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A Non–Financial Supply Chain Performance Measurement Framework for the Aerospace Division of Rolls-Royce

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MSc

A Non–Financial Supply Chain Performance Measurement Framework for the Aerospace Division of Rolls-Royce

by

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Abstract

Rolls-Royce places great emphasis on maintaining a consistent strategy with three main areas at the core of its business identified as being customer, innovation and growing profitability. The ability of the business to deliver on its promises and also putting the customer first is paramount to maintaining growth and securing the future of the company.

Driving delivery is part of the Rolls-Royce DNA which relates to the need for relentless focus on responsiveness and delivery. This study highlights the changing nature of the organisation and focuses on the new Aerospace Division and in particular the non-financial delivery metrics that operate within the supply chain.

The study reviews the current literature regarding supply chain performance methods, implementation strategies and factors affecting measurement frameworks. There is then a proposal put forward of what the new Aerospace metrics should be for the business together with an implementation proposal underpinned by a decision making and escalation framework.

Declaration

This dissertation is the sole work of the author, Stephen Cramp. No portion of the work referred to in this dissertation has been submitted in support of an application for another degree or qualification at this or any other university or other institute of learning

Copyright statement

Dedication

This dissertation is dedicated to my wife Liz for her years of support and spell checking of assignments throughout the MSc. Her unwavering patience and continual planning of activities for the kids so 'Daddy can work' has helped me through this course. Also a special thank you to my daughters Abbi and Freya for providing much needed distractions when required.

Acknowledgements

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List of Abbreviations

A-HPP	Agile Hierarchical Production Planning
BW	Business Warehouse
CEC	Customer Excellence Centre
CLE	Civil Large Engines
CFBU	Customer Facing Business Unit
CSME	Civil Small & Medium Engines
ERP	Enterprise Resource Planning
GTSC	Gas Turbine Supply Chain
HPP	Hierarchical Production Planning
IT	Information Technology
PO	Purchase Order
SAP	Systems, Applications and Products
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SCP&C	Supply Chain Planning & Control
SCU	Supply Chain Unit
SORB	Sales & Operations Review Board
TAT	Turn Around Time

1 Introduction

1.1 Background to Research

The supply chain of Rolls-Royce is driven by its culture statements in order to achieve the customer and business performance targets that are set for the company. The key emphasis in these statements is on "Delivering Success to Our Customers" which means individuals committing to delivering absolutely excellent service. The challenges set in the 2013 business plan demand the supply chain output an increase of 20% in 7 plants, 10% growth in 9 plants and 18 suppliers having to deliver 20% growth for the year. This culminates in a target of delivering a 16 point improvement for on time to customer purchase order from 79% to 95%.

This is a significant challenge for the supply chain which coupled with an organisational restructure to create a more customer value stream aligned business, causes an added dimension to meet the customer's needs. The organisational change means that the Civil Large Engines (CLE), Civil Small & Medium Engines (CSME) and Defence sectors will combine to make one Aerospace division. Bringing these businesses together is an opportunity to consolidate and standardise practices, part of this is having standard supply chain metrics that can be used to measure the performance of the business and the sectors in order to make sure that the high targets are met in the continuing years.

The author works in the supply chain part of the Aerospace division within a business called the Customer Excellence Centre (CEC). This part of the business is viewed as the central function for the supply chain in dealing with the critical parts supply for the business and dealing with the issues that can arise that would potentially impact the customer, thus damaging the Rolls-Royce reputation.

The specific role of the author is managing the Communications and Reporting team in the CEC. This is seen as a role which co-ordinates the reporting for supply chain and project based outputs. The difficulties of doing this task will be discussed later but it does give a rounded opinion of the current metrics available and what the proposed framework would be.

This study therefore, critically reviews the current non-financial supply chain delivery metrics and investigates the possibility of introducing a new framework to standardise the measurements across the Aerospace division. It will also try to understand the potential reasons for failure and propose and implementation strategy to counter these based on academic and industrial knowledge.

1.2 Rolls-Royce PLC

Rolls-Royce is a world-class leader in the industry of gas turbines occupying the 4 major markets of Civil Aerospace, Defence Aerospace, Marine and Energy employing over 40,000 people in 50 countries with an order book of over £60 billion.

Rolls-Royce prides itself on being one of the best in the business and the name is synonymous with excellence in its industry. This is achieved through customer satisfaction and providing a quality service that surpasses the customer's needs and delivering unrivalled products in an extremely competitive market.

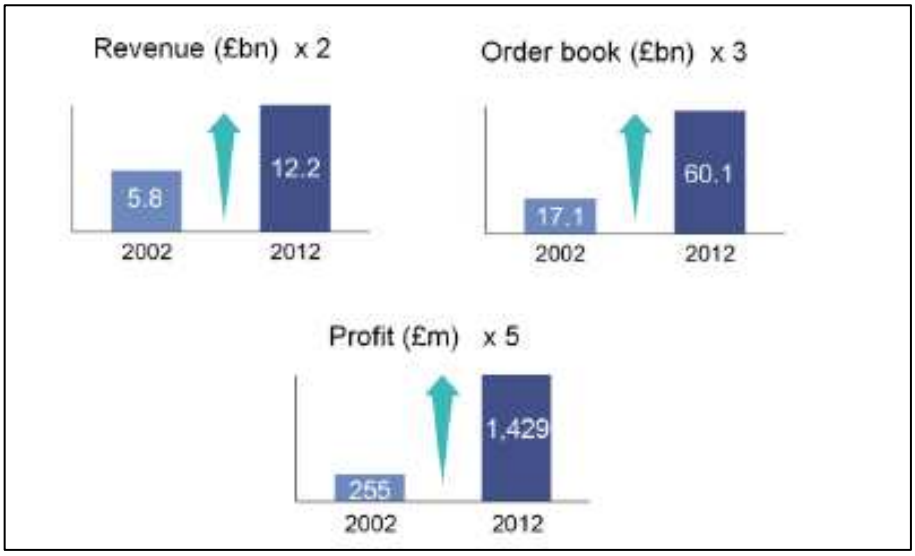

Figure 1: Growth figures (Source: Rolls-Royce Financial Report 2012)

Figure 1 shows the strong position that Rolls-Royce are in following the announcement of the 2012 results, the order book has increased by 4%, revenue increased by 8%, profit increased by 24% and shareholder payment increased by 11%.

Figure 2 shows the sales by market sector in terms of where the major revenue is from. It is clear that the greatest contributor is the Civil sector with the 74% of sales coming from original equipment, it should be noted that the higher revenue comes from the spares business.

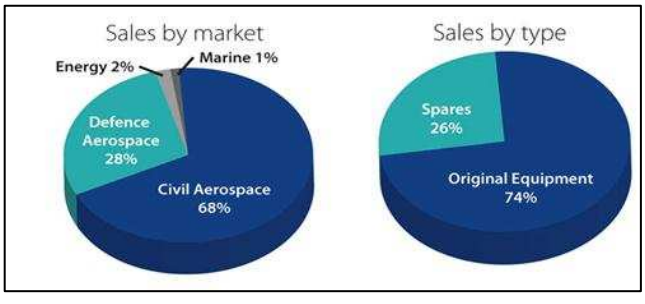

Figure 2: Sales by Sector and Market (Source: Rolls-Royce Infocentre)

The Chief Executive John Rishton, places the emphasis on a consistent approach as the reason for growth, naming three areas that are at the heart of the company:

Customer	• Place the customer at the heart of the organisation • Understand the shape of their requirements • Focus on responsiveness
Innovation	• Connect innovation to customers • Help our customers do more with less • Develop technology, capability and infrastructure
Grow profitability	• Grow our market share • Expand competitive portfolio • Focus on cash and cost

John Rishton places strong emphasis on the ability of the company to deliver on its promises to the customer and placing them at the heart of everything the company does. This highlights the importance of the company being able to articulate its position on delivery and being able to monitor what the current performance is to the customer.

1.3 Strategy of Rolls-Royce

Before attempting to critically analyse the structure of the organisation it is important to first understand what strategy actually is. There are many definitions for strategy for example Goold et al (1993), defines the concept of strategy as 'more than long-range planning or objective setting; it was a way of deciding the basic direction of the company and preparing it to meet future challenges'. Gould underpins this statement by introducing the concept that there was a need to focus senior managers, and the concept of strategy made it possible to simplify tasks of top managers as this would then help drive the organisation.

Grant, R (2005) defines the goal of strategy to 'ensure the survival and prosperity of the firm', explaining that there are two basic levels of strategy within an enterprise, *Corporate Strategy* and *Business Strategy*. The difference between the two relates to the focus of the organisation and specific areas of strategy.

Corporate is defined in terms of the industries the firm competes in, whereas business is how it competes in these chosen markets and industries.

Grant goes on to explain that strategy, in simplistic terms, is how the firm can make money and be a profitable organisation. An example of strategy in the context of the role of the corporation is Lloyds, one of the world's leading banks. Lloyds defines the role of its corporation to 'lead or support changes to help the market operate in the most commercially attractive and efficient manner'. In terms of this example Lloyds are looking to make sure that their firm remains profitable and ensures its survival through making correct decisions about where to invest and grow and relates back to what Grant describes as the basics of corporate strategy.

With this in mind the following sections will look in detail at the role of the corporation and its strategy for Rolls-Royce. Once this has been identified the assignment will look at the structure of Rolls-Royce and compare it to its strategy and its effectiveness.

The strategy of Rolls-Royce can shape the structure of the organisation as it has to mirror what it is trying to achieve with its long term goals.

The approach adopted by Rolls-Royce for strategy is,

- Address the four global markets in Civil, Defence Marine and Energy markets
- Invest in technology, infrastructure and capability
- Develop a competitive portfolio of products and services
- Grow market share and installed product base
- Add value for customers through the provision of product-related services

The strategy of Rolls-Royce can be put into context of the role of the corporation in the similar way that Lloyds bank aspires to. Rolls-Royce tries to operate with a broad product portfolio so that it can expand accordingly in its chosen markets, and develop these products to encourage long term growth prospects. This point answers the definitions of strategy in the introduction where strategy should be geared towards preserving the future of the company whilst staying competitive and lucrative. As an employee of Rolls-Royce, it is evident that the key factor about delivering the strategy of Rolls-Royce is making sure that the company stays cash positive and returns a dividend to the shareholders on an annual basis, whilst delivering its promises to the end customer.

Rolls-Royce underpins its strategy by developing very strong core competencies, Prahalad et al (1990) describes core competencies as the 'wellspring of new business development, they should constitute the focus for strategy at the corporate level'. Prahalad describes core competencies as being the collective learning of the organisation; diverse production skills; understanding the customer needs; as well as it communicated across the organisation.

Rolls-Royce describes its core competencies to be;

- Understanding the customer and derive what they want in terms of products and services
- Being technologically superior to competitors and having a deep understanding of the products
- Operational excellence
- World class engineering capabilities
- The recognised global brand synonymous with excellence
- Organisational capability retained by retaining the best people globally

Prahalad argues that the corporation structure grows like a tree from its roots, and that the core products are nourished by competencies and business units whose fruit are the end products. With respect to this statement, Rolls-Royce's core competence, above any, is engineering excellence, in producing a product that is continually improved and developed with the customer's needs in mind.

These high barriers to entry that Rolls-Royce have created, mean that the market in which they operate in is very hard to break into if you are not an established firm/brand, as a result competitors will find it difficult to imitate the products and services developed by Rolls-Royce therefore securing the future of Rolls-Royce and securing its long term prospects in line with its strategy.

1.4 Rolls-Royce Supply Chain

Figure 3 illustrates puts the challenge of the supply chain into perspective. To bring together routinely, on time, every time, over 30,000 parts ranging in value from 10p to £930m, manufactured internally and by major suppliers and partners across the globe.

Some key points from the details are that there are 14,200 employees in the supply chain with 500 suppliers globally. There are 14 Domestic, 5 manufacturing joint ventures and 22 Risk and Revenue Sharing partners.

The quantity of live parts that exist in the supply chain are approximately 33,500 contributing to an inventory cost of around £800m.

Cost of goods sold	£3.2bn
Employees	14,200
Suppliers	500
Manufacturing sites	16
Joint ventures	7
Partners	22
Active parts	33,500
Inventory	£800m
Parts delivered per annum	~260m
Major NPI programmes	8

Figure 3: Supply Chain Detail (Source: Rolls-Royce Infocentre)

1.4.1 The Structure of the Supply Chain

'The basic solution to organising complex organisations is hierarchy' according to Grant R (2005).

As Rolls-Royce is a global organisation, it is necessary for the company to adopt a structure that is hierarchical with a head office of executives for all the major functions to report into. But Jack Welch, CEO of one of Rolls-Royces largest competitors in all markets argues, 'Hierarchies tend to make little generals out of perfectly normal people who find themselves in organisations that respond only to rank'.

Welch goes onto argue that an organisational structure should be as flat as possible with blindingly clear reporting relationships and responsibilities. In terms of the structure of Rolls-Royce it is clear in figure 4 that the hierarchical option has been adopted which Welch argues against doing, but the structure has very clear lines of communication which in contradiction Welch strongly argues for.

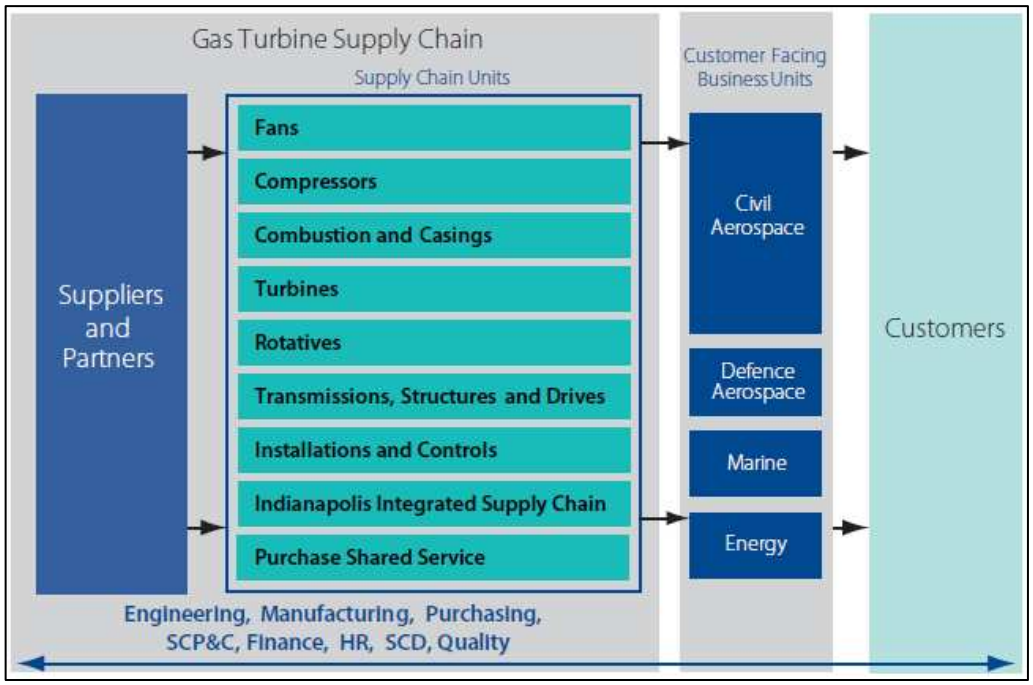

Figure 4: The organisational structure of Rolls-Royce (Source: infocentre at Rolls-Royce)

The structure of an organisation importantly influences the flow of information and the context and nature of human interactions (Miller, D 1987), which is evident in figure 1 for Rolls-Royce as all the hard lines flow into the top of the organisation from the Supply Chain Units (SCU) and the Customer Facing Business Units (CFBU) so this keeps the information flowing into the top level management, what this does not show is the interaction between the SCU's and the CFBU's.

The structure of Rolls-Royce is hierarchical at the top level but the lower level interactions adopt a matrix style structure. A matrix structure is an organisation that formalizes coordination and control across multiple dimensions (Grant, R 2005). In the case of Rolls-Royce the multi dimensions are geographical locations, cross functions and cross businesses. For example the SCU will manufacture parts that go into multiple products for the Civil CFBU and Defence CFBU and these CFBU's can be in multiple locations depending on the type of engine i.e. a Civil industrial engine can be assembled in Canada but a large Civil engine can also be assembled in Derby (UK). This would mean that the SCU would have stable processes to cope with the geographical differences and CFBU demands.

In answer to the earlier statement from Prahalad regarding core competencies being responsible for the roots of the corporation, the Rolls-Royce structure addresses two of its most important core competencies world class engineering and being close to its customers.

The structure addresses engineering as a core competence because its 'roots' are at the SCU level where all the parts are made. There can be a temptation to outsource a lot of production but as it is one of the key competencies for Rolls-Royce a lot of production remains in house because of the superior knowledge Rolls-Royce has about the products.

The customers are highly regarded by the organisation and so there are specific CFBU's aligned to each of the four sectors to manage the customer requirements and orders and flow this information and demand back into the supply chain in order to satisfy the demand. This has meant that Rolls-Royce is very close with its customers to the point that they provide tailored packages for customers particularly in Civil such as TotalCare which provides an aftermarket service for the life of the engine which Rolls-Royce looks after all maintenance for that product.

The organisation structure of Rolls-Royce conflicts with the argument of Jack Welch that the structure should be as flat as possible. It is has a lot of sub tiers and reporting lines within the SCU's and CFBU's and can cause decision making to be slow and cumbersome an aspect that will be discussed in the next section to conclude if the structure is effective or not.

1.4.2 Is the Structure of Rolls-Royce Effective?

Quantifying how effective the structure is of Rolls-Royce is quite straight forward because as stated at the start of the assignment, Grant simplifies it to look at whether the firm can make money and be a profitable organisation. This would establish if the structure that is in place is an effective one or not purely based on revenue.

The 2012 annual financial figures are impressive, but when compared with the potential revenue opportunity in the markets that Rolls-Royce operates in, shows there is a long way to go. These markets create a total opportunity worth in excess of US$2 trillion over the next 20 years and have very high barriers to entry.

The high levels of revenue and year on year profit for Rolls-Royce are encouraging but how can the structure be improved to access this potential market revenue? The core competencies of Rolls-Royce have already been identified as being very strong which shows how the company has achieved high specialization within the market. It is however susceptible to developing informal structures (thetimes.co.uk) where people identify new ways of doing their role to save time and make the job easier, employees work around the communication lines and employees work around the formal structure. This can cause conflict and confusion within the company and impact the overall strategy of the organisation.

A reason for informal structures occurring in Rolls-Royce is that employees are business aligned in their CFBU's i.e. Defence or Civil and try to drive for the best results in their sector causing internal competition. When applying the same problem to the SCU's they succumb to providing the best service to the biggest customer i.e. Civil is the biggest sector for Rolls-Royce and so can be seen to be getting a better service when compared to a smaller sector such as Energy. This can be mainly attributable to Civil having a very large volume and customer base.

1.5 Customer DNA

The DNA helix came out of the Executive Board in the autumn last year. It relates to the business and to the individuals of the company. The purpose of designing a picture such as this is to drive from the top down the importance of customers through the business.

People judge the Rolls-Royce performance against the strap line of "trusted to deliver excellence" promise so there are 2 areas where Rolls-Royce has to be world class. The 1st is "Customer" which has to be much more at the heart of the organisation. The business needs relentless focus on responsiveness and delivery promises.

The 2nd area is "Innovation". It's more than just technology; it's also the way the company performs in its role to deliver to the customer leading to the company having to develop technology, capabilities and infrastructure.

Figure 5 below shows the illustration of the DNA helix which has been developed by the exec board.

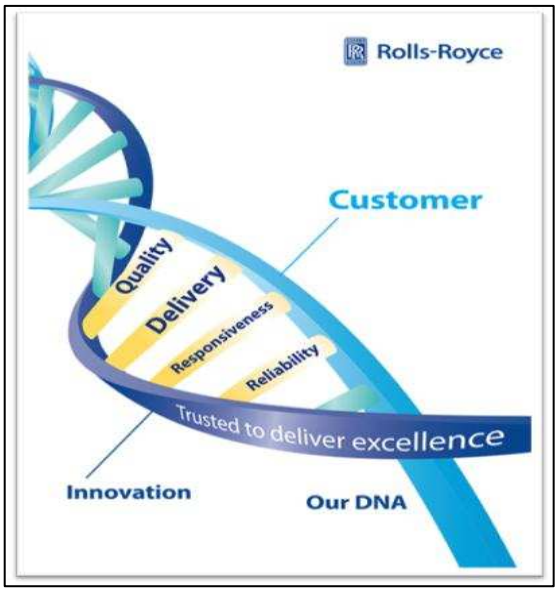

Figure 5: Customer DNA helix (Source: Rolls-Royce Infocentre)

Rolls-Royce now has 4 "Golden Threads", and they all need specific and personal attention in terms of success is delivered to the customer.

- Quality - Demands the continued improvement journey to process excellence
- Delivery - Making sure the customer commitments are maintained
- Responsiveness - Becoming more agile
- Reliability - More than product-integrity, it's defined as making sure the business does what it has committed to do

Mike Mosley, head of the supply chain, commented in a recent manager's communication session that the Boeing meetings held last year as part of the industrial review process, represented personally one of the most difficult and embarrassing meetings and presentations ever due to our delivery situation. On a day-to-day basis we need relentless focus on hitting delivery promises to our customers.

Delivery is shown as a "golden thread" for Rolls-Royce and is seen as a pivotal area for achieving growth as a business by delivering on our promises made to the customer.

1.6 Purpose of Research

The purpose of this research is to conduct a critical study of the use of non-financial supply chain performance metrics primarily focused on delivery. It is to assess the current state of the delivery metrics and to identify a possible new structure given the changing nature of the organisation.

1.6.1 Aim

The aim of this research is to investigate non-financial supply chain delivery metrics in Rolls Royce Planning & Control function and suggest possible improvements.

1.6.2 Objectives

1. Review the literature on Supply Chain Management in particular Supply Chain Performance Management
2. Identify the current situation on non-financial delivery metrics in Rolls-Royce at the supply chain level
3. Identify areas and reasons for change
4. Identify areas where the delivery metrics do not adequately support the business
5. Investigate potential improvements of the non-financial delivery metrics and propose a new framework

6. Investigate the potential difficulties in implementing a performance measurement system

1.6.3 Research Questions

1. Does the current framework for delivery metrics provide customer focused metrics that can help drive the supply chain?
2. What areas of the framework need to be improved?
3. What can be learnt from literature in order to optimise the implementation and governance stages of the framework?

1.7 Dissertation Structure

The remainder of the dissertation will be split up into the following chapters.

Chapter 2 – Literature Review

This chapter looks at the literature on supply chain performance measurement, the phases which are undertaken to implement a new framework and some example models currently in use. It also reviews the factors that have caused frameworks to fail to identify and lessons learnt from academic research.

Chapter 3 - Methodology

This chapter details the way in which the case study will be analysed and the methods for achieving the research aims.

Chapter 4 – Case Study

This chapter reviews the case study of Rolls-Royce and details the current framework for non-financial delivery metrics in the supply chain. It will also review what the limitations of the current framework are.

Chapter 5 – Framework Proposal and Discussion

The purpose of this chapter is to purpose a new framework in light of the literature gathered and to discuss the potential improvements that could be made in order to better suit the demands of the customer in the organisation.

Chapter 6 – Conclusion & Recommendation for Further Research

This chapter will conclude the findings and present recommendations for further research.

2 Literature Review

2.1 Introduction

The purpose of this chapter is to investigate the literature available for supply chain management and the topic of supply chain performance measurement. To complement the detail on these topics the literature review will also look at decision making, knowledge management and performance measurement systems.

2.2 Supply Chain Management

Supply chain management can be defined as the management of upstream and downstream relationships with customers and suppliers to deliver superior customer value at less cost to the supply chain as a whole (Christopher, 2005).

Christopher goes on to say that the focus of supply chain management is upon the management of relationships in order to achieve a more profitable outcome for all parts of the chain. The importance of demand chain is emphasised to reflect the fact that the chain should be driven by the market not the supplier suggesting that the customer should be the primary focus of the chain.

Supply chain management transforms the way that manufacturing and non-manufacturing operations meet the needs of the customers (Gunasekaran et al, 2004).

2.2.1 The Importance of Customers

A customer is the most important visitor on our premises. He is not dependent on us. We are dependent on him. He is not an interruption of our work. He is the purpose of it. He is not an outsider of our business. He is part of it. We are not doing him a favour by serving him. He is doing us a favour by giving us the opportunity to do so (Mahatma Gandhi, 1890).

Poirier et al (2004) identifies three areas of pressure where change in the supply chain is enforced these are: change, competitors and customers. Poirier explains that the three areas are linked to enforce an overall change in the supply chain otherwise it will run the risk of becoming a victim to more agile, networked competitors. The main area that Poirier identifies where pressure comes from is customers; they are becoming increasingly more demanding and require innovation with rock-bottom prices. This enforces the need for customization within the supply chain so that it can meet the ever-changing customer needs.

Considering that Poirier has identified customers as the main cause for change in the supply chain and increased responsiveness, it is important to define why it is vital to meet the ever changing needs of the customer.

Williams, K (2006) explains that customers are our most important asset. They are the life-blood of our business and their satisfaction is the ultimate objective of all we do. This may seem obvious, yet, without customers there would be no revenue for business; for example the idea of TotalCare for Rolls-Royce is to secure the revenue stream for the business by offering a customized service.

Williams highlights that the cost of attracting new customers to an organization to be eight times more than it does to keep an existing one, so it makes business sense to develop a customer-oriented organization. This could be achieved through quick customer response and customization through the supply chain to meet the end needs. The implications of this are costs to meeting the customer demands in the supply chain and making sure that the delivery of the product is achieved through quick customer response.

2.3 Supply Chain Performance Measurement

When you can measure what you are speaking about, and express it in numbers, you know something about it . . . [otherwise] your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in thought advanced to the stage of science. (Lord Kelvin, 1824-1907).

Performance measurement is the process of quantifying purposeful action, where the process of quantification is measurement and purposeful actions equates with performance. The goals of the organisation are achieved by satisfying their customer with greater efficiency and effectiveness than their competitors (Neely et al, 2002).

Neely develops this definition into three other variations:

- Performance measurement is the process of quantifying the efficiency and effectiveness of purposeful action
- A performance measure is an indicator used to quantify the efficiency and/or the effectiveness of purposeful plan
- A performance measurement system is the set of indicators used to quantify the efficiency and effectiveness of purposeful action

Neely then highlights that a performance measurement system can be examined at three different levels:

- The individual performance measures
- The performance measurement system as a whole

- The relationship between the performance measurement system and the environment within it operates

It is generally believed that a well-crafted system of supply chain metrics can increase the chances for success by aligning processes across multiple firms, targeting the most profitable market segments, and obtaining a competitive advantage through differentiated services and lower costs (Lambert & Pohlen, 2001).

Lambert et al argues that there is a requirement to go beyond internal metrics and take a supply chain perspective, illustrating the following as the need for supply chain performance measurement:

- The need to determine the interrelationship between corporate and supply chain performance.
- The complexity of supply chain management.
- The requirement to align activities and share joint performance measurement information to implement strategy that achieves supply chain objectives.
- The desire to expand the "line of sight" within the supply chain.
- The requirement to allocate benefits and burdens resulting from functional shifts within the supply chain.
- The need to differentiate the supply chain to obtain a competitive advantage.
- The goal of encouraging cooperative behaviour across corporate functions and across firms in the supply chain.

2.3.1 Why Measure the Supply Chain

Globalisation, environmental issues, radical business and organisational structures have brought significant pressures to bear upon companies, who, in an attempt to address these pressures, are forming enterprise networks that work together across the value chain in order to meet the more complex customer needs (Folan & Browne, 2005). Changes in global economic, social and environmental conditions are increasing the occurrence of fragmented supply chain networks. This induces the organisation to focus on on-going maintenance of supply chain performance measurement systems (Gopal & Thakar, 2012).

If you can't measure it, you can't manage it (Kaplan & Norton, 1996). This still is a very clear reason of why metrics in the supply chain are important.

Measures are required to guide and motivate people, be the basis for reward and compare and contrast performance with previous periods.

Measuring the supply chain can bring about improved performance and move closer to attainment of the elusive goal of supply chain optimisation. All participants in the supply chain should be involved and committed to common goals, such as customer satisfaction throughout the supply chain and enhanced competitiveness (Gunasekaran, et al., 2004)

Gunasekaran and Kobu (2007) develop the above statement further and highlight the cores reasons for measuring the supply chain as:

- Identifying success
- Identifying if the customer needs are met
- Better understanding of the processes
- Identifying bottlenecks, waste, problems and improvement opportunities
- Providing factual decisions
- Enabling progress
- Tracking progress
- Facilitating a more open and transparent communication and co-operation

Lambert et al (2001), agrees with Gunasekaran on the above reasons for measuring the supply chain but also adds that there is a need to determine the interrelationship between corporate and supply chain performance, the requirement to align activities and share joint performance measurement information to implement strategy that achieves supply chain objectives and the goal of encouraging cooperative behaviour across firms in the supply chain.

Akyuz and Erkan (2010), summarise from their research that the idea of a hierarchical balanced set of performance metrics compatible with top management strategy is required and lies at the heart of a performance measurement framework. An overall balance is sought between short vs. long term, internal vs. external focus, differentiation between levels in the organisation and multiple perspectives of stakeholders.

2.3.2 Predicting Delivery Performance

To investigate the point of having a balance in the framework it is worth considering the role of predicting delivery performance.

Traditional performance measurement systems encourage companies to measure historical delivery performance and respond to what has already happened. The practice is backward looking and lacks the ability to predict and mange future performance (Unahabhokha, et al., 2006).

The framework that is suggested by Unahabhokha et al for a predictive model consists of three main parts of selecting key predictors, develop a predictive framework and develop a preventative system. With these parts established the framework can be used as a mechanism to evaluate the potential hazard of failing to deliver a particular production order.

This model seems to be useful as Unahabhokha suggests that it strengths are the key predictors section, the framework allows a systemic approach to finding the right set of predictors. The part of this framework that would be of value to Rolls-Royce would be their use of incorporating an action plan which includes actions that need to be taken to prevent late delivery, this is incorporated into the prevention section of the model. The value comes from it forcing the business to assign action owners in the event of a potential delivery failure, this can assist the decision making process on what needs to happen with the information once it is identified. This links with a topic discussed later in the literature review on the subject of decision making.

2.4 Supply Chain Performance Measurement Systems

A performance management system has a number of constituent parts, Neely (2002) has defined these as the following:

- Individual measures that quantify the efficiency and effectiveness of actions
- A set of measures that combine to assess the performance of an organisation as a whole
- A supporting infrastructure that enables data to be acquired, collated, sorted, analysed, interpreted and disseminated

Designing the supply chain performance measurement system is a challenging task (Gopal & Thakar, 2012).

In implementing a new system and framework Brewer & Seph (2000) recommend the following areas to be aware of when designing a system:

- Overcoming mistrust – Trust in data sharing, acquisition and monitoring needs to be built in
- Lack of understanding – Multi-organisational measures are difficult to understand for managers focused on internal systems
- Lack of control – Managers and organisations wish to be evaluated on measures they control
- Different goals and objectives – Differing organisations have different goals and thus would argue for differing measures
- Lack of standardised performance measures – Agreed upon measures in terms of units to use, structure, format
- Information systems – Most corporate systems are incapable of gathering non-traditional information
- Difficulty in linking measures to customer value – Linkages are complex, the definition of who the customer may be inside a supply chain also is not clear
- Deciding where to begin – Developing supply chain-wide performance is difficult since it is not always clear where boundaries exist

Before embarking on designing and embedding a system it is important to look at the phases that will be faced as part of the project.

2.4.1 Phases to Implementing Performance Measurement System

Bourne et al (2000), argues that once managers have decided what to measure in the company then they struggle to implement the framework. Bourne therefore has developed a framework that assists in understanding the various stages of implementing a framework.

Figure 6 below shows the framework that is put forward in the literature. It can be divided up into three main phases: design of measure, implementation of measures and the use of the measures.

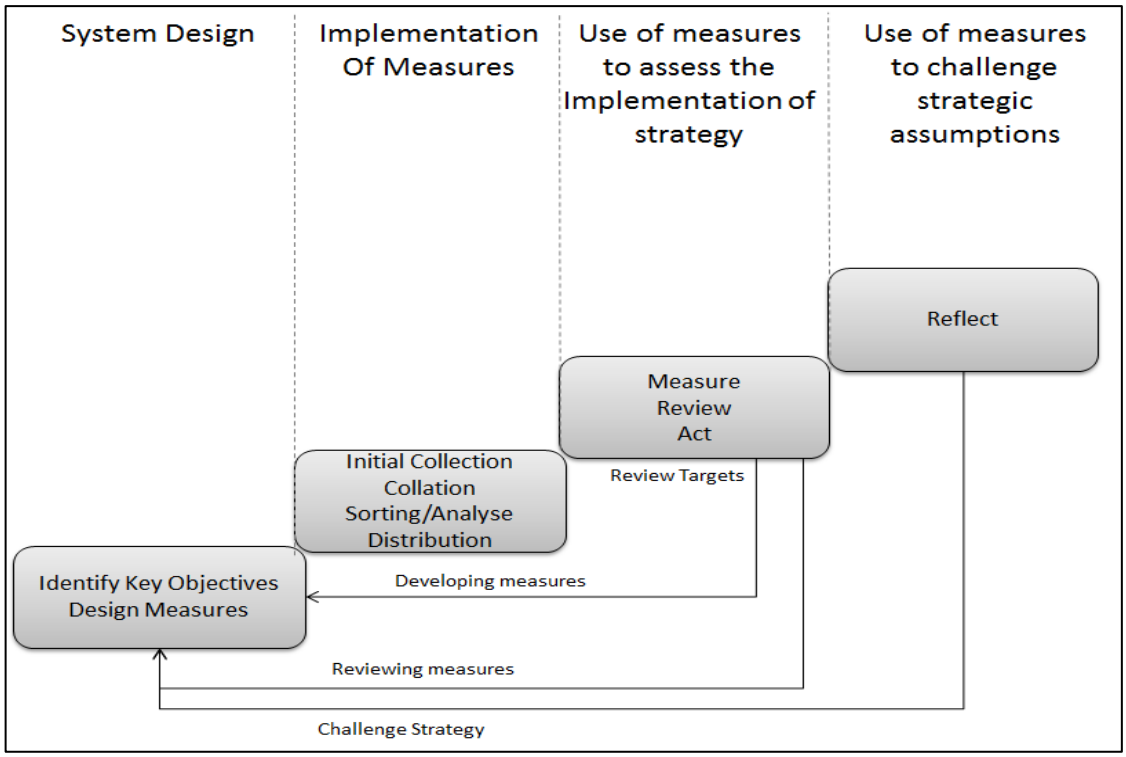

Figure 6: Framework for developing measurement system (Source: Bourne et al, 2000)

The above framework is credited for showing a distinctive breakdown of process that allows reviews at each stage to ensure a good method for implementing a solid framework. It also, and more importantly, forces checks on the type of measures and the targets through a review process this makes sure that the measures don't diverge from the strategy.

In theory this looks like a comprehensive framework to help implement a performance measurement system as it considers targets, strategy and overall measures along with a review process to keep everything in alignment.

The following sections will describe particular models that are in practice in the supply chain and outline their purpose.

2.4.2 Supply Chain Operations Reference (SCOR) Model

The SCOR model is a model that has been designed to provide a unique framework that links business processes, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities (Supply Chain Operations Council, 2013).

There are 4 core processes behind the SCOR model:

1. Plan – process to balance aggregate demand and supply to develop a course of action which best meets the business rule
2. Source – Process to procure goods and services to meet planned or actual demand
3. Make – Process to transform goods to a finished state to meet planned or actual demand
4. Deliver – Process to provide finished goods and services to meet planned or actual demand, typically including order management, transportation and warehouse management

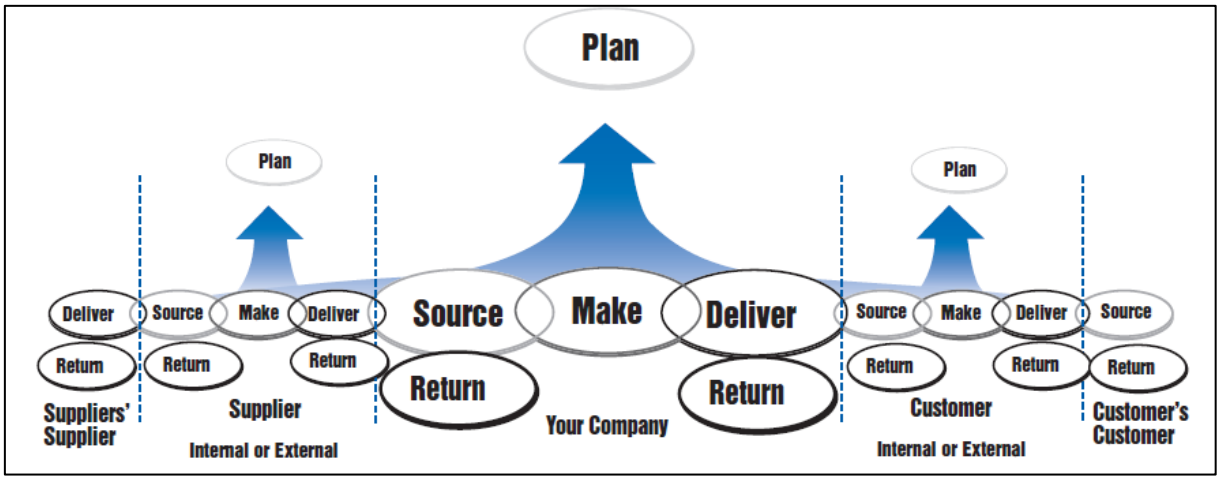

Figure 7: SCOR Model (Source: www.supply-chain.org)

Figure 7 is the map of how the SCOR model works from your supplier's supplier to your customer's customer.

The primary use of the SCOR model is to describe measure and analyse supply chain configurations.

- Describe: The breadth and depth of SCOR process definitions allow virtually any supply chain operation to be sufficiently characterised or configured
- Measure: Standard SCOR metrics enable regular benchmarking in a consistent and comprehensive manner
- Analyse: Supply chain practices and configurations may be efficiently evaluated to support continuous improvement and strategic planning

The SCOR model has 12 performance metrics defined at the appropriate level which can be used as the standard way of evaluating the supply chain. The supply chain council argue that standardising the metrics allows companies to benchmark effectively and easily to improve performance.

Table 1: SCOR Performance Metrics (Source: www.supply-chain.org)

Delivery Reliability	Delivery Performance (DR1)
	Fill Rate (DR2)
	Order Fulfilment lead time (DR3)
	Perfect Order Fulfilment (DR4)
Flexibility & Responsiveness	Supply Chain Response Time (FR1)
	Production Flexibility (FR2)
Cost	Supply Chain Response Time (CT1)
	Value Added Productivity (CT2)
	Warranty Cost or Returns Processing Cost (CT3)
Assets	Cash-to-Cash Cycle Time (AT1)
	Inventory Days of Supply (AT2)
	Asset Turns (AT3)

The SCOR model provides a common supply chain framework, standard terminology, common metrics with associated benchmarks, and best practices. It can be used as a common model for evaluating, positioning and implementing supply chain application software (Huan, et al., 2004).

2.4.3 Neely's Performance Measurement System

In 2002, Andy Neely published a book to help companies to design a holistic approach to setting up a measurement system that would best suit the business.

A the heart of the procedure are ten logical steps which are split up into two phases, phase 1 – identifying, designing and implementing the top-level performance measures and phase 2 – cascading the top-level measures and identifying appropriate lower-level performance measures.

The methodology from Neely has simple steps at every stage and suggests templates to use in order to engage the relevant stakeholders and action each step of the process model.

The 10 steps to the process model are as follows:

Phase1:

Part 1-What are our main customer-product groups?

Part 2-What are our business objectives?

Part 3-Are we achieving our business objectives?

Part 4-Have we chosen the right measures?

Part 5-Using our measures to manage the business

Phase 2:

Part 6-What can we use to drive performance towards our objectives?

Part 7-Which performance drivers are the most important?

Part 8-How do we know these drivers are working?

Part 9-Have we chosen the right measures for the drivers?

Part 10-Using the measures to drive business performance

These steps outlined by Neely are effective if approached with honesty and the correct group of individuals who can make the best assessment of what is required at each step. The next section takes a model Neely describes in step 4, which would prove particularly useful in the case study section.

2.4.4 Model for Reviewing Current Metrics

By reviewing the metrics that already exist in the organisation it will be possible to identify the strengths and weaknesses of the current portfolio. Neely et al (2002), present a framework that hels to achieve this and is represented in the following way:

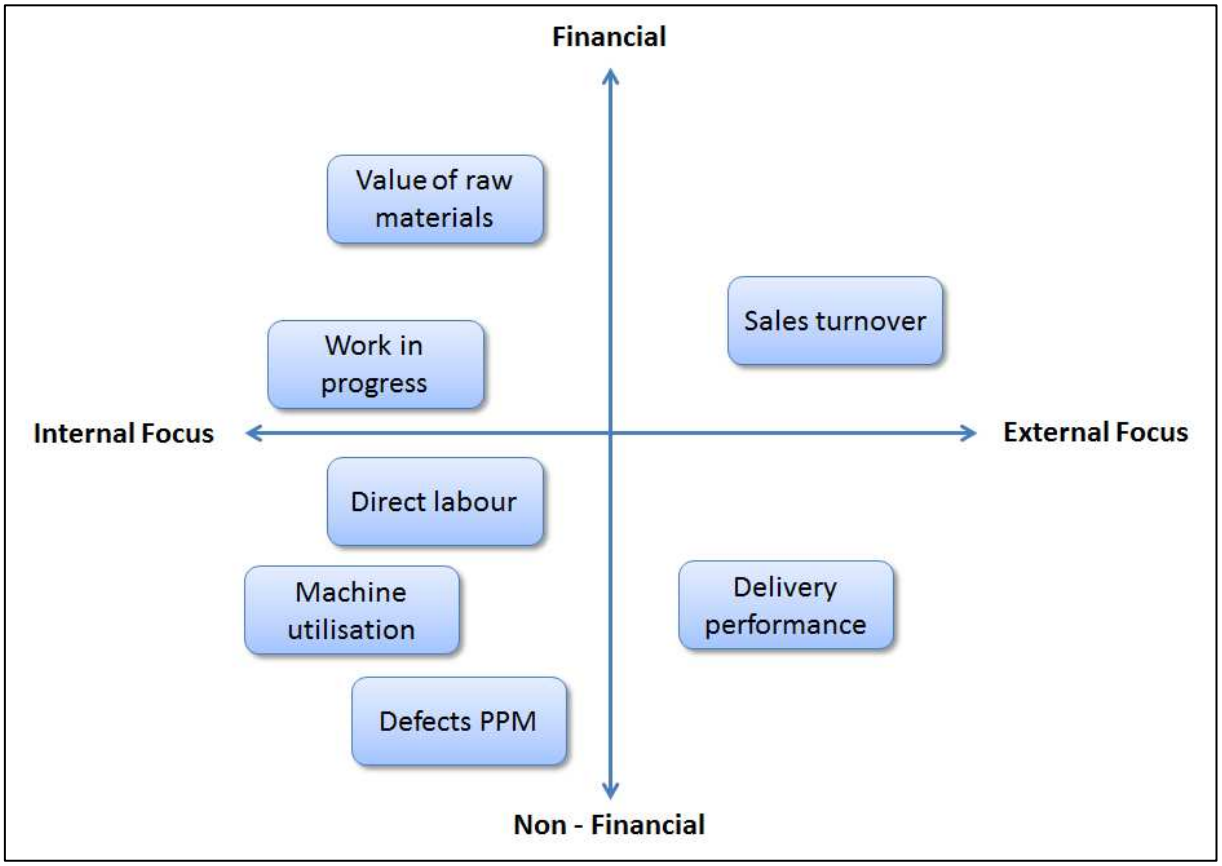

Figure 8: Identifying Metrics (Source: Neely et al 2002)

The model in figure 8 can easily show where the strengths and weaknesses are in the current range of metrics. The axis can also be manipulated to better suit the case study and allow a better fit for the organisation.

2.4.5 Supply Chain Mapping

Figure 9 illustrates the starting point that Lambert et al (2001) suggests should be the starting point when creating a metrics framework. Mapping the supply chain allows managers to identify the different entities in the company and the linkages comprising the supply chain.

Lambert makes the point that once the information flows and linkages are known then it helps to identify key customers and stakeholders in the design and implementation phase.

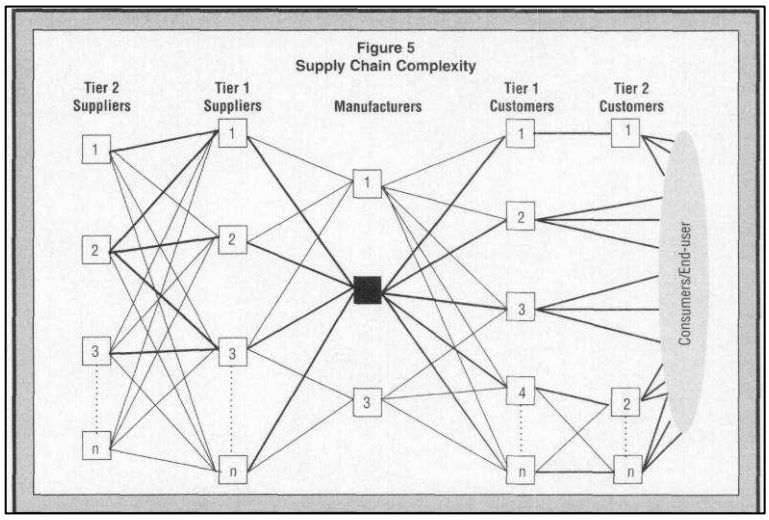

Figure 9: Supply Chain Mapping (Source: Lambert et al, 2001)

The following table shows the seven steps that Lambert suggests in creating a framework for supply chain metrics. Following these steps should achieve the overall objective of maximising shareholder value, for the total supply chain, as well as for the company.

Table 2: Seven Step Framework (Source: Lambert & Pohlen, 2001)

Step	Action
1	Map the supply chain from point-of-origin to point-of-consumption to identify where key linkages exist.
2	Use the customer relationship management and supplier relationship management processes to analyse each link (customer/supplier pair) and determine where additional value can be created for the supply chain
3	Develop customer and supplier profit and loss (P&L) statements to assess the effect of the relationship on profitability and shareholder value of the two firms.
4	Realign supply chain processes and activities to achieve performance objectives.

5	Establish non-financial performance measures that align individual behaviour with supply chain process objectives and financial goals
6	Compare shareholder value and market capitalization across firms with supply chain objectives and revise process and performance measures as necessary.
7	Replicate steps at each link in the supply chain

2.5 Factors Affecting Performance Measurement Systems

The issue of development of effective performance measures has received considerable attention from both academic and practitioner communities (Kennerley & Neely, 2002). What Kennerley's research paper indicates is that there are a number of factors why performance measurement systems do not evolve effectively over time, his findings suggest that only 40-60 per cent of the companies reviewed changed systems in the space of 5 years.

Kennerley categorises the factors into 4 areas:

- Process - Absence of an effective process
- People – Lack of necessary skills and human resource
- Infrastructure – Inflexible systems
- Culture – Inappropriate culture

In order to remedy these areas Kennerley explains that to correct the process a way of reviewing, modifying and deploying measures needs to be established. To resolve the people aspect, the availability of the required skills to use, reflect on, modify and deploy the measures must exist. The infrastructure issue can be tackled by having available flexible systems that enable the collection, analysis and reporting of appropriate data.

Finally the culture issue can be addressed by having the existence of a measurement culture within the organisation ensuring that the value of the measurement, and importance of maintaining relevant and appropriate measures are appreciated.

Bourne et al (2002) facilitated a piece of work with ten companies to help redesign their performance measurement systems and understand what the perceived factors that acts as blockers in the implementation stages were.

The findings of this paper are that there are four main blocking factors to the implementation of successful measures are as follows:

1. The effort required for implementation
2. The ease of data accessibility through IT systems
3. The consequences of measurement
4. Being overtaken by new parent company initiatives

Bourne also identified three factors which differentiated successful companies from unsuccessful companies when implementing new measures. Interestingly they complement the factors raised by Kennerley as areas if addressed properly can lead to a successful measurement system.

1. Purpose – expressed from the senior managers down through the company as a way of managing the business better
2. Structure – having a structured approach to implementation and a clear view where the metrics will be used and why
3. Culture – paternalistic culture would reduce the fear of measurement and therefore the resistance to implementation

Bourne concludes with a valuable point that all of the companies that were found to have successfully implemented a performance measurement system had a committed senior management team that drove the completion of the project.

Shepherd et al (2006), highlights the limitations of the current available measurement matrices including: they encourage short termism; they lack strategic focus (the measurement system is not aligned correctly with strategic goals, organization culture or reward systems); they encourage local optimisation by forcing managers to minimise the variances from standard, rather than seek to improve continually; and, they fail to provide adequate information on what competitors are doing through benchmarking.

Lambert et al (2001), also agrees that there is no evidence that meaningful performance measures that span the supply chain exist. Lambert describes the factors behind this to include: the lack of a supply chain orinentation, the complexity of capturing metrics across multiple companies, the unwillingness to share information among the company and the inability to capture performance by customer, product or supply chain.

Lambert concludes on the point that the major contributor behind the lack of supply chain performance measures is the absence of an approach for developing and designing such measures.

As Information Technology (IT) is highlighted as an issue as to why systems fail, the next section will look at the role of IT in the supply chain

2.5.1 Supply Chain Management through IT

Simchi-Levi et al (2003) describes the objectives of Supply Chain Management through IT as the following:

- providing information availability and visibility
- enabling a single point of contact for data
- allowing decisions based on total supply chain information
- enabling collaboration with supply chain partners

Auramo et al (2005), describes the role of IT in the supply chain as a means of reducing the friction of transactions between supply chain partners through cost-effective information flow. What both of these show, is that IT in the supply chain is a process and mechanism for sharing information about complex and ever changing aspects of the supply chain.

Auramo et al (2005) goes on to further elaborate on the functional roles of IT and develop a model shown in figure 10.

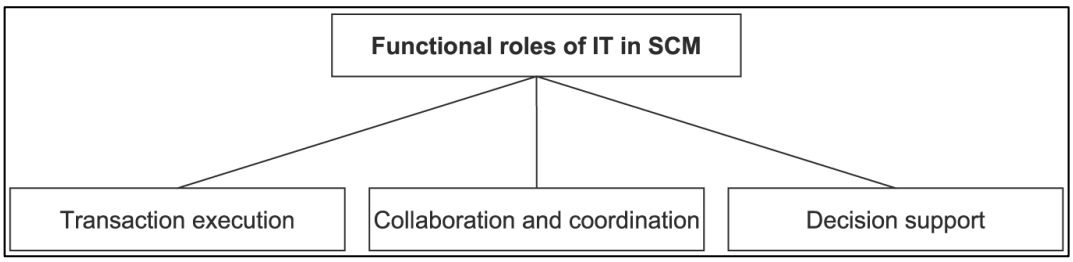

Figure 10: Functional Roles of IT in SCM (Source: Auramo et al, 2005)

The model ties together the connecting roles that help make systems an effective tool. The model is a good view of what processes need to be engaged, in particular the most relevant points are collaboration and coordination together with decision support.

The purpose of the paper from Auramo was to sample a variety of companies and discover what the benefits of having good e-business solutions for Supply Chain Management.

The findings of this survey are the following:

1. Improved customer service
2. Improving efficiency allows employees to focus on business critical activities
3. Improves information quality
4. Supports planning collaboration and improved network ability

An important factor in an effective IT solution is having a responsive system that can cope with high demands of usage and being available across the organisation. The need for real time information is crucial, putting emphasis on flexible IT-systems that can deal with large amounts of data and are easy to interconnect. In turn this will lead to the growing importance of system integration software and the process of creating standards (Helo & Szekely, 2005).

2.6 Data and Knowledge Management

Data is raw and meaningless figures and notation, as is visually demonstrated in Figure 11, when a context is applied to the data it becomes information, when the information is submitted in a context it becomes knowledge which when applied with understanding, and again in context, it enables the user to generate decisions (Pierce, 2003).

Figure 11 is a flow of the various stages of how data can be translated into knowledge and from knowledge a decision can be made for the best interests of the company. The analogy that is used by Fielder (2003) is of a car where the digits on the dashboard can be translated to information once it is put into context. This then means that the data can be used to look at the speed or the amount of fuel which is being consumed.

Once the submission of information takes place in this flow it can then be understood as information, in this case by the driver. The driver can then take action once that knowledge is understood so for this example the driver can slow down or refuel accordingly.

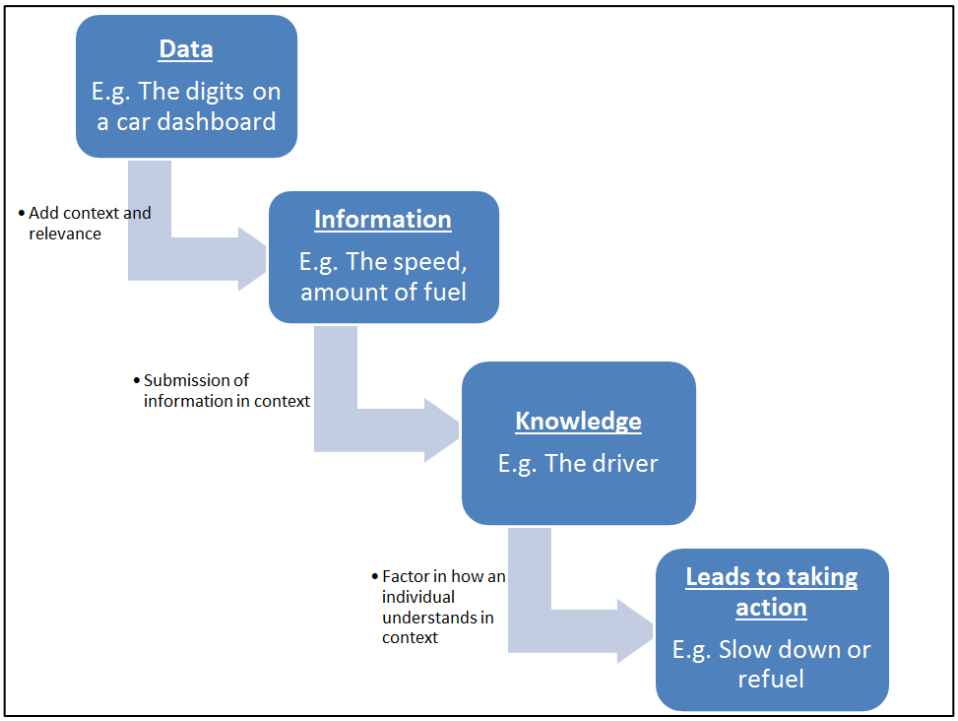

Figure 11: The evolution of data, adapted from (Fiedler, 2003)

This model can be used to evaluate the purpose for creating it and links with the decision making process discussed shortly. Now the evolution of data has been discussed the next section will look at knowledge management in more depth.

Knowledge management is rooted in many disciplines, including business, economics, psychology, and information management. It is the ultimate competitive advantage for today's firm. Knowledge management involves people, technology, and process in overlapping parts (Awad et al, 2007).

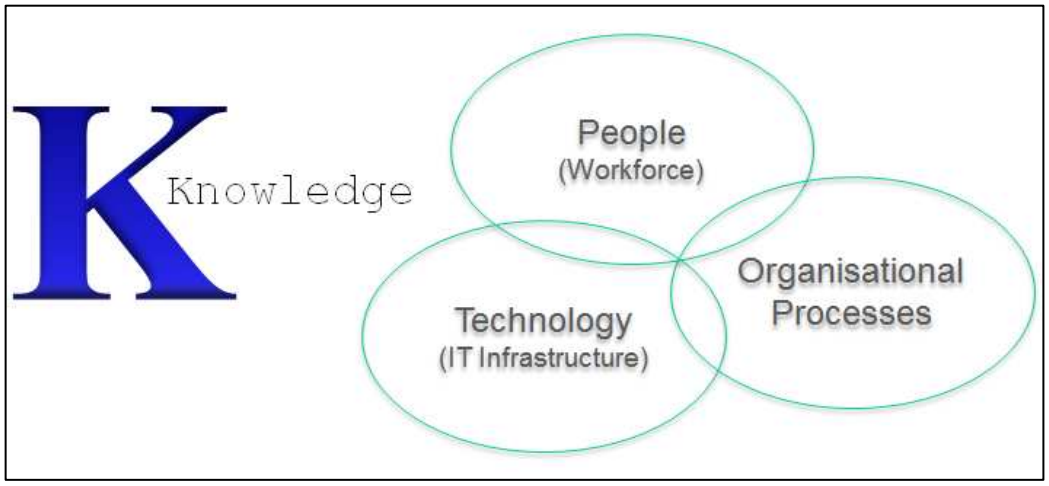

Figure 12: Organisational Factors in Knowledge Management (Source: Awad et al, 2007)

The model (figure 12) illustrates that the knowledge management process is intrinsically linked and to achieve a solid base for reliable and accurate information sharing then all aspects of the model have to be considered. Although in this model the parts are equally sized there would be an argument that the organisation would concentrate more on the processes and people aspects, whilst having a smaller part for IT which would underpin the first two but overlap none the less.

The important part of this model is the sharing of knowledge as well and developing from a simple provision of data to two-way sharing of sensitive information in the pursuit of new value creation, which will heighten the richness of the knowledge environment between customer and supplier (Lamming et al, 2001).

2.6.1 Knowledge Cycle

Nonaka (1994), identifies the theory of knowledge creation and the process of knowledge conversion between tacit and explicit and organisational knowledge.

Tacit knowledge is 'knowing how' in nature, it involves skills that are expressed through performance. Explicit knowledge is 'knowing about' and comprises facts, figures, theories and instructions (Grant, 2005). Once knowledge has been made explicit then it can be codified. Nonaka's theory describes that it is critical to companies to convert tacit knowledge into explicit so that the business can grow its capabilities.

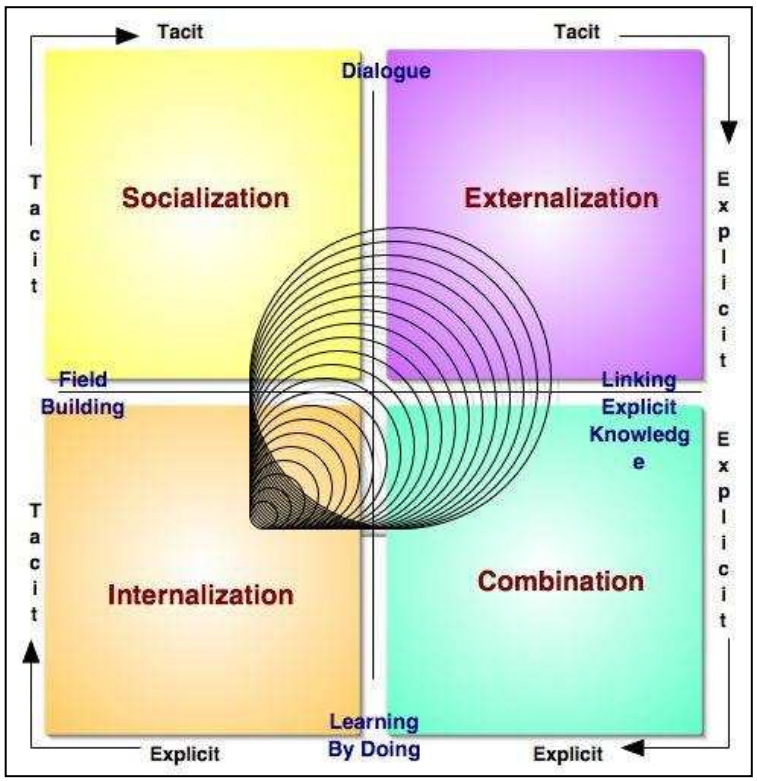

Figure 13: Nonaka Knowledge Cycle (Source www.nwlink.com)

Figure 13 is an illustration of Nonaka's knowledge cycle and also shows the four types of knowledge conversion that is created. It shows a continuous loop of knowledge creation of capturing it (externalisation) through to adding to it and creating best practice (combination), it then passes to goal based training (internalization) and finally developing new knowledge and lessons learnt (socialization).

Awad goes on to define that the ideal knowledge organisation is one where people exchange knowledge across the functional areas of the business by using established processes and technology.

2.6.2 Mitre Knowledge Management Model

The Mitre Corporation is a non-profit organisation chartered to work in the public interest. Mitre has expertise in systems engineering, information technology, operational concepts, and enterprise modernization. Mitre manages research for Defence, Aerospace, Homeland security and the U.S. courts.

Mitre have identified a model that is used to identify strengths and weaknesses in the process of knowledge capture their goal was not to create yet another definition, but to define KM within the context of Mitre's mission and goals.

The working definition of "corporate strategies employed to foster innovation, knowledge transfer, improved business process, and enhanced learning" was adopted along with a very simple vision. The vision states "Create a learning environment to continually enhance MITRE's value to its customers. In that environment, knowledge creation, sharing, and reuse are explicitly valued, expected, supported, and rewarded" (Mitre.org).

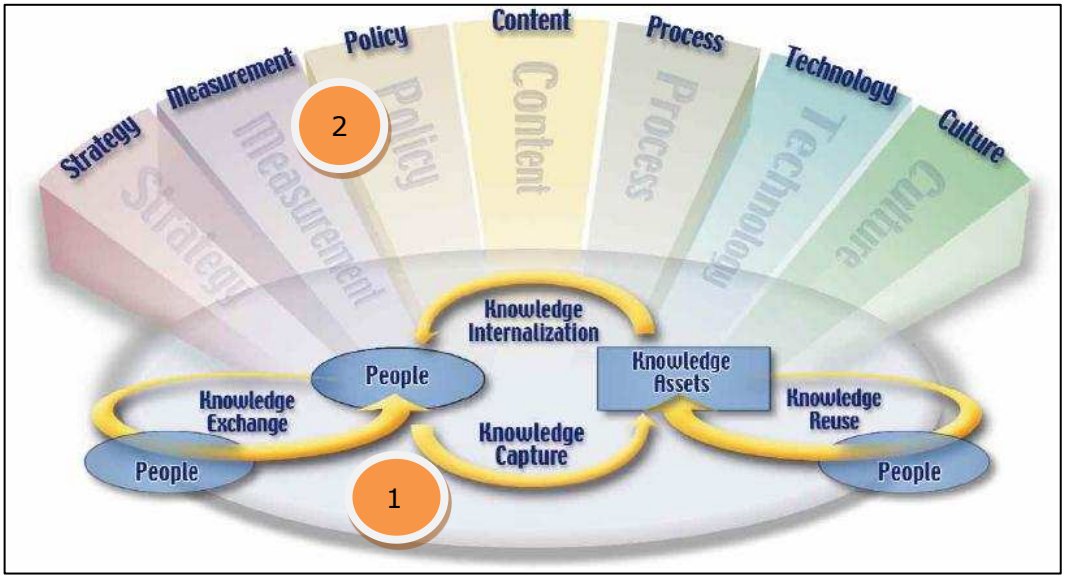

Figure 14: Mitre Knowledge Management model (Source: www.Mitre.org)

This particular knowledge management model has been chosen because it is a two dimensional perspective. Dimension 1 in figure 14 is the activities carried out to capture the knowledge which is directly comparable to the Nonaka cycle as described in the previous section. Collectively, these processes build a learning organisation one skilled at creating, acquiring, and transferring knowledge as well as adapting its actions to reflect new insight and innovation (Mitre.org).

The second dimension is described as the enablers for the organisation which splits the model into seven enablers:

- Strategy – to encourage corporate and KM strategies
- Measurement – metrics to maintain performance
- Policy – guidance
- Content – the actual knowledge captured
- Process – used by the workers for capturing knowledge
- Technology – IT that underpins the whole process
- Culture – values and practices that are adopted for optimisation

This model brings together the knowledge creation aspect and the enablers that need to be active to achieve best practice for knowledge management.

Now knowledge and data have been analysed the next section looks at making a decision once the data has been processed into information.

2.7 Decision Making

Decision making is a human activity and, as such, influenced by psycho-physiological effects and subject to cognitive limitations of the human mind. Decisions can be triggered by recognition of patterns in the state of the world (Bouyssou, 2006).

If the decision makers information is not so complete and does not know and cannot collect sufficient data to determine the probability of occurrence from some states of nature, nature being the set of exogenous factors that interact with the decision makers course of to produce an outcome, then they cannot find the expected value for each of the alternative actions (Meredith & Mantel, 2003).

With these models and frameworks the ultimate reason for producing these is twofold; firstly to be able to determine the current performance of the supply chain and secondly

where to act and this is means making decisions on the information that is created through the metrics.

2.7.1 Agile Hierarchical Production Planning (A-HPP) Paradigm

The hierarchical production planning (HPP) paradigm is used to control production in many industries it has been developed to improve decision making in a hierarchical decision process (McKay, et al., 1995).

McKay et al (1995), develops the HPP model as first described by Robert Anthony in the textbook 'Planning and Control Systems: A Framework for Analysis' (1965), and develops it further into the Agile Hierarchical Production Planning (A-HPP) paradigm.

Figure 15 shows the decision framework that has been created by McKay, the major components of the adaptive framework are:

1. An active information filter for manufacturing and non-manufacturing information
2. A tactical controller responsible for adapting the information filter and decision controller
3. A decision controller responsible for making the decisions and deriving schedules/plans

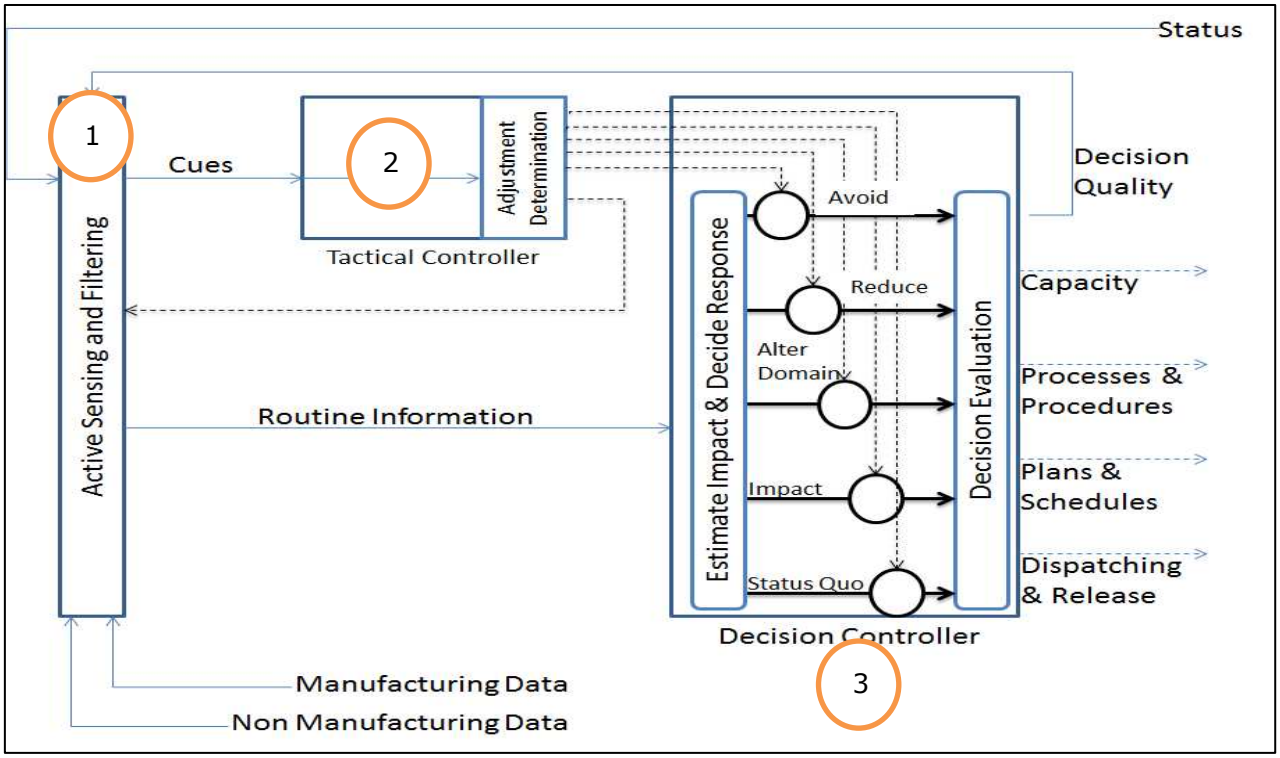

Figure 15: Detailed A-HPP Level (Source: McKay et al, 1995)

The A-HPP model layers the organisation with accountable levels (individuals) that monitor different types of data and looks for cues in the information before escalating to the decision controller to evaluate the potential impact the data is pointing to. McKay summaries the 5 points that the A-HPP framework helps to achieve:

1. A level in the structure is always active and has the ability to make decisions at any time
2. A level in the framework can make decisions normally reserved for higher levels or influence the higher level
3. A level has the ability to sense fluctuations and anticipate the impact
4. A level has an assortment of information and a computerised system
5. A level can manage its capacity in response to flagged circumstances

The key to this framework and the ability to make decisions is the information inputs to the decision makers. In this model it separates out manufacturing and non-manufacturing data as the key decision inputs that feed the base levels.

The A-HPP illustrates a structured approach on the best way to make decisions on the data which is generated the fundamental that underpins this model would be the quality and the data integrity of the information that is being put into this model, as it would have a direct impact on the quality of the decisions made.

2.8 Conclusion

The literature review has discussed the relevant academic theory on what supply chain performance is in context of supply chain management. The other areas discussed are why it is important to measure the supply chain, some typical systems/frameworks that are currently in practice. The topic of what the factors may be in causing system to fail was looked at. Finally the process of what to do with the data and how it becomes knowledge so a decision can be made was discussed.

3 Research Methodology

3.1 Introduction

This chapter explains the most appropriate research strategy that was selected for ensuring that the aim and objectives were achieved. The research was a part of a wider collaboration framework between industry and academia therefore recommendations have both industrial (practical) and academic implications.

3.2 Research Strategy

The seven step model (figure 16) proposed by Howard and Sharp (1983), which itself was based on earlier work by Rummel and Ballaine (1963), was adopted for developing the high level research strategy. The first stage requires an investigation of the broad area of research which will then lead on the second stage where the author needs to be concentrated in a selecting a topic with the development of aims and objectives for the research .

The third stage is deciding the research approach or in other words selecting the most appropriate research strategy that satisfied the research aims and objectives. The selection of a methodology is very much dependent on the nature of the research and the form of data required. In the fourth stage a plan need to be developed to monitor actions that need it to be complete in a timely manner. The model's final steps are concerned with collecting the information, analysing the data gathered and presenting the findings.

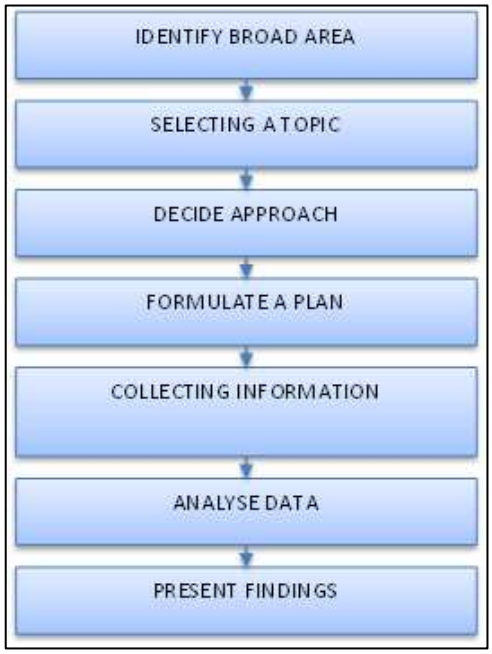

Figure 16: The Research Framework (Source: Gill & Johnson, 2002)

As it was already mentioned this research investigation is a collaborating framework between academia and industry. Therefore the author's broad area was chosen to be the area of working (supply chain). In the second stage a topic was selected that was concerned with the supply chain non-financial delivery metrics and aim and objectives where developed to address effectively the research problem. Again the author decided to undertake a topic which was very close to day to day work and the research problem was understood and widely known. In the next stage of the research the author designed the appropriate research methodology, according to Sanders (2003) there are several research strategies that the author can choose from in this specific research, it was decided to use the case study and elements of action research (figure 17).

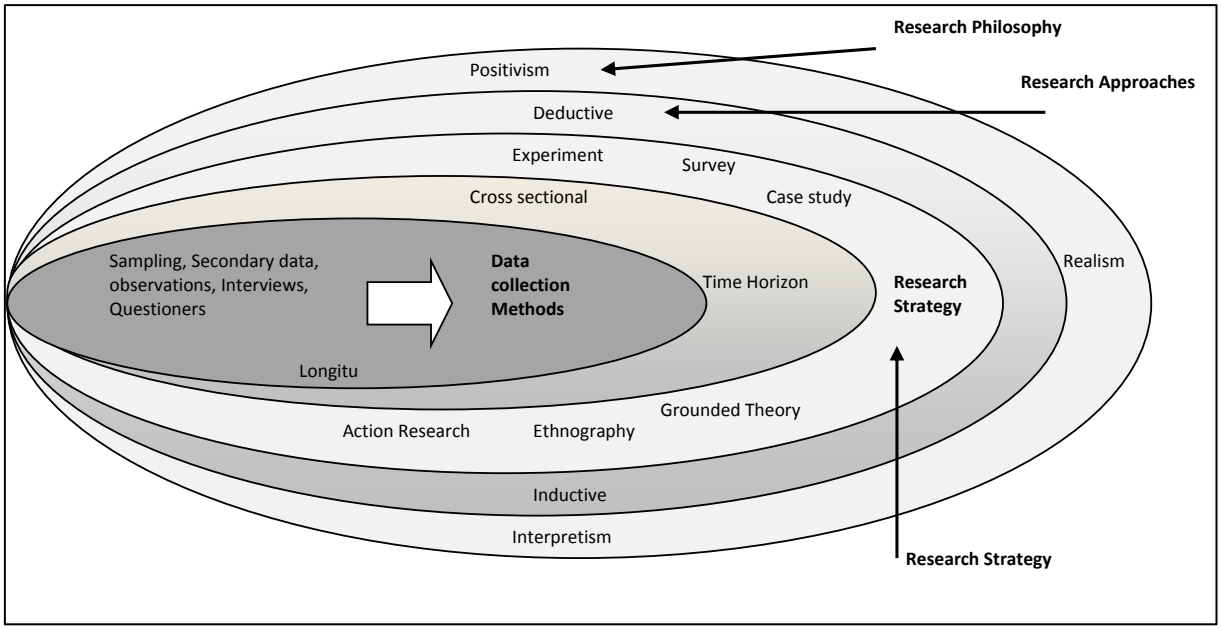

Figure 17: The Research Onion (Source: Saunders et al, 2003)

Rolls-Royce is selected as the case study. This was decided for a variety of factors, the topic and industry was well known to the author and so a great deal of knowledge could be applied to the case study from the perspective of the role in the supply chain the author has. Secondly, Rolls-Royce is a global company and so there are opportunities to look across multiple sectors in the business to understand how the business works.

The method of action research shown in figure 17 was adopted. Action research is a more of a holistic approach to the problem solving rather than a single method of collecting and analysing data. Researching in this approach is actively participating to continuing changing business environment by 'working and learning'. The main aim of Action research is the researcher entering into the situation to gather data generate results and monitor results.

In the fourth stage of the research journey the author formulated a plan to effectively monitor key stakeholders, activities completing in timely manner, progress and associates risks arising through the investigation.

In the fifth stage the author was required to collect information. Data could be described as qualitative or quantitative. As already discussed Qualitative data are in form of words, where quantitative data is in form of numerical values. There are two main categories when referring to data; primary data which includes questionnaires, observation, focus group and interviews and secondary data. Secondary data are the ones that have already been collected by other researchers. There are three main categories of secondary data, documentary, survey-based and multiple source data. The most important methods for collecting data by the most researchers are primary data. The author decided to use both quantitative and qualitative data, from both primary and secondary data. Primary data uses the form of observation and secondary data used multiple sources such as internal Rolls-Royce data and external data from several journal papers, internet websites and books.

The sixth stage is concerned with the analysis of the data. The author identified a best practice area by combining with the current situation identified with elements from best practice in the literature and paid particular attention to lesson learned and limitation of implementing new framework.

The final stage presents all the findings and drives both academic and industrial conclusions and recommendations for how to implement a framework and the decision that should be made based on the new set of metrics.

3.3 Limitations

The author works closely with the problem and has a vested interest and direct responsibility to work with the metrics described in the study as part of the role.

The constraint of time in being able to both work on the study and being able to carry on with day to day activities.

4 Case Study: Rolls-Royce PLC

4.1 Introduction

The purpose of this chapter is to analyse the case study of Rolls-Royce by looking at the current framework for supply chain non-financial metrics and to look at the delivery metrics in particular. The data and metrics that are gathered in this section are derived from the current metrics portfolio that exists in the supply chain. The author publishes these and is a point of contact for the supply chain on all of the delivery metrics that are outlined in this chapter.

4.2 Customer Value Stream and the Supply Chain

As previously shown in figure 4 the structure of the supply chain consists of being made up of different Supply Chain Units (SCU's) which deliver to the Customer Facing Business Units (CFBU's) in order for them to build engines for the customer.

This structure allows for a straight forward method of reporting in a horizontal fashion i.e. along the commodity chain, however this is a very insular view and does not take into consideration the performance of the individual projects like Trent 700 or Trent 900 for example.

The need to be able to report by customer value stream has become increasing important in the supply chain in order to show how the business is performing to the customer, thus linking to the strategy laid out by John Rishton of putting the customer first.

Figure 18 below is an illustration of how the projects intersect the SCU's to show the customer value stream view of the supply chain and how each SCU has an accountability to deliver to the customer.

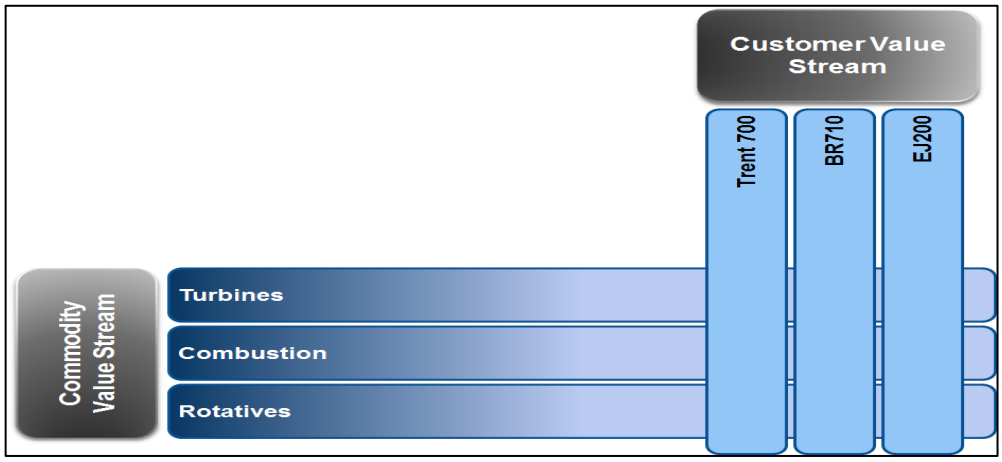

Figure 18: Integrating the customer value stream

Being able to dissect the metrics by customer value stream is becoming an increasing request in the supply chain and the deficiency and ability to robustly do this will be discussed later in the chapter. The next section will look at the current non-financial delivery metrics in the supply chain.

4.3 Current Supply Chain Metrics

This following section will show what the current agreed and functionally bought off metrics that drive the supply chain. It is important to note that these are the metrics that are owned and governed centrally in the supply chain, and there is a tendency for areas to create versions of metrics that are not signed off by the Head of the function as an agreed method for creating a metric.

Table 3: Supply Chain Metrics (Source: Rolls-Royce intranet)

Quality	Disruption Index ('000s) Manufacturing Process RFT Scrap £m (converted to %age for KPIs)
Cost Reduction	Standard Cost Improvement (£m) Continuous Improvement (£m) Cost Reduction Resources FTEs
Delivery	Internal Delivery Performance External Delivery Performance Days of Arrears (Days)
People	Total Reportable Incidents Rate Absence%
Strategy	Strategy Development Milestones Strategy Implementation Milestones
NPI	NPI Milestone Adherence

Table 3 shows the official metrics that are used in the supply chain to manage performance. The purpose of putting in the entire array of metrics is to illustrate the lack of a delivery focus for these, additionally, the point can be made that they are all commodity focused with none of them focused on customer performance, such as on time delivery to purchase order.

4.3.1 Reviewing the Metrics

In order to identify the potential areas for improvement the delivery metrics from table 3 will be transferred into the model identified in section 2.4.4 by Neely. To make the model more applicable to the case study of Rolls-Royce some changes will be made to the axis labels, on the horizontal axis internal and external focus will be replaced by short and long term in order to illustrate if the metrics are forward looking or rearward looking. The vertical axis will be modified to read Supply Chain and Customer instead of Financial and Non-Financial, this is to identify if the metrics are orientated towards the customer.

What the aim is from this application of the model is to flag if there are any missing areas in the delivery metrics that are not currently measured.

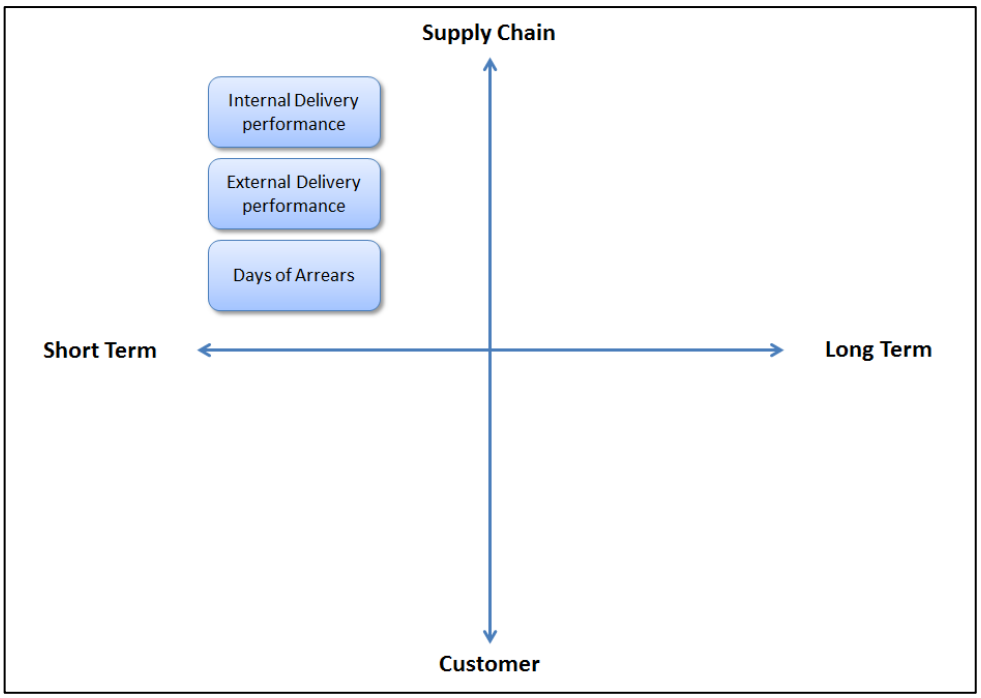

Figure 19: Current Delivery Metrics Mapped Using Neely Model

Figure 19 shows that there is a heavy weighting of metrics that are orientated towards the short term supply chain purpose, with no metrics that have a longer term view of the supply chain and also zero metrics that measure the performance to customer via project or holistically.

It is important to note that the above metrics can all be derived for the executive ERP system which is SAP in Rolls-Royce and are also available to all users via Business Warehouse (BW).

4.3.2 Non-standard Metrics

Through the latter part of 2011 there was a drive to create a central way of reporting to show the performance to the customer i.e. to purchase order, this later evolved into adding the performance to the internal Sales Order Review Board (SORB) plan which was an effort to illustrate how Rolls-Royce performance to their internal master schedule plan.

The author was central in creating and collating the information for this across the sectors and it was quickly adopted as a way of showing delivery performance.

This created several issues, firstly the metric was not bought off by the sectors as a formal way of showing delivery performance, and secondly it involved the CFBU's sharing sensitive information about their success or indeed failure of delivering finished products to the customer.

Figure 20 is another version of the axis model, but it now has the additional measure of delivery to customer purchase order and delivery to engine plan completion.

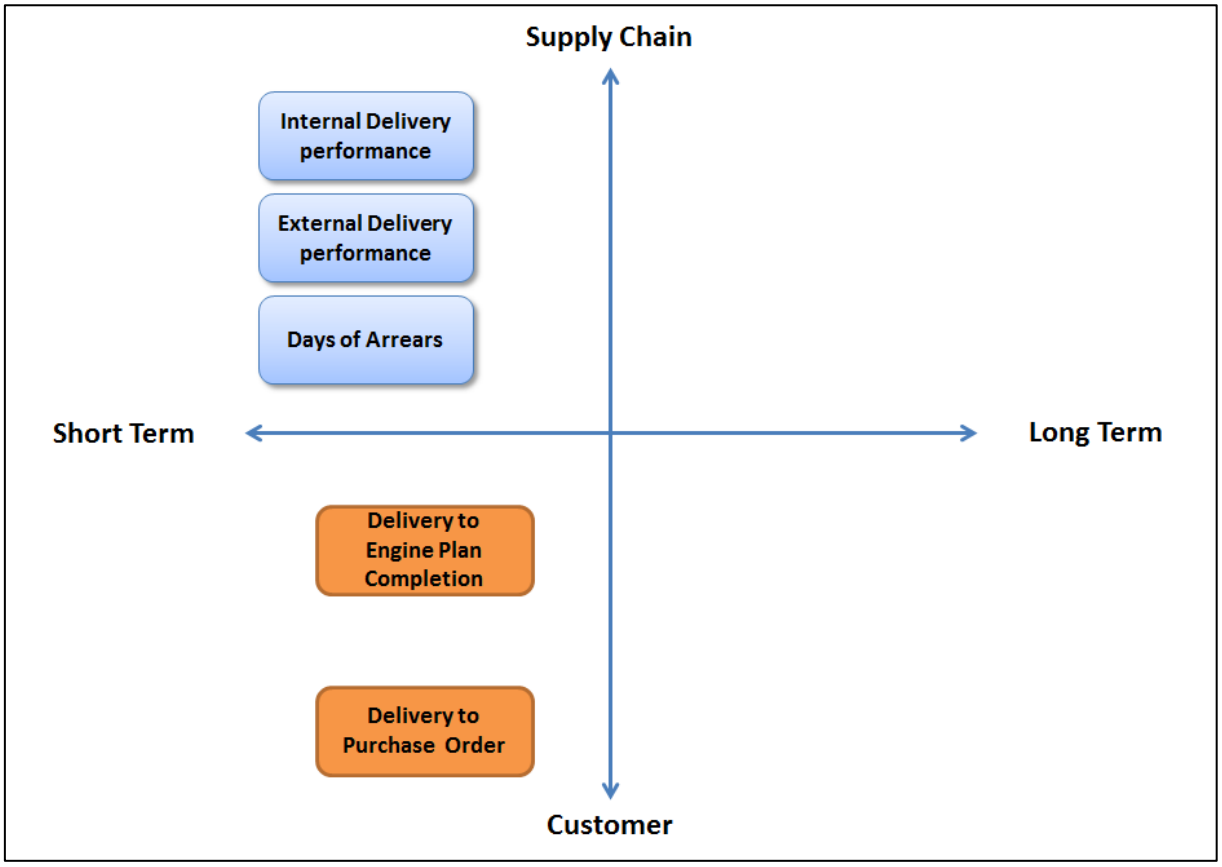

Figure 20: Additional Metrics Added to Axis Model

Figure 20 shows the additional metrics highlighted as amber to indicate that they are not formally agreed metrics bought into by the sectors with targets set for them, also to demonstrate if the performance is acceptable or not to the business. What these do show however, is performance to the customer, all be it in the short term filling a gap shown in figure 19. This is one of the reasons why these metrics were adopted so quickly by the seniors in particular because they started to show the performance of the supply chain to the customer.

Now the current metrics have been shown as an overview it is worth giving a brief description of each of the metrics and showing the points in the supply chain that they currently measure.

Table 4: Description of Current Supply Chain Metrics

No.	Metric	Description	Source
1	External Delivery Performance (%)	Performance of the suppliers delivering into Roll-Royce, measured by using schedule line adherence.	System Data (SAP)
2	Internal Delivery Performance (%)	Performance of the internal plants, measured by using consignment release (Conrel) adherence.	System Data (SAP)
3	Days of Arrears (Number)	Measured by totalling the value of arrears each SCU owes and dividing it by 1 days output in value.	System Data (SAP)
4	Delivery to Plan (%)	Master schedule plan adherence	Off System
5	Delivery to Purchase Order (%)	Purchase order delivery adherence	Off System

The full detail of how each metric is calculated can be found in appendix 1.

The reason for showing the source in the third column as part of table 4 is to illustrate that not all the metrics are derived from the executive SAP system, a point which will be discussed in the next chapter. Metrics 4 & 5 are shown as 'off system' which is defined as being kept in a non-central source and typically resides in a spreadsheet of some description.

4.3.3 Supply Chain Map

Each of the metrics in table 4 measure different points of the supply chain and to help show this in the context of Rolls-Royce figure 21 is a supply chain map, that has each of the metrics represented at the point at which they are intended to measure the supply chain.

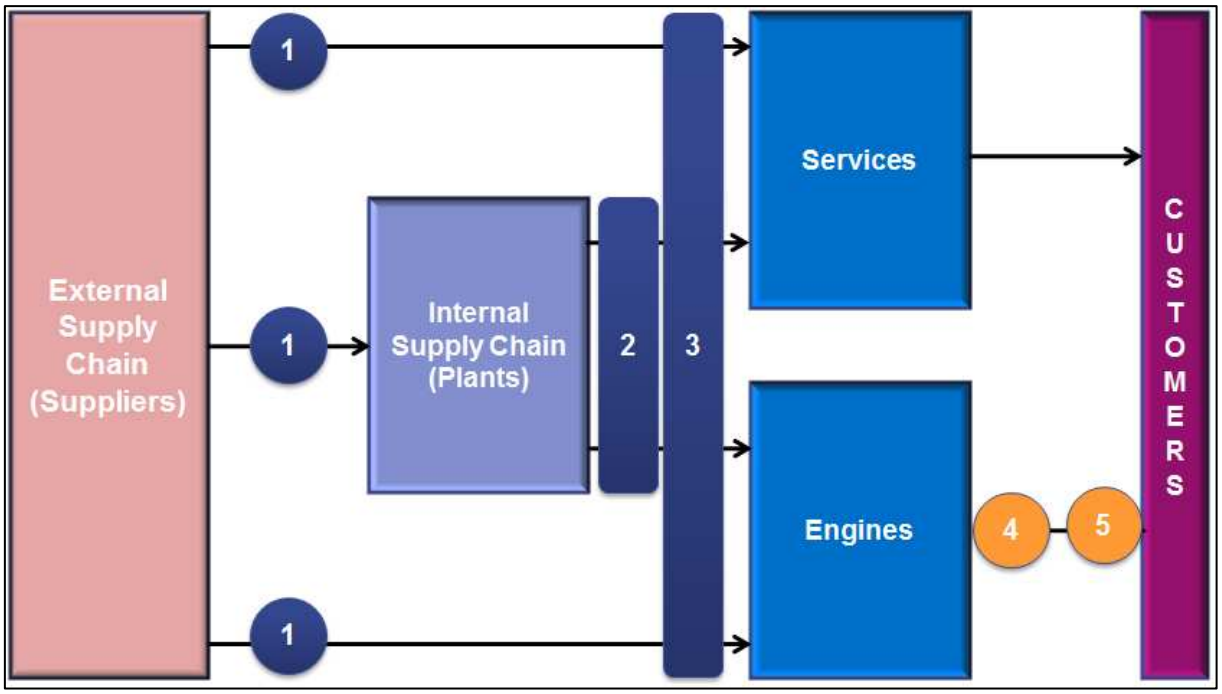

Figure 21: Generic Supply Chain Map with Measurement Points

Figure 21 makes use of the seven step framework that is suggested by Lambert & Pohlen (2001) in section 2.4.5, as part of the supply chain mapping exercise and understanding the linkages in the supply chain before designing a measurement framework.

Using the supply chain map shows how few customer focused metrics in the supply chain there are and those which are available are not official measurements. In particular, there is a lack of services focused customer metrics that mirror the same purpose as metrics 4 and 5, the discussion chapter will address this point in more detail and offer a solution for the gap identified here.

4.4 Problems Encountered with Current Metrics

The following points made are some of the core issues that affect the current portfolio of metrics. From the literature these can be categorised into Process, People and IT. These areas will be discussed further in the next chapter.

4.4.1 Process - Customer Focused

As the organisation has started to evolve into a more customer focused organisation and becoming more customer value stream aligned, the established metrics shown in table 4 (metrics 1-3) have become less pertinent to the supply chain. An example to explain this further is that the internal performance of an SCU can be explained in detail via the delivery performance, getting down to the most granular part number if required.

The problem occurs when the metrics are tried to be cut via the value stream as shown in figure 18. This is where a project director will ask what the performance of the supply chain is or an individual SCU for a project such as the Trent 700 or Joint Strike Fighter. There is no simple robust method for creating a correct metric for this, the reason being is that the reports that exist in the SAP system are not set up to cope with this demand, hence the evolution of non-standard metrics like the PO performance calculations (metrics 4 & 5) occur.

Towards the end of 2012 there was a work stream to improve the SAP system, requiring material master fields to have a value stream field incorporated, this would allow the reports to be redesigned accordingly to allow them to be dissected along the customer value stream. This new field will be utilised in the proposed framework in the following chapter in order to have a more balanced set of metrics for the supply chain.

What this issue promotes is a lack of understanding of how problems in the supply chain that affect the delivery performance. As described in the literature review the primary role of measuring the supply chain is to quantify its efficiency and effectiveness, this is not happening now the organisation is becoming more customer focused.

4.4.2 People - Sharing Information

The benefit of deriving the metrics for the executive system as is the case with metrics 1-3, is that it can be done with little bias and requires a lower amount of effort to maintain them. Essentially it allows the organisation to report on what is exactly in the system, without it being locally adjusted. Overall it promotes the supply chain to improve data integrity, so if an issue is highlighted or a low score is identified it can be recognised and resolved accordingly.

The issue with sharing information occurs specifically with metrics 4 & 5 in table 4 where sensitive information is required to show the performance to the customer and to the internal master schedule plan by each CFBU. The reason this is sensitive is that it can show the relative performance of the CFBU and if they are missing the customer contracts or not, which can cause emotion if it were published to the directors of the company. What this cultivates is a blame culture within the organisation and breeds a level of mistrust in sharing the information with the rest of the supply chain. The CFBU's tend to want to keep this type of data to themselves rather than sharing it along the entirety of the supply chain to help promote understanding of the company's position and where it is relative to its targets.

4.4.3 IT - Systems

The importance of having a robust IT system to enable effective supply chain management has been shown in the literature review (section 2.5.1), and in particular Simchi-Levi et al (2003) points out the objectives for such activity as single source data and decision making based on total supply chain information. Both these objectives are not currently achieved within the Rolls-Royce supply chain due to a fragmented system approach rather then driving information to be in the executive SAP system. As pointed out earlier in the chapter there is a tendency for information that is used for metrics to be 'off system', encouraging a grey area on how the information is shared with the supply chain.

The issue with this is that it means the data is not accessible to the supply chain community and becomes a question of who to ask, rather than which Business Warehouse (BW) report should be run to give the correct answer.

The following chapter will discuss this in more detail in reference to the proposed framework and why it is a key enabler for success.

4.5 Conclusion

This chapter has described the current framework for the supply chain non-financial metrics and shown them in two diagrams, firstly in the Neely axis model which was adjusted to suit the case study and secondly, as part of a supply chain map in order to demonstrate the points at which the metrics measure the supply chain.

The core problems that are currently evident with the framework have been described and highlighted three areas that are causing difficulties in showing accurate supply chain performance. The underlying issue highlighted here is that the current metrics do not meet the needs of the matrix organisation and is further underpinned by the change in aligning the Aerospace division, as described in the introduction. This shows a requirement that the measurement framework for the supply chain needs to be changed accordingly.

5 Framework Proposal and Discussion

5.1 Introduction

This chapter will propose a new framework that can be used in the Rolls-Royce supply chain and link the current theory to the proposal to help assess potential improvements and areas to be considered in the design and implementation phase.

It is important to make the point that since the re-organisation of the Aerospace division there has been a project initiated that is proposing a new framework for the supply chain metrics. The author of this study is a key participant in the project which is at the development stages and so the proposed framework in this study is what the finished solution should resemble given the research into the literature, and will be used as the proposal to the business of how the measurement framework might look like.

5.2 Developing the Framework

In order to gain a structured approach to developing the framework the implementation framework from Bourne et al (2000) will be used from the literature review which will integrate some of the other tools discussed. This hybrid approach will utilise the best elements identified in the research to create a suitable proposal.

The Bourne framework found in figure 6 breaks down the process into three main phases: design of measures, implementation of measures and the use of measures. The following sections will follow the same structure. During the implementation section of this chapter the three factors that can impact the framework, people, process and IT, will be discussed.

5.2.1 Designing the Measures

In the design phase the key part is to identify the objectives that the metrics should be used for and also what the measures are, the following is the proposal of what the objectives should be for the supply chain metrics.

- Metrics should be easily understood and each has a clear singular purpose.
- All metrics should be "through the eyes of the customer" and therefore they need to agree to the method of measurement.
- Each metric must measure:
    - Of what should have been done, how much was done and how timely was it.
    - Of what wasn't done, how much and how late.

- Each performance metric should have:
    - A target which can be compared against actual performance.
    - A trend of previous performance.
    - A prediction of future performance.
- Measurement points must be against universally agreed points on a generic supply chain map.
- The basis for each measure is common at all levels (although the data elements may change).

These objectives are derived from the experience the author has of being in a reporting function and also combining the theory that has been discussed earlier. The theory that has been used is namely from the points made by Lambert & Pohlen (2001) in section 2.3 which discuss the need to expand line of sight within the supply chain and encourage cooperative behaviour across corporate functions.

The objectives also point towards the necessity of having the ability not only to show the historic trend but also being able to attempt to predict the future performance in the supply chain. This considers the points made in the literature review from Unahabhokha et al (2006), on the topic of predicting delivery performance by moving away from the practice of looking backwards.

5.2.2 Supply Chain Mapping

From mapping the supply chain in section 4.3.3 as suggested by Lambert & Pohlen (2001), it was apparent that there are some gaps in where the metrics are required, mainly on the services side of the supply chain.

Figure 22 is a revised version of the supply chain map described in the previous chapter, the map now shows a more balanced approach to measuring the supply chain with the additional measurement points highlighted in green. These points have been identified through the simple process of visually analysing the previous supply chain map and looking identifying areas where a measurement point should exist to balance out the existing metrics. What each of the points measure will be explained in table 5 shortly.

They also encourage more of a customer view of the supply chain particularly in placing measurement points that mirror the engines metrics (4 & 5) at the services point of delivery to customer.

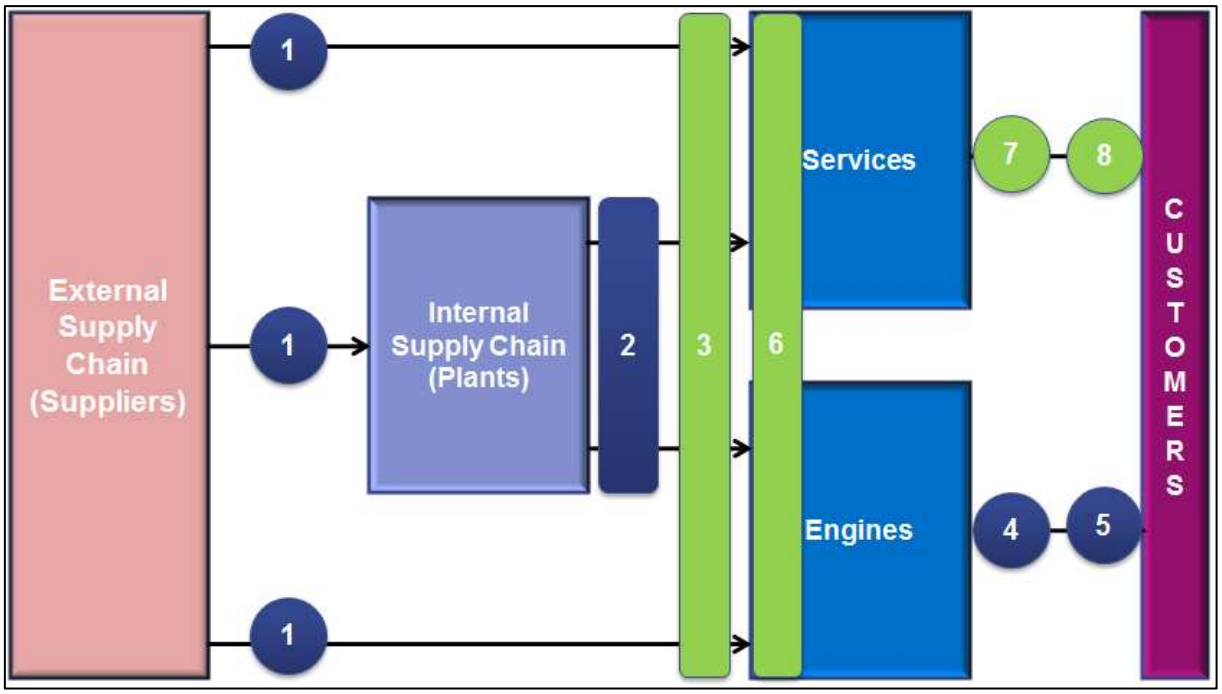

Figure 22: Revised Supply Chain Map

The supply chain map now shows that there is a measurement point along most of the track points in the supply chain, indicated by the arrows. The ability to view these metrics at this level will enable a degree of insight into supply chain bottle necks and delivery issues as highlighted by Gunasekaran & Kobu (2007).

The difficulty with the proposal is deciding which are the best metrics to use in the areas identified in figure 22 to measure the supply chain correctly. Through the literature review the SCOR model in section 2.4.2 identifies some key delivery metrics that are used as part of the standardised tool kit in table 2. Some of the metrics used are already in place for Rolls-Royce, such as delivery performance, so it is logical to retain these.

5.2.2.1 Data Design

Although this framework is focused on the types of measures it is important to understand the data design and the type of information that is required for the business to measure itself with a value stream focused view. Each of the arrows on the supply chain map represent a delivery item in effect. The proposed framework design will try to accommodate a cause and effect culture that will be carried out in various levels of the supply chain. This mainly highlights the need for a decision making framework that will build on the literature cited from McKay et al (1995).

To allow this framework to work effectively something will need to be undertaken that is a built in function in SAP called 'soft pegging'. Soft pegging will enable allocation of material delivery line to an Engine Serial Number (ESN) for certain tracks.

What this allows the business to do is look down the value stream to see where the issues and bottle necks are because the material is pegged to that engine.

Soft pegging would be a great risk to Rolls-Royce because it will remove some of the flexibility in the planning process by committing material to engines. #the complexity of this activity must be tested thoroughly within the business, but would provide a significant advantage in understanding the delivery issues in the supply chain.

In creating the framework it is important to understand the types of data fields that are required to build such a framework before proposing the metrics as it will help form the types of information required from SAP.

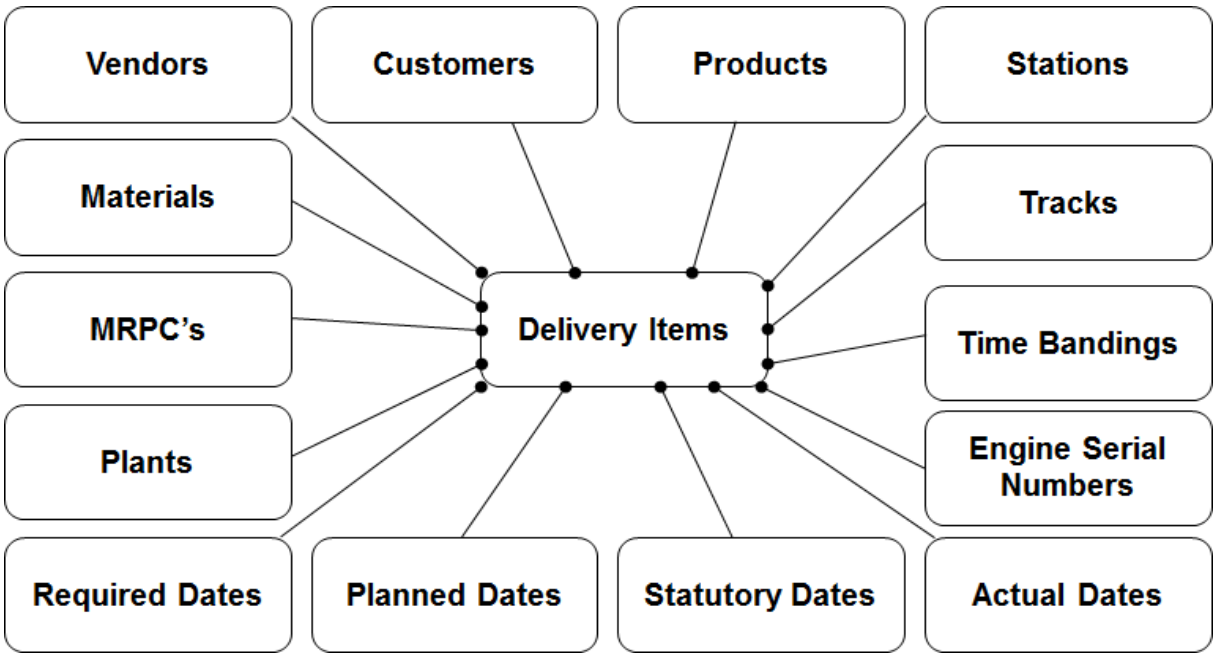

Figure 23: Data Design Model

The types of data fields identified in figure 23 from SAP would provide a flexible capability that could easily answer many complex delivery performance questions at various points in the supply chain map. It would also resolve the inability to cut data via the different value streams as both SCU and customer value stream fields are utilised in the data design.

Now that the types of data and the areas in the supply chain map have been identified that need to be incorporated into the framework, the next stage is to propose the metrics that should exist in those spaces to measure the supply chain.

5.2.2.2 Proposed Metrics

Table 5 is the description of each of the new metrics that are to be used in the proposed framework, they are numbered 1-8 and reference to the supply chain map in figure 22. The first metrics 1 & 2 have not been changed from their original description and purpose, this is a deliberate point as they are already embedded into the supply chain and see no reason to change them.

Table 5: Metrics Proposal

No.	Metric	Description
1	External Delivery Performance (%)	Performance of the suppliers delivering into Roll-Royce, measured by using schedule line adherence.
2	Internal Delivery Performance (%)	Performance of the internal plants, measured by using consignment release (Conrel) adherence.
3a	Days of Arrears (Value)	Measured by totalling the value of arrears each SCU owes.
3b	Day of Arrears (Longest Pole)	A measure of depth to show the latest part in the supply chain for the customer
4	Delivery to Plan (%)	Master schedule plan adherence
5	Delivery to Purchase Order (%)	Purchase order delivery adherence
6	Demand Coverage	Measures the availability of material when the build arrear requires it to start build activity
7	Order Fulfilment Lead Time (TAT)	Length of time it takes to fulfil the contractual time agreed with the customer for engines back into service
8	Fill Rate (%)	Rate at which the customer orders are fulfilled for agreed terms of business

Metric 3 which measure the arrears value in the supply chain has been split into two parts, 3a is now a value which shows the total of arrears in a financial context, 3b is now a longest pole calculated in days. The longest pole will give a view of depth of the arrears designed to complement the first part.

This is important because for example the highest value parts in arrears may not be affecting the customer but are highlighted because of their comparative worth to the business. The addition of longest pole therefore shows what are the worst parts affecting the customer from the point of when the part will be supplied, a customer could in theory be held up for a bolt as much as a rotatable disc.

Metrics 4 & 5 remain the same and are in place to measure the engine build portion of the supply chain. Metrics 6 – 8 are taken from the SCOR model in table 2 and renamed slightly to help make them understandable in the supply chain. By that it is meant that versions of these already exist in the business but not standardised and centralised to make them accessible to the supply chain as a whole. The naming convention will help the change management process and eases one of the blocking factors identified by Bourne et al (2002), of effort required for implementation.
If the audience are already familiar with some of the naming conventions this will aid the overall roll-out of the framework to the business.

The reason for adopting similar metrics to the SCOR model is due to the point highlighted by the Supply Chain Operations Council, that standardising metrics can allow companies to benchmark effectively and easily improve performance.
Metric 6 is proposed in the framework to provide a more customer orientated view of the supply chain's responsibility to deliver to the CFBU's. It simply looks at what stock is available for a build facility to start activities, whether it is to overhaul an engine or start new build. It is an aggregation of two of the SCOR model metrics namely Production Flexibility and Inventory Days of Supply, this is because it is looking at whether production can build what is required and the levels of inventory that are in stock to do so.

Metrics 7 & 8 are in place to measure the delivery to the customer for the services part of the business. Order Fulfilment Lead Time or Turn Around Time (TAT), as specified by Rolls-Royce is taken from the SCOR model. TAT is designed to look at how quickly the engines are overhauled once inducted and available for the customer. Fill rate, again taken from the SCOR model, is to measure the point at which once an order is placed by the customer it is fulfilled by Rolls-Royce normally on 5 days terms of business.
The point should be enforced again that these metrics are taken from existing types of methods in the supply chain, but brought together act as an overall measurement system for the supply chain.

To visualise what the framework looks like now, the metrics have been defined, the axis model from Neely will be populated to see if the framework improves the balance of the metrics across the supply chain, for both the customer and internally.

Figure 24 is the revised axis model that was suggested by Neely et al (2002) to identify the strengths and weaknesses in the frameworks. It is now populated with metrics 1-8 in the relevant measurement points for the supply chain. It is evident that there is an improvement in the balance of the framework by having a better number of metrics that align themselves to the customer. Demand coverage also now tries to bridge the gap of looking more into the future to allow some sort of predictive performance measure for the supply chain.

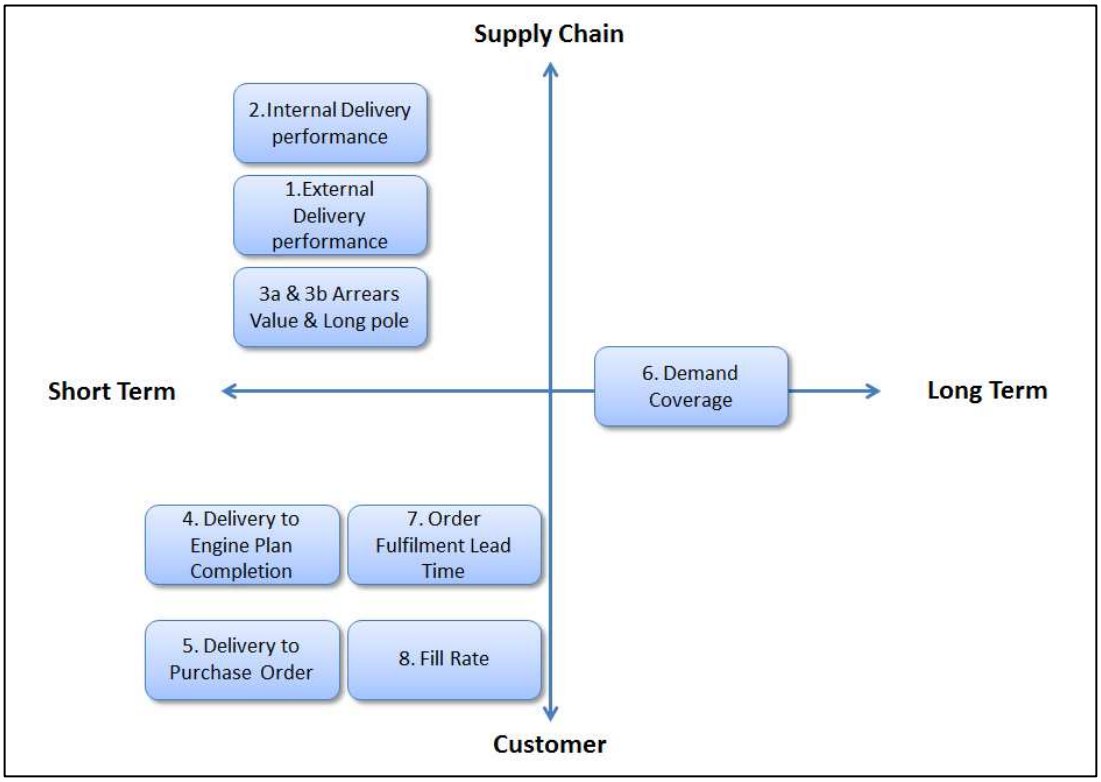

Figure 24: Axis Model with Proposed Metric Framework

To make these metrics relevant to the business and to be able to drive success, the customers is being able to dissect these measures by the two main value streams of commodity and customer as shown in the previous chapter. This particular aspect is dependent on the IT solution, by utilising the relevant SAP fields and making sure that they are maintained to show the correct value stream at part number level.

5.2.2.3 Visual Summary of Proposed Measures

To highlight the proposed changes to the metrics and show where the new areas that are proposed to be measured in the supply chain, the following is the visual comparison of the axis model and the supply chain map that have been discussed in the previous chapters.

Figure 25 shows the two Neely axis models that have been constructed. Although there is an improvement in trying to strike a balance between the supply chain and customer metrics, there is still a gap with the more forward looking metrics. This particular point will be raised in the next chapter in the further recommendations section.

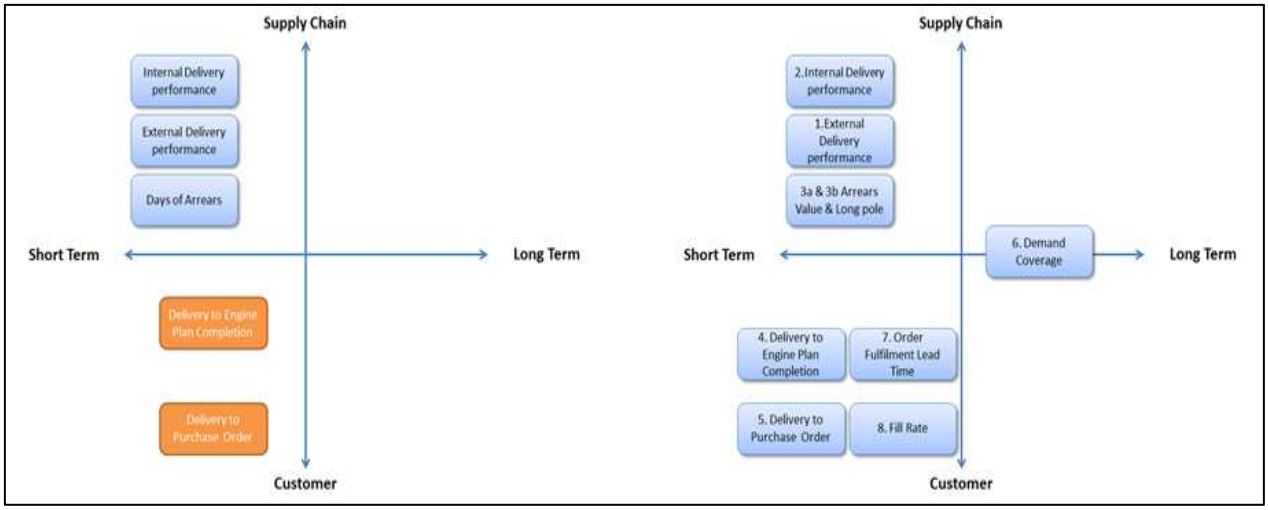

Figure 25: Neely Axis Models Comparison

Figure 26 shows the comparison of the supply chain mapping exercise that was carried out.

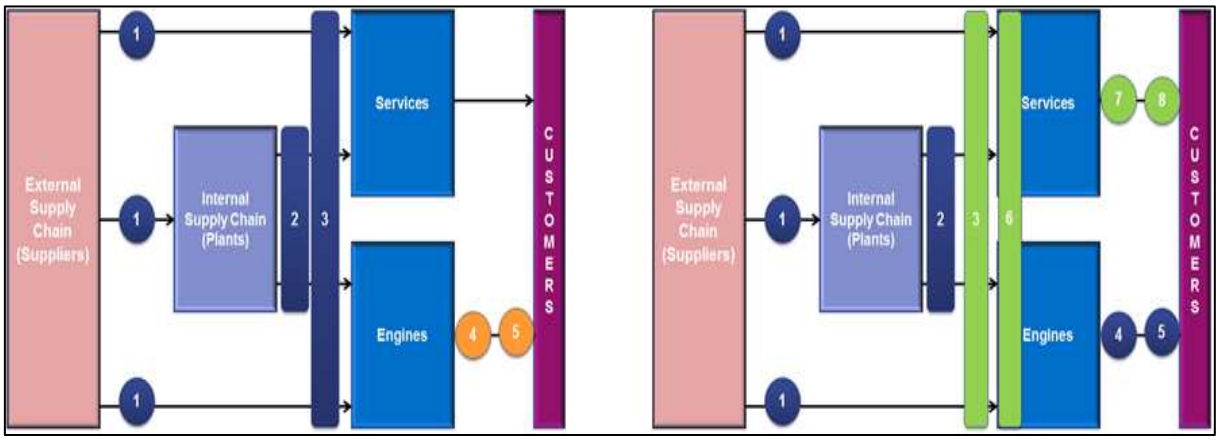

Figure 26: Supply Chain Map Comparison

The supply chain maps in figure 26 also underpin the balance that is sought after with the new measures. It show that there is an equal balance between the new build and services metrics for the customer, as well as having a more forward looking metric in the form of demand coverage (6).

5.2.3 Implementation of Measures

The next phase of the framework proposed by Bourne et all (2000), is to decide how the metrics should be implemented across the business now that they have been defined. The purpose of this section is to outline this implementation phase in the same way that Bourne proposes by looking at collection & collation methods, distribution and the importance of establishing targets. This also builds on the factors impacting the current metric framework from the previous chapter.

These can be grouped into the three factors identified as the most critical factors that can determine success or failure with the metric proposal, as argued by Awad et al (2007), Brewer et al (2000), Bourne et al (2002), Kennerly et al (2002) and Shepherd et al (2006).

The factors that need to be addressed in the implementation and governance phases are:

- People
- Processes
- IT infrastructure

These factors have been identified through the literature review initial analysis of current framework as the areas, where if addressed properly, will lead to a successful implementation of the delivery metrics framework for the Aerospace Division.

5.2.3.1 People

The factors impacting individuals is the challenge with the implementation phase and links with driving it into the culture of the business that the proposed metrics are the agreed way of measuring the business. The areas that need to be overcome are highlighted by Brewer & Seph (2000), as overcoming mistrust and lack of understanding whereas Kennerly (2002) adds that lack of skills is an issue. The area of culture is shown as an area of concern by Bourne, Kennerly and Shepherd, which is mainly generated a lack of understanding of the purpose and design of the metrics as well as making sure the workforce are engaged with the framework.

To overcome these factors the key is the method of communication used when rolling out this metric framework. The proposal would be to do the following:

1. Concise communication brief – Communicate the purpose and reason for change to by identifying stakeholders and target audience. Freely disclose the reasons for changes, where the changes have been made and when they will come into effect.

2. On-line learning - Utilise the current learning platforms in Rolls-Royce which allow an e-learning approach so that an on-line course can be run allowing easy cascade.

3. Up skilling – Target and train the relevant key users in the new framework so that local experts can be established to aid understanding of the framework.

4. Re-enforce through culture statements – As described in the introduction, the drive by the organisation is to put the customer first and make delivery a golden thread. With the communication strategy it is important to link the reasons for change into the culture statements to drive the change of mind set required for making a cultural change.

5. Top down approach – To aid the change management within the business and create a paternalistic culture, making sure the senior management have fully agreed and bought into the framework is imperative.

6. Overcoming mistrust/Sharing Data – This is possibly the biggest challenge as there must be trust in data sharing. This would be tackled by adopting a top down approach and also having a clear communication strategy so the data owners are engaged in the process.

5.2.3.2 Processes

As Kennerly argues the absence of an effective process is one of the key factors for a measurement system to fail. The key area where Brewer and Seph argue that the process area needs to be improved is on the standardisation of metrics. This can be developed for this framework by not only having a set of standard metrics across the Aerospace division, but also making sure that they a standard format, structure and units. This will ultimately aid the transparency of the metrics so that it will help to overcome the mistrust that is highlighted in the previous section.

Both Shepard et al and Brewer et al point out the need for metrics to be aligned to strategic goals and to have the ability to link them to customer value, particularly through the implementation phase. This can be achieved by assigning targets to each of

the metrics and make sure that they are written into employee objectives to create an obvious linkage between the metrics and the individuals performance. This point links with the model from Bourne et al (2000) in adopting a review process for targets so that they are relevant for the business, something which is distinctly lacking at the moment within Rolls-Royce.

Good executive reporting presents information to users rather than just data. It enables businesses to understand not only the "what" of their data but more importantly the "why". To help drive this understanding of why metrics are the way they are, the proposal of how this framework would fit into the governance structure and standard diaries of employees would be beneficial. This would help the business incorporate it into the working day of the sectors and be able to focus on how to resolve poor performance.

In summary the areas that are important in the process factor are:

1. Standard format
2. Transparency
3. Targets aligned to strategic goals and objectives
4. Governance process through standard diaries

5.2.3.3 IT Infrastructure

The platform for this framework is not in scope for this study but through the recommendations and conclusions a suggestion will be made as to which the best solution might be. As pointed out in section 4.3.2, a number of the metrics exist in out of system sources which are an inherent problem within the business. To drive clear, structured reporting the proposal is for this measurement system to be driven from the executive system, SAP, for all source data.

This will require a change in some of the information that is put into the system to make this proposal a reality. It is not a technical issue rather a cultural sharing of information which causes this to become a problem, it will also allow the data to be cut across the customer value stream and the commodity stream.

The reports when generated must be accessible through a central source to provide a non-bias approach to the metrics with clear accountabilities understood around service level agreements for when the data will be available for the business.

5.2.4 Use of Measures

The final part of the model from Bourne for developing the measurement system concerns the use of the metrics. As highlighted in the previous section the suggestion of making sure that the metrics for part of the standard diary for the business is important to help drive the "why" and understand where potential improvements can be made in the supply chain.

Through this section the proposal would be to build on the agile hierarchical planning (A-HPP) paradigm that was discussed in the literature review from McKay et al (1995). What can be taken from this model is that there are benefits to flagging up issues and that it appreciates the multi-level escalation points within an organisation. The reason for this is if an issue is found within the metrics, such as a bottle neck that could cause a potential customer purchase order failure, then there is a hierarchical escalation route for resolution and decision making on the best course of action to be taken. This is important within Rolls-Royce as a priority call may need to be made through the supply chain which only certain levels in the organisation can do.

Table 6: Hierarchical Escalation Model

Level	Role	Action
1	Operational Supply Chain Role (e.g. MRPC)	Checks information and declares potential issue
2	Supply Chain Controller	Escalated to central Customer Excellence Centre
3	Supply Chain Operations Manager	SCOM resolves problem or escalates to SVP/GPE also informs CEC Ops Room and P&C Executive
4	Senior Vice President or Global Purchasing Executive	SVP/GPE resolves problem or escalates to EVP
5	Executive Vice President	EVP resolves or escalates to COO of Supply Chain
6	Project Executive & Head of Value Stream	Disruption Report summarising status and identifying potential

What table 6 is trying to emulate from the A-HPP model is illustrating a structured approach on the best way to escalate and make decisions within the business. Most likely a lot of the issues can be resolved through levels 1-3 as part of the day to day activity and a key driver to this is data integrity.

Ultimately the goal is to provide a clear line of sight for employees when escalation is required through from understanding the metrics that are derived from this framework proposal.

5.3 Potential Limitations

There may be problems encountered when trying to implement this framework so it is worth trying to capture what these may be:

- Cost – The cost of creating this framework would be relatively low in terms of an IT solution, but there would be cost implications around resource required. The implementation process would take some skilled members of the organisation to initiate this and would potentially require a project team, this would mean time out of the day job for some employees.

- Executive System – The premise of this works on the basis that SAP can deliver the required information, and to the authors knowledge the relevant fields exist, but it still remains a potential issue that SAP may require some changes.

- Time – An estimated amount of time would be approximately six months to implement this framework, this could change depending on the above factors and availability of resource.

- Stakeholder Management - Engaging the relevant stakeholders would need to be an immediate action once the framework was agreed. This is highlighted as limitation as the framework would need to be approved so may be subject to change once the sectors and functions are engaged.

- Data Integrity – The framework is based upon a demand of large amounts of data that would be extracted on a weekly basis. SAP relies on teams of employees to keep it up to date with the latest information, therefore this is a limitation as the quality of the framework is based upon the integrity of the data that is put into the system.

- Retiring Old Metrics – This should not be overlooked, some metrics may need to be retired that have been used around the business so that one set of measures remains as the corporate tool set. Capturing what currently exists and their purpose would be the best action plan for this.

5.4 Conclusion

This chapter has introduced the new framework proposal for the non-financial supply chain delivery metrics. It has identified through a combination of industrial and academic information a proposal which builds on the current metrics in place.

Three phases have been identified through this chapter which are:

1. Designing of the measures – by understanding the objectives of what the metrics should be and highlighting the gaps in the supply chain through the mapping stage, a set of proposed metrics have been identified.

2. Implementation – by looking at the lessons learnt from the literature and areas to address while implementing the framework three factors were addressed. People, Processes and IT were discussed as being the important areas to consider in the implementation phase. A particular point is to ensure that the measures are linked to customer value and have targets determined so they can be put into objectives of the employees.

3. Use of the measures – while pointing out that a governance strategy and adoption of this framework into employee standard diaries is important, the critical part of using the measures is being able to make decisions from the information provided. An escalation and decision making structure was proposed but what underpins this is the data quality from the framework which would impact the quality of the decisions being made.

Potential limitations have also been highlighted as areas that would need to be considered when implementing the framework.

The next chapter will conclude and make further recommendations for this proposal.

6 Conclusion & Recommendations for Further Research

6.1 Introduction

The purpose of this chapter is to assess the objectives and the research questions that were posed at the start of the study and understand to what extent they were achieved. The chapter will then look at the recommendations based on this study and any opportunities for further research.

6.2 Achievement of the Aim and Objectives

6.2.1 Aim

The aim was to investigate non-financial supply chain delivery metrics in Rolls Royce Planning & Control function and suggest possible improvements.

This aim was achieved, a framework was identified through a combination of industrial and academic information. The literature review highlighted valuable lessons learnt and potential methods for implementation currently in practice from different practitioners. The case study of Rolls-Royce was discussed and the current framework for metrics was illustrated. The discussion and proposal chapter then outlined the new framework by incorporating areas of the academic research as well as personal knowledge form the author to create a new measurement framework.

6.2.2 Objectives

Objective 1: Review the literature on Supply Chain Management in particular Supply Chain Performance Management.

This objective was achieved as insightful academic research was found in the area of performance measurement systems, which would aid the implementation of the proposed framework in Rolls-Royce. The drawback with the literature was that there was very few cases of Aerospace specific cases found which would of enriched the study further by having a direct industrial comparison.

Objective 2: Identify the current situation on non-financial delivery metrics in Rolls-Royce at the supply chain level.

This was fully achieved and through the methods found in the academic research such as the supply chain map exercise and Neely axis model, the ability to visualise the current metric system was achieved.

Objective 3: Identify areas and reasons for change.

The reasons for change were identified through the study but were mainly concerned with the organisational restructure to the Aerospace division, the need for better customer value stream metrics prompted by the organisation change and finally the drive to place delivery as a golden thread for Rolls-Royce and place the customer first.

Objective 4: Identify areas where the delivery metrics do not adequately support the business.

This objective was met by adopting the supply chain mapping exercise which revealed several areas that were missing measurement points within the supply chain. These in particular were the services side of the business. The other major area that was identified was that they did not reflect the requirement to see metrics via both axis of customer value and commodity.

Objective 5: Investigate potential improvements of the non-financial delivery metrics and propose a new framework.

Through meeting this objective, a new set of metrics was introduced that incorporated the whole supply chain from the supplier to the customer on both services and new build. The framework also discussed the requirement for incorporating the outputs into the governance process and standard diaries of employees in the business and also creating the linkage between the framework and targets through the incorporation of objectives.

Objective 6: Investigate the potential difficulties in implementing a performance measurement system.

The potential difficulties were explained by using the factors highlighted in the literature review under the three areas of people, processes and IT infrastructure. The most challenging of them would be in changing the culture of the business to accept these metrics as part of the standard way of measuring the business. In particular, the area of sharing information was highlighted as the area which would cause the most friction. A number of remedies for this were proposed by adopting some of the academic arguments into the implementation phase of this framework. The fundamental issue is the lack of forward facing metrics where predicting delivery performance is concerned. There is an improvement in the framework where this is concerned but not a substantial forward focused metric. This is due to the complexity of what is involved with when trying to predict the performance of the supply chain.

6.3 Recommendations and Further Research

6.3.1 Recommendations

Implementation Phase: The most important aspect of this study has found that the need for a robust implementation strategy is required which is emphasised through the academic research. The ability to do this in a structured approach would enable this framework to be driven and accepted as part of the culture of the Aerospace Division. The first recommendation is to find an effective programme manager with experience of engaging key stakeholders in the business to help manage the change in the business if this framework was to be adopted.

Data Integrity: What will affect this framework and the decisions that would be based off of it would be the integrity of the data that is drawn from the executive system. The recommendation would be to drive ERP compliance in equal measure to help aid quality of the metrics produced and create a non-tolerance culture of poor quality data.

Long Term View: Being able to predict the performance of the supply chain is complex and difficult given the system that Rolls-Royce uses. The recommendation would be to investigate how other companies are able to predict delivery performance and understand best practice.

User Interface: Although the framework for the non-financial business metrics was discussed, the need for a user friendly front end that allows straight forward access to the metrics would be required. The recommendation would be to utilise some of the current methods inside Rolls-Royce, such as Cognos, an IBM solution, used by the purchasing function. This would require presenting this framework to a vendor so that a interface could be designed, but would incur additional costs to the business.

Executive Presentation Pack: An executive presentation pack that outlines the proposal in this study can be found in appendix 2. The purpose of this is to help engage initial stakeholders around the content of this framework to help summarise the proposals and the reason for change.

6.3.2 Further Research

This study was primarily focused on the Aerospace Division of Rolls-Royce which leaves the Energy, Marine and Nuclear sectors without a framework such as the one proposed. A feasibility study should be carried out to see if each of these sectors are able to adopt a similar framework within each business. It would require understanding each of the sectors and their current reporting capabilities, with the understanding that they are very different from the Civil and Defence business that make up the Aerospace Division.

Now that the framework incorporates metrics that are used in such methods as the SCOR model, then a benchmarking exercise is suggested as a further research opportunity. This can be undertaken once the metrics framework has been established and some meaningful data has been assimilated for comparison purposes.

Finally, the post PC revolution is very much finding its way into organisations globally with mobile devices being recognised as a modern business tool. Businesses increasingly want to view content on these mobile devices, with a lot of vendors now supporting mobile devices such as iPhone or iPad. The recommendation would be to look at the cost associated with developing such functionality and what the security and governance issues would be for a company such as Rolls-Royce. Technically the capability for this exists so the business would need to further define the audience for such capability as it would make the system a leading example in its class with such functionality.

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8 Appendices

8.1 Appendix 1 – Metric Definitions

8.1.1 Internal & External Delivery Performance

Function	Planning and Control
Metric	D1 Delivery performance - Total
First Line Owner	Julian Goulder
Sponsor	Mark Sutcliffe
Report Owner	Mark Jacob
Business Description of metric	Metric shows the number of external vendor schedule lines and internal customer orders fulfilled on time to the day (based on the contracted or statistical due date) for a period as a proportion of the number of schedule lines and internal customer orders required. All items are included except internal customer orders with a CFBU supplying plant. Ownership is indicated by the receiving MRP controller code. Perf (%) = Schedules received + ConRels despatched X 100% Schedules required + ConRels required Arrears are not in scope. Early delivery (outside a seven day early receipt tolerance) is not in scope.
Unit of Measure	%
Aggregation logic (organisation)	Based on items delivered in the period. Aggregated to Sector and Business by Value stream classification code. Aggregated to SCU by MRP Controller code.
Data Source	For Aerospace - BW only. No other sources are allowed. Other businesses should use their appropriate approved reporting system.
Method	Excel workbook will supply summarised information down to SCU and Value Stream. Complimentary BW reports will facilitate drill-down to other levels of detail for Aerospace Division.
Levels and frequency at which the metric will be reported	Weekly, with a summary each Accounting Period

8.1.2 Days of Arrears (Value)

Function	Planning and Control
Metric	Delivery Arrears volume - Total
First Line Owner	Julian Goulder
Sponsor	Mark Sutcliffe
Report Owner	Mark Jacob
Business Description of metric	Metric shows the total value of Customer plant external vendor schedule lines and internal customer orders which are past due based on the contracted date (statistical due date). All items are included except internal customer orders with a CFBU supplying plant. Ownership is indicated by the receiving MRP controller code. Arrears (£) = Sum (CFBU plant schedules past due + CFBU ConRels past due) .
Unit of Measure	GBP, USD, EUR Conversions between currencies are done using the yearly finance fixed exchange rate.
Aggregation logic (organisation)	Based on a snapshot taken at the end of the period. Aggregated to Sector and Business by Value stream classification code. Aggregated to SCU by MRP Controller code.
Data Source	For Aerospace - BW only. No other sources are allowed. Other businesses should use their appropriate approved reporting system.
Method	Excel workbook will supply summarised information down to SCU and Value Stream. Complimentary BW reports will facilitate drill-down to other levels of detail for Aerospace Division.
Levels and frequency at which the metric will be reported	Weekly, with a summary each Accounting Period

8.1.3 Days of Arrears (long pole)

Function	Planning and Control
Metric	Delivery Arrears Long Pole - Total
First Line Owner	Julian Goulder
Sponsor	Mark Sutcliffe
Report Owner	Mark Jacob
Business Description of metric	Metric shows how many calendar days overdue the most overdue Customer plant schedule line or internal order to a Customer plant is based on the contracted date (statistical due date). All items are included except internal customer orders with a CFBU supplying plant. Ownership is indicated by the receiving MRP controller code. Arrears (Long Pole) = Latest (CFBU plant schedules past due, CFBU plant past due ConRels)
Unit of Measure	Calendar days
Aggregation logic (organisation)	Based on a snapshot taken at the end of the period. Aggregated to Sector and Business by Value stream classification code. Aggregated to SCU by MRP Controller code.
Data Source	For Aerospace - BW only. No other sources are allowed. Other businesses should use their appropriate approved reporting system.
Method	Excel workbook will supply summarised information down to SCU and Value Stream. Complimentary BW reports will facilitate drill-down to other levels of detail for Aerospace Division.
Levels and frequency at which the metric will be reported	Weekly, with a summary each Accounting Period

8.1.4 Demand Coverage

Function	Planning and Control
Metric	Demand Coverage performance
First Line Owner	Julian Goulder
Sponsor	Mark Sutcliffe
Report Owner	Mark Jacob
Business Description of metric	The metric is calculated at part number, plant level. It shows the quantity of demands outstanding, which have stock in place as a proportion of the total quantity of demands outstanding. Hence, it is a fill-rate type of measure. All CFBU plants bought parts (internal and external) are in scope. In order that all part number plant data items are treated equally, aggregation is done by averaging the individual performance scores. Ownership is indicated by the receiving MRP controller code. Perf (%) = Quantity of demands outstanding, which have stock in place X 100% Total quantity of demands outstanding Part number plant combinations with no demands outstanding are not in scope. CFBU make parts are not in scope.
Unit of Measure	%
Aggregation logic (organisation)	Based on a snapshot at the end of the period. Aggregated to Sector and Business by Value stream classification code. Aggregated to SCU by MRP Controller code.
Data Source	For Aerospace - BW only. No other sources are allowed. Other businesses should use their appropriate approved reporting system.
Method	Excel workbook will supply summarised information down to SCU and Value Stream. Complimentary BW reports will facilitate drill-down to other levels of detail for Aerospace Division.
Levels and frequency at which the metric will be reported	Weekly, with a summary each Accounting Period

8.1.5 Delivery Performance to Purchase Order

<table>
<tr><td>Function</td><td>Planning and Control</td></tr>
<tr><td>Metric</td><td>Customer Purchase Order Delivery Performance</td></tr>
<tr><td>First Line Owner</td><td>Steve Redden</td></tr>
<tr><td>Sponsor</td><td>Mark Sutcliffe</td></tr>
<tr><td>Report Owner</td><td>Steve Cramp</td></tr>
<tr><td>Business Description of metric</td><td>The On Time Delivery calculation shows the OTD's in that time period as a percentage of the total orders delivered in the same period.

Number of Purchase Orders delivered in the period (on-time to the day or early) / number of Purchase Orders required in the period* x 100

*Period is defined by the current Rolls-Royce AP</td></tr>
<tr><td>Unit of Measure</td><td>% and Volume</td></tr>
<tr><td>Aggregation logic (organisation)</td><td>Based on items delivered in the period aggregated to sector and business</td></tr>
<tr><td>Data Source</td><td>
<table>
<tr><th>Sector</th><th>Exec Owner</th><th>Primary Contact</th><th>Secondary Contact</th></tr>
<tr><td>CLE</td><td>Andy Foulkes</td><td>Andrew J. Shaw</td><td>Alastair Shaw</td></tr>
<tr><td>CSME</td><td>Liam Smith</td><td>Christian Matthes</td><td>Matthias Kunze</td></tr>
<tr><td>Defence UK</td><td>Mike Allen</td><td>Chris Janes</td><td>Rob Crossland</td></tr>
<tr><td>RRNA</td><td>Mike Allen</td><td>Robert Ewoldt</td><td>Tracy Sulya</td></tr>
<tr><td>Energy GT</td><td>David Edwards</td><td>Jose Mendez</td><td>Richard Bannister</td></tr>
<tr><td>Energy Package</td><td>Brad Newman</td><td>Joseph Zeigman</td><td>Brad Newman</td></tr>
<tr><td>Marine</td><td>Paul McFarlane</td><td>Patrick Nowatzky</td><td>Nikolaos Grigoriadis</td></tr>
</table>
</td></tr>
<tr><td>Method</td><td>Microsoft Access database and Excel</td></tr>
<tr><td>Levels and frequency at which the metric will be reported</td><td>Each Accounting Period</td></tr>
<tr><td colspan="2"></td></tr>
</table>

8.1.6 Delivery to Plan

<table>
<tr><td>Function</td><td>Planning and Control</td></tr>
<tr><td>Metric</td><td>Delivery Performance to Plan</td></tr>
<tr><td>First Line Owner</td><td>Steve Redden</td></tr>
<tr><td>Sponsor</td><td>Mark Sutcliffe</td></tr>
<tr><td>Report Owner</td><td>Steve Cramp</td></tr>
<tr><td>Business Description of metric</td><td>The On Time Delivery calculation shows the OTD's in that time period as a percentage of the total orders delivered in the same period.

Number of products completed in the period* (on-time to the day or early) / number of products required in the period x 100

*Period is defined by the current Rolls-Royce AP</td></tr>
<tr><td>Unit of Measure</td><td>% and Volume</td></tr>
<tr><td>Aggregation logic (organisation)</td><td>Based on items delivered in the period aggregated to sector and business</td></tr>
<tr><td>Data Source</td><td>
<table>
<tr><th>Sector</th><th>Exec Owner</th><th>Primary Contact</th><th>Secondary Contact</th></tr>
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<tr><td>Defence UK</td><td>Mike Allen</td><td>Chris Janes</td><td>Rob Crossland</td></tr>
<tr><td>RRNA</td><td>Mike Allen</td><td>Robert Ewoldt</td><td>Tracy Sulya</td></tr>
<tr><td>Energy GT</td><td>David Edwards</td><td>Jose Mendez</td><td>Richard Bannister</td></tr>
<tr><td>Energy Package</td><td>Brad Newman</td><td>Joseph Zeigman</td><td>Brad Newman</td></tr>
<tr><td>Marine</td><td>Paul McFarlane</td><td>Patrick Nowatzky</td><td>Nikolaos Grigoriadis</td></tr>
</table>
</td></tr>
<tr><td>Method</td><td>Microsoft Access database and Excel</td></tr>
<tr><td>Levels and frequency at which the metric will be reported</td><td>Each Accounting Period</td></tr>
<tr><td colspan="2"></td></tr>
</table>

8.2 Appendix 2 – Executive Presentation Pack

Rolls-Royce

Aerospace Metric Framework

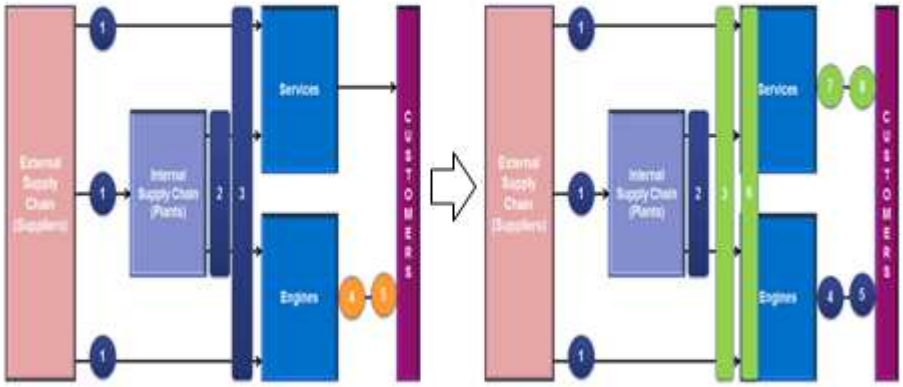
Aim

- Familiarise the P & C Exec community with the new Aerospace delivery performance metrics

Objectives of Metrics

- Metrics should be easily understood and each has a clear singular purpose.
- All metrics should be "through the eyes of the customer" and therefore they need to agree to the method of measurement.
- Each metric must measure:
  - Of what should have been done, how much was done and how timely was it.
  - Of what wasn't done, how much and how late.
-
- Each performance metric should have:
  - A target which can be compared against actual performance.
  - A trend of previous performance.
  - A prediction of future performance.
- Measurement points must be against universally agreed points on a generic supply chain map.
- The basis for each measure is common at all levels (although the data elements may change).

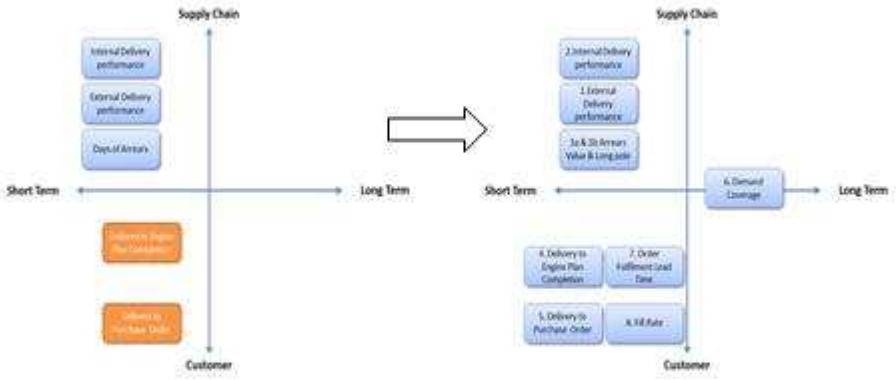
Supply Chain Mapping



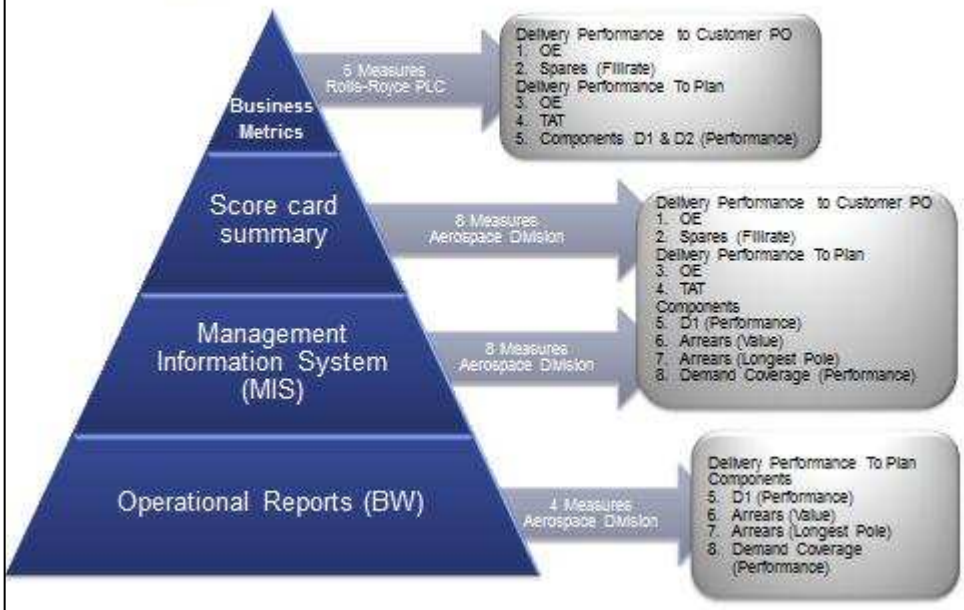
Aerospace Metrics

No.	Metric	Description
1	External Delivery Performance (%)	Performance of the suppliers delivering into Roll-Royce, measured by using schedule line adherence.
2	Internal Delivery Performance (%)	Performance of the internal plants, measured by using consignment release (Conrel) adherence.
3a	Days of Arrears (Value)	Measured by totalling the value of arrears each SCU owes.
3b	Day of Arrears (Longest Pole)	A measure of depth to show the latest part in the supply chain for the customer
4	Delivery to Plan (%)	Master schedule plan adherence
5	Delivery to Purchase Order (%)	Purchase order delivery adherence
6	Demand Coverage	Measures the availability of material when the build arrear requires it to start build activity
7	Order Fulfilment Lead Time (TAT)	Length of time it takes to fulfil the contractual time agreed with the customer for engines back into service
8	Fill Rate (%)	Rate at which the customer orders are fulfilled for agreed terms of business

Neely Axis Model



Delivery Metrics hierarchy



Hierarchical Decision Making

Level	Role	Action
1	Operational Supply Chain Role (e.g. MRPC)	Checks information and declares potential issue
2	Supply Chain Controller	Escalated to central Customer Excellence Centre
3	Supply Chain Operations Manager	SCOM resolves problem or escalates to SVP/GPE also informs CEC Ops Room and P&C Executive
4	Senior Vice President or Global Purchasing Executive	SVP/GPE resolves problem or escalates to EVP
5	Executive Vice President	EVP resolves or escalates to COO of Supply Chain
6	Project Executive & Head of Value Stream	Disruption Report summarising status and identifying potential