this has been tested by a number of applications with differing requirements. The chapter concluded with highlighting the contribution to knowledge and what this proposed design methodology has proved.

CHAPTER 8 : CONCLUSION

8.1 Chapter Introduction

This chapter will continue from the discussion and will conclude the research by highlighting the proposed design methodology. As well as concluding on the success of the proposed design methodology applications

8.2 Conclusion

The study was initiated from the research objectives and aims. The research investigated lean manufacturing theories and this involved investigating the lean environment (Section 2.3.2 (30)) and applications (Section 2.3.3 (page 31)). The inter-relationships of MBIM applications as they are currently practised were researched in Sections 2.4.1. to 2.4.6 (pages 46 - 66) and this information assisted with the creation of the proposed design methodology (Chapter 3 (pages 76 122)) which supported the many facets of the researched MBIMs (Sections 2.4.1 to 2.4.7 (pages 44 69)) including technical and cultural issues.

The research objectives have been clarified by reviewing all lean environments and applications, as well as assessing the interrelationship of currently practised MBIMs. This study has worked towards integrating a number of MBIMs alongside the fundamentals of lean manufacturing and created a clear roadmap of implementation by analysing the suitability, however it also supports technical and cultural issues. The objectives have been satisfied further by testing the methodology to diverse requiring case studies, thus demonstrating the design methodology flexibility.

The proposed design methodology that has been created from this research has developed into a ten stage roadmap of change, considering all aspects of operational, strategical and cultural concepts. The ten stages of the proposed design methodology are as follows;

Stage 1 – Project Alignment

Stage 2 – Planning the Measurements

Stage 3 – Recording the Information and Defining the Current State

Stage 4 – Analysing the Technical Data and Defining the Technical Future State

Stage 5 – Improving the Results and Defining the Overall Future State

Stage 6 – Analysing the Cultural data and Defining the Overall Future State

Stage 7 – Creating a Strategic Plan

Stage 8 – Implementing the Strategy

Stage 9 – Measuring the Results of the Progress

Stage 10 – Controlling the Project to Sustain

This proposed design methodology (Chapter 3 (pages 76 – 122)) has been applied to three case studies (Chapter 4 (pages 123 - 136), Chapter 5 (pages 137 – 218) and Chapter 6 (pages 219 – 285)). The success of the created proposed design methodology is measured against the completion of the applications and as well as the type of application.

These applications have demonstrated the versatility and flexibility of the proposed design methodology, as well as ease of application. Both Amphenol UK and BAE Systems are applying improvement techniques and the recommendations derived from these applications are currently being deployed. The author has given recommendations to Amphenol UK as a result of this study and they have employed new staff to carry out these suggestions.

The author is currently working within BAE Systems to reduce inventory levels and increase stock turns by implementing a bin system to enable better accuracy of material requirements and supplier replenishments. The author is able to continue applying this methodology first hand, to gain advantage for the company by reducing £40 million associated to material held in stores as well as increase real estate for increased production.

The creation of the proposed design methodology has been discussed and verified through each application (Sections 4.5 and 4.6 (pages 135 – 136), Sections 5.5 and 5.6 (pages 216 – 218) and Sections 6.5 and 6.6 (pages 284 – 285). This investigation has been discussed (Chapter 7) and concluded (Chapter 8), the contribution to knowledge has been highlighted in Section 7.2 (page 287). Finally further work that has been recommended as a result of this study has been discussed in Chapter 9 and this included many different subject areas.

8.3 Chapter Summary

This chapter has concluded the research by highlighting the 10 stage proposed design methodology.

CHAPTER 9 : RECOMMENDATIONS FOR FURTHER WORK

9.1 Chapter Introduction

This chapter discusses and highlights future work that is either a direct result of the proposed design methodology applications or from the literature review. There are a number of findings from the research and investigation undertaken. These areas of research that could be investigated in the future are summarised within this chapter.

9.2 Case study applications

- Immediate future work would be the completion of the case studies, work is currently being carried out to finalise these applications so that the information and results created from case studies 2 and 3 can be fed back into application 1. These applications will continuously develop through the application of Stage 10 of the proposed design methodology and the requirement to sustain the improvements, as well as continuously improve.

- To also apply the proposed design methodology to other manufacturing environments, as well as other industries.

9.3 Developing Areas within Lean Manufacture

- It is usually found when implementing lean manufacture concepts that very specific information is required to achieve results, which is achievable if there is a substantial data collection procedure currently in place. Otherwise a great deal of research time is spent collecting data. An area of particular interest could be to investigate the applicability of a generic data collection system that could be in place previous to any lean manufacture changes.

- Another concern is the level of accuracy of lean thinking within the supply chain. It is hard to manage lean manufacture changes at enterprise supply chain level purely due to the scale of data collection required. It is normally thought that lean manufacture changes at departmental level are consideration to be more accurate, this is because it is physically easier to gather data. It would be interesting to understand and research how the accuracy of lean manufacture implementation at departmental level, could be established within the whole supply chain with the same proper consideration, accuracy and precision.

- It could also be necessary to measure the effects of implementation lean manufacture departmentally throughout the supply chain. How would this affect the surrounding vertical processes and how it would impact the whole system needs to be examined.

- As highlighted in this research study, there are limitations to the lean manufacture one being the restriction on its applicability within certain environments. Further research could be to contemplate how to measure the success rate in this environment, as well as the adaptability of the concept in such circumstances. This would require extensive research into the factors that support and hinder the implementation process, it would also be necessary to study the effect of these impacting factors and how they could be decreased.

- Once a certain level has been achieved, the system is not always monitored as it is planned; this allows the improved system to lapse. Sometimes this is due to the lack of continuous improvement as this is a complex factor of lean manufacture to actually achieve. A strategic management methodology could be investigated to create a continually improving system. The success would be how these processes can be sustained.

9.4 Leagile Systems Possibilities

- Leagile systems are a newly developed concept. Conducting other potential research in this field would require the knowledge of lean manufacture which is a very structured and environmental specific technique. It would also be necessary to understand fully the very differing concept of agile production. It is thought that it is not very structurally particular but yet is very flexible. The interesting part of the research would be to understand how to productively amalgamate the two concepts alongside true industrial applications.

- In a leagile system it is necessary to have a decoupling point; this point is the transition between a lean to agile system. Depending upon to the type of manufacturing surroundings the position of the decoupling point is very significant. This research would require extensive analysis to study where the point is best suited in different manufacturing environments.

- Extended research could be to analyse whether a leagile system is applicable to all areas within a business. This would require researching and investigating how effective a leagile supply chain would be departmentally as well as across the supply chain.

9.5 Topics to Develop within Supply Chain Management

- Some elements of the supply chain have already been assessed, however it is also important to understand the standard structure of the supply chain external as well as internally. Research could be carried out to understand the relationships between the supplier and the buyer at all points in the supply chain. Communication is the most important factor and research could be carried out the assess this required in different instants, as well the discussing the factors of success.

- It has also been noticed within the research that businesses currently have a supplier base that is too large. It is thought that reducing this supplier base would be productive. However a large contributing factor is also the relationship that enjoyed between the supplier and the company. This research would require understanding how the supply chain should be structured to suit a particular company requirement, thus allowing to a structure methodology to reduce the supplier base dynamically.

- Within some supply chain structures there can be very comprehensive logistics within the distribution and transportation. These methods can be regarded as a waste in the production system. Further research would highlight how to reduce this waste and suggest suitable measures to replace.

- Another area for productive research would be to understand the theory of virtual logistics and warehousing. These methods would reduce inventory costs and decrease production lead-times.

- The use of the internet is another issue that would be very interesting; this would not just be limited to the supply chain but could be used in all areas of business improvements. Using the internet within a business for production reasons could potentially decrease the production lead-time, maybe through ordering techniques, shipments of payment and invoicing.

9.6 Research Issues within Six Sigma

- Six sigma is quite a well researched area, however due to these reasons there is misconception as to what six sigma really is. It could be advantageous to research the different strategies of perception and implementation.

- The latest six sigma advance is the introduction of the DMADV process. This is a implementation procedure for new production of products. It would be interesting to research the success of this new procedure and study how it would differ from the success of the older DMAIC process.

9.7 Potential Research within Discrete Event Simulation Modelling

- Discrete Event Simulation Modelling is quite common in a manufacturing production environment and is becoming more advanced in other industries. Further research would entail the understanding of the success rate from the use of discrete event simulation modelling in other applicable environments. Are the same problems and issue with creation apparent across the board of situations?

- Generally discrete event simulation modelling programs have their own optimisation tools. These are usually timely to use, as well as costly to purchase. Another method possibly could be to use six sigma quality improvement tools optimisation on a discrete event simulation model. It would be interesting to investigate the comparison between the two methods, looking into facts such as time, cost and human intervention.

- Again the use of the internet in this field would also be fascinating for the same reasons as within the supply chain. How this would affect a model and how this information could be modelled.

- Creating a lean environment within a discrete event simulation model has its limitations; this is due to models generally 'pushing' a production system through. With the specifics of lean manufacture the model would be required to 'pull' the production system. Further research would help understand how to overcome this problem without limiting capacity sizes and increasing logical restrictions.

9.8 Perspectives within Management Techniques

- It has been suggested in a review by The Economist (1994) cited in Chu (2003), that 85% of business improvement change projects actually fail due to two reasons:

  1. The Impact of the Change
  2. The Management Commitment

  Other authors Baker (2002) and O'Corrbui (1999) cited in Bhasin and Burcher (2006) state that;

  ...."Less than 10 per cent of UK organisations have accomplished successful lean implementation."

  It is believed that in order to successfully implement an integrated business improvement methodology that incorporates a number of philosophies and concepts, issues such as the organisational culture and the management of the change are to be successfully researched and incorporated into the design and implementation plan before the business improvement takes place. Further research could potentially identify the issues surrounding the affects of change in a production environment. This would facilitate (when implementing ideas) how to manage the change, it would also be useful to know how to measure the change at the implementation phase.

- The existence and / or resistance to change could also be developed further, to understand why these issues arise and how to overcome them. This research should investigate whether change be measured through employee satisfaction.

9.9 Prospective Manufacturing Environments for Implementation

- Many different manufacturing environments have successfully implemented these types of business improvements. Further investigation would give an industrial viewpoint to the theoretical ideas; this research would also highlight the subject areas, paths and routes of successful implementation as well as those that require more developments.

- It was found within this research that the automotive industry lead the manufacturing environment mostly with lean manufacture and quality initiatives. Comparisons were made between the automotive industry and the aerospace industry; potential research could be to understand the differences between the two different environments. It would be ideal to understand the applicability of business developments within the automotive industry, and investigate how these ideas and issues can be transferred over to the aerospace industry.

9.10 Potential Future Research beyond the scope of this Investigation

This methodology has a very complex structure, however as highlighted in the thesis through the applications this structure reduces significantly due the project requirements. This proposed design methodology would benefit by being developed into a software package, which could possibly eliminate sections of the proposed design methodology to aid ease of use.

9.11 Chapter Summary

This chapter has explained in great detail depth future research that could be investigated beyond the scope of the literature survey and has given specific detail around topical areas.

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APPENDIX

The appendix for the result work is contained on a CD at the back of the thesis.

5.1:- Slide 1 of a presentation that was given to the workforce at Amphenol
5.2:- Slide 2 of a presentation that was given to the workforce at Amphenol
5.3:- Slide 3 of a presentation that was given to the workforce at Amphenol
5.4:- Slide 4 of a presentation that was given to the workforce at Amphenol
5.5:- Slide 5 of a presentation that was given to the workforce at Amphenol
5.6:- Slide 6 of a presentation that was given to the workforce at Amphenol
5.7:- Slide 7 of a presentation that was given to the workforce at Amphenol
5.8:- Slide 8 of a presentation that was given to the workforce at Amphenol
5.9:- Slide 9 of a presentation that was given to the workforce at Amphenol
5.10:- Slide 10 of a presentation that was given to the workforce at Amphenol
5.11:- Slide 1 of improvement work that has been carried out at Amphenol
5.12:- Slide 2 of improvement work that has been carried out at Amphenol
5.13:- Slide 3 of improvement work that has been carried out at Amphenol
5.14:- Slide 4 of improvement work that has been carried out at Amphenol
5.15:- Slide 5 of improvement work that has been carried out at Amphenol
5.16:- Slide 6 of improvement work that has been carried out at Amphenol
5.17:- Slide 7 of improvement work that has been carried out at Amphenol
5.18:- Slide 8 of improvement work that has been carried out at Amphenol
5.19:- Slide 9 of improvement work that has been carried out at Amphenol
5.20:- Slide 10 of improvement work that has been carried out at Amphenol
5.21:- Slide 11 of improvement work that has been carried out at Amphenol
5.22:- Slide 13 of improvement work that has been carried out at Amphenol
5.23:- Slide 14 of improvement work that has been carried out at Amphenol
5.24:- Slide 15 of improvement work that has been carried out at Amphenol
5.25:- The initial assessment of the management questionnaire
5.26:- The production line questionnaire
5.27:- The results of the data collected from the production line
5.28:- The information used to reference in the simulation model
5.29:- Information on 'OTD' for the simulation model
5.30:- Information on the 'production quantity' for the simulation model