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**Development of a Process Driven Approach to Improving Supply Chain
Performance within the Airline Service Industry**

EXECUTIVE SUMMARY

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**Submitted in partial fulfilment of the requirements
for the award of Engineering Doctorate**

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ABSTRACT:

This programme of research investigated the development of a process driven approach to improving supply chain performance within the airline service sector. Work was undertaken within the Engineering division of an established UK scheduled airline, and specifically within the maintenance, repair and overhaul sector (MRO).

The underlying objective of this research was to establish the relevance of supply chain management as a source of competitive advantage to the airline service sector. A detailed review of the literature revealed that best practice originated predominately from the Japanese automotive sector, notably a manufacturing based industry. A review of the characteristic differences between these two industry sectors was undertaken to identify the opportunity for cross-sectoral transfer of knowledge. This was complemented by a thorough benchmarking analysis that identified the airline industry's position relative to best practice. This confirmed the relative immaturity of supply chain management within the airline service sector, which was representative of progress achieved by the automotive sector in the early 1980's.

The key aspects of best practice were then structured into a proposed process for improving supply chain performance. This process consisted of specific strategies with their corresponding tools and techniques for implementation. A number of case study implementations were then used to further validate, test and develop this generic process within a real airline operational environment. Significant improvements in both operational and financial performance were achieved through adopting this approach. A 40 % reduction in chemical sourcing costs was achieved, representing a £990,000 saving over three years for the case study company. A further 12.5 % reduction in landing gear overhaul costs was achieved (approximately £300,000), whilst at the same time improving the operational performance of this supply chain by 60 %.

This research concludes by recommending a generic process for improving supply chain performance. The benefits achieved through implementing this process further confirm the relevance of supply chain management to the airline service sector. Finally, this paper proposes a deterministic tool to assist practitioners in the selection of the most appropriate supply chain strategy for a given situation. Whilst this tool requires further validation, the possibilities for it's application extend far beyond those of the airline service sector. As a result this work has significantly contributed to knowledge in the field, representing considerable innovation.

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DECLARATION

The work contained in this submission is entirely the work of the author, unless otherwise acknowledged in the text. Furthermore this work has not previously been submitted for any other academic qualification.

All sources of information have been acknowledged by means of reference.

Javid Karim

May 2002

1.0 INTRODUCTION:

This paper summarises work undertaken between the period 1997 - 2001 to establish and apply best practice methodologies for improving supply chain performance within the airline service industry. This work was undertaken at a case study company operating within the maintenance, repair and overhaul (MRO) sector of the airline industry. Little research had been undertaken in this sector, with the majority of supply chain management research originating from the automotive manufacturing sector.

Upon commencing this programme of research it was anticipated that supply chain management was generally applicable to manufacturing industry only. Concepts such as lean production [1] and lean supply [2] had been derived from manufacturing based industries, and predominantly the Japanese automotive sector. The relative predictability of material demands in manufacturing resulting from a defined bill of materials and coupled with forecast production volumes, meant that customers and suppliers could co-ordinate efforts accordingly. The same level of repeatability was not present in the MRO sector with 60 % of the material requirements being unique for each aircraft maintenance visit [3]. Therefore the relevance of good practice supply chain management to this service sector business, and the resulting potential benefits required further clarification.

This programme of research commenced with a detailed review of the literature to identify best practice tools and concepts developed in other industry sectors. The bulk of the research then explored the opportunities available for cross sectoral transfer of knowledge from manufacturing to the airline service sector. This required a detailed analysis of the key characteristics between the two industry sectors. The key aspects of supply chain management which offered the potential for application to the MRO sector were then structured into a proposed process driven model aimed at improving supply chain performance. A considerable amount of work was undertaken by the author within the case study company to further develop, validate and test the proposed process model for supply chain improvement. This paper summarises the key stages undertaken to develop this model, and describes both the operational and financial benefits that resulted

following its implementation. For the avoidance of doubt the words process and model are used interchangeably throughout this paper, to describe the development of a generic approach to improving supply chain performance.

1.1 Reason for the Research:

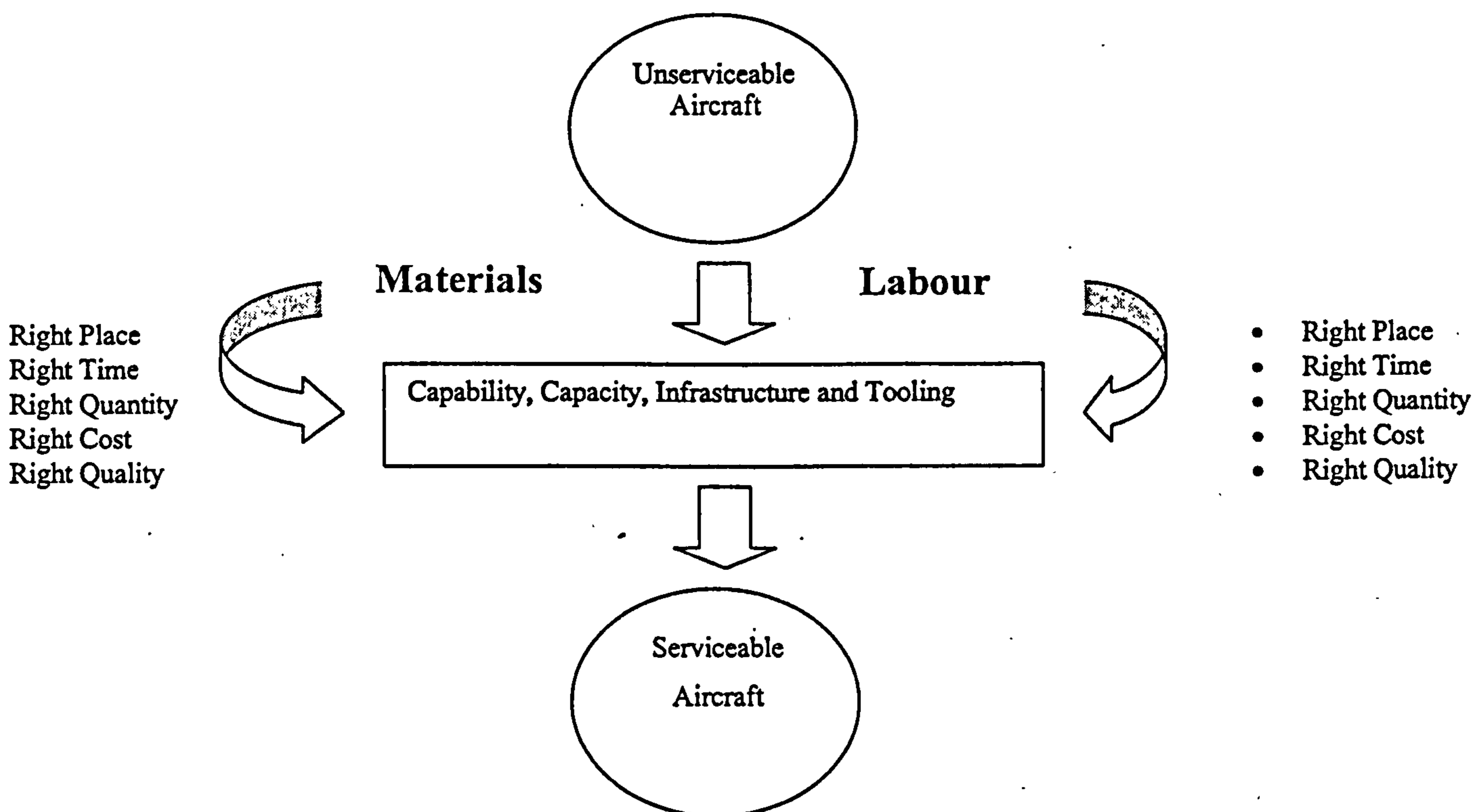
The key reason for undertaking this research was to identify sources of competitive advantage through the application of good practice supply chain management to the MRO sector. The need for this research was to identify methodologies for reducing costs associated with existing supply chains whilst at the same time maintaining or improving the associated levels of service. The airline service sector was traditionally a low margin industry, where a small percentage increase in cost could determine the difference between a profit or loss being made for a given financial period [4]. The continually declining revenue stream of traditional airlines caused in part by the increased competition of new low cost airlines, meant new strategies for reducing cost were necessary to ensure sustained competitive advantage.

In October 1997 the case study company was restructured under the leadership of a new Chief Executive Officer (CEO). This individual immediately set about defining a strategy for the organisation in the form of a company vision statement and goals (see Appendix A). The mission of the company was “*to be one of the world’s most respected Aviation Service Companies with consistent growth by breaking the industry-wide assumptions of what is possible in terms of quality, service, reliability and financial performance*”. The strengths and weaknesses of this mission statement were critiqued in a previous portfolio submission [3].

The core business of the case study company was the total maintenance support of its parent airline’s fleet of aircraft, and other 3rd party customers. The competitiveness of the case study company was therefore directly related to its capability in offering aircraft maintenance support “*within the customers space and time*”. This would require significant improvements in the accuracy of the maintenance planning process, and its associated degree of flexibility.

The then newly employed CEO who had considerable experience in aerospace manufacturing, quickly recognised that the performance of the case study company was fundamentally driven by the efficiency of its supply chain. The process of undertaking aircraft maintenance was essentially driven by two key inputs (i.e. material and labour). Providing that sufficient quantities of material and labour could be made available in the right place and at the right time, the output of a serviceable aircraft would result (see Figure 1). This programme of research focussed upon the material element of the process, and its associated supply chains. The strategy of being “one of the worlds most respected” companies would therefore demand the adoption of world class supply chain management techniques.

Figure 1: The Aircraft Maintenance Process:



At the time of commencing this research there was a considerable lack of awareness regarding supply chain management at the case study company. No formal training or development of staff had been undertaken in the field of purchasing and supply. The organisation therefore lacked the necessary knowledge and expertise required to improve the performance of its supply chains. Furthermore, there was a commonly held perception amongst staff that supply chain management was only relevant to the manufacturing sector.

The underlying reason for the research was therefore to explore opportunities for the case study company to become a world class supply chain organisation, and thereby identify sources for achieving sustained competitive advantage. In order to achieve this, methodologies for improving the effectiveness of purchasing and supply within the case study company were required. The case study company was therefore predominantly reliant on the author to review the key aspects of best practice and identify opportunities for the application of this knowledge to the airline service sector.

1.2 Background to the Case Study Company:

The case study company is the Engineering division of an established UK scheduled airline, operating within the MRO sector. At the time of commencing the research this division was set up as a separate operating company responsible for its own profit and loss (1997-1999). The parent airline had come under significant pressure from the establishment of a number of low cost airlines. The Engineering division was seen as a possible source of revenue generation, which could be used to reduce the cost base of the parent airline. A separate company was established with the intention of actively seeking additional 3rd party business from other carriers. The parent airline would remain a significant customer of the case study company.

Three years into the programme of research the decision was taken to re-integrate the case study company back into the parent airline (2000-2001). Whilst considerable success had been achieved through gaining 3rd party business, there was a perception within the parent airline that service was suffering. This combined with the parent airline's

aspirations to set up transatlantic operations required the dedicated support of the case study company. At the time of writing the case study company is once again operating as a separate division of the parent airline. For the avoidance of doubt the case study company from the period 1997-1999 referred to the Engineering division operating as a separate company. Conversely, for the period 2000-2001 the case study company was the Engineering division operating within the parent airline company. In either case the core business of the case study company and the requirement to improve its performance remained unchanged.

A detailed review of the case study company's business can be found in a previous portfolio submission [3].

1.3 Project Scope and Objectives:

The scope of the research was broad and far reaching given the reason and needs previously described. The general lack of awareness regarding supply chain management and the relatively poor knowledge base within the case study company, required the development of practical tools to guide the implementation of any supply chain improvements.

The overall project objectives were therefore as follows:

1. To establish the relevance of supply chain management to the airline service sector.
2. To establish the potential for supply chain management strategy to deliver sustained competitive advantage within this industry sector.

A summary of the specific research objectives were as follows:

1. To identify the sources of best practice in supply chain management that are applicable to the airline service sector.

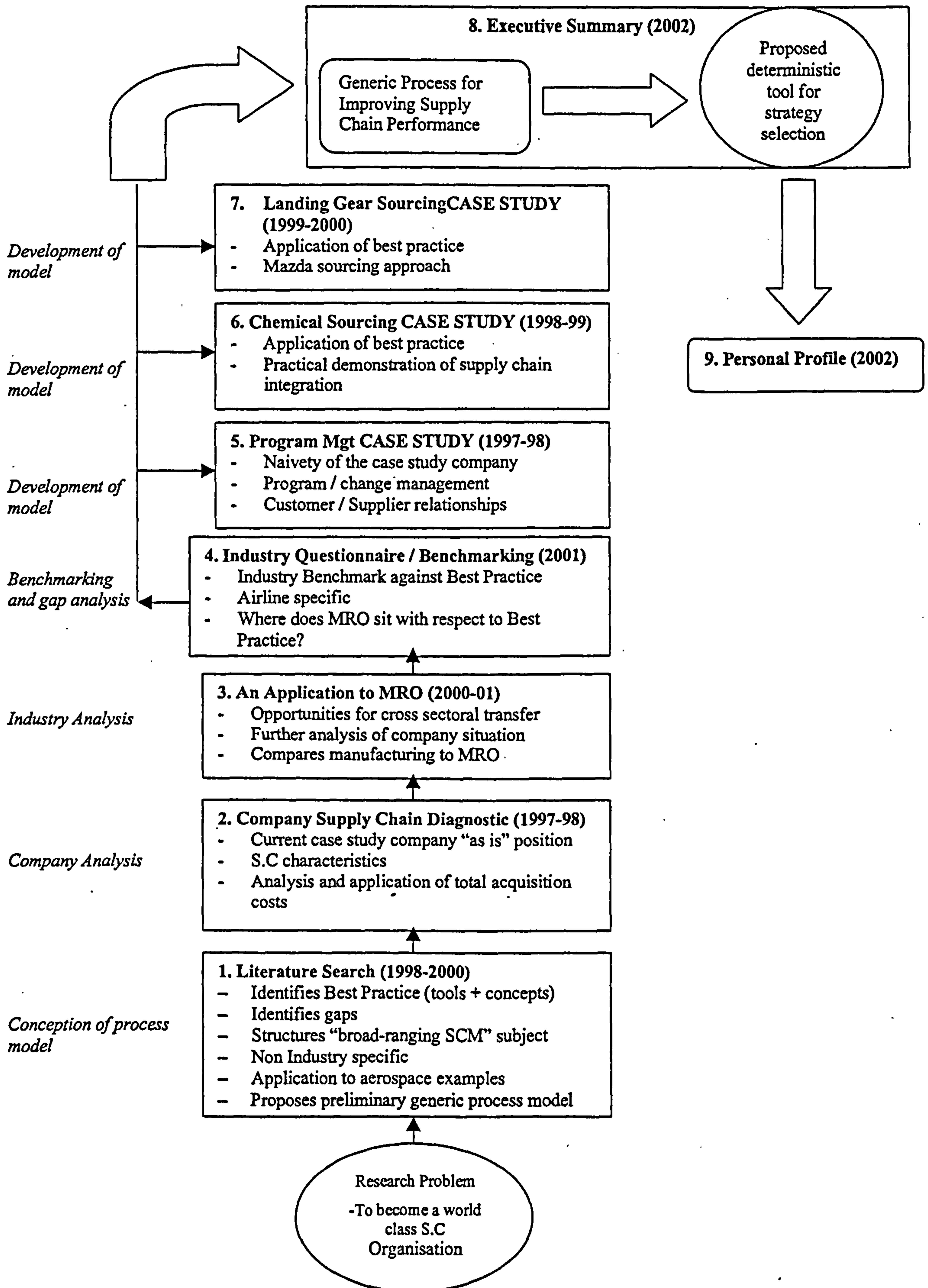
2. To identify the supply chain strategies necessary to support a world class supply chain organisation.
3. To structure these sources of best practice into a practical process driven model aimed at improving supply chain performance.
4. To identify the tools and techniques necessary to improve the effectiveness of the purchasing and supply chain function, as measured by both the operational and financial performance of the case study company.
5. To further develop, test and validate this process model through a number of case study implementations, and thereby validate (or otherwise) the relevance of supply chain management to the airline service sector.
6. To propose a deterministic tool to assist practitioners in strategy selection given a number of operational and financial inputs.
7. To achieve a significant improvement in business performance of the case study company, by adopting best practice in supply chain management, and thereby contribute to the overall company vision and goals.

Upon commencing this research it became increasingly apparent that there was an underlying need to develop, test and validate a process driven model for improving supply chain performance and one that incorporated all of the best practice tools and techniques identified as being applicable to the airline service sector. This required a number of case study implementations within specific supply chains, following which the model was further refined and amended to reflect the learning points and problems encountered. A key finding of the research was to develop a proposed deterministic tool for strategy selection given certain operational and financial performance inputs. The desired tools would be highly relevant to the airline service sector and would be demonstrated as being capable of having a major impact on business performance.

1.4 Structure of the Portfolio:

The suggested reading order for all of the papers and submissions is illustrated in Figure 2. This gives the proposed reading order of the work. The completion order of the work is indicated by the date periods specified in Figure 2. The reading order begins with the

Figure 2: Portfolio Structure and Logic



literature review [5] and then cascades through the various submissions and papers concluding with the personal profile.

The portfolio is made up of a selection of submission documents supported by conference papers that have been used to disseminate the findings of the research project. The structure and logic of the portfolio is further described under section two “The Research Methodology and Approach”.

1.5 Structure of the Executive Summary:

The structure of the Executive Summary integrates each of the relevant aspects of the portfolio submissions according to the specific stages of the proposed supply chain improvement process. It is not the intention of this paper to summarise each of the portfolio submissions in a sequential format. Instead elements of best practice and the lessons learnt from a number of case study implementations are introduced as appropriate in order to build the argument for the proposed process model. As a result this executive summary has been structured in a way that reflects the necessary steps taken in the proposed supply chain improvement process. It is intended for this approach to add considerable value to the research material, as opposed to summarising each portfolio submission in isolation.

The paper proceeds by addressing the research problem and describing the methodology and approach adopted (Section two).

Section three then explores the relevance of supply chain management to the airline service sector by describing the evidence and main findings of the research. This section begins by describing the conception of a generic process model for improving supply chain performance. This model was conceived by reviewing and incorporating the key aspects of best practice into a structured approach, following a detailed review of the literature [5]. Section three then describes the key findings of the research relevant to each stage of the proposed process model. This includes a thorough review of those aspects of best practice relevant to each stage of this process, whilst describing the key

operational and financial benefits that were achieved from a number of case study implementations.

Section three concludes by investigating the potential for application of this model to the airline service sector, thereby validating the relevance of supply chain management to this particular industry. This was based upon a thorough benchmarking analysis (including a gap analysis) of the airline service sector relative to the automotive manufacturing sector.

Section four of this paper consists of a detailed discussion and analysis of the proposed process model. In particular the key stages of development, validation and refinement of the model are reviewed, following lessons learnt from actual case study implementations. Section five then summarises the results of the research. This includes a detailed analysis of the innovation emerging from the research, and a discussion of the alternative approaches that were available to the author.

Finally, this paper concludes by describing how the research objectives were met and summarises the key recommendations resulting from the work (Section six).

2.0 THE RESEARCH METHODOLOGY AND APPROACH:

2.1 The Research Problem:

Given the reasons for the research previously described the problem at its highest level consisted of a number of key questions:

1. What was world class supply chain management?
2. What attributes did best in class organisations possess?
3. Where did best practice reside?
4. Was supply chain management relevant to this service sector industry?
5. How far away was the airline industry from achieving best practice in supply chain management?
6. What were the potential benefits of adopting state of the art supply chain management?
7. What strategies should be undertaken to implement best practice and what potential problems could be encountered?
8. And finally what tools were available to assist practitioners in implementing such strategies?

The limited knowledge of the case study company regarding supply chain management, further emphasised the broad scope of the problem. The first task was therefore to define an approach that would structure the problem into manageable elements.

2.2 Research Methodology and Approach:

The research methodology comprised a combination of desk based research, distribution of industry-wide surveys, and the complete implementation of specific change programmes within the case study company.

2.2.1 Desk Based Research

An appreciation of what comprised best practice was first required. This required a detailed review of the literature. The value of the literature review in this particular programme of research cannot be overstated. The projects commenced with a limited knowledge base of supply chain management. Identifying the key tools and techniques representative of best practice was fundamental to the success of this programme of research. The actual literature review can be found in Portfolio submission 1 [5]. This Executive Summary also incorporates the most recent literature found subsequent to completion of the respective Portfolio submissions.

Many of the concepts adopted in the projects were found to originate from the automotive manufacturing industry, with best practice predominantly found in the Japanese automotive sector. This work culminated in the conception of a proposed process driven framework for improving supply chain performance, the main findings of which are summarised in section three of this paper. The intention of this process model was to structure each of strategies representative of best practice, alongside the necessary tools and techniques required to implement them. This approach offered considerable scope for innovation because specific tools targeted to assist practitioners was severely lacking in the literature.

2.2.2 Distribution of an Industry-wide survey:

The next task in this research was to identify those aspects of best practice that could be transferred from one industry sector to another. This required a detailed analysis of the key differences between the manufacturing sector and the airline service sector. This included a detailed analysis of the MRO industry, and the business of the case study company itself. This work was addressed in Portfolio submissions 2 [6] and 3 [3]. The main findings from this aspect of the research can be found in section three of this paper.

It was anticipated that few airlines had realised the benefits of utilising the key elements of supply chain management. This assumption had to be validated by undertaking an

extensive benchmarking exercise. This consisted of development of a questionnaire targeted at specific airlines, incorporating the various aspects of best practice (see Appendix B). A detailed analysis of the methodologies used to design this questionnaire can be found in portfolio submission 4 [7]. Analysis of the results from this survey were then used to plot the progress of the airline industry relative to achieving best practice, as defined by the automotive manufacturing sector. This was the first time that such an analysis had been undertaken within the airline service sector, representing significant scope for innovation. Once the position of the airline industry had been established, possible paths towards best practice could be investigated, with opportunities for further innovation identified. This work was undertaken in Portfolio submission 4 [7] and the key findings can be found in section three of this paper.

2.2.3 Case Study Implementations:

A significant part of the research involved the implementation of specific change programmes within the case study company. These case studies, devised and managed by the author, were carefully selected to examine different aspects of the research and were all aimed at further validating, developing and refining the proposed process model. The main findings of this work can be found in section four.

The first case study investigated the characteristics of project management and contract management within the case study company. The specific programme examined the installation of a new cabin interior product across the parent airlines' fleet of aircraft. By reviewing the challenges of this programme a number of historic processes concerning programme and contract management were illustrated. This work also provided a further insight into the nature and development of customer-supplier relationships within the case study company. It also assisted in demonstrating the naivety of the company's supply chain processes with respect to best practice. This work was addressed in Portfolio submission 5 [8].

The second case study was specifically designed to validate and develop the conceptual process model for supply chain improvement. This focussed upon implementation of a

supply base optimisation strategy for the case study company. The objective was to apply best practice tools and techniques to improve the effectiveness of its chemical supply chain. A total acquisition cost approach developed by Ellram [9] was adopted using multifunctional teams to address a variety of strategic objectives. A re-engineered supply chain structure was proposed which introduced a variety of supplier tiers [2], where previous suppliers to the case study company provided material through one single source. A stock consignment programme was also set up whereby the single source supplier became responsible for the entire stock replenishment process and its associated costs. This work was addressed in Portfolio submission 6 [10] and the main findings relevant to development of the proposed process model are addressed in section four of this paper.

The third case study was intended to further validate and develop the proposed process model, by evaluating a supply chain integration project. The objective of this implementation was to improve the operational efficiency of the case study company's landing gear overhaul supply chain. The company had historically outsourced landing gear overhaul by adopting a single sourcing strategy. It had experienced significant problems regarding the on-time availability of landing gear components, and had attributed this to poor supplier performance.

A detailed analysis of both the internal and external supply chain characteristics was undertaken. This included a thorough supplier market review of the options available. The findings from this analysis dispelled the initial perceptions that poor supplier performance was to blame. The final recommendation resulted in the application of a dual sourcing approach to landing gear overhaul, as developed by the Japanese automotive industry (Mazda). As a result significant improvements in operational efficiency were achieved. The key findings of this case study that contribute to further development of the process model can be found in section four of this paper.

The potential scope of innovation resulting from these case studies was considerable. An all encompassing process for improving supply chain performance was found to be

severely lacking within the literature. Where tools were available there was often little guidance regarding how and under what circumstances they should be applied [5]. Validation and development of the proposed process model specific to the airline service sector would significantly contribute to knowledge in the field. Any resulting operational and financial benefits achieved in these case studies would provide further justification for the relevance of supply chain management to this service sector industry. Furthermore development of a proposed tool to assist practitioners in selection of the most appropriate supply chain strategy for a given situation would add considerable value. Development of such a model would represent significant innovation in the field, since majority of best practice had originated from the manufacturing sector [5].

2.2.4 The Authors Role and Contribution to the Research:

The methodology adopted to undertake the case studies was based upon the use of a number of multifunctional teams. This was a new approach for the company, and was introduced by the author following his review of good supply chain practice [5]. The author was responsible for selection and management of these teams. A variety of best practice tools and techniques were introduced by the author following desk-based research. The specific contribution of the author working within these teams required the overall management of the supplier improvement programme, which necessitated the following activities:

- a) To identify sources of both commercial and technical data, including the identification of any gaps.
- b) To review and establish the existing supplier accounts and service providers.
- c) To evaluate and formalise the existing sourcing process.
- d) To evaluate the existing supply chain limitations and weaknesses (from an internal customer perspective). This required a detailed analysis of the respective supply chain processes. The respective “process experts” of the multifunctional team were used to facilitate discussion.
- e) To undertake an extensive supplier market review [11].

- f) To develop appropriate performance metrics and obtain the agreement of the multi-functional team.
- g) To introduce aspects of best practice in supply chain management and thereby determine the potential solutions for improving supply chain performance.
- h) To develop and present formal recommendations for proposed supply chain improvements to senior management.
- i) To develop and communicate the strategic objectives of the change programme throughout the company.
- j) To understand and formulate the customers requirements by undertaking thorough interviews with key "process experts".
- k) To develop the appropriate criteria for evaluation of a competitive tender, and translate these into effective contractual requirements.
- l) To lead the supplier negotiations and agree the appropriate contractual requirements in order to reflect the inherent supply chain characteristics.
- m) To develop and present formal recommendations for supplier selection to senior management.
- n) To develop and lead adherence to an agreed implementation plan.

The author was also responsible for conception of a generic process for supply chain improvement. The author would ensure that the multifunctional team adopted these concepts at each stage of the process. During the research the author analysed and compiled the information generated by the team to further develop and refine the generic model. The specific contribution of the author regarding development of a generic process model can be summarised as follows:

- a) The author structured the wide-ranging subject of supply chain management into a logical sequence of events, by incorporating the key strategies, tools and techniques representative of best practice at each stage of the process. This resulted in the conception of a proposed generic process developed solely by the author.
- b) The author selected a number of case study programmes to further validate and develop each stage of the proposed generic process ([10] and [11]).

- c) The author applied each stage of the proposed process to the case study company's landing gear overhaul and chemical supply chains, respectively. Under the leadership of the author the multifunctional teams (including internal customers) were used to contribute their specific knowledge regarding the existing supply characteristics. For example, in the case of the chemical case study the company stores manager provided advice regarding requirements for the storage and transportation of hazardous materials.
- d) The author then ensured these specific characteristics were addressed within the proposed supply chain solution. The author was responsible for developing the solution by incorporating best practice applied from the literature review [5].
- e) Upon implementation of the change programme the author analysed the resulting operational and financial metrics to further validate the success of the proposed generic process.
- f) Upon completion of each case study the author undertook a thorough review of the work, ensuring any learning points were incorporated into the generic process. This resulted in further development and refinement of the proposed process model.
- g) Finally, by incorporating the knowledge gained during this programme of research, the author has proposed a further tool to assist practitioners in determining the most appropriate supply chain strategy for a given situation. Development of this deterministic tool has been solely undertaken by the author.

In each case the author was responsible for leadership and programme management of the projects. He acted as a senior interface between the teams and top management in order to get recommendations and solutions approved. In some cases this required Board level approval. He was also the main point of contact for the respective supplier base, and was instrumental in chairing supplier meetings.

Finally, design and analysis of an industry-wide benchmarking survey was undertaken solely by the author (see Appendix B). The specific tasks undertaken by the author within each case study can be found within the respective portfolio submissions.

3.0 DETERMINING THE RELEVANCE OF SUPPLY CHAIN MANAGEMENT TO THE AIRLINE SERVICE SECTOR:

3.1 *The Key Elements of Supply Chain Management:*

The conception and design of the proposed generic process was dependent on a detailed review of the literature [5]. The aim of the literature search was to define the key elements of supply chain management and identify sources of best practice. It soon became apparent that the field of supply chain management was broad and wide-ranging. Cox and Lamming [12] advised that there was extraordinarily little research currently available about purchasing thinking and practice, compared with other business disciplines. Cox [13] described purchasing and supply as an emerging academic discipline at the boundary of the embryonic and development stages, advising that the subject must mature significantly before robust academic theory and widely accepted tools were available.

A variety of definitions of supply chain management were available from the literature. Stevens cited in Towill, Niam and Wikner [14] stated "*a supply chain is a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together by a forward feedflow of materials and the feedback flow of information and cash*". The realisation that a supply chain has one ultimate source of funds which has to be shared by all members of the chain was illustrated by the key elements of supply chain management, as defined by Booz Allen and Hamilton (cited in Saunders [15]). They proposed *that the supply chain should be viewed as a single entity, that inventories should be used as a last resort, which in turn demanded closer integration with suppliers, implying the need for strategic decision making.*

Upon completing this programme of research it has become apparent that the Booz Allen et al elements provide the foundations upon which all other supply chain strategies are based. These are effectively the elementary particles of supply chain management. The need to use inventory as a last resort was illustrated by Forrester [16]. Forrester demonstrated that the amplitude of demand fluctuation increased considerably from the ultimate customer to other supply chain members, driven by each firm factoring their

own contingency requirements to manage uncertainty. The Booz Allen et al elements attempt to minimise the Forrester effect by improving supply chain visibility through closer customer – supplier integration.

The need to think strategically about supply chains was found to be the main differentiation between the role of traditional purchasing and procurement, as identified by Gattorna [17]. Traditional purchasing was driven by the need to “*purchase at the right price, for delivery at the right time, of goods and services to the right quality, in the right quantity, from the right source*” as defined by Bund [18]. The primary focus was on price as opposed to the total cost of ownership as described by Ellram [9]. This traditional approach to purchasing was representative of practice undertaken within the case study company at the time of commencing the research [6].

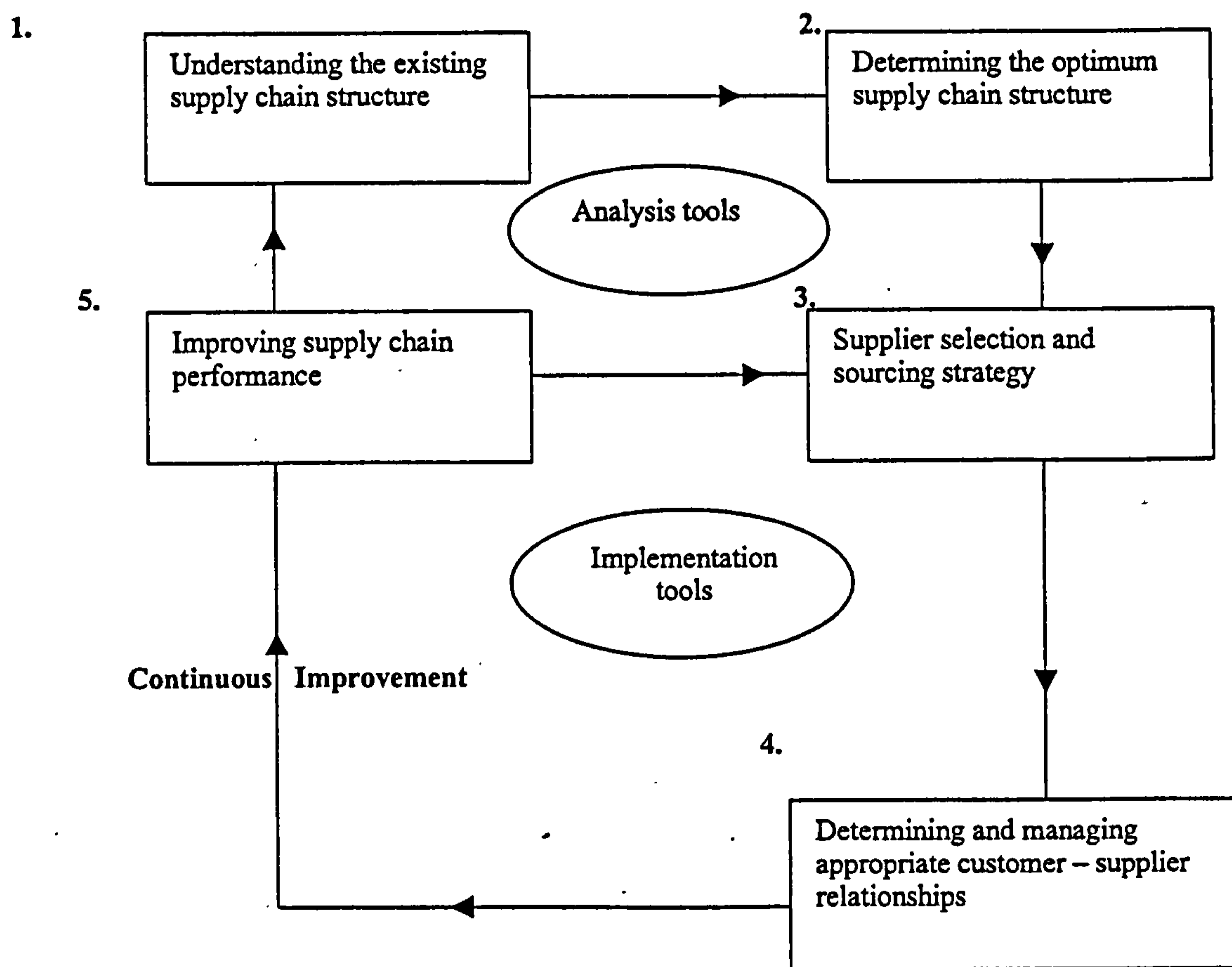
3.2 Conception of a Generic Process Model for Improving Supply Chain Performance:

Upon reviewing the literature it became apparent that each of the broad subject fields could be structured as illustrated in Figure 3. Figure 3 illustrates the earliest conception of a generic process for improving supply chain performance. This was the underlying structure adopted and further developed during the programme of research. It commenced by investigating the structure of an existing supply chain, in order to identify its associated costs and inefficiencies. The second stage then addressed the determination of an optimum supply chain structure. A variety of analysis tools were identified in the literature to assist practitioners between stages 1 and 2. Once a proposed solution had been determined stage 3 comprised supplier selection and sourcing. This enabled appropriate supplier sources to be identified prior to a formal commercial commitment being made.

Stage 4 then required the management of any resulting customer-supplier relationships, which in turn would impact supplier performance (stage 5). Stages 3 to 5 were supported by a number of implementation tools present in the literature. These stages also formed part of an iterative sub-process contributing to continuous improvement.

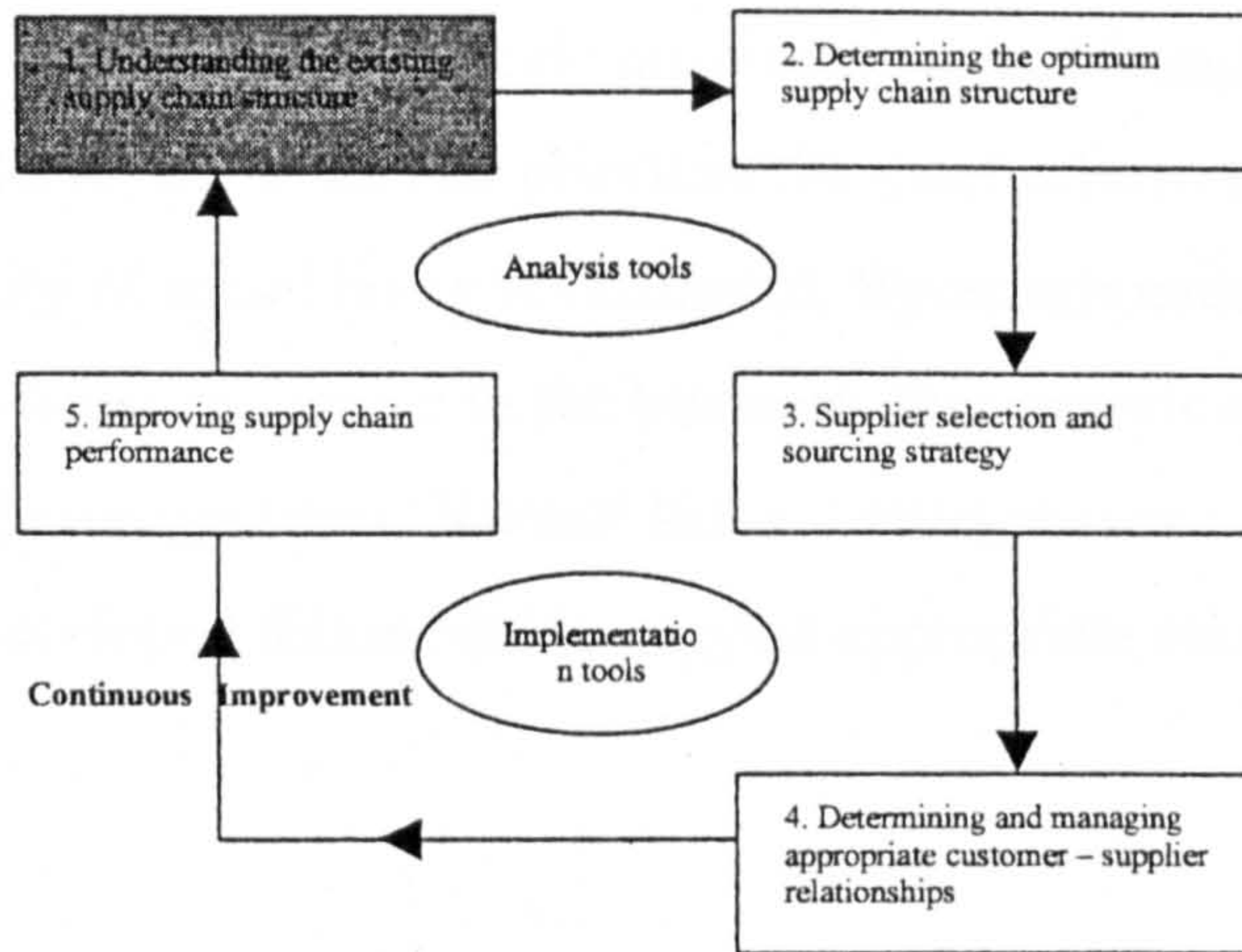
Figure 3 is fundamental to the structure of this programme of research. At the highest level it illustrates the generic stages of the proposed processes that were adopted throughout each of the case studies. It also forms part of the framework upon which the final recommended process for improving supply chain performance was based. Discussion of the key arguments developed throughout this paper has been structured in accordance with this approach. The remainder of this section will address the key findings resulting from each stage of the approach illustrated in Figure 3.

Figure 3: Supply Chain Management Road Map



3.3 Understanding the Existing Supply Chain Structure:

Figure 3: Supply Chain Road Map



3.3.1 Establishing the Importance of Supply Chain Management to the Company:

The importance of supply chain management can be emphasised by examining the amount a firm spends with external suppliers, as dictated by best practice [5]. The benchmarking exercise undertaken in portfolio submission 4 indicated that airlines spend a minimum of 70 % of their financial turnover on the external supply base [7]. Lamming discovered that the same calculation for the automotive sector was 80 % [2]. These significant percentage costs can have a considerable impact on company profitability if they are not managed effectively. A study undertaken by the Chartered Institute of Purchasing and Supply (CIPS) revealed that a significant proportion of chief executives did not know the percentage of their total costs spent with external suppliers [19].

A number of prioritisation tools were identified in the literature to further breakdown and classify different commodities of spend. Steel and Court [20] describe application of Pareto analysis as a way of prioritising supplier spend. This analysis broadly assumes that 80 % of supplier expenditure will be concentrated on 20 % of the number of suppliers. This is as a result of the characteristic supplier base tail as defined by Lamming, whereby a significant proportion of suppliers are involved with low value high frequency spend

[2]. A common approach found in the literature was to measure the total cost of acquisition, as defined by Ellram [9].

Kraljic's matrix was a strategic prioritisation tool found in the literature [21]. This provided a means to further prioritise the most effective strategies depending on the commodity of spend being investigated. By incorporating aspects of supply risk and the potential financial impact to the business, four generic sourcing groups were derived by Kraljic; *Leverage items*, *Normal items*, *Strategic items*, *Bottleneck items*. Van Weele further developed this model to suggest appropriate sourcing strategies for each category [22].

3.3.2 Understanding the Company's Supply Chain Characteristics:

Portfolio submission 2 investigated the case study company's supply chain characteristics as of 1998 [6]. Considerable difficulty was experienced in obtaining the historic supplier spend data for the company. Supplier commitments were categorised into purchase orders and repair orders. Purchase orders were items being bought direct from suppliers. Repair orders were for items being rotated through a repair cycle. A significant proportion of repair order costs was missing from the data obtained. This was attributed to the limited capability of the company's purchasing systems. Interestingly, four years on the company is now seeking approval for installation of a company-wide purchase order and requisition system, based upon benefits of increased financial control through better management information.

In summary, the data extracted from this review indicated that the company's supplier expenditure closely obeyed Pareto's 80:20 rule. The average external expenditure was approximately £10 million per annum spread across 450 suppliers (for purchase orders only). Interestingly, over 80% of this expenditure came from the top 100 suppliers. Therefore 22% of the supplier base was attributable to 80% of total expenditure. In fact over £5 million was spent with the top 20 suppliers. This demonstrated the existence of

Lamming's characteristic supply base tail with the majority of the supplier spend concentrated on a few suppliers [2].

In retrospect the company now has a far greater understanding of its supplier base profile. The work described above initiated a thorough review of total company external expenditure by supplier at group level. Four years on it is now known that the case study company has over 1000 suppliers with an average overall expenditure of £75 million per annum. This accounts for all of the repair order data previously missing. Furthermore, figures including the parent airlines spend indicate a considerable supplier base in excess of 3000 suppliers with an average overall spend of £400 million per annum. The same characteristic supplier base tail has been shown to apply to this data. Lamming indicated that best in class Japanese automotive firms had fewer than 250 suppliers [2]. As a result of the findings of portfolio submission 2 the company has since pursued an aggressive supplier reduction strategy [6].

Finally the data obtained from portfolio submission 2 revealed that over 25% of supplier orders were less than £500 in value [6]. Ellram's analysis of total acquisition costs was applied where it was found that a typical cost per order exceeded £195 [9]. Furthermore, over one third of all orders placed was found to be for commodities of lower unit value than the cost of placing the order. This suggested alternative purchasing practices were required for such commodities [5]. Since identifying these findings the company has implemented a purchasing card scheme for all high frequency low value orders. Purchasing card expenditure is now amounting to £4 million per annum based on approximately 40,000 transactions. This has saved the company approximately £7.8 million by reducing the cost of acquisition.

Portfolio submission 3 identified an important characteristic of MRO supply chains [3]. There was a strong cultural tendency for the case study company to use inventory as a means of protection, contravening one of the key Booz Allen elements [15]. This was driven by two factors. Firstly, the potential loss of revenue from grounding an aircraft due to a missing part would always outweigh the cost of procuring that part. However, it was

suggested that the MRO sector was not exceptional in this regard. A comparison was made with the automotive sector where it was found that stopping the assembly line would have similar cost implications due to the impact on annual output. Secondly, it was found that the average lead-time of procuring the part would always exceed the time available to repair an unserviceable aircraft. This combined with the fact that over 45 % of all material demands were only identified at the time of inspection, meant that the delivery time (D-time) would always exceed the production time (P-time). Jacobs et al stated that such a P-D time ratio would by definition require inventory to be held [23]. This finding emphasised the importance of minimising the Forrester effect [16] and improving supply chain visibility within the MRO sector, in order to optimise the amount of inventory held.

3.3.3 Organisational Issues and Multifunctional Teams:

Another important consideration when evaluating the existing supply chain was that of the organisational structure of the purchasing function. Lyson summarised the advantages and disadvantages of centralised and decentralised purchasing departments, respectively [24]. However, a key finding from the literature review was the need to establish multifunctional teams to varying degrees. In retrospect and following completion of the case studies the need to investigate processes both internal and external to the firm became apparent. Typically, this demanded a cross-functional approach to problem solving, because the inefficiencies discovered would often involve more than one department or function. The benchmarking analysis undertaken in portfolio submission 4 illustrated that a significant majority of airlines did not appreciate the benefits of such an approach. Furthermore, most airlines were organised into traditional functional structures, with the purchasing and supply chain departments not represented at Board level [7]. Similar findings from a variety of other industries were summarised in a study undertaken by CIPS [19]. The need to empower individuals with total ownership of specific supply chains on a cross-functional basis was found to be an important factor during the implementation of the case study change programmes.

3.3.4 Application of the Supply Chain Prioritisation tools within the Case Studies:

The overhaul of landing gears was found to be a strategic item of Kraljic's matrix due to the high supply risk and expensive nature of the equipment [21]. Van Weeles corresponding strategy dictated the need to create mutual commitment through long term relationships with the chosen providers in order to improve forecasting of future requirements [22]. Considerable effort was invested to improve the planning process and increase the level of visibility, given the company's requirements for flexibility when planning landing gear overhauls.

A critical part of the landing gear case study required a better understanding of the existing supply chain structure [11]. The company had historically single sourced landing gear overhaul and believed that it was maximising its commercial leverage and therefore minimising the cost of procuring these requirements. The company had begun to experience significant operational problems due to the late delivery of landing gears. This was attributed to the poor performance of its chosen supplier. It was only by undertaking a thorough analysis of both the internal and external processes related to landing gear sourcing, that resulted in the company's contribution to the problem becoming apparent.

Following an investigation into the historic supply chain structure it was found that the company production department did not consider the availability of serviceable landing gears within the overall decision making process for determining the aircraft maintenance schedule. As a result frequent schedule amendments were continually imposed on the supply base without consultation. There was no co-ordination of planning effort between internal departments, let alone with the supplier.

An analysis of the external supply chain characteristics was undertaken in a detailed supplier market review. This found that no single supplier was capable of reacting to continual schedule amendments at short notice. The expensive nature of the equipment and the need for suppliers to maximise the number of stock turns meant that surplus inventory was not available for unplanned requirements. This suggested the need for a

greater degree of customer-supplier integration within the planning process, although this alone would not be sufficient given the inventory requirements of the customer company. A revised supply chain structure was therefore required.

A similar degree of value was obtained by investigating the existing supply chain structure within the chemicals case study [10]. Analysis of the supplier spend profile once again revealed Lamming's characteristic supply base tail [2]. Application of Kraljic's matrix revealed that chemical commodities either fell into the "leverage" or "strategic" sourcing categories. This required a combined approach whereby development of a long term relationship would be suited to the strategic items, whilst at the same time ensuring access to local suppliers was maintained to instil a competitive situation for the leverage items.

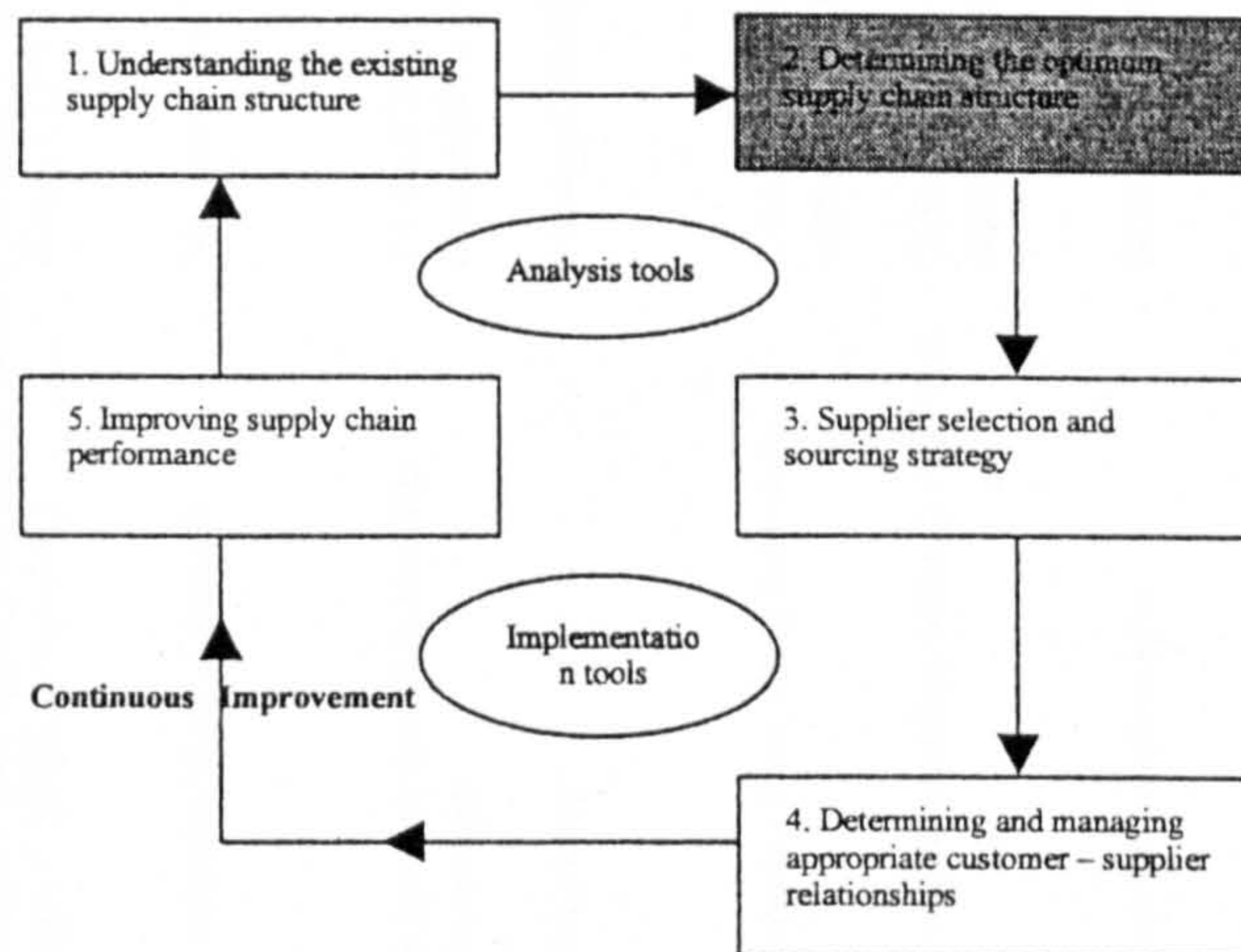
A key finding from this case study following a detailed review of the existing supply chain, was that no formal supplier selection process was being adopted for chemicals sourcing. The number of chemical suppliers continued to increase as a means of addressing the poor performance of existing suppliers. Furthermore, the large number of suppliers meant that the company was not maximising its commercial leverage. A detailed analysis of total acquisition costs revealed the true inefficiencies of the existing supply chain structure.

3.3.5 Summary:

Understanding the existing supply chain structure was effectively found to be the problem diagnosis phase of supply chain management. A review of best practice indicated the need to map out existing supplier spend profiles, prior to the application of certain prioritisation tools. This then enabled appropriate sourcing strategies to be determined. The case studies demonstrated the value of investigating both the internal and external aspects of supply chain structure and processes, with the inherent inefficiencies being identified. The need to evaluate processes was prominent in each of the case studies.

3.4 Determining the Optimum Supply Chain Structure:

Figure 3: Supply Chain Road Map



3.4.1 Summary of Best Practice:

Lamming [2], Hines [25] and Sako [26] were instrumental in developing current thinking in the field. Lamming developed a supply concept necessary to support lean production (Womack et al [1]) and called it lean supply. Following an extensive review of the automotive industry he developed his four-phase model of customer-supplier relationships. This model incorporated his findings that the automotive industry had progressed through four phases of development on the path towards achieving best practice. This was dependent on a number of supply chain attributes. The fifth phase of this model was effectively the lean supply phase. Hines further developed this model making it easier for practitioners to apply to their own businesses. He called this the “supply chain positioning matrix” [25]. This enabled a firm to plot their current progress with respect to best practice and determine strategies for improvement. These models were combined with the key Booz Allen elements of supply chain management in portfolio submission 4 [7], as illustrated in Figure 4.

The attributes within these models provide an indication of the characteristics necessary to attain best practice. The progress of best practice automotive firms towards each phase

Figure 4: Incorporation of the Booz Allen et al elements, Lamming's four-phase model, Lamming's lean supply phase and Hines's supply chain positioning matrix into one unified model.

	The five Booz Allen elements of SCM					Impact on Suppliers		Price Competition		Quality Competition		Close Co-operation		Strategic Partnerships		Lean Supply		
	Stage 1 (before 1975)		Stage 2 (1972-80)		Stage 3 (1980's onwards)		Stage 4 (1990's onwards)		Stage 5 (1990's onwards)									
<i>Undertake strategic decision making</i>	1. Buying Criteria	Lowest Price	Lowest Cost	Maximum Mutual Benefit	Maximum Network Benefit	As stage 4												
<i>Undertake strategic decision making</i>	2. Purpose of Supplier	To supply goods the customer does not make	To supply goods the customer cannot make	To provide possible benefits & advantages	To provide mutual competitiveness advantage	Strategic/stronger vertical + horizontal relationships												
<i>Undertake strategic decision making</i>	3. Relationship Type and Length	Adversarial/short	Arms length/variable	Close/long	Strategic/lifetime	Two way multifunctional teams												
<i>Interface closely with suppliers</i>	4. Customer Involvement in Supplier Activities	Little or non, from Purchasing	Sporadic, by Purchasing and/or quality	Frequent from many functions	Often from many process improvement teams	Customer-supplier boundaries blurred due to cross-functional processes												
<i>Interface closely with suppliers</i>	5. Interaction with Suppliers	One off or infrequently	Annual negotiation or quality audit	Frequent problem solving activities	Often seeking areas of competitive advantage	Fully integrated												
<i>Undertake strategic decision making</i>	6. Overall Relationship Description	Traditional/Reactive	Developing/Reactive or proactive	Progressive/proactive	Network/interactive	Suppliers undertake QA on behalf of customers												
<i>Involve suppliers early in sourcing process</i>	7. Quality Requirements	Minimal or none	Quality control	Quality assurance/TQM	TQM spread to own suppliers	Increased flexibility through improved visibility												
<i>Use inventories as a last resort</i>	8. Delivery Requirements	Minimal	Timely	Pseudo JIT	True JIT spread to own suppliers	Lowest total cost for supply chain												
<i>Undertake strategic decision making</i>	9. Cost Requirements	Lowest price by tender	Lowest cost by negotiation	Stable/non inflationary	Target costing/Kaizen reductions	As stage 4												
<i>Involve suppliers early in sourcing process</i>	10. Design Requirements	None	Limited (customer designs)	Design ability with customer	Integrated design with customer and suppliers	As stage 4												
<i>Involve suppliers early in sourcing process</i>	11. Technological Requirements	None	Limited (customer technology)	High with joint sharing with customer	Essential with joint sharing with customer and suppliers													

	Booz Allen elements of SCM					
	Impact on Suppliers	Price Competition Stage 1	Quality Competition Stage 2	Close Co-operation Stage 3	Strategic Partnerships Stage 4	Lean Supply Stage 5
<i>Integrate closely with suppliers</i>	12. Co-ordination by Customer	None	By occasional one-to-one meeting or standard letters	Yearly supplier conferences	Kyoryoku Kai (cascading down tiers)	Continuous
<i>Integrate closely with suppliers</i>	13. Development by Customer	None	Quality control instructions /audit feedback	One-to-one consultancy/ audit problem solving	One-to one group activities with Kyoryoku Kai	Two way + continuous
<i>Integrate closely with suppliers</i>	14. Reliance on Grading	None	Some reliance on reactive scores	Heavy reliance of reactive and predictive scores	Some reliance particularly on predictive scores	As stage 4
<i>Interface closely with suppliers</i>	15. Data Interchange	Little/infrequent at operational level only	Limited/sporadic at operational level only	Detailed and frequent at operational level, occasional at strategic level	Detailed and frequent at strategic and operational levels	As stage 4
<i>Interface closely with suppliers</i>	16. Cost Transparency	None	Occasional, but very limited	Transparent at highest tier buyer – supplier level	Transparent throughout supplier network	As stage 4
<i>Undertake strategic decision making</i>	17. Level of Pressure	Low/medium	Medium/high	Very high	Very high and transmitted to own suppliers	As stage 4 due to dependence on suppliers
<i>View the supply chain as a single Entity</i>	18. Number of Suppliers	Very high and unstable	High and relatively stable	Low and very stable	Very low and very stable	Few large suppliers with significant responsibility
<i>View the supply chain as a single entity</i>	19. Tiering Structure	None	Flat pyramidal	Steep pyramidal	Network format	Strong vertical relationships through tiering

of this model, with corresponding dates are provided for reference. Lamming's lean supply phase dictated that there would be fewer larger suppliers taking on more responsibility. This required the supply industry to be structured into tiers or separate levels, with stronger vertical and horizontal relationships. Hines exploited the benefits of these horizontal relationships through development of his network sourcing approach [25]. A key aspect of lean supply was that sustained competitive advantage was based upon the achievement of best practice, which will lead to reduced costs, improved quality and reduced time to market.

Lamming's original nine factors incorporated in the above models provide an insight into the attributes of best practice. He found that the nature of competition was an important factor affecting the degree of power within any relationship. Best practice dictated the need for a collaborative approach whilst maintaining a high degree of competition.

Despite this degree of collaboration the level of pressure in the relationship should still be very high because of the pressure to perform. The basis of sourcing decisions tended to adopt a total cost approach as defined by Ellram [9] with particular emphasis on long term cost of ownership. Best practice also dictated the need for two way sharing of information, even at the strategic level, with management of capacity co-ordinated and jointly planned. Dealing with price changes was no longer a game of conflict. The theory suggested that continuous improvement activities to jointly reduce costs and identify savings should result in a win-win approach. Finally, delivery practices were driven by small quantities on an agreed basis by adopting a just-in-time (JIT) approach to supply. However, the balance between flexibility and inventory held has been recently debated following the UK fuel blockades that caused major disruption to the supply of petrol in 2001 [27]. These debates have focussed upon the vulnerability of supply chains managed on a JIT basis, and have examined the associated costs of holding additional inventory to minimise risk and thereby increase flexibility.

Each of these factors relied on customers and suppliers developing closer relationships, and in the case of lean supply extending "beyond partnership" [2]. This was very much

dependent upon the degree of trust in the relationship. Sako defined the three types of trust as *contractual trust*, *competence trust* and *goodwill trust* [26]. An organisation's ability to move from trust based upon formal contractual commitments towards a relationship of mutual interest based upon goodwill only, was necessary to create the environment necessary for achieving the later stages of Lamming's and Hines models. The literature summarised these contrasting approaches as traditional adversarial relationships or collaborative relationships as defined by Saunders [28].

A firm therefore has to optimise its supply chain in order to ensure each of the above factors is addressed. Often this requires some form of supplier base reduction or rationalisation. The supply chain prioritisation tools previously identified often signal the need to reduce the number of suppliers a firm deals with. Lamming suggested that as the number of direct suppliers starts to fall the number of indirect suppliers starts to rise [2]. This was accomplished through the introduction of tiers into the supply chain, whereby responsibility and ownership of non-core activities (to the customer firm) are pushed down the chain. Gattorna described this process as determination of the optimum supply chain configuration, resulting in more effective allocation of a firm's purchasing resource [17]. The word optimum was used as recognition that increases or decreases in the supply base may be necessary to improve supply chain performance, and meet the end customers requirements.

Introducing a tiered structure into the supply chain frequently entered the realm of single versus dual sourcing. Hines focussed his research upon investigating the attributes of world class organisations, and in particular Japanese subcontracting [25]. This provided some significant findings with respect to optimising the supply chain, and illustrated that a variety of options were available to practitioners. Hines found that Japanese subcontracting was driven by the need to allow both customer and supplier to remain focussed on their core businesses. The structural features of Japanese subcontracting were found to adopt both single and multiple sourcing approaches, and reflected most of the attributes necessary for lean supply.

Japanese companies often entered into so called *Kyoryoku Kai* relationships defined as a mutually benefiting group of subcontractors, often with a degree of equity ownership provided by the customer organisation. This provided the basis for trust. The degree of co-operation within these relationships even extended as far as re-allocation of the profits between the customer and supplier during difficult economic times. This demanded a long-term view of the relationship. However, the short-term sacrifices made by the customer were more than offset by the medium to long-term benefits gained. This was illustrated by the Mazda approach to sourcing. By parallel sourcing certain commodities Mazda had managed to avoid the respective disadvantages of single and dual sourcing, whilst at the same time ensuring a degree of competition prevailed. This approach was applied to the landing gear case study resulting in significant improvements in operational efficiency [11].

In summary and following completion of this programme of research it is clear that best practice prescribes the need to *work more closely with suppliers*, whilst at the same ensuring that the limited resource of both customer and supplier companies *work more effectively*. Supply chain structures that aim to optimise these two factors will drive a company towards best practice.

3.4.2 The Airline Industry's progress towards optimising its Supply Chains:

The benchmarking exercise undertaken in portfolio submission 4 provided a snap shot of the airline industry with respect to best practice [7]. The key findings relevant to optimising supply chain performance revealed that airlines attributed little importance to achieving closer integration with their suppliers. Whilst supplier reduction programmes through traditional single and dual sourcing strategies were commonly adopted, the industry had a poor awareness regarding the benefits of parallel sourcing (a specific approach to dual sourcing) such as the Mazda approach. Furthermore, any supply chain optimisation programmes had failed to harness the benefits of redesigning the supply chain into different tiers or layers. Furthermore, supplier performance was only addressed at the first tier level in the majority of cases.

The strengths and weaknesses of the case study company's historic supply chain were analysed in portfolio submission 3 [3]. Key findings of this research were that the company lacked the resources necessary to manage its suppliers effectively, let alone undertake any kind of formal supplier development. This was due to the high supplier / buyer ratio resulting from the large supply base. Rationalising the supplier base in order to optimise supply chain performance was therefore a priority.

3.4.3 Supply Chain Optimisation undertaken within the Case Studies:

Both of the case studies consisted of the implementation of optimised supply chains ([10] and [11]). Once the existing supply chain inefficiencies had been established, structures that would deliver improved supplier performance whilst reducing cost were evaluated.

In the case of the chemicals sourcing work the company needed to design a supply base which considerably reduced the number of direct feed suppliers, whilst maintaining secure sources of supply for specialist commodities [10]. The company had failed to maximise its commercial leverage for chemicals with expenditure diluted over a number of suppliers. This not only resulted in higher unit costs but also degraded the level of influence and power the company had over its suppliers. As a result the company had made little progress in addressing the performance of its suppliers. This was further compounded by ineffective utilisation of buyers struggling to manage numerous suppliers.

The proposed solution was to rationalise the supply base by re-organising it into tiers. This was a revolutionary approach for the case study company, and one seldom undertaken by the industry as a whole [7]. The scope for innovation was therefore high. A single source supplier was selected to manage lower tier suppliers on behalf of the customer. As a result many direct suppliers to the company were instructed to feed direct into the single source supplier. This had a considerable impact on customer-supplier relationships, which had to be proactively managed. However, it had the effect of

maximising the commercial leverage of the company, whilst at the same time ensuring specialist sources of supply were not cut off. In some cases this required suppliers who were historically competitors to each other to establish a close working relationship, which was a radical approach for the industry.

The introduction of supplier tiers into the chemical supply chain also enabled the company to integrate more closely with the single source provider. This was necessary to achieve implementation of the stock consignment programme described in the case study [10]. This required an effective outsource of certain key processes including stock replenishment, inventory forecasting and supplier management. Reducing the number of direct suppliers down to one allowed the company to dedicate existing purchasing resource into managing these structural changes.

The optimisation strategy adopted in the landing gear case study was very different to that applied in chemicals sourcing, despite following the same generic process [11]. In this case the company had already established a single source provider. However, a lack of inventory within the supply chain as a whole, and the degree of flexibility required of the planning process, meant that a dual sourcing strategy was necessary. The Mazda parallel sourcing approach (a type of dual sourcing strategy) was applied to maintain a degree of competition within the supply chain, whilst gaining access to a wider inventory pool. This was the first time that such an approach had been applied within the airline service sector, assuming the results obtained from the survey were statistically significant [7].

However, the optimised supply chain was more than a structural change. A significant requirement was the need for closer supplier integration, as defined by Booz Allen et al. Simply just interfacing with the supplier base was not sufficient. The company's planning process had to be closely integrated with that of its suppliers, in order for improvements in operational efficiency to result. This was achieved by involving the supplier (and internal departments) up front in the planning process. The inventory constraints identified required a far greater planning horizon to be established. By agreeing a formal

mechanism within which schedule changes could be accomplished, both customer and supplier could plan with greater certainty. The result of this action was to minimise the Forrester effect by damping false demand signals throughout the supply chain [16].

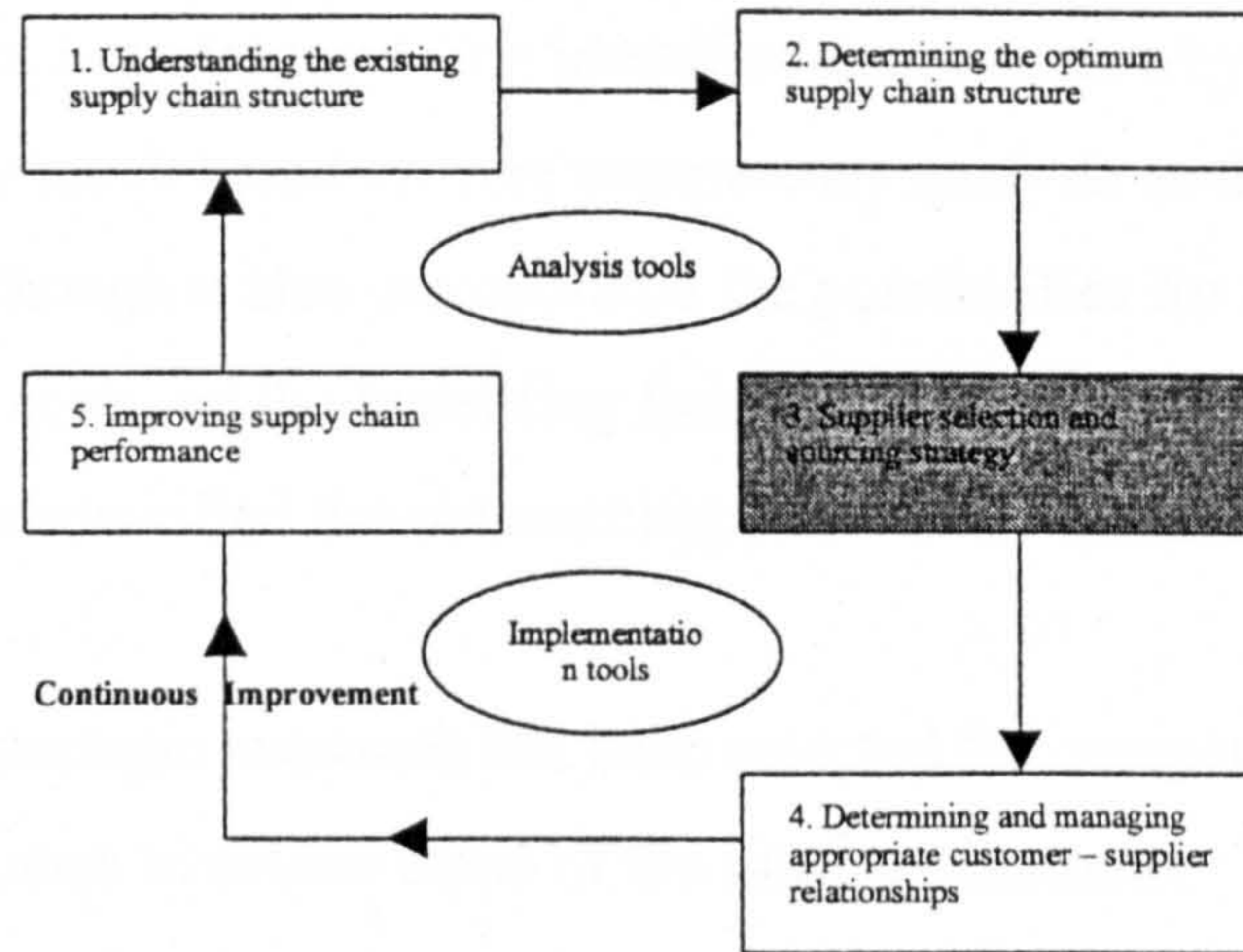
Therefore a significant element of this optimisation strategy required an appreciation and development of the relationship factors identified by Lamming and Hines. For example, a greater degree of information sharing prevailed with capacity and planning co-ordinated jointly with all the involved parties.

3.4.4 Summary:

In summary a review of the literature revealed the need for firms to optimise their supply chains on the path towards best practice. This could mean increasing *or* decreasing the number of suppliers a firm deals with. Lamming and Hines have identified the factors necessary to achieve best in class supply. In each case these are based upon the need to work more closely with suppliers and more effectively. Hines has identified a variety of Japanese subcontracting techniques, which reflect best practice. These are not solely restricted to single or dual sourcing methodologies. A variety of these strategies were applied in the case studies and had a major impact on supply chain performance.

3.5 Supplier Selection and Strategic Sourcing:

Figure 3: Supply Chain Road Map



3.5.1 Summary of Best Practice:

Identifying possible ways to optimise the supply chain invariably leads to the process of supplier selection. Even if the solution does not require the selection of a new source of supply, it will certainly require a review of any existing commercial arrangements with current suppliers.

The ATKearny strategic sourcing methodology provided a best practice approach to supplier sourcing [29]. This process demands considerable analysis prior to the supplier selection phase, unlike the traditional approach to purchasing. A detailed supplier market review is first required to explore the options available. This includes a detailed analysis of supplier capabilities with respect to the product or service being procured. A sourcing strategy is then selected. A key finding of this research was the need to select a sourcing strategy that supports the revised supply chain structure. Sourcing strategies were found to include cost reduction activities through one or more of the following: volume concentration, spend concentration, specification improvement, service level improvement, joint process improvement, joint purchasing and / or outsourcing.

Each of these activities demonstrated the need to think strategically about sourcing, compared with the traditional approach of best price evaluation. It was at this stage that the firm effectively undertakes the make / buy decision and may consider an outsourcing approach. Lonsdale and Cox identified the reasons why a firm may outsource [30]. This was very much based on core competency analysis as described by Prahalad and Hamel [31]. Although it also incorporated the possibilities for a firm to convert fixed costs to variable costs, whilst benefiting from a suppliers investment and innovation. Lonsdale et al further identified the outsourcing process and its associated risks [30].

Once a strategic approach has been selected the company must determine its specific requirements to reflect those of the ultimate customer. This often requires the adoption of a multifunctional team to ensure views of all respective “process owners” are incorporated.

This team can then be used to agree each of the criteria upon which the suppliers will be judged. Dickson summarised a variety of supplier selection criteria adopted by best practice firms [32]. These were effectively further categorisation of the “five rights” of traditional purchasing as defined by Bund [18]. For example, level of service, delivery performance, commercial competitiveness and supplier capabilities were common criteria found in the literature.

Strategic sourcing demanded this level of analysis to be undertaken prior to a firm going out to the market place [29]. At this point the firm may issue a request for information (RFI) or a formal request for proposal (RFP). An RFI is used when the customer seeks additional information from the supplier base when formulating its specific requirements. It is not a formal invitation for the supplier to bid. The RFP stage is typically an invitation for specified suppliers to participate in a formal competitive tender program.

The literature identified certain limitations of competitive tender programmes, with some academics questioning their value. These programmes originated from public sector procurement where there was a need to ensure the principals of public accountability,

allowing a non-discriminatory selection decision to result (Saunders [28]). Criticism of these programmes tended to concentrate on the high cost of administration and the length of time required for delivery. However, Roberts further argued that such programmes do little to encourage innovation [33]. The prescriptive format of RFP documents combined with the short timescales available for suppliers to respond diluted the quality of any supplier response.

In summary formal competitive tender programmes were found to be representative of a more traditional approach to purchasing. However, the literature revealed few alternative approaches. Mannion cited in Cox et al argued that long term relationships could arise from these programmes [34]. Furthermore, Erridge suggested that there was middle ground between competitive bidding and the partnership models by using it as a pre-supplier selection phase, before investing in relationship development with a few short listed suppliers, prior to contract selection [35].

Following supplier selection the remainder of the strategic sourcing process focuses upon a number of contract implementation issues, and opportunities for achieving continuous performance within the relationship [29]. These issues were further explored under customer-supplier relationships and supplier development.

3.5.2 Supplier Sourcing and Selection undertaken within the Airline Service Industry:

The benchmarking analysis undertaken in portfolio submission 4 provided a significant insight into the airline industry's adoption of strategic sourcing methodologies [7]. Competitive tender programmes formed a significant element of the strategic sourcing process, as indicated by 71 % of respondents. Each airline participated in one or more of the specific sourcing strategies summarised, with those strategies concentrating on maximising commercial leverage through spend or volume concentration being the most popular. Joint purchasing through airline alliances was also found to be a growing activity. Those strategies that harnessed savings through process improvements or specification changes were less widely adopted. These are clearly strategies that may require structural

changes to the supply chain before benefits can be realised and so are more difficult to accomplish. A key objective of this research was to develop a process to assist practitioners in implementing such improvements.

3.5.3 Adoption of Strategic Sourcing methodologies within the Case Studies:

Both case studies adopted a strategic approach to sourcing. This commenced by gaining an appreciation of the existing supply chain characteristics prior to proposing solutions based upon best practice tools and techniques.

In the case of the chemicals sourcing project the difficulty was in determining which suppliers should be nominated as first and second tier, respectively. These issues were addressed by inviting existing suppliers to the company to participate in a competitive tender programme. A multifunctional team was used to draw up a tender document based upon the incorporation of an agreed list of selection criteria [10]. A detailed list of commercial requirements was also drawn up. Based upon the initial supplier responses a short list of three suppliers was agreed, from which further negotiations would commence.

The supplier negotiations were based upon the traditional purchasing criteria as defined by Bund [18], but also incorporated a number of aspects of best practice, as defined by Lamming's four-phase model [2]. In particular, the suppliers approach to continuous improvement and its ability to share information on an "open book" basis was critically important. The outsourcing of certain stock management processes to a single source supplier, could have made the company particularly vulnerable. A considerable degree of *competence trust* as defined by Sako [26] was therefore required. The willingness of any supplier to share information therefore provided an insight into the potential degree of trust for any future relationship. This factor alone resulted in the de-selection of one of the short listed suppliers.

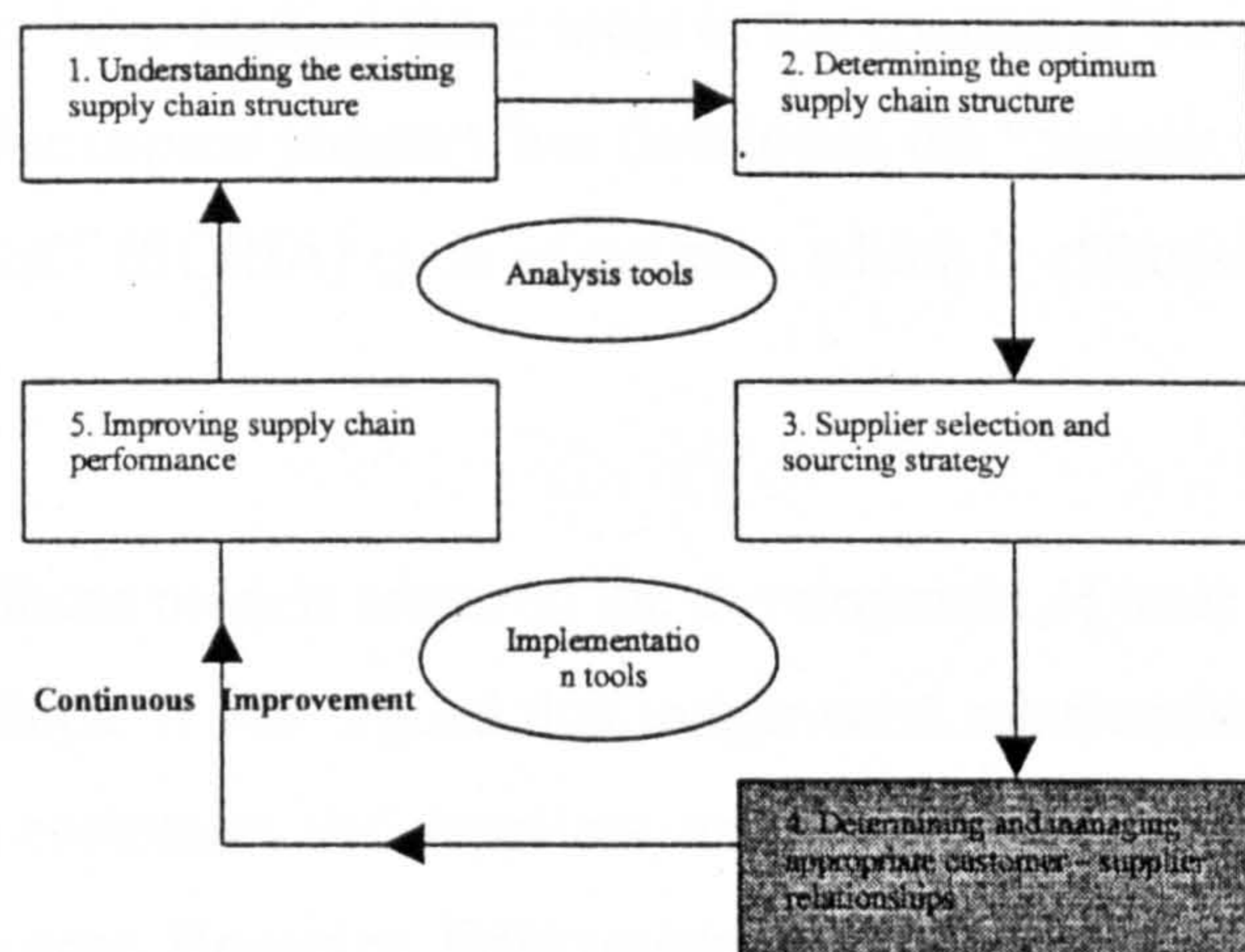
In summary, the competitive tender resulted in the selection of a single source supplier capable of meeting the company's commercial requirements. However, it was only by adopting a strategic sourcing approach that the successful supplier was able to comply with the strategic objectives of the project, as defined by the multifunctional team. This increased the likelihood of a successful implementation.

Similarly a competitive tender program was undertaken within the landing gears case study [11]. However, a critical aspect of this project was the need to undertake a detailed supplier market review. Only by gaining a realistic understanding of the supplier's capabilities could an effective tender document be drawn up. In retrospect this process effectively acted as the informal RFI stage of strategic sourcing. It resulted in the early involvement of certain suppliers within the sourcing process, who were then able to contribute to the overall solution. This addressed one of the factors identified by Lamming's four-phase model, although he developed this in the context of a manufacturing firm involving its suppliers early in the design process [2].

Again a multifunctional team was adopted to specify the company's commercial and strategic requirements. However, a prerequisite of supplier selection within the landing gear case study was need the to conduct a trial. The competitive tender programme in this context effectively acted as an initial screening phase. The actual supplier selection decision was based upon the suppliers performance during the trial, with specific metrics being determined by the team. It also enabled the company to further validate the potential benefits of the recommended Mazda sourcing approach. This can be likened to Erridge's approach described above [35]. It is important to note that cheaper solutions were available to the team, although they were not adopted. This further demonstrated that total cost and not price was the key criteria of supplier selection, with the cost of poor operational performance being the main concern.

3.6 Development and Management of Customer Supplier Relationships:

Figure 3: Supply Chain Road Map



3.6.1 Summary of Best Practice:

Following supplier selection and contract award a commercial commitment is made. This signifies the beginning of a customer –supplier relationship relative to the new terms agreed. Quinn and Himer proposed the “Potential Contractual Relationship model” which determined the type of relationship required dependent on the need for control and flexibility [36]. This was effectively a development of Kraljic’s model, which assisted practitioners in selecting the most appropriate relationship for a given commodity [21]. Commodities demanding high flexibility and low internal control suggested a short-term relationship. Conversely commodities demanding low flexibility but significant internal control suggested the need to maintain in-house ownership. However, this approach appeared too simplistic.

The need to select the most appropriate relationship for a given situation was identified by Lamming [2], and further developed by Hines [25] and Sako [26], respectively. The Lamming four-phase model and Hines’s supply chain positioning matrix provided tools for relationship assessment. Sako also developed a buyer questionnaire aimed at determining the level and type of trust in any given relationship [26]. Each of these models required the application of a scoring system to measure the relationship attributes and rank them accordingly. These attributes can be found in Figure 4. However, the

literature provides no indication regarding the relative weighting that should be applied to a given attribute. Lamming has indicated this is an area for further research. Different industries have applied these tools in the context of their own businesses. For example, the UK Aerospace industry has developed the “Supply Chain Relationships in Aerospace” (SCRIA) code of practice which is effectively a relationship assessment tool [37].

Each of these models required the development of trust through longer lasting relationships. It was argued that longer-term relationships improve the level of integration between customers and suppliers, and thereby introduce an ethos of continuous improvement. However, little research had been undertaken to establish the length of time necessary to realise these benefits. Graham and Daugherty found that a minimum of three years was necessary to establish any relationship [38]. Much of the research debated the benefits of long term relationships as required by Lamming’s lean supply phase. Ramsay determined that less than half of a firm’s purchases may be appropriate for partnership sourcing, and suggested that such an approach may only be appropriate for larger organisations [39]. The majority of these purchases fell into Kraljic’s strategic sourcing category [21], where there was a need to address the risk of losing power and influence within the relationship, as defined by Kraljic.

Cox, Saunderson and Watson suggested there were four types of relationship, dependent upon the inherent balance of power [40]. Should the balance of power be equal it was argued that working methods could either be non-adversarial but arms length, or non-adversarial but collaborative. Conversely, should the balance of power be unequal the working methods could either be adversarial and arms length or adversarial and collaborative [40]. This was an important finding regarding the complexity of relationship types.

Hines [25] discovered some key aspects of best practice found within the Japanese automotive industry. The failure of Western firms to adopt the partnership phase of Lamming’s model [2] required an appreciation of Japanese subcontracting policy. Hines

found that this was based upon the three assumptions that the customer controlled the relationship, that the specialist abilities of the supplier were not present in the customers business, and that some form of equity ownership in the supplier was necessary. Interestingly, this purported to the type of vertical integration that happened to satisfy each of the Booz Allen elements [15].

The strength behind these assumptions became apparent during difficult economic times in Japan. Hines found during times of recession when the pressure was high that most Japanese companies exhibited the greatest degree of closeness and mutuality. The opposite was true of Western firms. This finding was measured from the increased number of *kyoryoku kai* meetings attended by Japanese firms during such times. It was further reflected in Toyota's basic philosophy towards suppliers which was one of mutual co-operation and mutual benefit [25]. Many of the benefits achieved through mutual co-operation resulted from the effort invested in supplier development, which is addressed in the following section.

3.6.2 Customer – Supplier Relationships within the Airline Industry:

The benchmarking analysis undertaken in portfolio submission 4 provided a significant insight into customer-supplier relationships [7]. It was found that airline industry relationships tend to be dominated by *contractual trust* as defined by Sako [26]. Airlines tend to ensure supplier performance is complied with through adversarial measures such as strict contractual termination clauses and penalties for non-conformance.

The type of relationships found within the airline industry was found to be collaborative but arms-length. For example, the level of cost transparency was generally found to be limited amongst respondents. The duration of these relationships was found to vary depending upon the commodity of spend being investigated. This indicated some appreciation for the need to select relationships appropriate to the task, as suggested by best practice. However, evidence for short-term relationships was rarely found in the survey.

There was a consensus amongst respondents that the level of pressure within these relationships was typically medium with some sense of relief. This was partly due to the limited competition found within airline industry supply chains. However, the pressure to perform was not as high as it could be. Lamming's lean supply phase dictated the need for a high degree of predictable pressure driven by the need for suppliers to continually improve [2]. The airline industry was some way from achieving this.

3.6.3 Customer – Supplier Relationships issues found in the Case Studies:

Research undertaken in portfolio submission 5 provided a further insight into the nature of customer – supplier relationships within the case study company [8]. This case study consisted of the implementation of a new cabin interior product across the parent airline's fleet of aircraft. Most of the research focussed upon the contractual relationship with the prime subcontractor of the programme who was responsible for providing new aircraft seats.

It was found that a traditional adversarial relationship prevailed within the company, with a limited degree of contractual trust evident. The majority of the problems encountered resulted from a lack of supplier integration within the programme. The prime subcontractor was reluctant to share information regarding its own internal processes. Furthermore, the case study company had failed to involve the supplier early enough in the planning process. A number of production delays were therefore attributed to the phenomenon known as the Forrester effect [16].

The lack of trust was further compounded by the absence of a contractual mechanism to permit minor specification changes. These changes were often imposed by the company's Marketing department without the full involvement of the Technical function to assess any design implications. In each case the prime contractor would act as if a master design change had been requested citing an adverse impact on production time and cost. A game of conflict in negotiation would then follow to get the programme back on track. This negotiation was often a zero sum game as defined by Neumann [41].

This case study served to illustrate the company's relative naivety with respect to programme management and customer supplier relationships. The project did not view the supply chain as a single entity. As a result the customer and supplier tended to focus upon their own operations, with little thought given to the benefits of joint co-ordinated effort. However, an eventual success of this project was the closer integration achieved between internal processes, with the company's Engineering and Marketing departments gaining a greater appreciation of each others requirements.

A variety of other relationship issues became apparent during the implementation phases of the landing gear and chemicals sourcing case studies. The landing gear project started with the perception of a significant supplier performance problem [11]. Prior to undertaking the research the company had threatened to terminate its existing contract with the single source supplier. This had considerably damaged the relationship. This situation was recovered by involving the supplier early in the problem diagnosis phase. The threat of losing this business then acted as a lever with which the company could maintain a degree of pressure within the relationship. Upon implementation of the parallel sourcing approach the supplier maintained an acceptable level of performance. This was despite the fact that he had effectively lost a significant proportion of guaranteed business through the dual sourcing structure. The Mazda sourcing approach then served to maintain a degree of pressure given the additional business attainable over the long term.

The chemicals sourcing project presented a different set of relationship issues [10]. The single source solution implemented through introduction of a deliberately tiered supply chain structure, dictated the need for previously competing suppliers to form collaborative relationships. This approach was not without its problems. A key supplier to the case study company failed to accept the proposed solution and attempted to derail the economic arguments put forward to justify it. A new supplier had to be selected to cover the commodities previously supplied, but this was undertaken in partnership with the

newly selected single source. A phase of intense communication was necessary within the case study company to continue with the proposed approach.

However, this was an isolated event. Each of the lower tier suppliers were involved early in the implementation phase. The reasons for the approach were clearly communicated first on a one to one basis, and then jointly with the single source supplier. Each supplier was given reassurances regarding their potential levels of business for the future.

Furthermore, the case study company maintained contact with these suppliers, albeit indirectly. A contractual requirement of the single source supplier was to introduce lower tier suppliers to regular continuous performance forums with the aim of ensuring access to specialist knowledge and expertise. This approach helped to ensure that a smooth implementation was achieved.

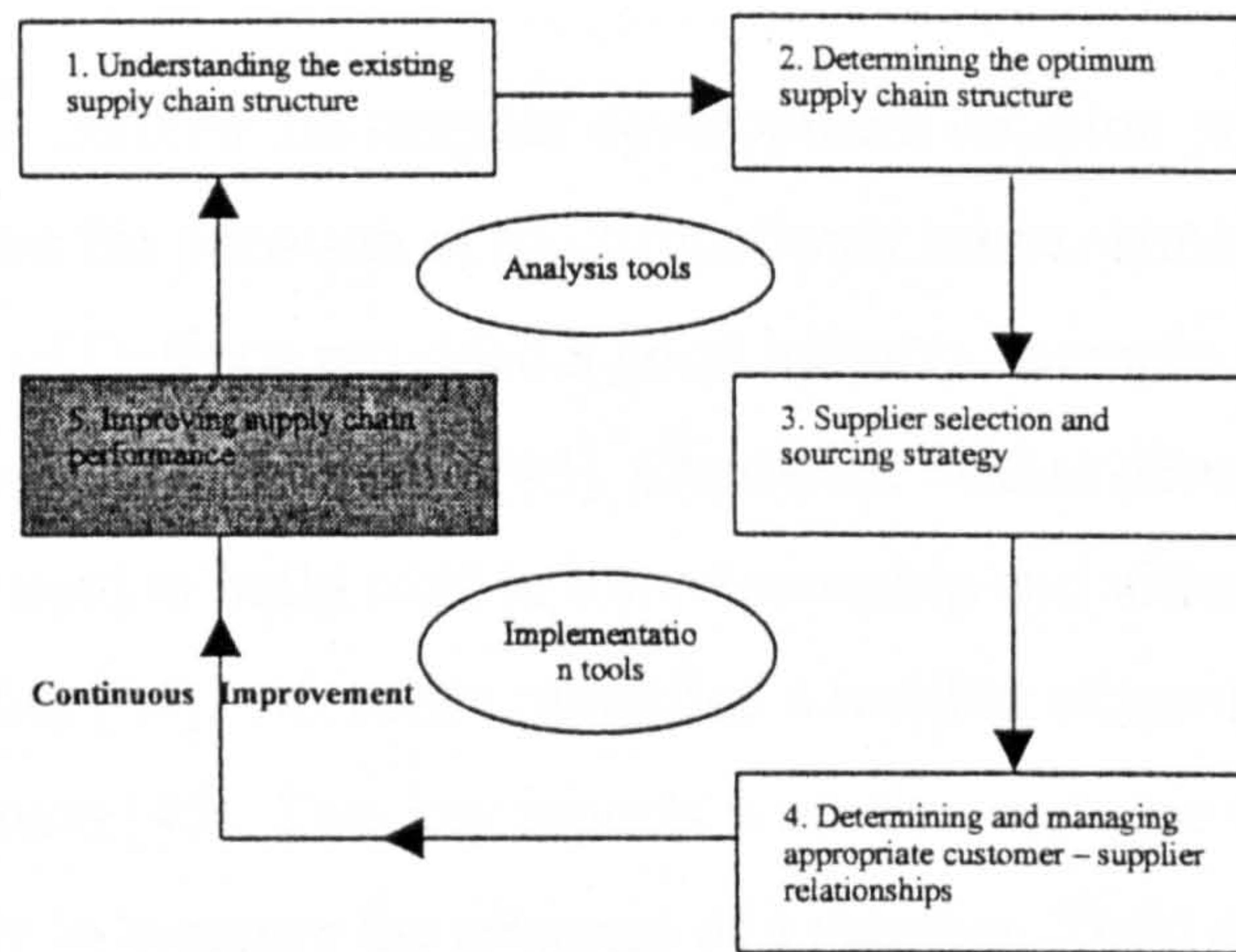
3.6.4 Summary:

A key finding of the research was the need to select a relationship type appropriate to the commodity being investigated, by addressing the inherent degree of power between the firms. Best practice did not necessarily dictate the need for long term relationships for every situation. The Lamming, Hines and Sako models provided a useful basis for assessing customer supplier relationships, although no formal scoring system has been devised.

Finally the relative naivety of airline industry relationships has been established. The case studies demonstrated the importance of addressing customer supplier relationships during all phases of the planned programme of change in order to ensure a successful implementation.

3.7 Improving Supply Chain Performance:

Figure 3: Supply Chain Road Map



3.7.1 Summary of Best Practice:

The literature describes a variety of supplier development activities as a means of improving supply chain performance through continuous improvement. Hahn developed a conceptual model for supplier development programmes defining them as a systematic organisational effort to create and maintain a network of competent suppliers [42]. Hines further categorised the related activities into supplier co-ordination and supplier development [25]. Supplier co-ordination was defined as the activities undertaken to mould a supplier into a common way of working so that competitive advantage could be achieved through the reduction of waste. Supplier development in this context was taken to mean the activities undertaken to improve the strategies, tools and techniques employed by the supplier on the road to achieving competitive advantage.

Interestingly these definitions assume the dominance of the customer organisation, hence the term *supplier* development. This reflected the nature of the automotive industry where the majority of supplier development activities had been found to occur. However, this was not necessarily the case in the airline industry, with many suppliers such as Boeing and Airbus Industries being more dominant than most of their customers. The less adversarial term *customer-supplier* development is now more widely adopted to

acknowledge the potential for both parties in the relationship to contribute to overall improvements in efficiency.

Hahn et al defined the supplier development decision process [42]. This was largely based upon the adoption of multifunctional teams within both organisations. The UK Ministry of Defence provided a good industry example of this through their adoption of “integrated product teams” [43]. Chadwick further described how the use of these teams could be used to build trust in the relationship and ultimately improve the performance of the supplier [44]. Monczka identified a number of pre-requisites for successful supplier development [45]. Two key aspects were the existence of a manageable supply base and the ability to measure the progress of a supplier. Todd and MacGrath summarised the variety of operational metrics available to a firm when measuring supply chain performance [46]. These metrics were based on a variety of cycle times such as lead-time and response time. Cousins complimented these measures by incorporating a number of “softer” management issues such as company culture and reputation [47].

Krause summarised the specific supplier development activities that were available to a firm [48]. Krause’s research found that the majority of firms participated in activities such as supplier evaluation and feedback, site visits, and requests for improved performance, as opposed to the training and education of suppliers. He further argued that the true benefits of supplier development came from achieving closer integration through co-ordinating each others processes.

Lamming provided an insight into the nature of best practice in supplier development, as necessary for the fulfilment of the partnership phase [2]. He suggested that suppliers should be involved in the determination of any performance metrics by which they would later be assessed, and that any performance evaluation should be two way. Furthermore, the concept of partners constantly vetting each other was contrary to the principals of lean supply. This was because it assumed a level of inefficiency or poor performance. Lamming argued that such schemes would eventually become redundant, other than those measures or criteria which addressed the nature of the relationship [2].

A key limitation identified by the research was the lack of any specific tools to assist small to medium sized (SME) organisations in the successful implementation of supplier development programmes. Best practice in supplier development was typically found in large organisations where the customer had significant influence and power, and predominantly within the Japanese automotive sector (Hines [25]). Many airlines lacked the resources necessary to undertake these programmes [3]. Furthermore, the literature provides little evidence for the relationship between effort invested in supplier development, and the resulting impact on supplier performance.

3.7.2 Addressing Supplier Performance within the Airline Industry:

The benchmarking analysis undertaken in portfolio submission 4 provided an interesting insight into the ability of an airline to address supplier performance [7]. The key findings of this research were that only 57 % of respondents had some formal means of measuring supplier performance. Even fundamental attributes such as supplier lead-times were only measured systematically by half of the airline sample. This suggested significant limitations in airline systems and processes.

The most commonly adopted supplier development activity was that of visiting suppliers and undertaking supplier audits. However, the extent of true customer involvement in supplier development was found to be limited to sporadic, with only occasional co-ordination on behalf of the customer. In summary the airlines were found to be generally reactive when addressing supplier performance. The limited internal resource combined with the excessive size of the supplier base was thought largely to blame. The need for the airlines to select a small number of “preferred suppliers” on which to concentrate supplier development activities was therefore recommended. It was suggested that further research should be undertaken to assess the degree to which *suppliers* actually develop their airline customers, given their superior size and influence.

3.7.3 Supplier Performance lessons from the Case Studies:

The landing gear case study was driven by the need to improve the operational performance of the supply chain [11]. A number of high level metrics were used to assess the performance of each supplier during the trial, as defined by the multifunctional team. These consisted of measures addressing the on-time availability of the equipment, the actual cost versus proposed costs, the associated quality non-conformances and the overall responsiveness of the supplier during the trial. These metrics were later applied within the long-term contracts of the selected suppliers, and were used to determine the remaining allocation of work as required by the Mazda sourcing approach [25]. Consequently, they were critical to assessing the benefits of the proposed sourcing strategy.

Supplier development within the landing gear case study was primarily based upon achieving closer supply chain integration. By undertaking regular joint problem solving activities greater transparency of the planning process resulted. The confidence in each party's ability to meet their own customer's requirements steadily increased. This culminated in the case study company being able to perform a landing gear overhaul without the need for a float set of landing gear, resulting in significant financial savings. Prior to undertaking this research the Engineering Director had forbidden such an approach because of the inherent uncertainty and risk within the supply chain.

The chemical sourcing case study was largely concerned with integrating certain stock management processes between the customer and the single source supplier [10]. This again required numerous joint activities between the cross-functional teams of both organisations. The resulting contractual framework also introduced an ethos of continuous improvement by obligating the supplier to chair quarterly performance reviews. The supplier was responsible for delivering improvements through product rationalisation, new product introductions and the introduction of new technologies. This could not be achieved without the contribution of certain company departments, and so encouraged closer customer-supplier integration throughout the contract term.

Finally, prior to undertaking this case study the company was contravening one of the pre-requisites of good practice supplier development, which stated the need for a manageable supply base (Monczka [45]). By introducing supplier tiers into the supply chain a more manageable situation has been developed. The single source supplier effectively became responsible for managing the performance of lower tier suppliers, something that the case study company had lacked the internal resource to address.

3.7.4 Summary:

The literature has identified a variety of supplier development activities employed by best practice organisations, aimed at improving supply chain performance through continuous improvement. The airline industry was found to have a poor grasp of these concepts, and was reactive when addressing poor performance. The importance of defining clear and measurable performance criteria was demonstrated by the case studies.

3.8 Key Deliverables (Operational and Financial):

The success of the process adopted in each of the case studies was demonstrated by the operational and financial benefits that resulted. These were summarised as follows:

3.8.1 Chemicals Sourcing Case Study:

The total acquisition cost approach adopted in this case study identified a variety of hidden costs not previously realised by the company:

- a) The cost of poor supplier performance
- b) The cost of nil stock events
- c) The cost of purchase order and invoice administration
- d) The cost of inaccurate stock forecasting and planning
- e) The cost of diluted spend and poor commercial leverage
- f) The cost of holding stock
- g) The cost of shelf life obsolescence
- h) The cost of shelf life disposals

- i) The cost of ordering unsuitable products

Analysis of the existing supply chain structure revealed the following characteristics:

- a) Maximum effort was placed on order administration
- b) Minimal effort was invested in managing supplier performance
- c) Minimal effort was invested in developing customer – supplier relationships
- d) There was poor product knowledge amongst the buyers, and individuals with specialist knowledge were not consulted
- e) There was poor integration with internal customers (i.e. shop floor engineers)
- f) The company lacked any formal supplier selection strategy
- g) Junior material planners were inadvertently determining the allocation of supplier expenditure
- h) None of the existing suppliers were under contract
- i) There was no clear strategy for chemical sourcing

Implementation of the optimised supply chain structure by introducing supplier tiers through a single source supplier resulted in the following improvements:

- a) Significant reductions in total acquisition costs
- b) Improved integration with the end customer was achieved by viewing the supply chain as a single entity
- c) Improved utilisation of internal resource through minimising the number of points of contact within the supply chain
- d) Improved stock planning and forecasting
- e) Introduced regular performance measures and an ethos of continuous improvement
- f) Improved supplier performance whilst reducing cost
- g) Improved operational performance of the case study company
- h) Ensured greater contractual protection
- i) Maximised the company's commercial leverage

Optimising the company's chemical supply chain in this manner resulted in financial savings of £390,000 over the first three years. This represented a 40 % reduction compared with the costs associated with the previous supply chain structure. Furthermore, an additional cash injection of £150,000 was achieved in the first year by undertaking a transfer of stock ownership. Finally, transactional savings of £450,000 were achieved over three years by reducing the total cost of acquisition. A detailed breakdown of these costs can be found in portfolio submission 6 [10].

3.8.2 Landing Gear Case Study:

In summary the design of an optimised supply chain structure within the landing gear case study resulted in the following improvements [11]:

- a) The company's production planning department agreed to consider all landing gear changes within the overall decision making process for aircraft maintenance.
- b) The company's production planning department agreed to minimise the occurrence of "back-to-back" scheduled changes because of the exceptional demands it put on overall supply chain inventory (i.e. changes within 30 days of each other).
- c) The company's production planning and commercial departments agreed to develop a schedule of requirements at least 12 months in advance. The supplier base was involved early on in this process. Further supplier integration was achieved by inviting the supplier to regular meetings in which future schedule amendments were discussed and agreed.
- d) A defined contractual mechanism for schedule amendments was agreed which incorporated the actual limitations of the supply chain, and put certain obligations on both the customer and supplier.

These improvements resulted in a minimum financial saving of \$449,950 (approximately £300,000) over the contract period, representing a 12.5 % reduction on total expenditure. This was achieved at the same time as increasing the on-time availability of landing gears

by 60 %, and thereby transforming the operational performance of this supply chain. A detailed breakdown of these results can be found in portfolio submission 7 [11].

3.9 The Relevance of Supply Chain Management to the Airline Service Industry:

The approach adopted in each of the case studies and the resulting improvements in financial and operational efficiency, demonstrated the relevance of certain aspects of supply chain management to this service sector industry. This was a key finding of this part of the research, given that the majority of best practice had originated from the automotive manufacturing sector. Interviews with certain company managers at the time of commencing this research indicated some strong doubts regarding its potential for application from one industry sector to another.

Portfolio submission 3 provided a detailed investigation into the characteristic differences between these two industry sectors [3]. The objective of this research was to identify those aspects of best practice applicable to the airline MRO sector, given the different factors present within each industry. This would identify the potential for cross sectoral transfer of knowledge. The key findings from this aspect of the research significantly contributed to knowledge in the field.

The MRO sector was found to have a low level of repeatability compared to manufacturing. Whilst each aircraft being maintained would follow a similar maintenance schedule there was little correlation in the resulting material requirements. Conversely, each production line in a manufacturing organisation would be driven by a known quantity of materials. The complexity within manufacturing supply chains would be driven by the degree of product standardisation (or lack of it). Whilst this would also be a factor of MRO supply chains, it was also driven by the respective utilisation of an aircraft.

Each industry sector had differing approaches to inventory. The automotive manufacturing industry had embraced the Booz Allen element which stated the need to use inventory as a last resort [15]. Low levels of stock were typically held with small

frequent deliveries being made on a JIT basis. In contrast the MRO sector was fixated by the need to protect the operation at all costs. This resulted in large amounts of safety stock being held on a “just-in-case” basis.

The inherent degree of influence and control over suppliers has already been contrasted between the automotive assemblers and the airlines. This combined with the limited competition present within airline industry supply chains posed specific challenges. Airlines tend to adopt a given supply chain following selection of an aircraft. This was due to the regulatory nature of the industry, which forbids airlines establishing relations with non-approved suppliers. In general this resulted in a lower degree of freedom regarding supply chain design, compared to manufacturing firms.

Another key difference concerned production volumes. The MRO sector was driven by “made to order” low volume / long lead-time production. This was further complicated by a high degree of product customisation. These factors make it difficult for the industry to reduce unit costs through economies of scale. The opposite was true of the manufacturing sector, which strives towards high production volumes and relatively short cycle times.

Finally, the associated costs of obsolescent stock are more actively controlled within the automotive sector. Ageing production models are phased out years in advance with suppliers capable of “ramping down” accordingly. Conversely, the MRO sector was dogged by mandatory modifications driven by the regulatory nature of the industry. The resulting material costs are normally imposed on the airlines in order to comply with certain safety requirements. Consequently large buffer stocks must be held to ensure the availability of serviceable aircraft, often leading to immediate stock obsolescence.

The prevalent characteristics of the MRO sector do little to dispel the potential relevance of supply chain management to the service sector. On the contrary they further demonstrate the need to improve certainty and reduce costs through greater integration with suppliers. These findings further support the need to implement the strategies

adopted in the case studies. The low predictability of material requirements emphasises the need to increase visibility and transparency within airline supply chains. This requires the introduction of a manageable supply base through supplier rationalisation, and the development of strategic relationships with key suppliers to enhance the limited degree of commercial leverage. Adopting such strategies would contribute significantly to a reduction in the high levels of inventory held within MRO supply chains. The ability of the automotive industry to reduce the amount of inventory held within any given supply chain, was a key finding of this research. This raised serious questions about how the MRO industry had historically gone about managing inventory levels, with little consideration given to total supply chain costs.

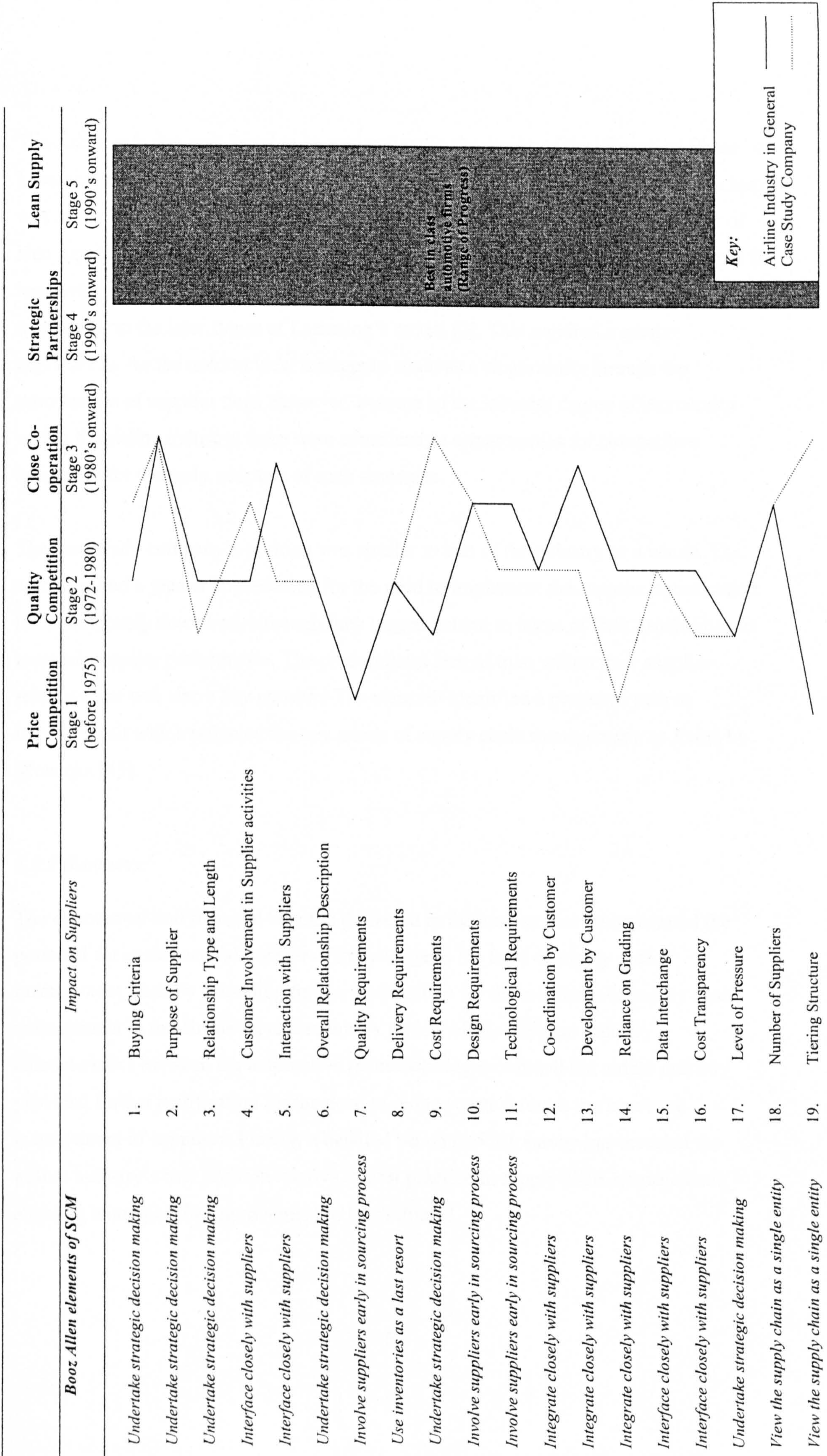
3.9.1 The Airline Industry's position relative to Best Practice:

Once the relevance of supply chain management to the airline service sector had been established, the research then focussed upon the degree of progress required for it to attain best practice.

The benchmarking survey undertaken in portfolio submission 4 was based upon the distribution of a questionnaire to key airlines [7]. The design of this questionnaire incorporated the key elements of best practice which were based upon a combination of Lamming's, Hines's and Sako's models as represented in Figure 4 ([2], [25], [26]). The results of the survey were analysed and compiled graphically by plotting the industry's progress relative to the respective development phases identified by Lamming [2]. The case study company was also represented on this model providing an indication of its position relative to the airline industry, as well as its progress towards best practice. These results are represented in Figure 5 and compliment existing gaps within the literature.

A key finding of benchmarking analysis was that the airline industry displayed a considerable degree of immaturity when compared with progress achieved by the automotive manufacturing industry.

Figure 5: Graphical Representation of the Airline Industry's Position Relative to Best Practice in Supply Chain Management



The airline industry was found to be somewhere in the region of the “Resolved Phase” of Lamming’s four phase model, which was representative of where the automotive industry was in the 1980’s. Considerable progress was therefore required before the benefits of lean supply could be realised. The airline industry therefore needed to adopt strategies for improving customer-supplier integration through proactive supplier development if it was to progress to the later stages of Lamming’s model [2]. This required a greater appreciation for the need to view the supply chain as a single entity through the introduction of supplier tiers. However, because of the inherent degree of immaturity within the airline industry, there were considerable opportunities for competitive advantage for the early adopters of such strategies.

The case study company’s position was similar to that of the industry as a whole. The company had a greater appreciation for the need to implement the supplier optimisation tools previously described, although they lagged behind in terms of their capabilities to measure supplier performance. The predominant lack of trust within their supplier relationships was also a key concern. The research identified a proposed path to improvement which reflected the key trends of supply chain management, as found by Monczka [45].

3.9.2 Summary:

The operational and financial benefits delivered in the case studies demonstrated the potential for cross sectoral transfer of knowledge in the field of supply chain management, thereby providing further justification for the relevance of supply chain management to the airline service sector. A review of the different industry characteristics between the automotive manufacturing sector and the airline industry provided further justification for the need to reduce costs through the improved management of suppliers. Finally, a detailed benchmarking survey has revealed the airline industry’s true position relative to best practice in supply chain management, enabling strategies for improvement to be evaluated.

4.0 DEVELOPMENT OF A GENERIC PROCESS FOR IMPROVING SUPPLY CHAIN PERFORMANCE:

4.1 A Synopsis of the Proposed Generic Process:

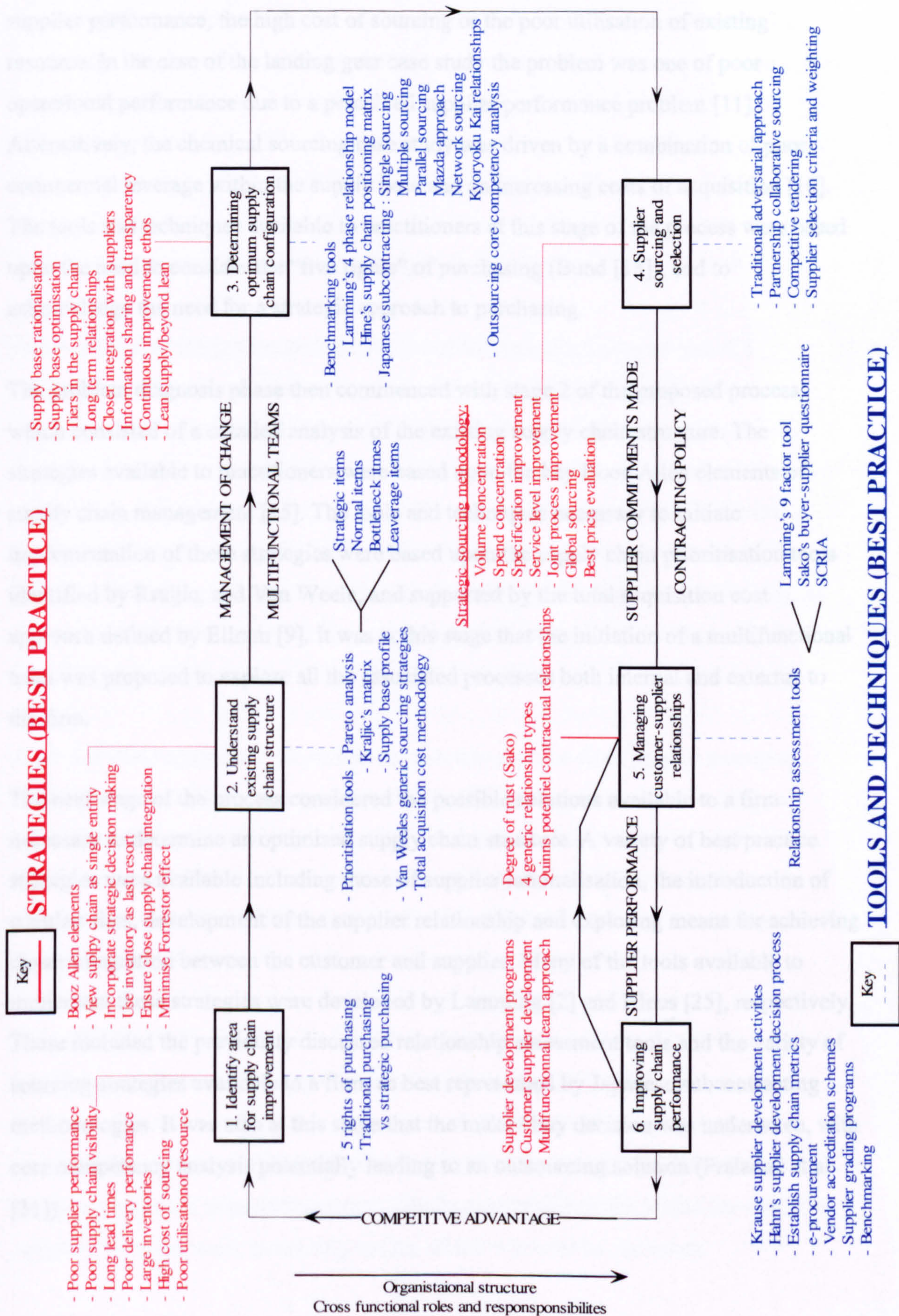
The literature review undertaken in portfolio submission 1 was critically important for this research programme [5]. Structuring the broad field of supply chain management resulted in the conception of a proposed process driven model for improvement. The earliest conception of this model was illustrated in Figure 3. This approach was then adopted throughout each of the case studies following which further development and refinement of the model was undertaken. The objective of the research was to present a model which practitioners could use in their own businesses with a reasonable degree of success.

Portfolio submission 1 concluded by incorporating all of the available best practice tools and techniques into the high level “road map” presented in Figure 3 [5]. An additional stage of the process was incorporated to reflect the need to “identify the area for supply chain improvement” prior to commencing any analysis. The findings from portfolio submission 1 [5] served as a concise summary of best practice whilst at the same time indicating a proposed sequence of events for their application to specific situations. Figure 6 illustrates this model as it was conceived in portfolio submission 1.

This model proposed six key processes necessary to improve supply chain performance. At each stage of the process two separate aids were made available to practitioners. The first consisted of a summary of supply chain strategies available to a firm which were representative of best practice. The second aid consisted of the available tools and techniques that could be applied to implement those strategies at each stage of the process (See Figure 6).

For example, the first stage of the proposed process required the identification of an area in need of improvement. This could be due to any number of reasons, including poor

Figure 6: A Proposed Process for Improving Supply Chain Performance:



supplier performance, the high cost of sourcing or the poor utilisation of existing resource. In the case of the landing gear case study the problem was one of poor operational performance due to a perceived supplier performance problem [11]. Alternatively, the chemical sourcing case study was driven by a combination of poor commercial leverage within the supply base and an increasing costs of acquisition [10]. The tools and techniques available to practitioners at this stage of the process were based upon the need to consider the “five rights” of purchasing (Bund [18]), and to acknowledge the need for a strategic approach to purchasing.

The problem diagnosis phase then commenced with stage 2 of the proposed process, which consisted of a detailed analysis of the existing supply chain structure. The strategies available to practitioners were based upon the key Booz Allen elements of supply chain management [15]. The tools and techniques necessary to initiate implementation of these strategies were based upon the supply chain prioritisation tools identified by Kraljic, and Van Weele, and supported by the total acquisition cost approach defined by Ellram [9]. It was at this stage that the initiation of a multifunctional team was proposed to explore all the associated processes both internal and external to the firm.

The next stage of the process considered the possible solutions available to a firm necessary to determine an optimised supply chain structure. A variety of best practice strategies were available including those of supplier rationalisation, the introduction of supplier tiers, development of the supplier relationship and exploring means for achieving closer integration between the customer and supplier. Many of the tools available to implement these strategies were developed by Lamming [2] and Hines [25], respectively. These included the previously discussed relationship assessment tools and the variety of sourcing strategies available to a firm, as best represented by Japanese subcontracting methodologies. It was also at this stage that the make / buy decision was undertaken, with core competency analysis potentially leading to an outsourcing solution (Praladad et al [31]).

Once the proposed approach had been determined and agreed by the multifunctional team, stage 4 of the process concentrated upon the actual supplier sourcing and selection activity. A variety of strategic sourcing strategies were identified at this stage [29]. Furthermore, the tools available to practitioners included a variety of approaches to competitive tendering, and the adoption of best practice supplier selection criteria (Dickson [32]). It was at this stage that a formal supplier commitment was made, in accordance with a firm's contracting policy.

Stages 5 and 6 of the proposed model at its earliest conception formed part of a continuous feedback loop. These stages were further developed following the lessons learnt from the case studies ([10] and [11]), as described later. The management and development of customer supplier relationships could contribute to an improved level of performance. A key strategy at this stage of the process was the need to determine an appropriate contractual relationship specific to the commodity being sourced (Quinn et al [36]). An awareness of Sako's classification of trust was also important at this stage of the process [26]. Once again the previously described relationship assessment tools were available to practitioners.

Stage 6 of the process concentrated on the possible supplier development strategies available to a firm. Tools such as Krause's supplier development activities [48] and Hahn's supplier development process [42] provided significant scope for improving supply chain performance. These combined with the more traditional supplier accreditation and grading schemes, were identified as fundamental to measuring actual supply chain performance.

The underlying objective of the originally conceived process illustrated in Figure 6, was to achieve competitive advantage through the elimination of inefficient supply chain processes. It is now clear that this proposed model represented a supply chain transformation process driven by the requirement for change, and enabled by a cross functional approach to problem solving. Application of this model within the case study company provided some interesting results, which will now be discussed.

4.2 Validation and Refinement of the Generic Process:

Application of the proposed process model to a number of MRO supply chains was necessary in order to validate its ability to deliver improvements in performance. Further development and refinement of this model was therefore dependent upon its ability to address each of the learning points arising from the case studies. Discussion will now focus upon incorporation of these learning points into the final recommended model.

The cabin refurbishment case study provided a useful illustration of the relative immaturity of the case study company with respect to change and contract management [8]. This case study highlighted the difficulties of managing cross-functional teams in a company that was traditionally functionally structured. A lack of top management appreciation and support for this approach meant that there was often a conflict between the Engineering and Marketing departments. A good example of this was the Marketing department's neglect of involving the Engineering department when communicating specification changes to the supplier. This would result in product changes being implemented without the technical implications being fully evaluated. This provided an opportunity for the supplier to incorporate delays into the programme and impose additional cost increases.

The adoption of cross-functional teams helped to increase the level of integration between these departments during the course of the project. However, a lack of top management support meant that both parties were unsure regarding their overall accountability and authority to take decisions. This was compounded by a lack of management empowerment at the highest level. For example, selection of a seat cover fabric could only be made by the Chairman. This made it increasingly difficult to obtain timely decisions necessary to support the project's demanding timescales.

These internal problems were magnified during the interactions between the case study company and its prime contractor. A traditional adversarial relationship was found to prevail where there was an inherent lack of trust between the parties. There was a

reluctance on behalf of the supplier to share information regarding its own internal operations. This resulted in a lack of transparency between both companies planning processes creating significant problems downstream, and allowing the presence of the Forrester effect to flourish [16]. The lack of a single point of contact between each organisation made managing these problems more difficult.

The key learning points from this case study therefore suggested the need to achieve a closer level of integration (both internally and externally) by involving all parties early within the sourcing process [8]. By gaining an understanding of each other's requirements and internal operations an environment in which greater sharing of information and improved transparency of the planning process would result. Furthermore, the benefits of a cross-functional approach would not be fully realised without top management support of the process. Effective communication through the change programme would be essential to enable each of these aspects. Finally, dispute resolution was found to be best addressed through development of a closer working relationship, as opposed to using the contract as a means of arguing a point.

The generic process proposed in Figure 6 addresses a number of these learning points by ensuring a formal approach was adopted. This approach dictates the need to investigate the existing supply chain processes both internal and external to a firm from the outset. This cannot be satisfactorily accomplished without involving the supplier early in the process and adopting a cross-functional approach. The remaining learning points emerging from the cabin refurbishment case study suggested the need for a detailed supply chain integration process. This was addressed by incorporating the lessons learnt from the chemicals and landing gear case studies, respectively (see later).

The model illustrated in Figure 6 was applied to both the landing gear and chemical case studies, respectively ([11] and [10]). The operational and financial benefits that were achieved in each case study were testimony to the overall process adopted. However, each case study provided a further insight into the proposed process, and resulted in further development and refinement of the model.

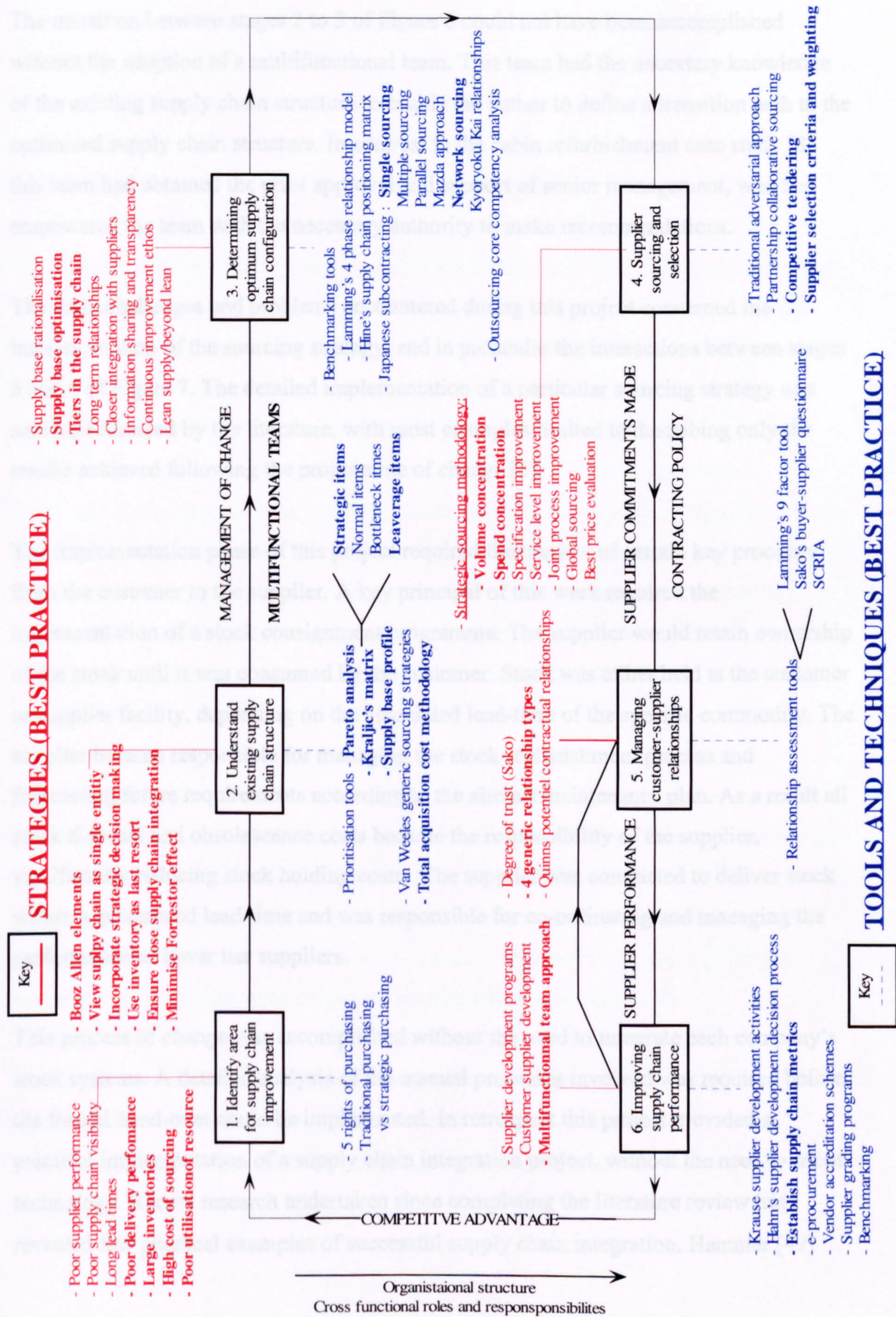
Application of the proposed process within the chemical sourcing case study concluded with the implementation of a single sourcing strategy, through the introduction of supplier tiers. Figure 7 highlights the specific tools and strategies adopted within this case study. The success in implementing this optimised supply chain was based upon the following factors, each of which were satisfactorily addressed by the model:

- a) It was dependent upon a strategic approach to supply chain management
- b) It was dependent upon viewing the supply chain as a single entity
- c) It required the adoption of multi-functional teams both prior to and during implementation
- d) The final solution was reliant upon the transfer of best practice from one industry sector to another.
- e) Constant and effective communication was critical throughout the change programme.

The process adopted immediately introduced a strategic approach to problem solving. By standing back prior to rushing to any solutions and investigating the existing supply chain structure, the strategic objectives of the project could be determined. These were significantly influenced by adopting the key Booz Allen elements [15]. Viewing the supply chain as a single entity identified the need to rationalise the supply chain structure. The need to use inventories as a last resort had considerable bearing on the final stock consignment solution. Finally, the need to minimise the Forrester effect demanded a solution that would improve the level of integration within the supply chain. This resulted in the transfer of certain stock replenishment processes from the customer to the supplier.

Design of the optimised supply chain was dependent on the transfer of best practice knowledge. Restructuring the chemical supply chain into a number of tiers resulted in supplier management activities cascading throughout the chain. This had the effect of maximising the effectiveness of the limited purchasing resource of the case study company.

Figure 7: Tools and Techniques adopted in the Chemicals Sourcing Case Study:



The transition between stages 2 to 3 of Figure 6 could not have been accomplished without the adoption of a multifunctional team. This team had the necessary knowledge of the existing supply chain structure to enable the author to define a transition path to the optimised supply chain structure. In contrast to the cabin refurbishment case study [8] this team had obtained the prior approval and support of senior management, who had empowered the team with the necessary authority to make recommendations.

The main challenges and problems encountered during this project concerned the implementation of the sourcing strategy, and in particular the interactions between stages 5 and 6 of Figure 7. The detailed implementation of a particular sourcing strategy was seldom addressed by the literature, with most examples limited to describing only the results achieved following the programme of change [5].

The implementation phase of this project required the transfer of certain key processes from the customer to the supplier. A key principal of this work required the implementation of a stock consignment programme. The supplier would retain ownership of the stock until it was consumed by the customer. Stock was either held at the customer or supplier facility, depending on the associated lead-time of the specific commodity. The supplier became responsible for managing the stock replenishment process and forecasting future requirements according to the aircraft maintenance plan. As a result all stock disposal and obsolescence costs became the responsibility of the supplier, significantly reducing stock holding costs. The supplier was contracted to deliver stock within a guaranteed lead-time and was responsible for co-ordinating and managing the performance of lower tier suppliers.

This process of change was accomplished without the need to integrate each company's stock systems. A detailed analysis of the manual processes involved was required before the formal hand-over could be implemented. In retrospect this project provided a practical implementation of a supply chain integration project, without the need to adopt technology. Recent research undertaken since completing the literature review has revealed few practical examples of successful supply chain integration. Hammer [49]

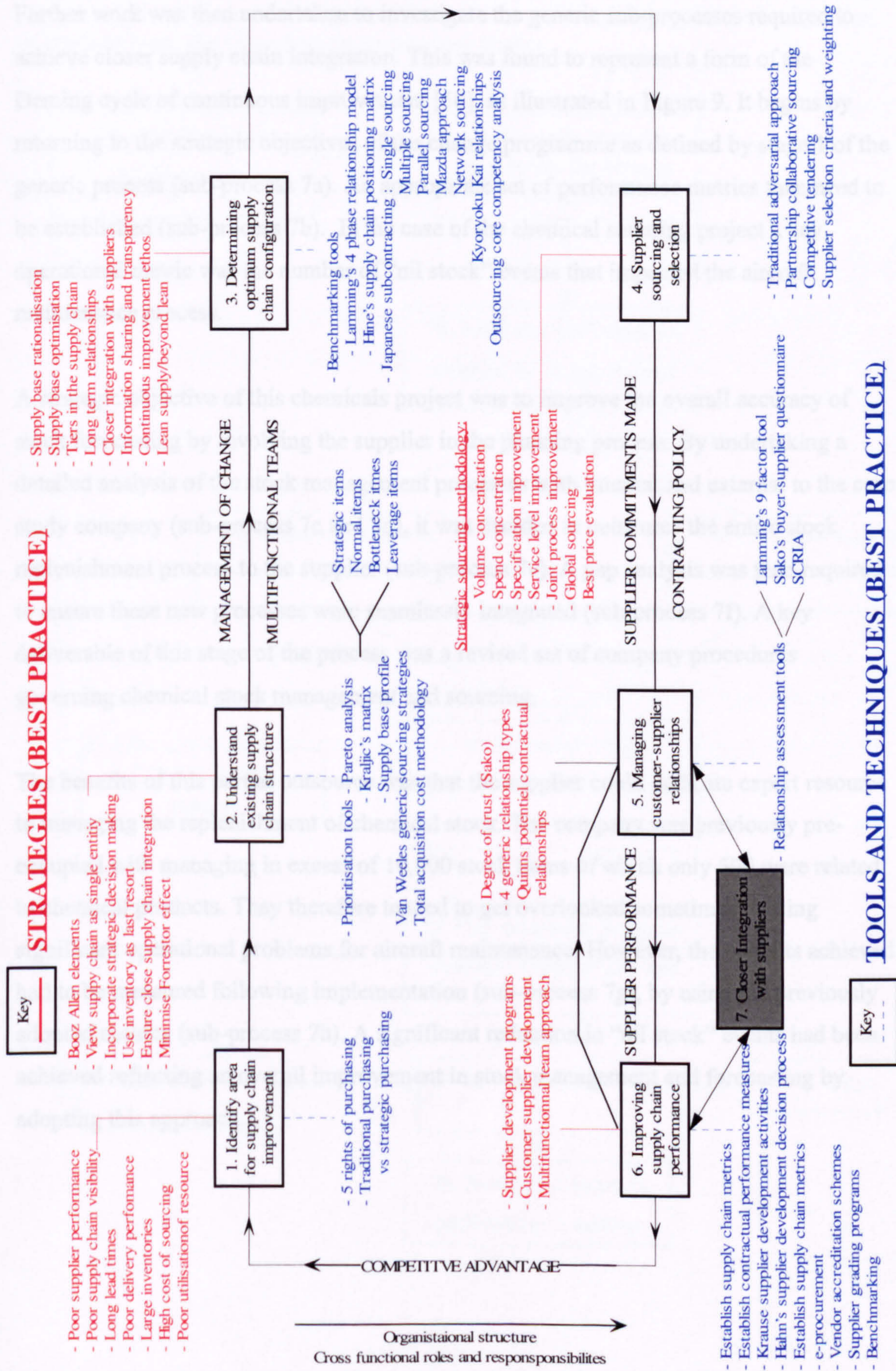
found that whilst the concept of supply chain integration was not new, companies have had trouble making it a reality. *“In most cases that is because they are viewed as merely a technological challenge rather than what it really is; a process management challenge”* (Hammer [49]).

A key learning point from the chemical sourcing work was therefore the need to breakdown the supplier integration phase between stages 5 and 6 of the proposed model. This was done by incorporating stage 7 to the overall process, and labelling it “closer integration with suppliers” (see Figure 8). This then formed part of an iterative process between stages 5 and 6, respectively. This was closely connected with managing the customer-supplier relationship as illustrated by the case study. There was a need to involve each of the company’s existing suppliers early in the sourcing process. Restructuring the supply chain into tiers would result in many previous suppliers losing their direct relationship with the company. Whilst the company would remain a source of business for these suppliers, distancing the relationship in this manner was clearly an area of concern for both organisations. A key aspect of supplier integration was therefore based on the need to ensure constant and effective communication during the sourcing process.

This was further illustrated when one supplier attempted to derail the entire process by refusing to supply through the chosen single source. The whole programme was brought into question when this particular supplier attempted to offer significantly lower prices in a bid to maintain a direct supply. It was only by effectively communicating the total acquisition cost approach embedded in the solution from the early stages of the process, that senior management were persuaded to continue with the approach.

This learning point was addressed by incorporation of stage 7 in Figure 8. It was therefore implied that following supplier selection, the customer would have to concentrate on development of the resulting relationship in order to encourage closer integration.

Figure 8: Development of the Generic Process following its Application to the Chemicals Sourcing case study:

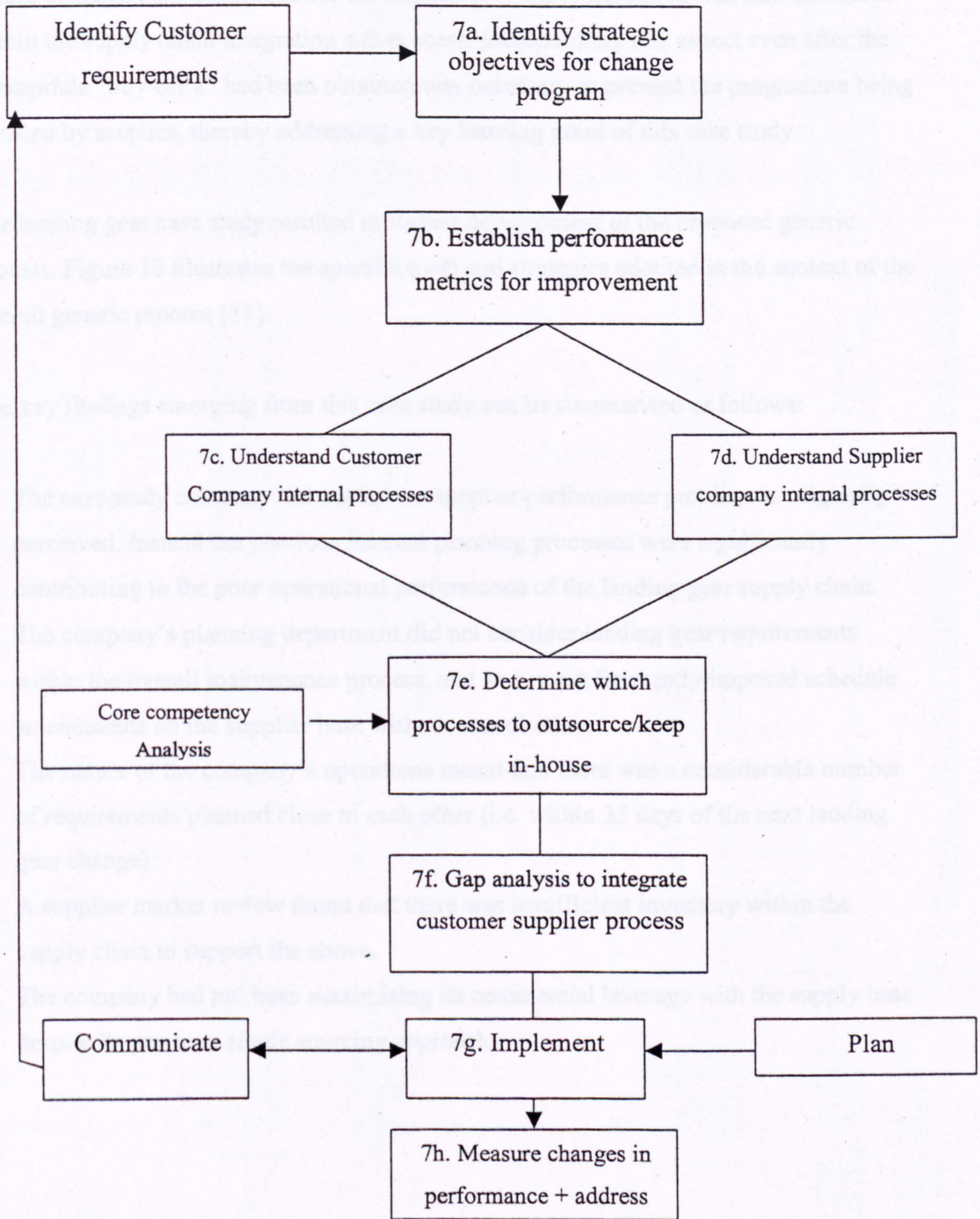


Further work was then undertaken to investigate the generic sub-processes required to achieve closer supply chain integration. This was found to represent a form of the Deming cycle of continuous improvement [50], as illustrated in Figure 9. It begins by returning to the strategic objectives of the change programme as defined by stage 1 of the generic process (sub-process 7a). An appropriate set of performance metrics then need to be established (sub-process 7b). In the case of the chemical sourcing project a key operational metric was the number of “nil stock” events that impacted the aircraft maintenance process.

A strategic objective of this chemicals project was to improve the overall accuracy of stock forecasting by involving the supplier in the planning process. By undertaking a detailed analysis of the stock management processes both internal and external to the case study company (sub-process 7c and 7d), it was decided to outsource the entire stock replenishment process to the supplier (sub-process 7e). A gap analysis was then required to ensure these new processes were seamlessly integrated (sub-process 7f). A key deliverable of this stage of the process was a revised set of company procedures governing chemical stock management and sourcing.

The benefits of this partial outsource was that the supplier could dedicate expert resource to managing the replenishment of chemical stock. The company was previously pre-occupied with managing in excess of 10,000 stock items of which only 500 were related to chemical products. They therefore tended to get overlooked sometimes causing significant operational problems for aircraft maintenance. However, the benefits achieved had to be measured following implementation (sub-process 7g), by using the previously adopted metrics (sub-process 7h). A significant reduction in “nil stock” events had been achieved reflecting an overall improvement in stock management and forecasting by adopting this approach.

Figure 9: The proposed Sub-Process for achieving closer Supply Chain Integration as derived from the Chemical Sourcing case study:



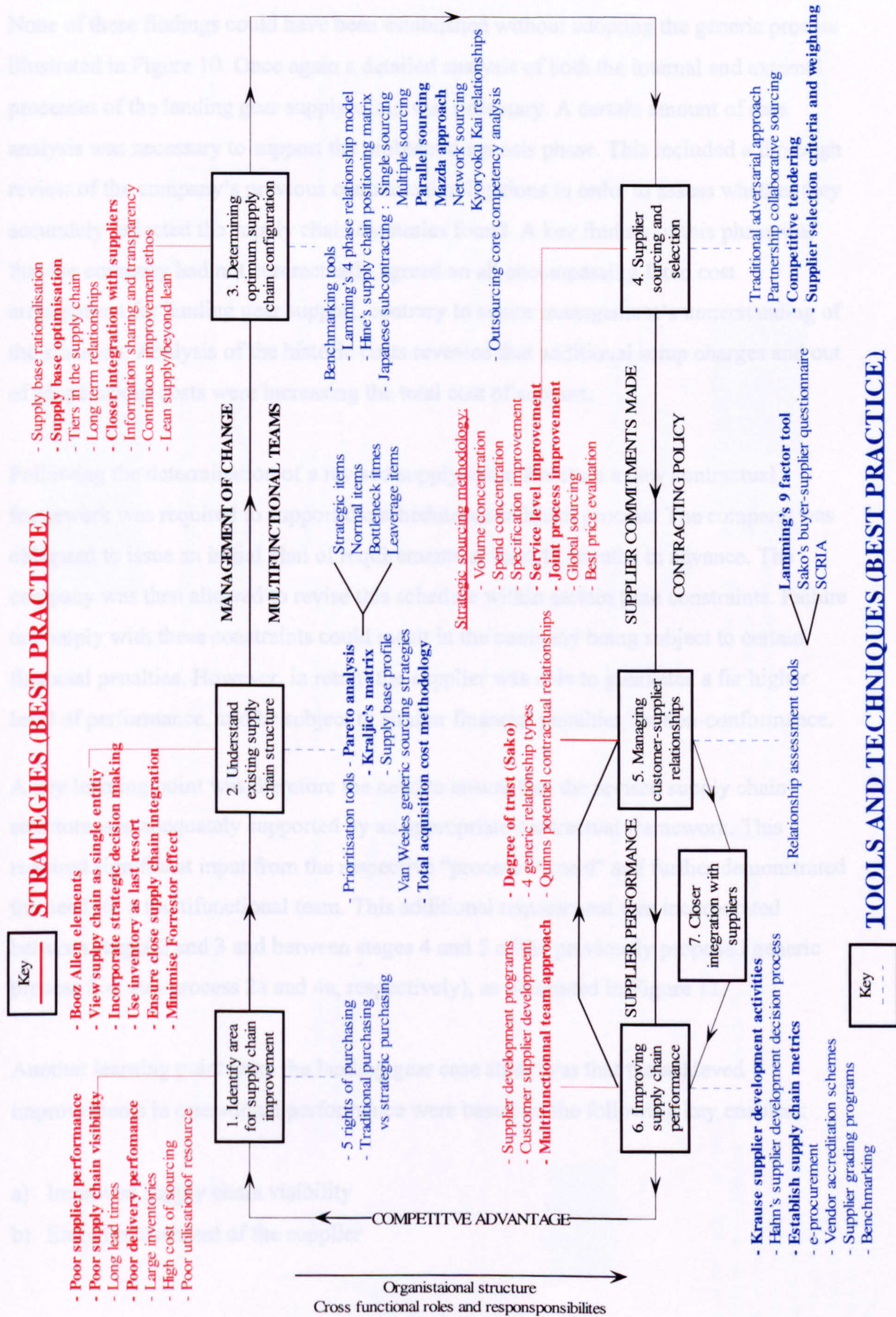
The nature of this continuous improvement process was that it was iterative, with each cycle delivering incremental improvements in performance (Deming [50]). The need to ensure constant communication for the reasons previously described was also addressed within the supply chain integration sub-process. Incorporating this aspect even after the appropriate “buy-off’s” had been obtained was necessary to prevent the programme being derailed by sceptics, thereby addressing a key learning point of this case study.

The landing gear case study resulted in further development of the proposed generic process. Figure 10 illustrates the specific tools and strategies adopted in the context of the overall generic process [11].

The key findings emerging from this case study can be summarised as follows:

1. The case study company did not have a supplier performance problem as originally perceived. Instead the previous internal planning processes were significantly contributing to the poor operational performance of the landing gear supply chain.
2. The company’s planning department did not consider landing gear requirements within the overall maintenance process, and as a result frequently imposed schedule amendments on the supplier base without consultation.
3. The nature of the company’s operations meant that there was a considerable number of requirements planned close to each other (i.e. within 35 days of the next landing gear change).
4. A supplier market review found that there was insufficient inventory within the supply chain to support the above.
5. The company had not been maximising its commercial leverage with the supply base despite its previous single sourcing approach

Figure 10: The Tools and Techniques applied during the Landing Gear case study:



None of these findings could have been established without adopting the generic process illustrated in Figure 10. Once again a detailed analysis of both the internal and external processes of the landing gear supply chain was necessary. A certain amount of data analysis was necessary to support the problem diagnosis phase. This included a thorough review of the company's previous contractual obligations in order to assess whether they accurately reflected the supply chain dynamics found. A key finding of this phase was that the company had not contractually agreed an all encompassing fixed cost arrangement for landing gear support, contrary to senior management's understanding of the situation. Analysis of the historic costs revealed that additional scrap charges and out of scope labour costs were increasing the total cost of support.

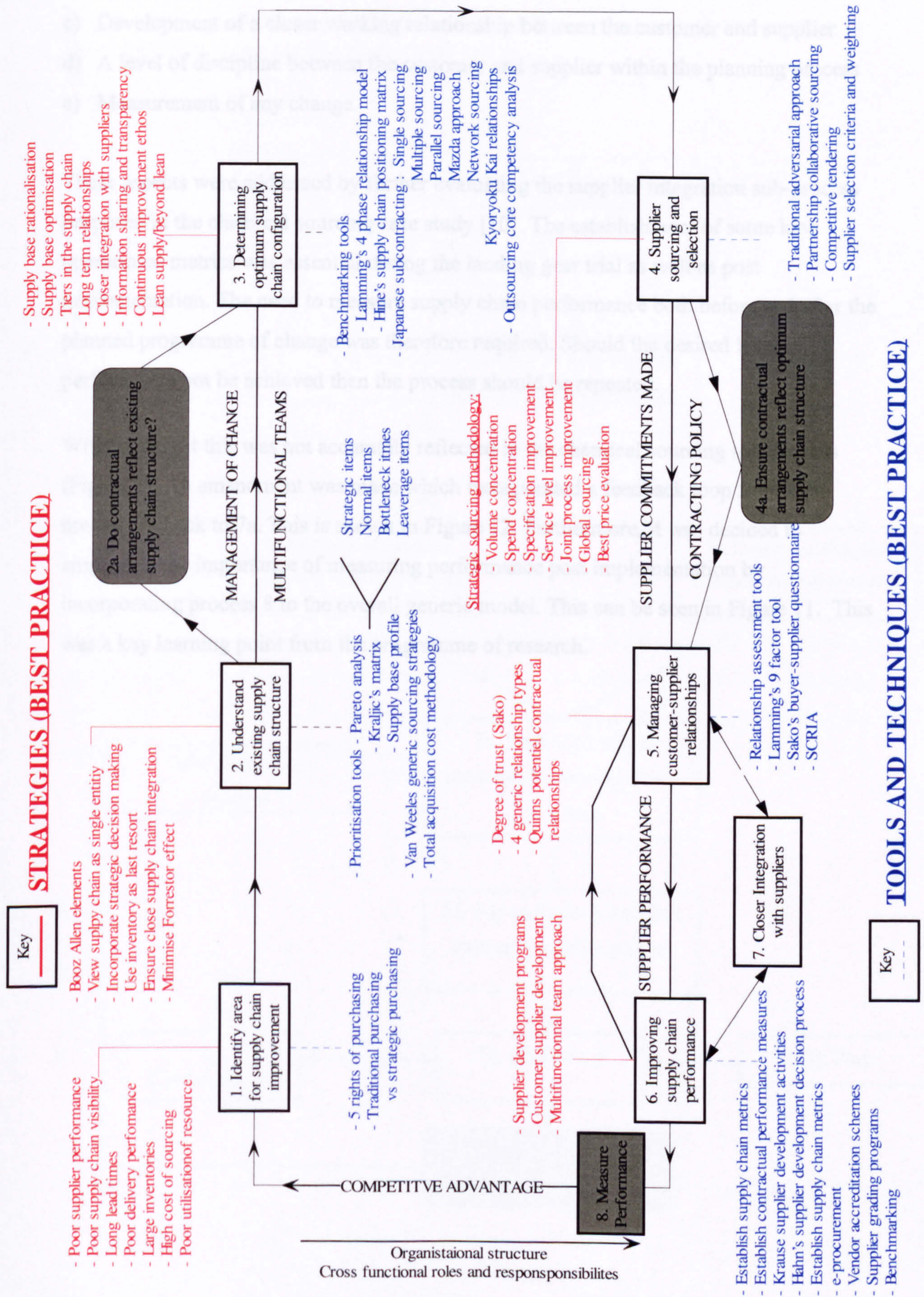
Following the determination of a revised supply chain structure a new contractual framework was required to support the schedule amendment process. The company was obligated to issue an initial plan of requirements at least 12 months in advance. The company was then allowed to revise this schedule within certain time constraints. Failure to comply with these constraints could result in the company being subject to certain financial penalties. However, in return the supplier was able to guarantee a far higher level of performance, and be subject to similar financial penalties for non-conformance.

A key learning point was therefore the need to ensure that the revised supply chain structure was adequately supported by an appropriate contractual framework. This required significant input from the respective "process owners" and further demonstrated the need for a multifunctional team. This additional requirement was incorporated between stages 2 and 3 and between stages 4 and 5 of the previously proposed generic process (i.e. sub-process 2a and 4a, respectively), as illustrated in Figure 11.

Another learning point from the landing gear case study was that the achieved improvements in operational performance were based on the following key enablers:

- a) Improved supply chain visibility
- b) Early involvement of the supplier

Figure 11: Further Development of the Generic Process following its Application to the Landing Gear case study:



- c) Development of a closer working relationship between the customer and supplier
- d) A level of discipline between the customer and supplier within the planning process
- e) Measurement of any change.

These aspects were addressed by further evaluating the supplier integration sub-process proposed in the chemical sourcing case study [10]. The establishment of some key operational metrics was essential during the landing gear trial as well as post implementation. The need to measure supply chain performance both before and after the planned programme of change was therefore required. Should the desired level of performance not be achieved then the process should be repeated.

With hindsight this was not accurately reflected in the chemical sourcing sub-process (Figure 9). An amendment was made which incorporated a feedback loop from sub-process 7h back to 7a. This is shown in Figure 12. Furthermore, it was decided to emphasise the importance of measuring performance post implementation by incorporating process 8 to the overall generic model. This can be seen in Figure 11. This was a key learning point from the programme of research.

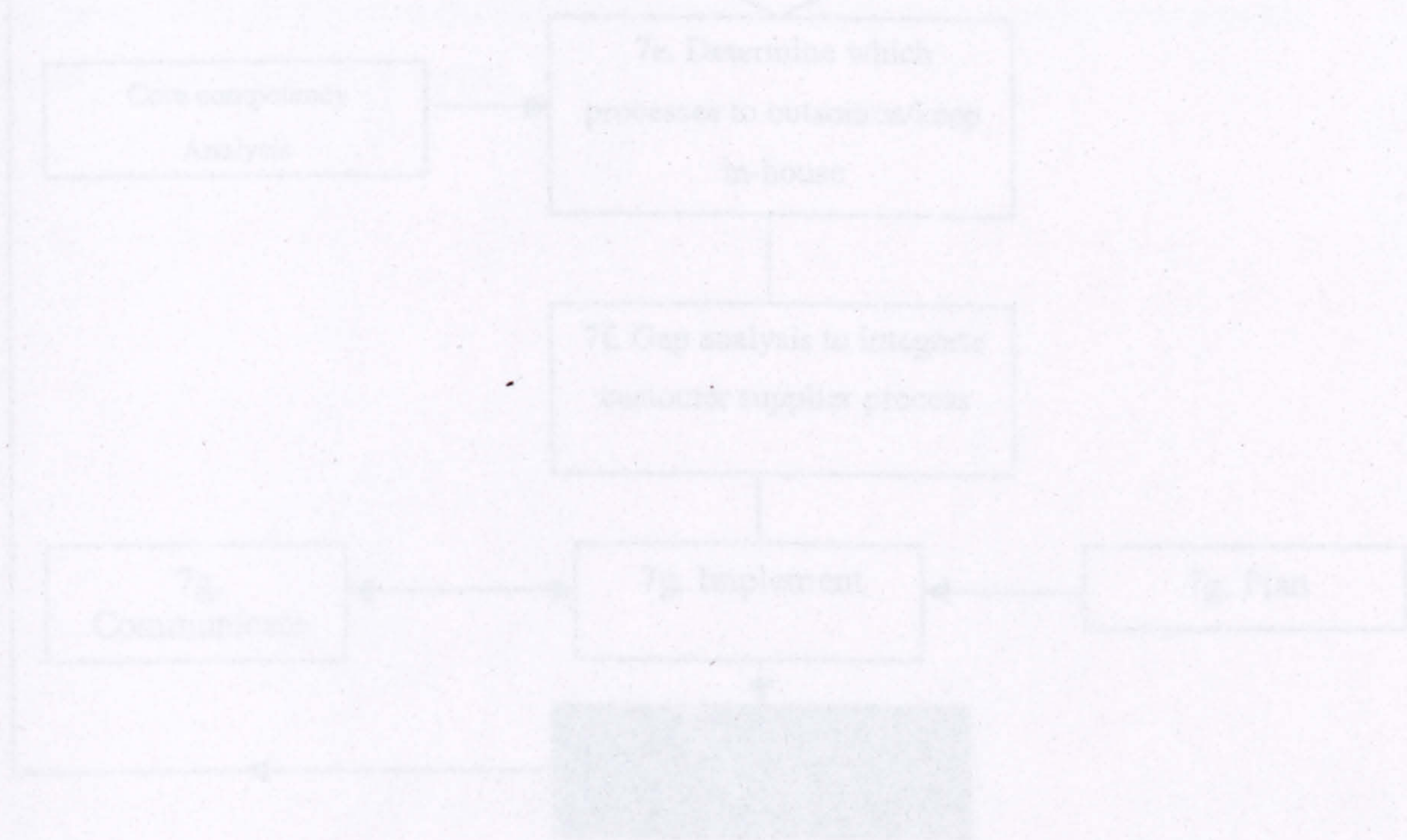
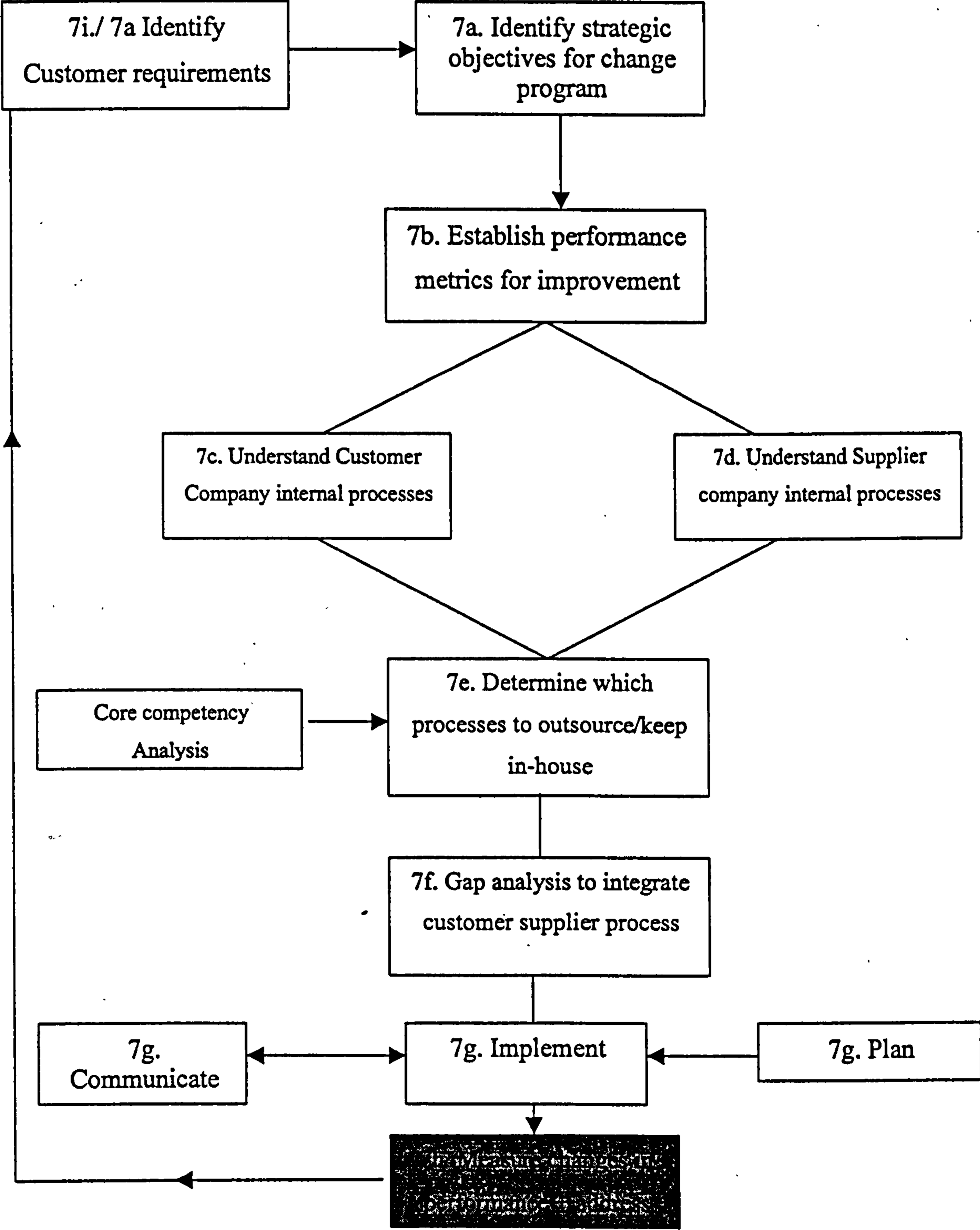


Figure 12: Further Development of the Supplier Integration Sub-Process following its Application to the Landing Gear case study.

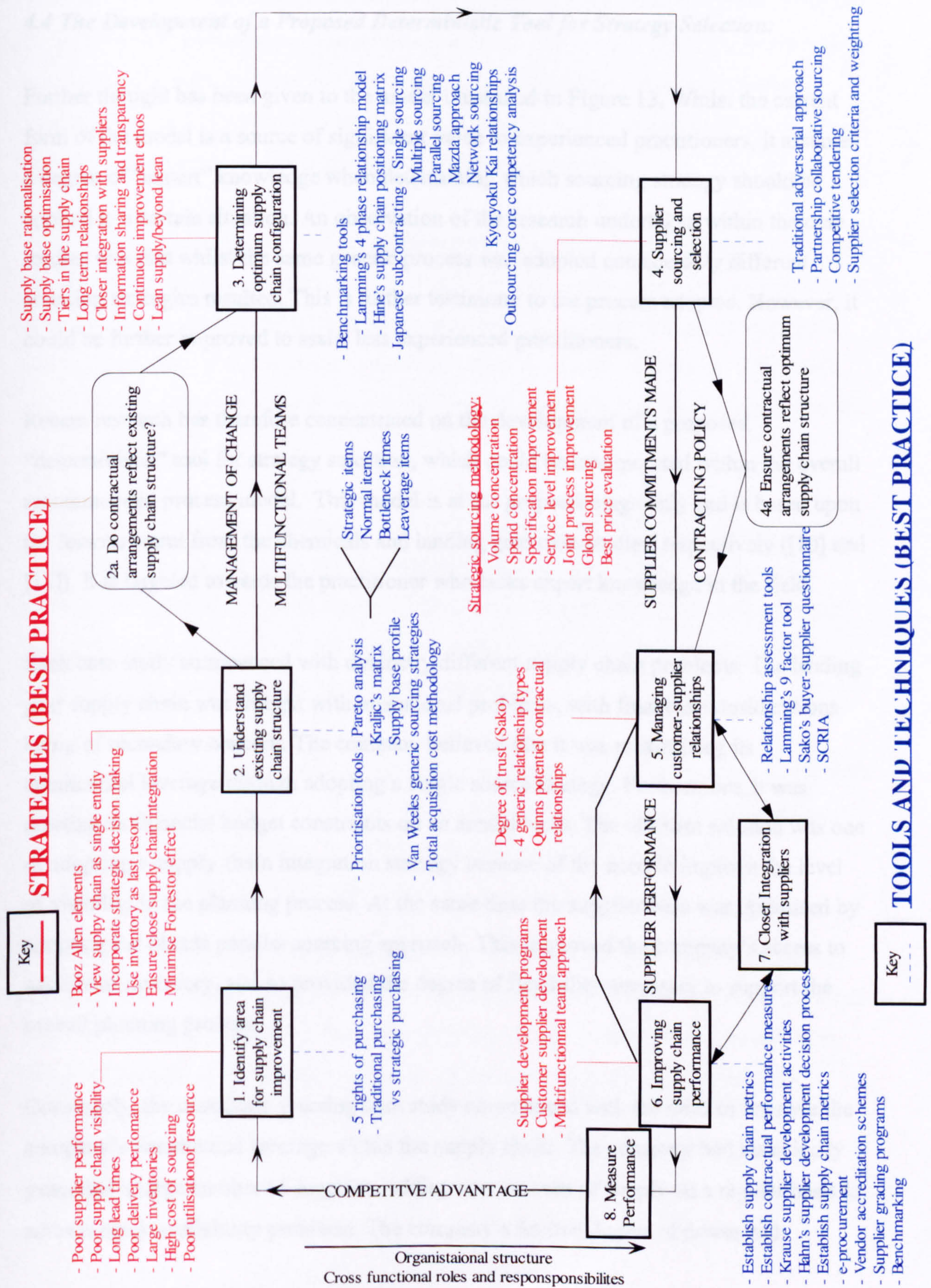


4.3 The Recommended Generic Process for Improving Supply Chain Performance:

The case studies served to further validate and develop the model conceived in portfolio submission 1 [5]. The core process of the model was amended to take into account the need to develop an appropriate contractual framework, and to measure the performance of the supply chain following the change. However, in the main these case studies provided further validation that the model could deliver significant operational and financial benefits. In retrospect it was apparent that this model provided practitioners with a generic process for transforming supply chains, by incorporating the key aspects of best practice. The relevance of supply chain management to the airline service sector has also been demonstrated by the operational and financial benefits achieved. The final recommended generic process can be found in Figure 13.

Finally, this research has demonstrated that application of the generic process will result in a sourcing recommendation that is specific to the supply chain problem being investigated. For example, during the chemicals sourcing case study a single sourcing strategy evolved from a multi-source situation. Conversely, in the landing gear case study a dual source strategy (specifically parallel sourcing) has evolved from a single sourcing arrangement. Both strategies represent best practice in supply chain management specific to the commodity being investigated.

Figure 13: A Generic Transformation Process for Improving Supply Chain Performance:



4.4 The Development of a Proposed Deterministic Tool for Strategy Selection:

Further thought has been given to the model illustrated in Figure 13. Whilst the current form of the model is a source of significant value to experienced practitioners, it assumes a degree of “expert” knowledge when determining which sourcing strategy should be applied to a certain situation. An observation of the research undertaken within the case studies was that whilst the same generic process was adopted considerably different sourcing strategies resulted. This is further testimony to the process adopted. However, it could be further improved to assist less experienced practitioners.

Recent research has therefore concentrated on the development of a proposed “deterministic” tool for strategy selection, which could be incorporated within the overall recommended process model. This model is at the proposal stage only and is based upon the lessons learnt from the chemicals and landing gear case studies, respectively ([10] and [11]). It is targeted towards the practitioner who lacks expert knowledge in the field.

Each case study commenced with distinctly different supply chain problems. The landing gear supply chain was fraught with operational problems, with financial considerations being of secondary concern. The company believed that it was maximising its commercial leverage through adopting a single source strategy. Furthermore, it was meeting its financial budget constraints on an annual basis. The ultimate solution was one of adopting a supply chain integration strategy because of the need to improve the level of visibility in the planning process. At the same time the supplier base was optimised by adopting the Mazda parallel sourcing approach. This improved the company’s access to additional inventory, and so provided the degree of flexibility necessary to support the overall planning process.

Conversely, the chemicals sourcing case study commenced with the need to improve the company’s commercial leverage within the supply chain. The company had historically generated a large number of suppliers, adding new sources of supply on a regular basis to address stock availability problems. The company’s limited degree of power and

influence in this commodity group, meant that they were unsuccessful in getting suppliers to improve their performance. The proposed solution was one of selecting a single source supplier and introducing tiers into the supply chain. This supply base optimisation strategy resulted in the company maximising its commercial leverage, which in turn increased the pressure on the single source supplier to perform.

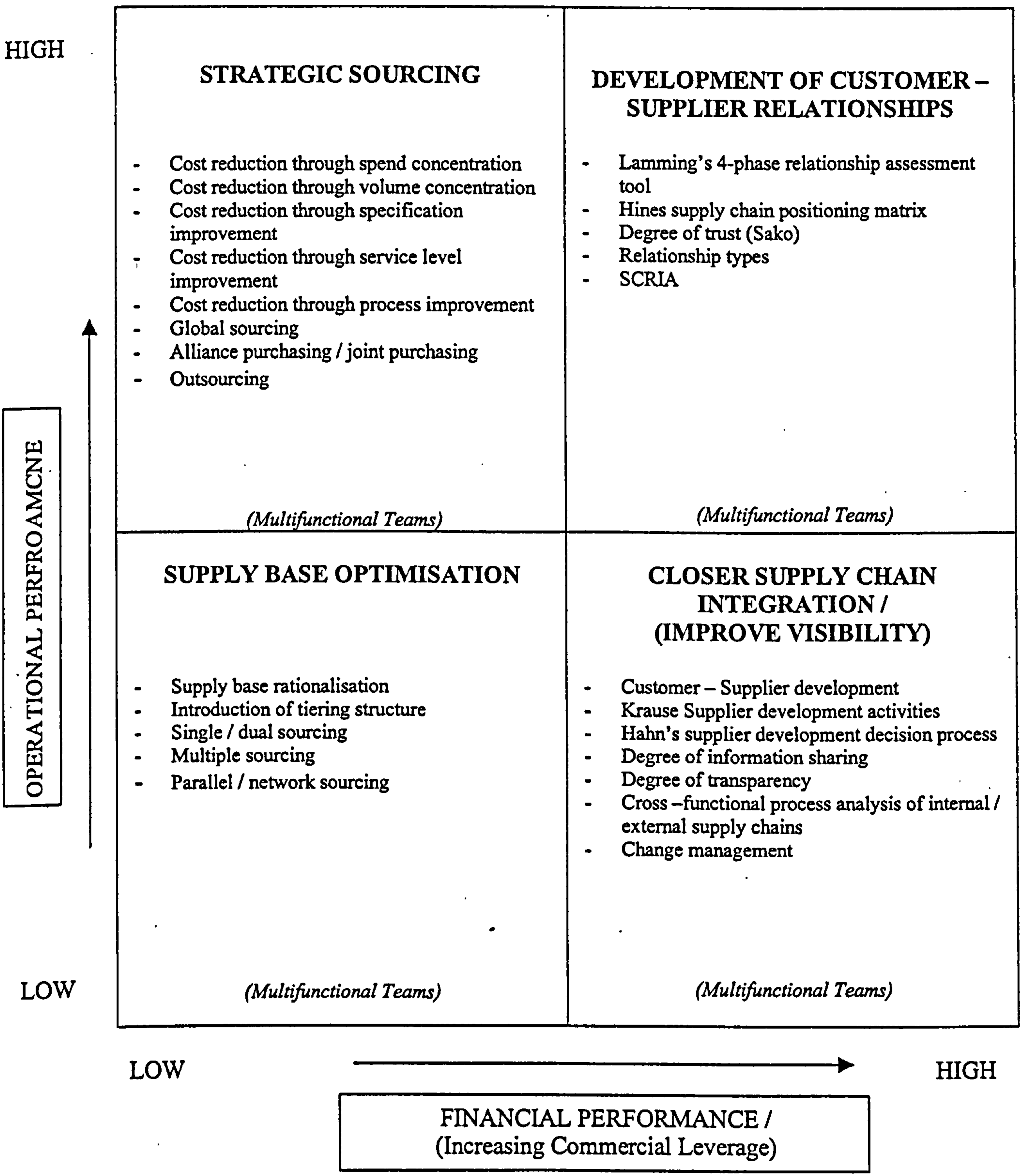
It is proposed that there was a relationship between the supply chain strategy adopted and the resulting influence on both operational and financial performance. This relationship is presented in Figure 14, which illustrates a proposed deterministic tool for supply chain strategy selection. If the relationship holds true then this model will pin point the most appropriate sourcing strategy given a firms current operational and financial attributes for a specific supply chain.

For a given supply chain commodity, this model suggests that if the operational performance is less than optimal (i.e. tends towards low) but commercial leverage is close to the optimum (i.e. tends towards high), then a “supply chain integration strategy” should be implemented (i.e. the landing gear supply chain). Each of the best practice tools and techniques available are listed for reference.

Secondly, for a given supply chain commodity, if the operational performance is less than optimal (i.e. tends towards low) and the inherent commercial leverage is less than optimal (i.e. tends towards low), then a “supply base optimisation strategy” should be implemented (i.e. the chemicals case study).

Thirdly, for a given supply chain commodity, if the operational performance is close to the optimum (i.e. tends towards high), but the commercial leverage is less than optimised (i.e. tends towards low), then a “strategic sourcing strategy” should be employed, with the available strategies listed for reference. These in the main are targeted towards improving financial performance.

Figure 14: A Proposed Deterministic Tool for Supply Chain Strategy Selection:



Finally, for a given supply chain, if both the operational performance and commercial leverage are close to the optimum, further “development of the customer supplier relationship” is necessary to maintain an ethos of continuous improvement. This can be achieved by adopting one or more of the available supplier development strategies.

In each quadrant the need for a cross-functional approach to problem solving has been highlighted through the adoption of multifunctional teams. However, it must be stressed that this is not necessarily the panacea for all supply chain problems. The extent to which they are adopted should be governed by the complexity of the task to be undertaken utilising the concept of “runners”, “repeaters” and “strangers” [23].

The model proposed above requires further validation through the application of a variety of sourcing scenarios. Both of the case studies supported this model. It is important to note that this model prioritises the strategy that should be addressed first. As with any Deming cycle [50] application of the model is an iterative process. For example, in the case of the landing gear case study, now that both operational performance and financial performance have been improved, the model indicates that further development of the supplier relationship is necessary to maintain a degree of improvement.

It is proposed that this tool once validated should be incorporated into the generic process as recommended by this research (see Figure 13). This would assist practitioners between stages 2 and 3 of the overall process (i.e. analysis of the existing supply chain and determination of an optimised supply chain structure). It also compliments Kraljic’s matrix [21] by suggesting which supply chain strategy should be adopted to improve the performance of a given sourcing category (i.e. regardless of whether the commodity is a leverage item, strategic item, normal item or bottleneck item, as defined by Kraljic). Further research should be undertaken to explore the specific relationship of this tool with Kraljic’s matrix. It is anticipated that the deterministic tool would sit beneath Kraljic’s matrix since it is not dependent upon the specific sourcing category being investigated. However, the relative weightings that define low and high performance may have a specific relationship with the Kraljic [21] commodity being investigated.

5.0 SUMMARY OF BENEFITS AND INNOVATION:

5.1 Benefits to the Case Study Company:

This programme of research has made a significant contribution to the performance of the case study company. The resulting improvements can be discussed in the context of those benefits achieved following the case study implementations, and those potential benefits attainable through the application of a generic process to other company supply chains.

Significant operational and financial benefits were delivered from each of the case studies. Portfolio submission 5 [8] resulted in the successful implementation of a new cabin interior product across the case study company's fleet of aircraft. This case study served to illustrate the suspected degree of immaturity within the company with respect to programme management and contract management, which was further quantified following analysis of the benchmarking survey [7]. This case study established the need for the adoption of cross-functional teams, which was a new approach for the company [8]. Whilst this resulted in considerable improvements regarding internal communication (particularly between the Engineering and Marketing departments), it lacked top management appreciation and support. This highlighted the challenges of managing multifunctional teams in an organisation where a traditional functional structure prevailed.

A significant benefit of portfolio submission 5 [8] was that it demonstrated the importance for a firm to look beyond its own functional boundaries and into the supply chain. Whilst the manner in which this was achieved was far from optimal, for the first time senior management became aware of the need to gain a greater understanding of a subcontractors internal processes, and specifically those of capacity planning. The need for the supplier to gain a similar level of understanding of its customers internal operations also became apparent. However, in this particular case study the naivety of both organisations resulted in this approach being interpreted with suspicion. In summary whilst this case study implementation had a significant impact on the company's business, it signified that there were more effective means of implementing such projects.

Implementation of the generic process for improving supply chain performance within the landing gear case study [11], resulted in significant operational and financial benefits. The application of a parallel sourcing technique taken from best practice Japanese subcontracting [25], combined with the closer integration of suppliers within the planning process, resulted in a 60 % improvement in the on-time availability of serviceable landing gears. This was achieved at the same time as reducing the overall cost of acquisition for landing gear support.

The company had previously adopted a single sourcing strategy for landing gear support, where it was assumed they were maximising their commercial leverage. However, the research found that the company had not previously contracted effectively. Interestingly, dual sourcing the requirement through the adoption of the Mazda parallel sourcing approach did not significantly dilute the company's commercial leverage, contrary to previous concerns. In fact a minimum financial saving of \$449,950 (approximately £300,000) was achieved over the contract period, representing a 12.5 % reduction over the cost of the historic supply chain structure.

Further operational and financial benefits were achieved from the chemical sourcing case study [10]. Application of the generic process for improving supply chain performance resulted in closer supply chain integration, with a single source supplier becoming responsible for certain activities on behalf of the case study company. By adopting a total acquisition cost approach representative of best practice (Ellram [9]) the true cost of the historic supply chain structure became apparent. The resulting improvements consisted of a greater degree of commercial leverage, a more efficient supply chain structure which maximised the effectiveness of company's internal purchasing resource, and a streamlined stock management process that improved the materials forecasting process.

This culminated in financial savings of £390,000 being achieved over the first three years following implementation. This represented a 40 % reduction compared with costs associated with the previous supply chain. Furthermore, an additional cash injection of £150,000 was achieved in the first year by undertaking a transfer of existing stock

ownership. Finally, transactional savings of £450,000 were achieved over the three years by reducing the cost of acquisition, and allocating internal resource more effectively.

Both the landing gear and chemical sourcing case studies provided further justification for potential benefits of adopting multifunctional teams ([10] and [11]). In each case the enablers for improvement were not technology or systems based (Hammer [49]), but were driven by the benefits of increased supply chain visibility, a greater degree of customer-supplier integration, and greater co-ordination of capacity planning. It is argued that this could not have been accomplished without the adoption of a cross-functional approach to problem solving. The respective “process experts” and internal customers had to be consulted at each stage of the generic process. As a result the case study company gained a greater appreciation for the need to become more process orientated, at least at the project level.

As well as the benefits achieved through implementation of the case studies, the research has provided considerable scope for the realisation of future supply chain improvements. The generic process conceived, validated and further developed throughout this research provides considerable potential for application to a variety of sourcing scenarios. The proposed deterministic tool illustrated in Figure 14 will assist company representatives in the selection and prioritisation of the most appropriate strategy for a given situation. The implications for this will be further discussed later (see Section 5.4).

5.2 Benefits to the Area of Research:

This programme of research provided a significant contribution to the field of supply chain management, in the context of the airline service sector. Whilst the literature provided numerous examples of tools and techniques originating from the manufacturing sector, it was severely lacking regarding practical examples within the service sector as a whole. Those that were available tended to focus upon the supermarket and retail industries, within companies such as Tesco and Marks and Spencer (Cox [13]). However, each case study found in the literature only described the results achieved through the

implementation of a certain supply chain strategy. The literature seldom described the practical challenges of implementation, neither did it indicate where and how certain strategies and tools should be applied.

In retrospect both the chemical sourcing and landing gear case studies provide a detailed analysis of the challenges and problems encountered through adopting a certain supply chain approach ([10] and [11]). In the main these challenges were driven by the need to manage change effectively, and were magnified by the numerous interactions that occurred both internal and external to the organisation. Both of these case studies provided a practical implementation of how to achieve effective supply chain integration. This is an aspect severely lacking within the literature.

In summary this programme of research demonstrated considerable innovation in the application of knowledge. The specific sources of innovation will now be summarised.

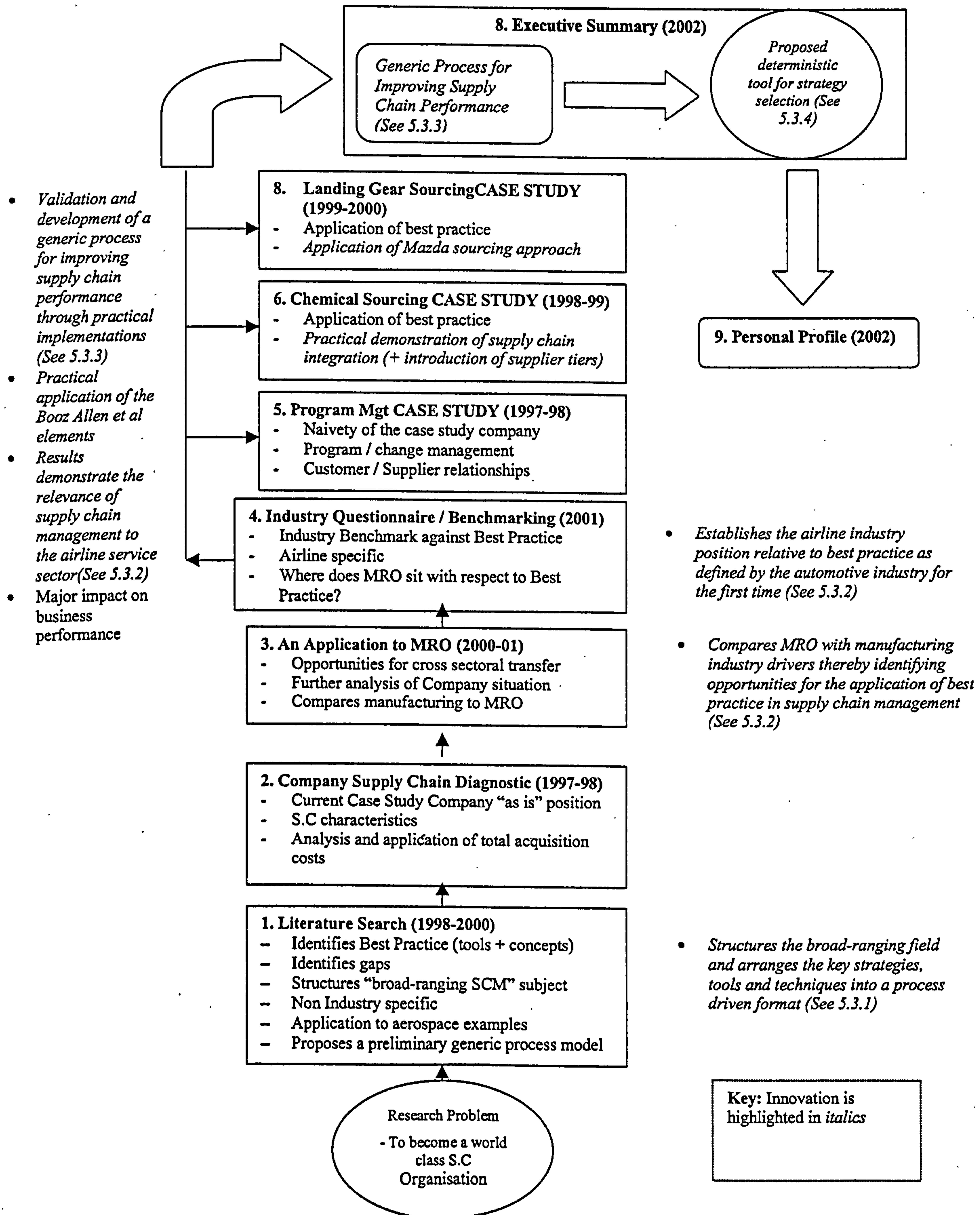
5.3 Summary of the Innovation:

A summary of the innovation resulting from this programme of research can be found in Figure 15. Each aspect of innovation emerging from the respective portfolio submissions has been annotated on Figure 15, and is further discussed in the following sub-sections.

5.3.1 Structuring the field of Supply Chain Management into a Process driven format:

It is suggested that structuring the broad and wide-ranging field of supply chain management into a process driven format provided considerable innovation in the field. This research has proposed a sequence of activities, incorporating best practice in supply chain management that should be undertaken when addressing a specific supply chain problem. Whilst the literature addresses many aspects of best practice in supply chain management, there is no common consensus for structuring the discipline in its entirety, in a way that is useful for the practitioner.

Figure 15: Summary of Innovation emerging from the Portfolio:



This research helps define the boundaries of supply chain management relative to other management disciplines, by incorporating all of the key aspects together in a unified process. In the authors' experience the term supply chain management is commonly misused and wrongly interpreted. The approach adopted will assist academics in communicating the boundaries of the field. In retrospect if a common structure to the field of supply chain management was available at the time of commencing the research, this would have significantly reduced the time taken to undertake the literature review. It should therefore assist both newcomers and practitioners alike to the introduction of this broad ranging subject.

5.3.2 Determining the Relevance of Supply Chain Management to the Airline Industry:

The literature is severely lacking in the application of supply chain management to the airline service sector. This research breaks new ground in the context that it demonstrates the relevance of good practice supply chain management to this industry sector, through a multifaceted approach. Portfolio submission 3 [3] commenced by investigating the characteristics of the MRO sector, and comparing them to those of the automotive manufacturing sector, upon which majority of best practice was derived. The findings of this research further emphasised the need to apply best practice in order to improve supplier performance, reduce cost and increase the level of certainty within the materials supply chain.

For example, prior to commencing this research the airline industry considered itself unique, whereby the potential loss of revenue from grounding an aircraft because of a material shortage, would always out-weigh the cost of acquiring the part. As a result airlines tended to stock-pile significant levels of inventory, and adopt a culture of sourcing at all costs. The findings from portfolio submission 3 suggested that similar excuses could have been adopted by the automotive industry. The potential loss of revenue through stopping the production line due to a material shortage would always exceed the cost of acquiring the part, because of the negative impact it would have on

annual output. However, this has not prevented the automotive industry from developing methods for optimising the cost of sourcing [3].

A key finding of this research was therefore the potential to reduce airline inventories through the adoption of best practice in supply chain management, as adopted by the automotive sector. Both industry sectors were driven by the need to ensure the operational performance of their supply chains by ensuring the continued availability of materials. However, the automotive industry had made efforts to optimise this process. By establishing the relevance of supply chain management to the airline service sector, the previously held misconceptions for maintaining “just-in-case” inventories had been dispelled. This will have significant implications in the way inventory is managed within MRO supply chains for the future (see section 5.5).

Finally, once the key differences between the two industry sectors had been identified, and any arguments against the application of supply chain management to the airline service sector dispelled, a thorough benchmarking analysis was undertaken to establish the degree of progress relative to best practice. Figure 5 represented considerable innovation in the field through the application of a variety of relationship assessment tools to the airline industry ([2], [25], [26]). This resulted in the first graphical representation of the airline industry relative to the automotive sector, indicating that the industry was some twenty years behind in its adoption of best practice tools and techniques.

5.3.3 Development of a Generic Process for Improving Supply Chain performance:

A key element of innovation emerging from the research was the development of a generic process for improving supply chain performance. This process was conceived by incorporating each of the aspects of best practice identified by the literature. It was further validated, tested and developed following its application to the case studies ([10] and [11]), delivering significant results in both operational and financial performance.

The final recommended process was illustrated in Figure 13 and its aim is to achieve competitive advantage through the elimination of inefficient supply chain processes. This model incorporates the specific supply chain strategies available to practitioners at each stage of the process, as well as the tools and techniques necessary to implement them. At its highest level it represents a supply chain transformation process driven by the requirement for change, and enabled by a cross-functional approach to problem solving. At the tactical level it provides firms with the tools necessary to re-design existing supply chains aimed at reducing cost and improving performance. Furthermore, this process has been demonstrated to apply to the airline service sector industry.

A transformation in supply chain performance can therefore result by applying the proposed model. However, incremental improvements in performance will also result through the application of the proposed sub-process for supply chain integration. This was developed following the lessons learnt from the case studies and represented a Deming cycle for continuous improvement [50].

The evidence for innovation is further supported by the lack of supply chain improvement tools found in the literature. Lamming's four phase model was a milestone in the development of the field of supply chain management, but it provided little insight into how the concepts could be applied [2]. Hines's further developed Lamming's model to assist practitioners in plotting their own progress relative to best practice [25]. However, this work provided no indication of how to weight certain relationship attributes. The same could be said of Sako's buyer-supplier questionnaire [26]. Each of these models were very much automotive industry related in terms of the attributes analysed and the language adopted.

Subsequent to completing this research a variety of authors have attempted to develop such models. Hammer has developed a process which he calls "Four Steps to Super-efficiency" [49]. This process describes the steps necessary to scope, organise, redesign and implement any type of process improvement, but it does not incorporate tools specific to best practice in supply chain management. Marien has also set about

proposing “a supply chain management process improvement plan”, but this again neglects to identify the specific supply chain tool that should be applied at each stage of the plan [51]. For example, under the implementation phase readers are advised to roll out a full implementation plan. It does not advise how this should be done, and which tools are available to support it.

Corini highlights a similar approach for “process re-design at the commodity level”, which shares the same weakness [52]. As with much of the current supply chain literature, this paper pre-supposes the solution to achieve supply chain integration through integration of company business systems, for every possible situation. This is representative of the wealth of supply chain papers recently devoted to the field of e-procurement. Finally, whilst Monczka [45] consolidates some of the available sourcing strategies into some “key stepping stones for competitive advantage” this model does not indicate when or how these strategies should be applied.

Conversely, the generic process developed during this research addresses many of the weaknesses of current models (See Figure 13). It provides a concise summary of best practice strategies together with the supporting tools and techniques for implementation. These are further structured into a logical sequence of activities that comprise a methodology in which to transform a supply chains performance. In summary, a review of recent literature provides further justification for the degree of innovation resulting from this research.

5.3.4 Development of a Proposed Deterministic tool for Supply Chain Strategy Selection:

A further source of innovation resulting from this research was the development of a tool to assist practitioners in selection of the most appropriate supply chain strategy for a given situation (see Figure 14). Whilst this tool was supported by the findings of both the chemical sourcing and landing gear case studies ([10] and [11]), it was acknowledged that it required further validation. However, such a tool would represent a significant degree of innovation in the field. There was no evidence of any such tool being available

from the literature. Interestingly, contrary to the majority of best practice this tool has originated from a service sector industry.

5.3.5 Summary:

This programme of research has contributed to a variety of sources of innovation in the field. Each of the case studies represented a practical implementation of the key Booz Allen elements of supply chain management [15]. They also provided a detailed insight into the factors necessary for improving closer supply chain integration, an aspect severely lacking within the literature. However, the underlying source of innovation from this work has been in the demonstration that the tools and techniques of supply chain management can be applied with equal success to the airline service sector. This eliminates previous pre-conceptions held by the industry and opens the way for further research and practical implementations.

5.4 Implications of the Work:

Further to the benefits already delivered from this programme of research, there are considerable implications resulting from this work. Upon commencing this programme of research the company lacked the knowledge necessary to determine those aspects of supply chain management relevant to its business. The importance and value of the literature review cannot be underestimated in this context. Considerable time was taken to review the subject matter and identify sources of best practice. This was necessary before any improvements could be implemented.

In retrospect if the knowledge gained from the literature review had been available within the organisation, the time taken to complete the case study implementations could have been significantly reduced. Considerable time was taken exploring all of the options available within each case study, with the author cross-referencing those aspects similar to the automotive sector, before recommending a best practice approach. The knowledge gained by the author would now allow a “smarter and quicker” approach to implementation for any future projects.

The recommended generic process for improving supply chain performance can now be applied to a variety of spend commodities and different sourcing scenarios. A number of spend prioritisation tools have since been applied by the company's procurement department, to focus on those areas in need of improvement. Commodities such as the procurement of hotel accommodation, telecommunications, computer hardware, transportation and freight, and printing services are currently being evaluated using the recommended generic process. The potential benefits identified by these sourcing projects amount to approximately £6 million in anticipated savings.

The company is currently using the proposed process as both a strategic and tactical tool for supplier sourcing and selection. At the strategic level the tool is being used to assist both the General Manager Procurement and the Chief Finance Office to identify the most appropriate approach for a given commodity. At the tactical level the tool is instilling a degree of discipline for company buyers throughout the sourcing process.

It is intended for the generic process to be translated into a training tool with which all company purchasing staff can be further developed. This will enable company staff to gain a greater appreciation of the aspects of best practice in supply chain management, without the need for expensive external consultants. It will also act to demonstrate the importance of adopting a process-orientated approach to problem solving, by providing practical examples of the benefits achieved through the adoption of cross-functional teams. Ultimately, the generic process for supply chain improvement will be incorporated into a set of standard operating procedures for the procurement department, thereby ensuring aspects of best practice are incorporated into the day-to-day operation of the department.

The General Manager Procurement is currently working with the author to use the key findings of the research to identify the implications for company purchasing as a whole. In particular, the organisational structure of the department is currently being reviewed, given the lessons learnt from adopting a cross-functional approach. At present the procurement department reports through to the Finance division, and so is indirectly

represented at Board level. The General Manager Procurement intends to use this research as further ammunition to ensure he has full ownership of company supply chains and is empowered to make the changes necessary both internal and external to the organisation.

Finally, the company continues to benefit from the research undertaken with the author applying the methodologies developed in his day to day role. Specific projects currently benefiting from the proposed process include a review of company transportation and freight (including the potential outsource of the Cargo division), and the sourcing and selection of a company-wide e-procurement system. Since completing this programme of research the author has also been utilised as an internal consultant for company staff requiring purchasing expertise and knowledge, adding significant value to the organisation.

With hindsight performing a benchmarking analysis of the airline industry both at the time of commencing the research, and at the point of completing the research, would have provided an interesting illustration of how the industry had progressed during the last four years. The findings of this research were limited to providing a snap shot of the industry's position relative to best practice. It was also assumed that the airline industry would follow a similar progression to that of the automotive sector, as described by Lamming's four phase model [2].

5.5 Areas for Further Work:

When considering opportunities for further work it is important to address any alternative approaches that could have been adopted. Further work could therefore investigate how the airline industry has progressed over time, with particular reference to the catalyst for any such changes. Furthermore, the relationship development model applied in Figure 5 could be further customised to more accurately represent those factors relevant to the industry. For example, the attribute of "integrated design" (item 10 of Figure 5) does not necessarily lend itself to a service sector industry. It is recommended that detailed interviews are undertaken with airline industry representatives to further validate their

responses to the survey. This would also provide a further insight into the industry drivers for change with respect to supply chain management.

Due to time constraints the benchmarking analysis neglected the input from aerospace OEM's or other manufacturing based firms. It was suspected that the relative size and influence of aerospace suppliers relative to their airline customers, would significantly impact the benefits achieved from supplier development. It is more likely that customer development activities will prevail, with smaller airlines such as the case study company having more to learn from these larger organisations. This hypothesis should be further explored.

The potential for cross-sectoral transfer of knowledge has been illustrated by this research. However, further work should be undertaken to explore the extent to which transfer of knowledge has already been achieved within other airlines. For example, it would be interesting to evaluate whether any of the Japanese airlines had benefited from the expertise gained from their domestic automotive suppliers.

A limitation of the proposed generic process for supply chain improvement was that it demands a level of internal resource that may not be available. Contrary to the automotive assemblers, many airlines fall into the category of small to medium sized organisations. These companies may lack the internal resource necessary to deliver such far reaching change programmes. A significant gap within the literature concerns the implementation of best practice in supply chain management within smaller organisations. Further research should investigate the potential for a scaled down generic process requiring less internal resource. Alternatively, opportunities could be explored to utilise the resource from key preferred suppliers to undertake such programmes. Clearly, this would demand a considerable level of competence trust within the relationship [26].

As previously discussed application of the generic process for improving supply chain performance will have significant implications on degree of inventory held in MRO supply chains. Further work should continue to investigate the potential for reducing

airline inventories through the optimisation of supply chain processes. This research has established the potential for reducing “just in case” inventory, although it has not determined the potential magnitude of any reduction. The cultural issues surrounding implementation of an optimised inventory management policy would also have to be explored, given the airline industry’s historical dependence on high stock levels to address poor supply chain performance.

Finally, as previously discussed further work is required to validate the proposed deterministic tool for supply chain strategy selection. This could be accomplished by applying it to a variety of other sourcing scenarios, both within and outside the airline service sector. The specific relationship between this tool and Kraljic’s matrix [21] should also be investigated. Further development of this model would provide a valuable tool for industry practitioners and academics alike.

6.0 CONCLUSIONS:

The general conclusions from this programme of research are summarised as follows (Specific learning points can be found in the respective portfolio submission):

1. Despite having its origins in the automotive manufacturing sector, this research has demonstrated the relevance of supply chain management to the airline service sector, by delivering significant improvements in operational and financial performance for the case study company.
2. This research has identified the strategies and tools necessary for the case study company to become a world class supply chain organisation.
3. This research has identified the tools and techniques necessary to improve the effectiveness of the company's purchasing department

A summary of how the research objectives were met and the main contributions to knowledge in the field, can be found below:

1. A detailed review of the literature has identified the sources of best practice in supply chain management, which were predominantly found in the Japanese automotive sector.
2. The characteristic differences between the airline MRO sector and the automotive manufacturing sector have been reviewed, with opportunities for the cross-sectoral transfer of knowledge in the field of supply chain management being identified. MRO supply chains were found to be driven by low volume "made to order" requirements with long lead times, further complicated by high degrees of product customisation. This combined with cultural attitudes to protect the operation at all costs has resulted in the generation of significant levels of "just-in-case" inventory. Strategies to rationalise the supplier base, improve supply chain visibility, and develop appropriate contractual relationships with suppliers have shown considerable potential for

optimising MRO supply chains and reducing inventory. This is despite the characteristic differences between the manufacturing and MRO industry sectors.

3. A detailed benchmarking analysis incorporating the key aspects of best practice has been undertaken, providing a graphical illustration of the airline industry's progress towards best practice. This work has confirmed the relative immaturity of the airline industry and established possible paths for improvement.
4. The key sources of best practice have been structured into a generic process for improving supply chain performance, with key strategies and the supporting tools and techniques for their implementation being identified. Development of this process represents considerable innovation in the field of supply chain management.
5. This generic process for improving supply chain performance has been further validated and developed following its application to a number of case study supply chains within the airline MRO sector. This has resulted in significant improvements in both operational and financial performance for the case study company. The impact on business performance further demonstrates the value delivered from this research programme.
6. The case studies represented a practical insight into the implementation of a supply chain integration programme, without the need for new technology. The importance of adopting "process orientated" cross-functional teams was demonstrated. Indeed, the research has underlined the importance of improving supply chain performance before adopting new technology solutions.
7. This research has proposed a further deterministic tool to assist practitioners in selection of the most appropriate supply chain strategy for a given situation, adding considerable value to application of Kraljic's matrix [21]. This was supported by a number of case study implementations and requires further validation. The continued

development of this strategic tool will significantly benefit the field of supply chain management, and its impact on the business environment.

In summary, this research has recommended a generic process for transforming supply chain performance. This process is driven by the requirement for change, and enabled by a cross-functional approach to problem solving, with the aim of achieving sustained competitive advantage for those who adopt it.

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APPENDIX A

CASE STUDY COMPANY VISIONS AND GOALS

VISION

One of the world's most respected Aviation Services Companies

with consistent growth by breaking through the industry-wide assumptions of what is possible in terms of quality, service, reliability and financial performance.

VALUES

Customers come first

Delighted by the commitment to safety, delivery of unique standards and services beyond their expectations.

Communication

Communication of vision and progress is free, regular and two-way, between employees, management, customers and suppliers.

Commitment based Company

Delivering beyond industry expectations through a workforce inspired to work as a team, sharing in the rewards of success

Respect of all stakeholders

Respect for the needs of customers, employees, the environment, community, government, suppliers and owners.

Integrity of service and people

Integrity of product delivered, service provided and of BM Aviation Services employees.

Trained, empowered employees

Working in technically competent, fully flexible teams, under the leadership of working group leaders and shift managers to provide 24 hours per day, 7 days per week cover.

Identity through standards

Identity of its employees through their standards and the quality of service and product provided.

Enjoyment

Customers to enjoy BM Aviation Services working for them, employees to enjoy working for BM Aviation Services and suppliers to enjoy being a supplier and contributing to the success.

APPENDIX B
AIRLINE INDUSTRY
BENCHMARKING SURVEY / QUESTIONNAIRE

Best Practice in Supply Chain Management

A Program of Research
undertaken in partnership with:

Warwick Manufacturing Group
Warwick University
A Case Study Company

BENCHMARKING SURVEY FOR THE AIRLINE INDUSTRY

Best Practice in Supply Chain Management A benchmarking survey for the Airline Industry

This survey undertaken by Warwick Manufacturing Group and the case study company forms one element of a review of best practice in supply chain management. The associated program of work is being undertaken by Javid Karim in accordance with a Doctorate degree program examined by Warwick University.

This survey aims to capture the current position of the airline industry with respect to best practice tools and techniques of supply chain management. Previous work has concentrated upon identifying best practice, which tends to originate from the automotive manufacturing sector, and predominantly Japan. This work aims to establish the current degree of maturity within the airline industry, and the potential for the application of knowledge from one industry sector to another.

The resulting analysis will be used to benchmark the airline industry as a whole against other industry sectors. It is NOT the objective to compare specific airlines against each other.

We would very much appreciate your views by ticking the appropriate box/s in each section. There are no wrong or right answers to the questionnaires and your *honesty* would be appreciated.

Confidentiality:

All information provided will be treated as strictly confidential. The identities of participating individuals or companies and the data provided will not be disclosed without prior consent. Results from the survey will be used in a manner which will be non-attributable to either the participants or their companies and will be used for research purposes only. A signed non disclosure agreement is enclosed should you require it. The overall analysis of data resulting from the work will be made available to all participants in the programme upon request.

THANK YOU. YOUR TIME IS VERY MUCH APPRECIATED.

Please complete this questionnaire in relation to the function for which you are responsible.

By Javid Karim
Contracts Manager – Procurement
Research Engineer (Doctorate Program)

(November 2001)

Section A: Background

A3.

What was the total annual sales turnover of this business for your most recently completed financial year? (Please give figures in \$US)

A1. Please provide your contact details:

Name _____
Position _____
Company _____
Phone No. _____
Email. _____
Address _____

Postcode _____

Tick one box only

- Less than \$50 million
- \$50 to \$150 million
- \$150 to \$250 million
- \$250 to \$500 million
- More than \$500 million

A4.

Does your company have a centralised or decentralised purchasing / procurement function?

Tick one box only

- Purchasing is totally centralised
- Purchasing is totally decentralised
- Technical purchasing is undertaken by the Engineering function
- And non technical purchasing is undertaken by the Airline.

Other (Please state) _____

A2. Which part of the business do you represent?

Tick one box only

- Airline
- Engineering, Maintenance Repair and Overhaul
- Both of the above
- Other

A5. Is your purchasing or supply chain management function directly represented at Board level (i.e. Supply Chain Director)?

Tick one box only

- Yes (directly)
 - No (indirectly)
- Where does it report to? (Please state) _____

A6. Approximately how many staff work in the purchasing and supply chain management functions? (including any materials planning and logistics staff, excluding the any stores personnel)

Tick one box only

- 1 to 10 staff
- 11 to 30 staff
- 30 to 50 staff
- More than 50 staff

A9 How would you describe the nature of competition between your company and its supplier base?

Tick one box only

- Highly competitive
- Competitive
- Limited competition
- No competition

A7. Approximately how many suppliers do you have in the supply base?

Tick one box only

- Less than 250 suppliers
- Between 250 and 500 suppliers
- Between 500 and 1000 suppliers
- Between 1000 and 3000 suppliers
- Greater than 3000 suppliers

A10 What degree of importance is associated with training your purchasing staff?

Tick one box only

- We seldom provide any training
- Training is limited and unstructured
- Training is available for those who want it
- We actively encourage the training and development of our purchasing staff.

A8 What is your approximate spend with suppliers?
(Please give figures in \$US)

Tick one box only

- Less than \$150 million
- Between \$150 - \$300 million
- Between \$300 - \$500 million
- Greater than \$500 million

B1. Does your organisation have a purchasing and / or supply chain management strategy?

Tick one box only

- Yes
- No
- Not sure

Section B: Purchasing and Supply Chain Strategy

B2. How would you describe your organisation's current supply chain strategy?

Please mark the most relevant description

- Non-existent Most elements defined in detail
- Patchy Very detailed and clearly defined
- Poor definition
- Some elements defined
- Lacks detail

B3. How important do you think your organisation's purchasing and supply chain strategy is to achieving competitive advantage?

Please mark the most relevant description

- Of no importance Significantly important
- Marginally important Critically important
- Important

B4. What do you perceive is the purpose of your suppliers?

Tick one box only

- To supply goods or services we do not make / provide
- To supply goods or services we can NOT make / provide
- To provide additional benefits and advantages
- To provide mutual competitive advantage

B5. What do you see as the most important supply chain management priorities for your business?

Please RANK items 1 to 6 where 1 = Highest priority

- Reducing price Reducing inventory costs
- Reducing total cost of acquisition Increasing customer service levels (internal or external)
- Improving delivery performance Improving quality

Other (*Please state*) _____

B6. Which of the following do you think have the greatest potential for improving supply chain performance in your business?

Please tick NOT MORE THAN THREE items from the list

- Vendor managed inventory Alliance sourcing
- Business process improvements Integration of business systems with suppliers
- Benchmarking e-procurement
- Stock consignment programs Other (*Please state*)
- Partnership and strategic sourcing

B7. Which of the following generic sourcing strategies are frequently undertaken by your organisation?

<i>Please tick where applicable</i>	<i>Frequently</i>	<i>Sometimes</i>	<i>Never</i>
Cost reduction through volume concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost reduction through spend concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost reduction through specification improvement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost reduction through service level improvement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost reduction through joint process improvement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Global sourcing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Joint purchasing / alliance purchasing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Outsourcing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vertical integration with suppliers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Best price evaluation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (<i>Please state</i>) _____			

B8. Which of the following specific sourcing strategies are undertaken by your organisation?

Please tick where applicable

Single or dual sourcing programs

Multiple sourcing programs

Parallel / network sourcing programs

Strategic sourcing programs

Competitive tender programs

Other (*Please state*) _____

B9. Which of the following supply chain management strategies are frequently undertaken by your organisation?

Please tick where applicable

Supply base rationalisation / supplier reduction programs

Supplier optimisation programs

Introduction and management of tiers into the supply base

Vendor managed inventories

Business process re-engineering

Benchmarking

Supplier development programs

B10. Which of the following statements apply to your organisation?

Section C: Customer - Supplier Relationships

Please tick where applicable

C1. Please describe the degree of trust in your relationship with suppliers.

B10(a) We view the supply chain as a single entity

Strongly Agree	<input type="checkbox"/>	Partially Agree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Not sure	<input type="checkbox"/>
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B10(b) We use inventories as a last resort

Strongly Agree	<input type="checkbox"/>	Partially Agree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Not sure	<input type="checkbox"/>
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B10(c) We make strategic decisions regarding purchasing and supplier sourcing

Strongly Agree	<input type="checkbox"/>	Partially Agree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Not sure	<input type="checkbox"/>
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B10(d) We integrate / interface closely with our suppliers

Strongly Agree	<input type="checkbox"/>	Partially Agree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Not sure	<input type="checkbox"/>
----------------	--------------------------	-----------------	--------------------------	----------	--------------------------	----------	--------------------------

B10(e) We involve our suppliers early in the sourcing process

Strongly Agree	<input type="checkbox"/>	Partially Agree	<input type="checkbox"/>	Disagree	<input type="checkbox"/>	Not sure	<input type="checkbox"/>
----------------	--------------------------	-----------------	--------------------------	----------	--------------------------	----------	--------------------------

Tick one box only

We fully trust our suppliers to perform to our requirements regardless of any contractual commitment

We trust our suppliers to perform to their contractual requirements

Rarely do we trust our suppliers to perform, they are only in it for themselves

We never trust our suppliers and are suspicious of their intentions

C2. Please describe *your perception* of whether your suppliers trust doing business with *your* organisation

Tick one box only

Our suppliers fully trust us, regardless of any contractual commitment

Our suppliers trust us to comply with our contractual commitments

Our suppliers have no reason to trust us, we are in it for ourselves only

Our suppliers never trust us and are deeply suspicious of our intentions

- C3. How would you describe the nature of your supplier relationships?**
- Tick one box only*
- Adversarial / arms length
- Non adversarial but arms length
- Collaborative but arms length
- Partnership and full open book
- C4. Does your organisation tend towards any of the following relationship types?**
- Tick one box only*
- Long term relationships (>2 years)
- Short term relationships (<2 years)
- Both long term and short term depending on the type of spend commodity
- No clear trends
- C5. How would you describe the level of pressure or stress in your relationship with suppliers?**
- Tick one box only*
- Low to medium / steady and predictable
- Medium / some sense of relief
- High / unbearable and volatile
- Very high but predictable
- C6. How does your organisation deal with price changes?**
- Tick one box only*
- Conflict in negotiation / a game of win or lose
- Ignore them
- Lowest price by competitive tender
- We manage to keep them stable / non inflationary
- We jointly target cost reduction opportunities
- C7. How would you describe your interaction with suppliers?**
- Tick one box only*
- One off or infrequent
- Annual negotiation or quality audit
- Frequent problem solving activities
- Continuous joint process improvement activities
- C8. How would you describe information sharing between your organisation and your suppliers?**
- Tick one box only*
- Little / infrequent and at the operational level only
- Limited and sporadic at the operational level only
- Detailed and frequent at the operational and occasional at strategic level
- Detailed and frequent at both the operational and strategic levels

C9. Please describe the level of cost transparency between your organisation and its suppliers.

Tick one box only

- None
- Occasional but very limited
- Transparent with some suppliers
- Transparent throughout the supplier network / full open book

D2.

What supply chain metrics does your company measure and monitor on an ongoing basis? Are these measurements recorded manually ("M") or generated systematically ("S") by a company business system?

Please tick the appropriate boxes (M = Manual / S = Systematic)

- | | M | S | M | S |
|-----------------------------|--------------------------|--------------------------|---------------------------|--------------------------|
| Delivery performance | <input type="checkbox"/> | <input type="checkbox"/> | Response time | <input type="checkbox"/> |
| Supplier lead-times | <input type="checkbox"/> | <input type="checkbox"/> | Warranty cost | <input type="checkbox"/> |
| Repair turn times | <input type="checkbox"/> | <input type="checkbox"/> | Quality / non conformance | <input type="checkbox"/> |
| Inventory turn / stock turn | <input type="checkbox"/> | <input type="checkbox"/> | Price movement | <input type="checkbox"/> |

Section D: Supplier Performance and Development

D1. Does your company have any formal means of measuring supplier performance?

Please mark the most relevant description

- No formal means
- Mainly informal means
- Limited formal means
- Some formal means
- Extensive formal means

D3. Does your organisation undertake any of the following activities?

Please tick where appropriate.

- Supplier development programs
- Supplier accreditation schemes
- Supplier grading schemes
- Supplier approval schemes
- In-house supplier conferences
- Benchmarking

D4. Which of the following attributes do you regard as most effective at ensuring / improving supplier performance?

D5. Do your purchasing staff make contact or visit your suppliers with a view to improving performance?

Please tick NOT MORE THAN FOUR items from this list

Tick one box only

- Contractual penalties for non conformance
- Strict termination clause in any contract
- Promise of future benefits based on performance
- Regular meetings and feedback
- Implementation of joint continuous improvement initiatives

- We address supplier performance proactively through regular meetings / visits
- We make limited contact with our suppliers depending on other business priorities
- We tend to be reactive in addressing poor supplier performance after the event
- We rarely address poor supplier performance

D6. Which of these supplier development activities do you participate in?

Which of these supplier development activities does your company participate in?

- Ensuring closer integration with our suppliers
- Shorter term relationships
- Longer term relationships
- Vendor accreditation schemes
- Supplier approval schemes
- Supplier grading schemes
- Set up and adoption of multifunctional teams
- Relationship building

- Tick where applicable
- Assessment of the suppliers performance through an informal evaluation.
- Assessment of the suppliers performance through formal evaluation, using established guidelines and procedures
- Providing the supplier with feedback about the results of its evaluation
- Verbal or written request that a supplier improve its performance
- Site visits and audits by your company
- Inviting suppliers to visit your site
- Training and education of a suppliers personnel
- Investment in a suppliers operation

E2. Which of these technologies offer the greatest potential benefit to the field of purchasing and supply chain management?

Please tick **NOT MORE THAN THREE** boxes

- E Auctions / online auctions
- E procurement systems
- Enterprise resource planning systems
- Internet purchasing
- Integration of systems with the supplier
- Web enabled exchanges (i.e. Aeroexchange)
- Fundamental purchasing and requisition systems

Other (Please State) _____

Thank You!

THANK YOU FOR YOUR TIME. PLEASE SEND YOUR COMPLETED QUESTIONNAIRE TO THE FOLLOWING ADDRESS. A PRE-PAID ENVELOPE IS ENCLOSED:

Please tick here if you would like a copy of the published results once available.

E2.

D7. At what level in the supply chain to you actively address supplier performance? (N.B your direct supplier will be the first tier supplier)

Tick one box only

- First tier suppliers only
- Down to 2nd tier suppliers
- Lower than 2nd tier suppliers
- We do not actively address supplier performance

Section E: Future Trends in Supply Chain Management

E1. How do you perceive the relevance of supply chain management when applied to the airline industry?

Tick one box only

- Supply chain management only applies to the manufacturing sector and is not applicable to the airline industry
- Supply chain management offers some potential for application to the airline industry
- Supply chain management is highly relevant to our industry
- Supply chain management is fundamental to achieving sustained competitive advantage within our industry