

**A proposed model for Servitization based collaboration in the UK Aerospace
Defence industry**

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ABSTRACT

In many sectors customers are increasingly seeking service contracts rather than buying products. High tech capital equipment firms attracted by the potential revenue benefits are choosing to move from supplying product only to supplying product and services. This concept is known as 'Servitization'. Through empirical evidence the academic literature has shown that businesses face challenges in undertaking the transformation from product to service provision and that organisational, cultural, commercial and operational challenges have the potential to erode the desired and expected benefits sought from such a transition. The research presented in this thesis investigates and identifies the features and challenges of servitization in the context of a complex engineering service provided by the UK Aerospace Defence industry. The research also explores the reported costs and front of mind costs for the provision of a complex engineering service. Particular attention is given to the problem of less than expected profitability during and post transformation to service. This research adopts a qualitative approach through the use of a single case study with multiple case examples of the complex engineering service. Findings identify a number of challenges associated with the transformation from product to service provision that include strategy, organisation and enterprise management, contracting, risk, culture and operations. Considering these findings holistically it is suggested that a paradigm shift needs to occur, changing both managers perspective and the business models employed if the firm is to provide a sustainable service offering. New ways of structuring and managing the enterprise to deliver the service value proposition will be required. This will include the development of performance management of all operations across the enterprise required as a minimum to ensure optimum performance of service delivery at lowest cost.

TABLE OF CONTENTS

1. INTRODUCTION (p10)

1.1 Research context and aim (p.10)

1.2 Research questions and objectives (p.11)

1.3 Literature review (p.12)

1.4 The research framework (p.13)

1.5 Research methodology (p.13)

1.6 Potential contribution to knowledge and practice (p.14)

1.6.1 Proposed contribution to knowledge (p.14)

1.6.2 Proposed contribution to industrial practice (p.15)

2. LITERATURE REVIEW (p.16)

2.1 Literature review introduction (p.16)

2.1.1 Literature review objectives (p.16)

2.1.2 The scope of the literature review (p.17)

2.2 An introduction to servitization (p.18)

2.2.1 Servitization (p.18)

2.2.2 Different characteristics of products and services (p.19)

2.2.3 Development and definitions of servitization (p.21)

2.2.4 Product Service Systems (p.23)

2.2.5 Service dominant logic (p.24)

2.2.6 Performance based contracting (p.27)

2.2.7 Complex engineering service systems (p.28)

2.2.8 Perceived benefits and transformation (p.29)

2.2.9 The service paradox (p.33)

2.2.10 Summary of an introduction to servitization (p.35)

2.3 Interacting theoretical features of servitization (p.42)

2.3.1 Competence (p.43)

2.3.2 Value (p.46)

2.3.3 Enterprise (p.54)

2.3.3.1 Enterprise development (p.55)

2.3.3.2 Business models (p.56)

2.3.3.3 Organising for complex engineering delivery (p.59)

2.3.3.4 Interdependence (p.64)

2.3.3.5 Enterprise imaging (p.67)

2.3.4 Performance (p.71)

2.3.4.1 Performance management (p.72)

2.3.4.1.1 Performance measurement (p.72)

**2.3.4.1.2 Supply chain and performance
measurement (p.76)**

2.3.4.1.3 Service measures (p.77)

2.3.5. Cost (p.81)

2.3.6 Summary of the interacting features of servitization (p.88)

2.4 Servitization literature review conclusion (p.95)

2.4.1 Conclusion (p.95)

2.4.2 Servitization literature review timeline (p.96)

3.RESEARCH METHODOLOGY (p.99)

3.1 Executive summary (p.99)

3.1.1 Overview of research activities (p.101)

3.1.2 Constructivism the theoretical perspective of the research (p.102)

3.1.3 The research approach (p.103)

3.1.4 The case study (p.108)

3.1.5 The interview, ethics and analysis (p.111)

3.1.6 Assessing the quality of business research (p.121)

3.1.7 Research methodology summary (p.124)

4. CASE STUDY FINDINGS (p.126)

4.1 Introduction (p.126)

4.2 Detailed research findings (p.129)

4.2.1 Servitization (p.130)

4.2.1.1 Typhoon support, the need for change (p.131)

4.2.1.2 Transformation (p.133)

4.2.1.3 Equipment design and arisings (p.138)

4.2.1.4 Summary of servitization case study findings (p.148)

4.2.2 Competence (p.151)

4.2.3 Value (p.156)

4.2.4 Enterprise (p.162)

4.2.5 Performance (p.168)

4.2.6 Cost (p.177)

4.2.6.1 Typhoon programme costs and targets (p.179)

4.2.6.2 Individual cost findings (p.181)

4.2.6.3 Simulation of different availability recovery approaches (p.191)

4.3 Summary of case study findings (p.197)

5. DISCUSSION (p.199)

5.1 Introduction (p.199)

5.2 Challenges of servitization (p.200)

5.3 A business model for service (p.209)

5.3.1 Customer segmentation (p.212)

5.3.2 Value proposition (p.213)

5.3.3 Channels (p.214)

5.3.4 Customer relationship (p.214)

5.3.5 Revenue streams (p.215)

5.3.6 Key resources (p.216)

5.3.7 Key activities (p.217)

5.3.8 Key partnerships (p.220)

5.3.9 Business model summary (p.222)

5.4 Performance management (p.224)

5.4.1 Service enterprise performance management (p.225)

5.4.2 Performance measurement (p.227)

5.5 Managing interdependency and the decoupling point shift (p.230)

5.5.1 A definition for dependence (p.236)

5.6 Cost (p.238)

5.6.1. Detailed analysis of cost findings (p.240)

**5.6.2 Simulation of different availability recovery approaches
(p.244)**

5.7 Summary of discussion (p.250)

6. CONCLUSION (p.254)

6.1 Introduction (p.254)

6.2 Research aim, methodology, literature review and case study (p.254)

6.2.1 Research aim, questions and methodology (p.254)

6.2.2 Literature review (p.255)

6.2.3 Case study (p.256)

6.3 Research proposals (p.257)

6.4 Summary (p.261)

6.5 Further research (p.261)

6.6 Personal statement (p.262)

7. REFERENCES (p.263)

8. LIST OF FIGURES (p.283)

9. LIST OF TABLES (p.285)

10. APPENDIX (p.287)

10.1 Servitization literature review, individual extracts (p.287)

10.2 The analysis of front of mind costs (p.290)

10.3 Additional focused literature review, research paradigms and methodologies and servitization literature (p.314)

10.4 Background information UK Ministry of Defence, BAE Systems and GE Aviation (p.323)

10.4.1 BAE Systems (p.323)

10.4.2 Typhoon (p.324)

10.4.3 GE Aviation (p.325)

10.4.4 The UK Ministry of Defence (p.326)

1. INTRODUCTION

This chapter introduces the research. It commences by presenting the research context, aim, questions and objectives. Sections covering the research framework, proposed literature review, research methodology and anticipated case study activity follow this. The potential contributions to knowledge and practice are subsequently presented.

1.1 Research context and aim

Through the review of relevant literature and the case study of the Typhoon service enterprise this research leads to a better understanding of servitization and its challenges, its performance management and costs where a complex engineering service is provided. From goods to service, price to value proposition, and value added to co-creation, the research examines multiple aspects of servitization.

This research on servitization is undertaken as part of the Costing for Avionic Through-Life Availability project. The UK Ministry of Defence, BAE Systems, and GE Aviation in partnership with the University of Bath, the University of the West of England and Loughborough University launched the project in 2011. Funded by the Innovative electronics Manufacturing Research Centre and the Engineering and Physical Sciences Research Council, the project has a target to understand servitization and establish a new cost modelling approach for the provision of a complex engineering service.

The aim of this research is to examine servitization in order to develop an improved understanding of how a firm can best transform to the servitised state. This includes creating an understanding of servitization and its features, including the challenges of servitization, how value is co-created and how to improve performance management across the service enterprise where interdependent activity exists. Achievement of the above supported by an analysis of front of mind costs will help identify and develop an appreciation of the costs arising where a complex engineering service is provided.

In particular the literature review has identified the problem of lower than expected profitability during and post servitization, labelled as the servitization paradox (Neely, 2008; Baines and Lightfoot, 2009; Ng, et al., 2011). The servitization research proposes to address the paradox and to provide a better understanding of how a firm might best transform itself from one that produces goods only, to one that also delivers service. The research will examine why the paradox occurs and what steps may be taken to address

the phenomena ensuring improved levels of benefit for all. The challenge of understanding why the paradox occurs specifically applies to the case study service enterprise where the MOD would like to reduce cost and the provider BAE Systems would like to increase levels of benefits.

The centre of the study is the Typhoon support service enterprise comprising the UK Ministry of Defence, BAE Systems and G.E.Aviation. The exploration of servitization and subsequent discussion has a natural focus towards servitization within a complex aerospace equipment context.

1.2 Research questions and objectives

The underlying research questions to achieve the above aim are as follows:

- What are the features and challenges of servitization where a complex engineering service is being provided?
- What performance management should be established at the level of the service enterprise?
- What are the reported costs and front of mind costs for the provision of a complex engineering service?

To address the research aim and gain a better understanding of servitization and its management, including improved insight into the servitization paradox the following specific objectives have been identified:

- Conduct an in-depth literature review of the concept of servitization, in order to gain a thorough understanding of key features and challenges related to its implementation. This will include the examination of transition challenges, value co-creation, interdependence, and enterprise and performance management. Specific attention will be given to the problem of lower than expected benefits, labelled the servitization paradox.
- To review and evaluate the existing performance management of the Typhoon service enterprise and investigate new performance management arrangements that can be used to improve business performance. This will include a review of the current performance management of the support service, enterprise wide management and supplier performance and how that relates to the problem of lower than expected benefits.

- To identify the reported costs and front of mind costs of the Typhoon service enterprise as a result of providing a complex engineering service. Special attention to be given to the cost impact of stakeholder interdependence.

1.3 Literature review

The literature review is designed to provide a detailed understanding of servitization, from its introduction, through changes to business dynamics to the latest conceptual thinking. The literature review is structured in four sections. The first section provides a detailed introduction to the literature review highlighting its scope and objectives. The second section explores and reviews servitization from the early definitions to latest concepts including the value added view, Product Service Systems, service dominant logic and complex engineering service systems (Smith, 1776; Levitt, 1972, 1976; Thomas, 1978; Zeithaml, et al., 1985; Vandermerwe and Rada, 1988; Vargo and Lusch, 2004, 2007, 2008; Neely, 2008; Spring and Araujo, 2009; Zott and Amit, 2010; Macintyre, et al., 2011). This provides a basic understanding of literature to date. The third section explores and reviews the interacting theoretical themes of servitization that have been identified as recurrent in the literature. These identified themes are subsequently used to build a research framework that inform and direct the research (see 1.4 The research framework and “3.1.3 The research approach” for details). Literature includes competence (Penrose, 1959; Andrews, 1971; Wernerfelt, 1984; Prahalad and Hamel, 1990; Barney, 1991; Parry, et al., 2010), value co-creation (Ramirez, 1999; Frei, 2008; Spring and Araujo, 2009; Ng, et al., 2011) and value in use (Prahalad and Ramasway, 2000, 2003 2004, Vargo, 2008; Ng, et al., 2011), enterprise (Bowen and Ford, 2002; Oliva and Kallenberg, 2003; Baines, et al., 2009; Martinez, 2010; Baines and Lightfoot, 2012; Mills, et al., 2012; Parry and Mills, 2013) performance (Maskell, 1989; Kaplan and Norton, 1992, 1996; Neely, et al., 1995; Beamon, 1999; Meyer, 2002; Slack, 2007) and cost (Newnes, et al., 2008; Scanlon, 2006; Castagne, 2008). This provides an understanding of the interacting features of servitization. The third section also introduces the theories of the resourced based view of the firm, the knowledge based view of the firm and theory of social capital (Wernerfelt, 1984; Bourdieu, 1986; Coleman, 1988; Barney, 1991; Spender, 1996; Grant, 1996; Widen-Wulff and Ginman, 2004). This provides an understanding of how relationships can be improved and how businesses can be developed. Supply Chain management theory (Porter, 1985; Duffy and Fearne, 2004; Poirier, 2004; Lambert, 2006) and complexity

theory (Anderson, 1999; Pascale, 1990) are also briefly introduced in this section in order to gain a better understanding of servitization operational dynamics. The fourth and final section provides the conclusion and literature review findings and a servitization literature timeline. The literature review underpins the production of a research framework, that helps structure and inform the empirical research.

1.4 The research framework

A research framework will be inductively developed from multiple sub themes that are identified as recurrent in the literature as the review progresses. The research framework will be designed to capture the key theoretical and conceptual themes and their interaction together that forms part of the servitization process. The research framework will inform the empirical investigation of the servitization paradox directing the detailed development of the study of servitization and each theme identified. Full details of the links between the literature findings and the research framework are provided in section “3.1.3 The research approach”.

The framework will be used as a common structure for the research. It will provide a structure to develop the case study interview questions against and a structure for the collection of data arising from the case study interviews at BAE Systems, GE Aviation and the UK Ministry of Defence. It will be finally used as a structure to help analyse data and answer questions raised by both the thesis and the project, helping to deliver project direction and research findings.

The framework reflects the trans-disciplinary nature of the research. Due to the complex nature of servitization and the fact that it traverses disciplinary boundaries it has been necessary to adopt this approach.

1.5 Research methodology

The selection of this research methodology is essentially motivated by the research aim, questions and initial literature review findings. The research approach reflects the epistemological position of the constructivist whose inquiry dictates that the positivist subject-object dualism and objectivism be replaced by an interactive monism and that interactivity between researcher and researched be recognised (Guba, 1990). This is achieved by seeing the situation through the eyes of those involved in the running of the business, interacting with objects yet creating their own understanding of those objects

and the situation surrounding them. This is consistent with a view that meaning or reality is constructed by individuals on objects which accommodates a concept that servitization is a recognised phenomenon that is still being shaped and detailed by academics and practitioners. Constructivism allows for an understanding of the objects of the industrial activity, the factory, the process, the product, and the different perceptions of the individuals of servitization and of those objects within it.

The research is based on an inductive approach and is qualitative in nature as the emphasis is on words rather than quantification and comprises a case study approach. The unit of analysis is the enterprise that delivers and supports the Typhoon avionics system. The enterprise comprises the industrial stakeholders BAE Systems, GE Aviation and UK Ministry of Defence. The case study is structured and delivered through three sets of semi-structured interviews at BAE Systems, GE Aviation and the Ministry of Defence.

Finally the research and interaction with industry is partly influenced by the industrial experience of the author who has over thirty years' experience in the Aerospace and Defence industry. Positions held at Messier Dowty, Augusta Westland, BAE Systems and Airbus which all provide an initial product and related services to their respective customers and markets has built experience in sales, programme management, supply chain operations and change management. This provides a significant business understanding of how processes, interfaces and relationships work in practice providing a platform of knowledge against which new ideas and concepts can be initially tested for relevance and practicality. Consistent with the research aim the author has a personal desire to establish an understanding of servitization and its challenges and to develop how the stakeholders can best interact.

1.6 Potential contribution to knowledge and practice

1.6.1 Proposed contribution to knowledge

The aim of the research is to establish a detailed understanding of servitization and build on the existing knowledge discussed in the literature review. Several features will be targeted which will benefit from further specific examination and development and thus provide an opportunity for contribution to operational management knowledge. They include:

- An improved understanding of the business model required for servitization.
- An improved understanding of the impact of interdependence between the enterprise stakeholders.
- An identification of the performance management required to manage a complex service activity.

Finally from the Costing for Avionic Through-Life Availability projects perspective there is an opportunity to contribute to knowledge through the development of a through life cycle cost model for avionics.

1.6.2 Proposed contribution to industrial practice

The Costing for Avionic Through-Life Availability project (CATA) and this research provides pragmatic proposals to the industrialists. Specifically how they can improve certain aspects of their business, by specifically:

- Providing an improved understanding of servitization and how it fits their business model.
- Identifying how they might better manage performance of availability contracting across the service enterprise.
- Providing a new through life cost model for a complex engineering service (delivered by the full project).

2. LITERATURE REVIEW

2.1 Literature review introduction

The scope of the literature review is informed by the research aim and objectives to improve understanding of servitization and the problem of lower than expected returns introduced in the previous chapter. The main aim of the literature review is to gain a better understanding of servitization and to develop a research framework. It commences with an introduction to servitization followed by an exploration of the literature to identify the multiple sub themes that recur and interact during the process of servitization and related theories. The recurrent themes led to more detailed reviews of the literature on competence and the resource based view of the firm, value co-production, co-creation, value in use, supply chain, enterprise, business models and interdependence, performance management and performance measurement and through life cost. It also includes a focus on how performance management has developed to support service activities. The literature review is completed by a short summary.

2.1.1 Literature review objectives

The literature review is designed to explore and review existing literature to develop an understanding of servitization and its challenges, performance management and through life costs. This design is required to answer the research questions detailed in the introduction. The objectives of the literature review include:

- Conducting an in-depth review of the literature related to the concept of servitization, in order to gain a thorough understanding of key features and challenges related to its implementation. This review will examine and consider the literature on the transition challenges, value co-creation, interdependence, enterprise, and performance management and through life cost. The findings will help construct the research framework that will inform the whole research.
- Gaining a greater understanding of the problem of lower than expected benefits labelled the servitization paradox (Neely, 2008) in order to better comprehend why the phenomenon occurs and what improvements can be introduced to improve benefits for all.

- Investigating the key theories underpinning the studies of servitization that can also be used in the development of a research framework. These theories include the resource-based view of the firm, the knowledge based view of the firm, social capital and supply chain theory.

2.1.2 The scope of literature review

The literature review which forms the basis for the development of the research theoretical framework explores studies on servitization and related concepts that discuss the business activities that may change as a firm moves from a product only organisation to one that provides both products and services. This is achieved via a top down and bottom up approach. The top down approach includes a review of recent papers and books from recognised contemporary leaders in the field (Vandermerwe and Rada, Ng, Baines, Lightfoot, Neely, etc.) including the identification and review of authors cited in their seminal papers. A 'bottom up' approach was taken that involves a systematic review of papers on servitization and further analysis of each of the recurrent and interacting theories that are employed by academic authors to describe what was happening during the process of servitization. The themes identified and considered as key are subsequently used to build a research framework (see section 3.1.3 The research approach for details). The literature reviewed includes servitization (Smith, 1776; Levitt, 1972, 1976; Thomas, 1978; Zeithaml, et al., 1985; Vandermerwe and Rada, 1988; Neely, 2008; Spring and Araujo, 2009; Zott and Amit, 2010; Macintyre, et al., 2011), servitization and competence (Penrose, 1959; Andrews, 1971; Wernerfelt, 1984; Prahalad and Hamel, 1990; Barney, 1991; Parry, et al., 2010), servitization and value in use (Prahalad and Ramasway, 2000, 2003, 2004; Vargo, 2008; Ng, et al., 2011), servitization and value co-creation (Ramirez, 1999; Duffy and Fearne, 2004; Frei, 2008; Spring and Araujo, 2009), servitization and enterprise (Bowen and Ford, 2002; Oliva and Kallenberg, 2003; Baines, et al., 2009; Martinez, 2010; Baines and Lightfoot, 2012; Mills, et al., 2012; Parry and Mills, 2013) and servitization and performance management (Maskell, 1989; Kaplan and Norton, 1992, 1996; Neely, et al., 1995; Beamon, 1999; Meyer, 2002; Slack, 2007). Searches against the above words were made against the academic databases available which include Business Source Premier, Emerald and Science Direct. Specific searches have also been undertaken against the resource-based view (Wernerfelt, 1984; Barney, 1991) and knowledge based view of the firm (Grant, 1996; Spender, 1996) social capital (Bourdieu, 1986; Coleman, 1988;

Widen-Wulff and Ginman, 2004) supply chain management (Porter, 1985; Poirier, 2004; Lambert, 2006) and complexity (Anderson, 1999; Pascale, 1999).

The research project has a focus on through life costing of complex engineering projects and the case study unit of analysis comprises three defence and aerospace organisations so this research and literature review adopts is focussed upon the context of aerospace and complex engineering service systems.

2.2 An introduction to servitization

This section explores and reviews the literature on servitization introducing and developing an understanding of the phenomena. The section commences with a brief description of servitization supported by an explanation of the differences between products and services (Zeithaml, et al., 1985; Edget and Parkinson, 1993; Lovelock and Grummesson, 2004; Macintyre, et al., 2011). This is followed by the review of a number of definitions and concepts of servitization including the value added view of servitization (Vandermerwe and Rada, 1988), Product Service Systems (Hockerts and Weaver, 2002; Neely, 2008), Service dominant logic (Vargo and Lusch, 2004, 2007, 2008) and complex engineering service systems (Ng, et al., 2011). The section then highlights the perceived benefits of servitization and reviews an empirical study of the financial reality of servitization. The study reveals returns are not as high as expected, especially for larger servitized firms. The section is completed with a short summary.

2.2.1 Servitization

Servitization is the move by manufacturing companies towards offering goods and services rather than goods alone (Neely, 2008; Baines, et al., 2009; Wilkinson, et al., 2010; Ng, et al., 2011). Refocusing substantial firm activity or transforming the entire firm orientation, from producing output of primarily manufactured goods to a concern providing goods and services can be likened to a revolution in business terms (Vandermerwe and Rada, 1988). This not only involves the provider firm changing the way it thinks and works but also drives change at the customer and through the supply base who all need to play a more active part throughout the product life cycle (Pralalad and Ramaswamy, 2000, 2003, 2004; Poirier, 2004; Zott and Amit, 2010). Servitization is causing companies to rethink their business model and change the way their entire

service enterprise works (Teece, 2010; Macintyre, et al., 2011; Ng, et al., 2011; Meier, et al., 2011).

Both customers and providers are driving the servitization movement. Customers are requesting a service rather than a product and manufacturing firms want to grow their business and increase benefits (Vandermerwe and Rada, 1988; Datta and Roy, 2011). Firms seeking to deliver growth and maintain their share of the market against increasing low cost competition are seeking to supplement the products they offer by providing an array of services to the market. Whilst some only wish to support their own previously delivered installed base, others also offer support to competitors' product (Neely, 2008).

2.2.2 Different characteristics of products and services

Since the eighteenth century goods and services have been viewed as different and described as having different characteristics (Macintyre, et al., 2011). Goods were viewed as; exchangeable having ownership rights (Smith, 1776); tangible having physical dimensions (Senior, 1863); separable from consumption; and homogeneous as like products are produced with the same characteristics (Sasser, et al., 1978; Macintyre, et al., 2011). Service however is viewed as; intangible and only exists in connection to other things; heterogeneous as each service provide a different experience; inseparable as services are inextricably linked with the customer in terms of production and consumption; and perishable as services cannot be stored (Sasser, et al., 1978; Macintyre, et al 2011). The service characteristics are often referred to as IHIP characteristics (Zeithaml, Parasuraman, and Berry, 1985). An extensive literature review in 1985 by Zeithaml, Parasuraman, and Berry of 46 publications by 33 authors (1963-1983), confirmed the above by determining the four most frequently cited service characteristics (Zeithaml, Parasuraman, and Berry, 1985). Intangibility, mentioned by all, inseparability of production and consumption or simultaneity, cited by the great majority, heterogeneity or non-standardisation noted by 70%, and perishability or inability to inventory cited by just more than half of the authors. A further detailed review by Edgett and Parkinson (1993) covering 106 publications during the period 1963 to 1990, yielded similar results. These reviews effectively enshrined the four unique characteristics of services, namely intangibility, inseparability, heterogeneity and perishability, as received wisdom.

However IHIP (intangible, heterogeneous, inseparable and perishable) has attracted opposition, as it cannot be used to distinguish all goods and services because exceptions can be found in every case (Macintyre, et al., 2011). Furthermore the characteristics do not cover all of the different types of services now identified (Lovelock and Grummesson, 2004). Lovelock and Grummesson (2004) therefore proposed a number of alternatives:

- Goods and service marketing views could be reunited under a service banner consistent with the views of Vargo and Lusch (2004).
- Products of manufacturing and services should continue to be viewed differently however the differences among services are equally significant and must be acknowledged by developing separate paradigms for different categories of services.
- A new paradigm should be created to cut across the traditional goods and services dichotomy. This would be labelled the rental paradigm based on the premise that those exchanges that do not result in the transfer of ownership from seller to buyer are fundamentally different from those that do. Services are presented as offering benefits through access or temporary ownership with payments taking the form of rentals or access fees.

Purchasing the right to use proposed by Spring and Araujo (2009) is another example of new thinking. Spring and Araujo (2009) also highlight a growing frustration with the product-centric view of IHIP. However rather than try to further develop Service Dominant Logic they focus on ownership and non-ownership. In doing so they promote their notion of the rental paradigm and the notion of purchasing the 'right to use'.

The difference between product and service characteristics provides a challenge for servitizing manufacturing firms. Challenges arise as many of the management tools and techniques that the new service managers use were originally designed to tackle the challenges faced by product companies. These tools and techniques may now need to be modified or replaced by new ones (Frei, 2008). Organisational structure and mind-set also need to be changed (Barnett, et al., 2013).

The following sections discuss the views of literature on these issues. This includes exploring the potential changes required to organisation, culture and strategic and operational management.

2.2.3 Development and definitions of servitization

Definitions of services date back many several hundred years. In 1750 Physiocrats define services to be all activities other than agricultural production (Alonso- Rasgado, et al., 2004). Furthermore the idea that it is not necessary to buy products to access the benefits they provide is not new. For example, pineapples were first introduced into Europe in the seventeenth century. They were so exotic that they were seen as a symbol of great status. However they were extremely expensive and poorer middle class families would even take to hiring pineapples for occasions when they wished to entertain, in order to appear grand, praying that no one would actually attempt to cut a slice (Wilson 2005). Many less exotic examples can be found with different degrees of complexity. From paint suppliers being engaged to take over painting operations or parents choosing to pay a weekly charge for a nappy laundering service rather than buying baby diapers (Spring and Araujo, 2009) to today's more complex examples such as 'power by the hour' engine service offerings from Rolls Royce (Baines, et al 2009), and Typhoon availability contracting (Barnett, et al., 2013).

Early literature focused on similarities of managerial concepts between products and services rather than differences (Levitt, 1972 and 1976). Here it was proposed that service organisations should adopt a manufacturing approach to providing services and support the industrialisation of services through both hard and soft technologies (Levitt, 1972 and 1976). In detail it was argued that service refers generally to deeds one individual performs personally for another and that methods previously adopted to improve performance had been insufficient. From ancient masters invoking the will of god, to the whip of the foreman, to modern day training programs and motivation sessions, all were considered to be inadequate (Levitt, 1972 and 1976). To correct the perceived poor performance Levitt (1972 and 1976) promotes the adoption of manufacturing style of thinking and action to a people-intensive service situation. To improve efficiency the introduction of equipment (hard technology) to mechanise services and the adoption of systems (soft technology) to control staff behaviour and channel their choices is proposed (Levitt, 1976). Hard technology is the substitute of machinery, tools and equipment for people wherever possible to mechanise service delivery, e.g. airport x-ray to replace the physical check and an automated bank teller replacing the receptionist and clerk. Soft technology is the substitution of organised pre-planned systems for individual service operatives. Whilst some modification of tools

may improve efficiency, essentially it is the systemisation of the process itself that delivers the desired results for both the customer and employee. McDonald's is an excellent example of this. Here we find carefully controlled execution of each outlets central function including the rapid delivery of uniform, high quality mix of prepared foods in an environment of obvious cleanliness, order, and cheerful courtesy (Levitt, 1972).

An alternative to the above is the understanding that service businesses often require different competitive strategies from those of product-oriented companies (Thomas, 1978). Here it is argued that products attain brand name identification in the market whilst service businesses develop a reputation for the type and quality of the service it produces. Managers in servitized firms must think less about brand identification and more about the reputation of the company and that the focus should be on the customer rather than the product (Thomas, 1978; Baines, et al., 2009; Ng, et al., 2011). Equipment-based services are also considered different to people based services and each should be managed in a different way. Equipment and systems can be used to improve efficiency. Elimination of unnecessary parts of a service and the introduction of cheap labour to replace expensive can cut costs (Levitt, 1972, 1976; Thomas, 1978). Literature also suggests that changing the language system of a servitized company can deliver benefits (Thomas, 1978). Due to manufacturing being the dominant force of the last century, most managers have been educated through experience to think about strategic management in product-oriented terms. As product thinking is irrelevant to the management of many service businesses the managers need to talk about services instead of products. The managers will then start to think about services and those characteristics that make services unique (Thomas, 1978). The introduction of Service Dominant Logic (Vargo and Lusch, 2004, 2007 and 2008) further develops the above idea of different language for service. This is considered an alternative to Goods Dominant Logic and includes some subtle but significant ideas that are discussed later in this section.

As the move of manufacturing firms to supply services as well as product developed the movement became known as servitization. Vandermerwe and Rada (1988) presented the movement as one in which companies consciously develop their businesses into services to gain competitive ground. They propose by adding services to core products already supplied firms differentiate their offering from competitors, increasing

customer dependency and establishing barriers to competition. Here servitization is described as value added where servitization is discussed in terms of adding services to products (Vandermerwe and Rada, 1988). From this period forward interest and understanding of servitization further increased with De Toni, et al. (1994) proposing servitization as a change in management philosophy. De Toni, et al. (1994) re-evaluated service as an integral part rather than a secondary part of the supply transaction with importance before and after the moment of the object supply. Furthermore Robinson, et al. (2002) highlighted the importance and benefits of relationships between the supplier and customer and believe servitization has the ability to deliver differentiation providing an escape from the cost leadership strategies of the product provider. These definitions and understandings have been followed by a number of new concepts including Product Service Systems (Hockerts and Weaver, 2002; Neely, 2008), Service Dominant Logic (Vargo and Lusch, 2004, 2007, 2008) and Complex engineering service systems (Ng, et al., 2011). These concepts are explained below.

2.2.4 Product Service Systems

Product Service Systems (PSS) capture the different ways products and services can be delivered. Hockerts and Weaver (2002), established three types of Product Service Systems, and Neely (2008) added a further two types making five PSS categories in total. Each type of PSS offers a different combination of product or service offering:

- *Integration oriented Product-Service System* involves going downstream by adding services through vertical integration. Ownership of tangible product is still transferred to the customer, e.g. financial services, consulting, transportation. One way of thinking about PSS is by thinking of products plus services.
- *Product oriented Product-Service System* is when the ownership of tangible product is transferred to the customer, but additional services directly relate to the product provided e.g. design and development, installation, maintenance and support.
- *Product-Service System* is where the services are incorporated into the product itself. Ownership of the product is still transferred to the customer but additional value added services are offered e.g. Health and usage monitoring.

- *Use oriented Product -Service System* is delivered through the product. Often ownership of the tangible product is retained by the service provider, who sells the functions of the product, via modified distribution and payment systems, such as sharing, pooling and leasing.
- *Result oriented Product Service System* seeks to replace the product with a service, doing away with the need for the product, or certainly an individually owned product. An example would be voicemail services where the service itself replaces the need for individuals to own their own answering machines.

The five Product Service System categories can be further broken down into multiple different individual forms of service that manufacturing firms can offer. Neely (2008) identified 12 servitization strategies, which are listed in decreasing prevalence:

- design and development services
- systems and solutions
- retail and distribution services
- maintenance and support services
- installation and implementation services
- financial services
- property and real estate
- consulting services
- outsourcing and operating services
- procurement services
- leasing services
- transportation and trucking services

2.2.5 Service dominant logic

Business logics are not academic theories, but instead capture the practical linkages made by manager's with regards to their mental representation of the world, as constructed from their experience and their likely response to change (Kiesler and Sproul, 1982). A dominant logic refers to the shared mental maps which groups of managers use and develop as part of core business operations (Ng, et al., 2011). Business in general has been developed around the dominant logic of tangible goods.

Adam Smith's (1776) declared that for a country 'production' means the creation of surplus tangible goods that could be exported to enhance national wealth. Since this declaration the lexicon of economics, business and society in general has been developed around the logic of tangible goods (Vargo and Morgan, 2005). The goods centred lexicon of product, production, goods, producer and distribution reflects more than just the words to talk about goods. It reflects an underlying paradigm for thinking about marketing and exchanges in general (Vargo and Lusch, 2007) and can be called Goods dominant logic. Here value is established in exchange when product ownership is exchanged for payment. The Goods dominant logic mind-set becomes a problem for discussing and describing a counter-paradigmatic view such as Service dominant logic as it often becomes necessary to employ the Goods dominant logic lexicon to describe the Service dominant logic foundation. Vargo and Lusch (2007) argue it is crucial we find new labels and phrases that help us think and conceptualise and then act afresh. Vargo and Lusch (2007, 2008) are leading a discussion across a community of scholars developing a new logic called Service dominant logic. This importantly introduces a shift from use of the term services (plural) reflecting a special type of output, an intangible product to be exchanged, to the term service (singular) reflecting the process of using ones resources for the benefit of another entity. In the latter goods are not referenced and service is the primary focus of exchange activity (Vargo and Lusch, 2008).

Service dominant logic proposes that a firm's value proposition is realised through co-creation with the customer (Vargo and Lusch, 2007). Vargo and Lusch (2007) believe a firm cannot satisfy a customer but can only collaboratively support value co-creation. Vargo and Lusch (2007) reframe the purpose of the enterprise and its collaborative role in value creation for both the actors involved in exchange and for society by proposing a foundational premise based on the following points:

- Service is the fundamental basis of exchange.
- Service is defined as the application of competences (knowledge and skills) for the benefit of another party.
- The customer is always a co-producer of value.
- Exchange can be conceptualised as relationships rather than transaction and quality viewed in terms of customer perception rather than engineering standards.

- Operand resources, tangible, static resources that require action to make them valuable are replaced by Operant resource. Operant resources are intangible, dynamic resources capable of acting on other resources to create value.
- The unit of analysis shifts from one of product to one of value creation and the concept of co-creation of value is further supported.

The following table developed by Parry (2011) builds on Vargo and Lusch (2008) and captures how goods and services thinking differ in relation to the approach to market.

Differences of Goods and Services

Transitional Concepts		
Goods	Services	Service
Products	Offerings	Experiences
Feature/attribute	Benefit	Solution
Value-added	Co-production	Co-creation of value
Profit maximisation	Financial engineering	Financial feedback and learning
Price	Value delivery	Value proposition
Equilibrium systems	Dynamic systems	Complex adaptive systems
Supply chain	Value-chain	Value creation network
Promotion	Integrated marketing communications	Dialog
To market	Market to	Market with
Product orientation	Market orientation	Service-dominant logic



Servitization

Table 1. Goods v Service, different approaches to market (Parry, 2011)

As a step change in thinking Service dominant logic has attracted many comments from the academic community. Some comments have been positive whilst others have been adverse and include differing views on the advantages and implications of SD logic and the sales function and involvement in value in use (Bolton, 2004; Aitken, et al., 2006). Vargo and Lusch (2006, 2007, 2008) however have used all of the comments positively to further discuss and develop their ideas. As one of its own foundational premises implies, the value of service-dominant logic is necessarily in its open, collaborative effort. Thus, the authors invite and welcome both elaborative and critical viewpoints to discuss recurring contentious issues among collaborating scholars, as they attempt to understand the full nature and scope of service dominant logic.

2.2.6 Performance based contracting

In addition to providers and suppliers seeking to move from product or product and services to service, the customers are also seeking new arrangements in which to cut costs reduce risk and improve the service. New ways of contracting are now being considered and used especially for high cost, high technology and long life products (Datta and Roy, 2011). Hence the customer pull is reinforcing the servitization movement.

Performance based contracting also referred to as Outcome based contracting (Ng, et al., 2009) is replacing traditional separate spares purchase and maintenance and repair contracts. Customers are now focusing on what is required in terms of equipment operations rather than how a facility is to be delivered according to a set of technical specifications (Gruneberg, et al., 2007). Defence organisations such as NATO and OCCAR-EA are increasingly recognising PBC in their guidelines, RTO 2007 (Ramaroson and Aliberti, 2010). Furthermore the UK Ministry of Defence are increasingly using availability based contracting, a variant of performance based contracting for the procurement of UK defence equipment.

“Underpinning the strategy is the need for an end-to-end and through life view that optimises logistics support solutions and provides opportunities and incentives for industry to align with DEandS capabilities and responsibilities”, UK Ministry of Defence, (2011).

Specific examples are the multi-year aircraft availability contract between the UK Ministry of Defence and BAE Systems for the Tornado aircraft (Mills, et al., 2009) and

the more recent five-year availability contract between the same parties for the Typhoon aircraft (BAE Systems, 2009). Here the customer contracts through life support based on equipment availability levels as opposed to traditional purchasing on demand. In addition to Aerospace and Defence other industries are also developing performance based contracting. This includes the provision of locomotives, elevators, machine tools, machinery and equipment (Hypko, et al., 2009).

Different approaches to performance based contracting can be established. The manufacturer can supply and support. In this case the supplier firm finances and retains the ownership of the machinery or equipment. Alternatively the performance provider can take over only the support activity and risk necessary to make the machinery or equipment available. The payment model can differ from the customer paying on availability or for the performance he actually demands (Hypko, et al., 2010).

Performance based contracting is an example of a result oriented industrial PSS (Data and Roy, 2011) and affects the way in which the supply network interacts with responsibilities redistributed based on target outcomes (Alonsa-Resgado and Thompson, 2006). Here all parties need to understand the process competencies and assets required to deliver the customers desired performance level. This can be best managed by sets of performance measures agreed between the customer and supplier (Datta and Roy, 2011).

2.2.7 Complex engineering service systems

A contemporary view of service within a complex aerospace equipment service context is the complex engineering service system. This view was developed to understand the challenges and activities of availability contracting or outcome based contracting (Ng, Parry, Wild, McFarlane and Tasker, 2011). Here new understanding is captured within an organisational transformation framework describing the new service activity replacing the past product only exchange on delivery arrangement. A transformation model comprising a system of dynamic activities and processes is central to the concept transforming three elements to co-create value in use. Co-creation is explained as the simultaneous transformation of information, materials and equipment and people involving the customer, provider and suppliers to deliver value (Ng, Parry, Wild, McFarlane and Tasker, 2011). Furthermore complex engineering service competency is viewed as the ability of the firm to design, deliver and manage the entire complex

engineering service that is able to carry out the three transformations in a consistent, stable and profitable manner co-creating value in partnership with the customer (Ng, Parry, Wild, McFarlane and Tasker, 2011). The literature on complex service engineering systems starts to explore and explain how complex service is delivered. More research of this type based on appropriate case study activity is required to further understand the dynamic.

2.2.8 Perceived benefits and transformation

Manufacturing firms are progressively moving towards offering services and believe there are multiple opportunities to secure increased benefits and longevity (Vandermerwe and Rada, 1988). The manufacturing firms seeking to deliver growth and maintain their share of the market against increasing low cost competition are more than ready to supplement the products they offer by providing an array of services to the market. Whilst some only wish to support their installed base, others become more adventurous offering support to competitors' product (Oliva and Kallenberg, 2003). Customers are also demanding a product complete with a service or even a service rather than a product (Datta and Roy, 2011). The perceived benefits of moving to servitization include the following:

- Firms believe that increasing services will deliver higher margins (Gebauer and Friedle, 2005).
- Offering Services as well as Products increases the level of differentiation (Vandermerwe and Rada 1988).
- More competitive service offerings are potential opportunities for firms to become more strategic business partners with their customers thereby improving customer retention (Anderson and Narus, 1995).
- Creating greater business value for customers through service offerings can reduce competition (Vandermerwe and Rada, 1988).
- Service offerings can increase deal size and enable firms to access new markets (Krishnamurthy, Johansson and Schliissberg, 2003).
- Advanced services are more difficult to imitate than goods and thus more extensive industrial services could become a source of competitive advantage (Oliva and Kallenberg, 2003). Here manufacturing firms are often well

positioned to undertake a transition into services as they have a deep knowledge of their products and market (Neely, 2008).

Once the decision to servitize has been taken the firm has to decide how much it wishes to develop and what it needs to do to achieve such a move.

Oliva and Kallenberg (2003) propose an approach where the provider takes the initiative and plans a structured progressive step-by-step approach towards the servitized state they desire (Oliva and Kallenberg, 2003). The first step involves the consolidation of existing services (currently required) providing a basis for future focus. This is seen as logical with potentially little resistance from the workforce (Oliva and Kallenberg, 2003). The second step is an initial move into the installed market base offering a mix of income from both product and services. This second step requires capital investment and motivation of staff (Oliva and Kallenberg, 2003). The third step is the expansion into the installed market base. This is either by a product centred approach based on availability and response or by a process centred service approach where integration of equipment into the customer value chain is the objective. Both moves require increasing levels of change. The former requires a move from a transactional interface with the customer to a relationship-based interface offering a service for a fixed fee over a period of time. Here the supplier takes the risk of failure. The latter involves moving the value proposition from the products operational performance to the products efficiency and effectiveness within the customer's process. Here technical application, partnering and networking all need to be mastered. The final transition involves taking on responsibility for the end users process. This transition is only likely to happen if the firm is firmly established in the maintenance and professional services market (Oliva and Kallenberg, 2003).

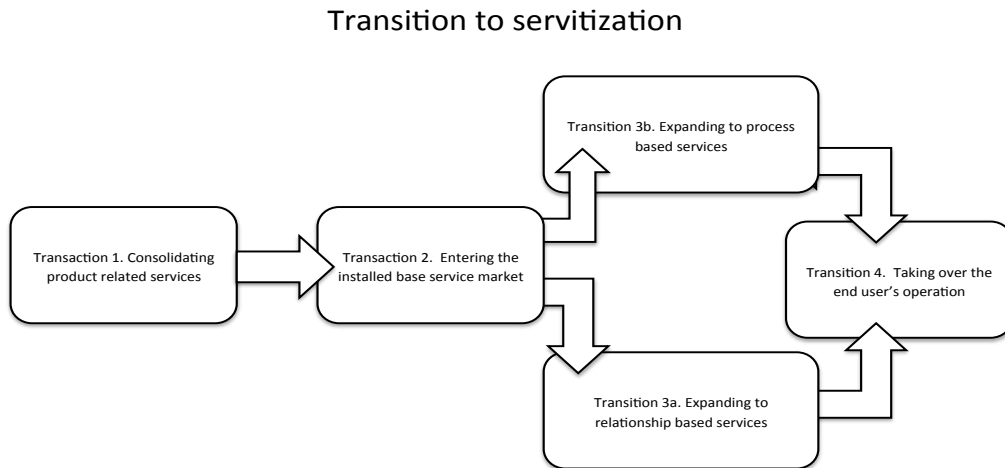


Figure 1. Servitization transitions (Oliva and Kallenberg, 2003), Copyright Emerald Group Publishing Limited

Alternatively the servitised state can be achieved in a more adaptive responsive manner by developing increasing levels of service and interaction with the customer. Here the customer and supplier move towards servitization together. The supplier and customer overlap increases across the main activities as the progression from product to co-designed total solutions is achieved (Martinez, et al., 2010). Rather than being identified in clear steps the provider and customer involvement evolves through a broadening of interaction from transaction to relationship. This evolution includes five challenges that have to be considered by the provider and customer. The five challenges include embedded product-service culture, delivery of integrated offering, internal processes and capabilities, strategic alignment and supplier relationships (Martinez, et al., 2010). A passion for service, mind-set alignment between the provider and customer, a common language and a positive relationship between the provider and his supply network are all considered as necessary (Martinez, et al., 2010).

Different constructs may be established for product and services delivery that may be delivered to the market separately (Baines, et al., 2009). Understanding the differences in scope, value and operational characteristics required for product focus, product centred services and service focused operations is viewed as key (Baines, et al., 2009). The different operational structures include:

- Product focussed operations tend towards physical transformations of materials into tangible goods. Product focussed operations are focused on selling and tend towards physical transformation and ownership. The system is a product-focused delivery system (Baines, et al., 2009).
- Product centric operations provide products with bespoke services. They tend towards physical transformation of materials into tangible assets sold along with support services to deliver functional capability to the customer. Product centric operations tend to be based on a blend of transactional and relationship and are delivered from an integrated product and service system (Baines, et al., 2009).
- Services focussed operations are larger conventional services that tend towards creating experiential transformation through facilitation and mediation. Service focussed operations tend to be relationship based delivered from a services focused delivery system (Baines, et al., 2009).

Capital investment and motivation of staff will be progressively required and operational difficulties will emerge as changes are put in place (Oliva and Kallenberg, 2003). With capital equipment offerings, such as found in aerospace sectors the product and services delivery system may be based around existing centralised capabilities whilst pure services activities are delivered by new capabilities located near the customer enabling the provision of a rapid response (Baines, et al., 2009).

The literature also introduces the need for greater innovation and change to co-create and deliver a service. The firm will need to align itself with the changing customer focus introducing wider organisational changes if necessary rather than taking a linear approach towards servitization (Barnett, et al., 2013). Knowledge and information management and increasing engagement of employee's will be required to support the new customer focused business model (Johnstone, et al., 2008).

Greater changes are required to deliver a complex engineering service. The service needs to be delivered by a complex system of interacting business parties transforming people information and materials and equipment simultaneously. Sharing of information and delivering transformation in a consistent, stable manner is identified as key to successfully co-creating value (Ng, et al., 2011).

Servitization literature highlights that both culture and operations need to change when a product based firm decides to move towards service. Service characteristics including intangibility and customer contact require service employees to display more initiative, to cope more effectively with stress, and be more interpersonally flexible and more cooperative than employees who work in manufacturing (Schneider, 1995). Companies undertaking servitization need to hire attitude and train for skills as it is unlikely that the service provider can teach the service attitude that their employees need (Bowen and Ford, 2002). The mind-set, skills and attitude need to shift from product to customer and timescales should be given more consideration (Neely, 2008).

Frei (2008) proposes that a service must get four things right; the design of the offering must meet the needs and desires of an attractive group of customers; an acceptable win-win funding mechanism must be established; the employee management approaches must match customer service preferences; and the provider must manage the customer by adjusting tasks for customers to perform (Frei, 2008). In support the customer and provider organisation, mind-set and culture should include cooperative and communicative values reflecting a partnering culture, which encourages reward and communication. A win-win situation is then created by complementary interdependence (Ng, et al., 2011).

2.2.9 The service paradox

Much of the literature on servitization is conceptual, appears anecdotal and little empirical evidence and analysis on the subject can be found (Neely, 2008). Although it was recognised that many manufacturing firms were in the process of moving up the value chain to deliver products and services, the real size and success of the movement had not been analysed in detail until 2008. In 2008 an exercise by Neely (2008) identified the level of fiscal improvements delivered for those taking part. Neely (2008) explores the financial consequences of servitization starting with a review of data from 12,000 plus firms located in twenty-five countries. After removing bankruptcies and erroneous classifications, an analysis was finally launched on 10,634 firms. Of that final number 30.05% were already in the process of servitization and 69.95% were pure manufacturing firms. The exercise provided the following key findings:

- The more developed the country the more servitised firms exist.
- Servitised firms offer different services in different countries.

- A number of firms identified within the original list of firms were found to be bankrupt and thus removed from the exercise. Fifty per cent of the bankrupt firms identified had undergone servitization.
- China is the country with the highest level of pure manufacturing firms.
- Servitised firms are generally larger in terms of sales.
- Servitized firms although generally larger in terms of sales revenues are collectively less profitable than the pure manufacturing firms.

Further analysis of Neely's 2008 findings combined with literature from Oliva and Kallenberg (2003), Gebauer, Fleisch and Friedli (2005) and Reinart and Ulaga (2008) provide the following improved understanding of the success of servitization to date.

Larger firms, measured by numbers of employees and revenues tend to servitise more than smaller firms. There tends to be more manufacturing firms that have servitised in highly developed economies than in emerging ones (Neely 2008). This development seems to be a natural as developed economies complete with mature firms and supply chains expect and require more services (Neely 2008). Furthermore firms in developed economies are more willing and able to move up the value chain in search of growth. This is consistent with the findings that China, a rapidly developing industrial nation, has far more pure manufacturing firms (identified as 99%) than other countries (Neely, 2008)

However, once servitized the larger more sophisticated firms with higher revenues (the very ones who chase servitization the most seeking higher profit) actually appear to generate lower profits than pure manufacturing firms. There are several reasons cited for this within the literature. First, servitised firms in general have higher average labour costs, working capital and net assets than the pure manufacturing firms. They also appear unable to cover the additional costs and investment with sufficiently increased revenues or margins (Reinart and Ulaga, 2008). Second, a service paradox results from cognitive phenomena limiting manager's motivation to extend the service business. Poor management motivation towards service results in poor performance that in turn leads to further poor motivation and further poor performance (Visnjic Kastalli and Van Looy, 2013). This self-fulfilling service quality erosion with a lower economic potential and higher risk needs to be understood and managed for a successful outcome (Gebauer, Fleisch and Friedli, 2005). Finally, organisational changes

are required as the business model emphasis changes from one where the focus is placed upon capturing financial value for the provider through transactional exchanges to focus upon a mutually beneficial relationship between provider and client where financial value is realised as the client uses the service. The ability to change has been observed as difficult and slow to put in place in the larger more complex organisations (Ng, et al., 2011, Baines and Lightfoot, 2012; Barnett, et al., 2013). Developing a new set of capabilities to meet these challenges will necessarily divert financial and managerial resources from manufacturing and new product development, the traditional sources of competitive advantage for the organisation potentially creating an additional challenge for managers (Oliva and Kallenberg, 2003).

Smaller servitised firms on the other hand may have higher net profits than their pure manufacturing counterparts. This may be because they are more agile and more adaptable to the changes required to succeed with servitization. Furthermore they do not suffer from such high costs as the larger more mature organisations (Neely, 2008).

Neely, et al. (2011) updates the original exercise on servitization and tests for significant change. Comparing the 2011 results to the 2008 results reveals the number of firms that have servitized has remained relatively the same. The proportion of revenues from service has also remained relatively stable. Furthermore the extent of servitization in different countries in general has remained very much the same with some notable exceptions. USA had fallen slightly (57.68% to 55.14%) and China had grown considerably (1% to 19.33%) demonstrating a clear desire to move up the value chain similar to manufacturers in developed economies (Neely, et al. 2011). Neely, et al. (2011) further identified that the four most popular services remained the most popular albeit their order of popularity had changed. Systems and solutions are still the most common offer followed by design and development, maintenance and support, retail and distribution. Finally it is reported that the paradox regarding earnings had not disappeared. Some firms were performing well and some performing badly. This highlights that the cultural and organisational shifts required often means that firms fail to capitalise fully on the potential opportunities servitization offers (Neely, et al., 2011).

2.2.10 Summary

Literature on servitization has progressively increased in popularity during the last 30 years and a range of understandings and concepts have been proposed around the

phenomena. This includes; the classification of four service features IHIP, intangible, heterogeneous, inseparability and perishability (Zeith, et al., 1985; Macintyre, et al., 2011), the value added perspective of servitization (Vandermerwe and Rada, 1988); the definition of Product service systems (Hockerts and Weaver, 2002; Neely, 2008); Service dominant logic (Vargo and Lusch, 2004, 2006, 2007); and Complex engineering service systems (Ng, et al., 2011). Two of these, IHIP and Service Dominant logic, have focused on the differences of service vis-a-vis manufacturing and have drawn most comment. First IHIP, describing service(s) as intangible, heterogeneous, inseparable and perishable has been the most cited, enshrining the four unique characteristics of services as received wisdom (Zeith, et al., 1985). Second, Service Dominant Logic (Vargo and Lusch, 2006, 2007, 2008) a new language and logic to be applied to the provision of service has been vigorously proposed. However IHIP and Service dominant logic have both attracted opposition. IHIP cannot be used to distinguish all goods and services because exceptions can be found in every case (Macintyre, et al., 2011), and Service dominant logic has received many adverse comments and to date remains ungrounded (Vargo and Lusch, 2007, 2008). Increased research is therefore required to further develop the understanding of servitization. Whilst it is beneficial to understand all the emerging views, what remains important is that internal and external actors continue to view a firm as product or service based, and the management of service is different from the management of product sales (Bowen and Ford, 2002).

A review of literature on transformation has been undertaken to understand what physical steps a firm needs to take to servitize. Three approaches were reviewed in detail to highlight that different approaches can be adopted. First, a transition model by Oliva and Kallenberg (2003) offers a stepped approach to the servitized state partially reflecting the progressive PSS definitions of Hockerts and Weaver (2002) and Neely (2008). Second, a model by Martinez et al. (2010) who propose a transition continuum identifying pillars of business activity that increases in intensity as the activity progresses. Martinez, et al. (2010) projects a broadening of interaction, transition to relationship, scope of change and those involved. Third, Baines, et al. (2009) propose that the characteristics of an organisation and its activities change with the move from product focused to service focused operations. Although all three approach the transition in a different way they can all be considered consistent in that they advocate

the need to progress along a continuum towards customer and service focus in a positive and conscious way.

The need for a customer-focused and strong service culture is also promoted as necessary by the literature. The strong service culture is necessary for the provider firm and also for the supply chain (Schneider, 1980; Berry, 1995; Bowen and Ford, 2002; Frei, 2008 and Neely, 2009). Improved relationship management is also required from all stakeholders involved (Duffy and Fearne, 2004; Ng, et al., 2011).

Notwithstanding the various definitions, concepts and challenges servitization is reported as gaining in strength with manufacturing firms moving to offer services. However an empirical review across some 12,000 firms, by Neely (2008) observes that fiscal returns against such a venture especially for the larger more sophisticated firms were not as expected (Visnjic Kastalli and Van Looy, 2013). This highlights the complexity of servitization and its associated challenges that are further explored in the latter sections of this chapter

Table 2 below provides a summary of authors reviewed within this section and their contribution to the understanding of servitization.

Author	Issues addressed	Relevance to servitization research
Levitt (1972 and 1976).	Both papers promote a similarity between product and service management proposing a systematic manufacturing approach to both.	The papers provide an original view of how services should be delivered by application of systematic manufacturing techniques.
Zeithamel, Parasurman and Berry (1985).	The paper discusses characteristics of products and services (intangible, heterogeneous, inseparable and perishable) and the development of customer	The paper builds an understanding of the differences between product and services characteristics by highlighting the

SERVITIZATION ISSUE 1 24.12.2013

	focus across the firm.	characteristics of services.
Vandermerwe and Rada (1988).	The paper introduces servitization, detailing the move from product to services as differentiation creating competitive advantage. This introduces concept of manufacturing firms seeking value through the addition of services	The paper provides an understanding and framework for a significant development in thinking about the provision of products and services labelled 'value added' services.
Bowen and Ford (2002).	The paper highlights the management differences of manufacturing and services. It compares producing a product (producing a tangible thing) to providing a service (intangible).	The paper provides increased understanding of the differences of providing products only to products and services.
Oliva and Kallenberg (2003).	The paper proposes a progressive four-step transition for a manufacturing firm moving from offering product only, to product and services to service provision.	The paper provides an understanding of transformation by detailing how a firm can servitize in a structured manner.
Vargo and Lusch (2007 and 2008).	The papers focused on the move from products to service introduce and then develop 'service dominant logic'. Highlights the need for a new mind-set and	The papers provide a significant step in understanding of what is required to provide a service. This is achieved through the introduction of

	language to counter Goods dominant thinking and action. Introduces a shift from services to service.	service dominant logic as an alternative to goods dominant logic. The new logic introduces a new mind set and language to help understand the move from product to service provision.
Neely (2008).	The paper presents an empirical study of servitization establishing the extent and profitability of servitization worldwide. Additionally introduces two new definitions of 'Product Service System'.	The study highlights the depth of servitization globally. It identifies that financial benefits are not as good as expected for many servitized firms. This helps scope servitization for the research and provides details on profitability.
Spring and Araujo (2009).	The paper discusses service, services and products introducing an alternative view of purchasing the right to use.	The paper provides an understanding of an alternative view to value added services and service dominant logic. The paper highlights the rental concept and the idea that the product does not necessarily have to be owned by the customer.
Baines, Lightfoot, Peppard, Johnson, Tiwari and Chehab (2009).	The paper identifies in detail changes required to successfully manage product and service centric	The paper provides details of operational differences between product, product and service and service provision delivering an

	offerings.	increased understanding of the changes necessary for a successful transformation.
Martinez, et al. (2010).	The paper proposes a flexible adaptive transition process towards service provision.	The paper highlights an adaptive approach towards transformation that can be used to compare with the progressive structured approach of Oliva and Kallenberg (2003).
Macintyre, Parry, and Angelis (2011).	The book discusses products and services, service design and delivery, complexity, variability and flexibility.	The book provides an overview of servitization increasing the understanding of the challenges involved.
Ng, Parry, Wild, Mcfarlane and Tasker (2011).	The book presents a framework for complex engineering service systems. It discusses core transformations of materials and equipments, people, and information, practice implications and enterprise required.	The book provides a contemporary view of complex engineering service systems building on the concept of service dominant logic. This strongly relates to this researches case study.

Table 2. An introduction to servitization, a summary of authors reviewed (Source author)

In addition to the literature review detailed above a focused review of servitization literature has also been undertaken considering the theoretical perspective of the authors and the research methods used. Twenty frequently cited papers from leading authors on the subject have been identified and reviewed to better understand the

enquiry paradigms chosen to help explain the phenomenon, and to identify the theoretical perspective and methodological approach employed in each. The twenty papers include: Levitt (1972), Levitt (1976); Thomas (1978); Vandermerwe and Rada (1988); Prahalad and Ramaswamy (2000); Bowen and Ford (2002); Prahalad and Ramaswamy (2003); Prahalad and Ramaswamy (2004); Vargo and Lusch (2007); Vargo and Lusch (2008); Neely (2008); Vargo (2008); Spring and Araujo (2009); Baines, et al. (2009); Gebaur, et al. (2010); Purchase, et al. (2011); Datta and Roy (2011); Meier, et al. (2011); Neely, et al. (2011); and Ng, et al. (2011). The papers have been reviewed and allocated to the perspectives of objectivism, subjectivism and constructivism to reflect the theoretical perspectives employed by their authors. Twelve papers are considered as written from a subjective, interpretivist perspective. This includes: Levitt (1972, 1976); Thomas (1978); Vandermerwe and Rada (1988); Prahalad and Ramaswamy (2000, 2003, 2004); Bowen and Ford (2002); Vargo and Lusch (2007, 2008); Vargo (2008); Spring and Araujo (2009). Six papers are considered as written from a constructivist perspective. This includes: Baines, et al. (2009); Gebaur, et al. (2010); Purchase, et al. (2011); Datta and Roy (2011); Meier, et al. (2011); Ng, et al. (2011). Two papers are considered as written from an objective, positivist's perspective (one paper and an extension by the same author) Neely (2008) and Neely (2011). The split in the use of enquiry paradigms is not surprising and may be a reflection of the age and development of the subject. As servitization is complex, relatively young and has been developing for a relatively short period one would expect to have a high proportion of conceptual papers introducing discussing and shaping the topic followed by case study papers adding detail. The split may also reflect the increasing popularity of alternative theoretical perspectives to positivism. Although Johnson and Duberley (2000) confirm positivism is still the most familiar epistemological orientation, a basis to build from and even a virtual aspect of our common sense they are quick to point out that it has recently been under increasing attack from a variety of rival orientations. The full review is included in Chapter 10 Appendix 10.3.

This part of the literature review which focuses on extant publications on servitization, has presented work that provides the core theoretical understanding of servitization, the challenges of transition (Vargo and Lusch, 2004, 2007; Baines, et al., 2009; Ng, et al., 2011), the perceived benefits of servitization (Gebauer and Friedle, 2005; Vandermerwe and Rada, 1988) and the service paradox (Neely, 2008). The insight generated provides

a knowledge base against which the research can progress towards its key aim of comprehending how the problem of less than expected revenue returns following servitization may be overcome. To progress the research, an additional review of literature on a number of linked theoretical themes that are considered significant in shaping and delivering servitization will be undertaken. These themes including competence, value, enterprise, performance and cost together with the basic understanding of servitization will contribute to the development of the research framework which when crystallised will inform the research case study activity. The research framework construction can therefore commence with servitization at its centre reflecting the findings within this section (2.2).

2.3 Interacting theoretical features of servitization

This section explores and reviews a number of key theoretical themes identified in extant literature on servitization. Five interacting theoretical high-level themes are identified from multiple sub themes that were recurrent in the literature review. These high level themes are considered in more detail as they form the features that are key to successful servitization. The review starts with competence and the resource-based view and knowledge based view of the firm. This reflects that firms possess resources, a subset of which enables them to achieve competitive advantage (Barney, 1991; Penrose, 1959). The key resources (skills, assets or technology) underpin the growth of the business and differentiate the business from its current and future competitors (Parry, et al., 2010). The review then moves to focus on value. This includes value proposition, value co-creation, value in use, and customer experience (Prahalad and Ramaswamy, 2000, 2003). The review continues with the service enterprise where the interacting parties transform dynamic resources (people, information and materials and equipment) to deliver a complex engineering service (Ng, et al., 2011). The enterprise becomes customer focused with stakeholders becoming highly interdependent with no single stakeholder managing in totality (Poirier, 2004). The review subsequently focuses on performance. Here an understanding is required on how to manage performance across the service enterprise to ensure an acceptable service provision is achieved. The review is completed with cost where through life costs are examined.

Social capital theory, supply chain management theory and complexity theory also underpin the framework. Social capital underpins the framework as a structure or

credential that delivers greater co-ordination among individuals and interacting units (Widen-Wuff and Ginman, 2004). Good understanding and positive application of social capital will enhance co-creation and working relationships across enterprise boundaries (Widen-Wuff and Ginman, 2004). Supply chain management theory is used to provide an understanding of how servitization works, especially the relationships involved between the buyers and suppliers (Beamon, 1999; Duffy and Fearne, 2004) and how the supply chain has developed as part of the service enterprise (Porter, 1985; Poirier, 2004). Finally complexity theory provides an understanding of how the various parts of the enterprise work together (Anderson, 1999; Pascale, 1999).

2.3.1 Competence

This sub-section explores and reviews the literature on competence and selected literature on the resource based view and knowledge-based view of the firm. Competence, considered a key building block of service within Service Dominant Logic (Vargo and Lusch, 2004, 2007), is included in the research framework. SD-Logic explains that, where a complex service is delivered, dynamic resources complete with new competences are required to deliver benefit for others (Ng, et al., 2011).

For more than fifty years the management of competence has been a key feature of business and economic literature. In her book 'The theory of the growth of the firm', first published in 1959, Edith Penrose wrote about the resource-based view of the firm. Penrose believed the firm consists of resources which when used in certain ways and in combination with different types or amounts of other resources can provide a different service or set of services. In other words the organisations resources can be reconfigured into alternative means of providing customers with access to capability (Spring and Araujo, 2009).

Penrose (1959) believed that resources can be defined independently of their use (p.22) and are the provider of the uniqueness of each individual firm. She also believed in specialisation and division of labour taking place within a firm, providing it with increased efficiency and the opportunity and capability to grow. Whilst the dividing of tasks worked within the industrial era where firms had specific product outcomes it does not necessarily fit with service and value co-creation. Value co-creation (explained below in section 2.3.2) does not follow the typical value chain as described by Porter (1985). It transcends disciplines, functions and organisational boundaries of the

customer and firm focused on outcomes and value in use (Ng, et al., 2011). A move away from a linear divisional approach is therefore believed necessary.

Further to Penrose (1959) multiple definitions of competence have been developed and captured in academic literature. Andrews (1971) describes distinctive competence as a set of things that the organisation did particularly well. Snow and Hrebiniak (1980) give distinctive competence the stronger definition of the capabilities belonging to a company that their competitors do not have. Prahalad and Hamel (1990) describe core competence as the collective learning in the organisation. They believe identification, cultivation and exploitation of core competencies provides for competitive advantage and makes growth possible.

Parry, Mills and Turner (2010) further clarified the definition of competence. Through discussion with industry they developed a clear definition for competence. Core competences are a skill, asset, and technology that underpin the growth of the business from its current and future competitors (Parry, Mills and Turner, 2010). The definition captures all previous theories and in addition the language used is straightforward, facilitating understanding. It was also highlighted that overtime competences degrade becoming threshold competences as competitors develop competing capabilities (Parry, Mills and Turner, 2010). This is considered a reflection of operational realities and underpins that strategy can be defined as the management of core competences and that core competences should not drive strategy.

Ng, et al. (2011) propose a conceptual framework for complex engineering service systems where a dynamic combined organisational competency across materials and equipment, people and information is needed to match an evolving customer need in order to create value. Where differing customer requirements can exist or where time and context change the requirements, the support of equipment and people has to be designed to achieve service provision. Ng, et al. (2010) define the complex engineering service competency as the ability of the firm to design, deliver and manage the entire complex engineering service system. That is the ability to carry out the three core transformations (materials, equipment, people and information) in a consistent, stable and profitable manner, co-creating value in partnership with the customer.

Resource management and competitive advantage is also central to papers written by Wernerfelt (1984) and Barney (1991) and is key to the theory of the resource-based

view of the firm. They both believe that the firm has key resources that can provide competitive advantage. Wernerfelt (1984) believes that the resource perspective provides a basis for strategy formulation. In particular he links resources to products considering which resources to exploit and which resources to develop given the profit they deliver and the barriers to market they create. Wernerfelt (1984) categorises brand names, in house knowledge of technology, skilled personnel, trade contacts, machinery, efficient procedures and capital as resources. He believes in the use of resources to develop strong market positions, being a first mover and then sustaining the position by retaining the key resource hence creating a barrier to entry for competitors. Barney (1991) promotes the resource-based view of the firm developing the link between resources and sustained competitive advantage. He argues that providing resources are different and immobile then once a market place is secured by use of those resources it can then be sustained. He details that resource should have the following characteristics. First, be valuable and able to improve efficiency and effectiveness. Second, be rare and ensure others do not simultaneously implement the same value-adding strategy. Finally, imitable so firms that do not have them cannot develop them.

The resource-based view of a firm considers resources as properties that carry out transformation. They can be physical, human, technological or organisational (Ng, et al., 2011). Competency is the capacity of a group of resources when well managed to carry out an activity (Ng, et al., 2011). This has echoes of the service dominant logic perspective (Lusch and Vargo, 2006), meaning that resources are only resources if used. The process through which such resources “become” is the capability or competence of the producer system (Ng, et al., 2011).

Once firms have established their competences they take make or buy decisions leading to the outsourcing of their non- core activities (McIvor, 2000). The outsourcing allows the firm to focus on their chosen core competency developing them to world-class status. This in turn provides the individual firm with competitiveness and market position (Poirier, 2004). Whole corporations can also adopt this approach. In the same way a corporate architecture is developed around competences and core products required to become world dominant in chosen markets. Sister firms are provided with core products at world-class prices creating flexibility and speed to access and dominate new markets (Prahalad and Hamel, 1990).

The sub-contracting of non-core activities creates greater dependence on an extended set of suppliers. The suppliers may choose to collaborate or subcontract (Poirier, 2004). This leads to a complex network of interacting firms required to work in unison to deliver to the customer. Furthermore servitization identifies the customer as co-creator of value as part of the network (Prahalad and Ramsworthy, 2000) extending the complexity of the network yet again.

The knowledge-based view of the firm considers knowledge as the most strategically significant resource of the firm. Knowledge bases and capabilities are major determinants of sustained competitive advantage and superior corporate performance (Conner, 1991). It is not only the management of explicit knowledge but also the access to and management of implicit knowledge and collective knowledge that delivers superiority (Spender, 1996). Grant (1996) in particular argues that knowledge assets remain resident within employees and that communication and coordination is not a trivial issue. He further details that the interaction within the substructure (intra firm) is more difficult than between substructures (extra firm) or across boundaries. Grant (1996) therefore advocates the use of rules, sequencing, routines and group solving and beneficial organisational structure to overcome the difficulties and deliver competitive advantage. This relates directly to service and co-creation where the supplier and customer are working together across borders sharing knowledge and understanding.

The literature on competence and the resource-based view of the firm identifies resource management and the development and application of the correct competence as central to delivering competitive advantage. Whilst many of the concepts have originally been established in a goods setting (Penrose, 1959) they are equally if not even more applicable where a service is being delivered by multiple interacting parties (Ng, et al., 2011). As new competences are required to deliver complex engineering service, competence is identified as a central theme for successful servitization and is included within the research framework.

2.3.2 Value

This sub-section explores and reviews the literature on value from the perspective of servitization. Value is specifically reviewed, as it is a central recurrent theme identified in the service literature. Further investigation of value can lead to a better

understanding of servitization and play a role in the development of the research framework.

Prahalad and Ramaswamy progressively introduce new ideas on value creation during 2000, 2003 and 2004. They introduce the concept of customer competence (2000), customer co-creation (2003) and personalised customer experience (2004). They also identify a shift away from formal, defined roles in business-to-business relationships driven by the deregulation, globalisation, technological convergence and rapid evolution of the internet. Here the consumer is introduced as the agent that is most dramatically transforming the industrial system, as we know it. In 2000 Prahalad and Ramasway introduce their concept that the consumer becomes a new source of competence for the corporation. They propose the competence that the customer brings is a function of their knowledge, skills and willingness and ability to engage in an active dialogue. Five activities of co-creation are identified. These are customer engagement, self-service, customer involvement, problem solving and co-design. Competence now becomes the function of the collective knowledge and skills of the extended enterprise. The central provider, the collaborators, the suppliers and the customer are now recognised as contributing in unison to create value. This is consistent with the Service dominant logic concept of value in use where the provider offers a value proposition that is realised through co-creation with the customer (Vargo and Lusch, 2007 and 2008). In this paradigm, service becomes a perspective of value creation rather than a market offering (Edvardsson, et al., 2005). Prahalad and Ramasway (2003, 2004) build on the above by developing the idea of the consumer having a personalised experience. Here the customer becomes very informed and active and key to the creation of quality integration jointly creating value with the provider.

Value production, value co-production (sequentially in value chain terms) and value consumption (by the end customer) have been well documented in goods dominant literature (Ramirez, 1999). However the interaction of service co-production and service value co-creation remains unclear with little written explicitly on the subject. Whilst some suggest, or at least treat service co-production and value co creation as interchangeable concepts (Nambisan, 2002; Kristensson, et al., 2008), others such as Vargo and Lusch (2008) believe that value co-production is nested inside of value co-creation. Edvardson and Olson (1996) believe in a clear separation of the two activities. They pronounce it is not the service itself that is produced but the pre-requisites for the

service. Likewise Ng, et al. (2008) identifies co-production as the measure of customer involvement in the delivery of the company's value proposition, not the outcome. Value co-creation in contrast is the customer realisation of the value proposition to obtain value-in-use. Therefore customers are always co-creators of value; they are not always co-producers of service. However notwithstanding the above Ng, et al. (2011) highlight that whilst separating co-production and co-creation is easy to differentiate for tangible goods, since consumption is separate from production, it is not so easy to split when considering service systems where value is co-created and co-produced in an interactive environment. The lack of understanding between co-production and co-creation is likely to remain until value co-creation is explicitly defined and universally agreed in detail. It may then be possible to identify the co-production as a pre activity or element of value co-creation.

Spring and Araujo (2009) provide an explanation of co-creation. In the context of service with customer inputs they define three types of customer input: customer self inputs wherein there is co-production and or the customer's body is acted upon (transport, health, restaurants); tangible belongings (the customer's car for repair, say); and customer provided information (e.g. income data for the preparation of a tax return). These are stated as being separate to customer involvement, explained as the provision of opinions about general products and selecting and consuming the output.

When considering more complex engineering service arrangements, Ng, et al. (2009, 2011) identify seven attributes of value co-creation. The attributes provide a starting point towards changing the internal organisation to ensure more effective interfaces with the customer. The seven attributes are detailed below:

- Complementary competencies, where both the customer and firm employees have to provide the right competences, in terms of expertise and judgement.
- Empowerment and perceived control where the employees are found with suitable autonomy to make situational decisions (empowerment) and where the employees and customers have the ability to demonstrate their competency over the environment, (perceived control).
- Behavioural alignment between the firm and customer's personnel leading to co-operation, teamwork, trust and open communication.
- Process alignment to enable exchange, meetings and seminars.

- Behavioural transformation of customers to ensure best use of assets and activities to ensure optimal outcome.
- Congruence of the customer's expectations.
- Congruence of the firm's expectations where each should be aware of one another's expectations and who is performing which tasks.

Value co-creation does not follow the typical value chain that has a compartmentalised activity (Porter, 1985). Value co-creation transcends disciplines, functions and organisational boundaries of the customer and firm and is focused on outcomes and value in use, (Ng, et al., 2011). Value co-creation requires a shift in mind-set and a new way of interaction between all parties to be successful (Ng, et al., 2011). The relationship needs to move to one of partnership and collaboration. Duffy and Fearne (2004) propose that within the enterprise management adversarial or transactional behaviour needs to be removed. This includes: short term focus on individual transactions, buying decisions made on price, many suppliers, low interdependence, haphazard production and supply scheduling, limited communication restricted between sales and purchasing, little coordination of work in processes, relationship specific investments avoided, information is proprietary, clear delineation of business boundaries, use of threats to resolve disputes, unilateral improvement initiatives, separate activities, dictation of terms by more powerful firm, adversarial attitudes, conflicting goals, opportunistic behaviour, act only in own interest and win-lose orientation.

Furthermore Duffy and Fearne (2004) propose that the adversarial or transactional behaviours need to be replaced by the collaborative traits of: commitment to long term relationships, buying decision made on value, high interdependence, order driven production and supply scheduling, open communication facilitated by multi-level multifunctional relationships, integration and co-ordination of work processes, increases in relationship specific investments, information is shared, creation of inter-company teams, joint problem solving approach to conflicts, continuous joint improvement sought, engage in joint activities, joint decision making; co-operative attitudes and teamwork, compatible goals, mutual trust exists, act for mutual benefit, and win-win orientation.

Consistent with the above Ng (2011) discusses transaction costs within outcome-based contracts highlighting opportunism and co-ordination as the two principle risks that

need to be managed to deliver successful value co-creation. These features, which apply to the relationship between the firm and the customer, are also relevant for the relationships required between the firm and the suppliers.

Ng (2011) explains that traditional contracting, dominated by protection against opportunism, discourages voluntary commitments and actions outside of contracts creating unresponsiveness. Outcome based contracting however based on incentives encourages positive behaviour, as a good outcome is of benefit to all parties especially the providing firm who now carries all the risk (Ng, 2011). The fact that the firm now carries most of the risk may encourage a redesign to establish a more reliable product and the provision of more efficient repair and logistic capabilities. Relational governance driven by social relationships is more suited service than formal governance driven by contracts. Social relationships are more fluid and flexible and can more easily adapt to environmental changes resulting in a strengthened cooperation through information sharing and solidarity. Finally, the transaction cost perspective benefits from collaboration, resource pooling and reduction of uncertainty (Ng, 2011).

The literature on servitization introduces value co-creation as a central feature of providing a service where providers and customers interact to realise a value proposition. The literature also emphasises that all parties must learn to interact and work together efficiently. This sub-section of the literature review therefore finishes with a brief introduction to social capital theory. Although it is considered as outside of the central scope of the literature review considering the importance of the relationships between the stakeholders it is useful to establish a top level understanding of social capital theory to capture how it might support the value co-creation interaction.

Social capital is a means of aiding the development of trust and sharing of knowledge (Widen-Wulff and Ginman, 2004). Organisations working in networks need social capital to help bind together and make activity efficient. Cross boundary efficiency can be improved against common goals through greater co-ordination among people and units. Three dimensions of social capital exist which all need to be managed correctly (Widen-Wulff and Ginman, 2004; Tsai and Ghoshal, 1998; Nahapiet and Ghoshal, 1997). First, the structural dimension concerned with access to other actors relates to network channels for communication (Widen-Wulff and Ginman, 2004). The structural

dimension manifests as social interaction and may stimulate trust and perceived trustworthiness (Tsai and Ghoshal, 1998). Second, the cognitive dimension is embodied in attributes such as shared understanding that facilitates a common understanding of collective goals and acceptable ways of acting in a social system (Tsai and Ghoshal, 1998). It is a visible condition necessary for formation and utilisation of social capital and includes communication function, information exchange, and problem solving and conflict management. Here the exchange of information enables the identification and resolution of problems. Behaviours of actors is shaped to reflect firm objectives and conflict is considered a valuable activity that must be managed as a regular and on-going process to provide positive outcomes. Third the relational dimension concerning expectations and obligations and how actors view themselves in relation to others. This comprises three elements, trust, identification (how actors view themselves as connected to other actors) and social system closure and the emergence of observable norms (Coleman, 1988; Widen-Wulff and Ginman, 2004; Tsai and Ghoshal, 1998).

Trust (alleviating the fear of opportunistic behaviour), positive social interaction, and common values and objectives enable the positive access to other actors across boundaries. This facilitates interactions and opportunities to exchange or combine resources thus enabling value co-creation (Tsai and Ghoshal, 1998).

Figure 2. redacted as Copyright permission unobtainable

Figure 2. A model of Social Capital and Value co-creation (Tsai and Ghoshal, 1988)

Social capital has been described as the aggregate of the actual or potential resources linked to the possession of a network or membership of a group who have collective credential (Bourdieu, 1986; Coleman, 1988). It can be further broken down to explain the basis of how social capital works. If *A* does something for *B* and trusts *B* to reciprocate in the future it establishes an expectation for *A* and an obligation on the part of *B*. This can be conceived as a credit slip held by *A* for performance to *B*. If *A* hold a number of credit slips for *B* and his colleagues and vice-versa then an on-going exchange will occur based around credits and trust (Coleman, 1988).

This sub-section also explores and reviews the literature on value in use. Value in use is also considered central to the concept of servitization as it moves the point and nature of realising value from one of exchange to one of use.

Value in use is the customer activity undertaken once value co-production has been completed (Ng, et al., 2011). By using or consuming the co-created product the customer realises value in use. The understanding of the relationship between value in use and value co-creation is similar to that between co-production and value co-creation. Following the discussion in the previous section value in use could be considered as nesting within value co-creation.

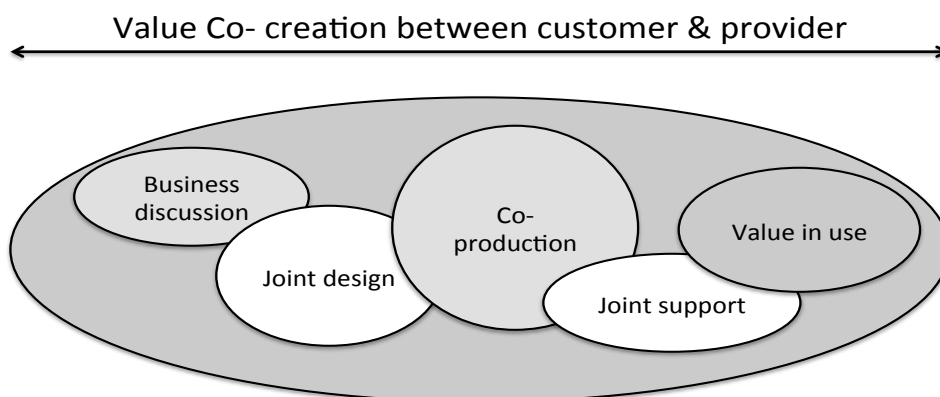


Figure 3. Scope of Value co-creation (Source author)

Value in exchange is believed to have stemmed from economics from the beginning of the industrial revolution. Economists such as Adam Smith (1776) theorised about the production and subsequent exchange of goods for other goods or payment generating wealth at an individual and national level. The traditional process of value creation is therefore producer centric. Value is created through a series of activities performed by the producer who then exchanges the product of his labour for payment. In modern day a series of like exchanges progressively building a product has been named a value chain (Porter, 1985). The exchange transaction represents the exchange of value between provider and customer (Ramirez, 1999). Literature on servitization moves the focus of value away from the understanding of exchanges to the concept of value creation and value in use. Rather than value being determined by the producer it is proposed to be an evaluation made by the customer obtained from the experience of the offering in use situations (Prahalad and Ramaswamy, 2004). The concept goes further introducing the idea of the customer as an active agent working with the provider in the creation of value (Prahalad and Ramaswamy, 2003).

Customers can actively construct their own consumption experience. Through personalised interaction they can create unique value for themselves (Prahalad and Ramaswamy, 2003). Value creation can be defined by the specific consumer experience, at a specific point in time and location in the context of a specific event. The individual and his interactions define both the experience and the value derived from it (Prahalad and Ramaswamy, 2003).

Delivery of an experience requires the involvement of many stakeholders. The nodal company, suppliers, partners, customer communities including the individual consumer can all be included. They can all link by a network moving from the product space to a solutions space (Prahalad and Ramaswamy, 2003).

Vargo (2008) develops this thinking. He provides a view of the future introducing the concept of a network-to-network perspective with value creation being understood in the context of a larger value configuration. The beneficiary who represents a supply chain network of public and private service providers determines the value. The provider firm is only one actor. Two networks are interacting, the network of the provider firm and the network of the customer where both the provider firm and customer are resource integrators and beneficiaries. A firm is best understood as the

integrator of the customer's resource as an input to value creation instead of being seen as the firm's integrator of customer resources for the production of output (Vargo, 2008).

The literature has identified that the goal of servitization is to change a firm's value capture process. The firm's focus of capturing value from product alone moves to a broader focus that includes capturing a greater proportion of value from service offers (Vandermerwe and Rada, 1988). Furthermore the literature on value identifies a number of core themes. The themes include value proposition, which is the firm's offer; value co-production (Ramirez, 1999), which is the way the offer may employ resources from the client; and value co-creation, which recognises that value is realized only in the context of use of an offer (Ng, et al., 2011). Additionally value-in-use is important to the customer experience (Prahalad and Ramaswamy, 2000, 2003), which is recognised as an outcome of service and therefore must be recognised with the servitization transition. Considering these multiple themes, value is identified as a key theoretical feature of complex engineering service provision. Value is therefore added to the research framework.

2.3.3 Enterprise

This sub-section explores and reviews the literature on the enterprise. The enterprise literature comprises multiple themes that describe the structure and activities of the extended service organisation that delivers complex services.

The review commences with a brief introduction to the development of the firm and the development of the supply chain (Porter, 1985; Poirier, 2004). How they both develop and interact with the customer establishing an enterprise to provide a service (Ng, et al., 2011) is reviewed. The section then explores and reviews the literature on business models (Teece, 2010, Zott and Amit, 2010) organisation and interdependence. Here it is explained why business models are required and details the various elements of a generic business model and how they relate to business activities. The section explores how a complex service enterprise might be assembled, organised and managed to deliver a complex service. This includes a review of interdependence providing definitions for independent, dependent and interdependent relationships and activities and how this fits with a complex service enterprise. Introducing and reviewing

enterprise imaging completes this section. The section also contributes to the development of the research framework.

2.3.3.1 Enterprise development

As firms develop and products and services become more complex and outsourcing increases, the role of the supply chain increases (Poirier, 2004). The firm's development accelerates as firms move towards focusing on selected competences and further increase outsourcing when external costs are lower than internal costs (Coase, 1988; Williamson, 1989). The firm moves from an internal to an external perspective focused on satisfying the customer and working with the supply chain to that aim (Poirier, 2004). The external value chain is created (Porter, 1985). The role of, and dependence on, the suppliers increases and extends further as they in turn develop sets of complimentary competences that only they and their own supply chains can deliver. The firm and their partner suppliers work closer together. Improved inter-enterprise synchronisation is established as complexity increases (Poirier, 2004). As collaboration succeeds the linked firms move into an industry leadership position and a value chain constellation begins to form (Porter, 1985). This entity is a set of firms co-operating as an extended supply chain enterprise with a focus on a targeted end consumer group. The network resources shift their attention from cost (bottom line) to new revenues (top line). The supply chain becomes a value network and information is shared to pin point all the costs and values from end to end of the network. Here partners focus on how they can optimise all the process steps to improve the delivery to the end consumer (Poirier, 2004). The development of the firm and its extended supply chain can be viewed as several levels of development. Through each level the significance of the supply chain, the sharing of processes and knowledge and the overall synchronisation increase (Poirier, 2004).

Ahuya and Carley (1999) view extended organisations as virtual organisations, a form of extended firm suited to the delivery of products and services that are competence based. Nightingale (2000) extends the concept describing enterprises, as complex, highly integrated systems comprised processes, organisations, and information and supporting technologies, with multi-faceted interdependencies and interrelationships across their boundaries. Mils, et al., (2004) propose a more succinct understanding describing the enterprises as sets of firms with complementary competences that

collaborate to deliver service. Value co-creation between the provider firm and its supplier network and the customer has been introduced (Prahalad and Ramaswamy, 2000, 2003, 2004, Vargo and Lusch, 2004, 2006, 2007). The customer can also have a network of suppliers, partners, government and corporate bodies (Vargo, 2008). This creates a large complex virtual organisation all linked and working towards a single end goal. Organisations of this nature have been named an enterprise. An enterprise has been defined as 'a boundary defining lens, which imposes a holistic management or research perspective on a complex system of interconnected and interdependent activities undertaken by a diverse network of stakeholders for the achievement of a common significant purpose' (Purchase, et al., 2011).

Once a decision to servitize has been taken management should consider what business model to adopt and how best to organise. The following sub sections review literature on both of these subjects.

2.3.3.2 Business models

The business model has been characterised as 'the value creating insight on which the firm turns' (Margareta, 2002). The business model is also explained as comprising a set of generic level descriptors that captures how a firm organises to create and distribute value (Fuller and Morgan, 2010). Whether an organisation is a new venture or an established player a good business model remains essential for success (Magretta, 2002). Whenever an enterprise is established, it either explicitly or implicitly employs a particular business model that describes the design or architecture of the value creation, delivery, or capture mechanisms it employs (Teece, 2010). This includes considering the logic of the firm, the way it operates and how it creates value for its stakeholders (Zott and Amit, 2010). The business model can also be considered as a system of interdependent activities that transcends not only the provider firm but can also include its customers and vendors to serve a specific purpose toward the fulfilment of the overall objective (Zott and Amit, 2010). A generic framework of business features and activities included in business models developed by Osterwalder and Pigneur (2010) is illustrated below in Figure 4.

Generic business model framework

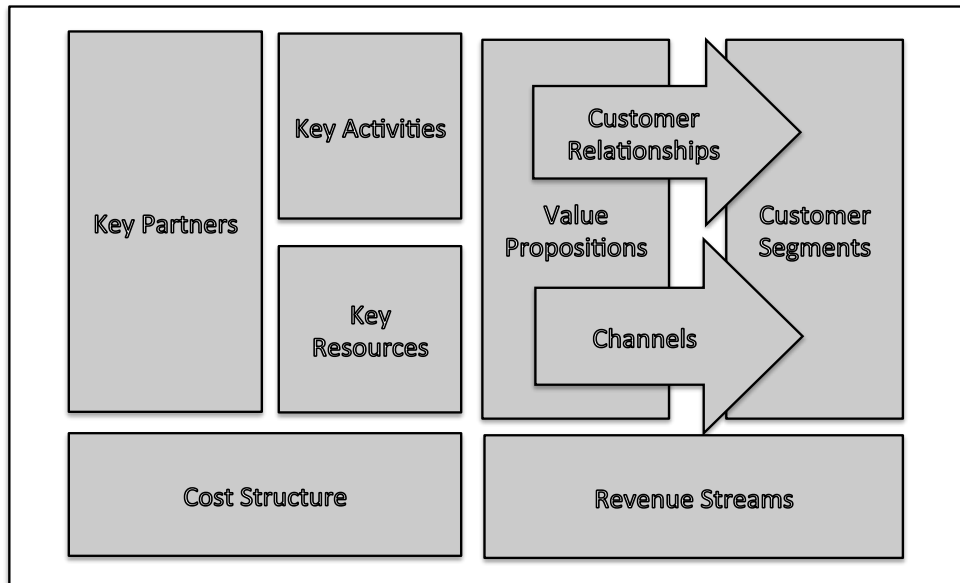


Figure 4. Generic business model framework (Osterwalder and Pigneur, 2010), Copyright Jon Wiley Inc

The framework is consistent with the discussions of Zott and Amit (2010) and Teece (2010) and includes the following features and activities:

- Customer segments, the groups of people or organisations an enterprise aims to reach and serve who may require separate product offerings or marketing mixes (Kotler, 1991). A market segment can be more fully defined as a group of customers or potential customers who are different to the rest of the market (in characteristics) but are relatively homogeneous within the group. An ideal segment can be described as identifiable, accessible and measurable, shows a need that the supplier can provide, and is responsive (Walsh, 1993; Gillespie, et al., 2007).
- Value proposition, the bundle of product and services that create customer value.
- Channels, how a company communicates, sells and distributes. Literature informs us that channels are the links between producers and final customers (sets of independent organisations called intermediaries). Producers can deliver

direct or indirect using intermediaries, merchants, warehouses, retail organisations, franchises or the internet (Hollensen, 2012). The fundamental aim of channel management is to supply the product to the end customer at the right time and in the manner most profitable to the manufacturer. Channel middlemen can assemble, break bulk, adapt goods to market, physically distribute, sell, promote and advertise, seek buyers and sell, and provide credit (Walsh, 1993).

- Customer relationship, the types of relationships a company establishes with specific customers.
- Revenue stream, how the company generates cash from each customer.
- Key resources, the most important assets required making a business model work.
- Key activities, the most important things a company must do to fulfil the overall objectives.
- Key partnerships are included in the network of supplier and partners that make the business model work.
- Cost structure, describes all the costs, incurred to operate the business model.

As the business objectives and way the business is conducted change the business model changes in support. Furthermore the nature of each of the features and activities that comprise the business model also need to be confirmed or changed. The business model is therefore characterised by its focus and weighted to deliver the objectives i.e. customer focused, finance or resource biased (Osterwalder and Pigneur, 2010). The business model will also need to consider external forces and their interaction such as technology or market trends or industrial forces including supplier, competitor stakeholder and substitute influences (Osterwalder and Pigneur, 2010). Finally to deliver the model the company will need to consider a strategy, a structure, processes, people and reward (Osterwalder and Pigneur, 2010). The business model should be a source of competitive advantage taking into consideration the specificities and challenges of servitization as discussed in the previous section. The business mode is more than just a good logical way of doing business and has to be different and innovative. The model must be honed to meet particular customer needs and must also be non-imitable to avoid immediate competition (Teece, 2010). Furthermore the business model can give managers and researchers a 'language,' concrete tools and a

tight framework for business design that can foster dialogue and promote common understanding relevant to the new requirements and challenges of servitization (Zott and Amit, 2010).

Given the vital importance of the business model for entrepreneurs and general managers, it is surprising that academic research (with a few exceptions) has so far devoted little attention to this topic (Zott and Amit, 2010). A conceptual toolkit is required that enables entrepreneurial managers to design their future business model, as well as to help managers analyze and improve their current designs to make them fit for the future (Zott and Amit, 2010).

Establishing business models for a new or existing product or business is viewed as an unnecessary step in textbook economics. It is believed there is simply no need to worry about the value proposition to the customer, or the architecture of revenues and costs, or about mechanisms to capture value (Teece, 2010). Economic theory suggests that customers will buy if the price is less than the utility yielded. Likewise producers will supply if price is at or above all costs including a return to capital. In both situations business design issues simply don't arise (Teece, 2010). However this is not the real world and equilibrium models are very rare. Intangible products are in fact ubiquitous, two-sided markets are common, and customers don't just want products. Customers actually want solutions to their perceived needs. In some cases, markets may not even exist. Here entrepreneurs may build organisations in order to perform activities for markets that are not yet ready. Accordingly, in the real world, entrepreneurs and managers must give close consideration to the design of business models and even to building businesses to execute transactions that cannot yet be performed in the market (Teece, 2010).

Business model descriptions can also provide us with typical forms that can be linked to firms who epitomise a particular form of behaviour (Fuller and Morgan, 2010). These types of firms therefore shape our understanding of business models and the business models shape the type of firm.

2.3.3.3 Organising for complex engineering delivery

Once it is understood that a new service enterprise business model is required and that value is now being delivered in a new manner it has to be considered how best to organise the provision of a complex service. As both the service and delivery organisation are considered complex a short introduction to complexity is provided below.

Scientists established the concept of complexity and complex adaptive systems to understand and describe how the living world works (Pascale, 1999). A number of descriptions of complex systems found in the literature are based on similar ideas. This includes the following understandings.

A complex system may be described as one made of a large number of interdependent parts. The parts make up a whole that is interdependent within some larger environment (Anderson, 1999).

Four tests can be made to confirm a complex adaptive system. It must comprise many agents acting in parallel; there are multiple levels of organisation; the system must be replenished with energy to function; and pattern recognition is employed to predict the future and learn (Pascale, 1999).

In the context of industry production and process, complexity can be measured across three dimensions. A vertical axis shows the levels within the organisation. A horizontal axis shows the number of departments and job roles. The third axis shows spatial complexity, such as different geographical locations (Daft, 1992).

In the context of complex IT systems Ribbers (2002) identifies three measures of complexity:

- variety that reflects the number of elements and their interrelations in a given situation or system
- variability relating to the dynamics and interrelations of the systems elements overtime
- integration of planned changes to the system, (Ribbers, 2002)

If the enterprise has the capacity to learn and adapt it can be considered a complex adaptive system (Pascale, 1999).

Finally complexity can be viewed from a different perspective reflecting the activities undertaken by a complex organisation and the characteristics of a complex outcome. In the context of comparing complicated to complex outcomes, Ng (2011) proposes that in a complex outcome there is no mission control and the outcome is achieved through co-creation and collaboration delivering an interactive emergent complex outcome.

The term service enterprise is used to describe the complex system of interconnected and interdependent activities undertaken by a diverse network of stakeholders for the achievement of a common significant purpose (Purchase, et al., 2011). The service is delivered by a complex system comprised interacting parties simultaneously transforming people, information and materials and equipment in a consistent stable manner (Ng, et al., 2011). As manufacturing firm's servitize and as their value proposition changes they must consider themselves as the leader of the greater service enterprise. In the context of complex engineering service provision where the provider firm takes over the customer activity this is considered as forward vertical integration (Baines and Lightfoot, 2012). The provider must change the way it thinks and works and also drive change at the customer and through the supply base (Barnett, et al., 2013). The provider, customer and suppliers must become one team where the service is concerned and take a more proactive part throughout the product life cycle (Poirier, 2004).

When new business arrangements and pressures arise, transaction cost analysis and stakeholder relationships may need to be revisited. The cost of conducting economic exchange in a market may exceed the cost of organising the exchange within the firm (Coase, 1937). Activities previously undertaken externally may now be better conducted within firm boundaries. The decision to reorganise should consider risk (Baines and Lightfoot, 2012) and also direct costs of managing the relationship and the opportunity cost of making inferior governance decisions (Williamson, 1985).

When a firm servitizes operations become less predictable. The firm may be forced into vertical integration to become more innovative and strengthen its relationship between service and production units (Turunen and Neely, 2011). The term vertical integration is usually understood as the extent to which a firm owns and takes responsibility for its upstream suppliers and its downstream customers (Baines and Lightfoot, 2012). A business is seen as being vertically integrated when it is engaged in different aspects of

production, such as growing raw materials, manufacture, transportation and retailing (Baines, 2005). Backward vertical integration refers to taking over activities of suppliers of inbound materials whereas forward integration is concerned with taking control of activities in the outbound supply chain and otherwise carried out by customers (Baines, 2005). Vertical integration can be thought of at the macro level, dealing with a combination of businesses or at the micro level, managing a combination of business (Baines, 2005). The concepts of servitization and vertical integration are closely related (Schemner, 2009). This is especially the case with complex engineering service captured by an availability contract where the provider assumes the activities previously undertaken by the customer. This has been named forward integration (Baines and Lightfoot, 2012). This may be coupled with a relaxing or increasing of backwards integration in order to deliver an effective execution of a servitization strategy (Baines and Lightfoot, 2012). The final level of vertical integration or in sourcing is established in response to two types of business pressures. The first is to fulfil contractual obligations to the customer (avoiding penalties) whilst the second is an internal pressure to deliver these as economically as possible (Baines and Lightfoot, 2012).

As an alternative to vertical integration suppliers can be co-located on the customer premises. Here the system boundaries and decoupling point between the customer and supplier shifts position. The decoupling point is the place in the value chain where material or component supply changes from push to pull i.e. the order point from customer to supplier (Mason-Jones and Towill, 1999; Garcia-Dastugue and Lambert, 2007; Olhager, 2010; Banerjee, et al., 2011). Where customer, provider and supplier co-location exists, the supplier becomes aware of the requirements of the customer and provider immediately.

Burns and Stalker (1961) propose there is more than one way to organise and offer extremes of organisational design – mechanistic (centralised, formalised) and organic (decentralised and unformalised). Whilst a mechanistic approach may suit a manufacturer focused on the repeat production of product a more organic style may suit the servitised firm delivering a service where greater task uncertainty and variety exists (Turunen and Neely, 2011). Extending the relationship with a broad client base, developing sophisticated service offerings for selected clients and the offering all the services efficiently all need to be achieved (Visnjic and Looy, 2013).

When moving from product supply to service supply changes to the operations also need to be considered. For the supply of a service the buyer-supplier exchange includes not only an object but also the complex activities and informative and operative interactions needed for the service completion (Poirier, 2004). These can be both intangible and tangible and thus difficult to manage (Macintyre, et al., 2011). The supplier must be able to take care of research and development and design, procurement, production and distribution phases that link him to the operations chain of the customer (De Toni and Tonchia, 1994). Furthermore due to the increased level of responsiveness and flexibility that service demands the supply chain poses different risks and challenges to the purchasing and providing company (Barnett, et al., 2013; Fitzsimmons and Fitzsimmons, 2000; Neely, 2008). Product supply chains and service supply chains can each experience the same management and operational issues (Ahlstrom and Nordin, 2006). Issues include those associated with relationships as a result of insufficient communication, conflicts between partners, lack of trust, cultural differences and organisational politics. These all add complexity and generate problems. Within the enterprise the relationships between buyers and suppliers can vary and add a level of complexity. These include; adversarial leverage, preferred suppliers, single source, network sourcing and partnerships (Cox, 1996). The challenge of enterprise management is also increased as the different types of firms involved can have additional diverse and potentially competing value propositions beyond that which binds them together within an enterprise. Behaviour will always default to self-interest and partners begin to adopt adversarial tactics (Williamson, 1985). Operational issues such as insufficient specifications, quality or performance can create problems and strategic problems may occur over a long period of time. These include such risks as losing core competence to the partner, losing control over key suppliers and bypass of the buyer direct to the market place (Ahlstrom and Nordin, 2006). Other supply issues are considered more applicable to the service situation (Neely, 2008). These include writing legal agreements for service exchanges, clearly specifying service processes to be transferred to the supplier, handing over service delivery to suppliers and finally losing control over relationship with the customer. Any buyer organisation to be successful should find a way of managing such issues (Ahlstrom and Nordin, 2006). Developing customer focus and flexibility becomes important for the provider whilst developing trust and contracting to reduce the risk and increase speed of recovery becomes important to the buyer (Barnett, et al., 2013). Although firms have always been

located in multiple networks, their dependence on other network members and hence their inability to control their own output has grown alongside a narrowing of the scope of their competences (Poirier, 2004). Thus calls for the need to take a wider enterprise or network perspective have grown (Mills, et al., 2010).

Service provides new operational challenges. Many are similar to those experienced in the supply of product. Existing supply chain management theory and management processes can be used to ensure performance of the service enterprise (Lambert and Garcia-Daustugue, 2006). Lambert and Garcia (2006) make the observation that the eight Global Supply Chain Forum (GSCF) cross-functional supply chain business processes (Lambert, 2006) can be employed to assist in the delivery of a complex service. The eight include customer relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, supplier relationship management, and product development and commercialisation and returns management. Lambert and Garcia-Daustugue (2006) match the supply chain processes to the foundational premises of Service dominant logic (Vargo and Lusch, 2007) to demonstrate alignment to new service thinking and demands (the Service dominant logic foundational premises are listed and discussed in 2.2.5). Through alignment of organisational knowledge and skills to the customer needs, the GSCF framework supports the adoption of the customer orientation (Lambert and Garcia-Daustugue, 2006). Here the cross functional nature of the GSCF processes provide a focus on relationships and the management of conflicting functional objectives promoting efficiency across the service enterprise (Lambert and Garcia-Daustugue, 2006).

2.3.3.4 Interdependence

An enterprise which delivers a complex engineering service may be described as one made of a number of interdependent parts (Anderson, 1999). This interdependence is captured in the construction of the research framework as a significant element of the enterprise' feature. Having an improved understanding of dependence will enable improved understanding, managing and reporting of performance. Literature explicitly defining dependence and interdependence in business operations is limited. However, sufficient literature exists to enable an improved understanding of the nature and difference of independent, dependent and interdependent activities. Donaldson (2001)

who proposes task dependency describes the way activities or products in an organisation are connected and how they relate to one another. Connectivity can be pooled (indirect connection), sequential (direct one-way connection) or reciprocal (two-way connection). Barrick, et al. (2007) describe a dependence relationship in the context of a management team as a situation where members of the team are dependent and some are not and the dependent is identified where their activity is contingent on another. Barrick, et al. (2007) also describes interdependence as the relationship or link between activities where each member is mutually dependent on the others. Each task you do is dependent on what others do (Barrick, et al., 2007). There is also a difference in the time frame. The interdependent activities unfold simultaneously and interact with each other in real time. Thus they are not planned in detail, do not have specific lead-times and are not necessarily sequential. When activities support one another to complete the task value emerges (Ng, et al., 2011). Interdependence changes the traditional view that maximising individual performance will lead to organisational success and is replaced by a focus on group performance. This refines the control process including the performance and accounting practices. The plan, do, review loop is redefined (McNair, 1990). The one to one mapping of individual actions to clearly identified outcomes is replaced by a focus on the effectiveness of a group of individuals engaged in interdependent activities (McNair, 1990). In an interdependent relationship, participants may be emotionally, economically, ecologically and or morally reliant on and responsible to each other (Barrick, et al., 2007). An interdependent relationship can arise between two or more cooperative autonomous participants. Interdependent teams perform best with high levels of coherence and communication. To achieve the best performance there is a need to match the degree of coherence and communication with the level of interdependence (Barrick, et al., 2007). The characteristics of independent and interdependent activities differ greatly. An independent activity reflecting an individual approach normally requires low communication and coherence between team members, and low innovation and flexibility. The interdependent activity, however, reflecting a common objective or team approach requires high communication and coherence between those involved. High flexibility and innovation due to emergent low predictability of task is also required (Barrick, et al., 2007; Callahan, Schenk and White, 2008; Aggarwal, Siggelkow and Singh, 2011).

Business model literature also refers to interdependence (Teece, 2010; Zott and Amit, 2010). Zott and Amit (2010) consider dynamic interdependent activities are central to the concept of an activity system and provide insights into the processes that enable the evolution of a firm's activity system over time as its competitive environment changes. Managers who shape and design both the organisational activities and the links that weave activities together into a system create these interdependencies (Zott and Amit, 2010). Such purposeful design within and across firm boundaries is the essence of the business model. The firm will perform some business model activities with others performed by suppliers, partners or customers (Zott and Amit, 2010).

Literature on collaboration provides a number of definitions for interdependence describing the way the organisations relate to one another (Emerson, 1981; Pennings, 1991; Cropper, 1996). The first vertical interdependence characterises interdependence between organisations within the supply chain. Here the customer seeks to ensure the provision of product or services by contracting with one or more provider organisations (Cropper, 1996). Likewise providers engage with one or more customers. Multiple vertical supply chain dependences are therefore created. Whilst the vertical chains may compete with one another they may also work together promoting mutual interests such as fairness in contracting or understanding of foreign market opportunities (Cropper, 1996). This is the second type of interdependence labeled horizontal that can manifest in trade federations and like organisations. The third and final definition of interdependence is symbiotic and extends the second definition. Here there is collective gain or benefit to individuals as a result of group action (Emerson, 1981; Kay, 1992).

With interdependence and if each partner is equally dependent on the other for success, there is an equal commitment to the making the partnership successful. The advantage is sustainability of the relationship. The disadvantage is that decisions are shared and may take longer to reach and there is more likely to be a compromise (Cropper, 1996). As the interdependence moves away from equality, the decisions become more influenced by the more independent partner. Generally the relationship has less commitment in both directions and is more likely to be temporary. True interdependent relationships can be slow to progress but are durable whilst the alternative, independent-dependent partnerships tend to be efficient but more fragile. Collaboration and interdependence can add complexity but will continue to exist as long as there is

comparatively productive, efficient and increased gain (Cropper, 1996).

Study can also be found on correlation between macro-economic interdependent phenomena (Li, et al., 2011). Here it is suggested that measuring potential interdependent activities or phenomena independently and understanding how they correlate may be beneficial as it may then be possible to replicate good performance by replicating the same individual performances and correlations. Correlation however may not imply causation (Li, et al., 2011).

2.3.3.5 Enterprise imaging

The challenge for firms within a multi-organisational service enterprise is to look beyond their own boundaries and design organisational solutions for service delivery from an enterprise perspective (Purchase, et al., 2011). Delivering services through multi-organisational enterprises requires organisations to move beyond their own narrow concerns and efficiencies to take an enterprise wide perspective (Mills, et al., 2012). Enterprise level management focuses on the whole of the service activity regardless of ownership (Brandt, 1998). Enterprise level management also considers all customers at all levels within the service value chain (Brandt, 1998).

Typical representation of multiple organisations which form an extended enterprise have been structured around concepts like supply chain, supply network or value chain (Mills, et al., 2012). They show flows of component product and service taking a holistic view of the organisation in hierarchic diagrams (Mills, et al., 2012). They do not acknowledge that many organisations do not have processes that fully integrate the behaviour of their sub parts. Thus, the concept of Enterprise Imaging (Parry and Mills, 2013) is currently being developed in order to provide a more visual understanding of all the organisations involved, depicting both the domains they operate in and who they interact with. Like service blue printing (Shostack, 1984) Enterprise Imaging focuses on value adding processes rather than the value enterprise itself building on the concept of backstage and onstage from Zeithaml, et al. (2009). Identifying and mapping the organisations involved provides visibility. The pictorial representation of a complex multi-organisational enterprise forms an improved picture of who interacts with whom. Furthermore the picture forms a boundary object for all the actors involved together with a shared common understanding that is considered key from a practical

management perspective (Mills, et al., 2013). Enterprise Imaging allows the enterprise actors to holistically see the diverse network of stakeholders who work together to achieve a common purpose. Only one part of a large company might be involved in a multi-organisational enterprise. For them, the picture makes it easier to explain their role and manage their operation within a complex system of interacting activities (Parry and Mills, 2013). The enterprise image can help:

- operational managers understand the cause of the complexity they face (Mills, et al., 2012; Parry and Mills, 2013)
- agree on one image across a wide set of partners (Mills, et al., 2012; Parry and Mills, 2013)
- provide a basis to discuss where organisations fit (Mills, et al., 2012; Parry and Mills, 2013)
- represent the entire enterprise, making it easier for non-operations staff to visualise all key functions (Mills, et al., 2012; Parry and Mills, 2013)
- accelerate the learning of the service operation (Mills, et al., 2012; Parry and Mills, 2013)
- provide help for the strategic management of the enterprise (Mills, et al., 2012; Parry and Mills, 2013)

Enterprise imaging has been developed to capture the activity of a complex service system. The standard framework of an Enterprise Image is detailed below. The Enterprise Image is created upon a standard framework of three separate areas. One area represents each contracting partner and a third area represents where both organisations work together. To define the areas, the Enterprise Image uses the concept of back office and front office. These terms define separate but co-ordinated areas within the enterprise. The front office space is where the provider and customer interact and the back office space is where the supporting customer and provider organisations operate. In the latter the partners have no visibility of each other's operations. A line of visibility separates the areas (Parry and Mills, 2013). See Figure 5 below for details.

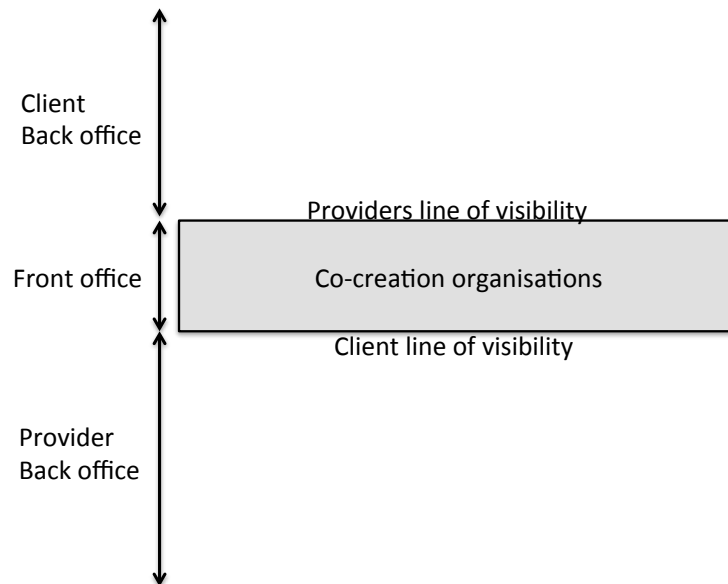


Figure 5. Enterprise Imaging (Parry and Mills 2012), Copyright Emerald Group Publishing Limited

The enterprise image clearly shows to those directly and indirectly involved the complexity and interdependence faced by all engaged in the delivery of the service (Mills, et al., 2010).

The Enterprise Image (Figure 5) introduces eight defined categories based on their location, roles and reporting lines. The categories which are sub- organisations units within the main provider, client or third party are characterised by different shapes and placed in either front office or back office locations dependant on the role they undertake (Mills, et al., 2010). The categories are shown on the standard image (Figure 6) and described below:

- The rectangle represents partnered direct service delivery organisations. These organisations are located in the front office and are directly involved in operational activities. They are fully visible delivering services to client and provider. They comprise both client and provider staff co-creating value (Mills, et al., 2012; Parry and Mills, 2013).

- The oval represents non-partnered outcome focused organisations. These organisations are located in the front office. These are sub-organisations that are co-ordinated by either the prime service provider or the client. They are highly visible and focused on the delivery of the service outcome (Mills, et al., 2012; Parry and Mills, 2013).
- The octagon represents un-partnered direct service delivery organisations. These are commercial third party contractor organisations located in the front office directly involved in service delivery supporting the availability of the product. They may be contracted to one or other main partners and are visible to the main enterprise. They are positioned between front and back office dependant on their visibility (Mills, et al., 2012; Parry and Mills, 2013).
- The parallelogram represents internal support resources located in the back office. These are organisations within the client or main provider organisations and may have a greater scope of activity than the contract being mapped. They are never the less critical to the service delivery (Mills, et al., 2012; Parry and Mills, 2013).
- The rhombus represents key supply chain organisations. This reflects third party suppliers providing services not already covered. These are placed in back office locations not normally visible to the opposite party (Mills, et al., 2012; Parry and Mills, 2013).
- The triangle represents governance organisations. These organisations are located in the back office. These organisations are deciders of how the operations are conducted. They determine the resources available and dictate resource co-ordination (Mills, et al., 2012; Parry and Mills, 2013).
- The hexagon represents customer representative organisations that are routes of communication with particular groups of workers, the customer or public. They are placed in the front office (Mills, et al., 2012; Parry and Mills, 2013).
- The diamond represents third party indirect resources. They are independently managed co-ordinated resources that have a direct influence on the outcome but may not be directly engaged in the contract (Mills, et al., 2012; Parry and Mills, 2013).

The set of shapes presented have been used in enterprise images to represent a broad range of complex enterprises. Although the set may not be exhaustive, they should be

interpreted as able to cover most organising units found in public and private sectors (Parry and Mills, 2013).

There is a paucity of servitization literature focused on how operations should change. However the literature that does exist proposes the move to successful servitization needs to be supported by redefinition of manufacturing and service boundaries and significant changes in the way firms are structured (Oliva and Kallenberg, 2003; Wilkinson, Dainty and Neely, 2010). The front office, back office enterprise imaging frame is consistent with the need to change and provides a suitable approach towards an organisation based on units dedicated to co-creation and support activities. Customer facing front office units are established to engage directly with customers from the point of first contact to the provision of the required service. Traditional production and service divisions are transformed into back offices providing the product platforms and service portfolios to the new front office service operations who integrate client and capability requirements to provide tailored solutions (Davis, et al., 2006; Johnstone, et al., 2008). The enterprise image provides greater understanding of such organisations (Mills, et al., 2012). Transformation of processes and the way firms operate on a daily basis is also required to support the new way of working (Wilkinson, et al., 2010; Oliva and Kallenberg, 2003).

The literature on servitization and enterprise including the importance of the fundamental sub themes of the service enterprise (Purchase, et al., 2011), the business model (Zott and Amit, 2010), vertical integration (Bains and Lightfoot, 2012) and interdependency (Barrick, et al., 2007) confirm that developing an understanding of enterprise is key to comprehending servitization. The literature recognises that a service enterprise operates differently to a product organisation and managers need to recognise this to ensure a service is provided with the desired level of efficiency and benefit (Wilkinson, et al., 2010; Zott and Amit, 2010; Purchase, et al., 2011; Ng, et al., 2011; Parry and Mills, 2013). Enterprise is therefore added as the third interacting theoretical feature to the research framework.

2.3.4 Performance

This section explores and reviews the literature on Performance. It comprises a detailed literature review on performance management and performance measurement. This

literature is included within the review as improved performance is key to offering an acceptable service.

2.3.4.1 Performance management

Performance in this context relates to performance management and performance measurement and how it is used to improve the effectiveness and efficiency of business activities.

'Why measure?' Whilst the saying goes 'you cannot improve what you cannot measure', to improve the performance in the service environment, first it is necessary to specify what is actually meant by customer service (Neely, et al., 1997). This statement directly translates to the move by manufacturing firms to service. Performance management and performance measurement literature is well established for the manufacturing sector (Maskell, 1989; Kaplan and Norton, 1993 and 1996; Neely, et al., 1996; Beamon, 1999; Meyer, 2002; Slack, et al., 2007). In comparison little has been written about performance measurement in the service environment (Neely, 2005).

The literature review provides a definition for performance measurement and breaks the topic down to individual measures, the performance measurement system, and the environment. These features are explained in the following section. The literature review highlights a bias towards performance measures for manufacturing. This bias identifies a gap in the literature and the need for research and literature that considers performance measurement for servitized organisations.

2.3.4.1.1 Performance measurement

Organisations achieve their goals by satisfying their customers with greater efficiency and effectiveness than their competitors (Neely, et al., 1995). Effectiveness refers to the extent to which customer requirements are met. Efficiency is a measure of how economically the firm's resources are utilised whilst providing a given level of customer satisfaction, (Neely, et al., 1995). Performance measurement in a business context can therefore be defined as quantifying the efficiency and effectiveness of action (Neely, et al., 1996). A performance measure is a prerequisite for judging whether an operation is good bad or indifferent (Slack, 2007). A performance measure can be defined as a metric used to quantify the efficiency and or effectiveness of action. The performance

measurement system can be defined as the set of metrics used to quantify the efficiency and effectiveness of actions (Neely, et al., 1996).

Performance measurement can also be viewed at three different levels. The individual measures, the set of performance measures, the performance measurement system as an entity and the relationship between the performance measurement system and its environment.

An individual measure is the first of the three elements. This can be split down into four different categories, quality, time, cost and flexibility. Each category has multiple measures and different definitions exist (Neely, 1995; Slack, 2007; James, et al., 2010). Wheelwright (1984) uses flexibility in the context of varying production volumes whilst Tunalava (1992) uses it to refer to a firm's ability to introduce new products rapidly. Firms should therefore carefully select which measures they require, what they use them for, how much they cost and what benefit they ultimately provide. The multiple dimensions of quality, time, cost and flexibility are shown below:

- Quality dimensions include performance, features, reliability, conformance, technical durability, serviceability, and aesthetics, perceived quality, humanity and value.
- Time dimensions include manufacturing lead-time, rate of production introduction, delivery lead-time, due-date performance, and frequency of delivery.
- Cost dimensions include manufacturing cost, value added, selling price, running cost and service cost.
- Flexibility dimensions include material quality, output quality, new product, modification of product, deliverability, volume, mix and resource mix.

Individual measures can also be described as static, dynamic and motivational (Dimancescu and Dwenger, 1996, Neely, 1995; Slack, 2007). These are described below:

- Static measures are gathered after the event has occurred. They are lagging indicators. Corrective action is therefore only possible after knowing the outcome. Static measures are results focused and include return on investment, profitability, etc.

- Dynamic metrics that acknowledge the dynamic aspect of the context are employed with live feedback as a goal. They are leading indicators that can be used to predict probable outcome of work in progress and hence launch corrective action.
- Motivational metrics are used to translate business objectives into meaningful and motivational measures. These measures are required to develop and drive performance enhancement and continuous improvement cultures required to develop and sustain competitive advantage.

The second element of the framework is the performance measurement system. The performance measurement system comprises the individual measures that can be examined as a whole. It can be viewed as having various dimensions, those that focus on results i.e. competitiveness and financial performance and those that focus on the determinants of the results i.e. quality, flexibility, resource utilisation and innovation (Neely, et al., 1995). A number of different approaches can be used to design a performance measurement system. Maskell (1989) proposed a set of performance principles directly related to the manufacturing strategy of the firm and selected to provide flexibility. Meyer (2002) proposes seven different dynamic purposes including lagging, leading and motivational indicators, roll-up and cascade down. The best of both approaches can be combined in a performance measurement framework. Perhaps the best-known framework is the balanced scorecard (Kaplan and Norton, 1993). The scorecard was initially structured to provide four perspectives. A financial perspectives, a customer perspective, an internal business processes perspective and a learning and growth perspective. This enables companies to track financial performance while monitoring progress in building capabilities and acquiring intangible assets needed for future growth. The scorecard was not a replacement for financial measures but complementary and was further developed as a strategic management system (Kaplan and Norton, 1996). The strategic management system introduced four new management processes that separately and in combination contribute to linking long-term strategic objectives with short-term actions. These included: translating the vision as a set of operational objectives and measures, communicating and translating the strategy to departmental and individual measures, business planning, prioritising and allocating resource, and feedback and learning. Furthermore monitoring of short-term results from the three new perspectives of customer, internal business processes and learning

and growth is included. This provides the ability to modify strategies to reflect real time learning.

The balanced scorecard however does have its limitations and a scorecard is very specific to the business unit it is designed for and only links at the divisional level if a well-defined strategy exists (Kaplan and Norton, 1993). The balanced scorecard has also been considered as static as the financial measures often tell the story of past events (Slack, 2007). Furthermore the fourth perspective of learning and growth tends to be under used (James, et al., 2010).

Meekings, et al. (2012) promote a new framework that provides connected performance. The framework comprises a number of features: performance architecture (who need what, when and why), performance planning (forward looking performance trajectories), performance culture (is it important and visible), performance exploration (what happened, why) and successful implementation (tailored approach). The framework is intended to provide a pragmatic basis for improving connectedness across the organisation connecting management and improving decision making whilst inspiring individuals and teams towards improved performance. This framework will help servitized firms deliver an improved performance by identifying and communicating who does what and why across the service enterprise. This will help to reduce mixed objectives, align effort and help to deliver a performance culture through understanding and visibility.

Environment is the third and final element. Once the performance measurement system has been developed it has to be implemented and interact with a wider environment. In fact it must interact with two dynamic dimensions, the internal environment being the organisation, whilst the external environment is the market within which the organisation competes (Neely, et al., 1995).

The internal environment performance management system should be consistent with the internal culture and the strategic control system where the performance system is seen as part of the wider system that includes goal setting, feedback and reward or sanction (Neely, 1995; Slack, et al., 2007; James, et al., 2010).

The external environment however consists of two distinct elements – customers and competitors. The performance measurement system should therefore include measures

of customer satisfaction, quality, delivery etc. and also measures on competitor performance. The firm should benchmark its own performance across a number of suitable measures such as product innovation, product development, process innovation and technology acquisition (Voss, et al., 1992; Slack, et al., 2007; James, et al 2010).

2.3.4.1.2 Supply chain and performance measurement

Specific literature on performance measurement of the supply chain has increased with the growth of outsourcing. Specific performance measurement is required as a typical supply chain is very complex comprising of multiple elements of supply, manufacturing, distribution and customers (Beamon, 1999; Poirier, 2004; Slack, et al., 2007; Parry, 2010).

Frameworks have been developed and key metrics identified to manage the complexity of the supply chain (Beamon, 1999). These frameworks include measures dealing with suppliers, delivery performance, customer-service, and inventory and logistics costs aligned to customer satisfaction (Gunasekaran, et al., 2001).

Measures used demonstrate certain characteristics. Inclusiveness measures all pertinent aspects, universality allows for comparison under various operating conditions, measurability ensures the data required is measurable and consistency ensures measures are consistent with organisational goals (Beamon, 1999).

Furthermore Beamon (1999) suggests it is not possible to achieve the desired characteristics with singular performance measures. He therefore advocates the use of a framework including three separate types of measures. These are resource measures, output measures and flexibility measures. The performance measurement system must contain at least one of each type and each chosen should support the organisations strategic goals:

- Resource measures include: inventory levels, personnel requirements equipment utilisation, energy usage and cost and are normally measured in terms of quantity or a composite efficiency measure. Examples of measures: total cost of resources used, total costs of distribution, total cost of manufacture, cost of associated inventory, incl. obsolescence, work in progress and finished goods and return on investment.

- Output measures include: customer response, quality and quantity of final product produced, and customer satisfaction and are normally expressed numerically. Examples of measures: total revenue, profit, on-time deliveries (lateness, average lateness, earliness and percentage on time), back orders, stock-out, response to customer order, lead-time, shipping errors and customer complaints.
- Flexibility measures, measure a systems ability to accommodate volume and schedule fluctuations from suppliers, manufacturers and customers. Two types of flexibility were identified by Slack (1991). Range flexibility and response flexibility. This refers to what extent can the operation be changed and the ease (in terms of cost, time, or both) with which the operation can be changed respectively.

An example is a surprise reduction in the systems resources (Beamon, 1999). This may impact negatively as the time to complete activities will extend. Like-wise how does the system cope with manufacturing schedule changes, introduction of new products or supplier shortages? Flexibility examples are volume flexibility, delivery flexibility, mix flexibility and new product flexibility. They are the measure of potential and are applied to other production objectives and have multiple dimensions (range and response). Beamon (1999) advises that whilst flexibility has been reviewed in manufacturing environments application in more complex systems such as supply chains has rarely been addressed.

2.3.4.1.3 Service measures

Traditional performance measures of effectiveness and efficiency have been detailed in literature and are well used by manufacturing firms (Neely, 1995). A limited number of different perspectives that characterise performance measurement of service can also be found. This includes the belief that the gap between expectation and perception needs to be managed by a special set of service measures (Sasser, Olsen and Wychoff, 1978), measuring inputs and outputs in services requires a more subjective approach than measuring inputs and outputs in manufacturing firms (Shaw, 1990), and service companies need to develop a new accounting metric. Metrics for outputs need to be subjective to take into account the heterogeneity of each customer's expectation of the output. Transaction based metrics measuring employee inputs need to be coupled with

a measure of customer inputs (Roach, 1991); in manufacturing processes involving tangible products, inputs and outputs are relatively easy to measure. In services, measurement of both outputs and inputs is problematic as some of the inputs are provided by the customer co-producing (Kingman- Brundage, 1995); existing measures need to be supplemented with subjective service measures for assessing service experiences (Bowen and Ford, 2002); the customer should provide an input to the service providers operation to the perceived quality of the service outcome (Parasuraman, et al., 1985) and consumption of the service is inseparable from the service and that inputs from customer and provider should be measured (Parry, 2010).

Furthermore the real measure of quality is the level of customer satisfaction. A list of determinants of service quality as used by the consumer is provided below (Parasuraman, et al., 1985):

- reliability, the consistency of performance and dependability
- responsiveness, the willingness and readiness of employees to provide the service
- competence, the possession of the required skills
- access, the approachability and ease of contact
- courtesy, the politeness, respect and consideration
- communication, the informing the customer
- credibility, the trustworthiness, credibility
- security, the freedom from danger and risk
- understanding, the knowing the customer- making an effort to understand the customer's needs
- tangibles, the physical facilities, appearance of personnel, and tools

Discussing the need to measure service performance is not new. Sasser, Olsen and Wychoff (1978) established a set of service measures and identified measurable design and delivery features that together feed a service level that specifically manages the gap between expectation and perception.

Figure 6. redacted as Copyright permission unobtainable

Figure 6. Service concept model (Sasser, et al., 1978)

The concept of the gap between expectation and perception was further developed by Parasuraman, et al. (1985) who believed quality is measured as a comparator between expectation and performance and identified five gaps:

- consumer expectation compared to management perception of what consumers expect
- managers perceptions versus the firms service quality specifications
- service specification versus actual service delivery
- actual service delivered versus external communications to the customer about the service
- expected service versus perceived service

Parasuraman, et al. (1985) focus on the importance of the customer input linking the customer's ability to provide an input to the service providers operation to the perceived quality of the service outcome. Consumption of the service is inseparable from the service and inputs from customer and provider should be measured (Parry,

2010). There is also a need to look closely at the inputs from both the providing firm and customer in value measurement. Essentially any co-created value may have an optimal position. A shortfall as a result of the value proposition mismatch or inability of a partner to deliver upon the expected value produces a shortfall from the optima (Ng, 2008).

Complex service enterprise performance measurement often suffers from too many unidirectional and non-dependant measures being established (Parry, 2010). A framework that captures measurement from across the service enterprise enforcing quality and appropriateness should be more accurate than one of quantity and role-up of measures and results via traffic light systems (Parry, 2010). A greater adoption of an enterprise view through a greater number of interdependent, two-way measures across the enterprise boundaries (customer and network, central provider and supply chain) is required (Parry, 2010). This allows customer issues to drive the operation as well as inform the customer when their behaviour needs to be modified. Furthermore increased visibility and knowledge across the organisation help facilitate a new service enterprise where shared objectives shape an enterprise to create value for all stakeholders (Parry, 2010).

Very limited literature on the performance and cost of value co-creation can be found. Ng, et al. (2008) considers performance between the provider network and the customer and proposes a representative framework to capture the concepts that should be included and how they come together to value co-create. Ng, et al. (2008) proposes that firms need to align their processes to those of the customer to achieve optimal results. Furthermore Ng, et al. (2008) propose that the efforts do not need to be asymmetric for optimal results and that both the provider and the customer each provide a value proposition through the use of their resources which results in benefit to both. Benefit to the customer and revenue to the firm (Ng, et al., 2008). The framework also suggests that when the firm manages the value co-creation well the benefits can be higher than when not managed well. This may encourage the customer to pay more for an improved service. Where product and services are provided the level of service becomes of central concern as an improved service level benefits performance. Hence firms are increasingly constructing product offerings to be more like service to deliver increased customer benefit (Ng, et al., 2008). Etgar (2006) provides a framework to explain value co-creation and provides detailed examples of

co-production (nested within the overall value co-creation activity) to demonstrate the role and cost impact of the customer and provider. Etgar (2006) uses a household example to identify that the benefit level produced by the total activity is determined by the mix and cost of resources selected by the customer. Here the cost of co-production rises and falls with the selection of in-house or sub-contract activity who's cost in turn is influenced by the age, availability, level of experience and level of cost of the resource involved. Etgar (2006) therefore demonstrates the level of cost and benefit can be controlled through careful selection of the resources required to deliver the desired result. Cost is therefore the next area relevant to servitization that will be considered.

The requirement to develop an understanding of performance is therefore applicable to developing an improved comprehension of servitization. Performance is thus added to the research framework. The literature identifies that achieving improved or acceptable levels of availability and performance is essential to delivering improved benefit during and post servitization (Neely 2008).

2.3.5. Cost

This section addresses the issue of cost, and more specifically the literature on through life cost. The review on cost has been included as the literature identifies that developing an improved understanding of the cost of providing a complex engineering service through life is central to successful servitization and to the construction of the research framework. Themes on through life costs (Newnes, 2008) and cost of complex service delivery are reviewed (Seddon, 2003; Ng, 2011) in order to gain a better understanding of the cost of a complex engineering service and hence improving the potential of achieving revenue and profit gains from service provision.

Traditionally purchase agreements have covered the supply of fully functioning products or services between suppliers and their customers. The customer takes receipt and pays a fee at which point ownership and responsibility is passed to the customer (Saravi, et al., 2008). The supplier is only concerned with the costs associated with concept, assessment, development and manufacture. Although traditionally the majority of costs incurred by the suppliers can be attributed to the manufacturing phase, up to 80% of the products total cost is committed during the balance of the products lifecycle during the in service and disposal phase (Saravi, et al., 2008).

Increasing levels of business-to-business service availability contracting within the servitization context (as explained in previous chapters) now also places the burden on the supplier for the in service and disposal period (Ng, et al., 2011). Unlike with purchase agreements the responsibility of the product through life cycle remains with the supplier, from concept stage through to disposal and the producer is expected to manage all costs, (Ng, et al., 2011). Under these new arrangements in service costs can account for up to 75-85% of the through life cost of a product (Manary, 2009). Hence predicting the in service cost for long life and low volume products is extremely important. This has led to an increased interest in through life cost estimating (Newnes, et al., 2008). Furthermore the greater the complexity of the service the greater the potential for overspend. The UK defence acquisition programmes for the provision and support of military equipment has a historical overspend equal to plus 40% on average. The USA suffers plus 49% for the same activity. The figures demonstrate that its essential to ensure a fit for purpose cost model is established (Bassford, 2012).

To enable a provider to cost such a service they need to estimate through life costs including design, initial manufacture and in-service (such as the manufacturing costs for repairs and upgrades). However, many cost modelling tools and methods are predominantly product based (Newnes, 2007; Scanlan, 2006; Castagne, 2008) or focus on predicting the obsolescence of e.g. electronic parts (Sandborn 2007). A review of the domain has also found that very few cost estimating tools model in-service costs, in particular suppliers meeting the performance requirements of the service (Cheung, 2009 and Hollick, 2009). Research to date has illustrated that products and services have unique properties and new methods are required to model the cost of a service (Huang, Newnes and Parry, 2009). This is emphasised by the goal programming approach adopted by Kumar (2007) where they attempt to optimise reliability, maintainability and supportability as current models do not optimise design selection based on cost of ownership through life.

The UK Ministry of Defence introduced the concept of through life management and developed the CADMID model as part of their Smart acquisition initiative during 1998. It is a keystone of their procurement policy providing a standard cycle definition for project acquisition from concept to disposal. The CADMID model details the elements of the lifecycle that requires costing and include concept, assessment, development, manufacturing, in-service and disposal. Eighty percent of costs are built in between

concept and development whilst seventy five percent of the costs actually occur in the inservice phase (Manary, 2009).

CADMID CYCLE

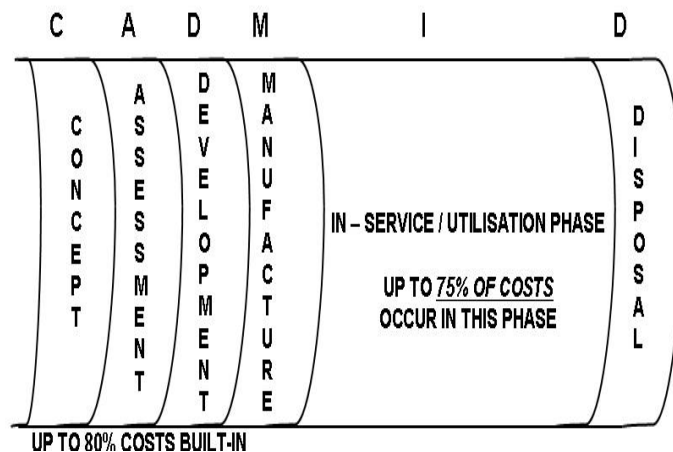


Figure 7. CADMID life cycle model (UK MOD Smart Buying, 1998), Open Parliamentary Copyright

Through life service of highly complex, low volume Aerospace and Defence equipment, with high customer interaction has the potential for high variety and high variation. The changing circumstance and differing customer expectations and requirements (Ng, et al., 2011) and varying product performance (Goh, et al., 2010) all increase complexity through the life of the service. As service may be heterogeneous and context specific each time there is a customer interaction new complexity may be generated (Parry, 2011).

Furthermore in a service situation within an extended enterprise involving multiple stakeholders the customer variety more easily permeates the system (Ng, et al., 2011). In traditional manufacturing systems there are production and consumption systems and customer variety may normally be controlled as it enters the system by recognised gates, such as new product introduction, sales channels and marketing channels. The

service interface on the other hand may be broad and seen as a permeable membrane where variability may penetrate at almost any point (Ng, et al., 2011).

According to the American institute of chemical engineers (Goh et al., 2010), total cost assessment needs to consider five categories with the trend of each category becoming increasingly more difficult to quantify:

- type 1, the direct costs (capital investment, recurring and non-recurring)
- type 2, the indirect (operating and maintenance, recurring and non-recurring)
- type 3, the contingent (future scenarios, accidental)
- type 4, the intangible (customer loyalty, worker moral)
- type 5, the external costs (societal costs)

Multiple uncertainties can be experienced through the life cycle phase during concept, development, manufacture, in service and disposal phases. Potential uncertainties for the life cycle phase, complete with classification between Epistemic, as a result of a lack of knowledge and Aleatory, as a result of system uncertainty (Goh, et al., 2011) have been detailed in Table 3 below.

	Life Cycle Phase				
	Concept	Development	Manufacture	In service	Disposal
Epistemic uncertainty.	Requirement changes. Design changes. Technology maturity. Funding availability. Performance indicators. Discount rate.	Design changes. Demonstration programme. Complexity. Testing regime.	Process selection. Manufacturing technology. Choice of suppliers. Tooling required.	In service date. Technology obsolescence. Design refresh. Maintainability. Supply chain disruption. Logistics options. Location of repair. Warranty and liability.	New legislation. Recycling technology. Disposal.
Aleatory uncertainty.	Market demand.	Development time. System performance. Learning rate. Measurement error. System reliability and life.	Overheads. Production rate. Labour hours and rates. Scrap rates. Material costs. Process capability. Material performance.	Maintenance cost (repair, time, material). Operational conditions. Operational overheads, (fuel, tax). Spares demand, Failure rates, Remaining life.	End of life value. Disassembly time.

Table 3. Life cycle phase uncertainties (Goh, et al., 2010)

Further potential in service phase uncertainties have been detailed in Table 4 below (Goh, et al., 2010; Frei, 2006; Ng, et al., 2011; Hockley, et al., 2011; Kerr, et al., 2008; Smith, et al., 2011; Poirier, 2004).

Origin of uncertainty/variability.	Type of in-service uncertainty/variability	Author
Requirement variability.	Request variability (different requirements per customer and across customers). Arrival variability (peaks and troughs in service). Capability variability (some require customer input/participation and customers will have different willingness to make an effort). Subjective preference variability (different and contradictory views of what constitutes good service).	Frei (2006).
Product.	Performance, reliability, maintainability, failure and repair. Remaining life of product. Spares demand.	Goh, et al. (2010).
Requirement changes.	State of world. Project risk. Life cycle changes.	Ng, et al. (2011).
Use of product.	What geographic environment is the product used in? Different conditions on different platforms. Storage conditions. Maintenance completed in diverse environments. Handling and transport in different environments and varied conditions, (vibration etc.).	Hockley, et al. (2011).
Changes (adaptive changes).	Adaptive changes to platform capability. Adaption of platform changes (technology insertion). Integration of past and future maintenance information. Obsolescence. Requirement for increased or new capability. Challenge of affordability. Design refresh. In service entry date.	Kerr, et al. (2008, 2011), Goh, et al. (2011).
Process.	Interdependence of value propositions and attributes. Repair, spare etc. Spare Availability. Adherence to process.	Smith, et al. (2010); Goh, et al. (2010).
Enterprise.	Capability to perform, willingness to perform and performance of customer. Capability to perform, willingness to perform and performance of provider firm. Strategy, ownership, capability, willingness and performance of suppliers, contract. Capability to perform, willingness to perform and performance of 3 rd party organisations. Availability of facilities. Availability of tooling. Performance of tooling.	Poirier (2004); Ng, et al. (2011).

Table 4. In service phase uncertainties (Source author)

In practice most organisations attenuate the variety they offer to the market place (Beer, 1981). However in the case of outcome based contracts for complex engineering service attenuation may be unacceptable to the customer (Ng, et al., 2011). The message for the producer is that it must not just match the variety demanded in the original specification but must also be capable of matching the variety as the user requirements

change due to use of the product in varied contextual states throughout the product life. This could result in unexpected cost (Ng, et al., 2011). It could also result in the introduction of innovation, flexibility and new business models (Ng, et al., 2011). The value of being innovative and flexible should not be overlooked as poor management of variability can easily lead to increased pressure in the form of artificial variability, a dynamic which has recently been observed within their operations and explained by the National Health Service (NHS Institute for Innovation NHSIFI 2011). As well as variation in customer demand (natural variation being the differences in symptoms and disease) artificial variation is created by the way we set up and manage systems (NHS Institute for Innovation NHSIFI 2011). The NHS believes that poorly managed demand variability increases variability. Poor scheduling of services, poor management of the working hours and planned leave of staff, poor management of the order in which the NHS see patients, the inability to work effectively in groups and how the NHS manage urgent cases are all cited as potential sources of artificial variability (NHS Institute for Innovation NHSIFI 2011).

Literature on cost assessment in a life cycle perspective is particularly rich with the approach being labelled alternatively as Life Cycle Costing (LCC), Through Life Costing (TLC), Total Cost of Ownership (TCO), and Total Cost Assessment (TCA) (Gupta and Chow, 1985; Blanchard, 1991; Carrubba, 1992; Artto, 1994; Emblemvag, 2003; Cooper and Slagmulder, 2004; Datta and Roy, 2010; Goy, et al., 2010). It encompasses a wide range of applications, often at the interface between different disciplines, including design, cost management, reliability and maintenance engineering, operations, production and supply chain management, and environmental sciences.

Techniques and applications of cost assessment in a life cycle perspective have been the object of several reviews, either considering the full life cycle (Korpi and Ala-Risku, 2008; Christensen, et al., 2005) or focused on specific aspects such as design (Newnes, et al., 2008; Asiedu and Gu, 1998), system's performance, reliability and availability (Datta and Roy, 2010; Gupta and Chow, 1985), uncertainty (Goh, et al., 2010), procurement policies (Ellram, 1996), and environmental management (Hunkeler, et al., 2008). Despite the body of literature that is currently available on this topic, cost assessment in a life cycle perspective is still perceived as an unfamiliar, poorly understood concept. Besides the efforts made to identify the factors affecting the extent it is used by firms,

there are still misinterpretations and confusions concerning the basic concepts, and even the nature of the analysis – whether it is a cash flow analysis, a costing method or a combination thereof (Emblemsvåg, 2003).

Design of products according to their performance in the manufacturing and use phase and controlling both production and post-purchase costs should lead to enhanced profitability (Wise and Baumgartner, 1999; Shank and Govindarajan, 1992). This confirms the importance to assess and manage costs in a life cycle perspective.

Integrated, product, service, system provided under availability contracting or other types of performance contracting poses major challenges to the traditional approach to through life costing (Meier, et al., 2010). Such challenges emerge as one contrasts the well-established backgrounds of through life costing (TLC) with some essential features of Product Service Systems (PSS), as described by Meier, et al. (2010). In order to guarantee permanently available means of production within availability oriented business models some business processes are shifted from the customer to the provider. The delivery flow has to be organised efficiently, involving the internal structure of the provider as well as the build-up of the service network and its control. Here the uncertainty and risk can be shared between customer and producer. The customer and provider should jointly assess and monitor the risk and uncertainties. Hence, the need to understand the whole life cost of PSS pushes towards managing and controlling long term operations, performance, costs and risks in these partnerships.

Literature considers the PSS as a system combining assets and through life activities where cost and performance is linked. Here the idea of taking a system approach to costing of service support is gaining momentum (Settanni, et al., 2013). This includes the need to cost value and failure demand where failure demands are caused by a failure to do something or do something right for the customer. In the same way as reducing waste in the manufacturing process flow (Womack and Jones, 1996) identifying and reducing failure demand cost in the service system is viewed as a powerful economic lever (Seddon, 2003).

Understanding cost is important to optimising benefit within a manufacturing or service undertaking. It is especially important where a new value proposition is being offered and where revenues are not as great as expected. Cost is therefore included as the final

theoretical feature of the research framework as understanding cost of service will inform the research case study towards developing a deeper insight of servitization.

2.3.6 Summary of the interacting features of servitization

This section has explored and reviewed literature on the interacting theoretical features of servitization, which form the basis of the research framework. Improved knowledge of the theoretical features of servitization emergent from the literature (competence, value, enterprise, performance and cost) is key to developing an understanding of servitization and the problem of less than expected benefits for the servitized firm.

The section commenced with literature reviews of competence, the resource based view and knowledge based view of the firm, value co-creation, value in use and social capital, establishing servitization as an extremely complex business dynamic. Here the literature review identifies competence and resource management and value co-creation as key building blocks of servitization (Penrose, 1959; Vargo and Lusch, 2004, 2007, 2008). The literature review also confirms value in use as a driver for servitization (Prahalad and Ramaswamy, 2000, 2003, 2004) and identifies improved relationship skills as key to value co-creation involving the customer, provider firm and suppliers (Ng, et al., 2011).

The review has also established that value co-creation and value in use are conceptually described by many publications related to servitization (Prahalad and Ramaswamy, 2000, 2003, 2004; Neely, 2008; Ng, et al., 2011) however limited literature defines these concepts in detail.

This section also reviews the literature on business models, organisation and operations of the service enterprise, and interdependence. The business model is introduced as a set of generic level descriptors that captures how a firm organises to create and distribute value (Fuller and Morgan, 2010). The business model is also described as an activity system that can be used for internal and external activities and can be used to help organise the focal firm and the customer, suppliers and third parties, i.e. the full service enterprise (Zott and Amit, 2010). Furthermore the section informs that the service enterprise is a complex system of interconnected and interdependent activities undertaken by a diverse network of stakeholders for the achievement of a common significant purpose (Purchase, et al., 2011). Vertical integration is introduced as a way a

provider firm can organise to improve service delivery performance through avoidance of dependency in an attempt to avoid penalties and keep costs to a minimum (Baines and Lightfoot, 2012). The provider may assume the customer role (forward integration) where good performance is essential. Finally interdependency is introduced and described as a relationship in which each member is mutually dependent on the others and where each task you do is dependent on what others do (Barrick, et al., 2007). Entrepreneurs or managers create the interdependencies. They shape and design both the organisational activities and the links (transactions) that weave activities together into an enterprise system. Such purposeful design, within and across firm boundaries, is the essence of the business model. The provider firm will perform some activities relevant to the provider firm's business model. Others activities will be performed by suppliers, partners and or customers (Zott and Amit, 2010). Furthermore the review identifies that the interacting organisations of the customer, provider firm and suppliers are described as the service enterprise that maps across the various organisational boundaries of those involved (Mills, et al., 2009, 2010, 2012). Here a tool for enterprise imaging to provide an improved understanding of the enterprise is included (Mills, et al., 2012; Parry and Mills, 2013).

The section is completed with a review of literature on performance management and through life cost. The literature review identifies that much has been written about performance management and performance measures and a number of well-known frameworks have been developed. The concept of the performance measurement system especially the balanced scorecard by Kaplan and Norton (1996) is popular and used to help business to link strategic goals to operational targets (Neely, 1995, Slack, 2007). The majority of the extant literature however is product oriented with little written about performance measurement of services. However with the increasing popularity of servitization new performance measurement ideas are being developed focusing on services introducing new concepts and ideas for measuring co-creation and managing across service enterprises (Meekings, et al., 2012). Further development however is still required. The section is finished with an introduction to literature on through life cost both in its own right and specifically in the servitization context. This provides a base understanding of the problems of through life support cost highlighting the need to further develop understanding.

Table 5 below provides a summary of selected authors reviewed within this section. Each of the literature findings selected contributes to the understanding of one or more of the individual themes used to build the research framework.

Author	Issues addressed	Relevance to servitization research
Penrose (1959).	The book introduces the resource-based view of the firm establishing competitive advantage through development of competences.	The book explains how resources and competence management can be applied to the provision of products and services. This literature adds to the understanding of the research framework theme of competence.
McNair (1990).	The paper which compares traditional and activity based accounting develops the view that individual performance should be replaced by a focus on group performance where interdependence exists.	The paper aids the understanding of performance management and accounting of service activities where more than one stakeholder is involved. This literature contributes towards understanding the research framework theme of performance.
Kaplan and Norton (1992 and 1996).	The papers Develop the balanced scorecard. Includes putting the balanced scorecard to use as a strategic management system. Describes how the balanced scorecard can be	The papers provide an understanding of performance measurement systems developing the general understanding of the research framework theme of performance.

	used to both set direction and deliver performance.	
Neely (1995 and 2005).	The papers provide a performance management definition and framework A review of the evolution of performance measurement research plus developments in the last decade.	The papers provide an essential understanding of performance management identified it as a key theme to be considered when developing understanding of servitization.
Meyer (2002).	The book proposes performance measurement ideas including leading and lagging indicators, cascade, roll up etc.	The book provides an understanding of performance highlighting the importance of individual performance measures. This further builds understanding on the research framework theme of performance.
Prahalad and Ramaswamy (2000, 2003, 2004).	The papers by Prahalad and Ramaswamy introduce new ideas on value creation during 2000, 2003 and 2004. They introduce the concept of customer competence (2000), customer co-creation (2003) and personalised customer experience (2004).	Seminal papers for servitization containing proposals for the concepts of value co-creation and value in use, providing a base understanding of two of the interacting features of servitization. The papers position value as a key theme of the research framework.
Duffy and Fearne (2004).	The paper discusses	The paper provides an

	partnership and collaboration the impact of the supply chain on supplier performance and how they buyer- supplier relationships should develop when engaging in value co-creation.	understanding of the supplier-buyer relationships required for efficient value co-creation (value co-creation is one of the key features of servitization highlighted by this research).
Newnes, et al. (2008).	The paper reviews through life costs management, a process of how to predict the whole life cost of a product at the conceptual design phase.	The paper introduces the concept of though life costing for complex defence equipments. This literature builds understanding on the research framework theme of cost.
Mills, Crute and Parry (2009).	The paper reviews value co-creation in a UK Air defence service availability contract for the Tornado. It discusses the problem of multiple customer perspective and diverse cultures and introduces enterprise imaging.	The paper provides details of a similar research project on the Tornado service support. This highlights similar problems and success of an enterprise delivering a complex engineering service. This literature emphasises the importance of the research framework theme of enterprise.
Wilkinson, Dainty and Neely (2010).	Wilkinson, Dainty and Neely (2010) propose operational changes required between product	The paper provides increased understanding of the operational and organisational changes required to establish an

	and service supply.	enterprise capable of providing a complex engineering service.
Osterwalder and Pigneur (2010).	The book proposes a generic business model framework complete with nine features that need to be considered.	The book provides a framework for business models highlighting business model features that can be used as building blocks for a service provision business model. This helps develop the understanding of the research framework theme of enterprise
Zott and Amit (2010).	The paper provides a conceptual view of the business model as a system of interdependent activities that transcends the focal firm and spans its boundaries.	The paper provides an understanding of business models as a system of interdependent activities that can be used in conjunction with the framework from Osterwalder and Pigneur (2010) to establish what is required when delivering a complex engineering service.
Ng, Nudurupatii and Tasker (2011).	The paper proposes value co-creation and contracting relationships in outcome-based contracts for equipment.	The paper provides details of performance based contracting building understanding of the importance of the research framework theme of

		performance.
Goh, et al. (2011).	The paper explains uncertainty in through life costing.	The paper provides a framework for understanding aleatory and epistemic uncertainties for through life costing. This literature develops understanding on the cost the final theme of the research framework.
Baines and Lightfoot (2012).	The paper introduces the idea of vertical integration to ensure performance where advanced service is concerned. Forward vertical integration (taking the role of the customer) as well as backward integration and insourcing are introduced.	The paper provides a detailed proposal and increased understanding of organisational changes required for the provision of a complex engineering service highlighting the importance of the research framework themes of performance and enterprise.
Parry and Mills (2013).	The document further develops an understanding of the service enterprise and details an Enterprise Imaging tool capable of mapping complex multi organisational service enterprises.	The document provides an understanding, framework and mapping tool for complex service enterprises (Enterprise is one of the key features of servitization highlighted by this research).

Table 5. Interacting themes of servitization, a summary of authors reviewed (Source author)

2.4 Servitization literature review conclusion

This section includes a conclusion to the literature review and a timeline for servitization.

2.4.1 Conclusion

The exploration and review of literature on servitization has identified that literature on servitization is relatively new and the understanding of the phenomenon is developing quickly. However the majority of the extant literature reviewed is at a conceptual level with less research exploring servitization in detail supported by case study data. Literature on specifics, especially through life cost and performance management for servitization are also limited.

Notwithstanding the above the review of literature on servitization and its key theoretical features has provided an in depth understanding of all aspects of servitization from definition to transformation strategies and operational performance. Literature does exist and definitions and concepts have been developed from the concept of value added services (Vandermerwe and Rada, 1988) to Product Service Systems (Hockerts and Weaver, 2002; Neely, 2008) to the recent concept of complex engineering service systems (Ng, et al., 2011). Transformation to the servitized state and how to organise the service enterprise activity has also been captured by literature although also at a conceptual rather than detail level (Oliva and Kallenberg, 2003).

The literature review has also identified that limited detailed literature exists on value co-production, value co-creation (Vargo and Lusch, 2004, 2007, 2008), value in use (Prahalad and Ramasway, 2000, 2003, 2004) and operations and performance management within a servitised enterprise. Further research providing a more detailed understanding of these theoretical features is therefore required to help understand servitization and the servitization paradox that large servitized firms are not always as profitable as expected (Neely, 2008).

A general understanding of performance measurement literature has also been established however little was found on performance management and measurement in the context of servitization.

Finally, and considering the literature review objectives an in depth review of extant servitization literature has been undertaken. This has delivered an in depth understanding of servitization. A number of key interrelating theoretical themes have emerged during the literature review that will be captured in the development of the research framework. The theoretical themes identified include competence, value, enterprise, performance and cost. The research framework is discussed in detail in the next chapter (see chapter 3. Research Methodology, section 3.1.3).

2.4.2 Servitization literature review timeline

A servitization literature review timeline has also been established. Table 6 below provides a 'recap timeline' of selected concepts reviewed. All of the literature findings selected contribute to the understanding of servitization.

YEAR	AUTHOR	SUBJECT
1776	Smith.	Clarified labour as productive when considering goods and non-productive when considering service.
1830	Say.	Introduced the concept of materiality.
1863	Senior.	Classified goods as an object and service as a performance.
1942	Hicks.	Identified characteristics for production and consumption. Simultaneous production and consumption of service.
1972, 1976	Levitt.	Believed servitization should adopt a manufacturing approach by introducing hard and soft technologies.
1985	Zeithaml, Parassurman, and	Extensive literature review establishes IHIP (intangible, heterogeneous, inseparability, perishability) as the

	Berry.	most popular understanding of service characteristics.
1988	Vandermerwe and Rada.	Introduction to servitization, detailing the move from product to services as differentiation creating competitive advantage. This introduces concept of value add where manufacturing firms seek value through the addition of services.
2000, 2003, 2004	Prahalad and Ramasway.	Prahalad and Ramaswamy introduce new ideas on value creation during 2000, 2003 and 2004. They introduce the concept of customer competence (2000), customer co-creation (2003) and personalised customer experience (2004).
2002	Hockert and Weaver.	Introduces the concept and first three types of product service systems: the Integration oriented Product-Service System; the Product oriented Product-Service System; and the Product-Service System.
2003	Oliva and Kallenberg.	Proposes a progressive four-step transition for a manufacturing firm moving from offering product only, to product and services to service provision.
2005	Gebaur and Friedle.	Paradox of poor returns from servitization described as a cognitive phenomenon limiting manager's motivation to extend the service business.
2004, 2007, 2008	Vargo and Lusch.	Focused on the move from products to service Vargo and Lusch (2004, 2007 and 2008) introduce and develop service dominant logic as an alternative to goods dominant logic. This creates a new mind-set and language to better understand the provision of service.
2008	Neely.	Empirical study of servitization establishing the extent and profitability of servitization worldwide. Additionally introduces two new definitions of Product Service System expanding to five types of Product

		service system in total. The Use oriented Product - Service Systems and the Result oriented Product Service Systems.
2009	Bains, Lightfoot, Peppard, Johnson, Tiwari, Shehab and Swink.	Details the differences between product focused, product centric, and service focused operations.
2011	NG, Parry, Mcfarlane, Wild, and Tasker.	Introduces a shift in thinking of how a complex engineering service system is delivered via simultaneous management of all resources (materials and equipments, people, and information).
2012	Baines and Lightfoot.	Introduces the concept of vertical integration for complex services proposing that providers of complex services can benefit from forward and backward vertical integration.

Table 6. Servitization literature timeline (Source author)

This timeline concludes the literature review on servitization.

3.RESEARCH METHODOLOGY.

3.1 Executive summary

This chapter introduces the research philosophies and methodologies selected as most appropriate to undertake this research including their definition and justification for selection. The chapter commences with an introduction to the project and research structure and provides a short summary of the research steps taken. Each research step is subsequently reviewed in more detail. The review includes the theoretical perspective chosen by the research approach, details of the case study, interviews, coding and analysis and a discussion on validity. Additionally the review includes an explanation of the methodology used to determine a new business model for servitization and the process established to compare different aircraft availability recovery simulations. The chapter concludes with a short summary of the research methodology.

Different types of business research exist, exploratory, descriptive, analytical and predictive (Bryman and Bell, 2011). They all aim to increase knowledge and should be rigorous and systematic in their approach. Social research is the use of controlled enquiry to find, describe, understand, explain, evaluate and change patterns or regularities in social life (Blaikie, 2010). Research explores, conceptualises and collects data, tests for associations between variables and generates tendencies of social behaviour (Durbin, 2011).

Each research activity has a topic and aim. The research aim can be related to the development of existing understanding or identifying and proposing a new understanding and theory, addressing a problem or answering a question. Research is therefore planned in terms of an issue, problem or question (Crotty, 1998; Johnson and Duberley, 2000).

As already mentioned in chapter one, this research on servitization has been structured around the specific aim of the overall CATA project. The aim is to develop an understanding of servitization including a specific consideration of the problem of less than expected returns. The research considers servitization as a real life contemporary phenomenon that is complex and needs to be further explored in-depth in order to better understand it (Ng, et al., 2011).

The research is guided from the perspective of a constructivist. It is inductive and qualitative, using a case study as the research vehicle where data will be collected via multiple semi-structured interviews. The servitization research lends itself to a qualitative approach as an in depth understanding of a specific situation is required, rather than developing general understanding. The research will be based on primary data collected during the case study interviews.

As part of the larger CATA project the servitization research benefits from a structured management approach providing increased rigor. This includes guidance, discussion, feedback and validation from a project steering team comprising of industrialists and academics from the stakeholder organisations. The interaction with stakeholders also progressively provides validation, incrementally building confidence. Steering meetings are held on a quarterly basis with special working groups arranged as and when required to discuss specific research topics. The project and research management and validation process described above is illustrated in Figure 8 below.

Project and research management and validation process

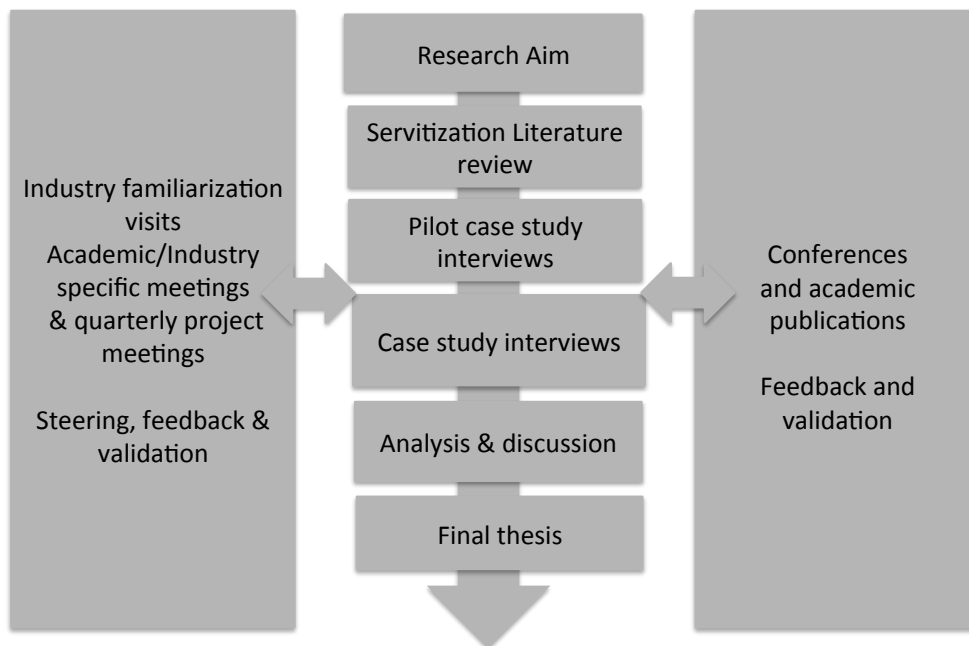


Figure 8. Servitization research, project and research management (Source author)

The servitization research is systematic, with each step of the research captured in a research framework developed post the literature review (see Figure 9). Furthermore participation in academic conferences on servitization and publication of academic papers relating to the work has aided the development of the research and its methodology and provided validation of findings.

The following section provides a short summary and the rationale for the selection of the research methods.

3.1.1 Overview of research activities

A constructivist's theoretical perspective has been selected to reflect the research context and provides an appropriate perspective of reality for this study. The choice is consistent with the reality of the Typhoon support service, which is created by individuals who build their individual and collective understanding of reality based on identifiable everyday objects such as assets, facilities, products and processes (Crotty, 1998).

An inductive approach has been taken such that any further understanding of the servitization transformation builds upon existing theories. The theoretical underpinning employed includes a focus on servitization, and the interrelated theoretical areas of competence, value, enterprise, performance and cost. A research framework capturing the above areas of study mentioned above is used to structure the case study activity and subsequent analysis of data is illustrated in Figure 9.

The inductive approach is supported by a qualitative research approach that places emphasis on words and understanding (Bryman and Bell, 2007). The qualitative approach is delivered through a case study (Yin, 2009). A single study with multiple cases has been undertaken via an investigation of the service enterprise created which is composed of three major stakeholders MOD (Customer), BAE Systems (Provider) and GE Aviation (primary supplier). The single study approach with multiple cases is mainly motivated by the need to gain an in-depth understanding of the individual organisations and their activities. The use of multiple cases also provided an opportunity to compare answers between the stakeholders and to develop a collective view of the service enterprise activity. The strength and limitations of a single study with multiple cases is further discussed in "3.1.6 Assessing the quality of business research".

Semi-structured interviews have been undertaken with lead selected individuals from across the case study firms, which encouraged extended discussion on the subject area. The use of the same set of questions ensured a consistent approach. The interviews were recorded and transcribed word for word to provide accuracy of data. A review of each script was subsequently undertaken to ensure the correct sentiment and understanding had been captured. The data was subsequently analysed and coded. Findings were then used to build new categories, theory and understanding.

Validity is ensured by the structured research approach (Yin, 2009), the involvement and cross comparison of multiple cases (Yin, 2009) and the feedback from the project stakeholders as the research progresses. Full details are provided in “3.1.6 Assessing the quality of business research”.

3.1.2 Constructivism - the theoretical perspective of the research

The theoretical perspective of constructivism guides this piece of research on servitization. Constructivism sits midway between objectivism and subjectivism where there is deemed to be an interplay between subject and object (Crotty, 1998). Constructivism reflects openness to new ideas and new ways of doing things mixed with a pragmatic approach building on existing understanding. The choice of paradigm and theoretical perspective is consistent with the perspectives found in the more contemporary research on servitization (Baines, et al., 2009; Gebaur, et al., 2010; Purchase, et al., 2011; Meier, et al., 2011; Ng, et al., 2011).

The research reflects the epistemological position of the constructivist whose inquiry dictates that the positivist subject-object dualism and objectivism be replaced by an interactive monism and that interactivity between researcher and researched be recognised (Guba, 1990). This is achieved by seeing the situation through the eyes of those involved in the running of the business, interacting with objects yet creating their own understanding of those objects and the situation surrounding them. The perspective accommodates the fact that servitization is an acknowledged phenomenon yet is still in the process of being shaped and understood by academics and practitioners. It also allows for the understanding of the factual side of the industrial activity, the factory, the process, the product and the different perceptions of the individuals of servitization and those very objects within it. The thesis author's background includes leading and working on complex defence programmes across

multiple organisations where multiple organisational and individual viewpoints exist on the same objects and situations. This experience has naturally influenced this choice. Finally, central to the research on servitization is the understanding that incremental changes to strategy and operations are insufficient to achieve a successful transformation from a firm supplying product only to one supplying a service. Servitizing firms need to rethink every facet of their business model and embrace the new conceptual ideas of service dominant logic and complex engineering service systems. Constructivism supports this understanding, as it is consistent with this application of developing new ideas and meaning to existing industrial constructs and activities. The research and findings from interviewees collectively may also reflect social constructivism a sub set of constructivism that has the same understanding as constructivism.

3.1.3 The research approach

The literature review has helped identify and describe the relevance of a number of key servitization themes. These servitization themes have been progressively assembled to create the research framework (see Figure 9 below). The framework captures the dynamic complexity, and interdependence that characterise servitization (Ng, et al., 2011; Baines and Lightfoot, 2012).

The framework informs the empirical investigation of the servitization paradox ensuring the research gathers suitable empirical evidence. Analysis is subsequently undertaken employing the selected theories within the context of a move towards the provision of a complex aerospace service. The aim of this research is to develop an understanding of transformation failures or inefficiencies that are the reason for the poorer than expected returns for the servitized firm, described as the servitization paradox in the literature (Neely, 2008). A detailed investigation of the development of servitization and each theoretical theme (comprised of multiple sub themes) was therefore undertaken using the framework as a guide to achieve the research aim of better understanding servitization. The framework is used throughout the research to provide focus consistency and structure. As such it appears multiple times in this document. Each time the framework is used to describe a different point in this document the figure attracts a new alpha key e.g. Figure 9, Figure 9a, Figure 9b, etc.

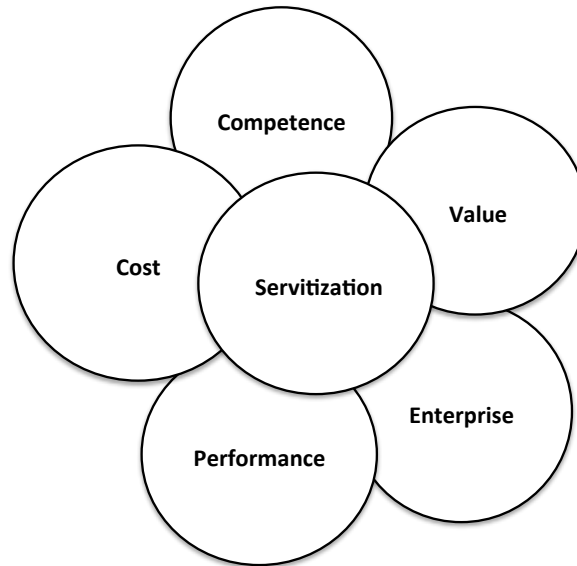


Figure 9. Research framework (Source author)

The research framework comprises servitization at its centre and the key theoretical themes that emerged repeatedly during the literature review. The framework includes competence, value, enterprise, performance and cost. The centre of the framework represents the servitization literature and theory to date including the challenges of transition (Thomas, 1978; Bowen and Ford 2002; Oliva and Kallenberg, 2003; Baines, et al., 2009; Spring and Araujo, 2009; Wilkinson, et al., 2010; Meier, et al., 2011; Ng, et al., 2011; NG, Parry, Mcfarlane, Wild, and Tasker, 2011; Baines and Lightfoot, 2012), the perceived benefits of servitization (Gebauer and Friedle, 2005; Vandermerwe and Rada, 1988) and the service paradox (Neely, 2008). The theoretical constructs illustrated in the outside ring, comprise multiple themes that interact with each other during the process of servitization.

Competence was the first area of literature identified as it is considered as a key building block of service within Service Dominant Logic (Vargo and Lusch, 2004, 2007). Within SD-Logic it is explained that dynamic resources enhanced with new competences are required to deliver benefit for others (Ng, et al., 2011). Resource integration practice and the process of dynamically structuring resource create service systems (Giddens,

1984; Vargo and Akaka, 2012). The focus on resource and competence builds on the theoretical perspective of the resource-based view of the firm. This highlights that firms possess resources that enable them to achieve competitive advantage (Barney, 1991; Penrose, 1959). Resources (skills, assets or technology) underpin the growth of the business and differentiate the business from its current and future competitors (Parry, et al., 2010) providing it with a first mover advantage strategy to develop a service business (Wernerfelt, 1984).

The next feature is value. Core and threshold competence are employed by firms to create value (Parry, Mills and Turner, 2010). Value is specifically included as it is a recurrent central theme identified in the literature as contributing to the understanding and achievement of servitization. The goal of servitization is to change the focus of a firm's value capture mix, from product to a much greater focus on capturing value from service offers (Vandermerwe and Rada, 1988). The literature on value covers a number of themes. The central theme of the value proposition describes what a firm offers. The value proposition is integral to the business model (Teece, 2010). Value co-production (Ramirez, 1999) is the way the offer may necessarily include resources from other organisations in an enterprise or the client. Value co-creation, recognises that value is realized only in the context of use of an offer (Ng, et al., 2011). Value-in-use is important to the customer experience (Prahalad and Ramaswamy, 2000, 2003). It is recognised as an outcome of service and therefore must be recognised within the servitization transition. These reoccurring themes of value have emerged during the literature review and are considered important in understanding servitization (Ng, et al., 2011) as they are central activities undertaken when providing a service.

The next area of literature is enterprise. Enterprises are comprised of processes, people, organizations, information, and enabling technologies. To create value efficiently, these various elements of an enterprise must be appropriately linked and integrated (Nightingale, 2002). Enterprise was recognised and included, as it comprises multiple themes that describe the structure and activities of the extended service organisation that delivers complex service. The work includes the concept of the service enterprise (Purchase, 2011) comprising the firm, customer and provider and supply chain engaged in delivery of the service. The literature recognises that interacting parties transform resources (people, information and materials and equipment) to deliver a complex engineering service (Ng, et al., 2011) through value co-creation (Poirier, 2004). The

enterprise becomes customer focused with stakeholders being highly interdependent with no single stakeholder managing in totality (Poirier, 2004). Themes included in this concept also cover business models for servitization where models for service need to be developed (Teece, 2010) and vertical integration, which discusses how service organisations can fine-tune their organisation to improve performance (Baines and Lightfoot, 2012). The final sub theme is interdependence (Barrick, et al., 2007). Here different approaches to recovery activity are reviewed, with a particular focus on the nature of interdependence and dependence between actors.

The framework continues with the next area of literature, which is performance. This is included within the framework as improved understanding is required of how to manage performance across the service enterprise in order to ensure acceptable service provision is achieved (Neely, 1996). Here common objectives for service (Purchase, 2011) and a focus on output for service (Baines and Lightfoot, 2012) are identified as necessary. The requirement to develop understanding of performance management and performance measurement for service is applicable to developing the general understanding of servitization. Understanding performance management is also required within the case study activity where improvement in performance management is required in the management of availability and repair turnaround times.

The final area of literature included within the framework is cost. This has been included as the literature identifies that developing an improved understanding of cost of providing a complex engineering service through life is central to the provision of successful service (Newnes, 2008). Costing in advanced services delivered through a service system is challenging especially as the prevailing approaches in the field of cost estimation, particularly through-life costing (TLC), do not seem capable of handling system costs (Newnes, Settanni, Thenent and Green, 2013). It is therefore necessary for research to investigate and understand the cost of delivering a service, taking a holistic view of costs. This includes the cost of doing something right from the customer's point of view and delivering value in use through an outcome, or dealing with the consequences of failing to do so (Newnes, Settanni, Thenent and Green, 2013). The theme of cost reflects sub themes on through life costs (Newnes, 2008), cost of complex service delivery (Seddon, 2003; Ng, 2011) and recent thinking on system costs (Newnes, Settanni, Thenent and Green, 2013) all of which develop new ideas helping to improve

the understanding of the cost of service.

The theoretical themes and supporting sub themes, which emerged whilst studying the literature and create the research framework, are illustrated in Figure 10 below.

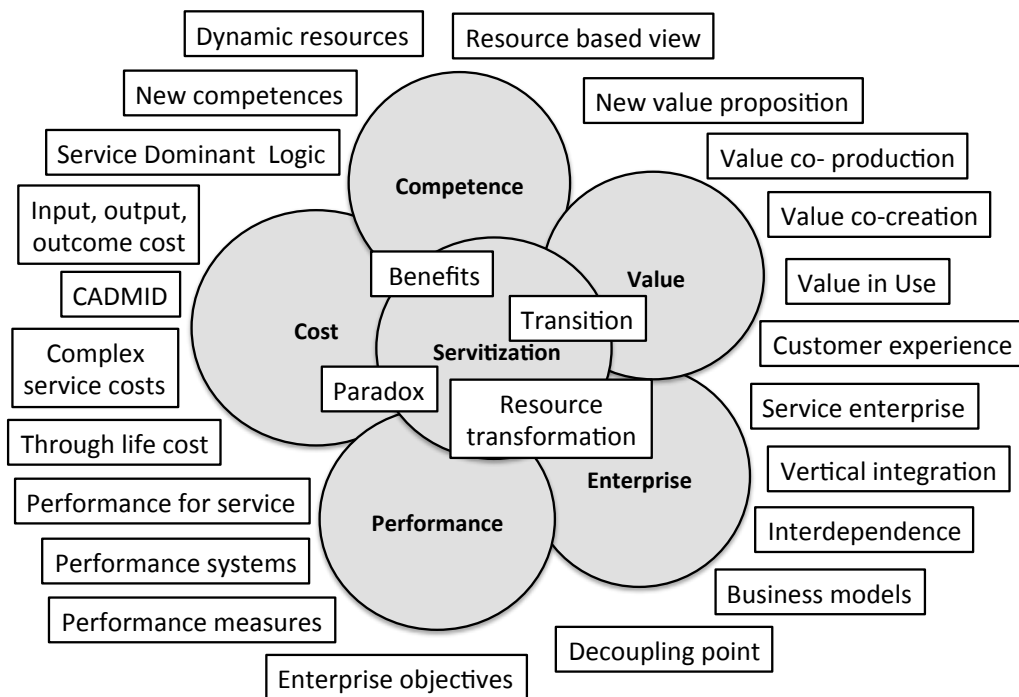


Figure 10. Framework theoretical features and themes (Source author)

The framework derived from the literature review is used to provide a common structure for the research. It also provides a structure to develop the case study interview questions and for the identification of people who would be suitable for interview at BAE Systems, GE Aviation and the UK Ministry of Defence. The research framework is used as an aid during analysis of data and as a source that directs the researcher to areas of literature that may provide answers to questions raised by both the thesis and the project, helping to deliver project direction and research findings. The diversity of theory in the framework reflects the trans-disciplinary nature of service research (Stauss, Engelmann, Kremer and Luhn, 2008). Due to the complex nature of

servitization (Ng, et al., 2011) and the fact that it traverses disciplinary boundaries, it has been necessary to adopt this trans-disciplinary approach. The framework provides a link from the literature review to the research methodology chapter where it is utilised within the research approach. Finally it is proposed that the framework makes a contribution to academic literature as it acts as a guide towards furthering the understanding of the challenge faced by firms in the process of servitization.

3.1.4 The case study

Once the research design is chosen then the data collection method can be selected. The case study is a suitable strategy for doing research involving empirical inquiry that investigates a particular contemporary phenomenon in depth and within its real life context especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2009). The case study data collection can be achieved via a number of different techniques all of which have strengths and weaknesses (Yin, 2009). Commonly used techniques include the review of documentation, use of artefacts, interviews and focus groups (Bryant and Bell, 2007; Saunders, et al., 2009). Existing documentation and archival records is considered stable, unobtrusive and exact. Alternatively they can be viewed as difficult to access and often biased (Yin, 2009; Stewart, et al., 2007). Physical artefacts can also be insightful regarding cultures or technical operations, but can suffer from ease of availability (Yin, 2009). Interviews can provide in depth understanding including perceptions however they can also be considered biased and inaccurate due to poor recall (Gubrium and Holstein, 2002).

As previously highlighted a case study approach has been chosen for the servitization research as how, why and what questions dominate and the focus is on a contemporary phenomenon within a real life context where an in depth understanding is required (Yin, 2009). The questions for this research include; why is servitization difficult; how should performance be established; what are the features and challenges of servitization; and what are the cost drivers of the new service activity. Servitization is a real life phenomenon and in depth understanding is required. A case study strategy has been established to set consistent direction (Saunders, et al., 2009; Bryman and Bell, 2011) and to include the areas of interest for the research that have been identified during the literature review and captured in the servitization framework. This includes servitization, and the interacting theoretical themes of competence, value, enterprise,

performance and cost. The framework has been used to structure the case study interview questions and thereafter used to structure the analysis of data collected.

The same study may contain more than a single case (Yin, 2009). Here the individual case can be considered less important in itself than the comparison each offers with the others and the combined understanding of the full study. Multiple-case designs have a distinct advantage in comparison to single designs as the evidence from multiple cases is often considered more compelling and thus the research considered more robust (Yin, 2009). However increased time and effort is often required to conduct a multiple case study therefore the decision to proceed in this way should not be taken lightly (Yin, 2009; Thomas, 2011). This research reflects a single study with a multiple case. Although in principle there is one case study unit of analysis, the Typhoon service enterprise, three stakeholder organisations (The UK Ministry of Defence, BAE Systems and GE Aviation) are involved in both the activity and the research. Research data will therefore be drawn from all three organisations and used to establish a single combined view of the servitization effort as understood from three different perspectives. This will strengthen the understanding gained on the service provision under review.

Single study, multiple cases

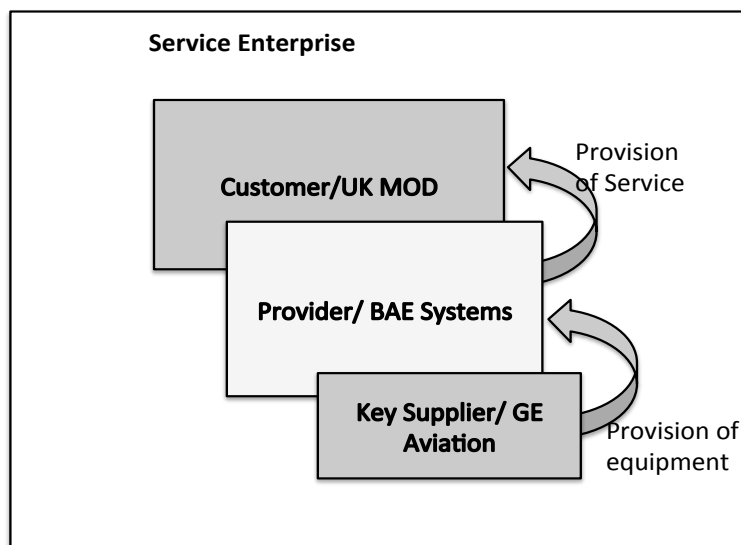


Figure 11. Single study, multiple cases (Source author)

The case study's unit of analysis is the enterprise that supports the Typhoon avionics system. Enterprises are complex, highly integrated systems comprised of processes, people, organisations, information and supporting technologies, with multi-faceted interdependencies and interrelationships across their boundaries (Nightingale, 2002). The case study unit of analysis is consistent with the definition of an enterprise provided by Purchase, et al. (2011). Here the enterprise is described as a boundary-defining lens, which imposes a holistic management or research perspective on a complex system of interconnected and interdependent activities undertaken by a diverse network of stakeholders for the achievement of a common significant purpose. The case study comprises the industrial stakeholders BAE Systems and its supply network, GE Aviation - a key supplier, and the UK Ministry of Defence - the customer and its supporting network. The research identified how the new service enterprise is working. This was established by interviewing each of the organisations: the customer, the UK Ministry of Defence, to understand their new role under the new arrangements; the provider, BAE Systems, to understand his new role as the full service provider and how performance is now managed; and the supplier, GE Aviation, to understand the impact of the new arrangements on their activity. The interviews give an understanding from each of their perspectives that enabled the creation of a combined view of the current Typhoon service, how performance is being managed and what new costs require attention. The findings in turn helped to develop an improved understanding of servitization where a complex engineering service is being provided fulfilling the aim of this research. A short summary of each of the industrial stakeholders is provided below (more details can be found in Appendix 10.3).

The UK Ministry of Defence is the customer who procures fast jets on behalf of the end user the Royal Airforce. They have recently introduced availability contracting in an effort to reduce increasing costs and unsatisfactory equipment performance.

BAE Systems are the provider firm. BAE Systems has traditionally developed, produced and supported fast military jet aircraft to their customer the UK Ministry of Defence and have legacy design from a world where the customer held the through life risk. At present in addition to developing and supplying new Typhoon aircraft, they have recently contracted with the UK Ministry Of Defence to provide availability of the Typhoon in service. This reflects the changing market where the customer now wants the provider to replace individual support sales and activity with the provision of an

aircraft availability service. As the level of defence expenditure is reducing BAE Systems are encouraging this new approach to support as a way of securing future business.

GE Aviation supplies avionics to the aircraft constructors. They are a key supplier of avionics for the Typhoon aircraft that is produced and supported by BAE Systems. GE Aviation's business is changing. Their service activity is increasing and they are moving to a mix of product and service, and customer availability contracting. GE Aviation are experiencing rapid evolution of products, (head down display to head up display to helmet).

The industrial stakeholders involved have a long history of working together and already have some experience of servitization, (River class surface ships, Harrier, Nimrod, Tornado). However the concept is progressively increasing in importance and they wish to better understand the challenges of servitization and how to overcome them. Whilst the case study research covers the full Typhoon support enterprise activity the project has a specific focus on the Mission Head Up Display unit that acts as a vehicle to aid understanding. GE Aviation supplies the Mission Head Up Display to BAE Systems who fit it to the Typhoon aircraft that is purchased by the UK Ministry of Defence. As the intention of the research is to understand what is happening now on the typhoon availability activity a snap shot time horizon is preferred. This is also reasonable considering the effort required to undertake in depth interviews.

3.1.5 The interview, ethics and analysis

The interview is considered as one of the most important sources of case study information. Although it is not the quickest or easiest data collection method (Yin, 2009), it is the method used for collecting information to questions that require interpretation and where an in depth understanding is sought. As this research required detailed information to develop an in depth understanding an interview approach was chosen.

The servitization research data collection was physically structured and delivered through three sets of semi -structured interviews, one with each of the industrial stakeholders, BAE Systems, GE Aviation and the UK Ministry of Defence. One to one interviewing across key functions of the industrial organisations were used as the data collection method. The interviews were held at a management level to provide both

specific and general operational perspectives. The questions covered each of the areas identified in the research framework and examined what drives cost and which costs are included in current life cycle models. Full details of the questions utilised with GE Aviation, BAE Systems and the UK Ministry of defence are provided in the Appendix (see 10.3).

Qualitative interviewing is like a guided conversation (Gubrium and Holstein 2002). The semi-structured interview is framed by defining the areas that are to be explored with a list of specific questions, with the balance being between tying the interviews to the topic and being tied up by them (Yin, 2009). Semi-structured interviews have been selected for this research for the following reasons:

- To help link the topics of the interviews with the literature reviewed (Yin, 2009). In this research the theoretical features of servitization, competence, value, enterprise, performance and cost identified during the literature review have been used as the basis of the interview questions.
- To make sure that the interviews have covered the intended topics by using the question list as a checklist during interviews (Yin, 2009). For this research standard question sets were used to ensure all areas of interest are covered.
- To ensure the collected data is consistent across interviews, by minimising the differences between the people interviewed and the difference between different interviews. This will build confidence and the ability to draw conclusions (Bryman and Bell, 2007). This research has selected experienced individuals currently working at a management level and has asked the same standard interview questions of each.
- To provide an opportunity for the interviewee to forward information over and above a direct answer providing the potential for alternative viewpoints, (Bryman and Bell, 2007). This research used semi-structured questions to encourage extended discussion.
- To compare like with like answers between or within stakeholders and thus allows for a check for bias and reliability (Flick, 2006). This research cross-compared the answers between the stakeholder organisations.

Ethics is a key consideration for research. Protecting those willing to take part is therefore considered as significantly important (Flick 2006). The interviewer must protect respondents from invasion of privacy, breaches of confidentiality or anonymity and distress caused by topics raised (Gubrium and Holstein 2002). During the initial contact with the host company a full explanation of the research, what is expected from the interviews and how the data and findings will be subsequently managed, should be provided. Proposed questions should be submitted to the management of the organisation involved in advance to obtain acceptance and ensure appropriate interviewees are selected. Care should be taken to avoid sharing the questions with potential interviewees to avoid any pre work and protect spontaneity of response, avoiding potential bias (Flick 2006; Gubrium and Holstein 2002). Pilot interviewees may be established especially where the subject is complex. Pilot interviews may help further shape the questions to ensure the best results are attained. At the start of each interview the interviewees should be provided with the same explanation together with a short introduction to the researchers background. Informed consent should be obtained from each interviewee following the introductory explanation (Gregory 2003; Flick 2006). Privacy and confidentiality should be protected (especially if vulnerable groups are involved) and any type of deception must be avoided at all times (Gregory 2003; Yin 2009). Prior to commencing with the questions proper the interviewer should capture an understanding of whom he is interviewing. This will provide supplementary information and a smooth start of the interview. Furthermore if interviews are to be recorded to accurately capture response (Flick 2006; Silverman 2010) permission of the interviewer should be sought prior to the start of the interview and unobtrusive equipment used, to ensure the interview is kept as natural as possible (Flick 2006).

The interview techniques and processes designed to avoid problems of an ethical nature (Gregory 2003; Flick 2006; Yin 2009) were all considered when preparing the interviews for the servitization research. This included considering the potential for ethical problems at both a company and individual level. This was necessary as the companies involved have differing commercial relationships on different defence programmes. Whilst the Ministry Of Defence maintain the ultimate customer position at all times BAE Systems and GE Aviation can be either customer or supplier, and can collaborate or compete with one another.

At the company level:

- Non-disclosure agreements were established between the participating University's and the participating firms to ensure the correct control, use and communication of research data and findings.

At an individual level:

- A written project brief was given to each interviewee. The brief provided a full understanding of the aims and collaborative nature of the project. The brief was provided to develop the interviewee's willingness to partake and to encourage open and honest responses to interview questions.
- A brief on the interviewer was provided to each interviewee to help build trust and smooth the dynamic between the interviewer and each interviewee.
- Assurance was provided to all interviewees that confidentiality would be maintained including full anonymity of each interviewee. This was aimed at encouraging open and honest answers to each interview question and avoiding any undue individual distress as a result of participation in the research.
- Pilot interviews were undertaken at the Ministry Of Defence, BAE Systems and GE Aviation to check the suitability of the proposed questions prior to the interviews proper and to ensure the interviewer was able to put the interviewees at ease with the process. Although the questions were considered politically acceptable and readily understood they were considered too numerous for the length of the planned interviews. The number of questions was therefore reduced, whilst still covering the desired data points, allowing the interviews proper to go ahead.
- Permission to record the interview was obtained from each interviewee and an unobtrusive recorder used to keep each interview as natural as possible.

The semi-structured interviews were held with senior managers from different functions at BAE Systems – who are the service provider (8) the UK Ministry of Defence – who are the customer (2) and GE Aviation Cheltenham – who are a primary supplier (5). Interviews took place between November and December 2011, and April and May 2012. The stakeholder management team who sat on the project steering board helped in the selection of the individuals for interview after discussion with the author. All interviewees selected were considered as the key actors involved in the Typhoon support activity within their respective organisation that would be most knowledgeable

and able to positively contribute to this research. As no others were involved the number interviewed represented a full group sufficient to capture knowledge from each organisation of the specific case study. The individuals selected also considered to have a strategic and operational view of the support activity and capable of providing unbiased answers.

BAE Systems functions represented by interviewees included Procurement, Procurement support services, Engineering support services, Engineering supply chain, Commercial aircraft programmes, Supportability, Mission systems engineering, Commercial and Supply chain. The selection of individuals from so many different areas reflecting the breadth of the BAE Systems organisation and the Typhoon support activity provided a comprehensive set of viewpoints. The GEA functions represented included, Sales, Service contracting, Customer support, Business and Programme management. The MOD functions represented included Commercial, Integrated Logistics Support and Cost assurance. Fewer MOD personnel were interviewed as their personnel were focused on the contracting and the result rather than the process of change. The MOD interviews were supplemented by a specific visit to the customer site at RAF Coningsby to better understand and record the customer operational activity. The visit to the customer site helped to fill gaps in customer knowledge. The interviews lasted two (2) hours each with all interviewees engaged in full discussion on each topic raised providing a large amount of data for analysis.

The following table provides the details of the above interviews.

Company	Interviewee function	Relevance
BAES.	Procurement.	Service supply chain management.
BAES.	Procurement Engineering support services.	Service engineering support.
BAES.	Engineering supply chain.	Service supply chain management.
BAES.	Commercial – customer	Commercial customer interface

	account management.	for service.
BAES.	Supportability.	Service design change support.
BAES.	Mission systems engineering.	Management of mission systems on aircraft.
BAES.	Supply chain.	Service management customer site.
BAES.	Commercial.	Service commercial management.
GEA.	Sales.	Senior supplier representative.
GEA.	Service contracting.	Supplier contracting authority.
GEA.	Customer support.	Service supplier support management.
GEA.	Business and Programme management.	Supplier service activity management.
GEA.	Customer support site representative.	Supplier support to service activity.
MOD.	Commercial and Cost assurance.	Service cost estimating, and contracting.
MOD.	Integrated Logistics Support.	Customer Service performance and contract management.

Table 7. In depth research interviews (Source author)

In addition to the interviews further information was obtained during general information gathering visits to the company sites. Visits included presentations on company operations and guided tours of the facilities which support and deliver the service.

Company	Host	Relevance
GEA Cheltenham.	Hosted by programme management.	Background information on company and service business including tour of operations.
MOD Abbey Wood.	Hosted by Service support.	Background information on MOD activity with focus on services procured.
BAES Warton.	Hosted by procurement and operations.	Background information on company and service business including tour of Typhoon assembly hall.

Table 8. General site visits generating global understanding of businesses (Source author)

Specific visits were also arranged to detail the support activity process.

Company	Host	Relevance
GEA.	Programme operations.	Development of supplier process flow for equipment repairs.
BAES.	Procurement operations.	Development of provider process flow for repairs.
MOD RAF Coningsby.	Hosted by service operation.	Development of customer process flow for equipment.

Table 9. Specific site visits to develop specific process maps (Source author)

Information and validation were also obtained during the regular steering group meetings held on a quarterly basis over a 3-year period. The representatives from all the

project stakeholders who attended the steering meetings made themselves available to answer further specific questions and discuss findings to ensure clarity in understanding and veracity of findings.

Company	Function represented	Relevance
GEA.	Programme management.	Extra information and clarification on supplier service as required.
BAES.	Procurement and operations.	Extra information and clarification on provider service as required.
MOD.	Cost management.	Extra information and clarification on customer view of service as required.

Table 10. Steer team representative (Source author)

The research interviews undertaken were recorded and then transcribed word for word by the researcher to avoid any bias or incorrect interpretation. The data was subsequently coded against the research framework (comprising servitization, competence, value, enterprise, performance and cost). This included findings on business model practices, value co-creation, value co-production, value in use and interdependence to allow for theory building. The approach allows for constant comparison building understanding of the unit of analysis and the move towards service provision as the process of interviews and analysis progresses. Collection of like issues was established for each area facilitating the development of new ideas and enhancement of existing theories. Pattern matching, explanation building and cross company synthesis (Yin, 2009) was also undertaken to check for like or unlike answers by comparing data from BAE Systems, the MOD, and GE Aviation. The process of analysis also helped to identify if different perceptions exist between the customer, provider and supplier. A second analysis and coding of the data was undertaken against the main issues of concern presented by interviews and arising inductively during the interview.

This included contract, culture and organisation, design, supply chain and arisings and returns. This provided further understanding of the process of servitization. The above process was employed to provide in depth analysis of the case study findings.

A detailed business model for the servitized firm was not identified in the extant literature. Therefore as part of building an improved understanding of servitization a new business model for the servitized firm was considered and developed as part of the research. The new business model will help scope the scale and nature of change a firm will need to undertake to successfully move to the servitized state. The traditional manufacturing based business models as discussed by Teece (2010), Fuller and Morgan (2010) and Osterwalder and Pigneur (2010) provided a baseline against which a model for the servitized firm was built and compared. The framework developed by Osterwalder and Pigneur (2010) was used to define individual business model features for the servitized firm developed by utilising the knowledge and understanding obtained during the review of extant servitization literature. The new service business model creates and communicates an understanding of the changes required across all recognised business model features (customer segmentation, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure). The business model features of value proposition, key activities and key partnerships are expected to be the core areas of the servitized firm and thus for the features of the new model. Specific consideration was therefore given to these areas.

The new service business model and its features were further developed and tested by the findings of the case study review. Furthermore specific validation of the proposed business model structure and elements was sought and obtained from managers at the provider firm.

In addition to the broad qualitative analysis a specific quantitative analysis and mapping of quotes that described costs was also undertaken. Understanding of the nature and flow of the costs that were front of mind for managers was developed, establishing at the project level that a systematic approach to cost modelling is required. The analysis of interviewee comments on cost utilised a number of frameworks from literature: complex engineering service systems transformation framework (Ng, et al., 2011); input, output and outcome analysis (Doost, 2006); and nature of failure (Hansen and

Mowen, 2007). The analysis identified the nature and origin of the reported costs, type of dependence and whether it is an input, output or outcome cost. The analysis also identified whether the cost was a result of poor performance, if the poor performance was a result of internal or external failure and the point of cost impact within the support process.

Finally, an analysis of simulations of availability recovery process approaches, constructed from the case study data and subsequently validated by the industrial personnel involved, was also undertaken. The analysis used lead-time and process information identified from the interview data to provide an understanding of speed and cost of various recovery approaches currently being utilised by the service enterprise. Five simulations of different case study approaches to availability recovery of the Typhoon were created to provide an understanding of the relative differences in the speed and cost of each approach. The simulations reflect typical recovery approaches being undertaken at the time of the case study and highlight the cost of the flow and illustrate how different outcome costs can occur. Furthermore, the analysis demonstrates that co-location and interdependent activity is faster and cheaper than sequential activities and provides the level of responsiveness demanded by the customer of the new service contract.

The simulations represent the correction (replacement or repair) of a failed Line Replacement Unit (LRU) where the aircraft has returned from flight operations for front line service. The aircraft is attended by front line service teams comprising of Customer (RAF), and Provider (BAE Systems) who work on the aircraft to provide 100% availability of the asset. Supplier teams may also take part in this activity if their equipment has been selected for on aircraft repair.

Approach 1 models the past traditional approach using spares only. Approach 2 models a replacement and repair approach. Approach 2a is a modification of approach 2 that establishes the impact of poor performance on approach 2. Approach 2b is a further modification that reflects the impact of poor performance and unscheduled customer damage. Approach 3 models a 'fix on aircraft' approach to service.

All of the recovery cost quantifications commence with one spare line replacement unit in stock and end with one line replacement unit in stock. This reflects a normal situation where stock is held to establish recovery without having to have an aircraft on ground

(AOG), or interrupt operational routine (IOR) service. Approach 3 reflects an advanced state of recovery on aircraft where stock is not held locally. For approach 3 if a local recovery is not possible the AOG service (24 hour response) or IOR service (48 hour response) is enacted. Each simulation reflects 2 cycles of expected fault arisings except for simulation 2a which includes a repair cycle and an unscheduled customer damaged line replacement unit. To model the processes the following variables were used:

- one day of effort = a
- repair parts y are the parts required to achieve the repair on the aircraft or achieve the repair in the supplier repair shop
- the balance of parts in a spare unit (those which do not require replacement or repair) is represented by z (z costs represent the bulk of parts and are much greater than y)
- extra parts required to correct customer damage (required in addition to parts requiring repair only) are shown as m

The simulations use actual turnaround and lead-time information collected during case study interviews. This includes a short turnaround used for an on aircraft or on base fix and a longer turnaround time used for a repair at the supplier. A consistent period of days for all simulations was used to ship parts from the base to the supplier providing both are in the UK. A similar period of days was used for a return shipment. Finally a consistent lead-time was used for an equipment sub assembly and assembly.

3.1.6 Assessing the quality of business research

Although the case study is a popular and distinctive method of research especially where depth of understanding is required many researchers find them less desirable than either experiments or surveys. The concern arises from a perceived lack of rigor, a view that the size of the case study where the number of interviews is limited is too small, and the perception that biased views will influence the research findings and conclusions (Yin, 2009). Furthermore some researchers believe that case studies take too long, that the researcher may not possess the necessary skills and that generalisation is difficult from a single case study (Flick, 2006; Yin, 2009).

The above concerns over the use of case studies have been considered and countered during this research where depth of understanding of a real life phenomenon in context

is considered the main driver. The interaction between a phenomenon and its context is a good opportunity to better comprehend complex issues (Weick, 1979). For Easton (1995) a single case approach, which is very specific to a given situation, is very likely to produce a thorough and in-depth analysis of complex engineering service.

As previously explained this research on servitization adopts a structured approach. The CATA project management provides one level of structure. This includes guidance, feedback and validation on approach and findings from the project steer team comprising of industrialists and academics from the stakeholder organisations (see Figure 9 shown earlier in this chapter). The repeated use of the research framework provides a second level of structure delivering consistency of approach (see Figure 9 detailed earlier in this chapter). The level of structure adopted together with the top down and bottom up approach to the literature review provides the necessary rigor.

Regarding any potential concern over size and as explained earlier in detail in this chapter this research benefits from being a single case with multiple studies. The single case with multiple studies adds size and validity with three separate organisations being interviewed in depth rather than one, including cross comparison between the findings from each. The approach delivers a stronger qualitative result with improved validity. Furthermore the number, length and depth of interviews undertaken delivered sufficient data to understand the operations and management approach. In particular the number and level of interviewees at the provider firm BAE Systems gave coverage of all areas of the firm and activity under review from both a strategic and operational perspective. This is especially important, as the research is provider centric. The work and understanding of the process was then validated by the steering group which represented managers in charge of the case study operations from the three organisations.

The classic case study approach adopted, supported by the momentum of the project and access given to senior managers as a result of being part of the project ensured a timely research delivery. Interviewing three firms provided an increased number of interviews and from three levels of the supply chain. The case study approach provided the opportunity to interview and understand responses and check for biases both within and between the three stakeholder organisations. Furthermore the authors past work experience in this sector provided an in depth understanding of the industry under

research. This experience helped guide the process and provided increased ability to check for biases and ensure the reliability and validity of the research finding. Subtle biases were identified between interviewees from each of the stakeholder firms. This is considered acceptable providing it is limited to a reflection of their position and role within the supply chain.

Consistency of interview approach both within and across the organisations within the unit of analysis (UK MOD, BAE Systems and GE Aviation) and recording of answers with word for word translation provided for reliability. In addition and when necessary discussion on findings were held with the stakeholders during CATA projects meetings to confirm interpretation and understanding of interview answers. Consistent use of the research framework, the use of a standard set of interview questions and recording of process steps provides for repeatability (Yin, 2009).

The structured project approach with quarterly steering and regular feedback meetings between the stakeholders provided confirmation of research findings and an opportunity to modify the direction of research as work progressed. It also provided validation of the developing understanding of servitization and potential new business models. Additionally further confirmation of understanding and approach was obtained as the research progressed through participation in conferences and papers submitted on servitization where academic feedback has been provided.

Generalisability is the ability to generalise the results of a study to other subjects, groups and other conditions (Yin, 2009). Given this research is Aerospace and Defence specific generalisability of its results is considered limited. However it may be possible to rework findings and transfer them to Commercial Aerospace where complex engineering services are also being provided and the same type of capital asset provision and challenges exist. It may be possible to translate and apply some of the findings to like activities found where complex expensive capital equipment and services are provided and servitization is taking place. Industries such as earth moving equipment, railways and elevators and ships could also be considered. Furthermore a case study with limited generalisation is little different to a single experiment (Yin, 2009).

3.1.7 Research methodology summary

This section includes a summary of the research. The research methodology details are captured in a summary table 11 overleaf. The table flows from left to right capturing the research questions, the literature review structure, the research approach and the research methods used.

Servitization, research methodology

Questions	Literature review	Research Approach	Research Methods (Case study)
<p>PhD Question.</p> <p>What are the features and challenges of servitization?</p>	<p>Includes review of literature on servitization, competence, value, enterprise, performance and cost.</p>	<p>Constructivist.</p> <p>Inductive approach.</p> <p>Qualitative research via a single enterprise case study. Based on semi-structured interviews with the emphasis on both fact and understanding.</p>	<p>-Multiple how and why questions on servitization, competence, value, enterprise, performance and cost.</p> <p>- Semi structured interviews at BAE Systems, GE Aviation and the MOD.</p>
<p>PhD Question.</p> <p>What performance management should be established at the level of the service enterprise?</p>	<p>Performance measurement, including service measures.</p>	<p>Unit of analysis is the service enterprise and activity providing and supporting the avionics for the typhoon, (BAE, GEA, MOD).</p>	<p>What drives cost and which costs are included in current life cycle cost models?</p> <p>-A snap shot.</p> <p>Data analysis to include coding and categorisation, explanation and theory building, cross company synthesis, check for reliability, repeatability and validity.</p>
<p>Project Question (3 PhD's plus).</p> <p>What are the reported costs and front of mind costs for the provision of a complex engineering service?</p>	<p>Through life cycle cost models, technical features of avionics, uncertainty modelling and servitization and performance measurement.</p>		

Table 11. Summary of research, (Source author)

This concludes the chapter on research methodologies.

4. CASE STUDY FINDINGS

4.1 Introduction

This chapter focuses on the case study findings. The chapter comprises an introduction, a section on detailed case study findings and a summary. The case study findings section is structured in sub sections based on the research framework theoretical themes of servitization. This includes sub sections on competence, value, enterprise, performance and cost (see Figure 9). The main findings of each of the themes are highlighted, explained and supported by quotes extracted from the main body of data. The final sub section detailing the findings on cost includes the reported support costs and reviews the findings of two detailed cost analyses. The case study findings are subsequently discussed and compared to the literature review findings in chapter 5.

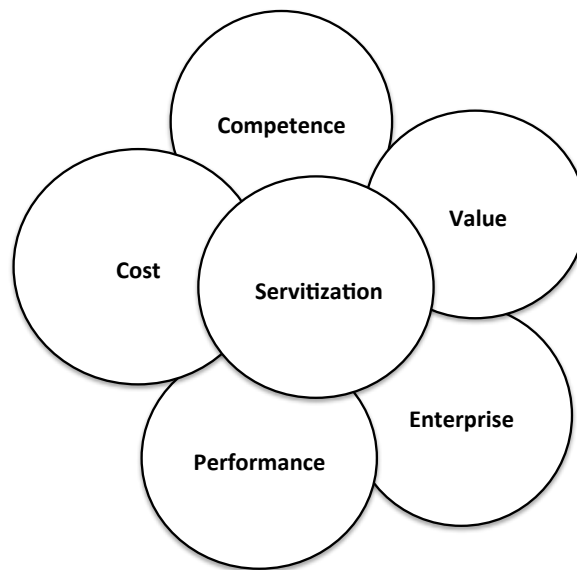


Figure 9. Research framework (Source author)

A case study of the Typhoon support enterprise has been undertaken. As explained in the previous chapter this can be considered a single study with multiple cases as the unit of analysis comprised the customer the UK Ministry of Defence, the provider BAE Systems and a key supplier GE Aviation. Familiarisation visits to gain an understanding

of the business and service provided, specific meetings to develop detailed understanding of process and organisation and in depth interviews to collect case study data have been undertaken at Warton (BAE Systems), Cheltenham (GE Aviation), Bristol (UK Ministry of Defence) and RAF Coningsby (RAF and BAE Systems). Quarterly review meetings with company stakeholders were also arranged over a 3-year period where additional information and validation of findings were provided.

As explained in the previous chapter the semi-structured interviews were held with senior managers from different functions at BAE Systems the provider (8) the UK Ministry of Defence the customer (2) and GE Aviation Cheltenham the supplier (5) during November and December of 2011, and April and May 2012. The stakeholder management selected the individuals for interview after discussion with the author. All were considered as the key individuals involved in the Typhoon support activity within their respective organisation. The individuals selected were also considered to have a strategic and operational view of the support activity. They were briefed on the research and encouraged to engage in open discussion providing unbiased answers.

BAE functions represented included Procurement, Procurement support services, Engineering support services, Engineering supply chain, Commercial aircraft programmes, Supportability, Mission systems engineering, Commercial and Supply chain. The GEA functions represented included, Sales, Service contracting, Customer support, Business and Programme management. The MOD functions represented included Commercial ILS and Support cost. The interviews lasted two (2) hours each with all interviewees engaged in full discussion on each topic raised providing a large amount of data for analysis.

The case study interviews were structured against the research framework theoretical features with a pre-established set of questions used to open discussion on servitization, competence, value, enterprise, performance and cost. The discussions were recorded and transcribed (80,000 words in total) and coded against the same six categories identified in the research framework (Figure 9 refers). Analysis of data and comparison between individual interview findings and cross-functional and cross company synthesis was undertaken. This provided findings against six inductive categories including servitization (reason for and transformation), and the interacting features of competence, value (value co-creation and value in use), enterprise and performance and

cost. A second coding was undertaken against the most popular issues arising within those categories. This established a further five inductively raised categories highlighting the interviewee areas of concern (see table 12 below). The second set of inductively raised categories includes culture and organisation, contract, design arisings and returns and supply chain.

Research framework inductive features (identified during literature review)	Number of issues raised against each feature	Inductively raised issues during interviews	Number of times issues raised
Servitization	42	Contract	100
Competence	37	Design	55
Value	39	Arisings and returns	70
Enterprise	33	Supply chain	33
Performance	119	Culture and organisation	151
Cost	117	-	-
Total coded issues	387		409

Table 12. Case study findings, coded categories (Source author)

The findings confirm the Typhoon service activity is of great importance to the UK Ministry of Defence (MOD) who contracts the support and availability of the aircraft on behalf of the Royal Air Force (RAF). The findings also confirm the activity is of great importance and is significant business for BAE Systems, (the provider firm) who now has the task of ensuring aircraft availability through the provision of the complete support service. Furthermore GE Aviation interviewees considered the Typhoon avionic

business as important and consistent with their business targets to develop increasing levels of service across all business activities.

In general the comments made against each of the categories were consistent across interviewees from all three organisations, the only differences being the weighting of comments reflecting their previous respective positions in the supply chain. The UK Ministry of Defence had most focus on cost and equipment arising's whilst BAE Systems and GE Aviation demonstrated a greater focus on culture, organisation and performance. Each of the interviewees demonstrated an understanding of each theme of Figure 9. All the interviewees confirmed that transformation from product sale to offering and delivering a service is slow, difficult and incomplete at present. The transformation was considered especially difficult considering the complexity of the service and complexity and size and nature of the organisations involved in the activity. All interviewees however reported that change is very apparent with management actively directing, shaping, redirecting and reshaping in order to achieve the necessary outcomes and results.

The initial inductively derived categories of servitization, competence, value (value co-creation and value in use), enterprise, performance and cost attracted open discussion delivering an improved understanding of these theories in practice with servitization generating the greatest interest and emotion. In particular the efficient management of equipment arisings and the associated cost was considered key to the success or failure of the new support activity.

The above findings are presented in detail in this chapter and compared to the literature findings and fully discussed in the next chapter.

4.2. Detailed case study findings

This section provides details of the discussions on each of the servitization categories covered during the interviews. This includes servitization, competence, value (value co-creation and value in use), enterprise, performance and cost. Details of each of the categories are supported by interviewee quotes. The categories used represent the theoretical and conceptual features identified in the research literature review that interact together as servitization occurs. The findings on these features are based on the interviewee responses to questions posed by the interviewer. In addition to the specific

review of cost the section also includes details of cost as perceived and reported by the interviewees throughout each of the categories.

4.2.1 Servitization

The focus of this section is servitization. Servitization is the central feature of the research framework (see Figure 9a).

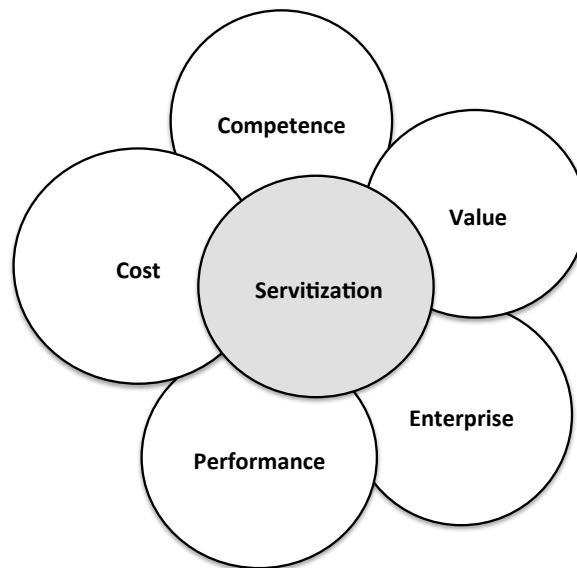


Figure 9a. Research framework, servitization (Source author)

This section titled servitization is split into three sub sections. The first sub section presents interviewee comments on the cost of aircraft support and the introduction of availability contracting. The second sub section comprises interviewee views on the challenges associated with the transformation to a service enterprise whilst the third provides the interviewees comments on equipment design and equipment arisings management. The understanding presented is established from the 42 coded findings on servitization and supported by selected interviewee quotes.

4.2.1.1 Typhoon support, the need for change

The discussions with the case study interviewees established an understanding of past and existing Typhoon support costs. The comments highlight that the UK Ministry of Defence considered the cost too high generating the need to establish new support arrangements to reduce cost. The servitization of the Typhoon support activity was therefore conceived and launched via the new Typhoon availability contracting and aircraft support arrangements between the UK Ministry of Defence and BAE Systems. All stakeholders have received this as positive towards reducing the through life support costs. The highlights of the discussions are detailed below. The cost information mainly came from the interviews with the customer, the UK Ministry of Defence.

The UK Ministry of Defence interviewees advised that the 1980s pre approved budget for full Typhoon programme was £39bn. The through life support costs were estimated at £13.1 billion of the total. The following quote from a Ministry of Defence interviewee provided the information.

*“The pre approved budget was £39 billion back in the 80’s including the whole programme through life manufacture logistics air command costs, the works, and £13.1 billion was earmarked for support (1980s economic conditions)”.
Customer/UK Ministry of Defence*

The phase 2 (systems acquisition phase) flying costs were understood to be Euro 12,000 per flying hour. As this was considered too expensive the phase 3 (sustainment phase 2010-2014) flying cost target was set at Euro 6,000 per hour. A fifty per cent (50%) reduction is required to achieve this ambitious target. The reduction initiative targeted the introduction of availability contracting and new support arrangements for the Typhoon including the improved utilisation of spares and reduced repairs, as these were understood to be the main cost driver of the support activity (a role previously undertaken by the Royal Airforce). These new support arrangements establish BAE Systems as the provider of aircraft availability. This involves BAE Systems taking over the service management and many of the support tasks previously undertaken by the customer the UK Ministry of Defence. The following quotes from a UK Ministry of Defence interviewee supports the above statement.

“Based on the cost per flying hour in phase 2 repairs were costing Euro12,000 per flying hour across all four nations, and industry agreed for phase 3 to reduce the cost by 50%, reducing exchanges on base, plus a common spares pool across the nations”. Customer/UK Ministry of Defence

“When we looked at the cost of the tranche three production it was considered unaffordable and that was primarily driven by support costs. The significant cost of support was spares (contract 4) and repairs (contract 5). So we negotiated between the nations and industry ‘the binding commitment’ to be put in place under phase 3”. Customer/UK Ministry of Defence

The UK Ministry of Defence interviewees advised that the cost reduction challenge of minus fifty per cent (-50%) has been achieved and the current flying cost was understood to be Euro 6,048 per flying hour. A UK Ministry of Defence interviewee made the following statement.

“Cost went down 50% for repairs through a massive gutting of the scope and we are currently in phase 3, which runs 2010 to end 2014. We achieved the challenge of -50%. The actual cost now is Euro 6,048 per flying hour”. Customer/UK Ministry of Defence

The above statement is thought to reflect the new agreement between UK Ministry of Defence and BAE Systems and a top-level understanding of progress made to date towards the cost reduction targets.

The Ministry of Defence interviewees also advised that a further cost target will be set for 2015 onwards. A target reduction of 70% over base is expected. The further reduction will be achieved by further increased efficiencies of the new service arrangements including the continued management focus towards the reduction of spares and repairs. The following quote from a UK Ministry of Defence interviewee explains the cost targets.

“The binding commitment also reduces the cost by 50% for phase 3 and then the phase after that against this baseline of Euro 12,000 achieves a reduction of 70% for the follow on which is something we will have to start looking into from 2015 onwards”. Customer/UK Ministry of Defence

The further cost reduction target translates to a target flying cost of Euro 3,600 per flying hour for 2015 onwards.

4.2.1.2 Transformation

Servitization refers to the transformation of manufacturers from providing products to providing a service (Baines, et al., 2009). This sub section contains the case study findings related to the transformation activity required to deliver the new availability support arrangements for the Typhoon. Here the customer (the UK Ministry of Defence), the provider (BAE Systems) and selected suppliers including GE Aviation are working together to provide an increased level of service at lower cost.

All interviewees at BAE Systems, the UK Ministry of Defence and GE Aviation when prompted by a brief explanation understood the concept of servitization and directly related it to the new Typhoon availability contract and support arrangements between the UK Ministry of Defence and BAE Systems.

The UK Ministry of Defence interviewees were aware of the progressive move towards out-sourcing increasing levels of support activity in an attempt to reduce costs and eradicate large budget overruns on expensive capital equipment. The Ministry of Defence interviewees advised that experience has been progressively gained on Helicopters, Ships and Aircraft (Tornado) however each major programme was different especially as different bases and groups of staff were involved and different levels of support contracted. The latest activity and the subject of this case study involves the outsourcing of the support for the Typhoon aircraft whose support activity is based at RAF Coningsby in Lincolnshire. To support Typhoon it was recognised that a joint RAF and industry team is required. This arrangement is considered necessary due to the increased sophistication of the Aircraft demanding increased knowledge and support skills. Furthermore it reflects the desire to industrialise the support activity in an attempt reduce costs. A joint RAF and industry team has been established and continues to be developed to deliver the desired support activity at the lower cost targets.

BAE Systems interviewees were also very aware of the progressive outsourcing of support activity being undertaken by the UK Ministry of Defence. They were also very aware that to provide the new Typhoon support their organisation is undergoing a significant transformation from product to service provider. This transformation is

necessary for those directly involved in the support activity and for those in the greater organisation who supports both the aircraft production and support activities. This was reported as slow and difficult by all, with one of the interviewees explaining that BAE Systems were just about reaching critical mass in understanding, with 50% of the employees having moved to a service way of thinking and working. The following statement was made by one of the BAE Systems interviewees.

"I think we are at the point where we have two equal camps. Half still in design and make world who think the job stops when we wave it off the end of the runway and then the other half of the business which is trying to get more recognition, more understanding and therefore more emphasis on changing behaviour, process and culture we need to effectively build a service". Provider/BAE Systems

Five of the provider interviewees also recognised and explained that the objectives of their business had changed and that increasing focus was being given to reducing the cost of delivering support. The BAE Systems interviewees further explained that the new objective is to deliver Typhoon availability for a fixed customer fee at the lowest enterprise cost.

*"It is all about affordability now, driving down the cost of delivering the support".
Provider/BAE Systems*

The provider has taken over the customers role of providing through life support for a fixed fee and thus has moved from securing as many spares and repair sales as possible to reducing them to the minimum possible. This is a fundamental change to the business where avoidance of customer penalties at the lowest cost is the key driver. BAE Systems as the provider is now expected to make the decision to repair a failed item or get a spare. This change in who takes the recovery decision is captured in the following quote from a UK Ministry of Defence interviewee.

"BAE now make the decision to repair an item or get the spare". Customer/ UK Ministry of Defence

The UK Ministry of Defence as customer has also positioned the provider BAE Systems to be the customer for all the third party contractors who had previously reported to the UK Ministry of Defence. This includes the reduction of alleviation of penalties previously given to the provider to cover late deliveries as a result of poor third party performance.

This change greatly increases the risk held by the provider, BAE Systems. This increase in accountability is captured by the following quote from a UK Ministry of Defence interviewee.

“We are currently negotiating the 3rd contract iteration. Each time we have increased the accountability on BAE to reduce our customer dependencies as much as possible”. Customer/UK Ministry of Defence

Three of the GE Aviation interviewees also recognised a move toward increased service provision and reported that GE has top-level business targets to achieve greater levels of service sales. They further explained that their engines division was far more advanced in the practice of service than the avionics part of the organisation. This is due to the advanced support activities developed and now expected in the engine after market. It also reflects the limited product that GE Aviation supply for the Typhoon and the related demands of their customer. During the research it became apparent that GE Aviation are still supporting the Typhoon in a product mode continuing to repair units at their factories for an agreed fee. Two of the GE Aviation interviewees expressed a desire to supply and support more equipment and position themselves on base to be able to respond in a true service manner. At present out of the equipment suppliers only Selex were operating in this mode. The GE Aviation interviewees also added that although they were conversant with servitization and the move to outsource increasing levels of aircraft support the communication on the move to availability contracting by the UK Ministry of Defence had not been done very thoroughly through the greater supply chain. One of the GE Aviation interviewees made the following statement.

“We are aware of servitization. As for communication I don’t think it has been communicated very well from the MOD to BAE and back into industry. If it is, it has not been flowed down to us”. Supplier/GE Aviation

The Ministry of Defence and BAE Systems interviewees reported that a joint service enterprise project management team has been established bringing together the customer (Ministry of Defence) and provider (BAE Systems). This team was in its early stages of development and has two leaders, one from the customer and one from the provider supported by commercial and operational leaders from each group.

“Within Typhoon across the project we are using our people, their people and their base against an availability contract managed by joint leadership. It is a project organisation. Two individuals one from BAE and one from the MOD jointly manage the project team that delivers Typhoon availability and that’s pretty unique”.
Provider/BAE Systems

The team and its project direction is recognised and acted upon by those in the immediate support team based next to the aircraft. However the off base support offices and related supply chain was believed to be subject to multiple business and project objectives which often cause delays in response. All interviewees believed the influence of multiple objectives became greater with increasing distance from the immediate aircraft support activity. It was explained that BAE Systems staff based in their aircraft manufacturing facilities in Warton did not always feel the urgency of the situation at the RAF base. Furthermore it was understood that suppliers have their own objectives and were often supporting multiple production and support activities. GE Aviation interviewees who explained their Typhoon equipment repair group also supported multiple programmes and equipments for many different customers evidenced this. This finding is supported by the following quotation from a GE Aviation interviewee.

“Our repair shop accepts repairs from multiple customers on multiple programmes generating work on both mechanical and electronic equipment”. GE Aviation/Supplier

The enterprise project team has started to focus their management effort towards the availability of the aircraft at lowest cost. The provider interviewees viewed this as a significant change as they had previously only focused on their own inputs in an individual way. They have now started to review their inputs considering their impact on asset availability. The following quote made by a BAE Systems interviewee confirms this change of focus.

“Once the teams started discussing contracting for output and introducing incentives for increased levels of performance the whole dynamics of the service requirements and relationships changed ”. Provider/ BAE Systems

The aircraft support is managed under a contract between the UK Ministry of Defence and BAE Systems. The name of the contract is the Typhoon availability support contract

(TAS). The TAS contract designed to provide availability of the UK's Typhoon aircraft comprises a number of principle elements covered by sub-contracts. The main elements include the provision of maintenance, logistics and technical support, aircrew training and ground crew training, ground support equipment and repairs and spares. The key cost drivers are the equipment spares and repairs that account for 70% of the support costs. Information on the contracts and the costs associated with the equipments is provided in the following quotes, two from a UK Ministry of Defence interviewee and one from a BAE Systems interviewee.

"Then we have a suite of 11 support contracts called procurement contracts. Some of them are quite small, ground training aids, and ground support system including engineering and mission support system, important but small, aircrew aids and simulators. The most important ones are procurement contract number 4 and number 5. Number 4 covers spares". Customer/UK Ministry of Defence

"TAS is a front end prime contract in effect between us and the MOD it sits on top off and try's to integrate and delivers things for the MOD but integrates a whole series of contracts behind it in effect, PC4 contracted back to Eurofighter, and NETMA for the delivery of spares, PC5 and others which deliver repairs across the various EPR's and then you have a whole series of other support contracts which interweave with that which have delivered overtime, about 11 of them in total. Purchasing contract number one to purchasing contract number 11 are actually collapsing now to a smaller number of contracts. The drivers remain 4 and 5. Spares and Repairs. You have to keep provisioning and you will have on going repair activity. PC11 is the international technical support and that bolts into the TFC at Coningsby". Provider/ BAE Systems

"Equipment was 70% of the problem and 70% of the support cost". Customer/UK Ministry of Defence

Although the prime contracts are constantly being revised in line with the new availability arrangements contracting between the key stakeholders and contracting throughout the supply chain is still considered as problematic impacting on the responsiveness of the service. Interviewees from BAE Systems and GE Aviation considered contracting as the start point and believed that contracting had not changed

sufficiently to reflect the new-partnered service business. This is evidenced by the following quote from a GE Aviation interviewee.

“Industrial relationships are good. The contracts get in the way”. Supplier/GE Aviation

Furthermore the BAE Systems interviewees expressed that contracts were still too product oriented and did not sufficiently reflect the new arrangements and the fact that the commercial and operational risk had now transferred to the lead provider (BAE Systems). The product and risk averse orientation of the contracts were viewed as driving the wrong culture, hindering the move to a more flexible responsive approach to the customer. It was also felt that the contracts did not reflect the new interdependence between stakeholders and did not include sufficient shared objectives required to drive optimal value co-creation and continuous improvement of financial results. The existing contracts that had been released in a piece meal fashion were also viewed by all as being too short in duration making it difficult to gain investment approvals against required design change as pay back periods were viewed as too short. The following quote from a BAE Systems interviewee supports the above statement.

“Where we were providing a product and contracting with a customer we would contract to deliver that product. The service arena is very different in the sense that we still contract in exactly the same way, but the financial framework has to change for us to be able to move it forward because all of the initiatives that have to be put in place address availability and affordability”. Provider/ BAE Systems

4.2.1.3 Equipment design and arisings

This sub section captures key points raised on equipment design and equipment arisings. Design was raised as an issue 55 times and arisings raised as an issue 70 times during the interviews.

Comments were initially collected about the design of the equipment. This was followed by detailed discussions on equipment arisings management. An equipment arising is where equipment fails to perform on the aircraft. The failure of a piece of equipment on an aircraft results in a recovery activity. Recovery is achieved by either repairing the failed equipment on the aircraft or replacing the failed equipment and returning the failed equipment to the supplier for repair and return. Arisings management is a critical

activity within the current support activities as the equipment spares usage and repair activity is a significant cost driver (70% of support costs) and impacts on availability of aircraft. Reducing the level of equipment arisings would significantly help lower costs.

Consensus existed between the UK Ministry of Defence, BAE Systems and GE Aviation interviewees who all believed that the equipment designs were not optimised for through life cost of the aircraft availability. This was principally due to the high level of failures being experienced earlier than would be expected when compared to the expected mean times between failures. The BAE Systems interviewees therefore highlighted the equipment designs as an area that created problem when providing a service offering. The following quote from a UK Ministry of Defence interviewee explains the problem with the mean time between arisings.

“The mean time between arisings was drawn up in the 1990’s. It was very optimistic. Our real mean time between arisings is not what it should be”.
Customer/UK Ministry of Defence

The equipment designs were reported as very old and in need of updating. However aircraft equipment redesign is a complex and expensive process. Cost of equipment redesign is very high due to the work share arrangements, rigid contracting and bureaucracy associated with accepting change. Whilst the change process had been instigated to minimise the associated non-recurring cost and recurring costs during the development and production phases it was far too rigid to accommodate the speed of change required in service situations. Furthermore as noted in sub section 4.2.1.1 the short term contracting makes it difficult to accept changes requiring long term pay back arrangements. This means some potential cost savings activities are difficult to implement due to the contractual arrangements. The following quote from a GE Aviation interviewee highlights the problem of justifying savings against short-term contracts.

“If you are looking for savings opportunities but cannot get savings back within the current contract it is really hard to justify”. *Supplier/ GE Aviation*

Nevertheless the UK Ministry of Defence are trying to improve the situation by progressively redesigning problematic equipment and are committing several million a year to develop products improvements. The following quote from a UK Ministry of Defence interviewee supports the above statement.

“We are pushing ahead with a couple of million a year in development to deliver product enhancements”. Customer/UK Ministry of Defence

In addition and when ever possible the joint RAF and BAE Systems aircraft support team are also endeavouring to introduce changes quickly on a local basis to avoid repeat in service problems. However local improvements have design authority problems and the local team has to take responsibility for maintaining airworthiness around the area of change until formal approval is received. The following quote from a BAE Systems interviewee explains this complicated situation.

“We are doing some design locally where traditionally we would have just passed it over the fence to the RAF. There are many examples where they just take the decision to change it, locally manufacture something and do it in 6 weeks. This goes on but how do you support it, as it hasn't been through the whole design cycle. As the design authority we would not take responsibility for it as it is now a locally manufactured procedure, it is not our procedure. And also the RAF will have to maintain the airworthiness around that part of the platform. So it creates problems”. Provider/BAE Systems

Under-optimised equipment designs and a difficult and a slow change process create an unacceptable level of arisings that in turn create an unacceptable level of spares and repairs. Poor arisings management and customer damage exacerbate the situation. Furthermore the repair system is also slow, trapping many assets in the greater system. This situation is an obvious concern to the provider BAE Systems who are now carrying the risk, as under the new availability contract, the provider funds the arisings exceeding the anticipated levels.

BAE Systems has established an anticipated baseline number of arisings based on anticipated aircraft operational activity, estimated equipment mean time between failures, and expected recovery management efficiency. The number of estimated arisings is subsequently used to establish the number of repairs included in the BAE Systems support fee. The fee is subject to challenge from the UK Ministry of Defence who are currently targeting a reduced fee (previously discussed in this section). After the providers fee has been negotiated and agreed, a judgement is taken by BAE Systems as to whether the number of arisings can be reduced. Contracts are then agreed with suppliers for a fixed number of arisings. Where arisings occur above the baseline

modelling and contract agreements with suppliers BAE Systems absorb their own costs and pay the suppliers for the extra repairs required. BAE Systems are thus holding the risk of arisings. This is central to the new support arrangements and is a driver for BAE Systems to improve support management and improve equipment performance to minimise the number of repairs required. The arisings rate is now a prime consideration for BAE Systems. The following quote from a BAE Systems interviewee highlights the risk share understanding.

“What you need to recognise is the work we are doing with the MOD is a true collaborative activity, it is a true risk share and gain share”. Provider/BAE Systems

The arrangements described above highlight that a market is operating in risk. The Ministry of Defence is trading risk that has been taken and held by BAE Systems who believe they can reduce the risk through improved management. One of the GE Aviation interviewees expressed their surprise that BAE Systems has taken increased risk against equipment arisings (availability for a fixed fee) but had not flowed down the risk contractually to GE Aviation (who could still charge for additional repairs if required above the base contracted number of repairs). The following quote from a GE Aviation interviewee explains how BAE Systems are currently managing the support risk.

“BAE have pulled back some of the risks. BAE manage them and pool the risk, it is like a bunch of insurance company's all pooling the risk and you can take a greater punt. BAE Systems on arisings rate risk for example, are pooling and holding the risk. GE Aviation is saying we would rather take on that risk and charge you for it. BAE Systems are saying no we will do that. Previously on the first phase of Typhoon we did have arising rate risk so regardless of how many times something failed we were obligated to take it back and repair it as part of our monthly cost, so fundamentally we take that risk. But now BAE Systems on Typhoon have pulled that back and I think it is BAE wanting to demonstrate value and obviously if you do take a significant risk on a bunch of equipment then you identify and charge the customer for that”. Supplier/GE Aviation

As highlighted earlier in this section the aircraft support is managed under the cover of 11 contracts between the customer and provider with the majority of the associated support costs generated by the equipment spares (procurement Contract 4) and the equipment repairs (procurement contract 5). The equipment spare and equipment

repair activities were reported to be 70% of the support costs. The following two quotes one from a UK Ministry of Defence interviewee and one from a BAE Systems interviewee support the above statement.

“Equipment was 70% of the problem and 70% of the support cost”. Customer/UK Ministry of Defence

“The key cost driver in any support solution is the initial provisioning, the spares and ground support equipment and the cost of repairing those on a daily, weekly, monthly, basis and the cost of man power to support the solution, be that manpower in maintaining aircraft or the manpower in supply chain activities and stores”. BAE Systems/Provider.

Of the two hundred (200) plus equipment Line Replacement Units (LRU's) pareto analysis has identified forty-eight (48) as the main cost drivers of the support activity as they are the more expensive of the units to support. In an attempt to reduce cost and risk the forty-eight (48) LRU's have been targeted with increased management attention at the aircraft support level. This is aimed at reducing the amount of repairs entering the system. Furthermore if a repair is required the LRU's are targeted with repair turnaround times. The turnaround times are contractually agreed timescales within which the supplier will evaluate and repair the failed LRU's. The turnaround time commences once the failed unit has been received with correct instruction at the supplier. The selection of forty-eight (48) LRU's is confirmed by the following quote from UK Ministry of Defence interviewees

“Now we have 48 items under turnaround (phase 3) and that's what the cost of service is against”. Customer /UK Ministry of Defence (Cost 2)

The high cost forty-eight (48) LRU's can be further split down. Nineteen (19) of the forty-eight (48) LRU's make up the Radar and Defensive Aid Sub System (RDASS). These are considered as high cost when compared to other equipments and are responsible for generating fifty per cent plus (50%+) of equipment costs (originally estimated as £4.55bn) equating to 35% (£4.55bn) of the total cost of service (originally estimated at £13bn shown graphically in Figure 12).

Typhoon support cost

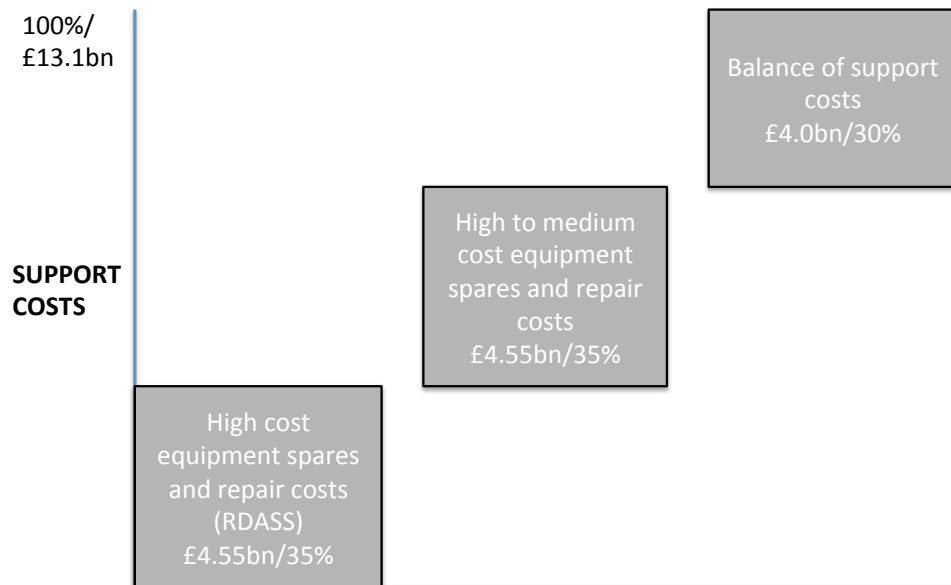


Figure 12. Typhoon support costs (Source author)

The Radar and Defensive Aid Sub System are both supplied by Selex. As the Radar and Defensive Aid Sub System (RDASS) make up such a significant proportion of costs they have been selected to test a new process for on aircraft or on base repairs. Repairing on aircraft or on base saves money by preventing or reducing the amount of equipment being returned to the supply chain for repair. The following quotes the first from a BAE Systems interviewee and the second from a UK Ministry of Defence interviewee highlight the past recovery spend against the RDASS equipment and the new understanding that the best place for repair is on aircraft.

“RDASS drives a huge amount of cost out of the supply chain. If you think what I said about the cost drivers in terms of support arrangements or in repair or in spares holdings and equally in manpower 50% of the spend is on DASS and RADAR. It is a massive part of cost of our equipment supply and then the on-going support”.
Provider/BAE Systems

“The best case repair is on aircraft, so keep it on aircraft, the worst case is on base. That’s what they try to do”. Customer/UK Ministry of Defence

Under this new regime of local repair the equipment’s are subject to a targeted turnaround of 5 days (previously 28 days). This improvement in repair turnaround time has also improved customer satisfaction by increasing the speed of aircraft recovery providing increased availability. The success experienced on the UK home base has also for the first time been replicated in active front line operations. Here Selex support engineers have travelled with the aircraft front line support team to provide front line support to the RDASS equipment. The front line support is considered a great success delivering 100% availability. The success is captured in the below quote from a UK Ministry of Defence interviewee.

“In operations we had 100% serviceability on RDASS in for the full time. We did not miss a sortie and that was generally viewed as a result of those engineers being on the base and also having the back office support to call up. A huge success and something we will look to take into the next phase as being critical”. Customer/UK Ministry of Defence

The customer and provider has achieved the improved service by working with the on base supplier team who have excellent contact with and support from the supplier facilities. Where possible this type of support activity will be taken forward in future contracts. Co-locating the supplier with the customer and provider in order to speed up the repair turnaround is an example of vertical integration. It can also be considered as integration of different elements of the supplier organisation as their staff in Edinburgh, Luton and Coningsby are also working in unison.

The balance of the higher cost forty-eight (48) LRU’s, are considered as medium to high cost and potentially problematic. These twenty-nine (29) high to medium cost units, accounting for 35% (£4.55bn) of known support costs, are managed on a 28-day repair turnaround, as the local fix is not possible. Here the supply chain is arranged to ensure a quick economic turnaround of the failed equipment. Increased speeds of logistics, lean processes and repair turnaround targets have been established through the supply chain. Strategically positioned part stock and use of sub components as an alternative to sending the complete unit through the full length of the supply chain all help to reduce cost and speed recovery of aircraft availability. The following quotes from two BAE

Systems interviewees explain how the supply chain turnaround time can be kept to a minimum.

“You can do things to influence the speed of the supply chain. Let’s assume the key thing to do is quicken the rate through the supply chain area, a faster turnaround. If you are out in theatre it might be about your ability to get assets back into the supply chain really quick. So how quickly can you get assets that are back from Libya say back into the supply chain for repair? How quickly can you get them from Coningsby to a supplier in Germany? If you can actually get it to the factory directly then that’s one opportunity to shorten the supply chain or the repair turnaround time”. Provider/ BAE Systems

“If you can get them to repair it faster that’s another opportunity to quicken it up. We have SRI’s (spare replacement items) on the shelves so we do not need to send the unit to the suppliers, and you only need to send the component or card for repair. You obviously have the cost to stock the shelves with SRI’s but if you can reduce the repair times you need less total assets, you buy less, pay for less, and save”. Provider/ BAE Systems

The GE Aviation supplied Mission Head Down Display (MHDD) is included in this category.

The Line Replacement Units over and above the first 48 units discussed above are considered to be low cost and high volume units or are unlikely to require frequent repairs. However these units can also give rise to significant costs as their failure is sporadic and the recovery processes are undertaken on a best endeavours basis against unfixed supplier repair turnaround lead-times. Here control can easily be lost resulting in overlong repair times leading to an increase in spares requirements. The following quote from a UK Ministry of Defence interviewee confirm the problems associated with the repairs managed on a case-by-case basis.

“The problem for us is not only the 48, it is the other case by case costs as well as you lose the logistics planning control because they are done on best endeavours”. Customer/UK Ministry of Defence

A major problem inductively arising and reported by all interviewees under the discussions on cost of servitization is No Fault Found (NFF) equipment returns. A No

Fault Found is the name given to equipment incorrectly diagnosed as the failure problem that is subsequently returned for repair. On receipt at the repair shop it is tested and found to be functioning correctly. The No Fault Found equipment returns were reported as a significant cost driver reported to be approximately 30% of the equipment costs (21% of the total support costs). The following quote from a BAE Systems interviewee highlights the problem of No Fault Finds.

“There are a number of studies on going to try to improve because the no fault found returns are big cost drivers. We have continually got too many LRU’s in the system. The equipments are 70% of the costs and 30% of that 70% are no fault founds. On a budget of 13bn it is a lot of money”. Provider/BAE Systems

From the percentage splits quoted above and considering the original through life support cost estimate of £13bn the potential through life cost due to No Fault Found returns can be calculated at £2.73 bn or at the reduced flying rates generating a cost of £1270 per flying hour.

The BAE Systems interviewees explained that the Royal Airforce is considered a ‘can do’ organisation that like to get their aircraft back into service as soon as possible. This in the past had created inefficient repair activities with many No Fault Found equipment repairs entering the returns system and or the generation of spikes or epidemics where the real cause is not corrected in a timely manner. This is further explained by the following quote from a BAE Systems interviewee.

“The Royal Airforce is a very dynamic organisation. They are very can do organisation and therefore there is a level of expectation on their people to be seen to be doing something. I think if you combine that with a complex product like the Typhoon you can end up in a position where you have a fault, it is not completely obvious where the fault is, or what the cause is and therefore people are under time pressure and cultural pressure to be seen to do something. Therefore you can pull the thing that you think is most obvious or in some cases the easiest to pull. What that drives for us is a cost in terms of no fault found”. Provider/BAE Systems

Under the new arrangement for the sustainment in operations phase (phase 3) the No Fault Finds risk shifts to BAE Systems. The BAE Systems interviewees recognised this and are therefore trying to minimise this type of return. A formal improvement initiative

has therefore been launched by BAE Systems to improve the efficiency of the fault diagnosis, as the enterprise cannot sustain a high level of incorrect returns and their associated system costs. The following quotes from a UK Ministry of Defence interviewee and a BAE Systems interviewee further highlight the No Fault Found problem.

“Under the previous full service any repairs we put in or any no fault finds were all part of the cost. Under phase 3 if it is a no fault found that’s extra cost, the call service covers all that we call accountable arising and we term accountable arising as genuine repairs”. Customer/UK Ministry of Defence

“One idea is obviously to try and reduce the amount of kit going back for repair, and get rid of no fault finds. If you take an asset off the aircraft incorrectly, you send it back to the supplier, the supplier sits with it in his work queue for a period of time and eventually tests it but finds there’s nothing wrong with it, so we could have left it on the jet and saved money”. Provider/BAE Systems

One BAE Systems interviewee reported that the No Fault Found equipment return problem is often compounded. Where the RAF front line fitters have difficulty identifying the aircraft problem they sometimes incorrectly remove multiple units for return to ensure availability of aircraft. This creates multiple No Fault Found equipment returns. The following quote from a BAE Systems interviewee explains the above problem experienced with No Fault Finds.

“The system is complex and when someone is on the line and he has to get that jet back flying the next morning and he knows there’s a problem in a radar and he says it is either LRU 3 4 OR 7 but I need to do a, b, c, d to check it, if I swap the 3 LRU’s for the 3 on the shelf then I am quite confident that when I start the aircraft it will work. That action generates no fault finds”. Provider/BAE Systems

Epidemics can also occur where the correct fix is not found and high numbers of the actual problem unit suddenly fail over a short period of time. This obviously puts an immediate strain on the supply chain. A BAE Systems interviewee highlights the above problem in the following quote.

“If you were to recognise that a particular component had broken on an aircraft and you did a sweep of 6 other aircraft and said right we need to ground them for

three days to get it fixed then the customer will say, and has on a number of occasions different instances, 'no just replace the item we need to get the sorties out in the air' and what it results in is failures of 10 and 20 components which would not have happened if the full fix had been done. An epidemic is created followed by a spike of activity ". Provider/BAE Systems

Finally on the subject of design the GE Aviation interviewees also advised that obsolescence is a major problem for the industry. This is due to the length of aircraft programmes and length of time in service (up to 40 years) combined with the speed of technology development and change in production techniques. As parts become unavailable (as they are no longer produced) they often need to be replaced with more expensive alternatives. Recovery of additional spend by the supplier however is dependent on the contracting in place. The problem of obsolescence is captured by the following quote from a GE Aviation interviewee.

"The other obvious risk on Typhoon avionics is obsolescence risk which is horrible. In any one year it will absorb millions of dollars for us with varying degrees of success of claw back through Eurofighter depending on the contract terms that apply at the point in time on that piece of kit". Supplier/GE Aviation

4.2.1.4 Summary of servitization case study findings

This section has detailed case study findings on the cost of the Typhoon support, findings associated with the transformation from supplying products to supplying a service and findings on equipment design and equipment arisings. The following summarises the findings.

Cost of the Typhoon support activity including the past and current costs of flying per hour where the cost of spares and repairs are reported as significant cost drivers. The unacceptable level of flying costs has lead to new support arrangements being introduced between the Ministry of Defence and BAE Systems in an attempt to reduce cost whilst maintaining customer satisfaction. Cost reduction targets have been identified and initial success has been reported but further improvements are expected. This highlights the significance of the new BAE Systems management challenge. It also highlights the significance of current pilots introducing on base management and repair of expensive equipments targeted to improve customer satisfaction and reduce cost.

The interviewee responses on servitization including consideration of the forty-two (42) coded issues confirmed they understood the concept, directly linking it to the new Typhoon availability arrangements. All interviewees recognised the business had changed and that transformation was on-going and difficult. The interviewees recognised the need for everyone in the service enterprise to focus on delivering availability especially through the efficient fix of failed equipments that were reported as key cost generators.

New on base teaming arrangements between the UK Ministry of Defence, BAE Systems and selected suppliers have been established increasing co-production and interdependent activity. This co-production was considered successful as it recovered availability of some of the high cost equipments in an efficient cost effective manner reducing repair turnaround times from 28 elapsed days to 5 elapsed days.

During the discussions on servitization all interviewees repeatedly highlighted contracting as an issue. Whilst they all accepted the need for contracts it was repeatedly stated that they were too rigid, too risk averse and too short term for the new way of working.

Equipment design and arisings was a main feature of the discussions. Interviewees from the UK Ministry of Defence, BAE Systems and GE Aviation talked extensively about under optimised designs and arisings; why failures occurred; the costs they created; and how they could be reduced and recovered more efficiently. Efficiently managing the arisings either on aircraft or through the supply chain was considered by all as key to delivering an acceptable service and healthy business return for all involved. The discussions also highlighted that agreeing a fixed fee to provide availability has passed the risk of arisings to BAE Systems. Furthermore BAE Systems have not passed this risk to suppliers. BAE Systems therefore have a key objective to reduce the number of arisings.

In addition to the case study interviews three specific meetings were held to establish a detailed process map of the equipment failure returns and repair process. Meetings were held with the customer at his RAF operational base at Coningsby, with the provider BAE Systems at Warton and with the supplier GE Aviation at Cheltenham to establish the process from fault identification on the aircraft to return of repaired equipment. Discussions were held with managers involved in the process discussing and

detailing each step of the process. The GE Aviation supplied Mission Head Down Display (a typical avionic line replacement unit) repair cycle was mapped as a typical example. The flow detailed below (see Figure 13) was established. The flow shows the activities and their ownership from the fault arising and diagnosis to repair complete. They are fairly typical to other like flows that can be found in the industry. The UK Ministry of Defence, BAE Systems and GE Aviation have validated the process flow.

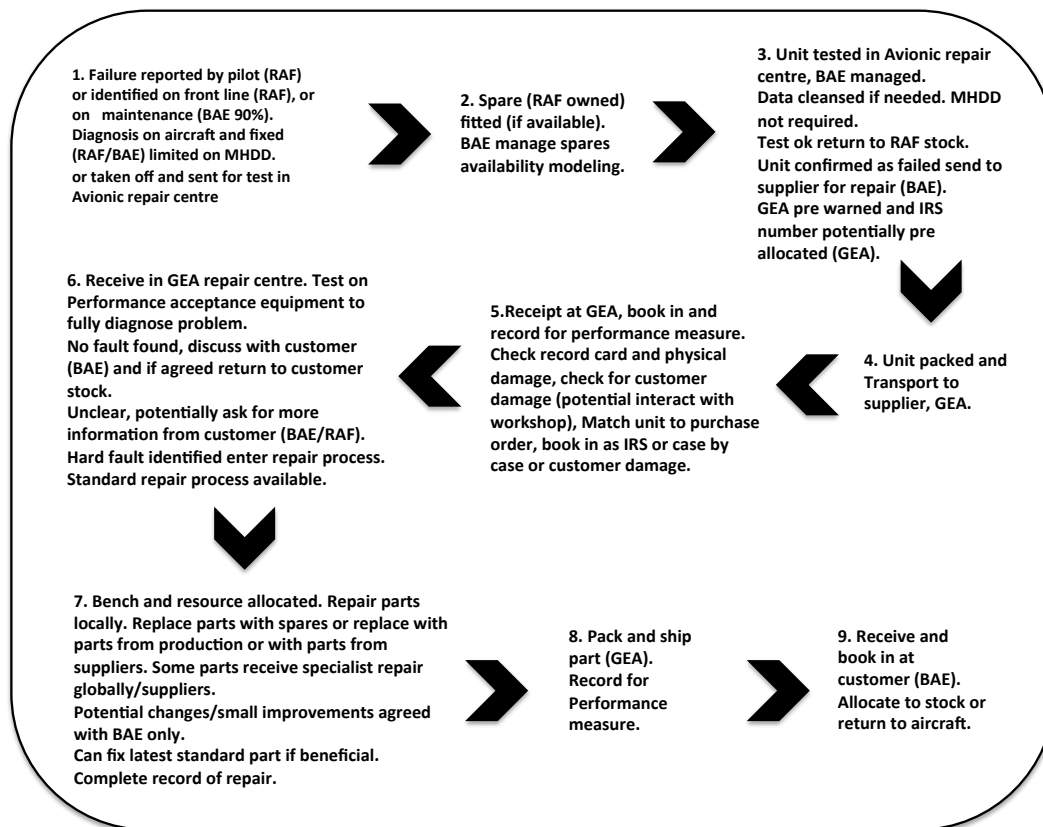


Figure 13. MHDD Repair flow (Source author)

The process flow established confirms and builds understanding for this research and provided details of the process flow to the CATA project in general helping to improve the understanding of the flow of cost.

The case study findings reported in this section (4.2.1) are discussed and contribute to the development of all of the research findings in the next chapter (5).

4.2.2 Competence

The focus of this section is competence. Competence is the first interacting feature of the research framework (see Figure 9). Thirty-seven (37) individual points on Competence were identified, coded and analysed within the interview data.

Competence can be described as the use of special resources that when used in certain ways and in combination with different types or amounts of other resources can provide a different service or set of services (Penrose, 1959). In other words the organisations resources can be infinitely reconfigured into alternative means of providing customers with access to capability (Spring and Araujo, 2009). The section includes discussions with the interviewees on the new application of resources and the competences and skills required by the new service enterprise stakeholders in the provision of Typhoon availability (see Figure 9b). This helps to understand the change required in competences and competence application when a firm moves from providing product only to providing service.

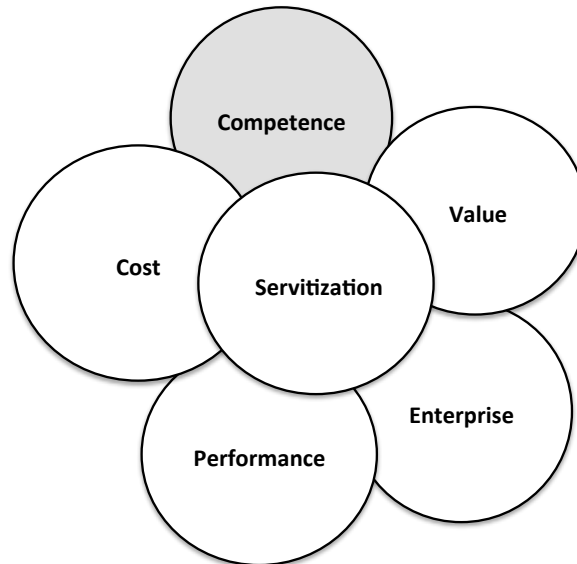


Figure 9b. Research framework, competence (Source author)

The UK Ministry of Defence and BAE Systems interviewees recognised their resources are now being deployed in new ways and new skills are required. The interviewees explained how the Typhoon support business has changed (see 4.2.1.2 Transformation) and that BAE Systems are now using their competences comprising of their skill, asset, and technology (Parry, Mills and Turner, 2010) to provide a the new value proposition of aircraft availability to the UK Ministry of Defence. In this context their new core competence becomes aircraft support replacing their past core competence of production which now becomes a threshold competence.

To deliver the new value proposition of aircraft availability BAE Systems have developed a joint team with the UK Ministry of Defence and have taken over the management lead of the support activity assuming the role of the customer. This is a fundamental change in the application of the BAE Systems resources. The BAE Systems resources have moved from providing products and services to being fully involved in the provision of a service. This positions BAE Systems as the decider and provider rather than provider or supplier. Furthermore as part of positioning BAE Systems in the customer role the UK Ministry of Defence has requested BAE Systems manage the third

parties who had previously reported to the UK Ministry of Defence. The following quote from a UK Ministry of Defence interviewee highlights the changes being introduced.

“We are currently negotiating the 3rd contract iteration. Each time we have increased the accountability on BAE to reduce our customer dependencies as much as possible”. Customer/UK Ministry of Defence

BAE Systems interviewees advised that as a result of the new arrangements the demands on their resources have not only changed but have also increased.

“Clearly as we have gone into providing more services we have applied more resource so the costs have gone up with the value proposition”. Provider/BAE Systems

The interviewees further explained that due to the nature of a complex engineering service many organisations and individuals can be involved. This can be ten (10) fold greater than the interfaces required for production. They reported the use of multiple resources across the supply chain increases cost and necessitates improved project management to co-ordinate the various efforts. Project management rather than production management becomes a key competence. The following quotes from BAE Systems interviewees highlight the amount of resources required to deliver a service in comparison to resources required to deliver a product.

“Providing a service rather than producing a product is more difficult as there is probably a factor of 10 times the number you need to interface with in order to deliver your element of the work”. Provider/BAE Systems

“When you are providing a service you have to link them all together. The project management, not as a function but all the individuals, whether they are working in manufacturing, engineering or procurement, there has to be a step change in pulling it all together and integrating it together. We very often hear the term cylinders of excellence that we are trying to link together”. Provider/BAE Systems

New skills and capabilities are also required. BAE Systems interviewees explained that in response to the new skills requirements they are trying to train and educate employees developing the necessary competence and skills required to provide a complex engineering service. This includes improving diagnostic skills and improving

relationship skills and customer focus. Furthermore they explained they were endeavouring to align their culture to become more responsive. The following two quotes from BAE Systems interviewees below highlight the changes required to skills and culture.

“You need to transition your skill set and your capabilities to look at how did the customer do it previously at a cost, how can we do it different or better at a reduced cost. That’s the hard bit. That’s the transition that we don’t know, to this decider provider. So they decide around flying aircraft, they have the knowledge and that’s the knowledge set we are trying to build up”. Provider/BAE Systems

“The culture and behaviours have been one of the most important things we have had to change. A lot of new capabilities have been put in place have needed people to understand that, and it has meant the behaviours of those people moving from a production environment or provider product environment to that service has been a fundamental change needed in order to make it operate.” BAE Systems/Provider.

The BAE Systems interviewees further advised they were developing the skills set of their resources to take over and improve on activities previously undertaken by the customer. The new skills will move them from being the provider or supplier to becoming the provider decider. This includes developing the ability to make the right diagnosis on aircraft problems and then take the right corrective supply chain decision and action. The decision in this instance taken from the perspective of the service provider may be the opposite of the decision they may have arrived at from a pure manufacturers perspective. However playing the part of the customer was considered more difficult to achieve than originally anticipated, as the product was very complex and knowledge slow to develop. The training predominately being undertaken by the provider is therefore considered important. This is captured by the following quotes from BAE Systems interviewees.

“One is capability development so recognising the new skill sets and competences of individuals to discharge a different contract”. Provider/BAE Systems

“We recognise the need to cross-fertilise people. We are trying to rotate people to get experience of delivering the service that we can then bring back into engineering where we develop the product”. Provider/BAE Systems

Joint support teams have been established comprising of customer (Royal Airforce) and provider (BAE Systems) engineers and leaders have been appointed from each side.

“Teams in maintenance are joint BAE and RAF”. Provider/ BAE Systems

These new arrangements drive the need for leadership and relationship training as well as technical skills development. The level of induction and training was reported as high as in addition to training the provider staff training is also required for the ever-mobile Royal Airforce engineers. The training for the Royal Airforce engineers is required to maintain a certain level of skills, as the Royal Airforce will have to continue to maintain the aircraft in the combat zone. This is further explained by the following quote from a BAE Systems interviewee.

“So within the joint teams in some cases industry people work for military officers and in others military people work for industry managers. This has to happen to allow the RAF to have competent people that they can deploy to wherever they are needed. That adds costs especially as the services move people around. It drives repeat induction, repeat training and extra cost”. Provider/BAE Systems

In addition to the RAF and BAE Systems employee's working together selected expensive equipments suppliers are also included in the teams on base. This is required to provide immediate access to the specific knowledge and skills required to identify problems and resolve them efficiently. This arrangement is new to the suppliers who are also applying their competences in new ways. GE Aviation however are not based on site as their business and the nature of their product and the demands of the customer does not necessitate it at present. In support the GE Aviation interviewees advised that their specific value proposition had not changed greatly so the demands on their competences and resources had not changed with the new support arrangements. They reported they recognised the need to have sufficient skilled staff but advised they did not need to increase their resource or further train staff due to the Typhoon business. They reported they only require one service engineer to interface with the on base activities as their equipments were always returned to GE Aviation in Cheltenham for repair.

The interviewees recognised that competence is a key issue and that stakeholder positions, responsibilities and activities were changing and resources were being

applied in new ways. Their responses and comments emphasised that understanding the new application of resources and establishing the training required to develop correct competences is key to delivering the new value proposition of providing aircraft availability.

The case study findings reported in this section (4.2.3) are discussed and contribute to the development of research findings 1, 2 and 6 in the next chapter (5).

4.2.3 Value

The focus of this section is value from the perspective of servitization. The section therefore includes a recap on the case study value proposition and findings on value co-creation and value in use. Thirty-nine (39) individual points on Value were identified, coded and analysed within the interview data. Value is the second interacting feature of the research framework (as illustrated in Figure 9c).

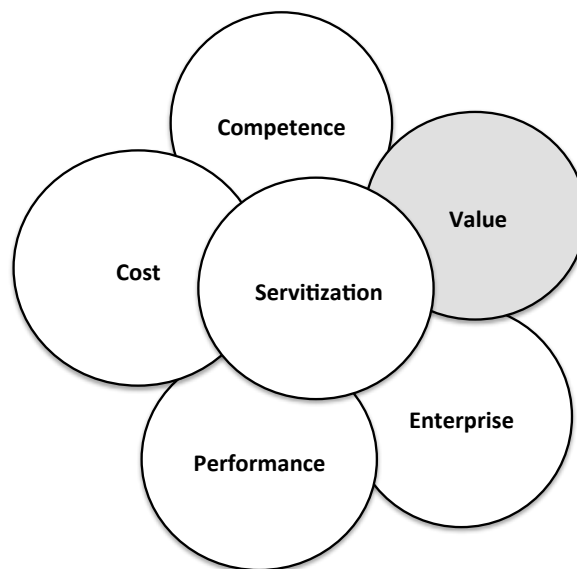


Figure 9c. Research framework, value (Source author)

As previously explained the UK Ministry of Defence and BAE Systems interviewees confirmed that the Typhoon support business between the UK Ministry of Defence and

BAE Systems has significantly changed (see section 4.2.1.2). The value proposition of the provider has changed from one providing a product to one providing a service. The customer, the UK Ministry of Defence, has initiated this change and both parties are working together to provide aircraft availability at the lowest cost.

The change in the value proposition has introduced a greater awareness and level of value co-creation throughout the support activity. Value co-creation can be described as interacting parties simultaneously transforming people, information and materials and equipment in a consistent stable manner to create value (Ng, et al., 2011). The customer, provider and key suppliers work together to co-create value (Prahalad and Ramasway, 2000).

Value co-creation is embodied in the new support arrangements and can be identified throughout the case study support activity. The case study value co-creation starts with the customer and provider developing and agreeing the design. This not only occurs at the start of the aircraft programme but also continues throughout the life of the programme as design changes and improvements are continuously required. This also extends to the efforts on design made by suppliers. Under the new arrangements it is important that they consider their equipment design is good enough to support through life. The following quote from a BAE Systems interviewee captures this understanding.

“The great moment I would like to see is when the supplier says to us in a development contract I am not going to sign the design declaration because our reliability is not good enough and I know that’s going to cost me through life”.

Provider/BAE Systems

The most obvious value co-creation however exists where BAE Systems and the Royal Airforce engineers are co-located and work together as a team to provide aircraft support and availability. This part of the value co-creation can also be described as co-production (co-production is considered by some as nested inside of value co-creation). Furthermore the joint teams are located on the customer facilities working on the customer asset and sharing tools and information. These arrangements further highlight value co-creation.

As a result of the new service value proposition and value co-creation activities the interviewees advised that increased numbers of staff have been engaged than when

delivering product only. This reflects a greater level of interaction and greater variety of skills are required when delivering a service. This is highlighted by the following quote from a BAE Systems interviewee.

“Providing a service rather than producing a product is more difficult as there is probably a factor of 10 times the number you need to interface with in order to deliver your element of the work”. Provider/BAE Systems

The BAE Systems interviewees further explained that significant numbers of BAE Systems employees were working in teams value co-creating with the Royal Airforce either under BAE Systems or Royal Airforce lead. The following quote from a BAE Systems interviewee confirms this understanding and highlights that the changes are successful.

“That has worked very well when we are all on base we all become part of one team”. Provider/BAE Systems

Although they reported that specific measures on value co-creation did not exist they reported that the joint operations worked well and in general were considered to be on an improving curve. It is obviously hoped that this arrangement will help to reduce the amount of repairs required and No Fault Finds. The following quote from a BAE Systems interviewee confirms the situation highlighted above.

“There isn’t a specific KPI on co-creation, that’s the RAF and BAE fitters working together on aircraft”. Provider/BAE Systems

Some selected suppliers are also located on base at RAF Coningsby to provide immediate diagnostics and skills to efficiently fix selected expensive equipments. This also extends the value co-creation effort to the suppliers. Whilst the on site presence may generate a small additional cost the overall benefit of fixing certain equipments on site from a cost and customer satisfaction perspective are viewed as significant. The following quote from a BAE Systems interviewee confirms the co-location of key suppliers on base.

“We have suppliers on base. They are physically located at Coningsby. They fix it there so that customer satisfaction is a key point, I don’t think we can go as far as to say obviously it has got to have more costs involved but it is the cost of having

that service on base or having a number of assets on base versus having the facility of sending it back and the cost of transport and the time taken, so that's some of the risk assessment". Provider/BAE Systems

The GE Aviation interviewees advised that their on-going interaction with the aircraft only needed one field representative. Although their representative was not co-located on base they reported that providing the representative was readily engaged when problems arise he could act proactively by helping to identify the most appropriate course of recovery action. Whilst not as explicit as the value co-creation above this can also be considered as extension of the value-co-creation activity. The benefit of a field representative is confirmed by the following quote from a GE Aviation interviewee.

"The field representative can help. He can sense what's happening and can act proactively". Supplier/ GE Aviation

The GE Aviation interviewees added however that if they had control of more equipment they would place resource next to the aircraft providing great efficiency gains due to expert knowledge being close at hand to trouble shoot.

The BAE Systems interviewees also advised that the required culture, understanding of value co-creation and immediacy of action exists at the front line locations on base where the teams are based and aircraft is physically serviced. When the recovery activity moves away from base to the support offices and the supplier offices across the greater organisation an apparent lesser understanding of value co-creation and willingness to be responsive has been observed. One interviewee advised that BAE Systems had employed video screens to explain an on aircraft problem to off base support office resources. This not only provided an explanation of the problem but also provided a feeling of urgency providing the motivation to deliver quick corrective action.

"The front office is virtually brought to the back office by having vision, dual screens showing what's going on base, providing up to the minute information, linking the right people together at the same time to get stuff done and it also gets the feeling of urgency which is seen at the operating base at the back office". Provider/ BAE Systems

Whilst the actions above help to communicate the immediacy of the problems on base the interviewees also highlighted that establishing common objectives is an essential element for positive value co-creation. The BAE Systems interviewees further advised that the dual headed project was trying to establish common objectives for the support activity.

“Things can always be improved, it is complete with multiple stakeholders across multiple sites with multiple objectives and complicated pieces of equipment and a whole series of complications on going all the time”. Provider/BAE Systems

The new value proposition not only introduces value co-creation but also introduces the concept of value in use. Value in use reflects the shift of the customer from realising value through exchange to realising value through use of the asset (Prahalad and Ramasway, 2000). This reflects the shift in the Typhoon support business from the customer paying for the product or services on an exchange basis to contracting and paying for availability where value is realised when the aircraft is flown. The service experience becomes important (Ng, et al., 2011).

Direct questions with each of the interviewees established that the interviewees had heard of the concept of value in use and when prompted they claimed to understand the difference between value in exchange to value in use as follows.

“Absolutely”. Provider/BAE Systems

“That’s our availability concept”. Provider/BAE Systems

“Totally understand”. Provider/BAE Systems.

Whilst the interviewees initial answers were typically positive however an extended discussion on value in use did not take place with follow on discussions limited to in use customer created problems.

The limited discussion on value in use highlighted that some confusion may exist. This may be a possible reflection of the fact that the customer has already purchased the asset (the aircraft) and the new arrangements only exist against the aircraft support. In addition product exchange still exists within the lower levels of the supply chain promoting a continued transactional culture. Different stakeholders will therefore hold different views of the business dependent on their position and enterprise activity.

Some may still view it as exchange whilst others may view it as value in use. Furthermore those interviewed were mostly involved in the service operations focusing on delivering the aircraft availability rather than using the asset. A UK Ministry of Defence interviewee expressed the transactional culture of suppliers by the following short quote.

“GE Aviation are very transactional”. Customer/UK Ministry of Defence

Both BAE Systems and GE Aviation interviewees however took the opportunity to discuss customer damage. Customer damage arises from misuse of equipment in theatre by the Royal Airforce and causes further repair activity spare provision and cost. This is where the customer damages equipment during use or when working on the platform and returns the equipment through the supply chain for repair. The returned equipment is a cost in itself. It also increases pressure on the supply chain and stock available. Furthermore it was reported as the cause of many disputes, which often delays the repair required and the return of the equipment. The following quotes from BAE Systems and GE Aviation interviewees highlight the problem of customer damage from different perspectives. The first expresses an expectation that the aircraft will be returned to the provider in a certain condition, the second provides an example of customer damage and the third reports that deciding who is liable for the damage can be difficult.

“Regarding Customer damage we assume if an aircraft is coming in for maintenance than we would expect it to be returned in a certain condition if not then we can charge them to bring it into the standard it should be in for us to do our work. I think on the whole they are responsible”. Provider/BAE Systems

“They load a data module into a receptacle and when you load it, it is supposed to be just slid slightly and the flap goes down. I understand that it is rammed home and it gets damaged. So you take the data module out, go to a different aircraft push it in and it has damaged that one and it is just an epidemic”. Supplier/GE Aviation

“If I handle the customer damage it gets very messy especially as the customer says I do not believe it is customer damage”. Supplier/ GE Aviation

The findings on value highlight that the new value proposition is recognised and that value co-creation has been established and recognised across the activity although it was mainly discussed in terms of the on base operational activities rather than at the level of the total end to end business activity. The RAF and BAE Systems fitters were reported as working side by side on the aircraft with suppliers joining to fix problems on high cost equipment. All reports on joint working were very positive. Finally mixed views on value in use were identified. This highlights that further and more specific research on value in use is required where the focus of research is the use of the asset rather than the provision.

The case study findings reported in this section (4.2.3) are discussed and contribute to the development of research findings 1, 2 and 6 in the next chapter (5).

4.2.4 Enterprise

The focus of this section is the case study enterprise. Enterprise is the fourth interacting feature of the research framework (as illustrated in Figure 1d). Thirty-three (33) individual points on Competence were identified, coded and analysed within the interview data.

The term enterprise is used to describe the complex system of interconnected and interdependent activities undertaken by a diverse network of stakeholders for the achievement of a common significant purpose (Purchase, et al., 2011). The case study service enterprise includes the key stakeholders, the customer, the provider and the key suppliers as a minimum. The section highlights key comments on the structure and culture of the enterprise and includes a number of key issues associated with this feature.

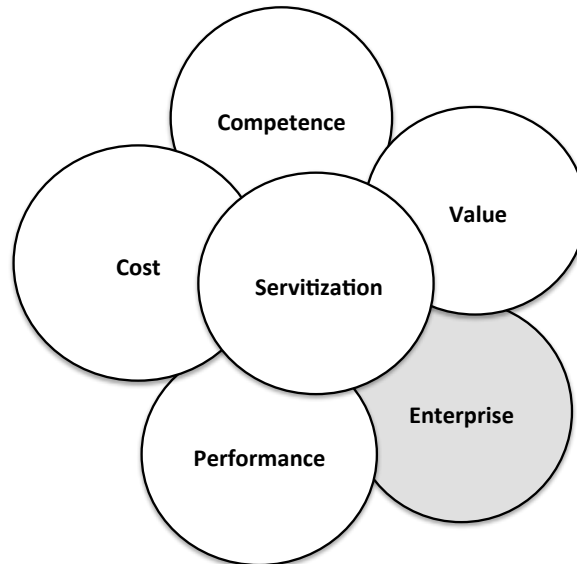


Figure 9d. Research framework, enterprise (Source author)

The case study enterprise providing the UK Typhoon aircraft availability is broad and deep and consists of multiple organisations operating at multiple levels. The organisations are both public and private and exist both on and off base. The enterprise includes the main stakeholders, the customer the UK Ministry of Defence and Royal Airforce and the service provider BAE Systems. It also includes approximately four hundred (400) recognised suppliers of equipments and parts. GE Aviation is one of these suppliers. As the Typhoon project is international many of the suppliers are based outside of the UK. Each of these organisations report to corporate divisions or headquarters and each have part and material supply chains. Third party suppliers of service and government furnished equipments are also considered part of the enterprise. Finally the enterprise also includes the European project bodies and the project partners from Germany, Spain and Italy.

The service enterprise is considered complex. This complexity is exacerbated by the fact that multiple enterprise stakeholders can have differing objectives. This includes different objectives between organisations and between functions within those organisations or a mixture of the two. This can drive incorrect decision-making and slow

responsiveness across the enterprise. A joint UK Ministry of Defence and BAE Systems dual headed project team, (one leader from BAE Systems and one from the Royal Airforce) has been established. The team has a brief to set common direction. The UK Ministry and Defence and BAE Systems interviewees believed the project team was working well, however they confirmed that real boundary crossing management did not exist and sharing of objectives was also unclear. GE Aviation interviewees also advised that they did not have much visibility of the Typhoon project management team and suggested improved communication and common objectives would improve the management. The following quotes from BAE Systems and GE Aviation interviewees highlight that multiple objectives exist.

“Different bits of the chain work in different ways, things can always be improved, it is complete with multiple stakeholders across multiple sites with multiple objectives and complicated pieces of equipment and a whole series of complications on going all the time”. Provider/BAE Systems

“It is difficult and maybe too big to manage and I think the way to do it is to have a virtual enterprise and make sure that people in it all have the same objectives to the middle and bottom”. Supplier/GE Aviation

It was reported by the interviewees that a challenge of prioritisation also exists across the multiple firms in the enterprise. Enterprise conflicts driven by customer priorities exist and operational imperatives may take priority over cost effectiveness. The right fixes or volume of fixes may not occur if the aircraft is required urgently. The associated impact is no longer absorbed by the customer but is absorbed by the provider BAE Systems who now hold the availability risk against a fixed fee. The following quote from a BAE Systems interviewee highlights the cost of different priorities.

“The difficulties that cost money are around the different priorities that the customer will have to ourselves”. Provider/ BAE Systems

The enterprise also comprises many levels. The effort required moving returns up, down and across the enterprise was considered significant and slow. One interviewee from BAE Systems stated the dependence for service was 10 fold that experienced in production. This slow movement was linked to potential extra cost by the interviewees.

“Providing a service rather than producing a product is more difficult as there is probably a factor of 10 times the number you need to interface with in order to deliver your element of the work. So your number of stakeholders quadruple to deliver the service which means that functionally I cannot deliver what I need to deliver from Engineering without the full involvement of the other functions whether it be maintenance, finance, procurement”. Provider/BAE Systems

The BAE Systems interviewees explained that the Typhoon support enterprise also includes international suppliers. International suppliers were required to reflect the international nature of the Typhoon project and accommodate production work share requirements. Whilst this was an acceptable arrangement for production it lacks the speed and dynamism required by an enterprise during the support phase where availability is at risk. This is highlighted by the following quote from a BAE Systems interviewee.

“The production has the benefits of manufacturing workshare but support is difficult especially where cost is a big driver. Especially difficult when one customer such as the UK wants to continue developing into the future”. Provider/BAE Systems

The international dimension of the enterprise makes the movement of the faulty Line Replacement Unit from the base or point of service to the place of repair problematic and time consuming. This can delay the returns process and add cost through delay.

“How quickly can you get asset back from Libya back into the supply chain for repair? How quickly can you get them from Coningsby to a supplier in Germany”? Provider/BAE Systems

The interviewees felt speed was of the essence and that it would be beneficial to re-source work to the UK. This however was viewed as impractical due to the high cost of new design and programme politics. This is highlighted by the following quote from a BAE Systems interviewee.

“Providing support via an international base is costly. Bringing it to the UK suppliers from the European suppliers was cost prohibitive. Work share also stopped it. Why would an Italian supplier give up the work when they have invested in it to buy that work”. Provider/BAE Systems

Many of the interviewees reported that the multiple levels of the enterprise generate a high level of enterprise stock. This directly increases stock and holding costs. This includes spares travelling through the supply chain and spares and parts (line replacement units, spare replacement items, parts) held at multiple levels (Customer initial provisioning, provider stock, and supplier stock). GE Aviation interviewees also advised that spares were always used to replace a failed mission head down display (MHDD) and that multiple spares were held in their repair facilities. The following quotes from GE Aviation and BAE Systems interviewees highlight that stock is held.

“There is obviously a cost to stock the shelves with spare replacement items”.

Provider/BAE Systems

“GE Aviation stock spares for repairs, this costs”. Supplier/GE Aviation

This section on enterprise also focuses on comments made about the enterprise culture. The comments detailed refer to the separate cultures of the service enterprise stakeholders interviewed, namely BAE Systems, UK Ministry of Defence and GE Aviation.

Interviewees at both BAE Systems and GE Aviation highlighted that their organisations were individually functionally strong and expressed concern at the continued product and risk averse enterprise culture. They viewed this as partly historic and partly driven by the contracts. The strong functional culture and divisions were viewed as stifling positive responsiveness to customer requests. It was also considered as part of the reason for slow flow of product and activity both across organisations and up and down the supply chain. Initiatives have therefore been established to improve flow of activities across boundaries. An enterprise supply chain group has been established by BAE Systems functions spanning the support activity from the aircraft to the supplier and a Typhoon integrated project team spanning all involved functions has been established at GE Aviation. Both initiatives were viewed as positive and assisting the organisational and cultural transformation of the enterprise from product to service. The following quotes from GE Aviation, BAE Systems and UK Ministry of Defence interviewees highlight the functional nature of the service enterprise.

“The RAF base is very functional even between buildings. This can slow the return of a repair”. Supplier/ GE Aviation

"I guess we still have silo activities in lots of ways. You will get a team that are operating well and another that are not operating so well." BAE Systems/Provider.

"GE Aviation are very transactional". Customer/UK Ministry of Defence

Finally during each of the interviews with the UK Ministry of Defence, BAE Systems and GE Aviation the opportunity was taken to establish and validate an enterprise image for the Typhoon support organisation. This was achieved by presenting the Tornado enterprise image to each interviewee and asking each to amend it to create an image reflecting the Typhoon enterprise. The image created collectively by the interviewees is illustrated in Figure 14 below.

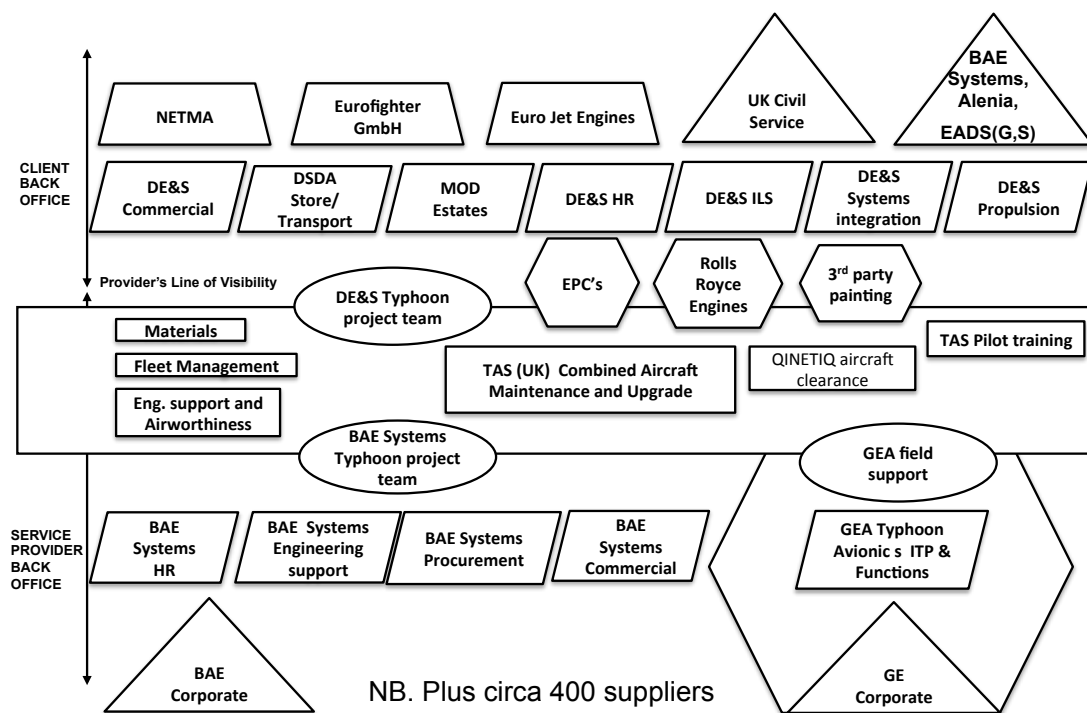


Figure 14. Typhoon service enterprise map (Source author)

The image clearly shows to those directly and indirectly involved the complexity and interdependence faced by all engaged in the delivery of the typhoon support service. Multiple interfaces between multiple organisations exist both horizontally and vertically all needing to find a way to work in unison to provide the Typhoon support at the lowest cost.

There was clear consensus between the UK Ministry of Defence, BAE Systems and GE Aviation interviewees who all believed the service enterprise was broad, deep and complex and difficult to manage. The international dimension further increases the complexity. Whilst it was reported that a dual headed project team was in place between the UK Ministry of Defence and BAE Systems all interviewees expressed a concern over differing objectives across the greater enterprise. The different objectives were viewed as slowing the returns process, adding unnecessary cost. Existing product culture was also viewed as strong in each of the stakeholder organisations and it was reported that a great deal of effort was being employed to change this situation. A new single responsive enterprise service culture was being sought. All interviewees viewed making the whole service enterprise work in a cohesive manner as key to providing an acceptable service and business return. BAE Systems and GE Aviation also provided specific comments on suppliers. The BAE Systems interviewees advised their main focus was with the suppliers of key and expensive equipment and they explained that they matched and used key performance indicators to a variety of contract solutions to drive the correct supplier performance. GE Aviation advised they were progressively flowing down requirements to their suppliers although they felt there was still some room for improvement. A variety of supply chain issues were also included in this category. All of these issues impacted on time to complete and cost.

The case study findings reported in this section (4.2.4) are discussed and contribute to the development of all of the research findings (1-6) in the next chapter (5).

4.2.5 Performance

The fifth category of the research framework is Performance (as illustrated in Figure 9e). This category includes findings from the discussions on the performance and performance management of activities required to deliver the service. This includes findings related to the performance measurement used at all levels of the enterprise that helps to build an understanding of current practice and changes required to performance management of a complex engineering service. One hundred and nineteen (119) individual points on Performance were identified, coded and analysed within the interview data.

Performance measurement for manufacture is well established (Kaplan and Norton, 1993 and 1996; Neely, et al., 1995; Slack, et al., 2007). A performance measure can be

defined as a metric used to quantify the efficiency and effectiveness of action and the performance measurement system refers to the framework of measurement employed (Neely, et al., 1995). A performance measure is a prerequisite for judging whether an operation is good bad or indifferent (Slack, 2007).

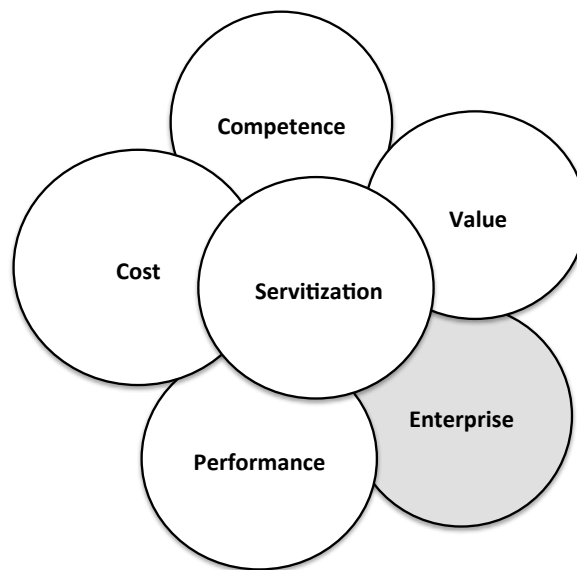


Figure 9e. Research framework, performance (Source author)

The new business arrangements make BAE Systems responsible for the availability of the Typhoon aircraft. To achieve availability BAE Systems has assumed the performance management activity of the customer and are now focusing on output. This shift from measuring their own input to focusing and measuring the output of the enterprise is viewed as a significant and successful change in approach. The following quote from a BAE Systems interviewee supports this statement.

“Once the teams started discussing contracting for output and introducing incentives for increased levels of performance the whole dynamics of the service requirements and relationships changed”. Provider/BAE Systems

Common objectives are also being put in place by the joint leadership team. Common objectives are required to align the efforts of each of the enterprise stakeholders to deliver optimal enterprise efficiency. The following quote from a BAE Systems interviewee describes the complexity of the enterprise highlighting the need for common objectives.

“The service enterprise has multiple stakeholders across multiple sites with multiple objectives and complicated pieces of equipment and a whole series of complications on going all the time”. Provider/BAE Systems

The case study enterprise has started to measure performance against four new top-level output measures, delivery, quality, cost and function. In support they review their inputs and consider impact on asset availability rather than achieving contractual requirements alone. All interviewees were aware of performance measures flowing from the four top-level performance indicators. The interviewees advised that measures cascade down and role up through the organisation and the greater supply chain. Tangible and intangible measures exist including measures on the customer. The following quote confirms the use of four performance measures.

“The front end contract comprises four measures of availability”. Provider/ BAE Systems

The performance measures are captured in general terms and conditions and specific statements of work agreed with suppliers. This captures the actual level of service they are seeking on specific equipment. The flow down of measures is highlighted in the following quote from a BAE Systems interviewee.

*“At the front end the customer has availability measures, which typically go around the number of flying hours. That is flowed down to some of the suppliers”
Provider/BAE Systems*

The BAE Systems interviewees advised they expend most of their effort on the top tier of suppliers, as that’s where the major problems occur and where the majority of cost exists.

“There’s a rationale, it is like most procurement and supply chain activities there is a sort of hierarchy of supplier contact. Top suppliers you do a lot with, certain ones you do less with and certain ones a little with and so on”. Provider/BAE Systems

The provider (BAE Systems) interviewees detailed the key performance measures and indicator’s (KPI’s) they use with their suppliers. There are a number of possible measures that can be selected depending on the contract type, and the objective that must be achieved. The Key Performance Indicators (KPI’s) cover all phases as described by the Defence Acquisition System. This includes the pre acquisition phase (phase 1), the systems acquisition (phase 2), and the sustainment phase (phase 3). At each phase and with each supplier the appropriate KPI’s are selected to support the contractual solution in place. The KPI’s can also be found in an Availability Contracting Handbook produced by BAE Systems Military Air Systems procurement. The nature of the KPI’s and the existence of the handbook reflect BAE Systems new role of providing asset availability. These KPI’s are detailed below:

- Demand satisfaction rate (DSR)
This measurement applies where suppliers make available to the customer a serviceable article to satisfy demand within a defined timescale known as a Demand Satisfaction Rate. The demand can be placed without the return of an unserviceable asset.
- Guaranteed replacement times (GRT)
This measurement applies within availability contracts where suppliers make available to the customer a serviceable replacement, which may not necessarily be the same serial number as the original unserviceable returned article. The serviceable replacement is provided within a defined timescale known as the guaranteed replacement time.
- Guaranteed turnaround time (GTRT)
Traditional method of measurement based on the repair lead-time of a product. Where repairs are required and insufficient asset pools exist to operate a GRT service then the suppliers repair performance is measured using a Guaranteed Turn Round Time.
- Technical services (time to respond to query)
This measurement applies to the time the provider takes to respond to a technical query raised when problems are experienced during flight operations.

- Delivery of engineering improvement plan
Measures taken against an engineering plan(s) established at the aircraft or supplier level to improve design where unacceptable levels of equipment failure are being experience.
- Reduction of No Fault Found (NFF) returns
An initiative has been launched to progressively reduce the occurrence of No Fault Found equipment returns. Improvement is measured across defined periods.
- Schedule adherence
Key Performance Indicator's established to measure schedule adherence.
- Lead time reduction
Key Performance Indicator's established to measure lead-time reduction improvement initiatives and their successes.
- Cost reduction
Key Performance Indicator's established to measure cost reduction success. Reductions achieved as a percentage of total spends.
- Reliability improvements/improved mean time between failures (MTBFS)
This measures the meantime between failures of aircraft equipments. Measurement is taken against the number of successes made against targeted reductions.
- Throughput measures
Logistics KPI's established to measure the time taken to pack and ship goods.
- SHE improvements
Improvement KPI's established to measure the introduction of Safety, Health and Environment improvements.
- Duty carried out
KPI's established to measure the success of flight operations.
- Customer satisfaction
Various performance KPI's established to measure aspects of customer satisfaction.

Although the BAE Systems interviewees confirmed their supplier management is undertaken using the tangible KPI's detailed above they advised problems still occurred resulting in extra costs. Poor performance is discussed with the suppliers and any

additional costs are minimised or absorbed by suppliers. However not every cost associated with disruption and extra effort through the supply chain are captured or recovered. Failed product can add cost as it moves through the supply chain especially if responsiveness is slow. Workaround cost, stock cost and recovery costs can all occur. Furthermore premiums were reported as having been paid to suppliers to obtain improved turnaround performance. The following two quotes one from a BAE Systems interviewee and one from a GE Aviation interviewee highlight these types of costs.

“When you have problems with suppliers products and performance that causes product to move through the supply chain it can cause even more cost which are sometimes hidden. We don’t try to recover them”. Provider/BAE Systems.

“BAE often pay suppliers a premium to obtain an improved repair turnaround time”. Supplier/GE Aviation

The UK Ministry of Defence and BAE Systems also use intangible measures based on customer satisfaction and Typhoon management undertakes a survey of satisfaction annually. Corrective action is established if necessary.

One of the BAE Systems interviewees believed that some of the bigger suppliers did not demonstrate sufficient effort required to deliver the correct performance. This reflects tension in the supply chain created by miss-aligned objectives between interfacing parties. This sometimes generated extra system recovery effort and cost. The following quote from a BAE Systems interviewee further explains poor effort on the part of some suppliers.

“My biggest frustration was I never felt we really got the suppliers attention. It is fine with some of the small guys who see us as a big partner but when you are dealing with some of the bigger guys it can be very clear where you fit in their priority list”. Provider/ BAE Systems

BAE Systems interviewees also admitted that as an organisation they suffered from a green performance culture even though performance and results were often poor. A green performance culture exists where staff repeatedly refuses to acknowledge that business problems exist and insist the performance is acceptable. The staff incorrectly report problems or poor performance as green on performance management tools where red means late, amber means recovering, and green means on track. This

situation was improving with treatment however it is still a concern and is highlighted by the following quote.

“Within the new availability arena’s we had a sea of green coming back to us from the various areas whether it be functional areas or support but it was not working”. Provider/BAE Systems

GE Aviation interviewees recognised that a number of tangible and intangible key performance indicators and specific turnaround times for repair had been flowed down to them from BAE Systems. Whilst this provided increased focus on performance management compared to that experienced on previous programmes the total demands were considered less onerous as BAE Systems have not flowed down all of the risk. This is reflected by the following quote.

“Typhoon probably feels tighter on the management of individual measures but the range of measures feels less onerous because they are taking back some of the risk. In terms of the key measure which is turnaround time for repair then they are tighter managing that”. Supplier/GE Aviation

However the GE Aviation interviewees revealed that performance management could still be improved. Minutes of progress meetings were seldom followed up and KPI’s were limited to turnaround times. This is highlighted by the following quotes.

“Minutes and reports on meetings with customer has not been discussed there since 2008”. Supplier/GE Aviation

“We do not really focus on KPI’s internally”. Supplier/GE Aviation

Notwithstanding the above quotes three GE Aviation interviewees believed they are slowly becoming more responsive and trying to deliver win-win changes and reduction of cost as they wish to be maintained as the on going supplier in future contracts. Their new Integrated Project Team is helping to achieve this. The following quote supports this statement.

“We want to deliver the service, so if we deliver that service the performance is here, then we look at the cost to take the cost down”. Supplier/GE Aviation

As a purchaser GE Aviation interviewees believed they had improved the management of their suppliers but still had improvements to make. A GE Aviation interviewee made the following quote.

*"We do not do enough with our suppliers and we are trying to get better".
Supplier/ GE Aviation*

A number of performance related problems currently being experienced were also discussed. The most popular are detailed below.

Some availability type arrangements have been introduced and some suppliers are working towards reducing arisings. The designs however are still not optimal for minimising through life cost. BAE Systems want suppliers to help with this on new designs in the future only releasing designs that meet the expected performance requirements. The following quote from a BAE Systems interviewee highlights the problem and emphasises what he would like the supplier to do in the future.

*"The great moment I would like to see is when the supplier says to us in a development contract I am not going to sign the design declaration because our reliability is not good enough and I know that's going to cost me through life".
Provider/BAE Systems*

On time demand forecasting to suppliers was raised as a key issue by several of the BAE Systems interviewees. The total support operation was viewed as complex with multiple equipments moving through the system at any one time. It was therefore considered essential that suppliers received good requirements forecasting to ensure they work on the correct units at the correct point in time and deliver the required level of performance. This point is supported by the following quote from a BAE Systems interviewee.

"Both the vendors and ourselves have to work together on spares and repairs especially where we are trying to improve. A lot of this is getting forecasting into the vendors so they can plan". Provider/BAE Systems

Improved instruction and communication and common objectives are also required across BAE Systems where batching of returns across the enterprise can create problems. The BAE Systems interviewees viewed batching as slowing the returns

process. As a result stock holding costs increase and the need for further replacements may also increase. This situation is further explained by the following two quotes from different BAE Systems interviewees.

“A problem that is a typical one is people tend to batch things up. If there is a problem, say a part is broken they may hold them until they have a few”.
Provider/BAE Systems

“A problem occurs where you have inventory stockpile and your supplier has only got capacity for 10 but someone sends 20 back they can only do 10 at anyone time”. Provider/BAE Systems

Alternatively some interviewees made the point that smoothing work in progress can add cost as it expands the amount of handling activities.

“Sometimes things are batched, not necessarily on orders but during the throughput. This is an activity we are trying to understand. However vendors sometimes work on a batch principle, so it is a mix. We know we need to smooth capacity in the vendor base and keep stock to a minimum”. Provider/BAE Systems

From the GE Aviation perspective three of their interviewees highlighted (as a supplier) that flow of equipment through the enterprise is not balanced. They advised that large batches were sometimes received. They explained that this was very disruptive and added increased management and repair costs into the system due to the extra effort required to work the batch. This includes increasing the flexibility of staff, benches and test equipment and introducing additional shifts to achieve turnaround times. The following quotes explain this feature.

“We tend to try and flex our capacity to suit expected arising. It is when an unexpected big batch is returned that it catches us out. It makes it difficult”.
Supplier/GE Aviation

“Flexibility is required to meet peaks and troughs of workload. Multiple product cells, three shift system and resources have flexible skills. This all adds cost”.
Supplier/GE Aviation

A number of the interviewees referred to the multiple supply-chain 'hand offs' that exist through out the enterprise supply chain. Although not explicitly stated it was inferred

that resistance or inefficiencies and hidden cost exists between activities which impact on performance. Such a phenomena could exist where equipment moves between functions or firm boundaries. This is highlighted by the following quote from a GE Aviation interviewee.

“The traffic up and down the supply chain however puts a lot of pressure on the overheads it is ridiculous. Very difficult to capture those costs as there are several hand offs. We can probably capture the costs within our business but there are inefficiencies which we pass on to each other”. Supplier/GE Aviation

In summary performance management was raised and considered as key by all interviewees. All interviewees believed that good service is underpinned by good enterprise performance required to ensure availability of aircraft in line with the customer requirement. BAE Systems interviewees advised they had now assumed the performance management role of the customer and were focusing on the output performance against 4 top level KPI's (delivery, quality, cost and function) that are now flowed through the enterprise helping to direct and improve performance at all levels. Interviewees however recognised that a culture of ignoring poor performance existed although they believed it is slowly being corrected.

The case study findings reported in this section (4.2.5) are discussed and contribute to the development of all off the research findings (1-6) in the next chapter (5).

4.2.6 Cost

The focus of this section is cost. Cost is the fifth and last feature of the research framework (see Figure 9f). One hundred and seventeen (117) individual points on cost were identified, coded and analysed within the interview data.

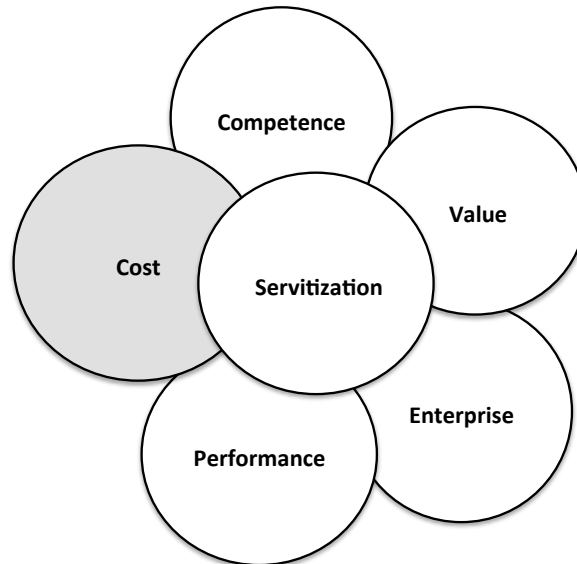


Figure 9f. Research framework, cost (Source author)

Forty of the cost points identified describe the existing understanding of cost. These are detailed in the first sub section providing a recap on the previously discussed reported programme costs and targets (see 4.2.1). The balance of the one hundred and seventeen (117) points identified on cost comprises seventy-seven (77) quotes highlighting forty-four (44) individual costs. These individual costs are the subject of the second sub section where each of the costs is detailed with a supporting quote in the same manner as the previous section. To add more detail an analysis has been undertaken and a categorisation of each cost developed. This categorisation is provided. The third and final sub section provides an analysis on availability recovery approaches currently undertaken by the case study enterprise. This analysis highlights the relative speed and cost of five different aircraft availability recovery approaches.

The seventy- seven (77) quotes on individual costs extracted from the interview transcripts have been analysed and used to establish forty-four (44) different costs. Whilst the forty-four (44) costs cannot be considered exhaustive they do provide a large amount of data that can be used to better understand servitization and its costs and thus what further changes are required to improve performance. Some of the costs

highlighted are expected, however the majority reflect interviewee perceptions that anticipate increased or additional cost as a result of operational problems and poor performance. This section analyses the nature and characteristics of the forty-four individual costs.

The sections detailed approach on cost provides an increased understanding of the costs within the enterprise support system, some of which relate to the issues identified during the previous sections of this chapter. This helps to establish an improved understanding of planned and unplanned costs associated with the provision of a complex engineering service including the cost of poor performance. It also helps to identify what further strategic and operational changes are required to reduce the unexpected costs. Furthermore it highlights the type of costs to be included in a complex service cost model. This assists in answering the research aim and directly answers the third research question - What through life costs should be included in the new CATA cost model?

4.2.6.1 Typhoon programme costs and targets

The discussions with the case study interviewees established an understanding of past and existing Typhoon programme support costs and current cost targets. As the Typhoon programme support costs and cost targets have been previously discussed (see 4.2.1.1) the costs only are re-stated below for completeness within this section.

The UK Ministry of Defence interviewees advised that the 1980's pre-approved budget for full Typhoon programme was £39bn. The through life support costs were estimated at £13.1 billion of the total. The following quote supports this statement.

*“The pre-approved budget was £39 billion back in the 80's including the whole programme through life manufacture logistics air command costs, the works, and £13.1 billion was earmarked for support (1980's economic conditions)”.
Customer/UK Ministry of Defence*

The phase 2 (systems acquisition phase) flying costs were understood to be Euro 12,000 per flying hour. As this was considered too expensive the phase 3 (2010-2014) flying cost target was set at Euro 6,000 per hour, a fifty per cent (50%) reduction. The following two quotes from the UK Ministry of Defence support this statement.

“Based on the cost per flying hour in phase 2 repairs were costing Euro 12,000 per flying hour across all four nations, and industry agreed for phase 3 to reduce the cost by 50%, reducing exchanges on base, plus a common spares pool across the nations”. Customer/UK Ministry of Defence

“When we looked at the cost of the tranche three production it was considered unaffordable and that was primarily driven by support costs.”. Customer/UK Ministry of Defence

The cost challenge of minus fifty per cent (-50%) has been reported as achieved by the UK Ministry of Defence and the current flying cost was reported to be Euro 6,048 per flying hour. This is reflected by the following quote.

“Cost went down 50% for repairs through a massive gutting of the scope and we are currently in phase 3, which runs 2010 to end 2014. We achieved the challenge of -50%. The actual cost now is Euro 6,048 per flying hour”. Customer/UK Ministry of Defence

The above statement is thought to reflect the new agreement between UK Ministry of Defence and BAE Systems and a top-level understanding of progress made to date towards the cost reduction targets.

The Ministry of Defence interviewees also advised that a further cost target will be set for 2015 onwards. A target reduction of 70% over base is expected. The further reduction will be achieved by further increased efficiencies of the new service arrangements including the continued management focus towards the reduction of spares and repairs. The following quote from a UK Ministry of Defence interviewee highlights the costs targets.

“The binding commitment also reduces the cost by 50% for phase 3 and then the phase after that against this baseline of Euro 12,000 achieves a reduction of 70% for the follow on which is something we will have to start looking into from 2015 onwards”. Customer/UK Ministry of Defence

The further cost reduction target translates to a target flying cost of Euro 3,600 per flying hour for 2015 onwards.

4.2.6.2 Individual cost findings

In addition to the reported programme support costs the interviews highlighted multiple individual costs. In total seventy-seven (77) quotes on cost have been identified and from these forty-four (44) individual costs have been established and analysed.

Each of the costs identified have been analysed against a number of frameworks to establish a number of characteristics. The analysis and frameworks used are detailed below.

- a). An adapted framework from Hanson and Mowen (2007) has been used to identify if the costs are; a compliant activity (an expected activity required to deliver the service i.e. a normal cost); an internal failure (a recovery activity required to recover from poor performance or problems which occur within the enterprise boundary; an external failure (a recovery activity required to correct an external failure i.e. a failure outside of the enterprise boundary); a preventative activity (an activity undertaken to prevent a problem); or a detection activity (an activity required to detect problems of product quality or performance).
- b). The costs have been analysed to identify if they are related to hardware, operational or other activities.
- c). The costs have been identified as costs with a local, an upstream impact (aircraft base) or downstream impact (supply chain).
- d). The costs have been identified as expected or generated as a result of poor performance.
- e). An analysis against the Doost (2006) framework has been undertaken to identify if the costs are input, output or outcome costs.
- f). The costs have been analysed to identify if they have arisen in an independent, dependent or interdependent activity.
- g). An analysis of the costs has been undertaken against the Ng, et al., (2011) transformation framework identifying if the costs arise in activities associated with the transformation of people, information or materials and equipment.

The forty-four costs identified have been numbered from one (1) to forty-four (44) for ease of tracking and are detailed below. The characteristics of each cost are subsequently detailed in the table below. Full details of the analysis complete with supporting quotes can be found in the appendix section 10.2.

Cost 1. Many of the equipment designs need improvement to extend their mean time between failures in service. The UK Ministry of Defence have therefore committed to providing funding monies for design improvement each year.

Cost 2. Obsolescence costs are those associated with obsolescence of materials and components through the life of the aircraft programme. This is a major problem as life of aircraft programme can be longer than forty years. This cost is escalating as the pace of technology development increases.

Cost 3. Training costs. Training required for the execution of the new allocation of task predominately being undertaken by the provider.

Cost 4. Cost of training the joint RAF, BAE Systems teams. Repeated induction and training required due to the high movement patterns of RAF personnel and need to move BAE Systems staff to ensure cross fertilisation of ideas and understanding of the new arrangements.

Cost 5. Selected suppliers have been positioned on base to work on aircraft with the RAF and BAE Systems teams. This is required to deliver 5-day turnaround repair activity. This adds cost.

Cost 6. Additional cost arising due to the unsuccessful use of on-base general performance acceptance test equipment (GPATE). Cost generated as attempts to test equipment on base failed due to lack of skills and equipment.

Cost 7. Cost arising as a result of the need to clean sensitive data from certain equipments prior to returning the equipments back through the supply chain.

Cost. 8. Cost arising as a result of different standards of equipment creating the need for different test and repair actions at the supplier.

Cost 9. Difficult suppliers. Extra budget and expenditure used to ensure management of problem suppliers.

SERVITIZATION ISSUE 1 24.12.2013

Cost 10. An agreed level of equipment arisings covered by procurement contracts. The contracts cover the baseline requirements as generated by the provider support modelling based on expected flying and known mean time between failures of equipments. This generates the basic, expected number of spares and repairs that generate a basic cost expectation against arisings (equipment failures). Equipment arisings were reported as 70% of the total support cost of £13.1 bn.

Cost 11. Additional cost as a result of equipment arisings above the expected mean time between failures and thus above the baseline contract agreements.

Cost 12. Equipment arisings with repair turnaround time managed on a case-by-case basis. These are additional costs incurred on repairing those equipments outside of the top 48 that do benefit from having an agreed turnaround repair time with the supplier. Lead times can extend (due to lack of control) adding cost.

Cost 13. Increased supply chain costs generated by No Fault Found equipment returns and customer damage. Increased supply chain pressure increases inefficiencies between parts of the supply chain increasing costs.

Cost 14. No Fault Found, exchanging the incorrect equipment doesn't resolve the real problem and epidemic breaks across multiple aircraft creating further cost.

Cost 15. The supply chain multiple tiers, supply chain handoffs and resistance all add time and cost when moving equipments up and down the chain.

Cost 16. Sourcing product from international suppliers can add extra cost. However it is difficult to change, as it is expensive and politically unacceptable due to the launch work share arrangements agreed between the participating countries.

Cost 17. The base team performance can be poor when returning units to the supply chain. This can increase the cost of recovery and possibly create unexpected disruption and stock costs.

Cost 18. The general performance acceptance test equipment (GPATE) on base can take longer to set up than expected. This can increase the cost of recovery.

Cost 19. Returning equipment failures from international locations and bases can take longer than expected and can include multiple logistics activities. This can increase cost of return and recovery activities thereafter.

Cost 20. Supplier performance including supplier willingness to perform can delay recovery, necessitate premium payments, consume management effort and create disruption costs.

Cost 21. When managing the repair of equipment failures to tight turnaround times capacity needs to be planned in advance. Late demand forecasting by the provider to the supplier can create delay and or extra effort and cost.

Cost 22. The supplier must receive all of the correct paperwork before the equipment repair activity can commence. Missing or incorrect paperwork can cause a delay and the need for special recovery activity hence adding extra cost.

Cost 23. All equipment failure repairs are different. The work required to repair the equipment is therefore different and emerges as the failure is investigated on test or strip. This makes it difficult to balance workflow across the enterprise and can also create delay. This can create additional cost.

Cost 24. Batching of equipment failure returns within the greater enterprise prior to return to the supplier creates unbalanced returns to the supplier causing activities that add cost. When the supplier receives a large batch they may not have the capacity to repair all of the units immediately. To maintain turnaround expectations the supplier will reorganise, work overtime and add new shifts. This extra effort adds cost to the enterprise system.

Cost 25. To complete the equipment repair within the expected lead-time replacement parts may need to be made within reduced lead-times. Special arrangements are made by the suppliers production department to be able to respond quickly. This creates extra cost.

Cost 26. To complete the equipment repair within expected lead-times parts may need to be procured by the supplier from his suppliers on a priority-ordering basis. The supplier may charge more adding extra cost.

Cost 27. Economic batching of equipments during the returns process increases the total repair lead-time and stock costs.

Cost 28. A balanced decision between stock required, stock held and recovery lead-times has to be taken. Holding of too much stock in the supply chain adds extra cost.

Cost 29. Unexpected random failures of equipment can occur where no safety net exists. This drives unexpected local output cost.

Cost 30. The resources and effort have increased with the provision of the new value proposition. This increases cost.

Cost 31. The UK Ministry of Defence as customer has positioned the provider BAE Systems to manage the third parties who had previously reported to the UK Ministry of Defence. This includes the reduction of alleviations on penalties previously given to the provider to cover late deliveries as a result of poor third party performance. This change greatly increases the risk held by the provider BAE Systems. This may potentially impact on availability and cost (operational disruption and or financial penalty).

Cost 32. Poor design and the slow design change process and or short term contracting slows the speed of change and hence slows the reduction of equipment arisings. This extends the level of failures arising adding extra cost.

Cost 33. Product and risk averse culture and contracting, slows responsiveness between customer and provider and provider and suppliers. This extends the lead-time of equipment repairs adding cost.

Cost 34. Cost related to green culture. This is where progress is incorrectly reported to plan but actually the real performance is unacceptable. This can hide and generate additional costs.

A green performance culture exists where staff repeatedly refuse to acknowledge that business problems exist and insist the performance is acceptable. The staff incorrectly report problems or poor performance as green on performance management tools where red means late, amber means recovering, and green means on track.

Cost 35. Rushed or poor fault detection of failed equipment on the aircraft can cause the selection and return of the wrong equipment (No Fault Founds). The incorrectly

selected equipments can be returned through the supply chain to the supplier, tested and when no fault is found are returned to base. This adds multiple unnecessary costs. The following quotes from multiple interviewees further explain this problem dynamic.

Cost 36. Difficult identification of problem on aircraft leads to exchanging multiple different units on aircraft to be sure on fix. This may lead to multiple no fault founds incorrectly returned through the supply chain raising multiple unnecessary cost.

Cost 37. Customer damage of aircraft equipment creates additional work and cost for the provider and the supply chain. This includes the cost to replace hardware, increased pressure on supply chain, and potential additional cost for parts for repair. Additional cost may occur if there is dispute between the customer and the provider delaying the recovery activity. The following quotes from BAE Systems and GE Aviation interviewees highlight the problem of customer damage.

Cost 38. Customer priorities (which are different to the provider priorities) may slow the return process for some units and add cost.

Cost 39. A mix of objectives between companies, functions and individuals can exist. This can lead to mixed decisions and incorrect action slowing the repair of equipments. This can add extra cost. This statement is supported by the following quotes from BAE Systems and GE Aviation interviewees.

Cost 40. Due to the nature of a complex engineering service many organisations and individuals can be involved. This can be ten (10) fold greater than the interfaces required for production. The multiple interfaces across the supply chain add cost.

Cost 41. The complexity of the aircraft mission systems and specific recovery activities required can add cost. Once the equipment has been checked the aircraft system must be synchronised. This can be time consuming and can lose sorties, hence loss of availability, and impact on cost and performance.

Cost 42. Spares costs and holding costs exist at multiple levels of the enterprise supply chain. This includes customer initial provisioning, provider stock, and supplier stock, LRU's, SRI's and parts.

Cost 43. Additional costs can be incurred when the aircraft systems supplied by multiple international parties require updating to fix operational problems. The complex

workshare arrangements generate additional cost when the updating of the design is required and extends across the 4 national industrial partners.

Cost 44. International collaboration can work for production activities but can become very slow, difficult and expensive when applied to support.

Table13 below captures the characteristics of each of the cost

Cost No.	Compliant activity, Internal failure, External failure, Preventative activity, (Hanson and Mowen, 2007).	Hardware, Operational, People.	Local, Upstream, Downstream.	Expected, Poor performance.	Input Output, Outcome, (Doost, 2006).	Independent, Dependent, and Interdependent activity.	Equipment and Material, Information, People transformation. (Ng, et al., 2011).
1	Preventative	Hardware and operational	Local	Poor performance	Input	Interdependent	Information
2	Preventative	Hardware and operational	Local, upstream, downstream	Poor performance	Input	Dependent	Material and equipment
3	Compliant	People	Local	Poor performance	Input	Interdependent	Material and equipment, People
4	Compliant	People	Local	Expected	Input	Interdependent	People
5	Compliant	Operational	Local	Expected	Input	Interdependent	People
6	Compliant	Operational	Downstream	Poor	Input	Dependent	Material and equipment
7	Compliant	Hardware and operational	Downstream	Expected	Input	Dependent	Material and equipment
8	Compliant	Hardware and operational	Downstream	Expected	Input	Dependent	Material and equipment
9	Compliant	Hardware and operational	Local	Expected	Input	Dependent	Material and equipment
10	Compliant	Hardware and operational	Local and downstream	Expected	Output	Dependent, and interdependent	Material and equipment
11	Compliant	Hardware and Operational	Local, Upstream, and Downstream	Poor performance	Output	Dependent	Material and equipment

SERVITIZATION ISSUE 1 24.12.2013

12	Compliant	Hardware and Operational	Local and Downstream	Poor performance	Output	Dependent	Material and equipment
13	Internal failure	Operational	Local, Upstream and Downstream	Poor performance	Output	Dependent	Material and equipment
14	Internal failure	Hardware and Operational	Local	Expected	Output	Dependent	Material and equipment
15	Compliant	Operational	Local	Expected	Output	Dependent	Material and equipment
16	Compliant	Operational	Local	Expected	Output	Dependent	Material and equipment
17	Compliant	Operational	Downstream	Poor performance	Output	Dependent	People
18	Compliant	Operational	Local and Downstream	Poor performance	Output	Dependent	Material and equipment
19	Compliant	Operational	Downstream	Poor performance	Output	Dependent	People
20	Internal failure	Hardware and Operational	Local and Upstream	Poor performance	Output	Dependent	Material and equipment
21	Internal failure	Operational	Downstream	Poor performance	Output	Dependent	Information
22	Internal failure	Operational	Downstream	Poor performance	Output	Dependent	Information
23	Compliant	Hardware and Operational	Local and Downstream	Poor performance	Output	Dependent	Material and equipment
24	Internal failure	Operational	Downstream	Poor performance	Output	Dependent	Material and equipment
25	Compliant	Hardware	Local	Poor performance	Output	Dependent	Material and equipment
26	Internal	Hardware	Local	Poor performance	Output	Dependent	Material and equipment
27	Internal	Operational	Local	Poor performance	Output	Dependent	Material and equipment
28	Compliant	Hardware	Local	Poor performance	Output	Dependent	Material and equipment
29	Internal	Hardware and Operational	Local and Downstream	Poor performance	Output	Dependent	Material and equipment
30	Compliant	People	Local	Poor performance	Outcome	Dependent and Interdependent	People
31	External	Operational	Upstream	Poor performance	Outcome	Dependent and Interdependent	People

SERVITIZATION ISSUE 1 24.12.2013

32	Internal	Operational	Local, upstream and Downstream	Poor performance	Outcome	Dependent	Information
33	Internal	Operational	Local, Upstream and Downstream	Poor performance	Outcome	Dependent and Interdependent	People
34	Internal	Operational	Downstream	Poor performance	Outcome	Dependent	People
35	Internal	Hardware and Operational	Downstream	Poor performance	Outcome	Dependent	Material and equipment
36	Compliant	Hardware and Operational	Downstream	Poor performance	Outcome	Dependent	Material and equipment
37	Internal	Hardware and Operational	Downstream	Poor performance	Outcome	Dependent	Material and equipment
38	Internal	Operational	Downstream	Poor performance	Outcome	Dependent	People
39	Internal	Operational	Local and Downstream	Poor performance	Outcome	Dependent	People and Information
40	Compliant	Operational	Downstream	Poor performance	Outcome	Dependent	People
41	Internal	Operational	Local	Poor performance	Outcome	Dependent	Material and equipment
42	Compliant	Hardware and Operational	Local	Poor performance	Outcome	Dependent	Material and equipment
43	Compliant	Operational	Local and Downstream	Poor performance	Outcome	Dependent	Material and equipment
44	Compliant	Hardware and Operational	Local and Downstream	Poor performance	Outcome	Dependent	Material and equipment
Totals	Compliant 24/54%, Internal failure 17/39%, External failure 1/2%, Prevention 2/5%.	Hardware 23/52%, Operational 37/84%, Other 3/7%.	Local 31/70%, Upstream 7/16%, Downstream 28/64%.	Expected 8/18%, Poor performance 36/82%.	Input 9/21%, Output 20/45%, Outcome 15/34%.	Independent 0, Dependent 40/91%, Interdependent 9/20%.	People 11/25%, Information 4/9%, Material and equipment 29/66%.

Table 13. Characterisation of Costs (Source author)

The above analysis of the case study cost findings highlights the variety of cost that may arise in a complex engineering service. The analysis also highlights that many of the problems impact on multiple areas potentially driving multiple increases in cost. Loss of

time for instance can result in increased hardware costs, operational costs and stock costs.

When considering the cost of availability recovery there are costs we can consider direct costs and others we can consider indirect cost. The direct costs are the costs associated with the act of delivering availability recovery and comprise hardware related cost (minimum spare costs and cost of repairs) and those cost arising from the related operations (support, supply chain and disruption costs). These costs can be linked to one another and can expand as a result of poor performance. In addition to the direct costs there are costs we can consider indirect cost. These are additional costs incurred as a result of decisions taken to cover the risk of poor or non-performance of the direct recovery cost activities and potential delayed availability. These are costs of additional stock to be held over and above the previously understood baseline of required stock. This can involve the procurement of additional spares and / or spare parts. There will also be associated holding costs. Although labelled indirect they can be considered semi linked. The decision to establish increased (or possibly decreased) levels of stock is taken after complex modelling of all aircraft availability, the current number and frequency of arisings, and the actual recovery performance.

The cost findings collectively indicate that a complex interlinking cost model comprising both hardware and operational costs is required. Significantly only 52% of the cost findings arise from hardware causation with 84% of cost findings arising from operational related problems. This underlines the need to capture all operational cost including those arisings as a result of poor performance. The cost model should also be capable of operating enterprise wide as problems in one part of the organisation can create problems and result in cost elsewhere. The allocation of cost findings between the supply chain activities (dependent) and the fix on base approach (interdependent) also highlight the need to maximise on the latter as less costs are highlighted against interdependent activities.

4.2.6.3 Simulation of different availability recovery approaches

As explained in Chapter 3 a second analysis on cost finding has been undertaken. Here five simulations of different case study approaches to availability recovery of the Typhoon have been established to provide an understanding of the relative differences in the speed and cost of each approach. The simulations that are typical of the recovery approaches being undertaken at the time of the case study highlight the cost of the flow and illustrate how different outcome costs can occur. The simulation represents the correction (replacement or repair) of a failed Line Replacement Unit where the aircraft has returned from flight operations for front line service. The aircraft is attended by front line service teams comprising of Customer (RAF), and Provider (BAE Systems) who work on the aircraft to provide 100% availability of the asset. Supplier teams may also take part in this activity if their equipment has been selected for on aircraft repair.

Approach 1 models the past traditional approach using spares only. Approach 2 models a replacement and repair approach. Approach 2a establishes the impact of poor performance on approach 2. Approach 2b reflects the impact of poor performance and unscheduled customer damage on approach 2. Approach 3 models a fix on aircraft approach.

All recovery cost quantifications commence with one spare line replacement unit in stock and ends with one line replacement unit in stock. This reflects a normal situation where stock is held to establish recovery without having to depend on an aircraft on ground (AOG), or interrupted operational routine (IOR) service. Approach 3 however reflects an advanced state of recovery on aircraft where stock is not held locally. Here if the local recovery is not possible the AOG service (24 hour response) or IOR service (48 hour response) is enacted. Each simulation reflects 2 cycles of expected fault arisings except for simulation 2a that includes a repair cycle and an unscheduled customer damaged line replacement unit:

- one day of effort = a
- repair parts y are the parts required for achieving the repair on the aircraft or achieving the repair in the supplier repair shop. These parts are less in quantity than the total number of parts included in the spare unit
- the balance of parts in a spare unit is represented by z (z costs represent the bulk of parts and are much greater than y)

- extra parts only required to correct customer damage are shown as m .

The simulations of the case study qualitative research findings is achieved by using actual turnaround and lead-time information collected during case study interviews. The interviewees highlighted two principle turnaround times. A 5-day turnaround is used for an on aircraft or on base fix and a 28-day turnaround is used for a repair at the supplier. To complete the simulation a consistent period of 5 days is used to ship parts from the base to the supplier providing both are in the UK. Similarly a period of 5 days is used for a return ship. A 180-day average lead-time (6 months) is used for an equipment sub assembly and assembly (time quoted by GE Aviation).

Approach 1, fit spares only. Post flight operations the aircraft is in the hangar being worked on by the front line service teams. Spare equipments are used to replace each and every equipment failure identified. The customer took this approach in the past as it was considered the most expedient. It is now considered an expensive approach as it generates too high a consumption of spares and thus is only used in emergencies.

Initial provisioning spare * 1, cost 180 days assembly + repair parts +
balance parts = $180a + y + z$

- 1st failure

Take off and fit spare ex stock 5 days = $5a$

Purchase replacement spare = $180a + y + z$

Receive and place in stock 5 days = $5a$

- 2nd failure

Take off and fit spare ex stock 5 days = $5a$

Purchase replacement spare = $180a + y + z$

Receive and place in stock 5 days = $5a$

Total cost of approach 1 = $180a + y + z, + 5a + 180a + y + z, + 5a,$
 $+ 5a, + 180a + y + z, + 5a = 560a + 3y + 3z$

Approach 2, replace and repair. Post flight operations the aircraft is in the hangar being worked on by the front line service teams. This approach involves using a spare to recover the initial equipment failure. Thereafter the failed unit is returned to the supplier for repair. The repaired unit is returned and subsequently placed in stock until it is used to replace the second failed unit. This involves the full supply chain in the repair of the failed equipment.

Initial provisioning spare * 1, cost 180 days assembly + repair parts +
balance parts = $180a + y + z$

- 1st failure

Take off and fit spare ex stock 5days = $5a$

Ship 1st faulty LRU to supplier 5days = $5a$

Repair faulty LRU at supplier 28 days plus repair parts = $28a + y$

Ship repaired LRU to aircraft base 5 days = $5a$

Receive repair and place in stock 5 days = $5a$

- 2nd failure

Take off and fit repaired unit 5days = $5a$

Ship 2nd faulty LRU to supplier 5days = $5a$

Repair faulty LRU at supplier 28 days plus repair parts = $28a + y$

Ship repaired LRU to aircraft base 5 days = $5a$

Receive repair and place in stock 5 days = $5a$

Total cost of approach 2 = $180 + y + z, + 5a + 5a + 28a + y + 5a + 5a + 5a + 5a + 28a + y + 5a + 5a = 276a + 3y + z$

Approach 2a, replace and repair and poor performance. Post flight operations the aircraft is in the hangar being worked on by the front line service teams. This availability recovery approach is the same as the 2nd approach however it includes poor supply chain performance. This involves the full supply chain with repairs taking place at the

supplier. The poor performance includes time lost in moving equipment up and down the supply chain and extra cost incurred to manage the impact of batching (as explained by BAE Systems and GE Aviation interviewees).

Initial provisioning spare *1 Cost 180 days assembly + repair parts + balance parts = $180a + y + z$

- 1st failure

Take off and fit spare ex stock 5days = $5a$

Ship 1st faulty LRU to supplier 10days, (base $5a$ * factor 2) = $10a$

Repair faulty LRU at supplier 28 days plus repair parts = $28a + y$

Ship repaired LRU to aircraft base 10 days, (base $5a$ * factor 2) = $10a$

Receive repair and place in stock 10 days, (base $5a$ * factor 2) = $10a$

- 2nd failure

Take off and fit repaired unit 5days = $5a$

Ship 2nd faulty LRU to supplier, held by batching 60days, (base $5a$ * factor 12) = $60a$

Repair faulty LRU at supplier 30 days on shift at time and half, (base $28a$ * factor 1.5) plus repair parts = $42a + y$

Ship repaired LRU to aircraft base 5 days = $5a$

Receive repair and place in stock 5 days = $5a$

Total cost of approach 2a = $180 + y + z, + 5a + 10a + 28a + y, + 10a + 10a + 5a + 60a + 42a + y, + 5a + 5a = 360a + 3y + z$

Approach 2b replace and repair, poor performance and customer damage. Post flight operations the aircraft is in the hangar being worked on by the front line service teams. This availability recovery approach is the same as the 2nd approach however it

SERVITIZATION ISSUE 1 24.12.2013

includes poor supply chain performance and unscheduled customer damage as described during the case study findings by the BAE Systems and GE Aviation interviewees. This involves the full supply chain with repairs taking place at the supplier.

Initial provisioning spare x 1 Cost 180 days assembly + repair parts + balance parts = $180a + y + z$

- 1st failure

Take off and fit spare ex stock 5days = $5a$

Ship 1st faulty LRU to supplier 10days, (base $5a$ * factor 2) = $10a$

Repair faulty LRU at supplier 28 days plus parts = $28a + y$

Ship repaired LRU to aircraft base 10 days, (base $5a$ * factor 2 = $10a$

Receive repair and place in stock 10 days, (base $5a$ * factor 2) = $10a$

Customer damaged unit

Take off and fit repaired unit 5 days = $5a$

Ship customer damage to supplier 5 days = $5a$

Discuss customer damage, agree 10 days = $10a$

Repair at supplier best endeavours 80 days (base $28a$ * factor 2.86) plus repair parts and replace damaged parts = $80a + y + m$ (damaged parts)

Ship repaired LRU to aircraft base 5 days = $5a$

Receive repair and place in stock 5 days = $5a$

- 2nd failure

Take off and fit repaired unit 5days = $5a$

Ship 2nd faulty LRU to supplier, held by batching 60days, base $5a$
 * factor 12 = $60a$

Repair faulty LRU at supplier 30 days on shift at time and half,
 base $28a$ * factor 1.5, plus parts = $42a + y$

Ship repaired LRU to aircraft base 5 days = $5a$

Receive repair and place in stock 5 days = $5a$

Total cost of approach 2b = $180a + y + z, + 5a + 10a + 28a + y,$
 $+ 10a + 10a + 5a + 5a + 10a + 80a + y + m + 5a + 5a + 5a + 60a +$
 $42a + y, + 5a + 5a + = 470a + 4y + z + m$

Approach 3, diagnose fault and fix on aircraft or base. Post flight operations the aircraft is in the hangar being worked on by the front line service teams. The co-located team comprising of the customer, provider and the supplier of the failed equipment, creates this 3rd approach. The team located next to the aircraft work together in an interdependent manner to diagnose and fix the failure on the aircraft or in the base workshop as described by the UK Ministry of Defence and BAE Systems interviewees.

- 1st failure

Fix on aircraft or in base workshop

5 days plus repair parts = $5a + y$

- 2nd failure

Fix on aircraft or in base workshop 5 days plus repair parts = $5a + y$

Total cost of approach 3 = $5a + y + 5a + y = 10a + 2y$

The above comparisons of the case study approaches to availability recovery emphasise the difference in speed and cost of each. Approach 1 represents cost only, whilst approaches 2, 2a, 2b and 3 results are representative of speed and cost. It is not the exact cost that is important but the demonstration of the relative difference between each approach. The actions taken and results of the simulations are consistent with the literature (Ng et al., 2008; Etgar 2006) where the level of provider firm network and

customer performance and selection of resources used increase or decrease the costs incurred and benefits achieved. For example, increased levels of supplier involvement on base (at marginal cost increase) results in much-improved benefits through lower overall cost. Like-wise poor performance of the customer through customer damage results in higher costs and lower levels of benefit.

The comparisons also confirm the case study approach to progressively increase on aircraft or on base repair in order to reduce cost. The results also highlight the importance of capturing the cost of every activity. This should include the hardware costs, all operational activity costs and costs related to the performance of each activity. This is important as performance related costs could create a significant cost delta when multiple recoveries are undertaken.

The results highlight a significant difference in the cost of adopting a supply chain approach full of dependent sequential activities (2) compared to a co-located, co-production, interdependent approach (3). The co-located, co-production, interdependent approach reduces the need for certain activities and reduces the amount of dependent activities that can attract poor performance. In turn this reduces cost.

Co-location and co-creation (including co-production) can be beneficial where a complex service is provided (Ng, et al., 2011). The case study, where speed of recovery is key to delivering availability and keeping all costs to a minimum reflects this understanding.

The case study findings reported in the above section are discussed and contribute to the development of research findings 2 and 6 in the next chapter.

4.3 Summary of case study findings

The case study research consisting of multiple semi-structured interviews with senior managers from the UK Ministry of Defence, BAE Systems and GE Aviation proved to be very informative yielding a great amount of interesting data (80,000 plus words). This data collected across the areas of servitization, competence, value, enterprise, performance and cost provide an excellent understanding of the challenges of the UK Ministry of Defences in establishing availability contracting. Analysis of this data highlighted a number of significant challenges including the design and equipment arisings, culture and organisation and performance. The need to reduce cost was

proposed by all interviewees with the need to control the cost of No Fault Found equipment returns highlighted repeatedly. These findings are compared to the literature review findings on the same features in the following chapter.

5. DISCUSSION

5.1 Introduction

This chapter comprises an introduction, five sections devoted to the discussion of the research findings and a summary. Sections two, three, four and six develop a research proposal each whilst section five develops two research proposals. The chapter reviews and discusses the theoretical and case study findings from the multiple theoretical themes of the research framework. Figure 15 illustrates the interaction between the research framework themes and research proposals.

Research framework features and research proposals interaction

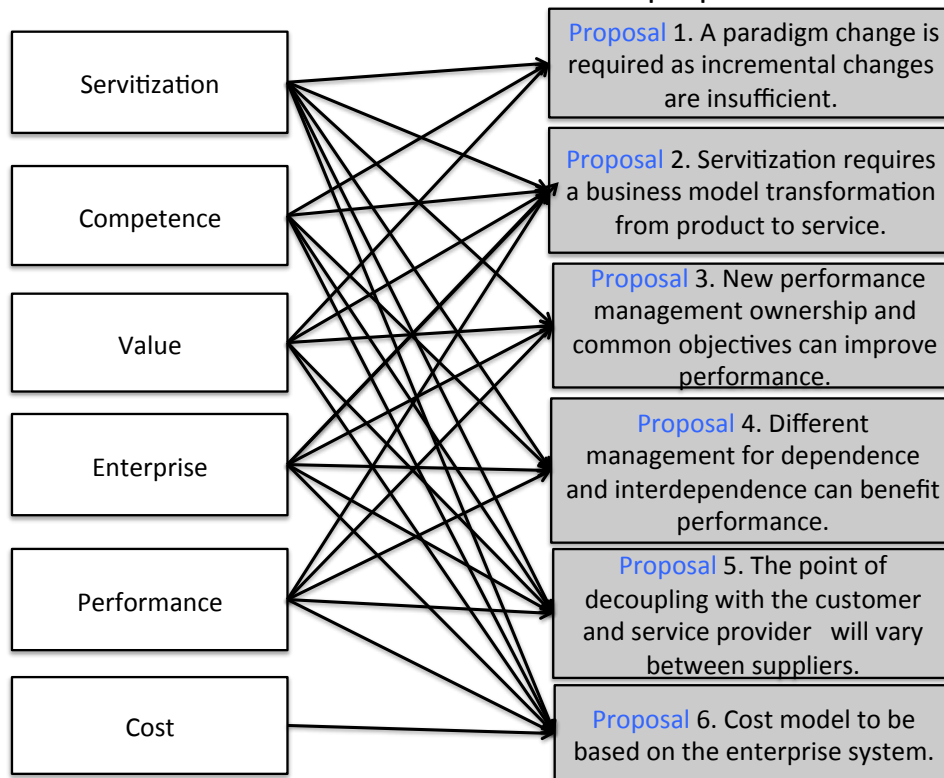


Figure 15. Research framework themes and research proposals interaction (Source author)

Section two links the servitization literature and case study findings to arrive at the first research proposal (Proposal 1). Here it is highlighted that incremental changes to management and operations are insufficient when moving from providing a product to

providing a complex engineering service and that a paradigm change in mind-set and organisation is required. The third section continues the theme of change by comparing the business model literature and research findings from the servitization, value and enterprise features. Here it is established that servitization in the context of complex engineering service can be viewed as the transformation from a manufacturing based business model to a service based business model. This establishes the second proposal. The fourth section of the chapter discusses performance management for service including common enterprise objectives and output performance measurement and the fifth section considers the differences between dependence and interdependence and the repositioning of the enterprise supplier decoupling point for service. Proposals are established in each case and a definition for dependence is also proposed. The sixth and final section on research findings complete the discussion on servitization with an analysis of the costs highlighted during the case study interviews. A final proposal on cost is identified here. A short summary concludes the chapter.

5.2 Challenges of servitization

This section focuses on the challenges of servitization and considers the literature and case study findings on the research framework themes of servitization, competence, value, and enterprise. The need to consider inputs from four of the themes to arrive at a singular research proposal underlines the level of complexity and interaction that exists between the servitization features in the provision of a complex service. Figure 9g illustrates this interaction.

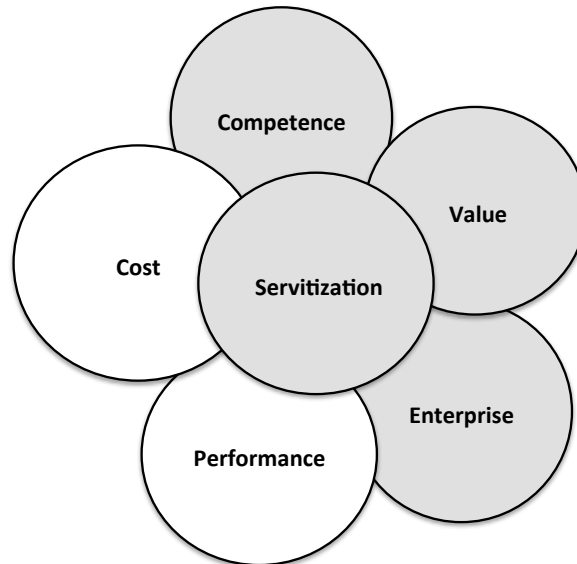


Figure 9g. Research framework, servitization, competence, value and enterprise (Source author)

At the time of writing the literature on servitization is relatively new and the understanding of the phenomenon is developing quickly. Early literature introduces servitization as a value added activity where services are added to supplement product already supplied (Vandermerwe and Rada, 1988). In support the literature proposes that incremental changes are introduced to culture and operations to ensure servitization (Oliva and Kallenberg, 2003). More recent literature on servitization however (Ng, et al., 2011; Baines and Lightfoot, 2012; Barnett, et al., 2013) focuses on service rather than product and services describing it as a dynamic activity where value emerges as a result of co-creation between customer, provider and suppliers (Ng, et al., 2011).

The literature suggests that customers are increasingly purchasing a service rather than a product (Neely, 2008; Ng, et al., 2011). Providers are also offering new value propositions and transforming from offering products alone to offering a service (Baines, 2009; Wilkinson, et al., 2010; Ng, et al., 2011). The research case study reflects this situation. Here the customer, the UK Ministry of Defence, are moving from

purchasing individual aircraft products and services (spares and repairs and support activities) to purchasing availability of aircraft at lower cost per flying hour (UK Ministry of Defence, Case study findings, 4.2.1.1, Typhoon support – the need for change). The provider BAE Systems has accepted the challenge of providing aircraft availability and is working with the customer to provide the support service at lower cost. This new value proposition for support not only involves transformation to the servitised state for the related activities but also involves reducing the amount of equipment failure arisings and improving the recovery activity efficiency where equipment arisings continue to occur.

However the case study organisations of the UK Ministry of Defence and BAE Systems do not appear to have adopted a strategic approach to service implementation as proposed in literature. They have neither chosen a progressive step-by-step development (Oliva and Kallenberg, 2003) or an adaptive approach (Martinez, et al., 2010) towards servitization. It would appear that BAE Systems has responded to the customers' business challenge and directly moved to providing availability contracting by adapting their existing organisation (BAE Systems, Case study findings, 4.2.1.2, Transformation). Furthermore whilst significant progress and learning has been achieved BAE System's whole organisation has yet to fully adopt a more responsive way of working (Ng, et al., 2011). This is making the transformation to service difficult and not as fast as the customer would like as they are trying to force the pace of change by proposing stretched short term cost reduction targets (UK Ministry of Defence, Case study findings, 4.2.1.1, Typhoon support – the need for change). The UK Ministry of Defence and BAE Systems interviewees reported that this is partly due to the existing risk averse contracting, partly due to a lack of customer focus and partly due to the existence of a product culture that remains strong, slowing a change in responsiveness to customer needs. It also reflects that BAE Systems continue to develop and manufacture aircraft whilst offering the new type of support. This situation is consistent with the literature findings that highlight similar problems of poor responsiveness as a result of long-term, rigid, risk averse contracts and strong product organisation cultures (Baines, et al., 2009, Ng, et al., 2011). Here it was proposed by the BAE Systems interviewees that the contracting for support needs to be updated to better reflect the new arrangements where the provider is now taking more risk. Notwithstanding the above BAE Systems are acting in a consistent manner with literature, recognising the

need to change culture and become more customer focused (Bowen and Ford, 2002; Neely, 2008).

The case study findings highlighted that the customer, provider and supplier interviewees all considered design of equipment as sub-optimal for availability contracting with mean time between failures too short (BAE Systems, GE Aviation, UK Ministry of Defence, Case study findings 4.2.1.3, Equipment design and arisings). Furthermore the BAE Systems and GE Aviation interviewees advised that design change is difficult to implement due to short-term contracts, high cost and an organisational culture that resists change. These equipment design issues are not unusual and are consistent with problems found in extant literature (Sasser, et al., 1978; Zeithaml, et al., 1985; Kerr, et al., 2008). Here the literature stresses the need for improved design where service is delivered. BAE Systems interviewees believed that too many equipment failures continue to occur, with many failures created in the past by the end customer, the Royal Airforce, whose dynamic management tendencies often result in the removal of the wrong equipment creating additional unnecessary work. BAE Systems, the provider, with increased management decision taking authority for diagnosis and management of failed equipment, are now trying to improve this situation.

The UK Ministry of Defence and BAE Systems interviewees advised that equipment failures are a major cost driver, are too numerous and take too long to fix (BAE Systems, UK Ministry of Defence, Case study findings 4.2.1.3, Equipment design and arising's). The long repair cycle time was reported as a result of the existing product focused culture, the existence of multiple objectives throughout the enterprise leading to poor enterprise management and the silo nature of the firms and their functions through the supply chain. The multiple levels and international nature of the supply chain exacerbate these problems. In response to this situation a service project group with dual leadership has been established between the provider and the customer to improve the management of the availability of the fast jets and the management of equipment failures through the supply chain for repair. A joint customer provider operational team based next to the aircraft with a brief to help reduce failure arisings and speed return operations supports the project management team. Training of the joint team and the enterprise supply chain and operational teams has been launched in support. This includes increasing diagnostic and decision making skills, improving supplier management and supply chain management skills and increasing customer awareness.

An increase in communication has also been established. All are targeted at improving supply chain responsiveness and speed of recovery of equipment and availability of aircraft. Whilst extant literature highlights problems and proposes solutions for all of the above on an individual basis including customer management, training for new skills, improved communication and breaking down barriers (Duffy and Fearne, 2004; Wilkinson, et al., 2010; Levitt, 1972, 1976; Vargo and Morgan, 2005; Ulaga, 2001; Prahalad and Ramasway, 2003; Oliva and Kallenberg, 2003; Poirier, 2004; Edvardson, et al., 2005; Spring and Araujo, 2009; Mills, et al., 2009; Ng, et al., 2009; Butterfield, et al., 2009; Ng, et al., 2011; and Purchase, et al., 2011) only a few discuss the establishment, management and responsibilities of new service enterprise teams (Ng, et al., 2011; Baines and Lightfoot, 2012).

However the case study project management and performance measurement currently in-place do not appear sufficient to overcome the cultural and organisational barriers. Even though improvement initiatives have been launched functional and firm silos still exist through the supply chain impacting flexibility and speed of response (BAE Systems, GE Aviation, UK Ministry of Defence, Case study findings 4.2.1.3, Equipment design and arisings). Furthermore whilst the project team may be positive for management of the immediate interface and tangible to the front office where the teams work on the aircraft it appears less tangible and physically remote to the back office or greater organisation also engaged in supporting the service activities. In addition it was recognised by all of the BAE Systems interviewees that interdependence between stakeholders required to deliver the service is creating a real need to work and function as one enterprise. This is also consistent with the literature that states that where interdependence exists teams perform best with high levels of coherence and communication (Barrick, et al., 2007). It is the ability to co-ordinate resources from multiple sources effectively which creates value propositions that directly create advantage in the market (Parry, et al., 2012). This suggests a real need to recognise the interdependence of stakeholders and to move away from vertical supply chains. This is consistent with the literature reviewed (Baines and Lightfoot, 2012). Traditional value chains with handover points as promoted by Porter (1985) may suit product exchange but complex service needs to be delivered by organisations simultaneously working together and creating value (Vargo and Lusch, 2007; Baines, et al., 2009; Meier, et al., 2010; Macintyre, et al., 2011; Ng, et al., 2011).

As the required case study service including the improvement targeted has still to be achieved more radical changes have been established. First the performance management role of the customer has been given to the provider BAE Systems who are now focused on the service output. This has changed the mind-set of the provider and is considered as a significant step forward (BAE Systems, Case study finding 4.2.5, Performance). Second a pilot study has been launched introducing the co-location of Selex as a key supplier of expensive equipment on base. This provides for immediate diagnosis and repair of their equipment reducing the number of repairs in the system and improving customer satisfaction (BAE Systems, Case study findings 4.2.1.3, Equipment design and arisings). Both of these initiatives are significant and covered in more detail later in the chapter.

Both the literature review (Baines, et al., 2009; Ng, et al., 2011; Purchase, et al., 2011; Baines and Lightfoot, 2012) and the case study analysis and findings (UK Ministry of Defence; BAE Systems; GE Aviation 4.2.1, Servitization) have highlighted that providing a service is considerably different to providing a product. Although BAE Systems has launched multiple service improvement initiatives that are consistent with literature findings both the UK Ministry of Defence and BAE Systems seek further improvement. An important body of the literature also suggests that when the customer requirement and provider value proposition change drastically all elements of the business model change (Teece, 2010; Zott and Amit, 2010). Furthermore managing two business models in parallel is very difficult where the former manufacturing based model supports the new service based model to serve the same client (Velu and Stiles, 2013).

Reviewing the literature and the case study research findings collectively, and building on and supporting extant literature (Ng, et al., 2011; Meier, et al., 2011) this research proposes that incremental changes in management and operations need to be replaced by a paradigm shift in mind-set and ways of working to successfully servitize (Barnett, et al., 2013). This proposal highlights that any future arrangement should consider establishing a single dynamic enterprise that has the prime shared objective of providing the required service. The enterprise should be as autonomous as possible and organised for efficiency with a strong outcome focused culture (Baines, et al., 2009). Proposal 1 is therefore detailed below.

Proposal 1. Based on the research findings and where availability of a complex engineering service is required incremental changes to the existing way of working and existing business model do not appear sufficient. It is therefore proposed that paradigm change in organisation, mind-set and ways of working is considered supported by the introduction of a new service business model.

Proposal 1 contributes to the body of literature on servitization. The finding is supported by empirical evidence and highlights that incremental changes are insufficient when transforming from a manufacturing organisation selling a product to one providing a complex engineering service. Furthermore from a practical perspective it highlights that managers need to adopt a radical approach when seeking to capture value from service provision.

Table 14 below provides a summary of the literature and case study findings that have been considered when formulating Proposal1.

Proposal 1

Based on the research findings and where availability of a complex engineering service is required incremental changes to the existing way of working and existing business model do not appear sufficient. It is therefore proposed that a paradigm change in organisation, mind-set and ways of working is considered supported by the introduction of a new service business model.

Supporting literature

Product culture (Levitt, 1976); Extended product value chain (Porter, 1985); Value add (Vandermerwe and Rada, 1988); Transformation challenges (Oliva and Kallenberg, 2003); Supply networks (Poirier, 2004); Service based culture (Duffy and Fearn, 2004); Service dominant logic (Vargo and Lusch, 2007); Service paradox (Neely, 2008); Partnerships and common objectives (Pay and Collins Bent, 2008); Enterprise mapping (Mills, et al., 2009); Service organisation (Baines, et al., 2009); Transformation to service (Martinez, et al., 2010); Enterprise objectives (Purchase, et al., 2011); Vertical integration (Baines and Lightfoot, 2012); Value Co-creation (Ng, et al., 2011); Servitization (Meier, et al., 2011); Management of two business models (Velu and Stiles, 2013).

Supporting primary data from case study

- The main driver for the MOD is found to be reducing cost.
- The customer interviewees reported poor service performance including extended repair and recovery lead times.
- The MOD and BAE Systems do not appear to have adopted a strategic approach to service implementation as proposed in the literature review.
- The transformation to service is difficult and not as fast as the customer would like.
- The BAE Systems interviewees reported that transformation is slow due to the existing risk averse contracting, partly due to a lack of customer focus and partly due to the existence of a product culture that remains strong, slowing a change in responsiveness to customer needs.
- The need to change culture and become more customer focused was reported by all the BAE Systems interviewees.
- The equipment failures are too numerous, form a major cost driver, and are too long to fix. Design change is difficult to implement due to short-term contracts, the high cost likely to be incurred and the perception of interviewees that there is organisational culture that resists change.
- The long repair cycle time was reported as a result of the existing product focused culture, the existence of multiple objectives throughout the enterprise leading to poor enterprise management and the silo nature of the firms and their functions through the supply chain. The multiple levels and international nature of the supply chain exacerbate these problems.
- The Interdependence between stakeholders required to deliver the service is creating a real need to work and function as one enterprise.
- The Customer (MOD) and provider (BAE Systems) co-location and co-creation are considered positive.
- The positioning of a key supplier next to the asset has been successful.
- The establishment of a project group with dual leadership has been established between the provider (BAE Systems) and the customer (MOD) to improve the management of the availability.
- The customer and provider have established a joint operational team next to the aircraft with a brief to help reduce failure arisings and speed return operations.

- The project management and performance measurement currently in-place does not appear sufficient to overcome the cultural and organisational barriers.

Table 14. Literature and case study findings that support research Proposal 1 (Source author)

Research Proposal 1 can be considered as the prime finding within this research which leads to analysis of literature findings and case study findings on business models, performance management for service, dependence, supplier decoupling points and cost of service. This leads to a further five proposals which are detailed in the next four sections. The proposals cover business model change (2), mind-set change (3), organisational change (4 and 5) and a cost proposal (6) that confirms and supports proposals one to five. Figure 16 illustrates the links between findings.

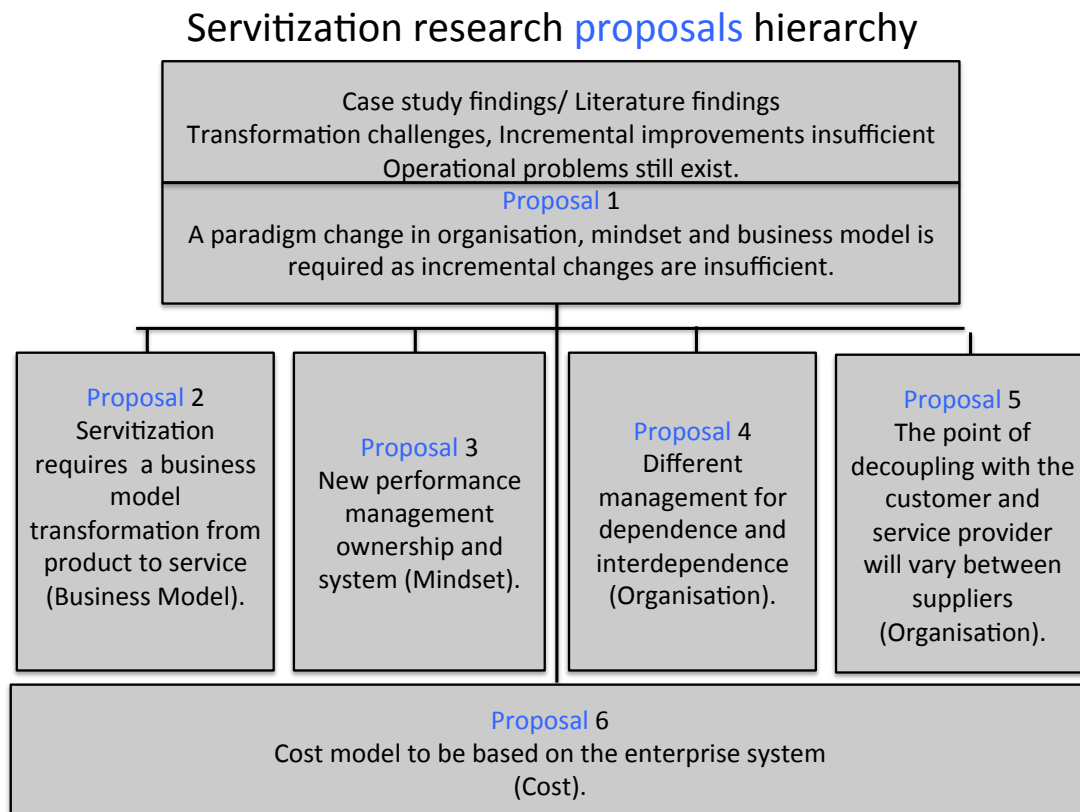


Figure 16. Servitization research proposals hierarchy (Source author)

5.3 A business model for service

This section considers the literature and case study findings from all of the research framework themes and develops the idea of change by developing a new business model for service (Figure 9h refers).

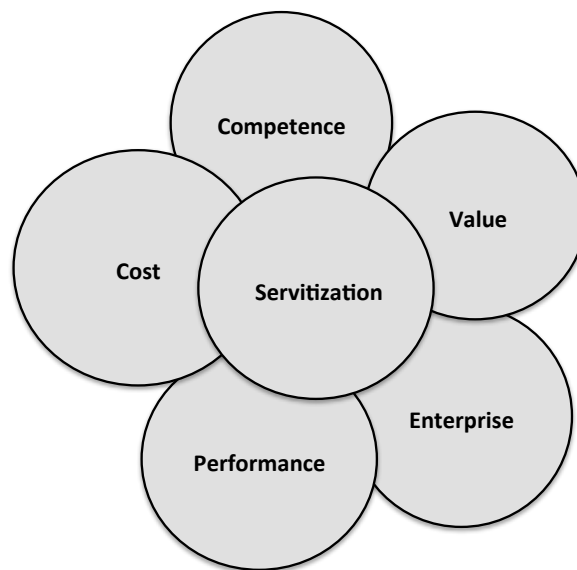


Figure 9h. Research framework, servitization, competence, value, enterprise, performance, and cost (Source author)

Extant literature on business models highlight that whenever a business enterprise is established, it either explicitly or implicitly employs a particular business model that describes the design or architecture of the value creation, delivery, or capture mechanisms it employs (Teece, 2010). The business model comprises a set of generic level descriptors that captures how a firm is organised to create and distribute value (Fuller and Morgan, 2010). This includes considering the logic of the firm, the way it operates and how it creates value for its stakeholder (Zott and Amit, 2010). The business model can be considered as a system of interdependent activities that not only applies to the focal firm but can also apply to the customer, supplier and third parties involved in the delivery of the service (Zott and Amit, 2010). Therefore it is necessary

for a servitizing firm to consider if a new business model is required (Velu and Stiles, 2013).

Whilst the literature findings highlight that a new business enterprise requires a new business model there was no evidence of this happening within the case study enterprise established to support the Typhoon. Furthermore rather than establishing a new business model for the enterprise to support the new value proposition and new service arrangements the provider firm BAE Systems appear to have commenced the service activity by incrementally adapting their existing organisation and way of working (BAE Systems, case study findings, 4.2.1.2, Transformation).

In the context of this research and considering the above findings servitization can be described as the transition from the business model and business model features of a manufacturer to the business model and business model features of a complex engineering service provider. Table 15 below uses the features proposed by Osterwalder and Pigneur (2010) to detail how the business model features of a typical manufacturer change to those of a potential complex engineering service provider. The following quote from a BAE Systems project interface validates the table.

“As a generic model, which proposes a business strategy and approach to equipment design in an Availability Contracting environment compared to a traditional Design Make and Sell scenario, we would agree it looks fine. Your model implies that we need to think about the support concept, and design an appropriate product around that concept”. Provider/BAE Systems.

The new model should reflect the way that value is now proposed and delivered and be able to meet the pressure to fulfil contractual obligations to the customer (avoiding penalties) and the internal pressure to deliver these as economically as possible (Baines and Lightfoot, 2012).

Servitization, the transition from a manufacturing business model to a service business model

Business model features (Osterwalder and Pigneur, 2010).	A. Manufacturer	B. Complex engineering service provider
Customer segmentation.	Multiple customers.	Focused on single customer.
Value proposition.	Products for sale.	Availability of asset.
Channels.	Delivers products or services direct or via distribution channels.	Delivers service at customer facilities via co-creation.
Customer relationships.	Traditional arms length contracting.	Partnership, co-creation.
Revenue streams.	Sale of products, payment on delivery (exchange).	Fixed fee for provision of asset and through life support/availability.
Key resources.	Value chain and capital equipment capacity.	Dynamic interaction of people and assets across the service enterprise.
Key activities.	Design and produce products and spares.	Provision of through life support including the scheduling and management of all enterprise activities.
Key partnerships.	Internal but can include collaborative partners.	Customer, collaborative partners, suppliers, 3rd parties.
Cost structure.	Based on product costs.	Based on system costs.

Table 15. Servitization, the transition from manufacturing business model features to service business model features (Source author)

Findings from the research literature review and the research case study can be used to illustrate the type of business model and individual business model features that a new complex engineering service enterprise may require. The research case study is particularly appropriate as the Typhoon service success is built on the transformation of a customer, provider and key supplier all with individual business models to a service enterprise where one business model serves the full enterprise. Here the new business model must be capable of matching a new meta organisation and be able to address complexity. Whilst the business model features of value proposition, key activities, key partnerships, and cost structure particularly connect to this research all of the business model features developed by Osterwalder and Pigneur (2010) are relevant and reviewed individually below.

5.3.1 Customer Segmentation

This sub section focuses on the changes to the business model feature of customer segmentation under servitization. When moving from supplying products and services to supplying a complex service the customer segment transitions from a feature considering multiple customers to one which focuses on a single customer.

The majority of the marketing literature (Kotler, 1991; Walsh, 1993; Gillespie, et al., 2007) covers market and customer segmentation for manufacturers. Here when considering the supply of multiple products and services the literature informs us that market segmentation is the process of dividing a market into discrete groups of customers (segments) who may require separate product offerings or marketing mixes (Kotler, 1991). A market segment can be more fully defined as a group of customers or potential customers who are different to the rest of the market (in characteristics) but are relatively homogeneous within the group. An ideal segment can be described as identifiable, accessible and measurable, shows a need that the supplier can provide, and is responsive (Walsh, 1993; Gillespie, et al., 2007).

A lesser body of literature exists on servitization and segmentation. Where a complex engineering service is provided this literature claims that the service enterprise focuses on one customer rather than multiple customers as they are now providing a distinct offer to one customer (Ng, et al., 2011; Osterwalder and Pigneur, 2010). Our case study reflects this latter understanding as the case study provider firm is now providing an availability service to one customer rather than producing and selling multiple products

across the market (BAE Systems, UK Ministry of Defence, case study findings, 4.2.1.1, Typhoon support, the need for change). Segmentation activity within the case study firm is therefore replaced by 100% focus on providing through life availability to one customer.

5.3.2 Value proposition

This sub section focuses on the business model feature of value proposition and how it changes with servitization. When moving from supplying products and services to supplying a complex service the value proposition transitions from a feature considering products for sale to one providing a service. This is reflected by the research case study where the provider firm has moved from manufacturing and selling aircraft products and services to providing asset availability.

Business model literature defines the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit (Teece, 2010). Where an engineering service is offered the value proposition describes the way value is created for a specific customer (Osterwalder and Pigneur, 2010). The engineering service provider must organise the service enterprise to create the value accordingly. The case study enterprise has changed in this way. Although the case study service enterprise has not explicitly considered a new business model the provider firm interviewees are consistent with the literature as they acknowledge that the objectives and value proposition of their business have changed (BAE Systems, case study findings, 4.2.1.2, Transformation). The case study business objective is now to deliver asset availability for a fixed customer fee and at lowest enterprise cost. The case study provider has taken over the customers role through forward integration consistent with new thinking from Baines and Lightfoot (2012) providing through life support for a fixed fee and has thus moved from securing as many spares and repair sales as possible to reducing them to the minimum possible. This is a fundamental change to their value proposition. The customer has also positioned the provider to manage the third parties who had previously reported to the customer including the reduction of alleviations previously given to the provider to cover late deliveries as a result of poor third party performance. These changes further change the provider's value proposition and greatly increase the risk on the provider.

5.3.3 Channels

This sub section provides an understanding of the business model feature of distribution channels and how they change as a result of servitization. The case study findings highlight that when moving from supplying products and services to supplying a complex service the distribution channels between the provider and the customer change radically. Here they transition from products either delivered directly or through channels to a service co-created at the customer facilities. This is reflected by the research case study where the provider firm has co-located at the customer facilities. It could be further argued that the need for a channel disappears.

As highlighted by the literature review, channels are the links between producers and final customers (sets of independent organisations called intermediaries). Producers can deliver directly or indirectly using intermediaries, merchants, warehouses, retail organisations, franchises or the internet (Hollensen, 2012). The fundamental aim of channel management is to supply the product to the end customer at the right time and in the manner most profitable to the manufacturer. Channel middlemen can assemble, break bulk, adapt goods to market, physically distribute, sell, promote and advertise, seek buyers and sell, and provide credit (Walsh, 1993).

The supplier communicates with and reaches the customer through channels. The supplier can also deliver its value proposition through channels (Osterwalder and Pigneur, 2010). Where complex engineering service is provided the customer, provider and supplier all become a single service enterprise (Ng, et al., 2011). The service enterprise stakeholders collocated at the customer facilities acts as one team. Communication is direct and immediate between all stakeholders and value emerges in the act of value co- creation delivering the availability. Distribution channels are not required in this situation. Our case study reflects this understanding as the customer; provider and a key supplier are all working in one co-located team at the customer facilities where the value proposition is co-created (BAE Systems, Case study findings, 4.2.1.2, Transformation).

5.3.4 Customer relationship

This sub section provides an understanding of changes to the business model feature of customer relationship under servitization. When moving from supplying products and

services to supplying a complex service the relationship between the provider and the customer transitions from one of traditional arms length contracting to one of partnership and value co-creation.

Literature informs us that the business model identifies the type of customer relationship required (Teece, 2010). When servitizing the manufacturing firm needs to move from the traditional arms length adversarial contractual relationship they have with their customer to one where the customer is the centre of their attention (Duffy and Fearne, 2004; Ng, 2011). Furthermore recent literature highlights that where complex engineering service is concerned the provider firm can take over the customer role thinking and acting on his behalf (Baines and Lightfoot, 2012). The case study findings are consistent with the literature findings. The case study customer the UK Ministry of Defence has encouraged the provider firm BAE Systems to take over many of the customer responsibilities including the customers' performance management activity (BAE Systems, Case study finding 4.2.5, Performance). Furthermore the relationship between the UK Ministry of Defence and BAE Systems has changed from one of customer and supplier to co-creating partners.

5.3.5 Revenue streams

This sub section provides an understanding of the business model feature of revenue streams and how they change under servitization. When moving from supplying products and services to supplying a complex service the revenue stream of the provider firm transitions from one arising from the sale of products with payment on delivery (exchange) to one of a fixed fee for provision of asset and through life support.

The business enterprise stakeholders will benefit from establishing a full understanding of the customer requirement and what value the customer is willing to pay for and thus what the new revenue streams are (Osterwalder and Pigneur, 2010). The enterprise can then offer a new value proposition and servitize to deliver (Teece, 2010). The case study provider firm now gets paid a fixed fee for providing availability of asset through life. The provider firm is acting consistent with literature by changing their emphasis (in line with the customer request) from maximising production to reducing activity and cost whilst maintaining the availability (UK Ministry of Defence, BAE Systems, case study findings, 4.2.1 Servitization).

5.3.6 Key resources

This sub section focuses on the business model feature of key resources providing an understanding of how they change with servitization. When moving from supplying products and services to supplying a complex service the key resources of the provider firm transitions from capital equipment and value chain capabilities to dynamic responsive staff with customer and problem solving skills (Neely, 2008).

The research literature review highlighted that every business has key resources (Penrose, 1959). The resource-based view of a firm considers resources as assets that enable firms to achieve competitive advantage through carrying out transformation (Barney, 1991; Penrose, 1959). They can be physical, human, technological or organisational (Ng, et al., 2011). These are the resources that allow an enterprise to shape and offer the value proposition (Penrose, 1959). Furthermore the literature review highlighted the differences between the resources of a manufacturer and those of a service provider. A manufacturer would normally consider his production capital-intensive equipment (to provide capacity), together with production skills and support from the value chain as his key resources. A service provider on the other hand needs to consider people skills including those that provide customer focus, flexibility and problem solving (Neely, 2008). Vargo and Lusch (2007) explain this difference as the difference between operand and operant resources. The manufacturing based operand resources, are tangible, static resources that require some action to make them valuable. These are replaced by service oriented operant resource: these are, intangible, dynamic resources that have agency. The literature review also highlighted that where the provider takes over the customer role (Baines and Lightfoot, 2012) and where co location is required to support co-production and value co-creation the service enterprise may make use of the customers' facilities. In this instance the customer facilities become part of the service enterprises key resources (Baines, et al., 2009; Ng, et al., 2011).

Our case study findings reflect the above literature findings as the new Typhoon support enterprises value proposition has changed the emphasis on the enterprise stakeholder's resources. The main production and assembly and design engineering capabilities at the provider plant are no longer the key resource. They have been replaced by an emphasis on dynamic staff skilled in diagnosis and repair based next to the asset (BAE Systems,

case study findings, 4.2.1.2 Transformation). Although this move in the use of resources is underpinned by management direction and training for problem solving, customer management and new service oriented operational skills it remains a major challenge as the culture of the providers staff is still very product oriented and less responsive than required (BAE Systems, case study findings, 4.2.1.2 Transformation). Furthermore the case study findings identified that the immediate support to the aircraft and management of the recovery activity is now carried out at the customer facility where the resources of the customer, provider and a key supplier are now based. This arrangement required to speed recovery of availability is also consistent with the literature findings on the utilisation of customer's facilities (Baines, 2009; Ng, et al., 2011) BAE Systems, case study findings, 4.2.1.2 Transformation).

5.3.7 Key activities

This sub section focuses on the business model feature of key activities providing an understanding of how they change with servitization. When moving from supplying products and services to supplying a complex service the key activities of the provider firm transitions from undertaking key activities required to design and produce individual product and spares for sale to undertaking key activities required to provide through life support including the management of the service enterprise.

The literature findings show that every business model calls for a number of key activities that are considered as the most important actions a firm must take to operate successfully (Osterwalder and Pigneur, 2010). Key activities are required to create and offer a value proposition, manage the execution across the enterprise and maintain customer relationships (Osterwalder and Pigneur, 2010). Where a complex engineering service is provided literature shows that the servitizing firm shifts from a business model where the key activities are manufacturing and selling products to one where the key activities focus on the efficient management of the service enterprise providing the service and customer satisfaction at the lowest cost (Neely, 2008). The new activities will include the management of and / or taking part in value co-creation where interacting business parties transform people information and materials and equipment simultaneously (Ng, et al., 2011). The value co-creation including the sharing of information and delivering transformation in a consistent, stable manner is a key activity for a complex engineering service provider (Ng, et al., 2011). Furthermore whilst delivering new service activities the servitizing firm will have to rethink how it is

going to continue to be exploitive and continue to make money through producing product (on its original base activity) whilst being exploratory through servitization seeking new ways to secure revenues (Turunen and Neely, 2011).

The case study findings identified that the service provider firm's key activities have changed consistent with the literature findings highlighted above. The service provider firm BAE Systems now recognise their key activity is to manage the delivery of a complex engineering service at lowest cost through the management of the service enterprise. The new key activity replaces their previous key activity of manufacturing products and services for sale including managing a supply chain of independent firms to produce products in support of that sale (BAE Systems, Case study findings, 4.2.1.2 Transformation). The organisations involved, the dynamics and the associated timescales of the activities have all changed and interdependencies between the provider BAE Systems, the customer, the UK Ministry of Defence, and key suppliers, have increased. The changes include the introduction of joint service enterprise project management and operational teams established between the customer and provider to deliver the service at lowest cost (BAE Systems, Case study findings, 4.2.1.2 Transformation). This prioritises co-creation between the customer and provider. As part of the new arrangement BAE Systems has taken over the role of the customer. This is consistent with the literature and can be considered as forward vertical integration (Baines and Lightfoot, 2012). The case study findings also identified that the case study enterprise project team considers that establishing the correct performance management is key to success as speed of recovery is vital to reducing spares consumption and cost. Performance management therefore becomes the key activity. In support and part of taking over the customer role the provider firm has taken over the performance management activity of the customer and is now focused on output. The output focus of the provider is now the availability of the asset. The case study service provider considers their focus on output a significant change as they had previously only focused on their own inputs. In support they have started to review their inputs considering their impact on asset availability rather than achieving contractual requirements alone (BAE Systems, Case study findings, 4.2.1.2, Transformation). Furthermore the avionic supplier also understands the target of asset availability and is committed to supporting it through the availability of their avionic product (GE Aviation, Case study findings, 4.2.1.2 Transformation).

The case study findings also identified that the support to the Typhoon aircraft is complex and comprised multiple support activities required to provide aircraft availability. The UK Ministry of Defence and BAE Systems interviewees all understood that key to achieving availability were the management and repair activity of failed equipments. Here reducing the number of equipment failures and speeding the return of the repair when required was reported as a key activity (BAE Systems, Case study findings, 4.2.1.3, Equipment design and arisings). Objectives to diagnosis and fix equipment problems on or next to the asset have been established and a pilot activity co-locating the supplier of expensive equipments has been launched in support. This further increases co-location, co-production and co-creation (Ng, et al., 2011).

The case study findings on value co-creation are consistent with the literature review findings including those highlighted above. The customer provider joint management team and the customer provider joint operational teams can be considered as a new co-creating activity being established to provide the service efficiently. The service enterprise stakeholders also consider value co-creation a key activity (BAE Systems, UK Ministry of Defence, Case study findings, 4.2.1.2, Transformation).

The literature findings also highlighted that backward vertical integration can also be established by including the key suppliers formally in the enterprise to improve performance and efficiency through adoption of common direction and thus protect against contractual penalties (Baines and Lightfoot, 2012). Here delivery of a complex service is positively impacted by the vertical integration into capabilities for sub-systems design and production, as this ensures speed and effectiveness of response while minimising costs (Baines and Lightfoot, 2012). The case study finding identified the above feature in practice as in addition to the customer and provider working together Selex a key supplier, has also been located next to the aircraft to provide immediate support on his equipment. This is an extension of the value co-creation effort that also reflects a radical change in the activity of the supplier (BAE Systems, UK Ministry of Defence, Case study findings, 4.2.1.3, Equipment design and arisings). Selex has been positioned on the front line both at the base and during active operations. This is an extraordinary step toward industrialists taking over military customer activities. The supplier positioned next to the customer and provider is able to deliver immediate support and problem solving skills reducing the amount of spares and repairs required. Availability and cost targets have been established and were reported as 100%

successful (UK Ministry of Defence 4.2.1.3, Equipment design and arisings). This feature is captured by the following quote from the UK Ministry of Defence.

“We had 100% serviceability on those systems the full time .We did not miss a sortie and that was generally viewed as a result of those engineers being on the base and also having the back office support the call up. They had the support back in Edinburgh, literally looking immediately at a problem in their labs there. Deemed as fantastic, it is debatable whether we would have had the serviceability without it. The new arrangements were considered a huge success from the perspective of availability and cost”. Customer/UK Ministry of Defence (UK Ministry of Defence, 4.2.1.3, Equipment design and arisings).

5.3.8 Key partnerships

This sub section focuses on the business model feature of key partnerships providing an understanding of how they change with servitization. When moving from supplying products and services to supplying a complex service the potential for partnership increases. Whilst manufacturing organisations are normally based on internal effort and can include collaborative partners the service enterprise comprises collaborative partners, suppliers and third parties.

Literature on servitization reports that the service enterprise required to deliver a complex service will benefit from being identified in full (Purchase, et al., 2011) with a nucleus of key stakeholders or partners co-located next to the asset to provide the necessary immediate support. Multiple individual organisations previously supplying individual products and services become a single enterprise comprising key partners who provide a complex service. The appointment of one enterprise leader with a single set of common objectives (Pay and Collins Bent, 2008) and repositioning of stakeholders to become one co-located team is necessary. Our case study enterprise has established their activity in this way. The case study service enterprise is recognised in part by the greater stakeholder organisations and the customer, provider and some supplier representatives are collocated next to the asset. All customer, provider and supplier interviewees directly involved view the co-location of customer and provider as very positive. Furthermore establishing an on base supplier team (Selex) supporting expensive equipment is considered a success by the customer and provider as

equipment fault arisings have been reduced to a minimum. However the recognition of belonging to a single enterprise does not appear as strong in the back office activities of the extended enterprise where they are remote from the immediate service activity and subject to multiple objectives. (BAE Systems, UK Ministry of Defence, Case study findings, 4.2.1.2, Transformation and 4.2.1.3 Equipment design and arisings).

The literature review also identified that process mapping and enterprise imaging can be used to help understand which organisations are involved in the service delivery and can be used to help develop roles and responsibilities (Mills, et al., 2013). The new service enterprise stakeholders can collectively work towards the same targets and collectively hold and manage the commercial and operational risk rather than contractually hand it off to one another (Pay and Collins Bent, 2008). To support working towards the same objectives the provider and suppliers need to develop a service culture (Duffy and Fearne, 2004). The customer also needs to change his behaviour (Ng, et al., 2011) and recognises that he is part of a team endeavouring to deliver the optimum result. Here the case study findings were consistent with an important body of literature (Neely, 2008; Baines, et al., 2009; Macintyre, et al., 2011; Ng, et al., 2011) again identifying that the stakeholders or partners were starting to work together more closely and that common enterprise objectives have been established. However whilst an increasing level of risk has been moved from the customer to the provider the risk has yet to be fully shared with the supply chain (BAE Systems, UK Ministry of Defence, GE Aviation, Case study findings, 4.2.1.2, Transformation and 4.2.1.3 Equipment design and arisings).

Finally when moving from supplying products and services to providing a service the partners have to become increasingly engaged with one another in order to create a service enterprise (Pay Collins Bent, 2008; Baines, et al., 2009; Baines and Lightfoot, 2012). The service enterprise should be viewed as the entity managing the business supported by a supply organisation rather than the supply organisation dictating to a virtual service organisation (as the latter reflects product mind-set and delivery rather than service). Key co-located suppliers can be directly involved bringing their technical expertise to bear immediately avoiding equipment failures, repairs and No Fault Finds in the system. Through co-location they will also experience the feeling of urgency prompting immediate action. The new service enterprise partners should however maintain direct links to their respective organisations and extended supply chains. This

will help speed any necessary repair or support. To establish the understanding of partnership at all levels in an ideal situation all employees across the partnering organisations should be aligned to the same rewards system avoiding two people with completely different contracts and incentives being employed on the same job (Parry, et al., 2011). This will help ensure commitment of all individuals involved. It is however accepted that the very different cultures of military and civilian employees makes this difficult to achieve.

5.3.9 Business model summary

The comparison of business model literature and case study findings demonstrates that when servitizing the business model transitions from one supporting the manufacturing and sale of product to one supporting the provision of a service. Furthermore a complex engineering service enterprise requires a new service business model rather than extending or incrementally changing its product-oriented models. In this way the service paradox of non-achievement of expected returns may be avoided (Neely, 2008). This is the case where the provider, customer and key suppliers need to co-locate and value co-create (Baines, 2009; Ng, et al., 2011; Baines and Lightfoot, 2012) to deliver the service highlighting the need for one business model rather than multiple individual business models. A second research proposal is therefore offered.

Proposal 2. A new business model, which embraces the service enterprise organisations and activities, is required where a complex engineering service is offered. As servitization progresses the business model transitions from one supporting manufacture and sale of product to one supporting the provision of service.

Proposal 2 contributes to the body of literature on servitization and is supported by empirical evidence. The case study extends the understanding of business models under servitization. The finding also highlights to industry that each feature of the business model as described by Osterwalder and Pigneur (2010) needs to be reviewed and changed to provide increased alignment between the new value proposition and its supporting activities during and post servitization.

Table 16 below provides a summary of the literature and case study findings that have been considered when formulating Proposal 2.

Proposal 2

A new business model, which embraces the service enterprise organisations and activities, is required where a complex engineering service is offered. As servitization progresses the business model transitions from one supporting manufacture and sale of product to one supporting the provision of service.

Supporting literature

Key resources (Penrose, 1959); Customer segmentation (Kotler, 1991); Distribution channels (Walsh, 1993); Organising to create and distribute value (Magretta, 2002; Fuller and Morgan, 2010); Partnerships and common objectives (Pay and Collins Bent, 2008); Framework for business features and activities (Osterwalder and Pigneur, 2010); Business value creation, delivery, capture mechanisms and revenue (Teece, 2010); Conceptual tool kit for business models (Zott and Amit, 2010); Key activities (Turunen and Neely, 2011); Co-location and Value co-creation (Ng, et al., 2011; Baines and Lightfoot, 2012); Managing more than one business model (Velu and Stiles, 2013).

Supporting primary data from case study

- The new service provision commenced by BAE Systems by incrementally adapting their existing organisation and way of working was reported as a sub optimal approach by all of the BAE Systems interviewees.
- The BAE Systems value proposition has changed. They are now providing availability rather than selling product.
- The provider firm (BAE Systems) interviewees recognise that the objectives of their business have changed.
- The provider firm (BAE Systems) has co-located to the customer facilities.
- The MOD and BAE Systems are now in a partnership, co-creating value.
- The case study provider (BAE Systems) has taken over the customer's role.
- The provider firm (BAE Systems) is managing the third party organisations who had previously reported to the customer.
- The new key activity of BAE Systems is to manage the delivery of a complex engineering service at lowest cost through the management of the service enterprise.
- The partners (MOD and BAE Systems) are starting to work together more

closely

Table 16. Literature and case study findings that support research Proposal 2 (Source author)

5.4 Performance management

This section focuses on performance management and performance measurement and considers the literature and case study findings from the research framework features of servitization, performance and enterprise (as illustrated in Figure 1i).

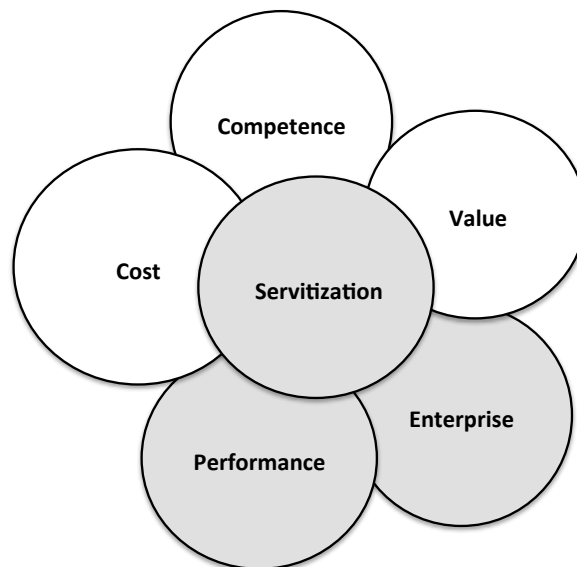


Figure 9i. Research framework, servitization, performance and enterprise (Source author)

The discussion considers the literature and case study findings to identify the performance management required where a new complex engineering service is being delivered. It considers common service enterprise objectives, the new performance management role of the provider and performance measurement for service.

5.4.1 Service enterprise performance management

The research literature review identified that where a new complex engineering service is offered the servitizing provider firm needs to shift focus from manufacturing and selling products to leading the performance management of the service enterprise (Baines and Lightfoot, 2012). The literature further informs us that this shift in focus and leadership can be achieved by forward integration (Baines and Lightfoot, 2012) where the provider assumes the role of the customer. The new role will include the management of value co-creation where interacting business parties transform people information and materials and equipment simultaneously (Ng, et al., 2011). Value co-creation including the sharing of information and delivering transformation in a consistent, stable manner is a key activity for a complex engineering service provider (Ng, et al., 2011). As previously explained the case study research identified that the case study provider firm has changed his mind-set and has taken over the role of the customer. The provider firm now realise the key activity is to manage the delivery of a complex engineering service providing asset availability at lowest cost. Providing aircraft availability at lowest cost is achieved by managing the full service enterprise including the managing of interdependent co-production activities. The new activity replaces their previous key activity of manufacturing products for sale including managing a supply chain of independent firms producing and exchanging products in support of that sale. A key part of the new activity for the provider is taking over the position and performance management activity of the customer. This shifts the provider's performance management focus to the service output rather than individual inputs alone. The BAE Systems interviewees all believed this switch is a significant break through helping to increase levels of performance (BAE Systems, Case study findings, 4.2.1.2, Transformation). The following quote from a BAE Systems interviewee highlights this point.

“Once the teams started discussing contracting for output and introducing incentives for increased levels of performance the whole dynamics of the service requirements and relationships changed”. Provider/BAE Systems, (BAE Systems, Case study findings, 4.2.1.2, Transformation).

The case study service provider considers their new focus on output a significant change as they had previously only focused on their own inputs. The focus of the provider and

customer team is now the availability of the aircraft. This is their new output measure. In support they have started to review their inputs considering their impact on aircraft availability rather than achieving contractual requirements alone (BAE Systems, Case study findings, 4.2.1.2 Transformation). This action is also consistent with the literature that proposes a focus on the output through the inputs rather than measuring the performance of their multiple inputs alone is beneficial (Neely, et al., 1995). Furthermore the avionic supplier GE Aviation also understands the target of aircraft availability and is committed to supporting it through the availability of their avionic product the Mission Head Down Display (GE Aviation, Case study findings, 4.2.1.2 Transformation).

The research literature review also identified that where a complex engineering service is being provided a service enterprise management team will benefit by establishing enterprise wide direction (Purchase, et al., 2011; Kaplan and Norton, 1993). The management team can establish an enterprise complete with a supporting set of objectives (Purchase, et al., 2011). The strategy and objectives will help provide direction when communicated across the enterprise. The objectives can be further cascaded to activities and actions to be measured by key performance indicators. This will link service enterprise direction and aircraft availability to operational KPI's (Kaplan and Norton, 1996).

The case study interviews delivered an in depth discussion on enterprise and performance management. The discussion confirmed the importance of establishing common objectives across the service enterprise and that the customer and provider service management team had established common objectives. Furthermore the service management team has adopted this approach with all measures cascading from and rolling up to four top line asset availability measures. This was considered as a major breakthrough when installed by our case study provider as it helps orientate the whole enterprise towards availability. Performance measurement of each activity should be established including the performance measurement of interfaces between firms or functions as delays can occur and costs accrue here (BAE Systems, Case study findings, 4.2.6, Cost). However all of the BAE Systems and GE Aviation interviewees confirmed that real boundary crossing management did not exist and sharing of objectives was also unclear. The service project teams direction is recognised and is currently closely followed by the support teams in front office activities but the back office and extended

supply chain appeared less aligned and subject to multiple business and project objectives. This was reported as slowing responsiveness and extending repair turnaround lead-times when reduced turnaround lead-times are required. Three of the supplier interviewees reported they have limited visibility (and thus limited direction) of the combined provider customer management and their objectives and suggested improved communication and common objectives would be of benefit to the extended enterprise (GE Aviation, Case study findings 4.2.4, Enterprise). The following quote from a GE Aviation interviewee supports this thinking.

“I think the way to do it is to have a virtual enterprise and make sure that people in it all have the same objectives from the top to the bottom. It should all be about availability”. Supplier/GE Aviation, (GE Aviation, Case study findings 4.2.4, Enterprise).

5.4.2 Performance measurement

Defence procurement and support activities of a complex nature currently have an average cost of completion of 140% (Assidmi, Sarkani and Mazzuchi, 2011). Improved performance is therefore required. Literature on performance measurement details that key performance indicators are required to measure effectiveness and efficiency. Effectiveness is the extent to which customer requirements are met and efficiency is how economically the firm’s resources are utilised (Neely, et al., 1995). In manufacturing processes involving tangible products, inputs and outputs are relatively easy to measure. In services, measurement of both outputs and inputs is problematic (Kingman-Brundage, 1995) especially where interdependent activities exist. The case study findings were consistent with the above and highlighted that the customer provider project team have started to measure performance against four new top-level output measures, delivery, quality, cost and function. In support the customer provider team have started to review their inputs considering the inputs schedule, quality, cost and performance impact on asset availability rather than achieving contractual requirements alone (BAE Systems, Case study findings, 4.2.5, Performance). All interviewees were aware of delivery, quality, cost and performance measures cascading down and rolling up to the main service deliverable engaging the extended organisation. The provider advised they agree the general terms and conditions with their suppliers together with specific statements of work that capture the actual level of service they

are seeking on specific equipment. At the earliest opportunity the procurement team agree the most appropriate key performance indicators with the supplier(s). Selection of metrics depends on whether it is the development, production or support phase and the agreed contract goal. The metrics may be agreed from a broad range such as; schedule agreement; lead time reduction; cost reduction; reliability improvements/improved mean time between failures (MTBF); reduction in no fault found; guaranteed repair turnaround times, guaranteed replacement times; demand satisfaction rate; technical services; and throughput measures. Once measures are agreed the provider's procurement team measure supplier's performance and key performance indicators get consolidated to the product level. The supplier interviewees recognised that a number of tangible and intangible key performance indicators and specific turnaround times had been flowed down to them from the provider.

Considering the literature and case study findings on performance highlighted in the above discussion the following summary and third finding can be offered.

The literature and case study findings highlight that when moving from manufacturing products to providing a service the mind-set of the principle stakeholders has to change from adversarial to working together. This can be positively supported and achieved through the development of common objectives. Furthermore it is advantageous for the provider firm to take the management lead and measure performance against output. In support performance management techniques developed to manage manufacturing activities can also be used to execute performance management of service activities. Proposal three (3) below captures this understanding.

Proposal 3. A service enterprise will benefit from common performance objectives between stakeholders. The service enterprise will also benefit from the provider assuming the position of the customer and leading the performance management of the service output.

The proposal contributes to the body of literature on servitization and is supported by empirical evidence from the case study. For operations management literature it develops the concept of the provider taking over the performance management role of the customer (Baines and Lightfoot, 2012). For enterprise literature the case study findings provide evidence for the need for common enterprise objectives (Purchase, et al., 2011). The proposal also supports industrial practice as it reflects the mind-set

change of the customer and provider confirming their current approach to performance management is a positive development.

Table 17 below provides a summary of the literature and case study findings that have been considered when formulating Proposal 3.

<p>Proposal 3</p> <p>A service enterprise will benefit from common performance objectives between stakeholders. The service enterprise will also benefit from the provider assuming the position of the customer and leading the performance management of the service output.</p>
<p>Supporting literature</p> <p>Performance measurement systems (Maskell, 1989; Meyer, 2002); Supply chain performance (Beamon, 1999; Poirier, 2004; Slack, et al., 2007; Parry, 2010); Performance measurement (Neely, et al., 1995); Strategic management system (Kaplan and Norton, 1996); Partnerships and common objectives (Pay and Collins Bent, 2008); Performance and cost of value creation (Ng, et al., 2011); Common enterprise objectives (Purchase, et al., 2011); Assuming the customer role and measuring output (Baines and Lightfoot, 2012).</p>
<p>Supporting primary data from case study</p> <ul style="list-style-type: none"> • The provider firm (BAE Systems) has taking over the position and performance management activity of the customer (MOD). This shifts the provider firm’s performance management focus to the service enterprise output rather than individual firm’s inputs alone. • The provider firm (BAE Systems) has started to review their inputs and their impact on aircraft availability rather than achieving contractual requirements alone. • The second tier provider GE Aviation also understands the service enterprise output of aircraft availability and is committed to supporting it through the availability of their products. • The measures cascading from and rolling up to four top availability measures was considered as a major breakthrough when implemented by the provider

firm (BAE Systems) as it helps orientate the whole enterprise towards availability.

- The interviews confirm the importance of establishing common objectives across the service enterprise.
- The BAE Systems and MOD interviewees considered the boundary crossing management was far from acceptable and sharing of objectives was also unclear especially away from the front line asset support activity.
- The extended enterprise appears less aligned and subject to multiple business and project objectives. Interviewees report that this slowed supplier responsiveness.

Table 17. Literature and case study findings that support research Proposal 3 (Source author)

5.5 Managing interdependency and the decoupling point shift

This section focuses on two linked features. The first feature concerns the different ways of managing dependency and interdependency. The second feature is the decoupling point shift between the provider and the suppliers of the servitized enterprise. The discussion considers the literature and case study findings from the research framework themes of servitization, performance and enterprise (as illustrated in Figure 9j).

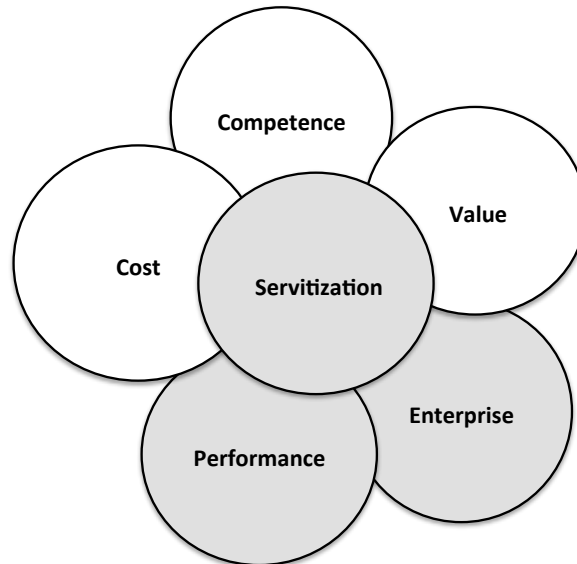


Figure 9j. Research framework, servitization, performance and enterprise (Source author)

The literature review highlighted that interdependence changes the traditional view that maximising individual performance will lead to organisational success and replaces it with a focus on group performance (McNair, 1990). Detailed planning and mission control is difficult as an emergent outcome is achieved through co-creation and interactive collaboration (Ng, 2011). The plan, do, review loop is redefined. The one to one mapping of individual actions to clearly identified individual outcomes is replaced by a focus on the effectiveness of a group of individuals engaged in interdependent activities (McNair, 1990).

The above literature review findings were reflected in the case study findings. Here the case study interviewees of the customer, provider and the supplier recognised interdependency of their activities and the need for the enterprise to work together efficiently. The customer the UK Ministry of Defence and the provider BAE Systems reported they had introduced increased co-location and co-production to improve performance where problems arise and where interdependency exists on expensive equipments. A supplier of expensive equipment has been co-located on base next to the

aircraft in order to work with the provider and customer team to help provide an immediate diagnosis of equipment problems followed by a quick on site fix. Here the stakeholders work together in a simultaneous interdependent way to achieve the fix. (BAE Systems, case study findings, 4.2.2.3 Equipment design and arisings). The stakeholders have a focus on the output and co-location and speed of interdependent activity were all reported as increased. The customer and provider both consider the co-located, interdependent way of working a success, delivering improved availability as a result of reduced turnaround times and lower cost as spares usage, stock and extended supply chain activity are minimised. Performance measurement is now focused on the enterprise team achieving a quick time to deliver asset availability potentially avoiding the need for spare utilisation. In support the contractual supplier repair turnaround time has been reduced from 30 days to 5 elapsed days. Performance is now measured against this 5-day target. A further 4 KPI's are also utilised. These KPI's measure; supplier time to respond to query; delivery against the engineering improvement plan; reduction in the number of no fault founds; and increased mean time between failure. These KPI's are aligned with the four output KPI's of delivery, quality, cost and performance now being used. The case study findings confirm that service enterprise management teams delivering a complex service will benefit from; recognising where interdependencies exist; establishing the optimal process to achieve the output; focusing on the time the team take to complete the activity required to re-establish availability; managing all inputs in support; and utilising appropriate performance measures (UK Ministry of Defence, BAE Systems, Case study findings, 4.2.13, Equipment design and arisings and 4.2.7, Performance).

The case study findings also highlighted that acceptable alternative approaches can be established where problems arise with less expensive equipment where on base diagnosis and fix is not considered profitable (BAE Systems, Case study findings 4.2.1.3, Equipment design and arisings). Here the reliance remains on the traditional dependent supply chain repair activity. To achieve the agreed 30 day or best endeavours turnaround the suppliers hold specific stock and engage in special efforts. Here interdependence also exists but only between the provider firm and customer when co-producing and co-creating at the aircraft level. The suppliers who remain contracted in a traditional way can be considered decoupled from the front line service customer, provider, supplier teams. These suppliers continue to operate in a product dominant

exchange mode, working to agreed turnaround measures. The supplier turnaround measure commences on receipt of clear instruction and parts received from the provider reflecting the sequential two-way dependent characteristic of the activity. The suppliers in this mode are also working for a fixed fee covering a fixed number of repairs with extra repairs being chargeable (BAE Systems, UK Ministry of Defence, GE Aviation, Case study findings, 4.2.1.2, Transformation and 4.2.1.3 Equipment design and arisings).

The case study findings also identified a movement to the provider and key supplier decoupling point during servitization. The decoupling point is the place in the value chain where material or component supply changes from push to pull i.e. the order point from customer to supplier. The decoupling point also reflects the system boundaries of the customer and supplier (Mason-Jones and Towill, 1999; Garcia-Dastugue and Lambert, 2007; Olhager, 2010; Banerjee, et al., 2011). Either during or post servitization where a key supplier co-locates with the customer and the provider to form the immediate enterprise team the decoupling point shifts to a new position within the immediate enterprise activity next to the customer and provider. Here the supplier knows the requirements of the customer end user, the customer and provider immediately. However for the suppliers who remain in a supply chain mode the decoupling point continues to exist between the provider back office and the suppliers. The latter is similar to the decoupling point position found in a manufacturing supply chain.

Considering the above literature and case study findings on dependence and decoupling the Proposals 4 and 5 are offered.

Proposal 4. Delivering a complex engineering service including value co-production and value co-creation can include both dependent and interdependent activity. Hence increased benefit can be secured from managing each type of activity in different ways.

Proposal 4 contributes to the body of literature on dependence highlighting that dependent and interdependent activities can be managed in different ways. The proposal is supported by empirical evidence from the case study. Proposal 4 also contributes to industrial practice by providing understanding of dependence within a complex engineering service activity.

Table 18 below provides a summary of the literature and case study findings that have been considered when formulating Proposal 4.

<p>Proposal 4</p> <p>Delivering a complex engineering service including value co-production and value co-creation can include both dependent and interdependent activity. Hence increased benefit can be secured from managing each type of activity in different ways.</p>
<p>Supporting literature</p> <p>Plan do review loop (McNair, 1990); Collaboration (Pennings, 1991; Cropper, 1996); Complexity (Anderson, 1999); Co-production (Ramirez, 1999; Ng, et al., 2008); Task dependency (Donaldson, 2001); Management and team relationships (Barrick, et al., 2007); Communication and coherence (Callahan, et al., 2008); Business models and interdependence (Zott and Amit, 2010); Value co-creation and co-location (Ng, 2011; Ng, et al., 2011).</p>
<p>Supporting primary data from case study</p> <ul style="list-style-type: none"> • The stakeholders recognise interdependency of their activities and the need for enterprise to work together effectively. • The BAE Systems interviewees considered that improved performance was delivered where increased interdependency, co-location and co-production had been established. • The speed of interdependency activity was reported as having increased following co-location. • The supplier of expensive Radar and Defensive Aid equipment has been co-located on base next to the aircraft to help provide an immediate diagnosis of equipment problems followed where possible by a more rapid repair on site. • The stakeholders work together in a simultaneous interdependent way to achieve more rapid equipment maintenance and repair. • The customer and provider both consider the co-located, interdependent way of working as a success delivering improved availability. • The BAE Systems interviewees reported that reduced turnaround times and lower cost as a result of lower spares usage, lower stock and shorter supply

<p>chain activity exist where interdependent activity had been introduced.</p> <ul style="list-style-type: none"> • The reliance remains on the traditional dependent supply chain repair activity where interdependent activity is not possible. Here the suppliers hold specific stock and engage in special efforts to support the 30-day or best endeavours turnaround requirements. This adds cost. • The majority of suppliers continue to operate in a product dominant exchange mode, working to agreed turnaround measures.
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Table 18. Literature and case study findings that support research Proposal 4 (Source author)

Proposal 5. Where the service customer, provider and supplier are co-located the decoupling point (where material or component supply changes from push to pull) shifts to the co-located activity as the supplier becomes aware of the requirements as they arise. For the non co-located suppliers the decoupling point remains as previous.

Proposal 5 contributes to the body of literature on servitization by identifying a shift of the decoupling point. The finding is supported by empirical evidence from the case study. Proposal 5 also contributes to industrial practice by highlighting the need to communicate supply requirements in a new way. This will be the subject of further research.

Table 19 below provides a summary of the literature and case study findings that have been considered when formulating Proposal 5.

<p>Proposal 5</p> <p>Proposal 5. Where the service customer, provider and supplier are co-located the decoupling point (where material or component supply changes from push to pull) shifts to the co-located activity as the supplier becomes aware of the requirements as they arise. For the non co-located suppliers the decoupling point remains as previous.</p>
<p>Supporting literature</p> <p>The decoupling point, value chain, order point and system boundaries of the customer and supplier (Garcia-Dastugue and Lambert, 2007; Mason-Jones and Towill, 1999;</p>

Olhager, 2010; Banerjee, et al., 2011).

Supporting primary data from case study

- The Typhoon support has improved where key suppliers are co-located with the customer and the provider to form the immediate enterprise team. By working alongside the customer's end-user, the customer and provider the supplier can know the requirements of the customer end-user, the customer and provider immediately. This speeds responsiveness and reduces operational cost.
- The majority of Typhoon support suppliers have remained in a supply chain mode and are not co-located.
- The decoupling point continues to exist between the provider back office and the suppliers for those firms who are not co-located. This is similar to the decoupling point position found in a manufacturing supply chain. The interviewees viewed this arrangement as inefficient.

Table 19. Literature and case study findings that support research Proposal 5 (Source author)

5.5.1 A definition for dependence

The following sub section considers the research literature findings on dependence and the research case study findings on dependence and interdependence and develops and proposes a definition for independent, dependent and interdependence.

The research literature review identified that literature explicitly defining independence, dependence and interdependence in business operations is limited (Barrick, et al., 2007). However sufficient was identified to enable an improved understanding of the nature and difference of independent, dependent and interdependent activities. Considering findings from the literature (McNair, 1990; Anderson, 1999; Donaldson, 2001; Barrick, et al., 2007; Callahan, et al., 2008; Zott and Amit, 2010; Ng, et al., 2011) and case study analysis (Case study findings, 4.2.2.3, Equipment design and arisings) a table contrasting the differences of independent and interdependent activities has been established (see Table 13.). Definitions for independence, dependence and interdependence are also proposed. The definitions provide an understanding of different types of activity occurring during and post servitization.

The characteristics of independent and interdependent activities are very different and are captured in Table 20 below.

Characteristic	Independent activity	Interdependent activities
Objective.	Individual objectives.	Common shared objectives.
Approach.	Individual approach to activity exists.	Team approach to activity required.
Coherence of players.	Low coherence exists between players.	High coherence required between players.
Communication of players.	Low, individual only.	High across team.
Predictability of task.	High fixed task.	Low, emergent requirements.
Innovation.	Medium.	High changing team task.
Discretion.	Low, repetition, individual task.	High changing team task.
Flexibility of players.	Low, individual task only.	High, flexibility between tasks.

Table 20. Characteristics of independent and interdependent activities (Source author)

Definitions of independence, dependence and interdependence are proposed in the following paragraphs. Here dependence is defined relative to a given enterprise.

An independent activity starts and finishes without input from other activities. It has its own output, can be measured and progress towards outcome can be monitored. Furthermore the independent activity does not have a relationship with other activities endogenous to the defined enterprise.

A dependent activity requires an input from a prior activity, has its own output and interacts sequentially with other dependent activities within an enterprise. A dependent

activity can be measured and progress towards outcome can be monitored. The dependent activity can be within the company or intra companies.

An interdependent activity exists where multiple activities interact simultaneously to deliver an output. Its process flows may be non-linear and in parallel and progress towards enterprise outcome is difficult to measure. Where an interdependent activity exists co-location of processes and focus upon the time to achieve final output is found to improve performance.

The definition for dependence in the context of a complex engineering service extends develops the body of literature on dependence and servitization. It also provides labels and definitions that industry can use to better understand and improve their enterprise activities and performance.

5.6 Cost

This section focuses on the literature review and case study findings on cost. The section considers the literature and case study cost findings of all of the research framework themes of servitization, competence, value, enterprise, performance and cost. This is illustrated in figure 9k below. The review includes consideration of the findings from the analysis on the nature of costs identified during the research and the simulations of recovery activities (both detailed in the previous chapter).

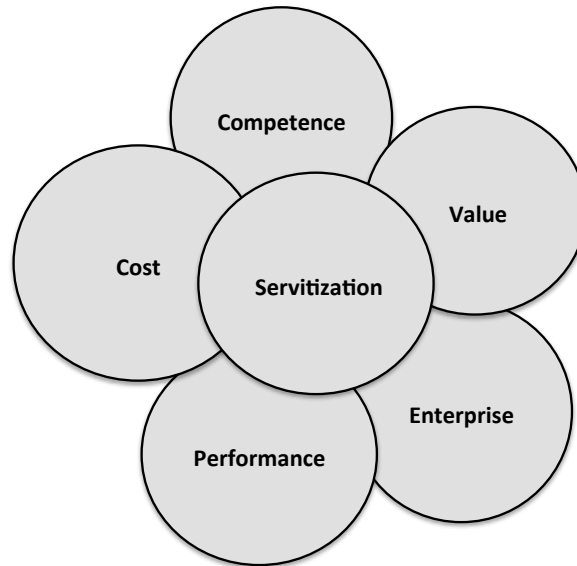


Figure 9k. Research framework, servitization, competence, value, enterprise, performance and cost (Source author)

The research literature review identified that the UK defence acquisition programmes for the provision and support of military equipment has a historical overspend equal to plus 40% on average (Bassford, 2012; Assidmi, Sarkani and Mazzuchi, 2011). The USA suffers plus 46% for the same activity (Bassford, 2012; Assidmi, Sarkani and Mazzuchi, 2011). Whilst the research case study findings did not explicitly identify large overspend on the Typhoon support the customer the UK Ministry of Defence did express that the Typhoon support costs were too high and that a reduced level of spend was required. New arrangements and a cost reduction challenge had therefore been established with the support provider BAE Systems (UK Ministry of Defence, Case study findings, 4.2.1 Background, existing budget and cost understanding). Furthermore the case study findings highlighted many different costs are currently incurred across the service enterprise. Some are expected whilst others may be due to poor design of equipment, internal failure of activity and poor performance when considering repair turnaround time requirements. The following section provides details of the case study cost findings.

5.6.1. Detailed analysis of cost findings

The case study transcriptions have been analysed and a list of interviewee quotes identifying potential costs has been established. In total seventy-seven (77) quotes on cost were identified. From these quotes forty-four (44) different costs have been established. Whilst the forty-four (44) costs are not necessarily exhaustive they are recognised as costs associated with the issues and challenges identified by the main case study findings. These are considered as front of mind costs. The costs have been analysed against a number of theoretical frameworks including an adapted Hanson and Mowen (2007) framework to test for cause and a framework to identify if the costs are input, output or outcome (Doost, 2006). The costs are also tested to see if they are as a result of poor performance, if they arise in a dependant or interdependent activity and if they are related to hardware or operational activities. These analyses identify the cause, characteristics and impact of the cost gaining an improved understanding of the type of cost incurred when a complex engineering service is provided. The findings are detailed below.

Initially and to establish confidence in the cost findings the cost quotes were analysed to test for strength of quote. The analysis tested to see if the cost quotes are an opinion or statement based on written documents. Thirty per cent (30%) of the cost quotes were considered an opinion whilst seventy per cent (70%) were considered a statement. A second analysis tested if they are ambiguous or if they have clarity? Here eighteen per cent (18%) were considered ambiguous and eighty-two per cent (82%) considered as having clarity. These results provide an acceptable level of confidence in the quotes selected for analysis.

The cost findings were also reviewed to establish the type of the impact they create. This builds a general understanding of the cost providing an indication of how obvious the cost is and how it can be identified, sized and captured. Fifty one per cent (51%) were considered a monetary impact; thirty one per cent (31%) were considered a monetary (£) and time impact; and eighteen per cent (18%) considered a time impact only.

The quotes and costs have also been analysed against the Ng, et al. (2011) Complex Engineering Service System (CESS) transformation framework. The analysis categorises each cost as a result of people transformation, information transformation, and material or equipment transformation (Literature review, 2.2.7, Complex engineering service

systems). Transform materials and equipments include manufacturing and production, store, move, repair, install, discard materials and equipment through supply chain, repairs, obsolescence management, and predictive maintenance. Transform information includes design, store, move, analyse, change information through knowledge management, information, communication and technological strategies, and data strategies in equipment management. Transform people includes training, change of use, build trust through education, influence, build relationship, and change mind-sets (Ng, et al., 2011). The analysis showed that twenty five per cent (25%) were considered as a result of people transformation, nine per cent (9%) were considered as a result of information transformation and sixty six per cent (66%) as a result of material and equipment transformation. This increases the understanding of the nature of costs being experienced and highlights that all costs are not necessarily incurred as a result of transformation of materials and equipment.

Each cost was also analysed to identify if they were a result of an independent, dependent or interdependent activity. This identified ninety one per cent (91%) of the costs arising in a dependent activity, twenty per cent (20%) in an interdependent activity and 0% in an independent mode. This suggests that the dependent supply chain activities have a greater propensity to generate cost than the interdependent activities.

Using the Doost (1996) framework the costs have been analysed and categorised as either an input cost, an output cost or outcome cost. In this context input refers to what was spent, output is what was accomplished and outcome gauges the effectiveness the accomplishment (Doost, 1996). Twenty one per cent (21%) were considered input costs; forty five per cent (45%) considered output costs and thirty four per cent (34%) considered as outcome costs. This finding suggests that the enterprises total costs are greater than the estimated input costs and that input and output and outcome costs need to be understood and managed.

Further analyses were undertaken to categorise the costs with respect to performance, impact location and cost destination. With regard to performance the analysis investigated whether the costs are expected costs or additional costs from poor performance. Eighteen per cent (18%) were considered to be as a result of expected performance and eighty two per cent (82%) from poor performance. From a location impact perspective the analysis considered if the costs have an immediate local impact a

downstream impact or an upstream impact? Here seventy per cent (70%) of the costs were considered to have a local impact, sixteen per cent (16%) of the costs were considered to have a downstream impact and sixty four per cent (64%) were considered to have an upstream impact. Furthermore many of the costs were considered to have multiple cost locations. This highlights that cost can arise in one area and impact that area but also impact other areas. A systems perspective on cost is therefore required. Finally from a destination perspective the costs were considered if they were a hardware cost or operations cost or other cost? Here fifty two per cent (52%) were considered as hardware, eighty four per cent (84%) considered as operations and seven per cent (7%) as training. This identifies that a significant percentage of the cost arise in operational activities.

Finally the costs were tested to see if they were as a result of internal failure, external failure, prevention or detection activity or a compliant activity. The following categorisations were established by utilising an environmental activity destination framework (Hansen and Mowen, 2003). Thirty nine per cent (39%) were considered internal failure; two per cent (2%) were considered external failure, five per cent (5%) were considered as a result of prevention activity and fifty four per cent (54%) as a result of compliant activity. This further builds up the understanding of the costs including establishing if the costs are driven by exogenous activity.

The analysis of the case study front of mind costs highlights the variety of cost that may arise in a complex engineering service. The analysis also highlights that many of the problems impact on multiple areas potentially driving multiple increases in cost. Poor performance in one area can deliver a loss of time that can result in increased hardware costs, operational costs and stock costs.

From the analysis of the forty-four costs the following high percentages have been identified:

- 54% were considered to be as a result of compliant activity
- 66% of the costs arise from equipment transformation activity
- 82% are considered avoidable being generated as a result of poor performance
- 91% of the costs arise in a dependent activity
- 64% are considered to have a downstream cost impact

- 84% of the costs were considered to be operational (supply chain) costs

Considered collectively the high percentage cost findings shown above increase the understanding of costs experienced when providing a complex engineering service. The high percentage cost findings indicate that a mixture of hardware and operational costs exist, many being generated by poor performance and many with downstream impact. Furthermore eighty two per cent (82%) were considered as a result of poor performance, ninety-one per cent (91%) rising in a dependent activity and eighty four per cent (84%) considered as operational. These percentages suggest that the dependent supply chain activities are difficult to manage and subject to poor performance. This supports the decision taken by the Typhoon service enterprise to locate the supplier of expensive equipment next to the aircraft (UK Ministry of Defence, BAE Systems, Case study findings, 4.2.1.3, Equipment design and arisings).

In addition and consistent with the above cost analysis findings the general case study findings highlight that the Typhoon availability contracting is all about speed of availability recovery and that the majority of all costs are reported as linked to the failure of equipment and their replacement or repair (UK Ministry of Defence, Case study findings, 4.2.1 Background, existing budget and cost understanding). The aircraft serviceability depends on the availability of equipment. In the event of equipment failure when replacements equipments are not available the slower the repair of the failed equipment the higher the risk of aircraft non-availability penalties being incurred. Furthermore this situation increases the potential for additional replacement stock being ordered to cover the risk of non-availability. The enterprise is therefore endeavouring to maximise the amount of on aircraft and on base equipment repair (50% at present). Where this is not possible the repairs flow from the aircraft through many supply chain steps to the supplier for repair and return. Here unresponsive culture, rigid contracting, mixed objectives and poor performance on the part of the customer, provider and suppliers can all slow the return and timely repair of the equipment. The slow repair can only be recovered by rearranging resources. This involves re-arrangement of shifts, test benches and people all creating additional cost. Furthermore to try and recover suppliers can be paid premiums to enhance their own and their supplier's delivery performance (UK Ministry of Defence, BAE Systems, Case study findings, 4.2.1.3, Equipment design and arisings).

The case study cost findings also indicate that within a service enterprise activity where assets and through life support activities combine there is a need to develop a cost model that captures all enterprise costs. Based on the cost analysis findings a model capable of capturing both hardware and operational costs and capable of reflecting poor performance in dependent type supply chain activities is required. Here costs may eventually arise downstream in a different part of the enterprise. The cost model should therefore be capable of capturing the cost of the flow. This includes the need to cost value and failure demand where failure demands are caused by a failure to do something or do something right for the customer. In the same way as reducing waste in the manufacturing process flow (Womack and Jones, 1996) identifying and reducing failure demand cost in the service system is viewed as a powerful economic lever (Seddon, 2003).

The allocation of cost findings between the supply chain approach to recovery (operational 84% and dependent 91%) and the fix on base approach achieved by interdependent activity also highlight the need to maximise the fix on base as here less costs were highlighted (9%). The findings established by the approach simulations discussed in the following section further support this finding.

5.6.2 Simulation of different availability recovery approaches

Five simulations of different case study approaches to availability recovery of the Typhoon have been undertaken to provide an understanding of the differences in the speed and cost of each approach (Case study finding, 4.2.6.3 Simulation of different availability recovery approaches refers). The simulations that are typical of the recovery approaches being undertaken at the time of the case study highlight the cost of the flow and illustrate how different outcome costs can occur. The simulation represents the correction (replacement or repair) of a failed Line Replacement Unit where the aircraft has returned from flight operations for front line service. The aircraft is attended by front line service teams comprising of Customer (RAF), and Provider (BAE Systems) who work on the aircraft to provide 100% availability of the asset. Supplier teams may also take part in this activity if their equipment has been selected for on aircraft repair.

Approach 1 models the past traditional approach of using spares only. Approach 2 models a replacement and repair recovery action. Approach 2a establishes the impact of poor performance on approach 2 whilst approach 2b reflects the impact of poor

performance and unscheduled customer damage on approach 2. Finally approach 3 models a fix on aircraft approach.

All recovery cost quantifications commence with one spare line replacement unit in stock and ends with one line replacement unit in stock. This reflects a normal situation where stock is held to establish recovery without having to depend on an aircraft on ground (AOG), or interrupted operational routine (IOR) service. Simulation 3 however reflects an advanced state of recovery on aircraft where stock is not held locally. Here if the local recovery is not possible the AOG service (24 hour response) or IOR service (48 hour response) is enacted. Each simulation reflects 2 cycles of expected fault arisings except for the fourth simulation (2b) that includes an unscheduled customer damaged line replacement unit. One day of effort = a , repair parts y are the parts required for achieving the repair on the aircraft or achieving the repair in the supplier repair shop. These parts are less in quantity than the total number of parts included in the spare unit. The balance of parts in a spare unit is represented by z (z costs represent the bulk of parts and are much greater than y). Extra parts only required to correct customer damage are shown as m . The best endeavours approach has not been included as a simulation due to its open-ended nature.

The simulations of the case study qualitative research findings is achieved by using actual turnaround and lead-time information collected during case study interviews. The interviewees highlighted two principle turnaround times. A 5-day turnaround is used for an on aircraft or on base fix and a 28-day turnaround is used for a repair at the supplier. To complete the simulation a consistent period of 5 days is used to ship parts from the base to the supplier providing both are in the UK. Similarly a period of 5 days is used for a return ship. A 180-day average lead-time (6 months) is used for an equipment sub assembly and assembly (time quoted by GE Aviation).

The recovery simulation results are detailed in Table 21.

Recover simulation results

Approach 1. Spares only =	560a	+ 3y	+ 3z
Approach 2. Spare and repairs =	276a	+ 3y	+ z
Approach 2a. Spare and repairs, poor performance =	360a	+3y	+ z
Approach 2b. Spare and repairs, poor performance, and customer damage =	470a	+ 4y	+ z + m
Approach 3. Fix on aircraft or on aircraft base =	10a	+ 2y	-

Table 21. Comparison of recovery simulation results (Source author)

The above comparisons of the case study approaches to availability recovery emphasise the difference in speed and cost of each. Approach 1 represents cost only, whilst the results of approaches 2, 2a, 2b and 3 are representative of speed and cost. It is not the exact cost that is important but the demonstration of the relative difference between each approach. The actions taken and results of the simulations are consistent with literature (Ng, et al., 2008; Etgar, 2006) where the level of provider firm network and customer performance and selection of resources used increases or decreases the costs incurred and benefits achieved. For example, increased levels of supplier involvement on base (at marginal cost increase) results in much-improved benefits through lower

overall cost. Likewise poor performance of the customer through customer damage results in higher costs and lower levels of benefit.

The comparisons also confirm the case study approach to progressively increase on aircraft or on base repair in order to reduce cost. The results highlight the importance of capturing the cost of every activity. This should include the hardware costs, all operational activity costs and costs related to the performance of each activity. This is important as performance related costs could create a significant cost delta when multiple recoveries are undertaken.

The results highlight a significant difference in the cost of adopting a supply chain approach full of dependent sequential activities (approach 2) compared to a co-located, co-production interdependent approach (approach 3). The co-located, co-production, interdependent approach reduces the need for certain activities and reduces the amount of dependent activities that can attract poor performance. In turn this reduces cost.

Co-location and co-creation (including co-production) can be beneficial where a complex service is provided (Baines, et al., 2009; Ng, et al., 2011). The case study, where speed of recovery is key to delivering availability and keeping all costs to a minimum reflects this understanding.

A number of different approaches to availability recovery have been identified within the case study support activities. These approaches have been simulated to show their relative costs and speed. The findings are consistent with the proposals of Ng, et al. (2008) and Etgar (2006) who emphasise that performance of both the customer and provider and the mix of the resources involved can influence the outcome. The results confirm that co-location and co-production including interdependent activity can be faster and cheaper than the alternative extended supply chain approach where dependent activities exist.

With interdependent activity the number of individual dependent activities required to achieve recovery and the scope for poor performance reduces. This can speed the availability recovery and reduce cost by reducing repair costs, the amount of replacements required and the amount of stock held in the support system. Where co-creation is not considered possible or beneficial and where the dependent supply chain activities continue to manage the repair it is essential to apply good performance

management and cost all service enterprise activities as the turnaround duration and cost can easily increase. Any associated cost model will therefore benefit from including all activities and be capable of accounting for performance.

Considering the literature and case study findings on cost a sixth and final proposal is offered.

Proposal 6. Where a complex engineering service is provided the most efficient asset repair is achieved by repairing equipment next to the asset. Such activity represents co-creation between the customer, provider and key suppliers. For this and other service activities the service cost model used needs to reflect the complete enterprise activity. The cost model should be able to capture the cost of the flow, the impact of poor performance and be able to calculate the outcome cost. Cost should include all hardware and operational activity (good and bad) including those activities and relationships that bridge functional and original firm boundaries.

Proposal 6 contributes to the body of literature on servitization and is supported by empirical evidence from the case study. The finding identifies that it is more efficient to manage equipment failure repairs next to the aircraft as opposed to returning the failed equipment through the supply chain for repair. This proposal is consistent with and supports the research findings 1 to 5. The finding also confirms to industry that there are advantages in fixing equipment failures next to the aircraft and having a cost model that is capable of estimating and capturing the cost of flow.

Table 22 below provides a summary of the literature and case study findings that have been considered when formulating Proposal 6.

Proposal 6

Where a complex engineering service is provided the most efficient asset repair is achieved by repairing equipment next to the asset. Such activity represents co-creation between the customer, provider and key suppliers. For this and other service activities the service cost model used needs to reflect the complete enterprise activity. The cost model should be able to capture the cost of the flow, the impact of poor performance and be able to calculate the outcome cost. Cost should include all hardware and operational activity (good and bad) including those activities and relationships that

bridge functional and original firm boundaries.
<p>Supporting literature</p> <p>Failure demand (Seddon, 2003); Selection of resource (Etgar, 2006; Ng, et al., 2008); Input and output costs (Doost, 2006); Operational cost and co-location (Baines, et al., 2009); Cost of the service enterprise (Ng, et al., 2011).</p>
<p>Supporting primary data from case study</p> <ul style="list-style-type: none"> • The increased levels of Typhoon supplier involvement on base has resulted in much-improved benefits through lower overall cost. • The case study highlights speed of recovery as key to delivering availability and keeping all costs to a minimum. • The case study simulation comparisons confirm the approach to progressively increase on aircraft or on base repair will reduce cost. • The simulation also identifies a potential significant increase in the cost when adopting a supply chain approach involving dependent sequential activities. • The case study co-located, co-production, interdependent approach reduces the need for certain activities and reduces the amount of dependent activities that can attract poor performance. In turn this reduces cost. • The number of individual dependent activities required to achieve recovery reduces with the use of interdependent support activity. Reducing dependent activity reduces the scope for poor performance and can speed the availability recovery and reduce cost. • The provider (BAE Systems) interviewees highlighted that where co-creation is not considered possible and where dependent supply chain activities continue to manage the repair, it is essential to pay significant attention to performance management and to cost all service enterprise activities as the turnaround duration and cost can easily increase. • The customer (MOD) reported that cost as a result of poor performance creates a significant annual cost delta when multiple recoveries are undertaken.

Table 22. Literature and case study findings that support research Proposal 6 (Source

author)

5.7 Summary of discussion

The research review identified that the majority of literature on servitization proposes that incremental changes to culture and operations are required to servitize (Kaplan and Norton, 1993; Johnstone, et al., 2008; Baines, et al., 2009; Wilkinson, et al., 2010). However the literature review has also shown that emerging servitization literature building on thinking introduced by Service dominant logic (Vargo and Lusch, 2007) propose that more extensive changes to mind-set, organisation and ways of doing things are required (Ng, et al., 2011; Baines and Lightfoot, 2012; Barnett, et al., 2013).

The research case study findings are consistent with the literature review findings. Here the Typhoon support enterprise initially tried to develop the provision of their support to the Typhoon through incremental changes but have realised they are insufficient. They have therefore chosen to establish more aggressive changes to mind-set and organisation. This includes the customer, provider and supplier collocating and co-creating next to the aircraft with the provider assuming the customer management role. The findings also suggest that an explicit business model change is required to accommodate and reinforce the change from manufacturing and selling product to the provision of a service at lowest cost.

The research has therefore through the review and consideration of all literature and case study findings established six (6) research proposals for servitization that introduce:

- a paradigm change rather than incremental change
- a transformation to the business model
- a mind-set change in the role of the provider in performance management of the service
- co-location of customer, provider and suppliers with different ways to manage dependent and interdependent activities
- a shift to the de-coupling point between the provider and supplier

- cost efficiency of availability recovery by repairing equipment next to the asset

Research proposals 1 to 6 are brought together and used to construct a new model for servitization. The new model can be considered as the prime contribution of this research identifying the paradigm change required when moving from a firm providing manufactured product only to one providing a complex service.

The new model for servitization is illustrated in figure 17 below.

**A MODEL FOR SERVICISATION BASED COLLABORATION IN THE
UK AEROSPACE DEFENCE INDUSTRY**

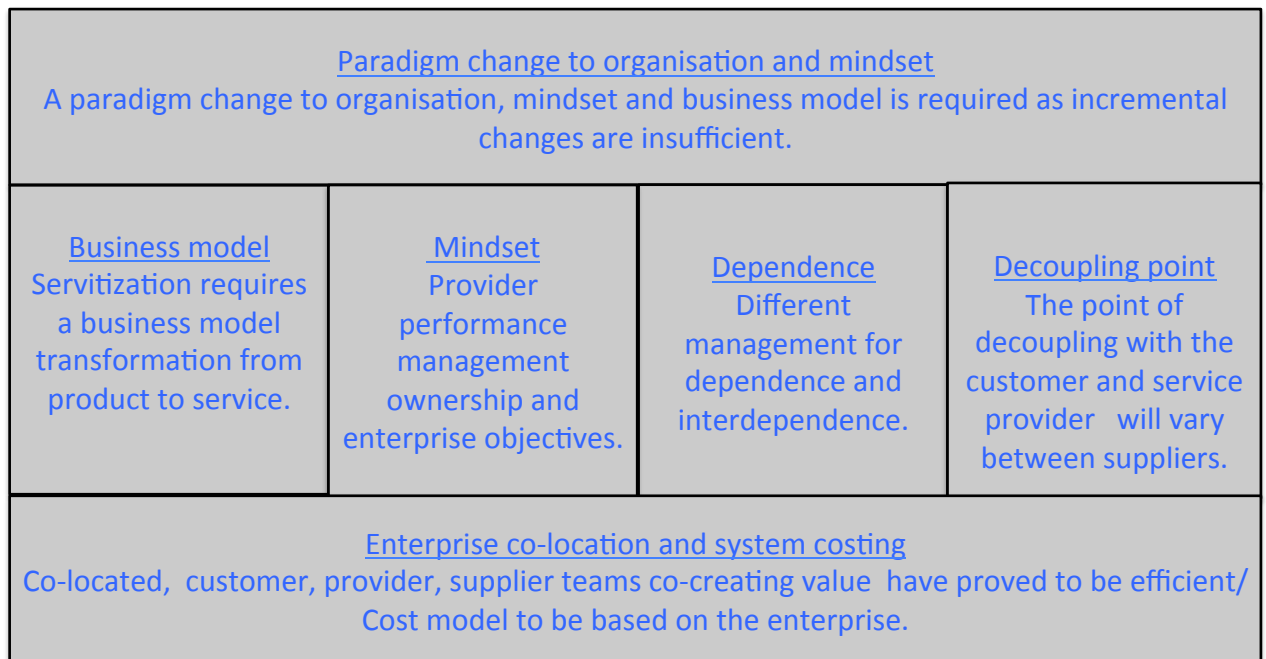


Figure 17. A model for servitization based collaboration in the UK Aerospace Defence industry (Source author)

The research proposals contribute to academic theory by extending and evidencing existing operational, enterprise and service theory. The research proposals also confirm to industry that their evolution through servitization including recent step changes to the way they think and work are correct.

It can be anticipated that research proposals 1 to 6 will manifest themselves in a new service organisation with a new culture designed to achieve maximum responsiveness. The following narrative and diagrams highlight the required shift from the supply chain product delivery structure (illustrated by Figure 18) to the new service enterprise organisation (illustrated by figure 19). Each of the research proposals will help form the new service organisation. It is proposed that these organisational ideas will be subject to further research within the involved organisations as the business implications are significant.

Pre servitization - Product Supply Chain

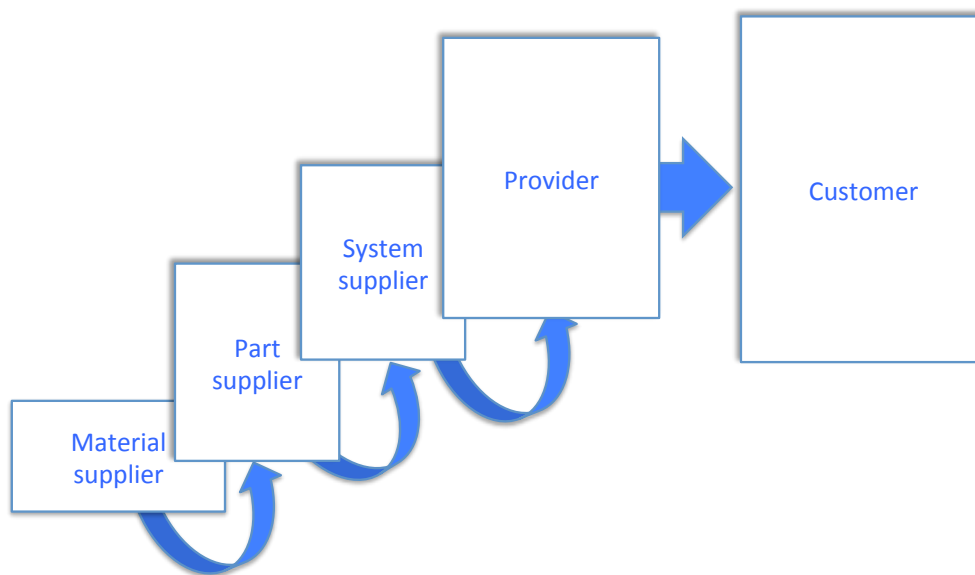


Figure 18. Pre servitization – Product Supply Chain (Source author)

The extant literature and the case study findings on Typhoon have identified those manufacturing organisations which servitize but remain tied to their previous industrial base and extended supply chain can be unresponsive, inefficient and too expensive. The extended supply chain, multiple management teams, mixed objectives, static resources and company and functional silos, and unresponsive product culture all lead to an inefficient service. Multiple unexpected costs arise reducing benefits for the provider.

The research proposes that to successfully servitize, the provider firm must embrace a paradigm change to both organisation and mind-set to create a service enterprise that is efficient and responsive. Physically this will mean moving away from the structure of the previous high cost industrial manufacturing organisation to create an agile focused service enterprise. To deliver efficiency and reduce cost an output focused dynamic single service organisation, with a single management structure, and a single set of objectives is required. As far as possible co-location of customer, provider and key suppliers is also desired to enhance value co-creation. Additionally the provider assuming the role of the customer, the increased use of interdependent activities, and the introduction of a service culture and skills will all deliver further improvement to the service enterprises performance. The service enterprise is illustrated in Figure 19 below.

Paradigm change to organisation and mindset required to deliver an efficient service enterprise

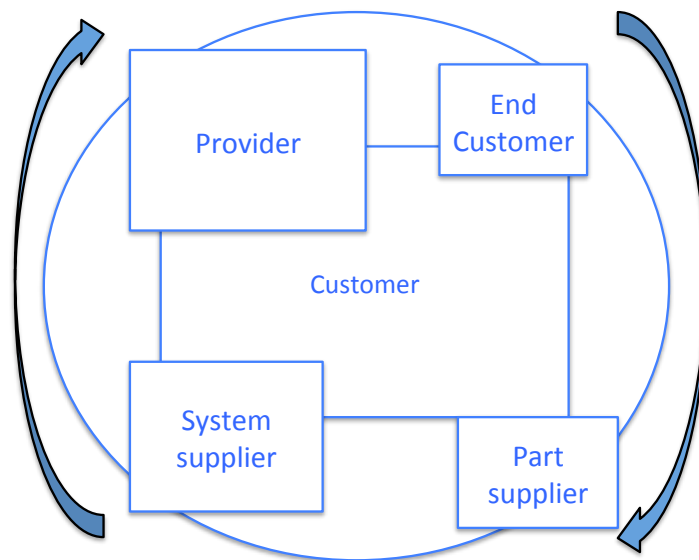


Figure 19. Service Enterprise organisation (Source author)

The organisational visions above will be subject to further research as the business implications are significant.

6. CONCLUSION

6.1 Introduction

This chapter provides a conclusion for the research. The chapter commences by restating the research aim, the underlying research questions and research methodology. Sections covering the literature review, the research case study activities and the research findings follow this. The chapter is completed with a short summary and personal statement.

This research has examined servitization and the interacting theoretical themes of competence, value, enterprise, performance and cost. The research has identified six findings. These findings combine to form a new model for servitization.

6.2 Research aim, methodology, literature review and case study

6.2.1 Research aim, questions and methodology

The aim of this research was to examine servitization to develop understanding of how a firm might best transform from one that produces goods only, to one that also delivers service. The study included developing understanding of servitization including the challenges of servitization, how value is co-created and how to improve performance management across the service enterprise where interdependent activity exists. This can help gain a better understanding of the problem of less than expected returns during and post servitization the dynamic labelled the servitization paradox by Neely (2008). Achievement of the above supported by an analysis of front of mind costs helped identify and develop understanding of the costs arising where a complex engineering service is provided.

The underlying research questions to achieve the above aim were:

- What are the features and challenges of servitization where a complex engineering service is being provided?
- What performance management should be established at the level of the service enterprise?
- What are the reported costs and front of mind costs for the provision of a complex engineering service?

In order to address the research questions a detailed review of servitization and related literature has been undertaken. A case study of a complex engineering service enterprise was completed providing a view of the dynamics involved. It was demonstrated that the research reflects the epistemological position of the constructivist whose inquiry dictates that the positivist subject-object dualism and objectivism be replaced by an interactive monism and that interactivity between researcher and researched be acknowledged (Guba, 1990). This was achieved by attempting to see the situation through the eyes of those involved in the running of the business, interacting with objects yet creating their own understanding of those objects and the situation surrounding them. Constructivism accommodates the fact that servitization is a recognised phenomenon that is still being shaped and detailed by academics and practitioners. Furthermore constructivism allows for both objective and subjective views. This helped the understanding of the objects within the case study industrial activity, the factory, the process, the product and the different perceptions of the individuals of their experience of servitization and those very objects within the enterprise.

6.2.2 Literature review

The exploration and review of extant literature on servitization has identified that the majority of the literature reviewed is at a conceptual level with less research exploring servitization in detail supported by case study data. Detail of practical application and knowledge captured from servitization in case studies is limited. Furthermore there is very little detail given on the areas pertinent to this study such as business models, performance management and through life cost where a complex engineering service is being provided.

Notwithstanding the above the review of literature on servitization and its key interacting theoretical themes has provided an in depth understanding of all aspects of servitization from definition to transformation strategies and operational performance. Literature does exist and definitions and concepts have been developed from the concept of value added services (Vandermerwe and Rada, 1988) to Product Service Systems (Hockerts and Weaver, 2002; Neely, 2008) to the recent concept of complex engineering service systems (Ng, et al., 2011). Transformation to the servitized state and how to organise the service enterprise activity has also been captured by the literature.

Here the majority of the literature on servitization proposes that incremental changes to culture and operations are required to servitize (Kaplan and Norton, 1993; Johnstone, et al., 2008; Baines, et al., 2009; Wilkinson, et al., 2010). However the literature review also identified that emerging servitization literature building on thinking introduced by Service dominant logic (Vargo and Lusch, 2007) proposes that more extensive changes to mind-set, organisation and ways of doing things are required (Ng, et al., 2011; Baines and Lightfoot, 2012; Barnett, et al., 2013).

As the literature review progressed, a research framework was inductively developed to capture servitization and the recurrent related sub themes identified in the literature (competence, value, enterprise, performance and cost). The research framework informed the empirical investigation of the servitization paradox directing the detailed development of servitization and each of the selected sub themes.

6.2.3 Case study

The single research case and multiple studies consisting of semi-structured interviews with senior managers at the UK Ministry of Defence, BAE Systems and GE Aviation highlighted the depth of change on-going at these organisations as a result of the servitization of support activities. Whilst all three organisations are undergoing change, servitization was especially apparent at the provider firm BAE Systems. Here BAE Systems are transitioning from manufacturing spares for sale and providing individual support services to providing the customer with asset availability at lowest cost.

The case study data collected on the areas of servitization, competence, value, enterprise, performance and cost provide an in depth understanding of the challenges of servitization currently being experienced by the Typhoon support enterprise. The case study confirmed the difficulties of transformation found in literature (Oliva and Kallenberg, 2003) highlighting multiple organisational, cultural and operational challenges that need to be managed and overcome to deliver optimal returns (Neely, 2008). The findings of the case study additionally highlight concerns over the design of equipment and customer management, which together with the problems associated with rigid contractual management and extended value chains are believed to give rise to equipment failures and inefficient recovery operations respectively. During the interviews the need to reduce cost including the reduction of No Fault Found was highlighted repeatedly.

The research case study findings are consistent with the literature review findings (Ng, et al., 2011; Purchase, et al., 2011; Baines and Lightfoot, 2012). The Typhoon support enterprise was found to have initially tried to develop the provision of their support to the aircraft through incremental changes to the organisation and way of working but realised this approach is insufficient. They have therefore chosen to establish more aggressive changes to mind-set and organisation. Approaches to achieve this include the customer, provider and supplier co-locating next to the aircraft with the provider assuming the customer management role. Under these new arrangements the provider is responsible for performance management of the service output rather than inputs alone. The findings also highlight that an explicit business model change is required to accommodate and reinforce the change from manufacturing and selling product to the provision of a service. Furthermore different ways to manage dependent and interdependent activities and a shift in the decoupling point of the co-located supplier are also identified. Finally the case study activity highlighted multiple front of mind costs associated with the provision of a complex engineering service. As part of the research a detailed analyses has been undertaken on these costs to establish their characteristics. A number of asset availability recovery approaches have been simulated using the data collected providing an improved understanding of the differences of speed and cost of each approach.

6.3 Research proposals

A synthesis of the literature review and case study analyses and findings has been undertaken and the following conclusions are drawn complete with six research proposals.

Reviewing the research findings collectively, and building on and supporting extant literature (Ng, et al., 2011; Meier, et al., 2011) and employing service dominant logic (Vargo and Lusch, 2007) to understand the dynamics of servitization this research proposes that incremental changes in management and operations need to be replaced by a paradigm shift in ways of working to achieve servitization (Barnett, et al., 2013). The findings highlight that servitizing firms should consider establishing a single dynamic enterprise that has the prime shared objective of providing the required service with a strong outcome focused culture (Baines, et al., 2009). The following proposal has therefore been established.

Proposal 1. Based on the research findings and where availability of a complex engineering service is required incremental changes to the existing way of working and existing business model do not appear sufficient. It is therefore proposed that a paradigm change in organisation, mind-set and ways of working is considered supported by the introduction of a new service business model.

Proposal 1 contributes to the body of literature on servitization. The proposal is supported by empirical evidence and highlights that incremental changes are insufficient when transforming from a manufacturing organisation selling a product to one providing a complex engineering service. Furthermore from a practical perspective it highlights that managers need to adopt a radical approach when seeking to capture value from service provision.

In support of the above this research identifies that the business model (Osterwalder and Pigneur, 2010) should be structured to help overcome the challenges of servitization and adjusted to reflect how value is now delivered. The business model is required to transition from one supporting the manufacture and supply of services offered in exchange for individually agreed fees to one supporting the supply of service for a fixed fee. The business model, businesses organisation and stakeholder arrangements should reflect one of a Complex Engineering Service System (CESS) (Ng, et al., 2011). A second proposal has therefore been established.

Proposal 2. A new business model, which embraces the service enterprise organisations and activities, is required where a complex engineering service is offered. As servitization progresses the business model transitions from one supporting manufacture and sale of product to one supporting the provision of service.

Proposal 2 contributes to the body of literature on servitization and is supported by empirical evidence. The case study extends the understanding of business models under servitization. The proposal also highlights to industry that each feature of the business model needs to be reviewed and changed to provide increased alignment between the new value proposition and its supporting activities during and post servitization.

The provider assuming the role of the customer (Baines and Lightfoot, 2012) and common enterprise objectives (Purchase, et al., 2011) will improve the enterprise

service performance. Furthermore orientating the performance management of the total enterprise system towards the availability of the asset is considered beneficial. Understanding and improving the performance and understanding and capturing costs created by interdependency will also contribute towards informed business decisions and improved business results. Commercial frameworks should also reflect that the commercial and operational risk is now shared across the enterprise (Pay and Collins Bent, 2008). This will further encourage flexibility and speed of response and problem resolution. Considering the above the following proposal has been established.

Proposal 3. A service enterprise will benefit from common performance objectives between stakeholders. The service enterprise will also benefit from the provider assuming the position of the customer and leading the performance management of the service output.

The proposal contributes to the body of literature on servitization and is supported by empirical evidence from the case study. For operations management literature it develops the concept of the provider taking over the performance management role of the customer (Baines and Lightfoot, 2012). For enterprise literature the case study findings provide evidence for the need for common enterprise objectives (Purchase, et al., 2011). The finding also supports industrial practice as it reflects the mind-set change of the customer and provider confirming their current approach to performance management is a positive development.

In addition to the three proposals above the research has also identified the following two findings that provide further support to the initial finding.

Proposal 4. Delivering a complex engineering service including value co-production and value co-creation can include both dependent and interdependent activity. Hence increased benefit can be secured from managing each type of activity in different ways.

Proposal 4 contributes to the body of literature on dependence (McNair, 1990; Barrick, et al., 2007; Callahan, Schenk and White, 2008; Aggarwal, Siggelkow and Singh, 2011) highlighting that dependent and interdependent activities can be managed in different ways. The proposal is supported by empirical evidence from the case study. Proposal 4 also contributes to industrial practice by providing understanding of dependence within

a complex engineering service activity.

Proposal 5. Where the service customer, provider and supplier are co-located the decoupling point (where material or component supply changes from push to pull) shifts to the co-located activity as the supplier becomes aware of the requirements as they arise. For the non co-located suppliers the decoupling point remains as previous.

Proposal 5 contributes to the body of literature on servitization and operations management by identifying a shift of the decoupling point (Ng, et al., 2011; Baines and Lightfoot, 2012; Mason-Jones and Towill, 1999; Garcia- Dastugue and Lambert, 2007; Olhager, 2010; Banerjee, et al., 2011). The proposal is supported by empirical evidence from the case study. Proposal 5 also contributes to industrial practice by highlighting the need to review and communicate supply requirements in a new way. This will be the subject of further research.

The sixth and final proposal has been established considering the case study reported costs, the multiple front of mind costs and the simulated recovery analysis.

Proposal 6. Where a complex engineering service is provided the most efficient asset repair is achieved by repairing equipment next to the asset. Such activity represents co-creation between the customer, provider and key suppliers. For this and other service activities the service cost model used needs to reflect the complete enterprise activity. The cost model should be able to capture the cost of the flow, the impact of poor performance and be able to calculate the outcome cost. Cost should include all hardware and operational activity (good and bad) including those activities and relationships that bridge functional and original firm boundaries.

Proposal 6 contributes to the body of literature on servitization and cost (Hanson and Mowen, 2003; Seddon, 2003; Doost, 2006; Ng, et al., 2011; Baines and Lightfoot, 2012) and is supported by empirical evidence from the case study. The proposal identifies that it is more efficient to manage equipment failure repairs next to the aircraft as opposed to returning the failed equipment through the supply chain for repair. This proposal is consistent with and supports the research proposals 1 to 5. The proposal also confirms

to industry that there are advantages in fixing equipment failures next to the aircraft and having a cost model that is capable of estimating and capturing the cost of flow.

As described in the previous chapter, the six proposals were brought together to construct a new model for servitization (see figure 17). This new model that can be considered as the prime contribution of this research identifies the paradigm change required when moving from a firm providing manufactured product only to one providing a complex service.

6.4 Summary

The six proposals and the servitization model extend and evidence the body of literature on servitization fully supported by empirical evidence. The research proposals also provide the industrial stakeholders with an improved understanding of servitization and confirm that the new arrangements introduced to their activities to date appear to be beneficial. Specifically the appointment of the provider to the customer role, the measuring of output, and the co-location of customer, provider and key supplier is considered positive by those involved and by this research. Considering the on-going problems associated with returns moving through the supply chain a further increase of on base activity should be considered.

The research proposals not only extend the body of literature on servitization but also answer the research questions in full. This in turn fulfils the research aim of developing the understanding of servitization and its challenges for industry.

6.5 Further research

The research is based on an in-depth single enterprise case study in the aerospace domain in the context of high-tech capital equipment service availability. Generalisability may be possible within aerospace where complex engineering service is being provided.

Further research is planned on the areas of servitization related to the findings of this research. This will include further development of the required organisational transformation to implement this paradigm shift including further investigation of the business model required, the changes to commercial arrangements and improvements to performance management required across the service enterprise.

6.6 Personal statement

This research has provided the researcher with an in-depth understanding of servitization together with an appreciation of multiple disciplines that interact with the phenomenon. Furthermore the research has revealed the complexity of the servitization to the researcher highlighting that an increased detailed level of research is required to further develop knowledge to guide and support servitization initiatives.

The research has also provided the researcher with an improved understanding of research methodologies including the understanding that mixed deductive and inductive approaches can be taken. The exercise has also highlighted the benefit of a responsive case study vehicle facilitating the collection of good primary data.

Finally the personal development offered and the findings of the research have far exceeded the researchers original expectations. The structure provided by the CATA project, the willingness of the industrial partners to engage in the work and the academic guidance were all very positive. The only limitations arising were those of the author as a result of his limited experience of academic life. However the research and opportunity to engage in teaching related subjects quickly balanced this leading to a rewarding experience increasing enthusiasm for more research.

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8. LIST OF FIGURES

- Figure 1. Servitization transitions (Oliva and Kallenberg, 2003) page 31
- Figure 2. A model of Social Capital and Value co-creation (Tsai and Ghoshal, 1998) page 51
- Figure 3. Scope of Value co-creation (Source author) page 52
- Figure 4. Generic business model framework (Osterwalder and Pigneur, 2010) page 57
- Figure 5. Enterprise Imaging (Parry and Mills, 2012) page 69
- Figure 6. Service concept model (Sasser, et al., 1978) page 79
- Figure 7. CADMID life cycle model (UK MOD Smart Buying 1998) page 83
- Figure 8. Servitization research, project and research management (Source author) page 100
- Figure 9. Research framework (Source author) pages 104 and 126
- Figure 9a. Research framework, servitization (Source author) page 130
- Figure 9b. Research framework, competence (Source author) page 152
- Figure 9c. Research framework, value (Source author) page 156
- Figure 9d. Research framework, enterprise (Source author) page 163
- Figure 9e. Research framework, performance (Source author) page 169
- Figure 9f. Research framework, cost (Source author) page 178
- Figure 9g. Research framework, servitization, competence, value and enterprise (Source author) page 201
- Figure 9h. Research framework, servitization, competence, value, enterprise, performance, and cost (Source author) page 209
- Figure 9i. Research framework, servitization, performance and enterprise (Source author) page 224

Figure 9j. Research framework, servitization, performance and enterprise (Source author) page 231

Figure 9k. Research framework, servitization, competence, value, enterprise, performance and cost (Source author) page 239

Figure 10. Framework theoretical features and themes (Source author) page 107

Figure 11. Single study, multiple cases (Source author) page 109

Figure 12. Typhoon support costs (Source author) page 143

Figure 13. MHDD Repair flow (Source author) page 150

Figure 14. Typhoon service enterprise map (Source author) page 167

Figure 15. Research framework features and research proposal interaction (Source author) page 199

Figure 16. Servitization research proposals hierarchy (Source author) page 208

Figure 17. A model for servitization based collaboration in the UK Aerospace Defence industry (Source author) 251

Figure 18. Pre servitization – Product Supply Chain (Source author) page 252

Figure 19. Service Enterprise organisation (Source author) page 253

9. LIST OF TABLES

Table 1. Goods v Service, different approaches to market (Parry, 2011) page 26

Table 2. An introduction to servitization, a summary of authors reviewed (Source author) pages 37, 38, 39, 40

Table 3. Life cycle phase uncertainties (Goh, et al., 2010) page 84

Table 4. In service phase uncertainties (Source author) pages 85

Table 5. Interacting features of servitization, a summary of authors reviewed (Source author) pages 90, 91, 92, 93 and 94

Table 6. Servitization literature timeline (Source author) pages 96, 97 and 98

Table 7. In depth research interviews (Source author) pages 115 and 116

Table 8. General site visits generating global understanding of businesses (Source author) page 117

Table 9. Specific site visits to develop specific process maps (Source author) page 117

Table 10. Steer team representative (Source author) page 118

Table 11. Summary of research, (Source author) pages 125

Table 12. Case study findings, coded categories (Source author) page 128

Table 13. Characterisation of Cost (Source author) pages 187, 188 and 189

Table 14 Literature and case study findings that support research Proposal 1 (Source author) pages 206 and 207

Table 15. Servitization, the transition from manufacturing business model features to service business model features (Source author) page 211

Table 16. Literature and case study findings that support research Proposal 2 (Source author) page 223

Table 17. Literature and case study findings that support research Proposal 3 (Source author) pages 229 and 230

Table 18. Literature and case study findings that support research Proposal 4 (Source author) pages 234 and 235

Table 19. Literature and case study findings that support research Proposal 5 (Source author) page 235 and 236

Table 20. Characteristics of independent and interdependent activities (Source author) page 237

Table 21. Comparison of recovery simulation results (Source author) page 246

Table 22. Literature and case study findings that support research Proposal 6 (Source author) pages 248 and 249

Table 23. Individual extracts (Source author) pages 287, 288, 289 and 290

Table 24. Philosophical paradigms and theoretical perspectives (Source author) pages 315 and 316

10. APPENDIX**10.1 Servitization literature review, individual extracts**

Throughout the text of the literature review on servitization key quotes have been identified. These quotes describe key concepts or understandings that help to provide an understanding of servitization. The extracts can be found below categorized against the research framework features.

Servitization framework feature	Individual servitization literature review extract
Servitization.	The larger more sophisticated firms with higher revenues, the very ones who chase servitization the most seeking higher profit actually appear to generate lower profits than pure manufacturing firms (Neely, 2008).
Servitization.	Service dominant logic importantly introduces a shift from use of the (plural) term <i>services</i> (reflecting a special type of output – intangible product) to the (singular) term <i>service</i> (reflecting the process of using ones resources for the benefit of another entity (Vargo and Lusch, 2007).
Servitization.	They proposed a new paradigm to be created to cut across the traditional goods and services dichotomy. This would be labelled the rental/access paradigm based on the premise that those exchanges that do not result in the transfer of ownership from seller to buyer are fundamentally different from those that do. Services are presented as offering benefits through access or tempory ownership with payments taking the form of rentals or

	access fees (Lovelock and Grummesson, 2004).
Servitization.	The focus of the value proposition moves from the product's operational performance to the products efficiency and effectiveness within the customer's process (Oliva and Kallenberg, 2003).
Servitization.	Service is characterised by inseparability between production and consumption and value is co-created with the customer. As service may be heterogeneous and context specific each time there is a customer interaction new complexity may be generated. Source, presentation by G.Parry (2011), adapted from G.M.Weinberg (2001).
Competences.	The resource-based view of a firm considers resources as that which we term properties that carry out transformation. They can be physical, human, technological or organisational. Competencies are the capacity of a group of resources when well managed to carry out an activity. The process through which such resources "become" is the capability or competence of the producer system (Ng, et al., 2011).
Value.	Value creation can then be defined by the specific consumer experience, at a specific point in time and location in the context of a specific event. The individual and his interactions define both the experience and the value derived from it (Prahalad and Ramaswamy, 2003).
Value.	Complex engineering service system competency is the ability of the firm to design, deliver and manage the entire complex

	engineering service system that is able to carry out the three core transformations, information transformation, material and equipment transformation and people transformation, in a consistent, stable manner, co-creating value in partnership with the customer and suppliers (Ng, et al., 2011).
Enterprise.	Dependence on other network members and hence their inability to fully control other network members and fully control their output has grown alongside a narrowing of the scope of their competences (Mills, et al., 2010).
Enterprise.	A boundary defining lens, which imposes a holistic management or research perspective on a complex system of interconnected and interdependent activities undertaken by a diverse network of stakeholders for the achievement of a common significant purpose (Purchase, et al., 2011).
Enterprise.	Whenever a business enterprise is established, it either explicitly or implicitly employs a particular business model that describes the design or architecture of the value creation, delivery, and capture mechanisms it employs (Teece, 2010).
Enterprise.	The concepts of servitization and vertical integration are closely related (Schemner, 2009). This is especially the case with complex engineering service captured by an availability contract where the provider assumes the activities previously undertaken by the customer. This can be considered forwards integration. This may be coupled with a relaxing or increasing of backwards integration in order to deliver an effective execution of a servitization strategy (Baines and Lightfoot, 2012).
Enterprise.	Interdependence changes the traditional view that maximising individual performance will lead to organisational success and is replaced by a focus on group performance. This refines the control

	process including the performance and accounting practices. The plan do review loop is redefined. The one to one mapping of individual actions to clearly identified outcomes is replaced by a focus on the effectiveness of a group of individuals engaged in interdependent activities (McNair, 1990).
Performance.	In manufacturing processes involving tangible products, inputs and outputs are relatively easy to measure. In services, measurement of both outputs and inputs is problematic especially where some of the input is provided by the customer, co-producing with the supplier (Kingman- Brundage, 1995).

Table 23. Individual extracts (Source author)

10.2 The analysis of front of mind costs

Cost 1. Many of the equipment designs need improvement to extend their mean time between failures in service. The UK Ministry of Defence have therefore committed to providing funding monies for design improvement each year.

“We are pushing ahead with a couple of million a year in development to deliver product enhancements”. Customer/UK Ministry of Defence

The cost analysis has identified the following for this cost:

- the cost is the result of a preventative activity
- the cost is a hardware and an operational cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an input cost
- the cost arises in an interdependent activity
- the cost arises during the transformation of information

Cost 2. Obsolescence costs are those associated with obsolescence of materials and components through the life of the aircraft programme. This is a major problem as life of

aircraft programme can be longer than forty years. This cost is escalating as the pace of technology development increases.

“The other obvious risk on Typhoon avionics is obsolescence risk which is horrible at any one year it will absorb millions of dollars for us with varying degrees of success of claw back through Eurofighter”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of a preventative activity
- the cost is a hardware and an operational cost
- the cost arises locally, upstream and downstream
- the cost arises as a result of poor performance
- the cost is considered an input cost
- the cost arises in an dependent activity
- the cost arises during the transformation of material and equipment

Cost 3. Training costs. Training required for the execution of the new allocation of task predominately being undertaken by the provider.

“One is capability development so recognising the new skill sets and competences of individuals to discharge a different contract”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a people cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an input cost
- the cost arises in an interdependent activity
- the cost arises during the transformation of people

Cost 4. Cost of training the joint RAF, BAE Systems teams. Repeated induction and training required due to the high movement patterns of RAF personnel and need to move BAE Systems staff to ensure cross fertilisation of ideas and understanding of the new arrangements.

“So within the joint teams in some cases industry people work for military officers and in others military people work for industry managers. This has to happen to allow the RAF to have competent people that they can deploy to wherever they are needed. That adds costs especially as the services move people around. It drives repeat induction, repeat training and extra cost”. Provider/BAE Systems

“We recognise the need to cross-fertilise people. We are trying to rotate people to get experience of delivering the service that we can then bring back into engineering where we develop the product”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a people cost
- the cost arises locally
- the cost is an expected cost
- the cost is considered an input cost
- the cost arises in an interdependent activity
- the cost arises during the transformation of people

Cost 5. Selected suppliers have been positioned on base to work on aircraft with the RAF and BAE Systems teams. This is required to deliver 5-day turnaround repair activity. This adds cost.

“We have suppliers on base. They are physically located at Coningsby. They fix it there so that customer satisfaction is a key point, I don't think we can go as far as to say obviously it has got to have more costs involved but it is the cost of having that service on base or having a number of assets on base versus having the facility of sending it back and the cost of transport and the time taken, so that's some of the risk assessment”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises locally
- the cost is an expected cost

- the cost is considered an input cost
- the cost arises in an interdependent activity
- the cost arises during the transformation of people

Cost 6. Additional cost arising due to the unsuccessful use of on-base general performance acceptance test equipment (GPATE). Cost generated as attempts to test equipment on base failed due to lack of skills and equipment.

“The way to go about it was to onshore the avionics repairs and develop test equipment called GPATE (General performance acceptance test equipment) but effectively it was flawed. During a pilot study it became obvious we did not have the capability”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an input cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 7. Cost arising as a result of the need to clean sensitive data from certain equipments prior to returning the equipments back through the supply chain.

“We sometimes hit complications; some of the equipment on Typhoon has data on it, which needs to be cleaned as it is confidential, mission critical, UK eyes only. The data is secret so is the procedure for cleaning so it is complicated and a problem as you have to store assets for cleansing as it is only efficient in a batch and that’s before sending it back. Multiple stages and restrictions take time and add cost”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost

- the cost arises locally and downstream
- the cost is an expected cost
- the cost is considered an input cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost. 8. Cost arising as a result of different standards of equipment creating the need for different test and repair actions at the supplier.

“Typhoon also has lots of different standards of equipment. Over time as it has constantly being developed and upgraded the assets are different standards and they may all need slightly different treatment, hence ideally we need flexibility on test benches and rework”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises locally and downstream
- the cost is an expected cost
- the cost is considered an input cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 9. Difficult suppliers. Extra budget and expenditure used to ensure management of problem suppliers.

“We do know the difficult suppliers which does impact. At negotiation of contract we often increase pricing to cover the potential problems that are then left to Procurement to manage”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises locally
- the cost is an expected cost

- the cost is considered an input cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 10. An agreed level of equipment arisings covered by procurement contracts. The contracts cover the baseline requirements as generated by the provider support modelling based on expected flying and known mean time between failures of equipments. This generates the basic, expected number of spares and repairs that generate a basic cost expectation against arisings (equipment failures). Equipment arisings were reported as 70% of the total support cost of £13.1 bn.

“We have 48 items under repair turnaround contract and that’s what the basic cost of service is against”. Customer /UK Ministry of Defence

“So the key cost driver in any support solution is the IP, the spares and ground support equipment and the cost of repairing and those on a daily, weekly, monthly, basis and the cost of man power to support the solution, be that manpower in maintaining aircraft or the manpower in supply chain activities and stores etc.”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises locally and downstream
- the cost is an expected cost
- the cost is considered an output cost
- the cost arises in both dependent and interdependent activities
- the cost arises during the transformation of material and equipment

Cost 11. Additional cost as a result of equipment arisings above the expected mean time between failures and thus above the baseline contract agreements.

“Any arisings above PC5 are chargeable” Supplier/ GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity

- the cost is a hardware and an operational cost
- the cost arises locally, upstream and downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in both dependent and interdependent activities
- the cost arises during the transformation of material and equipment

Cost 12. Equipment arisings where the repair turnaround time is managed on a case-by-case basis. These are additional costs incurred on repairing those equipments outside of the top 48 that do benefit from having an agreed turnaround repair time with the supplier. Lead times can extend (due to lack of control) adding cost.

“Going back to phase 3 the problem for us is not only the 48, it is the other case by case costs as well as you loose the logistics planning control because they are done on best endeavours”. Customer/UK Ministry of Defence

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 13. Increased supply chain costs generated by No Fault Found equipment returns and customer damage. Increased supply chain pressure increases inefficiencies between parts of the supply chain increasing costs.

“If it is a no fault found then there is a standard charge. The traffic up and down the supply chain however puts a lot of pressure on the overheads it is ridiculous. Very difficult to capture those costs as there are several hand offs. We can probably capture the costs within our business but there are inefficiencies which we pass on to each other”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is an operational cost
- the cost arises locally, upstream and downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 14. No Fault Found, exchanging the incorrect equipment doesn't resolve the real problem and epidemic breaks across multiple aircraft creating further cost.

"If you were to recognise that a particular component had broken on an aircraft and you did a sweep of 6 other aircraft and said right we need to ground them for three days to get it fixed then the customer will say and has on a number of occasions different instances no just replace the item we need to get the sorties out in the air and what it results in is failures of 10 and 20 components which would not have happened if the full fix had been done. An epidemic is created followed by a spike of activity ". Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises locally
- the cost is an expected cost
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 15. The supply chain multiple tiers, supply chain handoffs and resistance all add time and cost when moving equipments up and down the chain.

"Multiple stages and restrictions take time and add cost". Provider/BAE Systems

"Some repairs may seem very minor but when it impacts all the way down the supply chain it is going to drive your costs up and take spares out of service". Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises locally
- the cost is an expected cost
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 16. Sourcing product from international suppliers can add extra cost. However it is difficult to change, as it is expensive and politically unacceptable due to the launch work share arrangements agreed between the participating countries.

“Providing support via an international base is costly. Re-sourcing of equipment to the UK suppliers from the European suppliers is cost prohibitive. Work share also stopped it”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises locally
- the cost is expected
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 17. The base team performance can be poor when returning units to the supply chain. This can increase the cost of recovery and possibly create unexpected disruption and stock costs.

“The base is very functional even between buildings. This can slow the return of a repair”. Supplier/ GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity

- the cost is an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of people

Cost 18. The general performance acceptance test equipment (GPATE) on base can take longer to set up than expected. This can increase the cost of recovery.

“If you go down to Coningsby have a look at the general test equipment, it is not massively successful due to the time it takes to keep reconfiguring it. There’s a common core, basically an interface to bits of avionic kit. However with each box you plug in have to change the interface. It takes a long time to set up and configure for different boxes so it ends up being more costly”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 19. Returning equipment failures from international locations and bases can take longer than expected and can include multiple logistics activities. This can increase cost of return and recovery activities thereafter.

“It might be about your ability to get assets back into the supply chain really quick so how quickly can you get asset back from Libya back into the supply chain for repair. How quickly can you get them from Coningsby to a supplier in Germany”? Provider/ BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of people

Cost 20. Supplier performance including supplier willingness to perform can delay recovery, necessitate premium payments, consume management effort and create disruption costs.

“We are very good at measuring supplier performance. If it is poor performance we have the debate with the supplier and minimise the additional costs as much as we can or force them to absorb some costs”. Provider/BAE Systems

“My biggest frustration was I never felt we really got the suppliers attention. It is fine with some of the small guys who see us as a big partner but when you are dealing with some of the bigger guys it can be very clear where you fit in their priority list”. Provider/ BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises locally and upstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 21. When managing the repair of equipment failures to a tight turnaround time capacity needs to be planned in advance. Late demand forecasting by the provider to the supplier can create delay and or extra effort and cost.

“Both the vendors and ourselves have to work together on spares and repairs especially where we are trying to improve. A lot of this is getting forecasting into the vendors so they can plan”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of information

Cost 22. The supplier must receive all of the correct paperwork before the equipment repair activity can commence. Missing or incorrect paperwork can cause a delay and the need for special recovery activity hence adding extra cost.

“We receive the line replacement units at GE Aviation, book in and record for performance measure. Check record card and physical damage, check for customer damage (potential interact with workshop), Match unit to purchase order, book in as IRS or case by case or customer damage. It only starts when the paperwork arrives”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of information

Cost 23. All equipment failure repairs are different. The work required to repair the equipment is therefore different and emerges as the failure is investigated on test or

strip. This makes it difficult to balance workflow across the enterprise and can also create delay. This can create additional cost.

“We strip mechanicals to identify repair but we test electronic packages to find fault to repair. No repair is the same. Work is emergent. Testing is the most time-critical activity”. Supplier/ GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 24. Batching of equipment failure returns within the greater enterprise prior to return to the supplier creates unbalanced returns to the supplier causing activities that add cost. When the supplier receives a large batch they may not have the capacity to repair all of the units immediately. To maintain turnaround expectations the supplier will reorganise, work overtime and add new shifts. This extra effort adds cost to the enterprise system.

“Batching is a problem, it is disruptive. Again the guy who is consolidating them must understand balancing the work across the chain”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 25. To complete the equipment repair within the expected lead-time replacement parts may need to be made within reduced lead-times. Special arrangements are made by the suppliers production department to be able to respond quickly. This creates extra cost.

“It does cause us extra costs. To achieve the performance we have to say to the production guys we need you to work overtime. I go to my bosses to get the ok to do it and we have done that and we do that quite frequently to get over those peaks in demands”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 26. To complete the equipment repair within expected lead-times parts may need to be procured by the supplier from his suppliers on a priority-ordering basis. The supplier may charge more adding extra cost.

“Sometimes we have to order from suppliers on a priority basis, that sometimes costs”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 27. Economic batching of equipments during the returns process increases the total repair lead-time and stock costs.

“A problem that is a typical one is people tend to batch things up. If there is a problem, say a part is broken they may hold them until they have a few”.
Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 28. A balanced decision between stock required, stock held and recovery lead-times has to be taken. Holding of too much stock in the supply chain adds extra cost.

“There is obviously a cost to stock the shelves with spare replacement items but if you can reduce the repair times you need less total assets, you buy less, pay for less, and save. The problem is at some point you have to make the assumption about what the repair turnaround time will be, you’ve bought the asset so then you want to reduce the turnaround time which probably costs some money”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 29. Unexpected random failures of equipment can occur where no safety net exists. This drives unexpected local output cost.

“It is the strangers of failure the randomness of failures which you did not expect, you don’t have all the algorithms say what it is going to be you haven’t got the spares, you haven’t got the capability and at that point you are in trouble”.
Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an output cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 30. The resources and effort have increased with the provision of the new value proposition. This increases cost.

“Clearly as we have gone into providing more services we have applied more resource so the costs have gone up with the value proposition”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a people cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in both a dependent and interdependent activity
- the cost is as a result of people transformation

Cost 31. The UK Ministry of Defence as customer has positioned the provider BAE Systems to manage the third parties who had previously reported to the UK Ministry of

Defence. This includes the reduction of alleviations on penalties previously given to the provider to cover late deliveries as a result of poor third party performance. This change greatly increases the risk held by the provider BAE Systems. This may potentially impact on availability and cost (operational disruption and or financial penalty).

“We are currently negotiating the 3rd contract iteration. Each time we have increased the accountability on BAE to reduce our customer dependencies as much as possible”. Customer/UK Ministry of Defence

The cost analysis has identified the following for this cost:

- the cost is the result of an external failure
- the cost is an operational cost
- the cost arises upstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in both a dependent and interdependent activity
- the cost arises during the transformation of people

Cost 32. Poor design and the slow design change process and or short term contracting slows the speed of change and hence slows the reduction of equipment arisings. This extends the level of failures arising adding extra cost.

“The mean times between arisings drawn up in the 90’s were optimistic. The real mean times between failures are not what they should be due to incorrect design”. Customer/UK Ministry of Defence

“We are still in the design and make world where we unnecessarily compromise the through life performance to meet short term targets” Provider/BAE Systems (50)

“If you are looking for savings opportunities but cannot get savings back within the current contract it is really hard to justify”. Supplier/ GE Aviation

“Products are failing, some more than others. The design is not optimised for service. GE would like to introduce design changes but the change process and cost makes it difficult to obtain acceptance”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises locally, upstream and downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of information

Cost 33. Product and risk averse culture and contracting, slows responsiveness between customer and provider and provider and suppliers. This extends the lead-time of equipment repairs adding cost.

“Industrial relationships are good. The contracts get in the way”. Supplier/GE Aviation

“I think we are at the point where we have two equal camps. Half still in design and make world who think the job stops when we wave it off the end of the runway and then the other half of the business which is trying to get more recognition, more understanding and therefore more emphasis on changing behaviour, process and culture we need to effectively build a service”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is an operational cost
- the cost arises locally, upstream and downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in both a dependent and interdependent activities
- the cost arises during the transformation of people

Cost 34. Cost related to green culture. This is where progress is incorrectly reported to plan but actually the real performance is unacceptable. This can hide and generate additional costs.

A green performance culture exists where the staff repeatedly refuse to acknowledge that business problems exist and insist the performance is acceptable. The staff incorrectly report problems or poor performance as green on performance management tools where red means late, amber means recovering, and green means on track.

“Within the new availability arena’s we had a sea of green coming back to us from the various areas whether it be functional areas or support but it was not working”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of people

Cost 35. Rushed or poor fault detection of failed equipment on the aircraft can cause the selection and return of the wrong equipment (No Fault Finds). The incorrectly selected equipments can be returned through the supply chain to the supplier, tested and when no fault is found are returned to base. This adds multiple unnecessary costs. The following quotes from multiple interviewees further explain this problem dynamic.

“Under the previous full service any repairs we put in or any no fault finds were all part of the cost. Under phase 3 if it is a no fault found that’s extra cost”. Customer/UK Ministry of Defence

“The equipments are 70% of support costs. 30% of the 70% are from no fault finds on a budget of 13bn that’s a lot of money”. Provider/BAE Systems

“Their view of the service would be we have a problem it could be one of these 4 LRI’s we have them all on the shelf lets change them all. His pressure is getting the jet flying again. That behaviour is getting less. What happening as part of the availability is we recognise what drive cost down the supply chain. We’ve got to

much cost in stock or to much being sent back so we are now managing through arising rate management". Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 36. Difficult identification of problem on aircraft leads to exchanging multiple different units on aircraft to be sure on fix. This may lead to multiple no fault founds incorrectly returned through the supply chain raising multiple unnecessary cost.

"The system is complex and when someone is on the line and he has to get that jet back flying the next morning and he knows there's a problem in a radar and he says it is either LRU 3 4 OR 7 but I need to do a, b, c, d to check it, if I swap the 3 LRU's for the 3 on the shelf then I am quite confident that when I start the aircraft it will work. That action generates no fault founds". Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 37. Customer damage of aircraft equipment creates additional work and cost for the provider and the supply chain. This includes the cost to replace hardware, increased pressure on supply chain, and potential additional cost for parts for repair. Additional cost may occur if there is dispute between the customer and the provider delaying the

recovery activity. The following quotes from BAE Systems and GE Aviation interviewees highlight the problem of customer damage.

“I wont give you too many specifics but they load a data module into a receptacle and when you load it, it is supposed to be just slid slightly and the flap goes down. I understand that it is rammed home and it gets damaged. So you take the data module out go to a different aircraft push it in and it is damaged that one and it is just an epidemic and to the extent that at the end of last year we had a real shortage of these data modules”. Supplier/GE Aviation

“One problem is where the maintenance hasn’t been done to publications for a number of reasons and therefore that’s caused us problems”. Provider/BAE Systems

“The customer often damages the MHDD bolts, that add cost and effort”. Supplier/GE Aviation

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is a hardware and an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance,
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 38. Customer priorities (which are different to the provider priorities) may slow the return process for some units and add cost.

“The difficulties that cost money are around the different priorities that the customer will have to our selves”. Provider/ BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is an operational cost
- the cost arises downstream

- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of people

Cost 39. A mix of objectives between companies, functions and individuals can exist. This can lead to mixed decisions and incorrect action slowing the repair of equipments. This can add extra cost. This statement is supported by the following quotes from BAE Systems and GE Aviation interviewees.

“It is difficult and maybe too big to manage and I think the way to do it is to have a virtual enterprise and make sure that people in it all have the same objectives to the middle and bottom”. Supplier/GE Aviation

“Different bits of the chain work in different ways, things can always be improved, it is complete with multiple stakeholders across multiple sites with multiple objectives and complicated pieces of equipment and a whole series of complications on going all the time”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is as a result of an internal failure
- the cost is an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of people and information

Cost 40. Due to the nature of a complex engineering service many organisations and individuals can be involved. This can be ten (10) fold greater than the interfaces required for production. The multiple interfaces across the supply chain add cost.

“Providing a service rather than producing a product is more difficult as there is probably a factor of 10 times the number you need to interface with in order to deliver your element of the work. The number of stakeholders quadruple to deliver

the service which means I cannot deliver what I need to deliver from Engineering without the full involvement of the other functions". Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of people

Cost 41. The complexity of the aircraft mission systems and specific recovery activities required can add cost. Once the equipment has been checked the aircraft system must be synchronised. This can be time consuming and can lose sorties, hence loss of availability, and impact on cost and performance.

*"From a mission systems viewpoint on specific systems they are designed to work but occasionally break. Typhoon is very complex aircraft and when they fire up the aircraft they get multiple warnings some of which are not real, but if it does come up a number of times and it is a go no-go failure you then have to check it then the challenge is to get that system back in synchronisation with the rest of the jet and losing sorties left right and centre because other systems are not coming on line properly. These issues also drive cost and impact on key performance indicators".
Provider/BAE Systems*

The cost analysis has identified the following for this cost:

- the cost is the result of an internal failure
- the cost is an operational cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 42. Spares costs and holding costs exist at multiple levels of the enterprise supply chain. This includes customer initial provisioning, provider stock, and supplier stock, LRU's, SRI's and parts.

"Suppliers carry stock, we carry stock, customers carry stock and you have mountains of assets everywhere". Provider/BAE Systems

"GE Aviation stock spares for repairs". Supplier/GE Aviation

"You may have a lot of incentives on some to deliver spares out of Salmesbury or the rest of Europe but actually if there is no demand for that particular spare on a given day then it is just going to sit on the shelf and increase cost". Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises locally
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 43. Additional costs can be incurred when the aircraft systems supplied by multiple international parties require updating to fix operational problems. The complex workshare arrangements generate additional cost when the updating of the design is required and extends across the 4 national industrial partners.

"On Typhoon the responsibility for design is split so the navigation system may be a German system design responsibility, within that there are splits, a UK part a Spanish part, that's very costly to develop but also maintain. When you wish to update a platform the last thing you want to do is update a piece of equipment with four lots of overhead, integration costs, so it is difficult to see how that's a model for availability". Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

Cost 44. International collaboration can work for production activities but can become very slow, difficult and expensive when applied to support.

“I think in collaborative projects that’s fine when you are doing production and possibly when you are doing upgrades but when you get to the world of support it doesn’t really work very well but because on Typhoon we are not really at the point where all the production is finished and just into support no one is prepared to have those debates. It obviously drives cost into the system. Time, people, mark ups, EPCs levies, double dipping etc.”. Provider/BAE Systems

The cost analysis has identified the following for this cost:

- the cost is the result of a compliant activity
- the cost is a hardware and an operational cost
- the cost arises locally and downstream
- the cost arises as a result of poor performance
- the cost is considered an outcome cost
- the cost arises in a dependent activity
- the cost arises during the transformation of material and equipment

10.3 Additional focused literature review, research paradigms and methodologies and servitization literature

In addition to the literature review detailed in chapter 2 a further review of servitization literature has been undertaken focused on the theoretical perspective of the authors and the research methods used. This additional review has been undertaken to develop an understanding of which methodologies have been used to research the phenomena of

servitization as it has emerged. This identifies which research approaches have been successful and which style provides the deepest level of understanding. This review further assists in the selection of the most appropriate approach for this research where depth of understanding is considered crucial.

A sample of twenty papers from leading authors on the subject has been selected and reviewed to better understand the enquiry paradigms chosen to help explain the phenomenon, and to identify the theoretical perspective and methodological approach employed in each. The twenty papers include: Levitt (1972), Levitt (1976); Thomas (1978); Vandermerwe and Rada (1988); Prahalad and Ramaswamy (2000); Bowen and Ford (2002); Prahalad and Ramaswamy (2003); Prahalad and Ramaswamy (2004); Vargo and Lusch (2007); Vargo and Lusch (2008); Neely (2008); Vargo (2008); Spring and Araujo (2009); Baines, et al. (2009); Gebaur, et al. (2010); Purchase, et al. (2011); Datta and Roy (2011); Meier, et al. (2011); Neely, et al. (2011); and Ng, et al. (2011). The papers have been reviewed and allocated against a framework of theoretical perspectives (see Table 9 below). The framework informed by Burrell and Morgan (1979), Guba (1990), Crotty (1998), Gergen (1999), Johnson and Duberley (2000), Blaikie (2010), adopts the perspective of Crotty (1998) and the framework established by Burrell and Morgan (1979). It incorporates the perspective of Crotty (1998) who merges epistemology and ontology, as the underlying assumptions underlying every research are both ontological and epistemological (Blaikie 2010). Crotty (1998) merges the two and subsequently identifies a number of epistemologies set on a continuum. Crotty (1998) proposes objectivism (positivism) and subjectivism and interpretivism with constructivism in-between. This continuum is similar to the lower half of the framework proposed by Burrell and Morgan (1979) that positions interpretivism and functionalism (positivism) in a similar way. Table 16 below summarises this discussion.

Objectivism	Constructivism	Subjectivism
Positivist	Constructivist	Interpretivism
Truth and meaning reside in objects/objects exist.	Individuals construct meaning on objects reflecting interplay between object and subject.	Meaning imposed on the object by subject. Uncritical form of inquiry and understanding, accepts status quo.
Experiment.	Open interviews to gain understanding.	Culturally and historically based interpretation, Hermeneutics (bible), Symbolic interactionism,

		Phenomenology.
Mathematical, Natural science.	Qualitative, Words.	Deep understanding.
Neely (2008), Neely (2011).	Baines, et al. (2009), Gebaur, et al. (2010), Purchase, et al. (2011), Datta and Roy (2011), Ng, et al. (2011).	Levitt (1972,1976), Thomas (1978), Vandermerwe and Rada (1988), Prahalad and Ramaswamy (2000, 2003, 2004), Bowen and Ford (2002), Vargo and Lusch (2007, 2008), Vargo (2008), Spring and Araujo (2009).

Table 24. Philosophical paradigms and theoretical perspectives (Source author)

The sample papers have been allocated to the perspectives of objectivism, subjectivism and constructivism to reflect the theoretical perspectives used. Twelve papers are considered as written from a subjective, interpretivist perspective. This includes Levitt (1972, 1976), Thomas (1978), Vandermerwe and Rada (1988), Prahalad and Ramaswamy (2000, 2003, 2004), Bowen and Ford (2002), Vargo and Lusch (2007, 2008), Vargo (2008), Spring and Araujo (2009). Six papers are considered as written from a constructivist perspective. This includes Baines, et al. (2009), Gebaur, et al. (2010), Purchase, et al. (2011), Datta and Roy (2011), Meier, et al. (2011), Ng, et al., (2011). Two papers are considered as written from an objective, positivist's perspective (one paper and an extension by the same author) Neely (2008) and Neely (2011).

The split in the use of enquiry paradigms is not surprising and may be a reflection of the age and development of the subject. As servitization is complex, relatively young and has been developing for a relatively short period one would expect to have a high proportion of conceptual papers introducing discussing and shaping the topic followed by case study papers adding detail. The split may also reflect the increasing popularity of alternative theoretical perspectives to positivism. Although Johnson and Duberley (2000) confirm positivism is still the most familiar epistemological orientation, a basis to build from and even a virtual aspect of our common sense they are quick to point out that it has recently been under increasing attack from a variety of rival orientations.

The first category comprises twelve subjective, conceptual papers published from the 1970's onwards. This first category of papers adopts an interpretivist perspective reflecting that the subject imposes meaning on the object employing a methodology that relies heavily on naturalistic methods. They are written by senior academics (Levitt,

Thomas, Vargo and Lusch), use very few references or examples of industry and are short in comparison to the second category of papers written from a constructivist perspective. They include some interviewing, and observation but mainly pose their argument from original thoughts and through the analysis of existing texts (Bryman and Bell, 2011). The papers focus on new concepts in turn encouraging further original thought. Prahalad and Ramaswamy (2003) state that they use examples as thinking props to encourage the reader to think differently.

Interpretivism is viewed as a critical form of understanding that accepts the status quo and is culturally and historically positioned. Its intellectual roots can be traced back to the work of the early German idealists, Dilthey, Husserl and Weber and is regarded as a twentieth century phenomenon (Burrell and Morgan, 1979). Sub sections include, solipsism (the most extreme form of subjective idealism), hermeneutics (the study and understanding which is based on the bible and the least extreme), symbolic interactionism and phenomenology. The latter phenomenology includes the revisiting of existing meanings and theory in order to modify and develop them and can include much observation and dialogue that can extended to community discussion and agreement (Crotty, 1998). The first category of papers could be described as produced in this way as they try to put their immediate understanding aside to avoid immediate interpretation (Crotty, 1998). The research also reflects hermeneutics as the various research activities focus on interpreting and understanding the products of the human mind that characterises the social and cultural world (Burrell and Morgan, 1979). They follow the views of Dilthey who singled out hermeneutics as a key method in social sciences advocating that social phenomena of all kinds should be analysed in detail and interpreted as texts to identify their essential meaning (Burrell and Morgan, 1979). Finally the writers wish to develop ideas and concepts and hence gently invoke change. However this approach is far removed from the revolutionary change desired by those writers identified with critical theory driven by the need to challenge the class system and the oppression of man (Crotty, 1998).

This category of papers actually includes three sets of papers that refer to, reflect and build on one another developing their subject. In fact the set of papers from Vargo and Lusch (2007, 2008) and Vargo (2008) relate to a bigger set of papers numbering 12 in total running from 2004 to date, all of which incrementally build the idea of service dominant logic. Central to these papers on service dominant logic is the development of

a new way of thinking and language to help business find new labels and phrases that help us think and conceptualise afresh (Vargo and Lusch, 2007). Their view is consistent with that of Gergen (1999) who pronounced “if language is a central means by which we carry on our lives, then carrying the past into the present to create the future, then our ways of talking and writing become key targets of concern”. Here the authors believe that reality is considered as an output of how we think and discuss. Crotty (1998) states similarly that language is central to the human being, shaping the situations in which we find ourselves enmeshed, the practices we carry out and the understandings we are able to reach. He further adds that language represents and articulates our concepts of reality, which in turn reproduce or reflect reality.

The papers focused on service dominant logic actually introduce and build the concept through each paper released together with the inclusion or exclusion of comments made by the community of scholars interested in the subject. This reflects the approach of sharing and discussing concepts and theories within a community.

Service dominant logic represents an incomplete evolutionary shift and a perspective that is actively and collaboratively developing. Since 2004 the Foundational premise (Vargo and Lusch, 2004) has been tweaked several times and has also undergone a comprehensive update, all based on reactions and input from interested scholars’ (Vargo, 2008).

Theodore Levitt (1976) also draws attention to words and understanding and the need for new perspectives and underwrites the power of the senses by stating ‘man lives not by bread alone, but mostly by catchwords. What man believes and feels in his mind and emotions are more deterministic than what is in his physical possession’.

Two of the twelve papers and notably the later of the papers to be published Bowen and Ford (2002) and Spring and Araujo (2009) build on existing theory reflecting the hermeneutics approach (the study and understanding which is based on the biblical studies) interpreting and building on existing scripture. They raise points of interest, introduce new ideas and arrive at conclusions after reviewing and synthesizing what has already been said and written in previous papers. Bowen and Ford (2002, p.465) actually finish their paper by stating that ‘the evidence they have tabled suggest there are a great many opportunities for empirical investigations and they hope that their review has provoked interest in pursuing them’.

The papers comprising the second category are written from a constructivist perspective. They are the more recent of the papers included in the sample, published within the last four years and number six in total. These papers all have a similar methodological approach that is inductive and qualitative in nature reflecting the need to establish a deep understanding of the phenomena under review.

The papers are well structured, very detailed and the research approach is one of the social world. Each research includes an extensive detailed review of literature on servitization and research in the form of an industrial case study to better understand the reality of servitization in order to build on the existing theory and understand how these (theory's) impact on operations (Datta and Roy, 2011). These papers target the development of a deep understanding of servitization from those involved and thus obtain an understanding of the interplay between subject and object. This is the epistemological position of the constructivist whose inquiry dictates that the positivist subject-object dualism and objectivism be replaced by an interactive monism and that interactivity between researcher and researched be recognised (Guba, 1990). This is achieved by seeing the situation through the eyes of those involved in the running of the business interacting with objects yet creating their own understanding of those objects and the situation surrounding them. Everyday knowledge is the outcome of people having to make sense of their world and other people with social scientists reinterpreting this everyday knowledge into technical language (Blaikie, 2010). The researchers have therefore collected data from interviewees of organisations who have servitized. Here depth of interview and situational understanding is considered key. Each paper follows a similar pattern collecting data and developing understanding across selected industrial activities and processes and synthesizing those findings with literature findings with an aim to further develop theory. The case study organisations are complex providing high tech capital equipment and support and include BAE Systems, Rolls Royce, MBDA, Swiss Federal Railway and a collection of German equipment manufacturers. They are notably all operating in Northern European developed economies, a leading area for servitization (Neely, 2008). The approaches of the six researchers reflect the approach of a constructivist as the research inductively builds the meaning of reality on something that exists. This can be considered at the level of the phenomena (in this case servitization) and what is known about it and also at the level of the industrial activity and the products and services within. Each of the

researchers achieve their aims by interviewing individuals within their selected case study businesses to obtain their view of reality of the phenomenon of servitization in their place of work. It is research based on the understanding of reality from those involved and therefore reflects the constructivist perspective that meaningful reality is constructed by humans on their world and objects in their world (Crotty, 1998). The activities researched also reflect social constructionism, as there is an amount of shared meaning in the findings, and there appears to be consensus across the functions of the unit of analysis reflecting the existence of strong cultures.

The methodology chosen for these six researches can be considered typically constructivist and inductive as meaning is emergent. As the research and paper develops so does the meaning. They can also be described as qualitative as they are all about words and understanding. Relevance is preferred to rigor with an expansionist rather than reductionist stance towards inquiry (Guba, 1990). They include a review of existing theory, which is subsequently built on by the data from interviews of individuals working in servitization. Asking how and why questions to gain an understanding of reality as viewed by the interviewees through their frameworks obtains the research data. In general the interviews are conducted from multi functional perspectives with the findings coded, analysed and then used to construct the framework. All six researches can be considered ideographic as they all create a deep and full understanding of the case.

The six pieces of research deliver a variety of new understandings and concrete theoretical constructs and frameworks for the effective and efficient delivery of products and their associated services. In general they provide an improved understanding of what is required in terms of operations, skills, process and culture to deliver product and service providing a basis from which to construct a set of guidelines to assist industrialists in moving their organisations to a successful servitized state (Baines, et al., 2009). In support Meier, et al. (2011) believe and quote “the industrial projects (research driven) will help improve the methods”.

Finally the authors appear to have achieved the aim of constructivist science, which is to create idiographic knowledge understanding the meaning of contingent, unique and often subjective phenomena (Guba, 1990).

The third category comprises two papers from an objective, positivist perspective are Neely (2008) and Neely (2011). In fact they are not only by the same author but are linked, the second paper being an update to the first. The papers focus on servitization the movement of manufacturing firms to offer products and services (Vandermerwe and Rada, 1988) rather than products alone. The research aim is to fill a gap in the literature by presenting empirical evidence on the range and extent of servitization (Neely, 2008). It views that extant literature on servitization is generally based on case evidence with little empirical evidence truly exploring the phenomenon and its commercial impacts. Furthermore the paucity of empirical research concerning the phenomenon and that which does exist raises the question of a service paradox, namely that it appears more difficult for firms to make incremental profits by adding services than might be expected (Gebauer, et al., 2005; Reinartz and Ulaga, 2008). It is this gap in the literature, which the paper seeks to address, by presenting a detailed empirical analysis of the servitization of manufacturing. This is the only piece of work of this nature identified.

The two papers are clearly structured, contain multiple charts and tables and have the immediate look of a paper written from the theoretical perspective of a positivist. Neely (2008) recognises that the phenomenon of servitization exists and quotes, 'manufacturing firms are servitizing' and 'there is clear evidence for servitization of manufacturing'. He takes a positivist approach. He has his subject and existing theory and proceeds to test it. This reflects the received view of positivism often referred to as 'Popperian', which promotes the concept of 'test to refute', until you prove it correct. Popper argues nothing can ever be finally proved but that repeated testing (and survival of the hypothesis) means that something can be proved 'enough'. Neely (2008) compares and analyses multiple 'given' facts and data developing meaning and building reality taking a typical positivist's natural scientific approach. Neely (2008) seeks to explore questions such as to what extents are manufacturing firm's servitizing? If they are servitizing, how are they servitizing and are they profitable and do the observed trends vary depending on firm size and or country of firm incorporation? The research and paper is objective, value free and non-critical. Neely (2008) manages to deliver a balance paper that considers the findings and the phenomenon itself. This avoids the criticism that some positivists research attract that so much priority is given to the measurements that only its tangible aspects can be apprehended, and thus the indices of the phenomenon become more important than the phenomenon itself.

The methodological approach taken by Neely (2008) is typically positivist. The research in the first paper is deductive based on the analysis and comparison of facts to test and prove existing theory and Neely's hypothesis. Neely (2008) states "the intention here is not to suggest that solutions will replace products, or that relationships will replace transactions, but instead to highlight the fact that solutions are supplementing products, relationships are supplementing transactions etc." This can be considered accretion as it builds on existing academic theory. It is quantitative by nature and uses a sample of 10,651 firms from a large accepted, existing database of 44,000 firms worldwide. Neely (2008) codes, analyses, cross analyses and compares the facts including regression analysis to establish causal relationships and increased understanding. It can be considered nomothetic as it provides generalised understanding from a large sample. The research establishes key facts on the size, shape and extent of the movement. It also establishes correlations between size, location, profitability and cost of servitization that allows Neely (2008) to establish new understanding. Neely (2008) proposes that a number of management and operational issues need to be managed differently to avoid poor return. The challenges identified that need to be mastered are; the need to change mind-sets; the need to manage business over extended periods of time; the change in customer requirements; and the challenges of transformation itself. Neely (2008) also uses the paper and findings to increase the categories of Product Service System from 3 to 5. Finally the contribution of the paper lies in the fact that it is one of the first to unpack the notion of servitization empirically.

The second paper follows the pattern of the first updating the growth of the movement with a global focus significantly identifying that servitization within the world's developing economies is quickly catching up with servitization in the more developed economies of the western world. Of special note is the growth in number of manufacturing firms that have servitized in China. This has doubled from 10% to 20% within three years. This is a clear signal to the western world that the service market will quickly achieve the same competitive characteristics as the product only markets.

The review of the sample of twenty servitization papers suggests that literature on servitization has evolved in a natural way. The early concept based papers carry an interpretive perspective identifying servitization as a real phenomenon. Case study based papers from a constructivist perspective follow with an aim to better understand the drivers and impacts as seen by the people involved. These start to produce a deeper

level of understanding. Only one positivist's numerical attempt at scientifically measuring the phenomena has been identified. This type of approach may increase as the understanding of servitization is developed and more data and theory is available for test and comparison. The findings of this additional literature review suggest that this research will be best served by selecting a qualitative and case study approach, as its intention is to develop further in depth understanding of the phenomena. Furthermore the findings highlight that the research should aim to develop a deeper level of understanding than previously achieved through extensive interviewing of the case study enterprise guided by research findings found in extant literature.

10.4 Background information UK Ministry of Defence, BAE Systems and GE Aviation

The unit of analysis comprises BAE Systems, GE Aviation and the UK Ministry of Defence. Initial visits were made to all three organisations to obtain background information. The initial data collected was supplemented by additional information obtained from BAE Systems, Military Air information overview 2011, geaviation.com and Ministry of Defence - GOV UK/government/organisations/Defence Equipment and Support.

10.4.1 BAE Systems

BAE Systems is a global defence and security company with a turnover of £22bn (2010) and 100,000 employees worldwide. BAE MAI a key business unit of BAE Systems has a turnover of £4bn (2009) and approximately 15500 staff. BAE MAI has expertise in the development, delivery and support of military air platforms, components and technologies through its products. The business of BAE MAI however is changing and becoming more service oriented. Their commercial arrangements, operational activities, product and organisation are all changing to realign to the new business demands. BAI MAI is structured in two groups Air Combat and Information Superiority and Services.

Air Combat accounts for 60% of the headcount and provide 70% of the revenue. Information Superiority and Services accounts for 40% of the headcount and provides 30% of the revenue. The business sells globally and at present is 49% US based. Air Combat are developing, producing and supporting a number of platforms. These include Tornado, Typhoon, Hawk, F35 Lightning II and various unmanned aircraft projects.

Lives of programmes are currently 25/30 years. Air Combat has resource located at RAF Bases across the UK supporting in-service aircraft.

Funding arrangements for new products are changing and availability contracting for in service support is increasing. Some services are delivered with customers, and some with partners. Suppliers are also heavily involved where the original product is complex. BAE Systems currently provide availability of the Typhoon military aircraft to their customer the UK Ministry of Defence. Here they are providing a service for a fixed fee and thus taking on more risk. A number of BAE Systems customers have introduced availability contracting (replacing individual product and support sales) and less technical products are currently in development (military drones to replace manned aircraft in the future). BAE Systems believe they need to fully recognise this move towards availability contracting and adapt their business activities accordingly. Changes to culture and operating practices, design trade offs and new cost models are all required. Optimisation of co-creation, supply relationships and enterprise management within a complex service model is also essential. The research case study will test if the new features and required changes are acknowledged and or introduced.

10.4.2 Typhoon

The Typhoon is a four-nation collaborative military aircraft project designed and developed and currently produced by the United Kingdom (BAE Systems), Spain, Germany and Italy. Each country has a final assembly and workshare linked to government purchase of aircraft. Engines are government supplied.

As at the end of 2011 five hundred and fifty nine aircraft had been ordered across Europe. Of these two hundred and thirty two (37%) had been ordered by the UK. The UK also has the lead of an export orders from Saudi totalling seventy-two aircraft. Further export orders are anticipated. Tranche one, two, and the first aircraft of tranche three have been released. Tranche 2 aircraft are in production. There are approximately three hundred aircraft in flight.

Eighty per cent (80%) of BAE Systems Typhoon aircraft production costs are in equipment procured and fitted by BAE Systems such as radar, cockpit avionics, fuel management etc. A complex international supply chain exists and suppliers can be customer, partner or supplier in different parts of the chain. The supply chain is also

subject to workshare arrangements. BAE Salmesbury provides most of the aircraft structure.

The Typhoon programme is split into three phases. Phase one, the pre systems acquisition phase covering concept creation is complete. Phase two, the systems acquisition phase including development qualification and manufacture has commenced and aircraft delivery is on-going. Phase 3, the sustainment phase covering support during operational deployment is also on going. Support for phase 3 is provided by BAE Systems under an availability contract agreed with the Defence Equipment and Support organisation of the UK Ministry of Defence and the Royal Airforce during 2010. Costs are estimated at £500m for five years, with a rolling extension. The UK Ministry of Defence provides resource and facilities to assist BAE Systems deliver the support service. Competition for the contract is consistently present from Fimechannica Italy. A high level of availability of aircraft is required. The contract is based on flight hours. Improved reliability is expected including less spares usage. Service comprises advice, logistics (replacement availability), and supply chain motivation to fix on base, and supply chain motivation to fix back at supplier. The service activity that was previously 30% BAE Systems is now 100% BAE Systems with BAE Systems stood on the customers shoulder in the 1st line." BAE Systems are referred to as the provider firm through out this research.

10.4.3 GE Aviation

GE Aviation the Aerospace arm of GE has a turnover of \$17.6bn (2010) and has 39,000 employees worldwide. It is a leading provider of commercial and military jet engines, avionics and power systems, and components for aircraft. G.E.Aviation Cheltenham is a key and rapidly growing business unit of GE Aviation providing power systems, avionics, fuel systems and services and repair for military and commercial aircraft. GE Aviation have 1,536 employees. Their military business engages 60% of the staff whilst the commercial business engages 40%. Original equipment accounts for 60% of the turnover whilst spares and services account for 20% each.

GE Aviation original equipment supply includes; Electrical power systems for the, Apache helicopter, JSF35 jet, Business jet, C130J, and the Boeing 777, 767, 787 commercial aircraft; End to end power systems capability for aircraft; Back up batteries and Power distribution and magnetic products. GE Aviation has a large presence on the

Joint strike fighter including multiple systems, power, avionics and structure and on the Typhoon they provide displays and instruments. Here technology is moving from Head Down Display to Head Up Display to Helmet. On the large Airbus A380 commercial airliner GE Aviation provide Landing Gear Actuation system and on the new Boeing 787 Commercial airliner the high lift system.

The GE Aviation repair activity includes modifications and repairs. Repair is resource intensive as GE Aviation at Cheltenham supports 6000 live line replacement units across multiple programmes, products and customers. Repairs are also received from other sites. Flexibility is required to meet peaks and troughs of workload.

GE Aviation reported that their business is changing. This is driven by a management desire to increase service activity moving from product to a mix of service, customer availability contracting and product. GE Aviation's products are also rapidly evolving with both traditional head down display and head up display being developed and produced. GE Aviation reported they are currently moving towards a target of 50% of turnover from services. This will be achieved by offering spares and repairs and availability based contracting.

The Typhoon at the aircraft level has moved from traditional repair to availability contracting. Avionics however still has fixed repair fees and turnarounds. Different contract requirements flow down from BAE Systems and different maintenance plans exist. GE Aviation currently charges for repair, do not take pre-emptive action and do the minimum required to achieve their contractual obligations. In the future under availability contracting they will need to consider pre-emptive action, modifications and changes.

A planned detailed research activity is required to establish the full facts of this case.

10.4.4 The UK Ministry of Defence

The UK Ministry of Defence (MOD) is the United Kingdom government department responsible for implementing the defense policy set by the UK's government, and is the headquarters of the British Armed Forces.

The UK Ministry of Defence states that its principal objectives are to defend the United Kingdom and its interests and to strengthen international peace and stability. With the

collapse of the Soviet Union and the end of the Cold War, the UK Ministry of Defence does not foresee any short-term conventional military threat; rather, it has identified weapons of mass destruction, international terrorism, and failed and failing states as the overriding threats to the UK's interests.

The UK Ministry of Defence manages day-to-day running of the armed forces, contingency planning and defence procurement.

The procurement of defence equipment and its through life support is undertaken by Defence Equipment and Support. This is the name of the merged procurement and support organisation within the UK Ministry of Defence. It came into being on the 2nd of April 2007, bringing together two organisations owned by the UK Ministry of Defence, the Defence Procurement Agency and the Defence Logistics Organisation under the leadership of first Chief of Defence Materiel.

The organisation has a civilian and military workforce of around 20,000 (77 per cent civilian and 23 per cent military), based in the UK and abroad. The Defence Equipment and Support operates a single Top Level Budget and has 10,000 staff housed at Abbey Wood Bristol

The Defence Equipment and Support organisation procures fast combat jets for the Royal Airforce of the United Kingdom. The Royal Airforce is the organisation which fly's the jets and is the end user customer of our case study. The Royal Airforce are organised in squadrons located at Royal Airforce bases around UK. They have the skills and facilities to support the jets, as this has traditionally been their role. This support role however is now migrating to industry in the form of availability contracting in an attempt to reduce through life costs.

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Main body of PhD 80143

References, list, appendix, 18820