DEVELOPING MAINTENANCE SUPPLY CHAINS TO IMPROVE SHIP MAINTENANCE PERFORMANCE: AN EMPIRICAL STUDY IN INDONESIA

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DECLARATION OF ORIGINALITY

The thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.

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The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

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ABSTRACT

The shipping industry holds an important role as a service provider that underpins global trade. The emergence of maritime logistics concepts has served to reinforce this phenomenon. An expectation is made of the shipping industry that it will provide services that add value to supply chains in terms of timely, reliable and cost-efficient services. In turn, this expectation requires shipping companies to maintain the availability of their ships to undertake the scheduled voyages. Maintaining the availability of ships inevitably involves maintenance tasks that incur on-going expenses that affect the goals of shipping companies in maximising the return on their investment. However, the benefits resulting from undertaking ship maintenance do not appear to be fully understood.

This research investigates the implementation of a strategic approach to ship maintenance via supply chain management. A review of the existing literature on ship maintenance management and supply chain management indicates a paucity of conceptual and empirical research focusing on the strategic management of ship maintenance supply chains. Thus, the objective of the research is to investigate how ship maintenance is managed within its supply chains. To address the research objective, this study (i) assesses whether a supply chain management approach is applicable to ship maintenance; (ii) examines how ship maintenance management is currently undertaken; and (iii) examines the potential benefits that can be attained by undertaking a supply chain management approach to ship maintenance.

Shipping companies in Indonesia provide the context for this research because they represent the complexity of both ship maintenance management and supply chain management, in developing countries in particular. Most shipping companies in Indonesia operate aging ships that theoretically incur higher maintenance costs. As in many developing countries, there is a lack of logistics, infrastructure and access to information technology in managing supply chains in Indonesia. A questionnaire for a postal survey was utilised to access relevant shipping companies. The questionnaire consisted of items covering internal readiness, the condition of external relationships, the service processes of ship maintenance supply chains, and the overall performance of both ship maintenance and the shipping companies. A total of 230 shipping companies received the questionnaire which resulted in 48 useable responses, the equivalent of a 20.87 per cent response rate.

Data analysis of the results of the data collection reveals that a supply chain management approach is applicable to ship maintenance with some suggested recommendations. The data analysis reveals that the top management level of the shipping companies provide commitment and support for adopting a supply chain management approach for ship maintenance. However, Indonesian shipping companies still lack internal readiness to implement supply chain management as a strategic approach to ship maintenance, with one major reason being a silo mentality influencing the maintenance activities. To address the lack of internal readiness, maintenance managers should be involved in the management activities at the corporate level, and develop integrated communication processes within a computerised maintenance management system.

This thesis contributes to both academia and managerial practices in ship maintenance supply chain management. As there are limited studies on ship maintenance management and the supply chain management of service-oriented supply chains, this thesis has added empirical results to both sets of literature. From a conceptual context, this study proposes supply chain management as being a strategic approach to ship maintenance, which recognise the need for a seamless flow of materials and services, information and finances across the supply chains. This approach introduces a higher level of maintenance for shipping in particular. This thesis suggests that ship maintenance should no longer be recognised as an internal business of shipping companies that incurs ad-hoc expenses, but instead be a collaborative process of investment to improve competitive advantage. As with all research, limitations exist, these are addressed in the final chapter as are future research directions.

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GLOSSARY

CMMS	Computerised Maintenance Management Systems
GSCF	Global Supply Chain Forum
PRQ	Primary Research Question
SCME	Supply Chain Management Excellent
SCOR	Supply Chain Operations Reference
SRQ1	Subsidiary Research Question 1
SRQ2	Subsidiary Research Question 2

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Chapter One

INTRODUCTION

1.1 Overview of ship maintenance management

The emergence of the maritime logistics concept promotes a more significant role for the shipping industry in global trade (Panayides 2006). Based on this concept, the shipping industry is expected to not only provide maritime transportation services but also add value to the supply chain by which the industry operates. There are many examples in the literature that discuss the strategies used to deliver value-added maritime transportation in a timely, reliable and cost-efficient manner; for example, the joint routing and deployment of ships in a fleet (Álvarez 2009; Zacharioudakis et al. 2011), containerisation and box logistics (Notteboom & Rodrigue 2008) and ships' voyages scheduling (Hwang, Visoldilokpun & Rosenberger 2008).

Other examples of strategies to deliver value-added maritime transportation are evident in the following studies. Fagerholt and Christiansen (2000) discussed a combined multi-ship pickup and delivery strategy to improve the availability of shipping services. They proposed a computational solution that offers an optimal matching between the types and amount of freight with the suitable ships. Their work found that reliable ships are necessary to ensure that the right ships will be available for the right cargoes. Notteboom and Merckx (2006) note that shipping companies develop unique service portfolios to enable freight integration which provides competitive advantage. They found that freight integration could serve as a shipping business strategy, but there is no single best strategy for the shipping industry to accommodate global production networks.

In another example, Notteboom (2006) studied the trade-off strategies that are deployed by shipping companies to maximise their schedule reliability. In his study, Notteboom (2006) found that waiting times and delays due to port congestion and infrastructure constraints incur concerns in the schedule reliability of shipping that increase logistics costs to the customer. In a similar topic, Vernimmen, Dullaert and Engelen (2007) found that low reliability of shipping schedule services can have serious consequences for various entities in a supply chain. To deliver a timely shipping service in intra-Asian service routes, Feng and Chang (2008) proposed a revenue management strategy to enhance shipping companies' profits whilst maintaining the performance of shipping agencies. Despite efforts to improve shipping services, the main business of shipping is still handling, moving and/or storage of cargo using ships as the main means of transportation (Robinson 2005; Stopford 2009). Thus, the major demands of customers tend to reflect the need for timely delivery of their cargo and therefore a demand for the availability of reliable ships to undertake scheduled voyages.

Demand for the availability of reliable ships is not only for the shipping industry but also for enabling the growth of global trade (Visvikis 2008). Within the global trade system, and since production networks are worldwide, products should be shipped around the world at the lowest possible cost before they arrive at the points of consumption (Coe, Dicken & Hess 2008b; Hesse & Rodrigue 2006; Jaehne et al. 2009). Accordingly, efficient and reliable transportation is required to ensure the success of these global production networks in order to obtain the lowest possible costs. Low cost and high carrying capacity of shipping transportation suggest a flow-on effect to attain the lowest possible costs in the global production networks (Cerit 2000; Tseng, Yue & Taylor 2005). As more than 80 per cent of global trade volume is transported by ships, the availability of reliable ships is pivotal to the growth of global trade (Berle, Rice & Asbjørnslett 2011; Cullinane & Panayides 2000; UNCTAD 2010, 2011). The availability of reliable ships underpins the efforts to provide shipping services with the expected added value to customers.

Maintaining the availability of reliable ships inevitably involves maintenance tasks that incur on-going costs to shipping companies. However, the extant studies appear to overlook the importance of the management of ship maintenance in underpinning the operations of shipping. Despite the important role of shipping, maintaining the availability of reliable ships exposes shipping companies to several challenges. Stringent rules and regulations such as the International Convention for the Prevention of Pollution from Ships, the International Regulations for Preventing Collisions at Sea and the International Safety Management Code have been enforced for the safe operations of ships, crews on-board and the environment within which the ships are operated (for example see Banawan, El Gohary & Sadek 2010; Kiriaki 2003; Talley, Jin & Kite-Powell 2005; Thai & Grewal 2006). To comply with these rules and regulations shipping companies need to undertake maintenance tasks to sustain ship’s equipment to operate in safe condition. Any failure to comply with these rules and regulations may incur significant losses for the shipping companies (Nedal 2012). However, undertaking maintenance tasks or to perform proper maintenance incur significant flow-on costs to shipping companies (Jacobs & McComas 1997; Salonen & Deleryd 2011). This means the shipping companies' goals in maximising the return on their investment are affected whether all, some or no maintenance is undertaken.

Ship operations are recognised as being relatively low in speed performance (Cerit 2000; Tseng, Yue & Taylor 2005), volatile to demand fluctuations (Bendall & Stent 2003; Fusillo 2003) and impacted on by fuel cost surcharges (UNCTAD 2010, 2011). The turbulence of shipping markets (Bendall & Stent 2003; Plomaritou, Plomaritou & Giziakis 2011) and the relatively short period of the economic lifetime of ships (Lorange 2005; Tvedt 2003) also contribute to the high level of risks for the shipping industry. These challenges require the ships to be readily available and be operated reliably and safely. As a consequence, ship owners tend to maximise the operation of ships to gain the highest possible return on their investment (Koehn 2008) while at the same time accepting ship maintenance as being a less controllable expense to the gained revenue (Bitros & Kavussanos 2005).

Research suggests that shipping companies have little control over the costs of ship maintenance as they are significantly affected by suppliers of maintenance materials and/or services (Bao, Mittal & Dean 2010; Bitros & Kavussanos 2005; Koehn 2008). This manifests itself in the decision to operate the ships as long as still profitable rather than capitalising on the potential benefits from strategically managing ship maintenance (Koehn 2008). Cholasuke, Bhardwa and Antony (2004) and Alsyouf (2007) argue that the successful management of maintenance will lead to an increased profit. A strategic focus on maintenance management will contribute to the maximum operations of ships whilst sustaining the safe operations of ships, the crew on-board and the environment (Eccles, Ashe & Albrecht 2010), whilst still attaining increased profits (Coetzee 1999). However, research on ship maintenance management still appears to be in the emergent phase. For example, Mavromatakis, Colyvas and Nicolaou (1996) and Bitros and Kavussanos (2005) found that ship maintenance management tends to be undertaken for regulatory compliance purposes, and hence lack a strategic approach.

Mokashi, Wang and Vermar's (2002) study of the implementation of reliability-centred maintenance programs in maritime operations found that maintenance activities undertaken by shipboard personnel are tending to impact on their workloads. Computerised maintenance management systems (CMMS) for ships have been suggested by Cang et al. (2011) to provide shipboard personnel with an automated system to administer the complex data regarding the maintenance history of ships' equipment. However, the implementation of CMMS may not automatically reduce the complexity of ship maintenance management as it involves additional training, time and finances to deal with more suppliers who offer the software and its maintenance requirements.

Of interest is that the previously mentioned research appears to deal with ship maintenance at the operational level of shipping companies rather than at the strategic level of management. As a result, ship maintenance tends to be considered as a source of ad hoc expenses rather than a strategic investment to improve shipping companies' competitive advantage. Recent research by Bao, Mittal and Dean (2010) found that unplanned maintenance activities remain dominant in contemporary ship maintenance, which indicates a lack of strategic management to capitalise on ship maintenance (Bitros & Kavussanos 2005; Lazakis, Turan & Aksu 2010). The apparent paucity of a strategic approach to ship maintenance provided motivation for the investigation in this thesis including whether, as it is explained below, a supply chain management approach might be relevant to ship maintenance.

1.2 Supply chain management

A supply chain consists of entities (organisations or individuals) that are linked in the upstream and downstream flow of materials, services, money and information, from the initial suppliers to the final customers (Chen & Paulraj 2004b; Lambert, Cooper & Pagh 1998; Mentzer et al. 2001; Pettit, Fiksel & Croxton 2010). A generic supply chain consists of entities such as suppliers that provide materials and/or services, the focal company that converts the materials and/or services into products, and the customer as buyer of the products. In dyadic relationships, the focal company is referred to as the buyer of products from the suppliers, and it re-sells the products to its buyer, the customers.

Lambert, Cooper and Pagh (1998) discuss a generic supply chain as being a complex network as shown in Figure 1.1. They explain that management processes such as planning, communication and information flow, workflow structure, control and evaluation are involved in the focal company to transform materials from the supplier into products as required by the customer. Across the supply chain network, these entities are linked by business processes to accommodate the flow of materials, services, information and money (Cooper, Lambert & Pagh 1997; Lambert, Cooper & Pagh 1998).

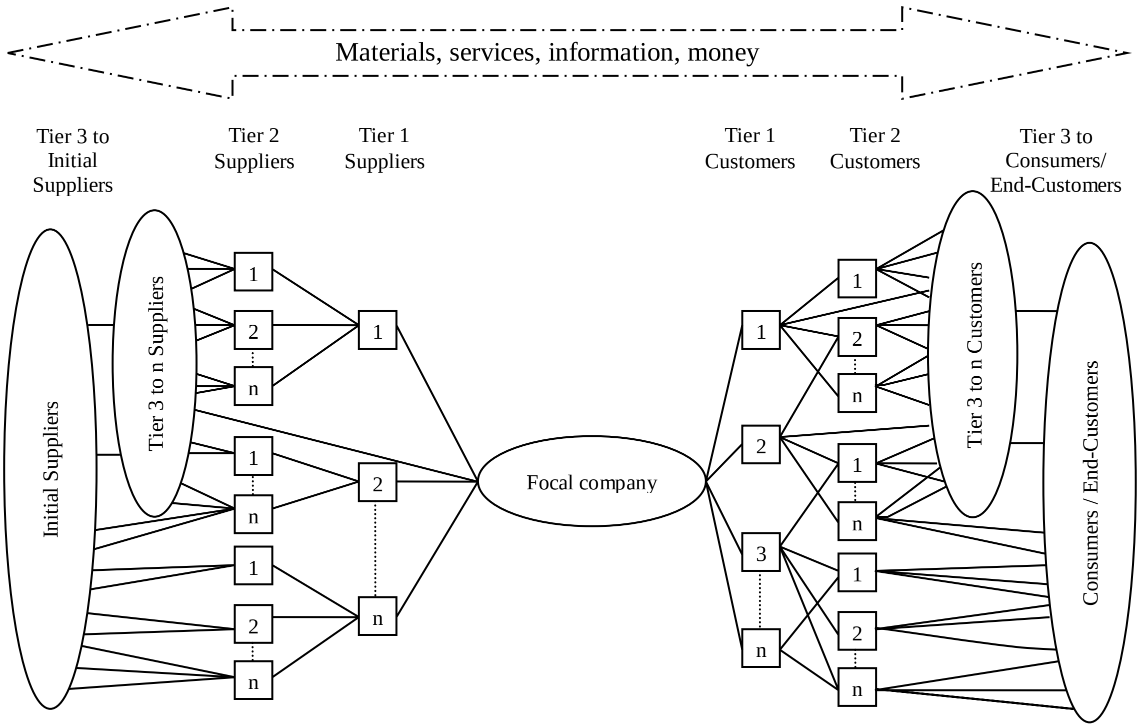


Figure 1.1: A supply chain network structure

Source: Lambert, Cooper and Pagh (1998, p. 3)

One objective of supply chain management is to integrate all entities in the network through business processes to attain a shared competitive advantage in providing customer requirements at the lowest cost (Ellram, Tate & Billington 2004; Lambert, Cooper & Pagh 1998; Mentzer et al. 2001). A successful implementation of this approach provides benefits to the supply chain as well as to the entities that comprise it. Some benefits of successful supply chain management include increased customer satisfaction and service (Fawcett, Magnan & McCarter 2008a), better inventory control (Abuhilal, Rabadi & Sousa-Poza 2006), increased quality and business performance (Agus & Hassan 2008), reduced uncertainty (Albino et al. 2006; Alony & Munoz 2007) and adding value to service providers (Blanchard, Comm & Mathaisel 2008). With regard to the existence of supply chains in various business contexts (Ayers 2001; Blanchard 1998; Bowersox, Closs & Cooper 2002), it appears that managing supplies for ship maintenance can leverage the shipping companies' capacity to control their costs and gain more profits. As explained later in this thesis, shipping companies may be able to utilise supply chain management as a strategic approach for ship maintenance to obtain higher profits.

Most research regarding supply chain management appears to have been based on manufacturing. For example, Ellram, Tate and Billington (2004) and Giannakis (2011) explain that a manufacturing-oriented supply chain involves a transformation of raw materials into finished or semi-finished products, but this does not apply to service-based supply chains such as maintenance supply chains. Furthermore, Ellram, Tate and Billington (2004) argue that maintenance services, unlike materials in manufacturing-oriented supply chains, cannot be stored as inventory. They suggest that services could capitalise on the benefits of a supply chain management approach by adjusting some of the best practices of manufacturing-oriented supply chains. Further detail about the management of service-oriented supply chains is discussed in Chapter Two.

1.3 Maintenance supply chains

Maintenance consists of the processes that sustain physical assets in a desired operating condition, that may include restoring them back to their desired condition (Dhillon 2002; EN 2010; Geraerds 1992; Mobley 2008; Tsang 1998). The processes involve the coordination of relationships with internal entities of a company and stakeholders and suppliers external to the company (Al-Turki 2011). An input-output model has been developed to visualise the processes in the maintenance context (Visser 1998 in Al-Turki 2011, p. 153; Tsang 2002, p. 10). As shown in Figure 1.2, the model visualises maintenance as a system within a production and enterprise system. The items on the lefthand side of the model — labour, material, spares, tools, information, money and external services — indicate the inputs which are required for maintenance. The items on the righthand side comprise several outputs, for example, the maintenance system results in the availability and maintainability of equipment of the production system; the production system results in output (which is explained by Tsang (2002) as being volume, quality and cost of production) and safety of the operation of the production system; and the enterprise system results in profits for its stakeholder.

Figure 1.2 suggests inputs may be sourced from external entities and that a range of output products is delivered to its customer. As a result, the whole system depicted in Figure 1.2 implies a supply chain network as discussed in section 1.2 (see Figure 1.1, p. 8). The model identifies the inputs needed for undertaking maintenance in a company; however, it fails to identify the process that links the entities that provide these inputs to the company's maintenance system. Failure to manage these links could result in high-cost but less-effective maintenance (Backlund & Akersten 2003; Bechtel & Patterson 1997; van Niekerk & Visser 2010).

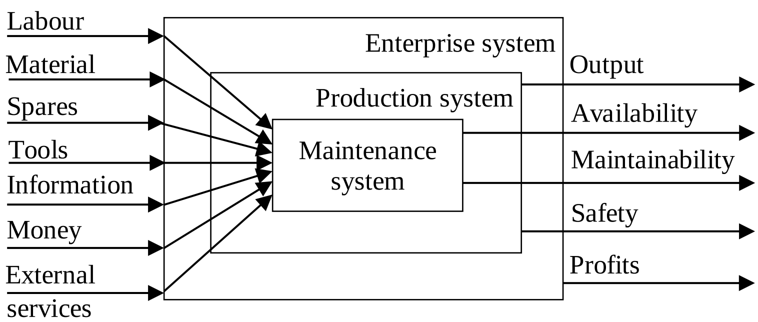


Figure 1.2: Input-output maintenance model

Source: Al-Turki (2011, p. 153)

Recognising maintenance as a supply chain involving internal and external entities may enable management to be aware of why they should coordinate across maintenance processes in order to deliver profits for the company. It appears that the management of maintenance could benefit from a supply chain management approach. However, as it has been discussed, research into supply chain management is shown to be widely practised and studied in manufacturing-oriented supply chains (for example see Agus & Hassan 2008; Beresford, Pettit & Liu 2011; Blanchard, Comm & Mathaisel 2008; Chen & Paulraj 2004b; Ellram, Tate & Billington 2004; Lambert, Cooper & Pagh 1998; Luan, Wu & Xia 2013), but is less evident in service-oriented supply chains. These issues created the impetus in this thesis to investigate the implementation of supply chain management in ship maintenance.

1.4 Research questions and purposed contribution

This chapter has argued that shipping companies may be able to benefit from a supply chain management approach when managing the maintenance of their ships to increase efficiency and profitability. However, based on the extant literature, no previous research investigating this topic was found. Therefore, the primary research question (PRQ) states:

> **Is a supply chain management approach applicable to improve ship maintenance performance?**

To answer this research question, it is important to explore the current extent of research and industry application of ship maintenance management. The investigation may provide insights that enable the strategic development of ship maintenance management by providing information on the current industry practices (Wheelen & Hunger 2002). Therefore, the subsidiary research question one (SRQ1) is:

> **How is the management of ship maintenance currently undertaken?**

Although the potential benefits of a supply chain management approach has already been highlighted, they have a manufacturing-oriented supply chain focus. It is unknown whether they may be applicable in the context of ship maintenance management. In addition, as shipping companies are involved in an uncertain and dynamic business environment, profitable ship operations can become losses within a short period (Bendall & Stent 2003). Therefore, the subsidiary research question two (SRQ2) of this research is:

> **What benefits can shipping companies attain by undertaking a supply chain management approach to ship maintenance?**

A number of potential contributions may be provided by this research. First, as indicated earlier, research in both service-oriented supply chain management and ship maintenance management appear to be an emergent interest. Thus, an objective of this research is to extend the horizon of knowledge in service-oriented supply chain management and ship maintenance management by empirical testing. Second, this research may provide a foundation for developing a strategic approach for ship maintenance. Third, an opportunity to benchmark the implementation of a supply chain management approach in the context of ship maintenance may be possible that will provide value to shipping companies. The findings should also assist shipping companies in improving their ship maintenance performance to increase profits.

1.5 Organisation of the thesis

This chapter has explained the research background to establish the purpose of this thesis and identified a gap in the literature focus in relation to the possible absence of a supply chain management approach for ship maintenance. Chapter One has also explained the rationale for primary and subsidiary research questions, and in this section provided an outline of this thesis to illustrate how the research problems will be addressed.

Chapters Two and Three of this thesis provides in-depth discussion on supply chain management principles and maintenance management. Although maintenance supply chains are introduced in section 1.3, research on supply chain management and maintenance management are often not integrated. Whilst most research on supply chain management is based on the manufacturing industry with a focus on seamless flows of materials and services from suppliers to end customer, research on maintenance management focuses on undertaking maintenance using minimum resources to provide the highest possible availability of equipment. The discussion in Chapters Two and Three follows the same approach to enable the important practices and concepts in each discipline to be captured before synthesising them into a ship maintenance management context in Chapter Four.

Chapter Four provides a synthesised discussion of service-oriented supply chain management and maintenance management within the context of ship maintenance management. This is followed by explaining the supply chain management approach to be investigated in the current research. This chapter also highlights the gaps in the literature relating to ship maintenance management.

Chapter Five addresses the research design and methodology, including the use of postal surveys and the decisions made for collecting data from Indonesian shipping companies. The methodological approach in this chapter explains the decision to investigate how ship maintenance management is practised in Indonesian shipping companies. Conducting this research on the Indonesian shipping companies may provide necessary context to an empirical approach for acquiring better understanding on supply chain management of ship maintenance, particularly in developing countries with similar demography to Indonesia. This chapter also discusses the development of the questionnaire for the postal survey based on the literature from the previous chapters.

Chapter Six discusses the results of the survey and the analysis of data from the data collection. Both descriptive and inferential statistical tools are utilised to discuss the demographic profiles of respondents and their shipping companies in Indonesia and to assess the implementation of a supply chain management approach in ship maintenance. The first and second subsidiary research questions are addressed in this chapter to inform the response to research question. The chapter concludes with discussion on whether undertaking a supply chain management approach enables the improvement of ship maintenance performance.

This thesis concludes with Chapter Seven which summarises the current research by highlighting the importance of the research, addressing the limitations and suggesting possible future research directions.

Chapter Two

SUPPLY CHAIN MANAGEMENT

2.1 Introduction

This chapter begins by reviewing the literature to establish the construct of a supply chain management approach. The review is necessary for supporting the identification of the research topic, contextualising the research within the literature, and identifying the literature to which the research will contribute (Rowley & Slack 2004). The roles of supply chain management are discussed to provide an understanding of the importance of the implementation of such an approach to the management of ship maintenance. The chapter then provides further attention on the strategic approach to attaining a successful implementation of supply chain management.

2.2 Supply chain and supply chain management

A Google search on the term supply chain, at the time of this writing, yielded 181 million results. Another search was conducted using the ABI/Inform Complete database through ProQuest. This covers a large number of periodical publications including most of the social science journals such as *Business and Management*, *Supply Chain Management*, *Logistics Management*, *Operations and Production Management*, *Physical Distribution and Logistics Management*, *Maritime Economics and Logistics* and *Maritime Policy and Management*. The search yielded 734,061 results including 273,783 trade journals, 67,762 scholarly journals, 55,283 newspapers and 8,549 dissertations and theses from 1980 to 2013. The term supply chain management yielded 83.8 million hits from the Google search, and 55,119 trade journals, 23,595 scholarly journals, 29,264 newspapers and 6,581 dissertations from the ABI/Inform Complete database over the same period. These results show that the term supply chain is not new and it has been widely used in both academia and industry. The term supply chain management, however, appears to be relatively new and implies more specific purposes than the term supply chain (Cooper, Lambert & Pagh 1997; Monczka et al. 2011). The term supply chain management was introduced for the first time by Keith Oliver in the 1980s and has become prominent in management lexicon since the 1990s (Croom, Romano & Giannakis 2000; Feller, Shunk & Callarman 2006; Lambert, Cooper & Pagh 1998).

2.2.1 Definition of supply chain

Table 2.1 provides some definitions of supply chain from the literature. Based on these definitions, it is evident that across the decades scholars are converging on the definition of a supply chain. The definitions always recognise a supply chain as being a network of entities linked in a business process to accommodate the two-way flow of products, services, finance and information. Regardless of the size of the network, the supply chains work in interconnected business processes to deliver products (goods and/or services) to the end customer. These definitions also imply that a supply chain either exists naturally or is created to fulfil the customers' requirements (Choi, Dooley & Rungtusanatham 2001).

Of interest, even though the definitions in Table 2.1 include both the flows of goods and services as a result of business processes, the mechanisms of their supply chains can be significantly different (Ellram, Tate & Billington 2004; Giannakis 2011; Sengupta, Heiser & Cook 2006). The supply chains of goods involve conversions of materials into tangible products which are referred to as manufacturing-oriented supply chains; whilst the others involve the providing of intangible services which are referred to as service-oriented supply chains (Ellram, Tate & Billington 2004). The service-oriented supply chains do not necessarily involve conversions of materials. Management of the two supply chains involves different approaches since the intangible services cannot be stored as inventory as can the tangible products (Ellram, Tate & Billington 2004; Giannakis 2011).

Table 2.1: A sample of definitions of supply chain

Authors	Definition
Towill, Naim and Wikner (1992, p. 3)	A system that links materials suppliers, production facilities, distribution services and customers through a forward flow of materials and back flow of information.
Harland et al. (2001, p. 20)	An inter-organisation network that consists of interconnected entities through which goods and services flow from original supply sources to end customers.
Mentzer et al. (2001, p. 4)	A set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances and/or information from a source to a customer.
Ayers (2002, p. 5)	A life cycle process supporting physical, information, financial and knowledge flows for moving products and services from suppliers to end-users.
Sundaram and Sameer (2002, p. 532)	A network of facilities and distribution operations to perform the functions of procurement, transformation and distribution from suppliers to customers.
Lee, Park and Lee (2003, p. 243)	A business process that links manufacturers, customers and suppliers as one virtual organisation of resources.
Hertz (2006, p. 209)	A typical network which focuses on the connections and dependencies between firms from raw material to final customer.
Robinson (2009)	A set of organisations that create and deliver customer value and gain rewards through the processes between source of materials and point of consumption.
Monczka et al. (2011, p. 12)	A set of three or more organisations linked directly by one or more of the upstream and downstream flows of products, services, finances and information from a source to a customer.

2.2.2 Definition of supply chain management

In contrast to the convergent definitions of supply chain, there are diverse definitions of supply chain management. As shown in Table 2.2, the term supply chain management has been defined and redefined in many ways such as approaches in managing the flows of materials (Ayers 2002; Monczka et al. 2011; Simchi-Levi, Kaminsky & Simchi-Levi 2003; Wu 2003), integration of business processes (Croxton et al. 2001; Ellram, Tate & Billington 2004; Lambert, Cooper & Pagh 1998; Soon & Udin 2011) and strategic relationships across and within companies (Bichou & Gray 2004; Carr & Pearson 1999; Chen & Paulraj 2004b; Christopher 2005; Marquez 2010; Mentzer et al. 2001; Simatupang & Sridharan 2002). Many more definitions which show the diversities can be retrieved from the literature (see Chen & Paulraj 2004a; Chen & Paulraj 2004b; Soni & Kodali 2011; Varma, Wadhwa & Deshmukh 2006).

The diverse definitions in Table 2.2 reflect no universal agreement on the multi-faceted perspective of supply chain management. Despite the differences of the definitions of supply chain management, there is a common principle that indicates requisite seamless-coordination and -cooperation between entities in order to develop a collaborative supply chain. Supply chain management can be understood as an approach to orderly manage the flow of materials and/or services from suppliers to end customer where the point of consumption is recognised. However, the diversity of the definitions leads to challenges in configuring the construct of a supply chain management approach. A review on the roles of supply chain management is provided in the following section to establish better understanding of the approach.

Table 2.2: A sample of definitions of supply chain management

Authors	Definitions
Ayers (2002)	A design, maintenance and operation of supply chain processes for the satisfaction of end-user needs.
Simchi-Levi, Kaminsky and Simchi-Levi (2003, p. 1)	A set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses, and stores … to minimise system-wide costs while satisfying service level requirements.
Monczka et al. (2011, p. 12)	A proactive management of two-way movement and coordination of goods, services, information and funds from raw material through end users.
Lambert, Cooper and Pagh (1998, p. 1)	An integration and management of key business processes across the supply chain.
Croxton et al. (2001, p. 1)	A management of key business processes throughout a supply chain network.
Ellram, Tate and Billington (2004)	A management of information, processes, capacity, service performance and funds from the earliest supplier to the ultimate customer.
Soon and Udin (2011, p. 506)	An integration of multiple processes and activities from suppliers to customers.
Carr and Pearson (1999)	A method for developing collaborative/long-term relationships with up-stream and/or down-stream entities of a supply chain in addition to discrete transactional relationships.
Mentzer et al. (2001, p. 18)	A systemic and strategic coordination both across and within internal organisations to improve their long-term performance as well as performance of the whole supply chain.
Bichou and Gray (2004)	An extended principle of logistics integration to all organisations in the supply chain through strategic partnerships and co-operation arrangements.
Chen and Paulraj (2004b, p. 147)	A novel management philosophy that recognises competition at supply chains level rather than individual competition.
Christopher (2005, p. 5)	A management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole.
Marquez (2010, p. 17)	Methods by which organisations engage in creating, distributing and selling products.

2.3 Roles of supply chain management

Before elaborating on the implementation of a supply chain management approach, it is important to understand its roles in underpinning the success of the supply chain as well as the entities within. Although definitions of supply chain management vary in many ways, they all suggest the need for coordination and collaboration between entities across various business processes along supply chains to attain the agreed shared goals in the long term. Accordingly, the roles of supply chain management can be underlined as a function to establish strategy driven management that enables entities in the supply chain to pursue long-term shared goals. Some key issues associated with the roles of supply chain management in a business context are identified through the following discussions.

The ultimate source of value across the supply chain originates from the end customers who are willing to pay for the perceived value they receive (Feller, Shunk & Callarman 2006). If the highest customer value can be delivered with a total lower cost, then more supply chain value can be gained and distributed among supply chain entities (Dwivedi & Maffioli 2003). This notion applies to the supply chain itself rather than the individual entities since individual value maximisation could jeopardise the competitiveness of the supply chain (Robinson 2009). Furthermore, the entities across the supply chain should not gain profit at the expense of their partners (Croom, Romano & Giannakis 2000). Consequently, entities in the supply chain understand the necessity of acquiring a trustworthy environment (Mentzer et al. 2001). For this, supply chain management is responsible for assuring that the goals are proportionally visible and viable to all supply chain entities so that the required environment may be established.

The need to obtain the highest customer value with the lowest costs has encouraged entities in the supply chain to source materials from around the world, resulting in at times a fragmented production system (Cua, McKone-Sweet & Schroeder 2006) and forcing a transfer of ownership of materials as a work-in-progress asset (Coe, Dicken & Hess 2008a). Consequently, management of the distribution function as part of logistics activities becomes a critical point throughout the supply chain that influences the creation and/or distribution of customer value (Panayides 2006). This distribution function should be seamless in order to enable a transfer of ownership of the work in progress assets which prevents the products' value from diminishing across the supply chain network before being received by the end customer (for example see: Huemer 2006; Huq et al. 2010; Thron, Nagy & Wassan 2007). This suggests that an additional role of supply chain management is the development of an effective distribution function. Supply chain management should enable the entities to establish a seamless process to receive, add and transfer the value of products prior to their arrival at the point of consumption because the streamlined flows should lead the supply chain towards the maximum value creation to be distributed among its entities (Feller, Shunk & Callarman 2006).

A streamlined flow should also anticipate uncertainty in supply chain management. Uncertainty has been recognised as the most prominent challenge that hinders the supply chain entities from achieving the benefits of supply chain management (Choy et al. 2007; Christopher 2002; Christopher & Holweg 2011; Lee, Padmanabhan & Whang 1997; Svensson 2003; Towill, Childerhouse & Disney 2000; Wikner, Towill & Naim 1991). van der Vorst and Beulens (2002) explain that the nature of supply chain management is that it experiences constant changes in equilibrium which in turn creates an uncertainty effect. These constant changes may originate from the suppliers, the focal entity, the customers, and the processes along the supply chain (Towill, Childerhouse & Disney 2000). Furthermore, uncertainty also escalates along the supply chain where each entity of the supply chain adds extra requirements to anticipate both the uncertain demand and supply, which is known as the bullwhip effect (Behzad, Moraga & Chen 2009; Choy et al. 2007; Cook, Heiser & Sengupta 2011).

Uncertainty can seriously influence the performance of a supply chain (Barry 2004; Chan, Chung & Choy 2006; Rodrigues et al. 2007; Vanany, Zailani & Pujawan 2009). Vanany, Zailani and Pujawan (2009) note that uncertainty depletes organisations' efficiency levels as they expend resources in attempting to anticipate uncertain demand and supply from their counterparts in the supply chain. Uncertainty may also hold back decision-making processes in a highly dynamic supply chain network, which results in an inefficient supply chain (van der Vorst & Beulens 2002) and increased total operational costs (Rodrigues et al. 2007). The situation can amplify rapidly due to the existence of the bullwhip effect in the supply chain network (Alony & Munoz 2007). Consequently the competitiveness of the supply chain is at risk of being rapidly impaired (Acar, Kadipasaoglu & Schipperijn 2010). For these reasons, it is essential to manage the supply chain strategically to achieve a streamlined process so that uncertainty can be reduced to the lowest level possible.

In sum, the roles of supply chain management can be attributed as enabling clear visibility between entities in a supply chain to streamline the flows of materials, services, information and funds in order to achieve the agreed shared goals in maximising customer value at minimum total costs. Thus, it can be argued that adopting supply chain management as a strategic approach can underpin the companies' success. However, implementing such an approach can be a daunting task due to a long-term process and emerging operational issues that might hinder the achievement (Barratt 2004; Deshpande 2012; Varma, Wadhwa & Deshmukh 2006). A strategic approach for implementing supply chain management is critical since it gives direction to accomplish the goals (Terpend, Krause & Dooley 2011; Wheelen & Hunger 2002).

2.4 The service-oriented supply chains

With regard to the purpose of this thesis, it is important to explain the nature of service-oriented supply chains and the challenges in managing this supply chain. Most research on supply chain management has been developed based on the manufacturing industry (Ellram, Tate & Billington 2004; Soni & Kodali 2011; Wu 2011). Fewer investigations have been made into service-oriented supply chains when compared with manufacturing-oriented supply chains (Ellram, Tate & Billington 2004; Luan, Wu & Xia 2013; Wu 2011). As indicated earlier, the differing mechanisms involved in manufacturing-oriented and service-oriented supply chains require different approaches.

Ellram, Tate and Billington (2004) emphasise the need to develop a supply chain management framework that is appropriate for service-oriented supply chains in order to face increasing competition and customer expectations. They argue that the service-oriented supply chains are lagging behind manufacturing-oriented supply chains in capitalising on how they are managed. Concerns about the capability of industries across the service-oriented supply chains have been raised for a relatively long period of time as service companies strive to develop a strategic management to maintain their growth and survivability. For example, Nayyar (1992) suggests that the lack of attention towards the supply chain management approach has caused service companies to suffer from difficulties in capitalising on the benefits of economies of scope in achieving customer satisfaction with the provided services.

The uniqueness of service-oriented supply chains can be traced back to the characteristics of services. Services are inherently intangible, cannot be stored as inventory, and there is no precise measure of expected service (Ellram, Tate & Billington 2004; Nayyar 1992). Unlike customers in manufacturing-oriented supply chains, customers in service-oriented supply chains experience difficulties in precisely expressing their requirements with regard to the services they are purchasing (Ellram, Tate & Billington 2004; Nayyar 1992). These difficulties may relate to customer satisfaction associated with the acquired services which comprises multi-dimensional measures (Giannakis 2011).

Although maintenance may look different to other services such as hotel, hospital or airlines, maintenance also provides some values as offered by these sectors. Maintenance service aims to provide satisfaction to customers by maintaining the availability and readiness of assets at a reasonable cost in order to obtain profit. Similarly, measuring customer satisfaction on maintenance services is as complex as the other services mentioned (Ellram, Tate & Billington 2004, 2007). Customer may consider that they over-pay for the maintenance services they receive, and/or on the other hand the supplier considers that they are under-paid for the maintenance services they provided. The complex dimensions of customer satisfaction with regard to the acquired services suggest the need to develop a framework for service-oriented supply chains that enables service companies to capitalise on the benefits of the supply chain management.

2.4.1 Challenges in the service-oriented supply chain

Adapting practices from manufacturing-oriented supply chains to service-oriented supply chains may provide some guidance in identifying the challenges for service-oriented supply chains. Ellram, Tate and Billington (2004) identify some of these challenges. They explain that unclear specifications, lack of competency in developing service specifications, skills imbalance, and lack of recognition of the problems of service management hinder the performance of service-oriented supply chains. Unclear specifications for executing a purchased services agreement may cause value leakages that contradict the objective of the management of supply chains (Chopra & Meindl 2010). A skill imbalance may generate differing perceptions about the services to be provided which leads to a violation of the relationships in the supply chain (Fawcett, Magnan & McCarter 2008a). As a result, both the buyer and provider may have different perspectives on the purchased services. The buyer may consider he/she overpaid for the services whilst the provider may consider the delivery was more than what has been paid for. Similar to Ellram, Tate and Billington (2004), Waart and Kemper (2004) highlight the lack of interest of management towards problems in services as being a cause of sub-performance in service-oriented supply chains. With regard to the increasing role of service, Behzad, Moraga and Chen (2009) and Waart and Kemper (2004) suggests the need for service-oriented supply chains to be strategy driven to anticipate the challenges.

2.5 Supply chain management framework

Discussions and reviews on several frameworks of supply chain management are available in the literature (see: Chen & Paulraj 2004b; Lambert, Garcia-Dastugue & Croxton 2005; Soni & Kodali 2013). Soni and Kodali (2013) argue that inconsistencies are present in existing supply chain management frameworks. Thus, it is important to understand how these frameworks provide guidance on how to implement a supply chain management approach (Deros, Yusof & Salleh 2006; Yusof & Aspinwall 2000).

Lambert, Garcia-Dastugue and Croxton (2005) evaluate several supply chain management frameworks, and they argue that only the global supply chain forum (GSCF) framework and the supply chain operation references (SCOR) framework provide sufficient details to be implemented. They add that these two frameworks are based on the implementation of business processes that connect entities in the supply chain and include cross-boundaries activities. Whilst Lambert, Garcia-Dastugue and Croxton (2005) propose the use of the GSCF and SCOR framework for business implementation, Soni and Kodali (2013) propose the supply chain management excellent (SCME) framework based on an evaluation on 57 frameworks appearing in the supply chain management literature. The 57 frameworks appear to be fragmented in discussing supply chain management and lack of generalisation (Soni & Kodali 2013). Thus, the following discussion reviews the GSCF, SCOR and SCME frameworks.

The SCME framework consists of nine pillars of management in achieving the companies' goals via supply chain management (Soni & Kodali 2013). These pillars include strategic management, manufacturing management, marketing management, integration, information technology, logistics management, supplier management, demand management and collaboration management. Although this framework provides comprehensive pillars of management, it fails to explain the business processes that are involved. Comparing the GSCF and SCOR frameworks, the GSCF framework emphasises the cross-boundaries relationships between entities in a supply chain whereas the SCOR framework focuses on the supply chain's operations (Georgise, Thoben & Seifert 2012; Lambert, Garcia-Dastugue & Croxton 2005).

Without disregarding the importance of the other frameworks, this thesis utilises the GSCF framework due to its focus supply chain management approach, which emphasises on integration between entities of supply chain (Antai 2011), and its detailed guidance to implementing supply chain management as a strategic approach into business processes. Furthermore, the GSCF framework has been used to develop a supply chain management approach for managing service-oriented supply chains which involve intangible products such as maintenance service (Ellram, Tate & Billington 2004). Use of the GSCF framework therefore aligns with the purpose of undertaking the current research.

2.6 The Global Supply Chain Forum (GSCF) framework

The GSCF framework comprises three major and related elements: the supply chain structure, the supply chain business processes and the supply chain management components (Lambert, Garcia-Dastugue & Croxton 2005). Each of these elements is discussed in the following sub-sections.

2.6.1 Supply chain structures

This sub-section deals with the structural dimensions of entities in the supply chain. Many academics and practitioners concede the competition level of ‘supply chain against supply chain’ as being the contemporary business paradigm (for example see: Antai 2011; Ayliffe 1996; Buddress & Raedels 2000; Fawcett & Magnan 2004; Lee 2004; Matopoulos et al. 2007; Zhang & Dilts 2004). This paradigm encourages business organisations to develop strategic relationships with entities of the supply chain which may determine their sustainability and survivability in an environment of intensifying competition and escalating customer expectations (Carter & Rogers 2008). Sundaram and Sameer (2002) and

Zachariassen (2008) identify three different structures in the supply chain management approach: independent, semi-integrated and integrated.

The awareness of the entities of the supply chain with regard to collaborative competitiveness may determine the way organisations manage their relationships (Croom, Romano & Giannakis 2000; Jain & Benyoucef 2008). Adopting an integrated supply chain network performs with the lowest supply chain cost when compared to other structures (Deshpande 2012; Ewert 2006; Sundaram & Sameer 2002). However, developing integrated relationships with all entities in the supply chain may incur excessive costs and complexity to each company in managing the relationships. Thus, entities of the supply chain should define their relationships in the categories of managed, monitored and not-managed relationships or recognise the existence of different entities as non-members of the supply chain (Lambert, Cooper & Pagh 1998). These categories lead to the different forms of supply chain structure. The managed relationships with the suppliers comprise the integrated structure, and the monitored and not-managed relationships comprise the semi-integrated and independent structures respectively.

2.6.2 Supply chain business processes

Supply chain business processes have been identified as business strategies in the literature, for example supplier partnership (Agus & Hassan 2008; Chen & Paulraj 2004b), supplier selection (Banomyong & Nucharee 2011; Bhutta & Huq 2002; Dowlatshahi 2000), strategic customer relationship (Albino et al. 2006; de Kok et al. 2005), strategic purchasing (Zhu, Zhang & Tsung 2007; Zsidisin, Ellram &

Ogden 2003), information sharing (Barlas & Gunduz 2011; Durmusoglu 2009; Hsu et al. 2008; Pereira 2009) and supply chain integration (Fabbe-Costes, Jahre & Roussat 2009; Jiang & Chen 2007). Within the GSCF framework, these strategies are recognised as elements of supply chain business processes.

The supply chain business processes of the GSCF framework comprise eight processes which commonly occur in the supply chain: customer relationship management, customer service management, demand management, order fulfilment management, manufacturing flows management, supplier relationship management, product development and commercialisation, and return management (Cooper, Lambert & Pagh 1997; Lambert, Cooper & Pagh 1998). Ellram, Tate and Billington (2004) argue that these business processes are developed based on manufacturing-oriented supply chains which are not suitable for managing service-oriented supply chains. They propose six elements of service processes including capacity management, demand management, customer relationship management, supplier relationship management, service delivery management and cash flow management as alternative elements of supply chain business processes in service-oriented supply chains. Despite these activities being described in detail for each element, their application requires careful contextual adaptation.

Ellram, Tate and Billington (2004) provide further details about the similarities and differences between the business and services processes, which is summarised in the following. The customer relationship, demand and supplier relationship function in the same manner for both manufacturing and service-oriented supply chains, but this is not the case for the other elements. As discussed in section 2.3, the service-oriented supply chain, unlike the manufacturing-oriented supply chain, involves intangible products which cannot be stored as inventory and it is difficult not only to articulate requirements precisely but also to measure its performance in terms of customer satisfaction. Therefore the GSCF framework processes of manufacturing flow, product development and commercialisation, order fulfilment and return management are not applicable to service-oriented supply chains. The intangible characteristic of service-oriented supply chains makes it necessary for companies to understand their service capacity, provide a tool to measure the purchased or delivered services, and manage the delivery of services.

Capacity management involves a company's investment in the skills of their personnel to undertake the required service such as maintenance. These skills are not limited to the manner in which services are delivered but also include the capability to assess their own capacity to undertake services and to assess those of other entities in the supply chain by which their company purchases or delivers the services. Service delivery management involves developing a precise service level agreement to minimise bias of perceptions of the purchased or offered services. From the buyer's perspective, service delivery management includes scrutinising the offer from the supplier or developing a detailed specification of the required services; from the supplier's perspective it includes similar processes but from the opposite direction. Capability to scrutinise the service level agreement will affect both supplier and buyer as an agreed cash flow management needs to be developed to finance the purchased/delivered services. Table 2.3

presents the elements of business and service processes of a supply chain. The elements under the service processes do not necessarily substitute the element in the same row under the business process unless they have the same titles.

Table 2.3: The business and service processes of a supply chain

Business processes (Lambert, Cooper & Pagh 1998)	**Service processes** (Ellram, Tate & Billington 2004)
Customer relationship management	Customer relationship management
Demand management	Demand management
Supplier relationship management	Supplier relationship management
Customer service management	Capacity management
Order fulfilment management	Service delivery management
Manufacturing flow management	Cash flow management
Product development and commercialisation	
Return management	

In relation to purchasing of maintenance materials and/or services, it appears that detailed information from maintenance personnel is essential across the capacity, service delivery and cash flow management. It is the maintenance personnel who deal with the details of processes of the maintenance and conditions of the equipment (Lee & Scott 2009). Their involvement, therefore, may be valuable in underpinning the successful management of a service-oriented supply chain.

2.6.3 Supply chain management components

The management components of the GSCF framework include physical, technical, managerial and behavioural factors of a company in managing their internal and external relationships (Lambert, Cooper & Pagh 1998). Furthermore, Lambert, Cooper and Pagh (1998) explain that the physical and technical factors include planning and control methods, work flow structure, organisational structure, information flow structure, and product facility structure. The managerial and behavioural factors include management methods, power and leadership, risk and reward, and organisational culture and attitude. The product facility structure may be changed to service facility structure in the context of service-oriented supply chains.

The GSCF framework provides general guidance on this element since it involves management approaches that are common across business processes. However, the strategic approach to implementing supply chain management involves long-term processes which require commitment and support from the most senior level of management of the companies (Al-Turki 2011; Mishra, Anand & Kodali 2006). With regard to the complexity of managing a supply chain and the need for a seamless flow of information, companies need to invest their resources in terms of personnel and facility to master the management of the supply chain (Kotzab et al. 2011). This investment should allow the companies to approach the management of their supply chain strategically.

2.7 Strategic implementation to supply chain management

Supply chain management, as a strategic approach, must be strategically planned, organised and executed in order to capitalise on its potential benefits. Although the GSFC framework comprises detailed elements in managing and implementing a supply chain management approach, the framework fails to identify the conditions required to be successful during implementation. Kotzab et al. (2011) have developed a model to identify the antecedents for the adoption and execution of a supply chain management approach. The model includes internal readiness condition, external relationship conditions, supply chain processes and execution of supply chain management approach. Each of these can be used to identify the elements of the GSCF framework in order to assess their conditions towards the execution of a supply chain management approach.

The internal readiness condition includes the supply chain management components of the GSCF framework — these relate to both the physical and technical factors and managerial and behavioural factors of a company. The internal readiness condition comprises the commitment and dedication of resources for managing the supply chain relationships, top management commitment and support, the use of information system for data exchange within the company and the integration behaviour at the corporate level. The external relationship conditions include the external parts and the supply chain configuration elements of the framework. These external relationship conditions measure joint planning and controlling system, long-term relationships initiative, information sharing on inventory status, mutual dependency and inter-organisational personnel exchange. The supply chain processes include the seven service processes proposed by Ellram, Tate & Billington (2004).

In terms of implementation, Kotzab et al. (2011) and Min and Mentzer (2004) emphasise the importance of developing internal readiness prior to managing the external relationships and executing the supply chain related processes. For example, Trent (2004) states that it is necessary to involve engineering or technical personnel as an integral part of the management to assess capacity and capability of companies' suppliers so that a strategic relationship with them may be developed. Kotzab et al. (2011) found that developing internal readiness for supply chain orientation is in the first priority of the antecedents' hierarchy for organisations for adopting and executing a supply chain management approach. Consequently, measurement of the internal readiness for supply chain orientation may provide the insight necessary for assessing the implementation of a supply chain management approach of entities in the supply chain network.

2.8 Summary

This chapter has discussed the significance of supply chains and supply chain management in providing customer satisfaction and its roles in determining the success and survivability of business organisations. The supply chain has been defined through its characteristics that include the existence of three or more organisations with business processes linkages to accommodate the flows of materials, products and services, finance, and information downstream or upstream, or in both directions. Supply chain management represents a coordinated network of entities that work in a collaborative environment to create and distribute values across the supply chain in the most cost-effective manner with regard to these challenges (Chan, Chung & Choy 2006; Chopra & Meindl 2010; Mentzer et al. 2001; van Hoek & Chong 2001).

This chapter suggested the GSCF framework as being useful to apply to service-oriented supply chains, and thus for maintenance. The framework comprises supply chain structures, supply chain business processes and supply chain management components. Adjustment to the GSCF framework were suggested in relation to elements proposed by Kotzab et al. (2011) which includes internal readiness conditions, external relationships conditions, supply chain related processes and execution of supply chain management approach. It was highlighted that companies need to acquire internal readiness conditions so that other components for capitalising on the supply chain management approach can be managed.

In terms of theory building, Soni and Kodali (2013) found a lack of industrial-based data to verify the practicability of the framework. They argue that the GSCF framework has been mostly verified through academic-based literature. The GSCF framework provides the detailed elements of supply chain management, and the industrial-based nature of the current research should underpin the verification, the practicability and the maturity of the framework. The current research suggests the GSCF framework may be a useful management approach when considering a strategic approach via supply chain management for ship maintenance. Chapter Three changes the focus away from supply chain management to review the current state of maintenance management research. This will enable a synthesis of the literature discussed in Chapters Two and Three to be explored in Chapter Four in relation to developing a supply chain management approach for ship maintenance.

Chapter Three

MANAGEMENT OF MAINTENANCE

3.1 Introduction

This chapter provides an overview of maintenance management by highlighting trends, perspectives and the roles of maintenance management in various industries. This should establish an understanding of the best practice of the management of maintenance. This chapter also discusses needs for a strategic approach to maintenance management in contributing profits for companies. The discussion then proposes undertaking a supply chain management approach that will enable a greater strategic focus on maintenance by senior managers.

3.2 Maintenance management — an overview

The importance of maintenance management has received increasing attention as companies endeavour to sustain the availability and reliability of their assets to gain a competitive advantage in terms of cost, service, quality and on-time delivery (Uusipaavalniemi & Juga 2009). This greater attention on maintenance management reflects the evolution of maintenance and the associated paradigms of thought, all of which is discussed in the following sub-sections to provide a general understanding of how maintenance has developed. To begin this section, the terminology in relation to maintenance management is explained so that the terms used in this thesis may be clarified. This is followed by a discussion on how companies manage the maintenance of their assets in terms of the goals, the roles and the organisation of maintenance activities.

3.2.1 Terminology

The field of maintenance involves multiple disciplines that create an overlapping use of terminologies (Kobbacy & Murthy 2008). For example, total productive maintenance and reliability centred maintenance are used to refer to both maintenance concepts and manufacturing techniques (see Amari, McLaughlin & Pham 2006; Backlund & Akersten 2003; Borris 2006; Fore & Msipha 2010; McKone & Weiss 1998; Peimbert-García et al. 2012; Tsang 2002). These terms are also attributed to maintenance strategies (see Visser & Jordaan 2009) and maintenance policies (see Bevilacqua & Braglia 2000; Braglia et al. 2006; Huo et al. 2005; Papic, Aronov & Pantelic 2009; Pintelon & Parodi-Herz 2008). The purpose of this sub-section is to provide a more consistent approach to the terminology and thus greater clarity and preciseness when discussing and comparing various maintenance concepts.

It is important to understand the definition of maintenance that is used in this thesis, as this impacts on how other terms, such as maintenance strategy, concept, policy and tasks are discussed. Some definitions of maintenance from the literature are provided in Table 3.1. The definitions of maintenance tend to converge around the efforts to retain or restore equipment conditions so that they can perform their designated function. However, some extended definitions are evident in the inclusion of administrative and managerial actions (see EN 2010; Khazraei & Deuse 2011), which enable a broader outlook of maintenance. Thus, to obtain a consistent approach to the definition of maintenance, this thesis refers to the definition provided by the European Standard that includes lifecycle period of an item, which states maintenance as:

> Combination of all technical, administrative and managerial actions during the lifecycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function, which include corrective and preventive maintenance.
>
> (EN 2010, p. 5)

Table 3.1: A sample of definitions of maintenance

Definition	Reference
The engineering decisions and associated actions necessary and sufficient for the optimisation of specified capability.	MESA (Maintenance Engineering Society of Australia) (MESA in Tsang 1998, p. 87)
All actions appropriate for retaining an item/part/equipment in, or restoring it to, a given condition.	Dhillon (2002, p. 16)
A set of activities to keep a system in a condition where it can perform its function.	Budai, Dekker and Nicolai (2008, p. 321)
Set of activities required to keep physical assets in the desired operating condition or to restore them to this condition.	Pintelon and Parodi-Herz (2008, p. 22)
A science-art-philosophy due to science reliance executions, unique approach for each problem and deliberate adjustment requirements.	Mobley (2008, p. 1.9)
The routine recurring work of keeping a facility in such condition that it may be continuously used at its original or designed capacity and efficiency for its intended purpose.	US-DOD (United States – Department of Defence) (2009, p. 321)
Combination of all technical, administrative and managerial actions during the lifecycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function, which include corrective and preventive maintenance.	EN (European Standard) 13306 (2010, p. 5)
All measures for maintaining and restoring the target condition as well as determining and assessing the actual condition of the technical equipment in a system, which include preventive, inspection, and repairs.	DIN (Deutsches Institut fur Normung) (DIN 31051 in Khazraei & Deuse 2011)

The term maintenance strategy is used when focusing on long-term operational issues of maintenance including a set of policies which reflect the art and science for achieving a successful implementation of maintenance concepts (Bevilacqua

& Braglia 2000; Khazraei & Deuse 2011; Kobbacy & Murthy 2008; Pintelon & Parodi-Herz 2008). Maintenance strategies encompass combinations of maintenance concepts that provide guidance on the deployment of various maintenance policies (Khazraei & Deuse 2011; Papic, Aronov & Pantelic 2009). The term maintenance policy refers to a set of corrective, preventive and predictive interventions to restore or sustain equipment condition back to or within its desired operational state (Khazraei & Deuse 2011). Corrective maintenance refers to interventions to restoring assets' condition after failure-related incidents take place, whilst preventive and predictive maintenance refers to interventions to sustain assets in their desired operating condition in order to prevent any occurrence of failure-related incidents (Dhillon 2006; Nevenhoven 2008; Pintelon & Parodi-Herz 2008).

Several terms such as such as total productive maintenance, condition based maintenance, reliability centred maintenance and computerised maintenance management system provide guidance on deployment of preventive and predictive maintenance to minimise corrective maintenance, and thus to minimise unexpected failed equipment (see Ahuja & Khamba 2008; Backlund & Akersten 2003; Cang et al. 2011; Peimbert-García et al. 2012). In relation to the terms maintenance strategy and maintenance policy, the mentioned terms can be referred to as maintenance concepts. In addition, the term maintenance task is used to represent actions that should be carried out by the personnel (technicians or operators of equipment) based on certain procedures, using proper tools and resources (Dhillon 2002; Kobbacy & Murthy 2008). Maintenance tasks may involve simple actions, such as cleaning, oiling or tightening, to sophisticated actions such as vibration and oil condition analyses.

This sub-section has provided definition on several terminologies in maintenance including strategy, policy, concept and task. These terms are used throughout this thesis in discussing management of maintenance. As indicated earlier, this thesis aims to establish consistency and clarity in discussion on maintenance management by providing these definitions.

3.2.2 The organisation of maintenance

Madu (2005) and Mitchell, Robson and Prabhu (2002) emphasise that a successful adoption of best practice maintenance into business strategy assists companies in achieving higher performance and, further, success for the companies. However, companies have experienced failure in attempts to adopt a perceived best practice in maintenance (Backlund & Akersten 2003). This failure may relate to the lack of a strategic approach that would anticipate managerial and organisational obstacles during the adoption process (Backlund & Akersten 2003; Coetzee 1999). Accordingly, it is important to provide a discussion on how maintenance is organised in order to gain insights from the processes that exist along maintenance flows and the managerial levels involved which influence decisions about the maintenance.

Based on their complexity, maintenance tasks can be grouped into three major levels (Blanchard 1998; Tsang 2002). Level-one maintenance comprises simple activities such as cleaning, lubricating and tightening, which are undertaken on-site by equipment operators or maintenance personnel with simple maintenance skills; level-two maintenance comprises activities such as detail adjustment and part replacement; and level-three maintenance comprises activities such as general overhauls, reconditioning and modifications (Tsang 2002). Furthermore, level-two and level-three maintenance requires the failed equipment to be transferred to a certain site and involves a higher level of maintenance skills to ensure that maintenance is performed properly (Kumar & Chaturvedi 2011). Figure 3.1 provides a diagram of the flows of maintenance and spare parts, and shows the sites where the three maintenance levels may take place. However, this model fails to address the flow between operational sites and spare parts suppliers, and the possible relationships between entities of maintenance chains.

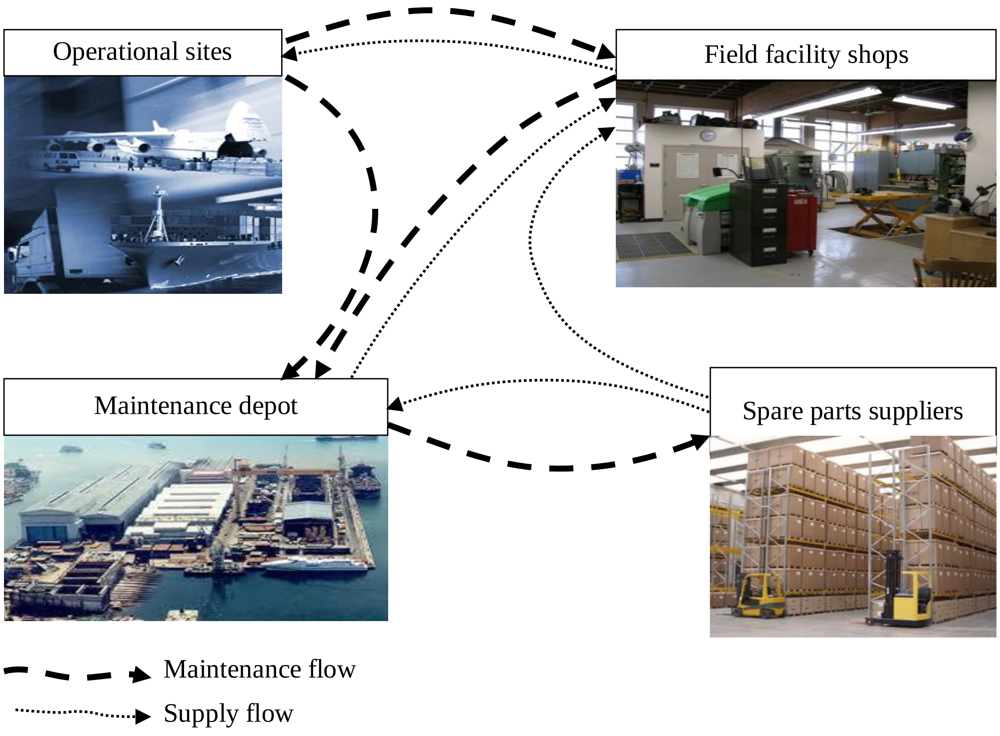


Figure 3.1: Maintenance flows

Source: Adapted from Blanchard (1998, p. 7)

The grouping of maintenance tasks within three levels of organisation could assist in the effective management of maintenance requirements at each level. For example, since cleaning and lubricating are grouped within level-one maintenance, procurement for cleaning materials and various classes of lubricating oil and grease can be allocated in a cyclic manner since no sophisticated control is required. However, maintenance at levels two and three may require certain spare parts that may be costly to be stocked (Karsten, Slikker & van Houtum 2012; Louit 2007; Tranfield, Denyer & Burr 2004). Controlling the quality of maintenance materials and/or services at these levels may also require certain skills that should be acquired by companies' personnel. Accordingly, managing the actions of all maintenance levels can be complex with regard to the number, the equipment, the maintenance requirements, the availability of spare parts needed and the involvement of external companies to provide the spare parts and services of maintenance (Sheng et al. 2009; Takata et al. 2004; Visser & Jordaan 2009). Hence, the management of maintenance should be strategically driven to properly phase in the actions and coordinate the inter-related entities in order to achieve successful maintenance.

Decisions with regard to maintenance may occur from any of the three levels of management: operational, tactical and strategic (Coetzee 1999; Hassanain 2002; Marquez 2007). Decisions at the operational level cover level-one maintenance, whilst decisions at the tactical and strategic levels cover maintenance levels two and three respectively (Tsang 2002). Hassanain (2002) notes that decisions at the operational level concern day-to-day maintenance activities whilst decisions at the tactical level concern the effective use of companies' resources when undertaking maintenance, and decisions at the strategic level concern the long-term objectives of companies. With regard to the long-term effects provided by the maintenance function (Tsang 2002), a strategic approach to maintenance management should enable decisions to integrate maintenance needs at all levels.

As shown in Figure 3.2, decisions regarding level-one maintenance can be made autonomously by operators of the equipment or maintenance personnel without interfacing with other departments of the company. However, clear guidance should be made available for decision making at this level and provided by the higher level of management, the tactical level. The same logic applies to decisions about level-two maintenance which are derived from the strategic level of the company's management. Decisions regarding level-three maintenance provide guidance concerning maintenance priorities which transforms the corporate business strategy into maintenance strategy (Marquez 2007). Figure 3.2 also indicates how maintenance decisions at the lower level are predetermined by the higher level of management.

In terms of cross-organisation coordination, Figure 3.2 suggests that undertaking level-one maintenance does not necessarily involve other departments within a company or other business organisations since it can be undertaken autonomously within its operational loop. Undertaking levels two and three maintenance requires coordination with the other departments to ensure that maintenance is undertaken properly. Moreover, the maintenance facilities for undertaking level-three maintenance of capital-intensive assets commonly belongs to different business organisations due to the high capital investment and the focus of the companies on their core business competencies (Alsyouf 2006; Marquez & Gupta 2006). Thus, it can be understood that the numerous maintenance activities in a company should be properly coordinated, phased and led through a strategic approach to management of maintenance for the benefit of business organisations (Coetzee 1999; Marquez 2007; Sheng et al. 2009).

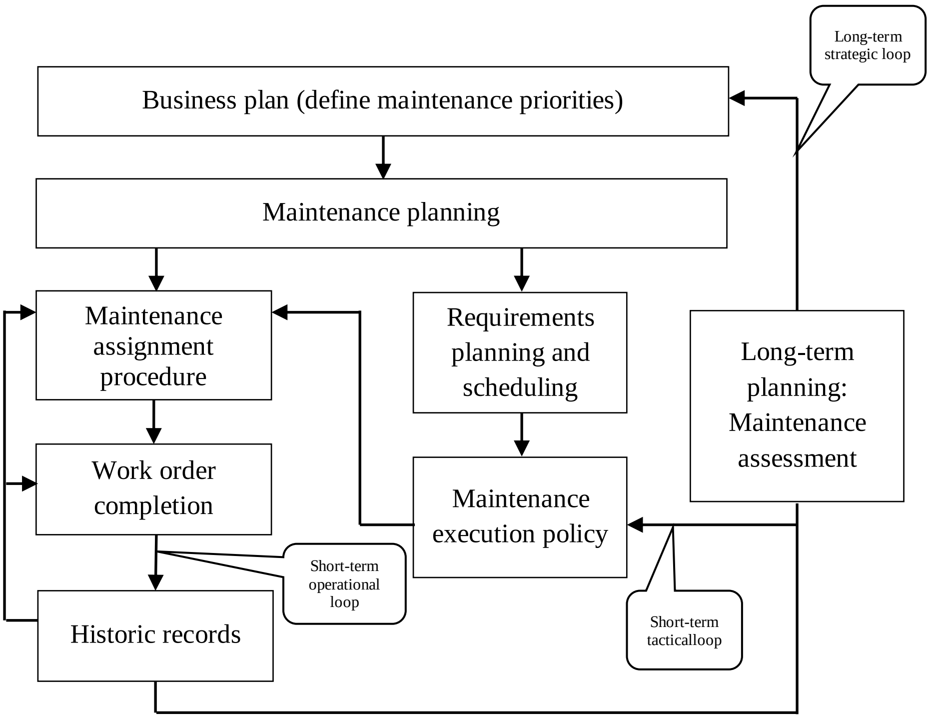


Figure 3.2: Maintenance decisions at three management levels

Source: Marquez (2007, p. 25)

Table 3.2 tabulates the summarised attributes of maintenance organisations as discussed thus far in this chapter. It is evident that maintenance involves multiple processes and parties that are involved throughout maintenance flow, which incurs increasing complexity in dealing with maintenance management.

Table 3.2: Maintenance organisations

Attributes	Classifications
Occurrence of failures	Corrective maintenance
	Preventive maintenance
	Predictive maintenance
Complexity	Maintenance level one
	Maintenance level two
	Maintenance level three
Decision levels	Strategic
	Tactical
	Operational

3.2.3 Maintenance roles

Maintenance roles have evolved over time along with the increasing pressure on companies to seek ways to gain competitive advantage. As shown in Figure 3.3, Pintelon and Parodi-Herz (2008) discuss the evolution of maintenance roles from a time perspective that illustrates how maintenance has been managed. Up until the 1940s, maintenance was primarily conducted to restore failed equipment to its operational state in situ by technicians without any recognition of its role in the success of the company (Borris 2006; Kobbacy & Murthy 2008). Little attention is evident in the scholarly and industrial publications of this period where the discussions are dominated by a focus on technical instructions or education (see Coffey 1885; Falkiner 1876; Köhler 1932; Pond 1936; Stone 1932). Maintenance was only recognised as being part of the daily activities of a company's operations that surfaced only after equipment broke (Kobbacy & Murthy 2008).

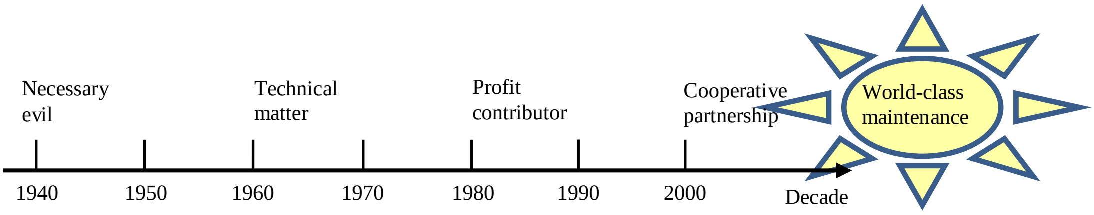


Figure 3.3: Maintenance roles from a time perspective

Source: Pintelon and Parodi-Herz (2008, p. 26)

During the period from the 1940s to the 1960s, there was a growing awareness of the importance of maintenance. However, maintenance was recognised more as an expense (for example Gould 1956; Wickenden 1953; Youngs 1954) and a ‘necessary evil’ which depleted companies’ revenues (Garg & Deshmukh 2006; Pintelon & Parodi-Herz 2008). During this period, undertaking maintenance to sustain the operability of equipment was still not apparent. The recognition of maintenance as an expense generated interest for academics and industry practitioners who sought greater control over maintenance.

Many maintenance concepts were introduced from 1960 to 1980. This is referred to as the ‘technical matter’ phase since during this time the major focus for controlling maintenance was on the procedure to undertake maintenance tasks effectively (Pintelon & Parodi-Herz 2008). This phase flagged the introduction of advanced concepts in undertaking maintenance such as reliability centred maintenance and total productive maintenance (Backlund & Akersten 2003; Ben-Daya 2000; Garg & Deshmukh 2006). Other maintenance concepts were also established such as condition based maintenance (see Amari, McLaughlin & Pham 2006; Oke 2004; Tsang et al. 2006), computerised maintenance management systems (see Braglia et al. 2006; Huo et al. 2005; Zhang, Li & Huo 2006), safety based maintenance (see Papic, Aronov & Pantelic 2009) and industrial based maintenance (see Waeyenbergh & Pintelon 2009). The emergence of these concepts developed a focus on improving the availability and reliability of equipment in underpinning the operations of the companies.

Maintenance during the period 1980 to 2000 is recognised as being a 'profit contributor' for companies. With global competition increasing, companies sought ways to improve their competitive advantage including maintenance (Luxhoj, Riis & Thorsteinsson 1997). The various maintenance concepts from the earlier periods began to be integrated with the recognition of their potential for increasing profits from the improved availability and reliability of equipment (see End 1987; Hughes et al. 1989; Parkinson 1991; Smith 1992; Soncini 1996). However, there was still a lack of understanding in linking maintenance expense to business outcomes (Al-Najjar & Kans 2006; Atkinson 2007; Coetzee 1999; Lazakis, Turan & Aksu 2010) thus hindering the efforts in capitalising on maintenance as a profit contributor rather than just an analytical argument. For example, Bitros and Kavussanos (2005) and Lazakis, Turan and Aksu (2010) have found there is still a 'necessary evil' perspective of maintenance that is a source of routine ad hoc expense rather than a profit contributor. Subsequently, during the post-2000 period, the maintenance role became identified as a 'cooperative partnership' between departments in a company that led to the development of the 'world-class maintenance' phase.

Pintelon and Parodi-Herz (2008) suggest that the evolution towards the role as cooperative partnership was inevitable. They suggest that maintenance roles should evolve to align with the technological evolution in production equipment and processes. Undertaking maintenance has become a more complex task that evolved from a simple purpose into a strategic one (Pintelon & Parodi-Herz 2008). In response to the increasing complexity in undertaking maintenance, the requirements of maintenance are also increasing beyond the capacity of a single company (Visser & Jordaan 2009). For example, acquiring special tools, using maintenance specialists and other maintenance requirements can be operationally expensive and economically uncompetitive when undertaken by a single company, whereas it might become more viable through multi-organisation partnerships (Sheng et al. 2009). Accordingly, it is important to understand a broader perspective of maintenance roles to enable inter-organisational partnership in undertaking maintenance.

3.2.4 The broad and narrow perspective of maintenance roles

The roles of maintenance comprise both narrow and broad perspectives (Al-Turki 2011; Bamber, Sharp & Castka 2004; Murthy, Atrens & Eccleston 2002). The narrow perspective recognises maintenance as a support function, being non-productive and adding little value (Bamber, Sharp & Hides 2002; Bamber, Sharp & Castka 2004). This perspective aligns with maintenance being a ‘necessary evil’ (Pintelon & Parodi-Herz 2008), a manufacturing overhead (Pinjala, Pintelon & Vereecke 2006) and a prime target for budget reduction purposes based on historical expenditure review (McKone & Weiss 1998; Mobley 2002; Salonen &

Deleryd 2011). Considering maintenance merely from this narrow perspective inhibits visibility from the top level of management towards considering the strategic value of maintenance (Marquez 2007; Salonen & Bengtsson 2011), and keeps maintenance as an isolated sub-function (Knapp & Mann 1998).

A broad perspective for undertaking maintenance recognises the potential of maintenance and its strategic value (Salonen & Bengtsson 2011; Tsang 2002). This broad perspective extends maintenance beyond the isolated sub-functional level to business strategy and, further, to being included within a supply chain management strategy. Furthermore, the broad perspective explains how maintenance influences the total lifecycle cost of assets' operations (Barringer & Humble 1998; Hayek, Voorthuysen & Kelly 2005; Takata et al. 2004) and provides greater profits for companies (Bechtel & Patterson 1997; Cholasuke, Bhardwa & Antony 2004; Madu 2000, 2005; Salonen & Bengtsson 2011). The broad perspective assists in gaining acknowledgement of maintenance as a profit contributor that encourages efforts to undertake maintenance in a 'cooperative partnership' internally and externally. With this perspective, maintenance is no longer considered an expense but an investment that yields returns (Alsyouf 2006). However, the broad perspective requires a balance of technical and management responsibilities to ensure profitability of operations (Al-Turki 2011; Lee & Scott 2009; Murthy, Atrens & Eccleston 2002; Pintelon & Parodi-Herz 2008; Smith & Hinchcliffe 2006). Thus, companies need to manage maintenance strategically in order to be able to benefit from the broad perspective.

It is important to embrace the broad perspective of maintenance roles. Through this approach, maintenance may enable its visibility by top-level management as a contributor of competitive advantage for the companies as well as for the supply chain by which the organisation operates. Merely embracing the narrow perspective could be myopic and overlook the strategic dimensions of maintenance which provide lasting effects on the future of business companies (Tsang 2002). Hence, it is evident that companies need to move beyond this narrow perspective to strategically manage maintenance, capitalise on the maintenance function as a profit contributor and achieve world-class status. Furthermore, embracing the broad perspective may underpin efforts in addressing the gap in managing the flow of supplies and relationships between entities of maintenance chains as discussed in section 3.2.2.

3.2.5 The roles of maintenance management

Maintenance management can be defined as the overall management of maintenance which involves activities that determine the objectives or priorities, strategies and responsibilities of maintenance, and implements them through planning, controlling and supervision, and several improving methods including economical aspects in the organisation (see: Dhillon 2006; Kobbacy & Murthy 2008; Marquez 2007; Palmer 2006). Maintenance management includes the management of internal capacity, planning and control, spare parts inventory control, evaluation of results, specification of undertaken maintenance and budget allocating to perform maintenance (Geraerds 1992). Hence, maintenance management roles can be associated with managing the complexity of maintenance through proper phases and coordination that require a strategic approach (Coetzee 1999; Salonen & Bengtsson 2011).

The need for a strategic approach to the management of maintenance increases with changes in the nature of production environments (Christopher & Holweg 2011; Lorange 2005; Marquez et al. 2009; Marquez & Gupta 2006). For example, a lean production system, which is introduced by eliminating or minimising the burden of inventory costs, requires available and reliable production plants (Madu 2005), which becomes more critical for ensuring the success of the production operations (Hertz 2006). However, achieving the required availability and reliability of production plants involves a series of planned stoppages for maintenance and additional costs (Deac et al. 2010). This situation may result in a conflict of interest between departments responsible for the operations and the maintenance of the production plants. Subsequently, a strategic approach to maintenance management becomes necessary to manage coordination between the compulsory stoppages with the target operations, and to compensate the increasing costs with the benefits capitalised on maintenance.

Visser and Jordaan (2009) and Sheng et al. (2009) note that the complexity of maintenance tasks relates to the increasing number and variety of equipment, enhanced technology, design and new maintenance tools and techniques. They add that these complexities also include the multi-partners' participation and network-based services. Raouf and Ben-Daya (1995) and Hipkin and De Cock (2000) point out issues such as increasing gaps between technology, equipment operators' and maintenance technicians' skills in the context of shortened products' lifecycle that intensify the complexity in undertaking maintenance. Companies need to manage these complexities strategically in order to balance the rapid enhancement of technology applied in production plants and maintenance tools and techniques.

The complexity of maintenance also relates to the stringent requirements to comply with rules and regulations with regard to environmental safety and sustainability, which emphasises the pivotal role of maintenance management. The rules and regulations concerning maintenance for environmental sustainability have forced companies to finance extra costs for maintenance. Examples of these regulations include the gas emitting pollutant limitation on ship emissions ('Court ruling backs California's strict low-sulfur air rules for ships' 2011; Eilperin 2008; Hanson 2007) and the International Safety Management (ISM) code for safe ship operations and pollution prevention (Goulielmos & Giziakis 2002; Knapp & Franses 2010; Mavromatakis, Colyvas & Nicolaou 1996). To comply with these rules and regulations, business organisations have to perform a series of necessary maintenance, which subsequently incurs additional expenses (Shinohara 2005). As a consequence, business organisations should strategically manage their maintenance function to enable compliance with these rules and regulations whilst simultaneously satisfying business objectives (Takata et al. 2004).

Maintenance is also referred to as a missing link for a total supply chain management (Bajgoric & Moon 2009; Jonsson 2000; McGrath 1999). A total supply chain management strategy emphasises the importance of ensuring uninterrupted operations by minimising costs throughout the supply chain (Madu 2000). This strategy suggests that any single failure at any point of the supply chain generates systemic losses which jeopardise the competitiveness of the whole supply chain network (Davis 1993; Lynch 2009). The failures may result from the unavailability of equipment or deteriorated quality of products due to unreliable equipment (Aoudia, Oumhani & Zwingelstein 2008; Luxhoj, Riis & Thorsteinsson 1997; Pun et al. 2002; Terpend, Krause & Dooley 2011). These losses may include loss of revenue, loss of data, deterioration of the brand's image, decreasing or even loss of customer satisfaction, slumping shareholders' value, and higher insurance costs (Bajgoric & Moon 2009). Thus, a strategic approach to maintenance management underpins the success of the strategy of total supply chain management.

In addition, although maintenance costs may contribute significantly to the organisation's expenses (Al-Najjar & Kans 2006), these costs can be overwhelmed by the costs of failed assets (for example see: Cleveland 2006; Jonsson 2000; Korosec 2010; Wang 2002; Yanchunas 2010). Cleveland (2006) provides the example of the Exxon Valdez in 1989 where Exxon Mobil was liable to pay a penalty of more than US $3.2 billion for legal responsibilities. The incident involves spillage of 37,000 ton of crude oil from Exxon Valdez oil tanker, in Bligh Reef in Prince William Sound, Alaska. In addition, the environmental impacts take 15 years to recover. It became evident that developing a strategic approach to maintenance management could preserve both profits and environment.

With regard to the maintenance-related incidents, which cause failure in the supply chain, every entity needs to ensure the availability and reliability of their equipment in order to ensure uninterrupted operations. This in turn requires these entities to adopt the broad perspective of maintenance which encourages efforts to ensure the existence of uninterrupted operations throughout the supply chain and prevents the occurrence of systemic losses by sustaining the availability and reliability of critical assets (Bardey et al. 2005; Salonen & Bengtsson 2011; Sheng et al. 2009). In terms of supply chain management's missing link, every entity across the supply chain needs to ensure that their production plants operate constantly without interruptions even for maintenance reasons. There are perceived conflicts between the need to increase organisational efficiency and the need to improve and/or sustain the reliability of assets, which inevitably incurs maintenance requirements and costs augmentation (Deac et al. 2010; Faria 2008; Kraš & Sviličić 2006). Consequently, for these reasons, a strategic approach to maintenance management is critical to provide maintenance as a profitable missing link, which underpins sustainable linkage for the total supply chain management.

3.2.6 World-class maintenance

Providing world-class maintenance is the ultimate goal of undertaking maintenance (Atkinson 2007; Ingalls 2010; Tomlingson 2007). The term world-class maintenance refers to an aspiration to deliver the best maintenance-based support for the competitiveness of the organisation (Mishra, Anand & Kodali 2006; Silverberg & Idhammar 1997). To explain the perceived value of world-class maintenance, Silverberg and Idhammar (1997) contrast world-class maintenance against non-world-class maintenance. They identify world-class maintenance as an active approach to anticipate the future, and the planning and scheduling of various maintenance-related actions such as defining certain maintenance concepts, developing formal procedures to perform maintenance tasks and developing a list of key performance indicators to evaluate the performance of the undertaken maintenance tasks. World-class maintenance comprises continuous innovations such as selection and evaluation of maintenance concepts to find the core problem of failed equipment rather than focussing on solving the recurrent problems.

World-class maintenance capitalises on strategies which comprise anticipation, planned actions, revealing the cause of failure rather than solving recurrent problems, a focus on lifecycle cost rather than lowest purchase price, and being effective and cost efficient and accepted by the organisation (Atkinson 2007; Ingalls 2010; Silverberg & Idhammar 1997; Smith & Hinchcliffe 2006). World-class maintenance integrates maintenance with the other business organisation's functions such as production, procurement, logistics, finance and management (Muchiri et al. 2011). In addition, world-class maintenance encompasses self-benchmarking and continuous improvement of the implemented maintenance concepts (Silverberg & Idhammar 1997). In sum, world-class maintenance suggests a concept that comprises a cycle of maintenance program determination, implementation of the program, and evaluation of the implementation, as depicted in Figure 3.4.

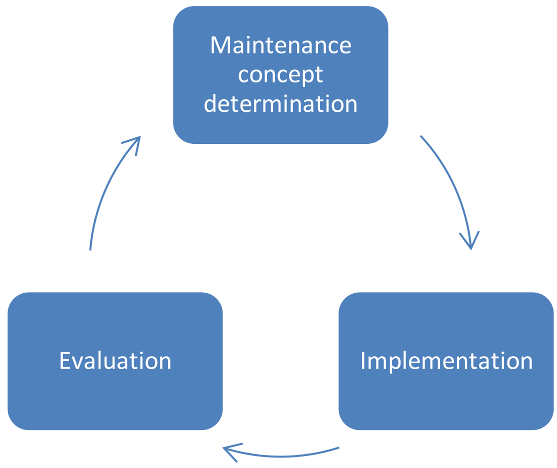


Figure 3.4: The world-class maintenance cycle
Source: Author

Several authors, as listed in Table 3.3, discuss how to provide world-class maintenance. Maintenance concepts such as reliability centred maintenance, total productive maintenance, effectiveness centred maintenance, computerised maintenance management system and condition based maintenance should be adopted to initiate the cycle towards world-class status. However, beyond the promised success of these concepts, many companies encounter failures during the attempt to implement the concepts due to the emergence of various managerial and structural challenges during implementation (Backlund & Akersten 2003). Accordingly, a strategic approach to maintenance management for adopting these concepts is necessary for companies to attain successful maintenance.

As shown in Table 3.3, it appears that there is no certain formula for achieving world-class maintenance status. A strategic maintenance management is required to tailor a mixed maintenance concept to overcome challenges found in the unique contextual environment of each company. However, the literature shows that the development of a maintenance strategy remains in isolation of departmental boundaries, which inherently constrains the capability of the companies to capitalise on the maintenance function (Chopra & Meindl 2010). Several authors suggest the need for a strategic approach to maintenance management which enables a proper integration of various departments and organisations that are involved across the maintenance processes (Ferrario, Waters & Smyth 2000; Ferrario & Smyth 2001; Jenab & Zolfaghari 2008; Sheng et al. 2009; Trappey, Hsiao & Lin 2011).

Table 3.3: Guidance for world-class maintenance status

Author	Guidance
Silverberg and Idhammar (1997)	1) Set up a maintenance program; 2) Cost-effective maintenance procedures; and 3) Key performance indicators.
Idhammar (1998)	1) Focus on lowest LCC; 2) Integrate production, engineering; and 3) Maintenance as a team pursuing the same results.
Jonsson (2000)	1) Integrate preventive maintenance; 2) CMMS; and 3) The structure and actors in the organisation.
Fernandez et al. (2003)	1) Customise CMMS in 3 modules (run to failure, corrective action, and preventive maintenance); 2) Implement maintenance organisational maturity grid.
Waeyenbergh and Pintelon (2004)	1) Identification of the objectives and resources; 2) Selection of the most important systems and identification of the most critical components; 3) Maintenance selection and optimisation of the parameters; 4) Implementation and evaluation; 5) Feedback.
Smith and Hinchcliffe (2006)	1) View maintenance as a profit centre; 2) Focus resources for the best ROI; 3) Avoid intrusive maintenance; 4) Measure results; 5) Employ an effective management system.
Atkinson (2007)	1) Create a formal maintenance program; 2) Create a thorough division of duties; 3) Make sure the program facilitates quick changeovers.
Ingalls (2010)	1) Proactive maintenance to prevent any occurrence of failures.
Lazakis, Turan & Aksu (2010)	1) Employ well-structured maintenance approach; 2) Flexible maintenance approach; 3) Obtain feedback from operations; 4) Involve experts' judgement; 5) Include periodical reviews and incorporate changes; 6) Include maintenance information technology system.

3.3 Strategic approach to maintenance management

A strategic approach to maintenance management is critical for companies, in particular those whose assets are technologically sophisticated and involve a significant amount of capital investment (Bendall & Stent 2005; Coetzee 1999; Sheng et al. 2009; Tsang 2002). This approach should prevent companies from having a short-term myopic perspective about maintenance and can underpin the achievement of long-term benefits (Tsang 2002). It is one of the key factors influencing the success of maintenance and thus the companies (Aleksic & Stanojevic 2007). Relentless efforts have been made to attain benefits from maintenance, which has resulted in several maintenance concepts as mentioned in previous sections. However, numerous failures hamper the attempts to capitalise on the maintenance function, and these are related to the lack of strategy driven management (Backlund & Akersten 2003; Coetzee 1999; Hansson, Backlund & Lycke 2003; Simões, Gomes & Yasin 2011).

In a study on the strategic dimensions of maintenance management in companies with significant investments in physical assets, Tsang (2002) provides a detailed discussion on Visser's input-output maintenance model (as shown in Figure 1.2). This model depicts maintenance as a process to transform inputs for maintenance through a company's maintenance system and into expected output. The input comprises labour, materials, spare parts, tools, information, budget and external services; and the output comprises availability and maintainability of the company's assets, safety operations of production system and profits for the company. Based on this study, Tsang (2002) identifies four strategic dimensions of maintenance management: service delivery, organisational design, maintenance methodology and support system.

The service delivery dimension covers the management of inputs. Managing these inputs may involve cross-organisational boundaries relationships. The organisational design and maintenance methodology dimensions cover the maintenance system of the company. These dimensions relate to the orchestration of various maintenance concepts and decision making which have been summarised in Table 3.2 (section 3.2.2, p. 49). The support system dimension covers the infrastructure to support decision making about maintenance such as having commitment from top management and all employees, organisational hierarchy, information and communication technology, and reward and recognition for all employees. Tsang (2002) suggests the importance of internal commitment for achieving successful maintenance and the use of information technology to accommodate the flow of information across maintenance processes. However, further detail is not provided to accomplish this need, which provides some motivation for this research to propose an approach to overcome this gap.

Coetzee (1999) emphasises the need for a holistic approach to strategically manage complexity in maintenance. With regard to this holistic approach requirement, the four strategic dimensions of maintenance management (Tsang 2002) should be considered as a whole. Otherwise, it might introduce a fragmented solution in managing the complexity in maintenance. Discussions on maintenance concepts such as reliability centred maintenance and total productive maintenance cover only the organisational and methodological dimensions of maintenance management. In this respect, the discussions are limited to a focus on a maintenance system within the organisation system of Visser's model. Furthermore, applying these two strategic dimensions of maintenance management to the decision levels of management as shown in Figure 3.2 could provide insights that various maintenance concepts contribute fragmented solutions to the complexity of maintenance in the operational and tactical loop of management levels. These circumstances may corroborate the arguments that various maintenance concepts only provide fragmented solutions to the efforts to capitalise on maintenance (Coetzee 1999; Tsang 2002). Without disregarding the strategic value of planning the maintenance system of the companies, a strategic approach to maintenance management should not only focus on the maintenance concepts.

Measurement of the outputs of the model appears to be overlooked. Several authors (for example: Åhrén & Parida 2009; Al-Najjar & Hansson 2004; Mitchell, Robson & Prabhu 2002; Richard et al. 2000) focus on benchmarking as a key for enhancing maintenance management in industries. Richard et al. (2000) use benchmarking as a strategic approach to management of maintenance for power plants that focuses on customer requirements to improve the performance of the plants. Mitchell, Robson and Prabhu (2002) benchmarked the deployment of maintenance practices in manufacturing organisations in the United Kingdom and found that manufacturing organisations, which were grouped as leaders in good maintenance practices, perform better than those that are grouped as lagers.

Åhrén and Parida (2009) suggest that benchmarking is an effective tool for continuously improving maintenance management performance in the railway industry. Al-Najjar and Hansson (2004) explain that benchmarking may provide an effective tool for the never-ending management of maintenance performance improvement. By incorporating measurements of the outputs of the model with the four strategic dimensions of maintenance management, a strategic approach to maintenance management may be obtained.

Managing the inputs and support system dimensions of Tsang's four strategic dimensions may involve cross-organisational relationships. The inputs in Visser's model might belong to other companies (Visser & Jordaan 2009). Consequently, the development of strategic relationships between the external suppliers is necessary in order to obtain inputs in a profitable manner. With regard to efforts to attain successful maintenance, implementing a strategic management approach to these inputs may result in reduced maintenance costs and increased revenue for the companies. In terms of support system dimension, a strategic management of maintenance should involve all employees, including the top management level of the companies (Coetzee 1999; Trent 2004). The involvement of top management is essential since managing maintenance suggests a long-term process that requires their commitment and support (Tsang 2002). In addition, holistic involvement from all employees determines companies' capabilities to manage their maintenance and the relationships with suppliers of the inputs (Kotzab et al. 2011; Trent 2004).

By understanding the processes and the requirements of maintenance using the Visser's input-output model, it appears that managing the supply chains of maintenance introduces a strategic approach. The process to determine the required inputs and the suppliers of a company's maintenance system to provide the expected output in a profitable manner indicates some elements in the supply chain management. However, research on maintenance using a supply chain management approach has not been found in the literature. This gap in the literature provides motivation for this research to propose a supply chain management approach as strategy driven maintenance management to manage complexity in maintenance. In addition, this research may provide further insights for the implementation of management of service-oriented supply chains as indicated in Chapter Two. Research interest in management of service-oriented supply chains appears to be an emerging research interest (see: Ellram, Tate & Billington 2004; Giannakis 2011; Marosszeky 2005). The next section will discuss the supply chain management approach in the context of maintenance management.

3.4 The supply chain management approach

As discussed in Chapter Two, the supply chain management approach to be investigated in this research is based on the Global Supply Chain Forum (GSCF) framework. This framework has been adjusted to accommodate the uniqueness of service-oriented supply chains (see Ellram, Tate & Billington 2004). The adjusted framework consists of network structure, service processes and management components.

Acknowledging that the competitiveness of a supply chain may influence the organisation's performance (Lynch 2009) and maintenance provides a missing link to the total supply chain management (McGrath 1999), the implementation of a supply chain management approach for maintenance management can be of benefit and value to the body of knowledge associated with supply chain management and maintenance management.

3.4.1 Maintenance supply chain network structure

Managing the supply chain structure requires identification of the members of the supply chain, the structural dimension, and the types of linkages among these members (Lambert, Cooper & Pagh 1998). In their research concerning an integrated maintenance network, Trappey, Hsiao and Lin (2011) propose a model that conceptualises relationships between business organisations throughout the maintenance process. Using multi-agent system modelling, they propose a collaborative environment by which a maintenance provider integrates other organisations such as assets' owners, original equipment manufacturers, service providers, and suppliers for spare parts and consumables. Another model is proposed by MacDonnell and Clegg (2007) in designing support for the maintenance supply chain in the aerospace industry. The model recognises entities in the supply chain such as assets (aircraft) owners, original equipment manufacturers, maintenance provider organisations, parts traders, and vendors for repairing failed parts.

Both of the above models discuss maintenance chains in specific industries, such as power plant generators and aviation. Both models have carefully identified the entities in the related maintenance chain which consists of the suppliers, the focal companies and the customers. Furthermore, these models discuss the maintenance supply chains by assigning the maintenance provider as the focal company. The suppliers of maintenance requirements are consolidated by the focal company, whilst asset operators are considered the customers of the maintenance supply chain, as shown in Figure 3.5. The asset operators may consist of the owner of the equipment who directly manages the equipment operation or merely the equipment operators as employees of the companies that operate the business in the corresponding industries.

The original model in Figure 3.5 has not recognised the importance of seamless flow of information, materials, services and finances across the entities of the maintenance chain, and the need to develop strategic relationships between the entities. By integrating these requirements, this thesis uses the maintenance chains model as a generic design of integrated maintenance supply chains. The original models of maintenance chains (MacDonnell & Clegg 2007; Trappey, Hsiao & Lin 2011) assume the entities of the supply chains are voluntarily integrated with the supply chain management, which is initiated by the focal company. In contrast, integrating entities across supply chains incurs challenges which may cause underperforming supply chains (Fawcett, Magnan & Fawcett 2010; Fawcett, Magnan & McCarter 2008b). However, this model provides insights into the supply chain structure of service-oriented supply chains by identifying the entities and their possible linkages. These models may serve as a foundation to the research of the ship maintenance supply chains in Chapter Four.

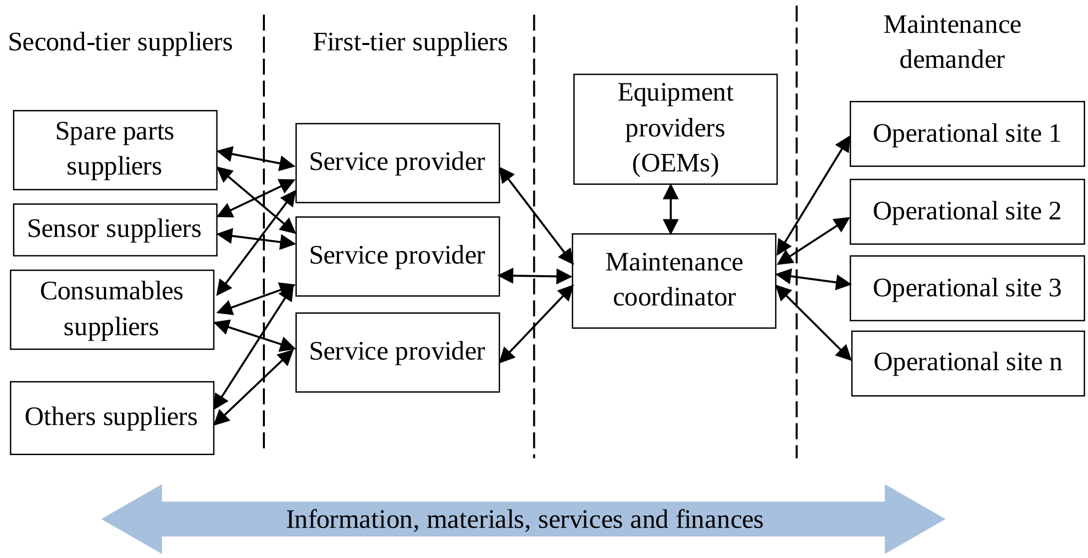


Figure 3.5: A maintenance supply chain model

Source: Adapted from Trappey, Hsiao and Lin (2011) and MacDonnell and Clegg (2007)

In addition, in research into the construction industry, Marosszeky (2005) found that service-oriented supply chains are characterised by fragmentation of numerous suppliers with short-term transactional and long-time procurement processes. It becomes challenging to develop a collaborative management in service-oriented supply chains. Even though Ellram, Tate and Billington (2004) argue that service-oriented supply chains networks can capitalise on the benefits of the supply chain management approach, long-term commitment and support should be provided to overcome the barriers for collaborating suppliers in the networks (Briscoe & Dainty 2005; Dainty, Briscoe & Millett 2001). The commitment and support must first generate internal readiness of companies before they take further steps to develop the inter-organisational relationships of the supply chain management approach (Kotzab et al. 2011).

3.4.2 Maintenance supply chain service processes

In general, the supply chain business process involves activities to manage inputs, value-adding processes, and delivering products as outputs (Alsyouf 2006). However, the intangible characteristics of service requires adjustment to the business processes in order to fit into the different contexts of supply chain management (Georgise, Thoben & Seifert 2012). Ellram, Tate and Billington (2004) argue that the intangible product that flows across service-oriented supply chains requires a different set of activities. They suggest adjusting business processes into service processes which include capacity management, demand management, customer relationship management, supplier relationship management, service delivery management and cash flow management as the activities that comprise the business processes across the service-oriented supply chains. This model, as shown in Figure 3.6, accommodates cross-departmental and organisational boundaries of the maintenance supply chain.

Figure 3.6 indicates that information flow plays a critical part in service-oriented supply chains (Ellram, Tate & Billington 2004). A seamless flow of information between departments in companies and entities in the supply chain could help all parties to work effectively and reduce uncertainty in the supply chain (Childerhouse & Towill 2004; Choy et al. 2007). Web-based communication may enable the supply chain to develop seamless information flow (Trappey, Hsiao & Lin 2011). For managing capacity to deliver services, Ellram, Tate and Billington

(2004) explain companies need to invest in their personnel skills, assets availability and its reliability to perform intended functions. Flin, O'Connor and Mearns (2002) explain that in the aviation industry the investment involves crew resource management which includes designing of equipment to reduce errors, training in leadership and teamwork and skill development to undertake maintenance tasks. They add that this approach has been adapted in other industries such as the nuclear power industry, aviation maintenance and offshore oil industry. Companies may also develop a module of tasks which explains the available capacity (Bask et al. 2010).

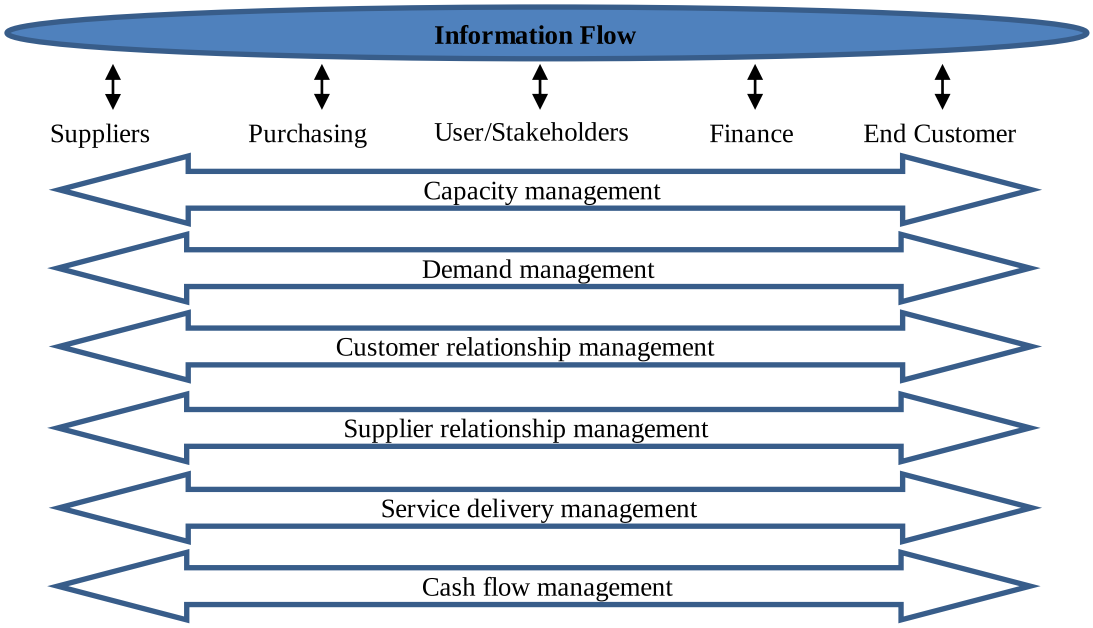


Figure 3.6: The supply chain service processes

Source: Ellram, Tate and Billington (2004, p. 24)

Demand management involves matching the company's own capacity with the services on offer (Ellram, Tate & Billington 2004). The matching process may involve assessment of current workload and potential to overtime or outsource additional resources (Giannakis 2011). It appears that the modularity approach above can assist managers to carry out this matching task. The modularity approach may also underpin the process to discover the relationships between service and cost (Guo & Gershenson 2007).

Management of the customer relationships, supplier relationships, service delivery and cash flow appear to relate each other. Customer relationship management is explained as suppliers' efforts in developing an understanding of what the customer needs and meeting those need, whilst supplier relationship management pertaining to identification and specification of own companies' needs to purchase services from suppliers (Ellram, Tate & Billington 2004). Both customer and supplier are connected to each other when developing and scrutinising service level agreements of service delivery management. Having a capability to develop detailed service level agreements influence both parties to plan the payment of the purchased or delivered services, which appears in cash flow management (Ellram, Tate & Billington 2004; Giannakis 2011)

In maintenance supply chains, the involvement of maintenance personnel at the corporate level of management could influence companies' capability to manage these service processes (Lee & Scott 2009; Trent 2004). Maintenance personnel deal with the real condition of companies' assets and can provide relevant information in assessing companies' partners in the supply chains who provide assets' maintenance services. Precise information about the condition of assets is important for decision making on maintenance (Braglia et al. 2006; Huo et al. 2005). In addition, involvement from all employees such as equipment operators and technicians is essential for providing the necessary information to obtain maintenance-related data (Huo et al. 2005). It appears that a holistic maintenance involves all employees, and the involvement of maintenance personnel at the corporate level of management to influence companies' capability to manage service processes in the supply chain.

3.4.3 Maintenance supply chain management components

Supply chain management components comprise the physical and technical management components and the managerial and behavioural management components (Lambert, Cooper & Pagh 1998). The physical and technical components comprise planning and control methods, activity structure, organisation structure, communication and information facility structure, and product flow facility structure (Spens & Bask 2002). The other components comprise management methods, power and leadership structure, risk and reward structure, and organisational culture and attitude (Spens & Bask 2002). These managerial components provide an essential foundation for successful supply chain management as they disclose the integration and management of business processes in the supply chain (Spens & Bask 2002). It appears that managing the management components of the supply chain internally pertains to developing internal readiness, whilst managing the components with other entities pertains to developing external relationship conditions (Kotzab et al. 2011).

3.5 Summary

Throughout this chapter, the pivotal role of maintenance management in the contemporary business environment has been highlighted for its ability to properly phase and coordinate various maintenance activities. A strategic approach to maintenance management can provide world-class maintenance, and it promotes maintenance as one of the profit contributors. Various maintenance concepts from the literature suggest a fragmented solution to deal with the complexity of maintenance, and they are subjected to cost-reduction programs and lack of strategy driven management which hinder its visibility from top level management of companies (Coetzee 1999; Salonen & Deleryd 2011).

A supply chain management approach based on Visser's model is proposed as a strategic approach to maintenance management. The approach recognises the supply chains of maintenance that consists of supply chain structure, supply chain service processes and management of supply chain. Adopting this approach may help companies to plan and control managerial and organisational challenges, which usually emerge during the implementation of suitable maintenance concepts for a specific industry.

However, examples of the implementation of the supply chain management approach in the maintenance context, specifically in the shipping industry, cannot be found either in the engineering or business literature. The lack of studies regarding ship maintenance utilising a supply chain management approach has provided the impetus for this research to conduct an empirical study in the shipping industry. The supply chain management approach will be incorporated into a ship maintenance context in Chapter Four. Research on the implementation of a supply chain management framework to ship maintenance may provide an extended horizon for both supply chain management and the maintenance management bodies of knowledge. Furthermore, shipping companies from which the data for this research is collected may benefit from the research by capitalising on the supply chain management approach for maintaining their ships and improving the shipping organisations.

Chapter Four

SHIP MAINTENANCE MANAGEMENT

4.1 Introduction

The previous two chapters established the construct of a supply chain management approach for maintenance. This chapter discusses the implementation of this construct as a strategic approach to managing ship maintenance to improve its performance. The importance of shipping is first discussed to establish the context of the shipping industry and the supply chains through which the shipping companies operate. This discussion of ship maintenance from the perspective of supply chain management as a strategic approach is to establish the empirical research of this thesis.

4.2 The shipping industry

To understand the importance of ship maintenance management, this section discusses the roles of shipping companies in the context of global supply chains. In the globalised environment, transportation is the only function that physically links entities of the supply chain (Lambert & Cooper 2000; Morash & Clinton 1997; Stank & Goldsby 2000). This role attributes transportation as a key integrator of global supply chains (Helms & Dileepan 2005). Transportation also is also a catalyst in leveraging the performance of a supply chain in terms of effectiveness and responsiveness to satisfy customer requirements whilst maintaining operational efficiency to lower its total costs (Kutanoglu & Lohiya 2005). These roles have shifted the need for straightforward transportation services towards bundled services of logistics management, which is referred to as logistics services in this thesis (Helms & Dileepan 2005).

The need for logistics services provides an impetus for shipping companies to shift towards logistics service providers (Panayides 2006). The movement of shipping companies towards being logistics service providers is evident due to developments towards one-stop integrated freight movements with door-to-door features (see Addico 2010; Evangelista & Morvillo 2000; Notteboom & Merckx 2006; Panayides 2006). By offering logistics services, shipping companies strive to satisfy customers with value added services in terms of time and cost efficiency (Panayides 2006).

The shipping industry is a traditional industry which remains important in underpinning the success of international trade and global growth (Cheng & Choy 2007). By volume, more than 80 per cent of global trade volume is seaborne, which equates to 70 per cent of the value of global trade (Berle, Rice & Asbjørnslett 2011; Cullinane & Panayides 2000; UNCTAD 2010, 2011). The industry is an effective and important part of the multi-modal transportation system due to its capability to reach remote locations that cannot be reached by other modes of transportation (Grama & Patache 2011). Within this context, the availability of ships and their reliability to undergo the scheduled voyages could affect supply chain performance (Notteboom 2006).

Despite the important roles of shipping companies, they face relentless challenges in gaining more than marginal profits (Hwang, Visoldilokpun & Rosenberger 2008). Furthermore, shipping companies should also continuously improve their performance in order to stay competitive in business (Cheng & Choy 2007). The need for, and the importance of, logistics services in addition to narrowing profit margins in the shipping industry are forcing shipping companies to explore various options for managing their operations more profitably.

4.3 Ship maintenance in the shipping industry

It has been discussed that ships provide the main means in underpinning the shipping industry and global trade by handling and/or moving and/or storage of cargoes (Robinson 2005; Stopford 2009). The importance of these activities is demonstrated by the resulting revenue which represents the core income for shipping companies to finance their operations (Zacharioudakis et al. 2011). Thus, it is important for shipping companies to maintain the availability of ships of their fleet to undergo the scheduled shipping services. Discussion in Chapter One indicated that various strategies have been studied to improve shipping performance in terms of schedule reliability, but not in ship maintenance management. Accordingly, it is important to provide a discussion to establish an understanding of how ship maintenance underpins shipping performance.

4.3.1 Shipping performance

Shipping performance has been intensively discussed in the literature as the capability of shipping companies to meet the requirements of diverse stakeholders (see Feng & Chang 2008; Fusillo 2004; Ting & Tzeng 2003; Vernimmen, Dullaert & Engelen 2007; Zacharioudakis et al. 2011). Casaca and Marlow (2007) classify the stakeholders in the shipping industry by using a business process approach that includes suppliers, the focal company and the buyers. The suppliers include port operators, shipbuilding yards, consulting firms, ship management, ship chandlers, ship agents, and bunker suppliers. The focal companies comprise shipping companies, which include ship owners and ship operators, whilst shippers and charterers are the buyers of shipping industry, the customers. These stakeholders may have conflicting interests and the satisficing of their interests depends on the strategic management approach implemented by the shipping companies. Strategic management should enable shipping companies to attain optimum value whilst accommodating these conflicting interests. The success of shipping companies in satisficing the conflicting interests can be attributed as their performance.

The performance of shipping organisations can be assessed through various attributes (see Table 4.1). These attributes imply the capability and the capacity of shipping companies to meet the requirements of their stakeholders, both as the suppliers and the buyers of the shipping services. As outsourcing became more prominent in the contemporary business environment (Berglund et al. 1999; Wallenburg et al. 2010), many companies in the supply chain network searched for logistics service providers whose performance can leverage their capability to meet customer expectations. This in turn put pressure on shipping companies to improve, or at least maintain, the performance of their fleet despite the high and increasing expenses of ship operating costs (Fusillo 2003).

As shown in Table 4.1, in research on financing for the shipping industry, Dimitras, Petropoulos and Constantinidou (2002) found that financial institutions emphasise the capability of shipping companies in generating profits from shipping operations. This implies that ships should be available for sailing the scheduled services in order to generate revenue and profit for the companies. Scholars such as Fusillo (2004), Lewis, Singh and Fay (2006), Shinohara(2005), Langfeldt (2006) and Pawlik (2006) have studied ships' operating expenses in relation to generated revenue for the shipping companies. Some information emerging from the studies indicates that although operating the ships incurs costs it still provides revenue for the companies. Fusillo (2003) found most shipping companies operate their ships at a loss so that they could sustain their market share in the shipping market. He explains that while most shipping companies decide to operate at a loss, this can be compensated in another shipping period. This is preferable to losing their market share, which would indicate the companies are no longer in business.

Table 4.1: Attributes of shipping performance

Attributes	Reference
Ability to generate profits	Dimitras, Petropoulos and Constantinidou (2002)
Reliability of delivering service and capacity of shipping	Becker, Burgess and Henstra(2004), Ting and Tzeng (2003)
Frequency of services	Feng and Chang (2008)
Schedule reliability	Kjeldsen (2011)
Schedule and transit time reliability	Notteboom (2006)
Ship schedule reliability and cost leadership	Vernimmen, Dullaert and Engelen (2007)
Cost leadership	Fusillo (2004), Lewis, Singh and Fay (2006), Shinohara(2005), Langfeldt (2006)
Proper transport service at the right time and the right port, with appropriate ship, at appropriate freight levels	Plomaritou (2008)
Optimal ship's operational profile	Zacharioudakis et al.(2011)
Availability and adequacy of shipping space, frequency of services, safety of cargoes on board, freight rates, and standard compliance of ships	Addico (2010)
Service quality, reliability, speed, flexibility, and cost	Pawlik (2006)

Other scholars such as Ting and Tzeng (2003), Becker, Burgess and Henstra (2004), Notteboom (2006), Feng and Chang (2008), Kjeldsen (2011) and Zacharioudakis et al. (2011) indicate the importance of available and reliable ships to undergo the scheduled shipping services. The discussions above suggest that shipping performance is significantly influenced by the availability of ships and the reliability of the ships to sail their scheduled voyages. Therefore, it is important to measure availability of the ships and their reliability in undergoing their scheduled voyages in order to assess the performance of shipping companies. Subsequently, shipping companies need to undertake ship maintenance to maintain the availability and reliability of the ships as it is this which underpins shipping performance.

4.3.2 Ship maintenance

As capital-intensive investments with a relatively short economic life, ships are required to be in an operational state for as long as possible to satisfy high-level expectations of occupancy and to provide the highest revenue to overcome the shrinking profit margin (Branch 2007; Hwang, Visoldilokpun & Rosenberger 2008). However, ships are subjected to a vast number of rules and regulations for safety and sea-worthiness which obligate the ships to undergo a series of maintenance and surveys (Banawan, El Gohary & Sadek 2010; Crocker & Sheng 2008; Stopford 2009; Thai & Grewal 2006). Even though compulsory ship maintenance and surveys can promote competitiveness in relation to ships' availability and reliability, managing ship maintenance incurs additional costs which has been a perpetual challenge for shipping companies to justify this expense as compared to turnover from its operation (Dwight 1994; Ward et al. 2010). These obligations could deplete the stringent operational state of the ships in order to earn expected revenue for the ship owners. Thus, a strategic management approach to ship maintenance is necessary to accommodate all obligations whilst maintaining the profit margin for the companies.

The literature indicates that the maintenance of ships has been conducted merely for the purposes of complying with the vast number of rules and regulations rather than being managed as a contributor to companies' profit (Bitros & Kavussanos 2005; Crocker & Sheng 2008; Garg & Deshmukh 2009; Li & Cullinane 2003). The extensive rules and regulations and the number of maintenance tasks to be performed creates a greater complexity in undertaking ship maintenance as well as more demand for resources in terms of time, finance and manpower. In research on implementing reliability centred maintenance in maritime operations, Mokashi, Wang and Vermar (2002) indicate that personnel on ships are overburdened with numerous tasks in maintaining the equipment on board. In addition to the rules and regulations, the equipment may also be bound to insurance conditions from the manufacturers. Many tools have been introduced to deal with the maintenance problem, some of which further increase the complexity in determining how to maximise the use of these advanced tools (Bengtsson 2008).

Managing ship maintenance activities so that the availability and reliability of ships can be sustained within a confined operational period and cost structure appears to be a complex but yet essential task. If a ship is randomly out of service for unforeseen maintenance reasons, the resulting disruptions to ship operations may cause a domino effect which increases total logistics costs to the customers and incurs serious consequences for various organisations in the supply chain (Notteboom 2006; Vernimmen, Dullaert & Engelen 2007). For example, when a ship breaches safety regulations due to incomplete maintenance, it may lead to operational stoppages or other incidents that severely impair the competitiveness of the ship in multimodal logistics services (see: Casaca & Marlow 2005; Cleveland 2006; Faturachman & Mustafa 2012a; Paul & Maloni 2010; Yip 2008).

Ship maintenance appears to be only considered at an operational level rather than at the strategic level of the shipping companies. This approach makes it difficult for the strategic value of ship maintenance to be visible to top-level management. This suggests the need for a strategic approach to ship maintenance management. With regard to the long-term benefit from maintenance (Tsang 2002) and the strategic value of maintenance to provide available and reliable ships, a strategic approach to ship maintenance should be made at a management level which is capable of overseeing any possible disruption within and outside shipping companies.

4.4 Research in ship maintenance management

Although the literature on maintenance practices is relatively advanced, the research on ship maintenance, particularly at the strategic level, is yet to emerge. To explore this proposition further, a search for maintenance management was conducted through the Google and Google Scholar search engines and ABI/Inform Complete Database across the period of 1980–2014. The search was conducted using several keywords such as maintenance, maintenance management, ship maintenance, ship maintenance management, aircraft maintenance and aircraft maintenance management. The numbers of hits resulting from each keyword and search engine are provided in Table 4.2. The search for maintenance and maintenance management resulted in a numerous range of links including engineering, social, health, business, manufacturing, advertising, public opinion and other perspectives on maintenance. However, the results show a significant difference when the word 'aircraft' and 'ship' was inserted into the keywords. The results from Google and Google Scholar search engines, although yielding fewer results than the first search, still provided broad discussions. The results from ABI/Inform Database show a much smaller number of links in comparison. These data provide some initial indication of the paucity of research in ship maintenance management in comparison to the broader fields of maintenance.

Table 4.2: Search results

Keywords	**Google**	**Google Scholar**	**ABI/Inform**			
			Trade	Report	Theses	Scholarly article
Maintenance	179,000,000	3,640,000	963,891	141,132	444,597	685,021
Maintenance management	978,000	3,140,000	27,191	732	1,463	5,217
Aircraft maintenance	23,900,000	744,000	9,140	2,737	1,290	1,032
Aircraft maintenance management	14,000,000	257,000	41	36	18	25
Ship maintenance	474,000	3,790	617	221	119	109
Ship maintenance management	242,000	69	5	1	2	1

From the results found in the ABI/Inform database, 12 articles were found to be relevant to the focus of the research of this thesis (see Table 4.3). The focus of the research can be categorised into two major groups. The first group discusses the technical context of ship maintenance management. This group includes research by Mavromatakis, Colyvas and Nicolaou (1996), Deris et al. (1999), Mokashi, Wang and Vermar (2002), Oke and Charles-Owaba (2006), Buksa, Siegulja and Tomas (2009), Mahulkar et al. (2009) and Lazakis, Turan and Aksu (2010). The second group discusses the management context of ship maintenance as represented by Bitros and Kavussanos (2005), Kennedy (2005), Veenstra, Zuidwijk and Geerling (2006) and Houghton and Lea (2009).

As shown in Table 4.3, the research focus of the first group indicates interest in implementing some maintenance concepts into ship maintenance, such as ship maintenance scheduling (Deris et al. 1999), reliability centred maintenance (Mokashi, Wang & Vermar 2002), maintenance concepts adjustment (Buksa, Siegulja & Tomas 2009) and fault tree analysis (Lazakis, Turan & Aksu 2010). Although this research focuses on the technical context of ship maintenance, all of them suggest the need for a holistic and integrated involvement of all departments in shipping companies. The second group of studies extend the concept of ship maintenance within shipping companies. For example, Bitros and Kavussanos (2005) explored the policies of shipping companies with regard to maintenance expenses and Veenstra, Zuidwijk and Geerling (2006) studied the influence of spare parts on the availability of ships. The discussions in both groups indicate some degree of strategic management of ship maintenance. However, the discussions were limited to within departments of the shipping companies.

Table 4.3: Scholarly articles on ship maintenance management

Authors	Journal/ Conference	Research focus
Group of technical context of ship maintenance		
Mavromatakis, Colyvas and Nicolaou (1996)	Conference on Marine Engineering Systems	Maintenance management policy in relation to safety regulation compliances.
Deris et al. (1999)	European Journal of Operational Research	Ship maintenance scheduling to minimise overlapping activities.
Mokashi, Wang and Vermar (2002)	Journal of Marine Policy	Application of reliability centred maintenance program towards maritime operations.
Oke and Charles-Owaba (2006)	Journal of Quality and Reliability Management	Preventive maintenance for shipping industry
Buksa, Siegulja and Tomas (2009)	Strojarstvo	Structure of maintenance costs and concept adjustment for ship propulsion engines.
Mahulkar et al. (2009)	Systems, Man, and Cybernatics, Part A: Systems and Humans	Modelling interconnected system for decision making in Navy warships environment to increase machinery availability.
Bao, Mittal and Dean (2010)	Fleet Maintenance Modernisation Symposium	Implementation of lean principle to accommodate unplanned repair and maintenance jobs across ship operations.
Lazakis, Turan and Aksu (2010)	Journal of Ships and Offshore Structures	Failure modes, effects and criticality analysis and fault tree analysis to increase ship operational reliability.
Group of management context of ship maintenance		
Bitros and Kavussanos (2005)	Journal of Social Science Research	Correlation between ship maintenance and operational policies.
Kennedy (2005)	National Defense Industrial Association	Coordination among shipyards for efficient ship maintenance to minimise laid-up time
Veenstra, Zuidwijk and Geerling (2006)	International Conference on Service Operations and Logistics and Informatics	The benefits of supply chain collaboration in the dredging industry.
Houghton and Lea (2009)	Maintenance and Asset Management Journal	Contract management for managing and supporting the availability of ships.

Kennedy (2005) indicated the need for coordination between navy ship operators and shipyards who, as maintenance providers, provide efficient ship maintenance for minimising the laid-up time of ship. The coordination involves teamwork from both parties to overcome complex maintenance problems. This research work implies, to some extent, the need for cross-department coordination to capitalise on such an approach to ship maintenance. However, the discussion reveals that in one organisation, the US Navy, there is no indication of an inter-organisational relationship such as in supply chain management. Bao, Mittal and Dean (2010) investigated implementation of lean principles to minimise the waste which is inherent in ship maintenance in relation to planned maintenance policy. They propose a concept to optimise the use of companies' resources in terms of personnel, tools and facilities to overcome unplanned maintenance tasks that exist in the policy. The lean principle discussed in their research is applied to matching the emerging maintenance request to the availability of companies' personnel, tools and facilities. Thus, their research applies to the operational level of ship maintenance management. Based on the extant literature on ship maintenance management according to the results obtained from Google, Google Scholar and ABI/Inform database, no research was investigating the implementation of a supply chain management approach.

4.5 The supply chain management approach for ship maintenance

The importance of ships for shipping companies and the supply chain by which they operate have been highlighted. Discussion in Chapter Three has established the construct of supply chain management in the context of maintenance in general. The construct of the supply chain management as a strategic approach to maintenance consists of management components, supply chain structures and supply chain service processes (Ellram, Tate & Billington 2004; Lambert, Cooper

& Pagh 1998). This section establishes a foundation for investigating the implementation of such a construct in the context of ship maintenance. The management components comprise the development of internal readiness of the shipping companies for adopting a supply chain management approach for ship maintenance and the supply chain structure comprises the relationship conditions with external entities (Kotzab et al. 2011). The supply chain service processes consist of the seven elements proposed by Ellram, Tate and Billington (2004), which include information flow, capacity management, customer relationship management, demand management, supplier relationship management, service delivery management and cash flow management.

4.5.1 The internal readiness of shipping companies

Trent (2004) and Kotzab et al. (2011) suggest that internal readiness for supply chain orientation determines the success of adopting a supply chain management approach. Their notion suggests that before moving towards inter-organisational relationships for managing the supply chains of ship maintenance, shipping companies should consolidate internally to develop an internal readiness. This internal readiness comprises the commitment of the company's resources to facilitate and master supply chain management relationships, data exchange across departments and the development of internal integration behaviour among all employees and the management of the company (Kotzab et al. 2011). Accordingly, this research will investigate the elements of internal readiness of the shipping companies.

Commitment and support from top management is essential for implementation of a strategic approach to maintenance management since it involves long-term development, companies’ behavioural attitude, inter-organisational relationship and benefit (Mishra, Anand & Kodali 2006). It is therefore necessary for top management of shipping companies to provide commitment and support for facilitating and advancing supply chain management for ship maintenance. The allocation of companies’ resources for developing and implementing a supply chain management approach for ship maintenance involves a strategic decision making that can only be obtained from the top management of shipping companies. Top management serves as the ultimate control and management of the companies that defines the objectives of corporate business strategies (Branch 2007). The commitment and support from top management should enable shipping companies to employ dedicated personnel and to allocate financial resources to oversee supply chain management issues in relation to ship maintenance.

The use of information technology in conducting data exchanges becomes a necessity to accommodate a seamless flow of information, which is suggested as essential for developing and implementing a supply chain management approach (Ellram, Tate & Billington 2004). Since management in shipping companies mostly consists of on-shore headquarters and on-board management, the use of computerised technology to facilitate communication between both sides of management is essential (Branch 2007). This computerised technology enables the on-shore headquarters to obtain real-time data about ships’ physical condition in relation to maintenance requirements. This technology should also enable shipping companies to devolve responsibilities to more accountable personnel at all management levels, which is very important for assuring the seamless flow of information and provides benefits for the companies (Fawcett, Magnan & Fawcett 2010).

For developing internal integration behaviour, shipping companies need to generate teamwork projects which consist of cross-boundary membership to manage various activities related to ship maintenance. The cross-boundary membership involves horizontal relationship between departments and vertical relationship between management levels of shipping companies. The cross-boundary involvement of personnel from various levels of management in the ship maintenance management activities should provide some insights into the level of integration behaviour in the shipping companies. With regard to the important value of internal integration behaviour, shipping companies need to commit resources for obtaining necessary expertise to develop and maintain the implementation processes of supply chain management in the context of ship maintenance.

4.5.2 The external relationship conditions

The literature review in Chapter Three indicated that there is a model of maintenance supply chains structure available which is based on research into the power plant and aviation industries (see Figure 3.5). The model focuses on the maintenance coordinator as the focal company which coordinates maintenance services to customers of the maintenance supply chain. The model considers the owner of the assets (the power plant and aviation companies) as the customers of the supply chain, and service and/or material providers as suppliers to the maintenance coordinator. In this model, the maintenance coordinator does not necessarily undertake the maintenance service; rather it coordinates the services from the other providers. Although the model may reflect the reality of maintenance supply chains of the power plant and aviation industries, the relationships between entities were not discussed in the literature (see MacDonnell & Clegg 2007; Trappey, Hsiao & Lin 2011). The model appears to be assuming that the relationships between entities of the supply chain are in place, which may not be the case. Furthermore, the model may differ when this is applied to supply chains of ship maintenance. This indicates a gap in the literature that will be investigated in the current research.

No literature has been found that assesses the vertical relationships between shipping companies and the entities of the ship maintenance supply chains. In a study into shipping marketing, Plomaritou, Plomaritou and Giziakis (2011) identify several possible interactions in the relationship management of shipping companies. These interactions consist of direct interactions within companies and indirect interactions in the inter-organisations' relationships. They suggest that every relationship between shipping companies and their customers, the shippers and/or charterers, can affect the quality of shipping services and the profits that can be gained. However, relationships with the suppliers of shipping companies are not addressed in their study. It is important to conduct research to investigate the relationship between shipping companies and the suppliers of ship maintenance materials and/or services to configure the supply chain structure of ship maintenance. Thus, a part of the research of this thesis is investigating these relationships.

In terms of external relationships with the suppliers, the involvement of suppliers across maintenance management activities (planning, controlling and evaluating) should provide information on the implementation of a supply chain management approach in the context of ship maintenance. Some collaborative attributes with the supplier such as the joint development of service level agreements, project groups, personnel visits and meeting attendance should provide a measure of the extent of relationships with the suppliers (Kotzab et al. 2011). Collaborative relationships with suppliers of ship maintenance materials and/or services may provide efficient and cost-effective ship maintenance such as reduced redundant works, improved communication with suppliers and minimised laid-up time for periodic survey maintenance (Kennedy 2005).

The attributes for assessing the external relationship conditions between entities in the supply chain consist of physical and technical management and the managerial and behavioural management (Spens & Bask 2002). Spens and Bask (2002) developed the attributes for these elements based on the construct of a blood donor supply chain. They explain that the physical and technical management components comprise the level of joint planning and control, work flow structure, cross functional and organisational integration, the use of information technology and product flow facility. Concerning the unique characteristics of ship maintenance as a service-oriented supply chain, the product flow facility may not be applicable for undertaking investigation in this research.

Although the blood donor supply chains differ from the nature of ship maintenance supply chains, these attributes may help to establish the measurements for assessing the external relationship conditions of the supply chains of this research. The level of joint planning is considered low when it is undertaken based on a reactive approach but high when the company actively manages the relationship through a proactive approach (Spens & Bask 2002). The work flow structure, cross-functional and organisational integration reflect how the firm performs maintenance tasks. When the tasks are undertaken in a functional and on an occasional basis, it means the company remains in a siloed approach. On the other hand, when a process approach is assumed and cross-organisational teamwork is available, the company performs an integrated work flow structure.

The use of web-based information technology should indicate a high level of integration across ship maintenance management that provides a seamless flow of information between entities in the ship maintenance supply chains (Trappey, Hsiao & Lin 2011). This is also being investigated in the thesis since no literature has been found which discuss the use of web-based communication in the context of ship maintenance. In addition, suppliers' capability and willingness to provide training for the personnel of shipping companies in undertaking maintenance tasks should strengthen the relationships between shipping companies and the suppliers.

This information should provide insights into the structure of ship maintenance supply chains within the shipping industry being studied.

The managerial and behavioural management components consist of management methods, commitment levels of power and leadership, management of risk and reward, and level of attitude towards collaborative relationships (Spens & Bask 2002). The management methods assess the techniques to synchronise departments in the shipping companies, whether it is hierarchical or process oriented. The leadership level assesses the focus on the transactional relationship or strategic relationship development across the supply chain network. This relationship influences the win-lose or win-win approach for determining risk and rewards structure within shipping companies and across ship maintenance supply chain members (Spens & Bask 2002). The attitude towards collaborative relationships measures whether the relationship exists at the personal, firm or supply chain level. Pursuing all of these management attributes may be useful in assessing the levels of the relationship between the departments within shipping companies and the relationship between shipping companies and their suppliers.

4.5.3 The service process

The execution of supply chain management as a strategic approach to ship maintenance may appear in the service processes that include information flow, capacity management, demand management, customer relationship management, supplier relationship management, service delivery management, and cash flow management (Ellram, Tate & Billington 2004). The current research investigates the current practices of these service processes in the shipping companies. The information that flows between entities in the supply chains accommodates them to perform these service processes. A seamless service flow appears to be one of the key successes of implementing a supply chain management approach in a service such as maintenance (Luan, Wu & Xia 2013; Scupola 2012).

The use of web-based communication should accommodate a seamless information flow (Trappey, Hsiao & Lin 2011). Mahulkar et al. (2009) simulated the use of web-based communication for personnel on board the ship, and the results indicate the increased performance of the availability of ship's engines. However, the use of web-based communication for a broader network, which includes shipping companies that involve personnel on board the ship, land-based management and other entities of ship maintenance supply chains, has not been addressed. Accordingly, it is necessary to investigate the extent of implementation of web-based communication in ship maintenance supply chains. The investigation should reveal whether web-based communication is in place to accommodate the need for seamless flow of information in ship maintenance supply chains. This information is important in enabling the implementation of a supply chain management approach to ship maintenance.

Capacity management in service-oriented supply chains concerns a company's investment in undertaking maintenance tasks (Ellram, Tate & Billington 2004). In addition to the employment of dedicated personnel to oversee the supply chains of ship maintenance, investment in terms of spare parts inventory should also enable the companies to undertake the necessary maintenance. Accordingly, this thesis investigates the shipping companies' policies in managing the spare parts inventory for undertaking ship maintenance.

In terms of customer relationship management, this research recognises the internal departments of shipping companies as customers of the ship maintenance supply chain. Accordingly, customer relationship management is discussed in relation to the internal relationship between departments within the shipping companies. This relationship may comprise joint planning and scheduling of ship maintenance and operations (Mahulkar et al. 2009). Other collaborative relationships may occur between maintenance, purchasing and inventory departments which may provide benefits such as lower inventories, fewer emergency deliveries, reduction in distribution costs and reduction in stocking costs (Bechtel & Patterson 1997; Laszkiewicz 2003; Sheng et al. 2009).

Across the seven service processes mentioned above, it appears that the involvement of maintenance personnel in all maintenance management activities is essential. This involvement will enable companies to comprehensively evaluate the suppliers of maintenance requirements (Lee & Scott 2009; Trent 2004). In addition, Ellram, Tate and Billington (2004) note many service level agreements for purchasing maintenance services have been executed without clear specification. The servicelevel agreement serves as a contractual document which may help entities in the service-oriented supply chains to develop a long-term relationship (Kutanoglu & Lohiya 2005). Ellram, Tate and Billington (2004)explain that problems in developing service level agreements relate to the lack of recognition of the need for professional maintenance personnel in the field. Accordingly, the current research also investigates the involvement of maintenance personnel in maintenance management activities.

4.6 Summary

The chapter addressed the importance of ship maintenance in underpinning the successful performance of shipping companies. Ship maintenance supports shipping companies in maintaining the availability of services for not only delivering cargoes on behalf of the shippers but also sustaining their share in the shipping market. Accordingly, a strategy driven management for ship maintenance is a necessity to enable shipping companies to achieve their goal in maintaining the availability and reliability of their ships in an efficient and cost-effective manner.

With regard to the paucity of research on ship maintenance management, and from the context of supply chain management, the research of this thesis attempts to investigate the implementation of supply chain management as a strategic approach to ship maintenance. To carry out this objective, this thesis established the construct of a supply chain management approach based on information from the literature, and presents it in the road map as shown in Figure 4.1. Having established the construct of supply chain management in undertaking the research, the next chapter explains the research design and methodology to enable data collection.

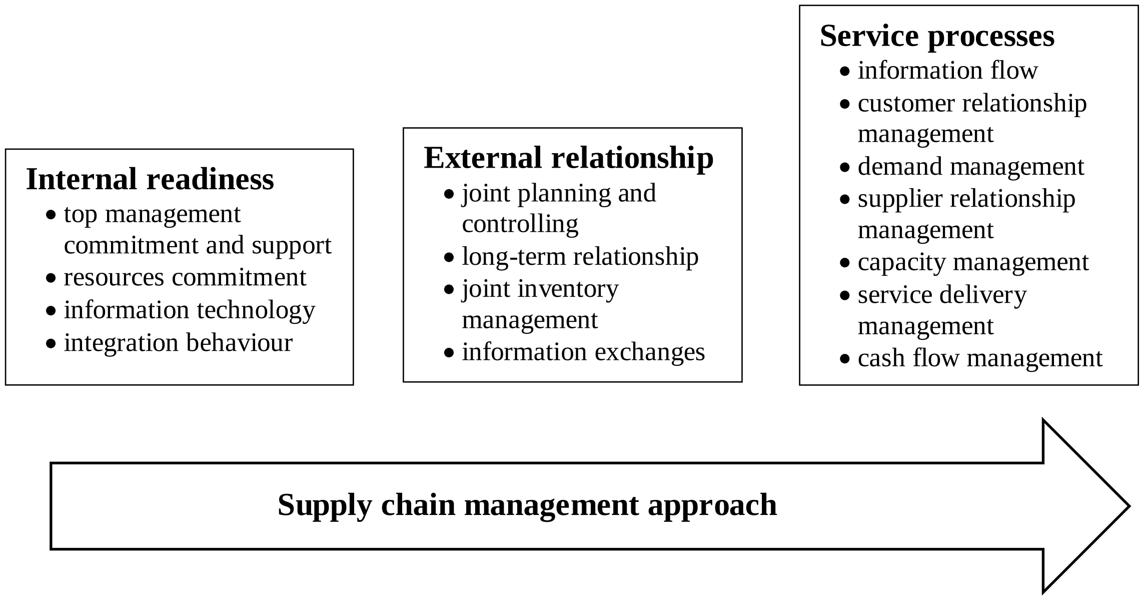


Figure 4.1: Road map to implementing a supply chain management approach

Chapter Five

RESEARCH METHODOLOGY

5.1 Introduction

Previous chapters provided a literature review in establishing the construct of supply chain management as a strategic approach for ship maintenance. This chapter discusses the processes that formulate a research design appropriate for conducting empirical research in ship maintenance management. The literature review explained the construct of the supply chain management approach and proposed a strategic management for ship maintenance supply chains. However, the paucity of research in terms of ship maintenance management results in the need for empirical data collection so that the research questions can be addressed (as shown in Chapter One). This chapter discusses the nature of the research, the generation of the population for the survey, survey sampling design, data collection method, the survey instrument development and pre-testing and error control processes which are important to minimise the total survey error.

5.2 Research objectives

The main objective of the current research is to investigate the contemporary practices of maintenance management in the shipping industry. The focus of this study was approached from service-oriented supply chain management and maintenance management, as discussed in the previous chapters. As discussed in Chapter Two, service-oriented companies such as shipping may capitalise on supply chain management to improve the performance of their ship maintenance, which in turn may improve their business performance. However, there is a lack of conceptual and empirical study focusing on supply chain management as a strategic approach for ship maintenance. The literature review suggests that research on service-oriented supply chain management is an emerging interest and there is a paucity of research on ship maintenance management. These provide impetus for this study to conduct empirical research to address the research objectives. A primary research question (PRQ) with two subsidiary research questions (SRQs) has been formulated to accommodate this study in addressing the research objectives. As discussed in Chapter One, the PRQ and the two SRQs are as follows:

PRQ: *Is a supply chain management approach applicable to improve ship maintenance performance?*

SRQ1: *How is the management of ship maintenance currently undertaken?*

SRQ2: *What benefits can shipping companies attain by undertaking a supply chain management approach to ship maintenance?*

The PRQ was formulated to explore the implementation of a supply chain management approach in the context of ship maintenance. The two SRQs were developed to enable this research to properly address issues related to the PRQ. SRQ1 explores the contemporary practice of ship maintenance management through the lens of service-oriented supply chain management. As discussed in Chapter Three, this research explores the internal and the external relationships of shipping companies in the context of ship maintenance management. The investigation into internal management relationships consists of the operations, maintenance, procurement and finance departments of the shipping companies.

The investigation into external relationships includes the suppliers of ships' engines and equipment, dry dock facilities providers, maintenance and repair providers, suppliers of spare parts and suppliers of consumables.

The purpose of SRQ2 is to identify possible benefits from implementing supply chain management as a strategic approach to ship maintenance, such as reduced fluctuations of demands in ship maintenance, increased availability and quality of supply of maintenance materials and services at competitive costs, and increased availability of reliable ship in sailing the scheduled voyages. These benefits are also investigated in relation to the possibility of achieving successful maintenance which in turn leads to the successful performance of shipping companies in terms of availability and reliability of shipping services.

5.3 The nature of the research

The nature of the research influences the decision in developing a research design as to which is the most suitable and viable method to select to ensure the research is successful (Cooper & Schindler 2011; Veal 2005). This research investigates management of ship maintenance in the shipping companies, which involves their personnel. In particular, this research is concerned with attitudinal measures of the shipping companies' personnel, thereby little opportunity, if any, is available for the researcher to conduct experimental research (Veal 2005). Non-experimental research in collecting data from the shipping companies appears to be part of the nature of the current research.

The limited number of studies into supply chain management of ship maintenance prompted utilisation of an exploratory research method which enables better understanding and clarifies the concept of this research interest (Cooper & Schindler 2011, p. 143; Zikmund 2010, p. 55). Several scholars have used this method to undertake research in similar circumstances where there are limited sources of related knowledge available. For example, Arlbjørn, Freytag and de Haas (2011) used this method to investigate lean practices in service supply chain management, and Behzad, Moraga and Chen (2009) in exploring the bullwhip effect in a healthcare service supply chain. Other examples appear in the studies of Georgise, Thoben and Seifert (2012) in investigating the implementation of a supply-chain operation reference model in developing countries, Giannakis (2011) in exploring the management of service supply and Prakash (2011) in exploring service quality in supply chains in the Indian automotive industry. The method enables the current research to explore the internal readiness of the shipping companies, the external relationship conditions and the supply chain service processes that are involved in adopting supply chain management as a strategic approach for ship maintenance (Kotzab et al. 2011).

This research also applies a deductive approach to formulate the research questions, which were developed based on the available literature (Cooper & Schindler 2011; Creswell & Clark 2007; Veal 2005; Zikmund 2010). The construct of a supply chain management approach for ship maintenance, for example, was developed based on the literature on supply chain management and maintenance management. This deductive approach prompts the need for observations so that the necessary data from the research may be collected (Cooper & Schindler 2011). The results of the observations are then analysed so that some conclusions about the investigated phenomena can be drawn (Cooper & Schindler 2011).

This research also assumes a positivist paradigm by which the researcher is considered as an external element of the shipping companies (Cooper & Schindler 2011; Veal 2005). This paradigm allows the researcher to explore the phenomena across numerous shipping companies without intervening in the natural environment of the shipping companies. Mangan, Lalwani and Gardner (2004) argue that the majority of management research is undertaken within a positivist paradigm. However, it is important for this research to assume this paradigm due to its capability to allow an objective observation of the management of ship maintenance to obtain genuine results in addressing the research objectives (Cooper & Schindler 2011).

This research proposes a strategic approach for ship maintenance management in the context of business research. This, in turn, requires a qualitative and quantitative approach which is capable of enhancing strategic managerial decisions (Naranjo-Gil & Hartmann 2006; Näslund, Kale & Paulraj 2010). This study therefore involves both a qualitative and quantitative approach to undertaking the research. The qualitative approach provides valuable insights from the business environment whilst the quantitative approach provides a level of confidence in the research findings through comparable measures necessary for decision making (Hesse-Biber 2010; Min et al. 2005). Whilst the qualitative method enables this research to capture the perspectives of the participants under real-world conditions and the insights from existing concepts such as supply chain and maintenance management or emerging concepts such as service-oriented supply chain management (Yin 2011), the quantitative method enables the research to explain the relationships found in the qualitative data (Arcidiacono, Procentese & Di Napoli 2009). Moreover, some qualitative information can be explored in the form of quantitative measures such as in the use of Likert type scale (Veal 2005).

Having addressed the nature of this research, the following section discusses the generation of the population and the sampling method from which data will be obtained in order to determine the most suitable method by which to carry out the data collection.

5.4 Population and sampling

Selecting the population from which data will be collected concerns several issues. Firstly, even though collecting data from all members of the population may provide rigorous data and enhance generalisability of the findings (Dillman et al. 2009), it may not be statistically efficient, incurs excessive costs and time and becomes less practical for inferring valuable conclusions about the population (Cooper & Schindler 2011). The selection criteria should be established to enable this research to provide generalisable findings and valuable insights from the selected population.

Secondly, there is the issue of which shipping companies are to be included in the research as the population sample. The selection focuses on the shipping companies that provide services in terms of operating the ships rather than providing intermediary services such as cargo pooling and warehousing. The decision was made to include only the ship operators and not the intermediary service providers. Thirdly, the issue of selection of the research participants from whom data will be collected also needs to be considered. These issues need to be taken into consideration so that the researcher can address the constraints of research resources such as time, funding and facilities in order to meet the research objectives (Cooper & Schindler 2011). The following sub-section discusses the population frame that is used to determine how the population for this research is selected using the appropriate method.

5.4.1 Population frame

As indicated earlier, this study conducts a survey to obtain statistical and practical efficiency. Thus, it is important to select the population which enables generalisability of the findings. A random selection determined by framing the population should enable this study to generalise its findings on ship maintenance management (Cooper & Schindler 2011). As stated previously, a general framing was applied to determine that only shipping companies that operate the ships would be included. However, it is almost impossible to conduct a random selection of the shipping companies due to the unknown actual population and various types of ships and shipping operations involved around the world (see Álvarez 2009; Kjeldsen 2011; Koufopoulos, Lagoudis & Pastra 2005). With regard to the topic of this thesis, the population generation for this study is approached from the supply chain management literature.

There has been a plethora of research on supply chain management since it was introduced by Keith Oliver in 1982 (see Soni & Kodali 2012). However, most of the research on supply chain management is conducted based on industries from developed countries such as the UK, USA, Australia, Sweden, Turkey, Canada and the Netherlands (Soni & Kodali 2012, 2013). Infrastructure and logistics for managing a supply chain that are available in developed countries may not be applicable in countries that are developing (see Lipsey & Sjöholm 2011; Prasad & Tata 2010; Prater, Swafford & Yellepeddi 2009). These differences could influence the implementation of a supply chain management approach since infrastructure and logistics could affect the performance of a supply chain (Khavul, Prater & Swafford 2012; Prasad & Tata 2010).

Some examples of the differences found in the literature are provided as follows. Devlin and Yee (2005) found inefficient transportation services in developing countries leads to long shipping times and incurs substantial cost on price of product, and Oke, Maltz and Christiansen (2009) suggest that reliability to deliver materials and services is the key factor when selecting suppliers from developing countries. Another example is the study of supply chain management in developing countries by Sohrabpour, Hellström and Jahre (2012). They found that in developing countries different packaging was required due to temperature and humidity of the environment, and this impacted on the management of the supply chain. Accordingly, it is important to conduct empirical research based on data collected from developing countries.

In relation to the topic of this thesis, data should be collected from a developing country with a shipping industry that accommodates the research into ship maintenance management. Among the developing countries of the world, Indonesia presents an interesting profile for conducting research on supply chain management of ship maintenance. This country has a pivotal role in the South East Asian region which may influence the global economy (Laksmana 2011), which makes Indonesia an important partner in the emerging global production network. This position in turn increases the need for an available and reliable inter-island transportation system, which is the domestic shipping industry. In terms of fleet age, most of the shipping companies in Indonesia operate aging ships (Faturachman & Mustafa 2012a; Sudarsono 2012), which require strategic management in undertaking maintenance to sustain service availability (Bitros & Kavussanos 2005; Grama & Patache 2011). This potential to influence the global production network, as well as the inherent complexity of ship maintenance management as a result of aging ships and lack of logistics support, make Indonesia's shipping industry an essential focus for research.

Indonesia is the world's largest archipelagic nation with the most spatially diverse resource endowments and economic activity (Hermana & Silfianti 2011; Hill, Resosudarmo & Vidyattama 2008). This diversity causes significant reliance on inter-island shipping services, with the volume of domestic sea-freight cargo traffic and inter-island passenger traffic contributing about forty to fifty per cent of its national GDP (Espada, Kumazawa & Tambunan 2005). As a nation with significant reliance on maritime transportation, the Indonesian shipping industry should have adequate maintenance systems in order to underpin safe maritime operations. However, some maritime accidents in Indonesia, for example, the fire accidents on board the Kirana Motor Ship (Wadrianto 2011) and the Teratai Prima Motor Ship (Faturachman & Mustafa 2012a), the explosion on-board Indra Sakti Adyaksa Motor Ship (Sucipto 2011) and Sumber Mutiara IX Motor Tanker (Buol 2014) may reveal a different case. Undertaking this research should provide valuable insights into the complexity of ship maintenance management in a developing country such as Indonesia.

Although Faturachman and Mustafa (2012b) and Artana et al. (2012) mention that a poor maintenance system contributes to the causative factors of ship accidents in the Indonesian shipping companies, there is no further discussion of why the maintenance system in the Indonesian shipping companies becomes a poor system. Thus, acknowledging the notion of poor maintenance system in the shipping companies in Indonesia (Artana et al. 2012; Faturachman & Mustafa 2012b), this research was developed for collecting data from the participants without asking for any suggestion for improving their maintenance performance. Nevertheless, the collected data enables this research to gain valuable insights from the shipping companies, which explain some correlations to their capacity to adopt supply chain management for their ship maintenance. The insights might also be valuable for shipping industry, professionals and scholars to understand the importance and the complexity of supply chain management for managing ship maintenance in developing country such as Indonesia. Furthermore, the insights might also enable them to identify necessary actions to overcome the emerging challenges in implementing supply chain management.

5.4.2 Indonesian shipping companies

With regard to the complexity of ship maintenance, this research focuses on shipping companies that provide shipping services as the freight carrier or the operator of the ships, whilst shipping companies that lease barges and pontoons are excluded from the population of the current research. This is because barges and pontoons are not equipped with machinery that involves complex maintenance tasks. Therefore, the sample frame of this research is Indonesian shipping companies that provide inter-island shipping services for passengers, bulk cargo (dry and liquid bulk), specialised cargo (liquefied gas and chemical), and general cargo (loose cargo, pallets and containers).

A list of Indonesian shipping companies was obtained from the Lloyd's List directory (Lloyds 2012). The directory is an open source that provides lists of shipping companies all over the world. The Lloyd's List is a specialist publication that provides business information about shipping worldwide such as Baltic Dry Index, Baltic Dry Indices, Protection and Indemnity insurance and ship operations and regulations. Obtaining data from this directory provides some level of confidence about the population of shipping companies in Indonesia. According to this directory, there are 1,124 shipping companies in Indonesia that are registered as Indonesian shipping companies (Lloyds 2012). The data comprised information about the shipping companies such as name, address, phone and facsimile numbers, email addresses and companies' websites. However, this information does not differentiate between the type of services provided by the shipping organisations, such as shipping companies, intermediary services companies, barge and pontoon charterers, shipping chandeliers, training companies and others.

In order to anticipate the perceived coverage error from a single source of data (Dillman, Smyth & Christian 2009), the data was cross-referenced with other available open sources such as companies' websites and group blog archives. Some shipping companies' websites from the Lloyd's List directory can be accessed, such as Berlian Laju Tanker (www.blt.co.id), Samudera Indonesia (www.samudera.co.id), Arpeni Pratama Ocean Line (www.apol.co.id), Tempuran Emas Shipping (www.temasline.com), Meratus Line (www.meratusline.com), Tanto Intim Lines (www.tantonet.com) and Salam Pacific International Lines (www.spil.co.id). These shipping companies are considered to be the major companies, based on their market share and the size of the fleet, in the Indonesian shipping industry (Dick 2008; Gurning 2010). However, there are additional shipping companies whose information cannot be obtained via the internet. An initial database was developed to differentiate between the shipping companies that are ship operators and the other types of shipping companies.

Further efforts were made by using Google internet search engine to obtain information about the population and the type of services offered by the shipping companies. Using keywords such as 'perusahaan pengapalan di Indonesia' (shipping companies in Indonesia), 'alamat perusahaan pengapalan Indonesia' (addresses of shipping companies in Indonesia), 'daftar perusahaan pengapalan Indonesia' (list of shipping companies in Indonesia) and 'Indonesian shipping companies' results in several websites and group blog archives. The websites and group blog archives listed from the search included www.world-ships.com, www.ihsfairplay.com, www.insa.or.id, www.datacon.co.id, www.google.com, www.dephub.go.id, www.bumn.go.id/iki, www.shippingindonesia.com, www.lloydslist.com, www.detik.com, http://informasipelaut.blogspot.com.au, www.yellowpages.co.id and http://daftarperusahaanpelayaran.blogspot.com.au. These websites and blog archives provide lists of shipping companies with various details of companies' fleet and services. These data were cross-referenced to generate the population of shipping companies for the current study.

The obtained information was then cross-referenced in order to gain sufficient confidence about the population of shipping companies in Indonesia which are needed for this research. The cross-referencing resulted in 604 freight carriers or ship operators that constitute the population of inter-island shipping companies in Indonesia. However, most available information about the population only comprises companies' addresses and telephone numbers but no websites.

5.4.3 The sample

The advantages of utilising samples for data collection in social research are widely known, such as cost efficiency, greater speed, greater scope of population elements and greater meaningful findings (Guo & Hussey 2004; Mammen & Sano 2012). However, it is the sampling method by which samples are selected from the population that determines the quality of the research (Lambert, Knemeyer &

Gardner 2004). Based on the nature of this research which specifically selected a certain type of shipping company, the sampling is a nonprobability method (Zikmund 2010). Despite the weakness of the nonprobability sampling method, the method provides better applicability and common sense in business research, and overcomes the constraints of the current research which include limited resources of time, funding and facilities available for the researcher and an inherent uncertainty about the population (Cooper & Schindler 2011; Dillman, Smyth & Christian 2009; Guo & Hussey 2004).

The population of 604 shipping companies is dispersed across several provinces in Indonesia. The capital city of these provinces is used as an identifier of the dispersion locations of these shipping companies, which are Batam, Jakarta, Makassar, Palembang, Pontianak, Samarinda and Surabaya. These cities are also identified as origin-destination cities of the domestic maritime traffic network in Indonesia (Espada, Kumazawa & Tambunan 2005). In addition, these cities are located on different islands of the Indonesian archipelago. Batam is in the Riau Island, Jakarta and Surabaya are in Java, Palembang is in Sumatera, Pontianak and Samarinda are in Kalimantan and Makassar is in Sulawesi. The distance between Jakarta and Surabaya is 665 km (359 nautical miles), Jakarta and Makassar is 1400 km (756 nautical miles). The complete table of distances between these cities are provided in Appendix A. Figure 5.1 presents a map of Indonesia which shows the estimated location of each of these cities.

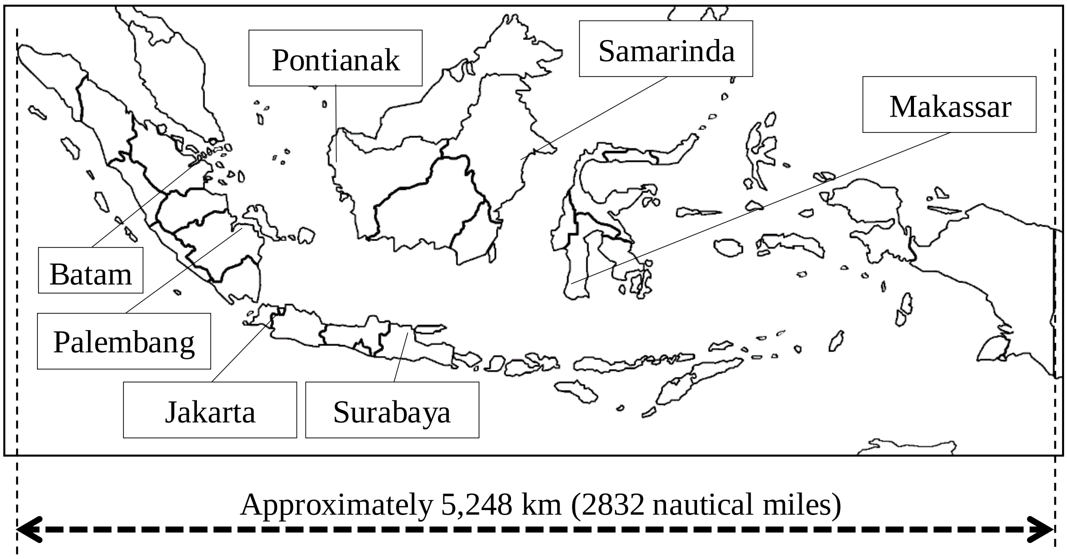


Figure 5.1: City locations of the samples

The sample population was then generated from the data about Indonesian shipping companies. With regard to the dispersion of the 604 shipping companies above, this research assumes a nonprobability quota sampling. Despite its category as a nonprobability sampling method, the use of the quota sampling method still provides adequate representativeness of the sample towards its population (Cooper & Schindler 2011). This sampling method will provide equal probability to each shipping company to be selected as a sample of the research. Ensuring this equal probability is important to ensure that this research gives a generalisable finding of the population.

For a population of 604, the minimum sample size necessary to produce a 95 per cent confidence interval of $\pm$ 5 per cent is 230 (see the equation in Figure 5.2). To obtain the precise sample size, this research used the interpolation approach to calculate the numbers from the table of sample size and population size in the literature (see: Cavana, Delahaye & Sekaran 2001; Saunders, Lewis & Thornhill 2009; Veal 2005). The table shows that for the population size of 1000 and 500 the required sample sizes are 278 and 217 respectively. These numbers were then interpolated to obtain the number of the necessary sample number for the current research.

As shown in Figure 5.2, the symbol S_x refers to the minimum sample size of x number of population, and the symbol P_x refers to the population size of x. Accordingly, the symbols S_{1000}, S_{500} and S_{604} refer to the minimum sample size of *1000*, *500* and *604* population respectively; and the symbols P_{1000}, P_{500} and P_{604} refer to the population size of *1000*, *500* and *604* respectively. The interpolation equation resulted in the minimum sample size for the 604 population being 229.2, which was then rounded up to the sample size of 230.

$$S_{604} = S_{500} + \left(\left(\frac{P_{604} - P_{500}}{P_{1000} - P_{500}}\right) x \; (S_{1000} - S_{500})\right)$$

$$S_{604} = 217 + \left(\left(\frac{604 - 500}{1000 - 500}\right) x \; (278 - 217)\right)$$

$$S_{604} = 229.69$$

Figure 5.2: Equation for minimum sample size

The sample size for the population of 604 is 230, which is equal to 38.08 per cent. Then, the number of shipping companies from each city was multiplied by 38.08 per cent in order to obtain the city sample sizes (see Table 5.1). The shipping companies from each city are selected with priority based on the most complete data such as website, phone numbers, addresses and postcodes. This convenience sampling is important for increasing the probability of a response from the shipping companies.

Table 5.1: Dispersion of the population

City	Number of shipping companies	Number
Batam	15	6
Jakarta	463	176
Makassar	5	2
Palembang	14	5
Pontianak	5	2
Samarinda	5	2
Surabaya	97	37
TOTAL	**604**	**230**

Source: Author

5.4.4 The participants

To ensure relevant and significant insights are gained, the data collection required participants with particular attitude, behaviour, attributes, expertise and experience. Pinjala, Pintelon and Vereecke (2006) explain that collecting required data from participants whose positions are at a higher managerial level provides some confidence about the information provided. This suggests that participants from senior-level management of the shipping companies should be eligible for the data collection. However, the senior-level management may not be aware of the management of ship maintenance at the operational level. Therefore it is necessary to obtain data from the professionals in the shipping companies who have access to senior-level management and deal with maintenance at the operational level of the business.

This research seeks participants who have responsibility for directly overseeing the management of maintenance for the ships of the companies' fleet. This position in the shipping companies is commonly known as technical manager or marine superintendent. Where these job positions are not evident, the operations managers of the shipping organisations was the next priority before the procurement managers and the head of the management department respectively. However, the title and the availability of these positions may vary from one shipping organisation to the other. These variations were addressed in the construction of the survey instrument and the administration of the survey.

5.5 Data collection

This study is an attitudinal research, by which the involvement of the participants is the primary focus (Spurlock et al. 2008). Based on this approach, information from the participants is the primary source and valuable for gaining insights about ship maintenance from the shipping companies. Secondary data have been utilised for establishing the background theory of the study. The following discussion explains the use of secondary and the collection of primary data for this research including the data collection method to be used.

5.5.1 Secondary data collection

Among the various data collection methods available (see Cooper & Schindler 2011; Spurlock et al. 2008; Veal 2005; Zikmund 2010), this research has utilised the secondary data collection method through the use of available literature in the area of supply chain management and maintenance management. Both areas comprise academic and business articles, reports, electronic web information and journals. In terms of the theory background for this research, the literature in both areas has been used to reconfigure the construct of the service-oriented supply chain management approach to be investigated.

In terms of population generation, as discussed in the previous section, secondary data from various sources were utilised to develop a database of shipping companies in Indonesia. Some government websites such as www.dephub.go.id, www.bumn.go.id and association websites such as www.insa.or.id were visited to establish the data. Some shipping companies, particularly the major shipping companies in the Indonesian shipping industry (see section 5.4.2), provide assessable proprietary data such as annual reports, brochures and the structure of the organisation. However, the majority of the shipping companies listed do not provide this detailed information, only company address and fleet. Furthermore, information sharing about maintenance management does not yet appear to be part of the culture (Plomaritou, Plomaritou & Giziakis 2011; Veenstra, Zuidwijk & Geerling 2006). No previous study on ship maintenance management in Indonesian shipping companies was found. Accordingly, this research was also prepared to collect primary data in order to accomplish the research objectives.

5.5.2 Primary data collection

The sample population and the constraints of the current research, a questionnaire-based postal survey appears to be the most viable method for completing this research. This method is capable of providing an efficient data collection process from the wide-spread geographical dispersion of the large number of the sample population (Aitken et al. 2004; Cook, Dickinson & Eccles 2009; Cummings, Savitz & Konrad 2001; Kanso 2000; Sahlqvist et al. 2011; Ziegenfuss et al. 2012). Using this data collection method will allow the researcher to contact the participants at a relatively similar time by posting all the surveys at once.

The postal survey method has been criticised as being lacking in researcher control (Owens 2005). However, the lack of researcher control also provides the advantage of preventing bias from interviewer influence during the data collection process (Cooper & Schindler 2011; Larson 2005; Larson & Poist 2004). A questionnaire-based postal survey also provides anonymity which in turn allows participants to complete the survey at their convenience (Schirmer 2009). Furthermore, the data collection project through postal survey has been accepted as the most cost-efficient method (Aitken et al. 2004; Cook, Dickinson & Eccles 2009; Gattellari, Zwar & Worthington 2012; Holland et al. 2010; Larson 2005; Terpend, Krause & Dooley 2011).

The other data collection methods available in the literature include experiment, observation, case study, interview and web-based survey (Cooper & Schindler 2011; Dillman, Smyth & Christian 2009). The experiment method is not suitable due to the exploratory nature of the current research. In exploratory research, no controlled behaviour should be attempted in obtaining genuine attributes of the phenomenon to be explored (Cooper & Schindler 2011). Observational research requires researcher to visit the sample in certain period of time (Holmes & Bloxham 2009). Attending each location of the geographically dispersed 230 shipping companies involved in this research may result in excessive cost and time to complete the research.

In term of case studies, the current research is explorative in nature in order to obtain insights into the shipping companies rather than to observe detailed phenomena regarding a certain management type of ship maintenance of the company. In most case study research, the researchers rely on a single company – a case – to collect necessary detailed data for their research (see Alsyouf 2007; Anette von 2008; Bamber, Sharp & Hides 1999; Bechtel & Patterson 1997; Beresford, Pettit & Liu 2011; Chan et al. 2005). To make generalisable conclusions about the phenomena being researched, several study cases are required to be contrasted (Veal 2005). Whilst collecting data from 230 shipping companies using study case requires the researcher to deal with one company at a time, the postal survey allows him/her to deal with all of the companies during one relatively similar time period. The mail survey will prevent bias in terms of different time and business environment during the data collection process. Accordingly, a case study method is neither suitable nor viable for undertaking primary data collection for the current research.

The other available research methods are the interview and web-based survey. The interview method includes face-to-face and telephone survey. The time consuming and cost issues make the face-to-face method not viable in conducting data collection of this research. There are constraints of time, finance and facilities for the researcher to complete this study. For the web-based survey, accurate participants' email addresses and participant's accessibility to internet are critically required in order to be able to undertake these data collection methods (Dillman et al. 2009; Dillman, Smyth & Christian 2009; Ward et al. 2012). As discussed in the sampling section (see section 5.4.3), the email address and company's website of the shipping companies are not always available. In addition, there is the issue of internet infrastructure which is not yet fully developed in Indonesia and should be taken into consideration (Elliot 2012; Hermana & Silfianti 2011).

Both issues of incomplete database and internet access difficulty create coverage bias issues in relation to internet connectivity coverage, accessibility to the targeted participants or undelivered surveys resulting from malicious emails control or wrong email address (Cobanoglu, Warde & Moreo 2001; Dillman, Smyth & Christian 2009). Another weakness which stems from the incomplete database concerns the sample representativeness and sample participant quality, sample control and diversification (McConkey, Stevens & Loudon 2003). These methods are not applicable to accommodate this study in order to address the research objectives.

The poor quality of the telephone directory may create coverage bias that prevents the utilisation of telephone interviews for data collection purposes (Díaz de Rada 2011; Tuckel & O'Neill 2002). Telephone interviews also suffer from inaccessibility and unwillingness issues, barriers due to automatic answering machines, declined calls, interrupted interviews and interviewer bias (Díaz de Rada 2011; Tuckel & O'Neill 2002). In addition, conducting interviews with 230 participants would become a time-consuming task for collecting the data.

Furthermore, with regard to the researcher's location in Australia, at the Australian Maritime College, excessive cost may be encountered for doing the intended interviews due to international direct dialling charges when contacting the 230 participants in Indonesia.

As indicated earlier, there is limited time, funding and facilities available for the researcher to complete the current research. Accordingly, conducting a questionnaire-based postal survey becomes the most suitable and viable option to undertake the data collection project. The perceived benefits of postal surveys, the characteristics of targeted participants, the limited timeframe, funding and facilities underpin the choice of this mode of survey for primary data collection in the current research. Furthermore, the use of postal survey should enable flexibility in geographical coverage, a low-cost survey method (compared to phone or face-to-face), prevention of interviewer variability and a level of convenience for the participants to complete the survey. The following section discusses the development of the research instrument and the questionnaire in order to address concerns about undertaking postal surveys to capitalise on the benefits whilst anticipating the weaknesses as indicated in the literature.

5.6 Questionnaire-based postal survey

The questionnaire for the postal survey was specifically designed for this research (see Appendix B1). The choice of using postal surveys for collecting the primary data of the current research has a direct influence on the crafting of the questionnaire, scale types and structure in order to accommodate the exploratory nature of the research. In this section, the first sub-section discusses "what is asked" in the questionnaire, and the second sub-section discusses "how the question is asked". Both sub-sections critically underpin the questionnaire development in order to determine the necessary information to be successfully collected from the survey (Passmore et al. 2002; Platek 1985; Rattray & Jones 2007).

5.6.1 Questionnaire development

A survey is known as a systematic means of data collection in order to be able to describe, compare and explain a practice, knowledge, behaviour or attitude of the participants (Fink 1995 in Cholasuke, Bhardwa & Antony 2004). The survey is also used to explore participants' attributes to enable further statistical analysis in relation to the demographic characteristics of the participants. The questionnaire collects the necessary information from the participants in a tailored manner and allows the inference of results to the wider population (Rattray & Jones 2007).

In terms of "what is asked", the literature review on service-oriented supply chain management and maintenance management in Chapters Two and Three indicates there are three dimensions of the supply chain management approach in relation to the implementation process in the context of ship maintenance. These dimensions comprise the internal readiness, the external relationships and the service processes. The literature review also indicates the value of ship maintenance performance and maintenance-related activities to the shipping companies that operate the ships. These elements comprise the concept to be asked in the survey. In addition, some demographic questions such as the fleet size (item H1), and the participants' experiences in the shipping industry (items H2 and H5) were asked to enable further statistical analysis about the companies and the participants.

With regard to the exploratory nature of the current research, the three dimensions explore the elements of the Global Supply Chain Forum framework in the context of ship maintenance. The internal readiness dimension covers the management elements in relation to ship maintenance within shipping companies to implement supply chain management as a strategic approach. The investigation was carried out by assessing the existence of dedicated personnel for managing the ship maintenance (items A1–A3) and the purchasing for maintenance requirements (items A5–A7). The questions about internal readiness also asked about top-level management commitment and support (items C14–C16), and the use of information and communication technology within the companies (item F8).

Items A9–A14 was provided in a six-row by five-column array in order to enable the assessment of the companies' internal integration behaviour. The six rows consist of the entities within shipping companies such as Board of Directors, chief executive officer, operations manager, maintenance managers, procurement manager and finance manager; and the five columns include maintenance management activities at corporate level such as planning, organising spare parts inventory, performance evaluation, defining maintenance specification and budgeting. Analysis based on this data should reveal the internal relationships between these entities in the context of ship maintenance management.

The external relationships dimension covers the management of the supply chain network of ship maintenance. Items B1–B5, D10, and C9–C13 explore the extent of shipping companies' relationships with the suppliers and the suppliers' suppliers. These items are necessary in establishing the construct of the ship maintenance supply chains. In assessing the information flow across the supply chains, the questionnaire was provided with items assessing modes of communication between entities and the quality of the shared information (see items E1–E7). This research also assesses the extent of strategic relationships between the shipping companies and their supplier. For example, items D8–D14 ask whether the relationship is based on mutual benefits, long-term orientation and/or quality development.

The service process dimension covers the internal management of the shipping companies in managing maintenance capacity, demand, supplier relationship and service delivery. The availability of spare parts for undertaking maintenance tasks is assessed through items F4–F7. This data should provide information about shipping companies' policies on inventory management. Assessing this information in relation to the internal readiness of shipping companies may reveal the impacts of maintenance management on the company's capacity in undertaking maintenance tasks. In a similar way, assessment of each service component should reveal the impact of internal readiness to the shipping companies' capability in managing these processes.

The questionnaire was also designed to collect information about the performance of ship maintenance in the shipping companies. For example, the participants were asked to indicate the actual maintenance expenses as a percentage of the companies' planned maintenance budget (see item G7, G9). Further questions were prepared to collect the participants' perceptions of ship maintenance contribution to the performance of the shipping companies (such as items G12, G13, G14). These items should provide insights into the shipping companies' paradigms regarding the undertaking of ship maintenance management. The major dimensions, the questions themes and the related items' numbers in the questionnaire are summarised in Table 5.2.

Table 5.2: Major dimensions and questions themes

Questions themes	Items' number
Internal readiness conditions	
Dedicated personnel for maintenance	A1, A2, A3
Dedicated personnel for purchasing maintenance requirements	A5, A6, A7, A8
Top management commitment and support	C14, C15, C16, C20
Integration behaviour	A4, A9, A10, A11, A13, A14
Information and communication technology	F8
External relationships conditions	
Supply chain network configuration	B1, B2, B3, B4, B5, D10
Relationships with suppliers	C9, C10, C11, C12, C13
Strategic relationship development	C1, C2, C3, C4, C5, D8, D9, D10, D11, D12, D13, D14, C7, C8
Information sharing	E1, E2, E3, E4, E5, E6, E7
Service processes	
Capacity management	F4, F5, F6, F7
Demand management	C17, C18, C19, C21
Supplier relationship management	B7, D9, D10, D11, D1, D2, D3, D4, D5, D6, D7
Service delivery management	B8, B9
Maintenance performance	
Maintenance tasks ratios	F2, F3
Compliance to maintenance plans	G7, G8, G9, G10, G11
Maintenance contributions	G1, G2, G3, G4, G5, G6, G12, G13, G14, G15, G16
Demographic	F1, H1, H2, H3, H4, H5, H6, H7

Source: Appendix B1

5.6.2 Units of measurement

The questionnaire was developed using multiple measurement scales such as dichotomous, Likert, multiple categories and open-ended. The total number of items for each scale is provided in Table 5.3. These multiple measurement scales were utilised to enable differing depths on data analysis processes for addressing the research questions. As seen in Table 5.3, the majority of usage was of Likert scales across the questionnaire, 64.9 per cent, reflects the essential function of the scale to investigate the attitudes, behaviours and attributes of the participants in social surveys such as this research (Dittrich et al. 2007). The use of a Likert scale enables this research to collect attitudinal information in a simple manner due to the transformation of attitudinal expressions into a linear intensity continuum (Rattray & Jones 2007). The use of a Likert scale also underpins the questionnaire to obtain accuracy, brevity and clarity in collecting the required information (Agrawal et al. 2009). The use of Likert scale is expected to encourage the participants to participate in the survey, which is important for the postal survey in order to gain a satisfactory response rate.

Table 5.3:Measurement scales

Types of scales	No. of items	Percentage
Dichotomous	3	3.1
Likert	63	64.9
Multiple categories	18	18.6
Open-ended	13	13.4
Total	**97**	**100.0**

Source: Appendix B1

The Likert scales in the questionnaire were provided with five-point categories to enable parametric data analysis methods to be used (Parker, McDaniel & Crumpton-Young 2002; Rhemtulla, Brosseau-Liard & Savalei 2012). This provides better statistical power for drawing conclusions towards a wider population (Parker, McDaniel & Crumpton-Young 2002; Rovai, Baker & Ponton 2013). Furthermore, the Likert scales with five-point categories appears to be commonly used to enable parametric data analysis methods for gaining better statistical ground (see Dittrich et al. 2007; Lubke & Neale 2008; Lubke & Muthén 2004; Parker, McDaniel & Crumpton-Young 2002; Rattray & Jones 2007; Rhemtulla, Brosseau-Liard & Savalei 2012).

Using a five-point Likert scale also prevents the questions from becoming too sensitive which may be annoying or confusing for the participants (Cooper & Schindler 2011; Frary 1998). Also, the questions were worded positively in order to minimise potential errors due to the use of multiple-item measures in the questionnaire (Alexandrov 2010). These circumstances should be anticipated during the questionnaire development to minimise the item-nonresponse issue in the survey. To operationalise the questionnaire, the five-point Likert scale was coded with ‘1’ to ‘5’ which corresponded to the defined endpoints of the scale: ‘strongly disagree’ to strongly agree’, ‘very unimportant’ to ‘very important’, ‘very little effect’ to ‘very significant effect’ and ‘never’ to ‘always’. For example, in items which ask for levels of agreement, scale number ‘1’ is assigned for ‘strongly disagree’ whilst scale number ‘5’ is for ‘strongly agree’ (see items B1, B2, C14, C15 and the like).

In addition, with regard to participants' convenience when completing the questionnaire, the use of the five-point Likert scale should provide a mid-point category to accommodate any neutral response by the participants. This mid-point category is coded with the value '3' as a neutral response, which provides a balance towards both positive and negative responses. To anticipate the misuse of the mid-point category (Kulas & Stachowski 2009), the questions were also provided with 'Not Applicable' or 'Don't Know' response options (Agrawal et al. 2009). Whilst both responses were coded with '0' in the questionnaire, the code was attributed separately in the data sheet to provide the respective values as provided by the participants. These responses may provide a solution where the questions are not applicable to the participants' companies or they do not know the answer rather than forcing them to make a guess (Agrawal et al. 2009).

The questionnaire also included open-ended questions which enable the participants to respond by means of a short answer rather than read through a long list of options or to expand their answers and provide more in-depth responses (Cooper & Schindler 2011; Rattray & Jones 2007). This type of question was also provided where possible responses may prohibit preparing the options in advance (Cooper & Schindler 2011) (for example see items A1, A2, A3, C7 and C8). The questionnaire included a multiple-response scale of both simple (dichotomous – yes/no) and multiple-response categories (checklist). The dichotomous and the checklist questions were also provided with an open-ended option, which enables the participant to provide further detail about their answer (for example see items A4, A8, C21). The checklist items were included to allow the research to generate a comprehensive picture of the participants' attributes. The checklist items also encompassed an 'other' option to allow the participants to provide further information to complete the list (for example, see items A4, A8, E1). The open-ended options also enable the research to gain further insights by identifying new items for future questionnaire development (Rattray & Jones 2007).

The participants' perceptions with regard to the currently undertaken ship maintenance management were asked in relation to the quality of maintenance materials and/or services from suppliers of the companies (see items B7, B8, B9). In terms of their beliefs, the questionnaire seeks the participants' perception of the reality of the companies' maintenance performance (see items D1, D2, D3, D4, D5, D6, G7, G8, G9, G12, G13, G14, G15, G16). The participants' behaviours were also assessed in order to discover their past actions across the ship maintenance management activities (see items A9, A10, A11, A12, B1, and B2). This variety of questions was developed in order to sustain the participants' interest in completing the questionnaire.

5.6.3 Questionnaire design

Following the establishment of the information to be asked and the scales of measurement involved in the questionnaire, this section discusses "how these questions are asked" in more depth. Questionnaire-based postal surveys involve a structured type of survey and rely entirely on the accuracy, brevity and clarity of the verbal communication for its success (Agrawal et al. 2009). Thereby, great care was taken when designing the questionnaire in order to yield a valid and reliable means for the survey. This section discusses the processes involved in designing the questionnaire in terms of general layout and item wording.

5.6.3.1 General layout

A questionnaire allowing for the convenience of the participants in reading and completing the questionnaire without misinterpreting the questions is paramount for this postal survey. Díaz de Rada (2005a) notes that easiness and attractiveness offset when filling in the questionnaire influence the success of a postal survey in gaining maximum response rates. In relation to the size of the questionnaire, some scholars suggest that it should not be more than twelve pages in order to prevent potential bias from exhausted participants in answering the items (Edwards 2004; Jepson et al. 2005; Kasprzyk et al. 2001; Platek 1985). Edwards (2004) and Jepson et al. (2005) suggest that a shorter questionnaire length can increase the possibility of respondents completing the survey and returning it to the researcher. In particular, Edwards (2004) explains that the average length of a good mail survey is in the range from four up to twelve pages. Otherwise, a lengthy questionnaire will come at a cost in terms of nonresponses, loss of precision and higher possibility of bias. Despite the exploratory nature of the research, careful trade-off has been made to maintain the questionnaire size within the suggested range. The questionnaire consists of eleven pages including the cover and introduction pages. To obtain an adequate quality of the presentation, the questionnaire was printed on one side of A4 size white paper of 80 grams per square metre thickness.

The questions were organised in several topics in order to maintain the participants' focus on one issue at a time throughout the questionnaire. The items within the sections were labelled in an alphanumerical format such as A1, A2 and A3 (see Appendix B1). The first section, section A, was designed to ask the participants to respond to several general open-ended questions such as title of job position in the company. This layout prevents the questionnaire from asking sensitive questions at the start of the questionnaire (Rattray & Jones 2007). Some demographic questions were placed at the end of the questionnaire in order to provide a less intense end to the survey. Green, Murphy and Snyder (2000) and Teclaw, Price and Osatuke (2012) suggest that the placement of demographic questions will not provide any statistical significance as to the level of response rates. However, the demographic questions of the current research were placed at the end of the questionnaire, in section H, to maintain participants' engagement and prevent the occurrence of premature boredom which risks the occurrence of items nonresponse bias (Rattray & Jones 2007).

To render a compact questionnaire, some items were designed in a matrix. For example, items A9 to A14 asked the participants about the involvement of entities in the shipping company's maintenance management activities by filling in the value of '1' to '5' in each cell of the matrix (see Appendix B1). In addition, the matrix also shortens the questionnaire format by succinctly delivering numerous items in one form of a table. A similar matrix was also used in delivering items B7 to B10, C9 to C13, D1 to D7 and F4 to F7. If, for example, the items A9 to

A14 were not arranged in a matrix form they would have resulted in 30 repetitive items, which expand the size of the questionnaire significantly.

The questionnaire was developed with a cover, introductory, questionnaire body and gratitude expression pages (see Appendix B1). The cover page was designed with an interesting survey title as this page may function as the hook in obtaining participants' interest in completing the survey (Díaz de Rada 2005a; Gendall 2005). On the cover page, the logos of the Australian Maritime College and University of Tasmania were provided as they indicate that the survey is an official study. This was expected to provide the participants with confidence to participate in the survey (White, Carney & Kolar 2005). An imprinted 'CONFIDENTIAL' banner was also provided to indicate all information obtained from the questionnaire was to be treated with care to maintain its confidentiality.

Detailed information about the questionnaire was provided in the introduction on the second page of the questionnaire. This page was also provided with researcher's points of contact, to enable the participant to phone or send email when necessary, and signature to personalise the questionnaire. The first items of the questionnaire were arranged on the questionnaire's third page so the participants may detach the first and second page to maintain their confidentiality. To conclude the questionnaire, a request for the participants' email address is made to allow further contact with the participants and to enable the sending of the summary of research findings as per participants' request. This step represents an expression of the researcher's gratitude to the respondents and may also increase the response rates (Dillman et al. 2009; Zikmund 2010).

As an additional effort to maintain the focus of the participants, a consistent approach was taken in the writing of questions' instructions, topics and introduction statements. Each of these elements was typed in a different font to enable them to be clearly distinguishable. Each section was separated with an easily identifiable topic title, which was followed by a brief introductory statement to lead the participant towards the focus of the section. Likert scale response boxes were positioned at the side of each item to administer convenience to the participants when filling in their responses and minimise error from the responses. The layout was also designed to minimise the possibility of data entry error during the data analysis process.

5.6.3.2 Item wording

With regard to the requirements from the Ethics Committee of the University of Tasmania, the questionnaire was first developed in English and then translated into Indonesian once approval was obtained from the Committee. Despite the translation process, the wording in the questionnaire was developed to ensure accuracy, brevity and clarity in delivering the messages from the researcher to the participants (Agrawal et al. 2009). Accordingly, the items in the questionnaire have been carefully developed to deliver simple, familiar and unambiguous words to the targeted population; to avoid colloquialisms or slang, double-barrelled questions or double phrases such as, "do you agree or disagree to the statement of …". These wording issues were assessed through pre-testing the questionnaire, which is discussed in the following section.

5.7 Pre-testing of the questionnaire

The questionnaire was pre-tested prior to the execution of the actual data collection. Pre-testing was the very last step before the actual distribution of the questionnaire. This step is very important for mitigating inherent bias from the questionnaire design such as ambiguous questions, wording and order of the questions (Bolton 1993; Schwartz 2002). Items lacking clarity or inappropriate delivery for participants might be identified during the pre-test process. Pre-testing is also important for validating the contents of the questionnaire with the delivery purposes (Armando et al. 2008). Comments and feedback from the pre-test are used to refine the questions and to ensure that the time taken to complete the questionnaire is satisfactory. Subsequently, the questionnaire was subjected to some modifications based on the comments and suggestions from the pre-test samples.

As suggested by Passmore et al. (2002), two stages of pre-testing were taken to refine and improve the quality of the questionnaire. These two-stage pre-tests not only identified any inherent errors, but also resulted in a shorter questionnaire, such as rewrite or drop an item due to redundancy or possibility of creating uncertainty to the participants (Cooper & Schindler 2011; Passmore et al. 2002). The two-stage pre-tests involved a researcher pre-testing and a collaborative pre-test (Cooper & Schindler 2011). The researcher pre-testing was taken as the first step in order to validate the construct of the questionnaire. This step involved a review of the questionnaire by academic experts and research colleagues. In total, the researcher pre-testing process involved two academic experts and two research colleagues. The review was conducted in the daily environment of academic and research activities. The purpose of this step includes assessment of the ease of administration of the survey, that all necessary items covered the concept, and the clarity of items and instructions. The researcher pre-testing resulted in feedback which was then followed up by making fine adjustments to validate and prepare the questionnaire for the collaborative pre-test. For example, items A9 – A14 (Appendix B1) were written as a long list of repetitive questions with the five-point Likert scale placed at the side of each item. Via researcher pre-testing, it was found that the questions involved similarities in maintenance management activities. The items were therefore rearranged in a matrix form as seen in Appendix B1.

The collaborative pre-test involved broader pre-testing samples. As there are no general principles of good pre-testing (Cooper & Schindler 2011), a mix-background of pre-testing samples was selected to ensure that comprehensive feedback could be gained in order to improve the quality of the questionnaire. The collaborative pre-testing involved a sample of twelve consisting of four academic experts, three professionals from shipping companies in Australia and Indonesia, one member of the general public and four research colleagues in the Department of Maritime and Logistics Management, Australian Maritime College, University of Tasmania. The academic experts sample were those with a background in maritime and supply chain management, thereby contributing to the construct of the questionnaire in terms of academic approach and question wording to ensure accuracy and clarity of the questionnaire. Feedback from the professionals provided invaluable insights from the potential sample of the targeted population of the survey. Their feedback provided insights into whether the questionnaire covers topics relevant to the interests of the targeted population, which contributes to the success in gaining the required response rate (Jenkinson 2004; Schirmer 2009). Feedback from the member of the general public provided information related to ethical issues in conducting the survey.

A set of hard copies of the questionnaire and their accompanying letters (see Appendix C) was delivered to the participants in the collaborative pre-test. This document included a pre-testing letter and a set of survey documents (the cover letter (see Appendix E1), the participant information sheet (see Appendix F1), the questionnaire (see Appendix B1) and a sample of the reminder letter (see Appendix G1), reminder postcard (see Appendix H1) and stamped return envelope). By means of a pre-testing letter (see Appendix C), the pre-test samples were clearly informed about the objectives of the pre-test, the procedure for conducting the postal survey and the major issues to be highlighted from the pre-test. To undertake the pre-test, the pre-test samples were asked to assess the reading convenience level of the questionnaire's layout, the clarity of the instructions, the content of the questionnaire, the occurrences of ambiguous words and/or questions and the potential duration for completing the questionnaire.

Following the pre-testing process, the questionnaire was then adjusted based on the pre-test samples' comments and suggestions. Some questions were revised after the pre-testing; for example in question item D8 of the questionnaire the term 'mutual need' replaced the term '… interdependency rather than power' as it was deemed to be an unusual term in the industry. Some adjustments were also made to some of the wording of the items following the feedback which suggested they were not suitable for delivering the questions to the industry people who will comprise the actual sample of the research.

The two stages of pre-testing, as suggested by Passmore et al. (2002), were completed in order to verify the accuracy, brevity and clarity of the questionnaire. The average time to complete the questionnaire was reported to be in the range of 25 to 30 minutes. The average length as indicated from the pre-testing results should prevent the participants from cognitive fatigue which may cause nonresponse bias or bias to their answers (see Ackerman & Kanfer 2009; Jensen, Berry & Kummer 2013). Therefore, apart from any flaw that might inadvertently have been overlooked during these steps, the questionnaire was ready for the administration process for executing the primary data collection.

5.8 Administering the postal survey

This section describes the strategies undertaken to execute the data collection project for obtaining reliable survey data. In particular, this section discusses the strategies to minimise bias issue caused by nonresponse in postal surveys which incurs smaller data samples and low response rates. This section also discusses the preparation of the questionnaire in terms of posting processes and the planning for executing the data collection to administer the postal survey.

5.8.1 Preparing the questionnaire document

There is a range of strategies to deal with the inevitable nonresponse issue such as the design of survey instrument, preliminary notification, personalisation, institutional sponsorship, follow-up reminder: telephone, letter and postcard, premium outgoing postage, monetary incentives, stamped addressed return mail and deadline dates (Cook, Dickinson & Eccles 2009; Edwards 2004; Hager et al. 2003; Kanso 2000; Levy et al. 2012; Rogelberg & Stanton 2007). The strategy that related to the design of the questionnaire has been addressed in an earlier section (see section 5.6.3). Thus, this section discusses the rest of these strategies. In addition, the strategy used to address the international geographical differences between the researcher and the targeted participants is also explained.

Most scholars affirm that using monetary incentives, institutional sponsorship, follow-up reminder and stamped addressed return envelope in postal surveys provide a positive impact in increasing the response rates (Cook, Dickinson & Eccles 2009; Edwards 2004; Hager et al. 2003; Kanso 2000; Larson & Poist 2004; Leung et al. 2004; Levy et al. 2012; Osler et al. 2009; Rogelberg & Stanton 2007; Shaw et al. 2001; Silva, Smith & Bammer 2002; Taylor & Lynn 1998; Waltemyer, Sagas & Cunningham 2005). With regard to the constraint of funding available for undertaking the current research, this research could not include a monetary-incentive strategy. Furthermore, the targeted sample includes middle-management-level personnel in the shipping companies who might appreciate a different type of incentive such as feedback from the results of the study rather than money (Larson & Poist 2004). This offer was situated in the concluding part of the questionnaire as part of an expression of appreciation to the respondents who had completed it and by way of encouraging them to return it.

The follow-up reminders consisted of a reminder letter and a reminder postcard. The reminder letter was prepared for all participants with the aim of communicating the researcher's gratitude to those who had completed and returned the questionnaire, and encourages those who had not. The reminder postcard was prepared only for those who had not completed the questionnaire before the cut-off date for the data collection (see Schirmer 2009).

In terms of institutional sponsorship, the data collection project was approved by the Ethics Committee of Tasmania University (see Appendix D). The approval was declared in the information sheet of the survey as evidence about the institutional sponsorship. The information sheet explains the details of the research. This also includes the assurance of the confidentiality of the participants, only a small amount of time is required for completion and no risks may be incurred. In addition, all of the questionnaire documentation (the cover letter (see Appendix E1), the participant information sheet (see Appendix F1), the questionnaire (see Appendix B1) and the follow-up reminder letter (see Appendix G1) was printed on paper that includes the Australian Maritime College and the University of Tasmania logos. The envelopes used for sending the documentation and the stamped addressed return envelopes were official University of Tasmania printed envelopes. The aim of using University stationery was to gain the participants' confidence on the academic purpose and originality of the survey to participate in the survey and complete the questionnaire (see White, Carney & Kolar 2005).

In terms of personalisation, it has been suggested that personalisation of the survey with written addressee's details and signatures only provide a marginal contribution to improving response rates in postal mailed surveys (Kanso 2000; Kawash & Aleamoni 1971). However, recent research finds that personalisation which is coupled with letter and postcard reminders remains an effective way to improve the response rates (Leece et al. 2006; Levy et al. 2012; White, Carney & Kolar 2005). Furthermore, current computer technology allows printing the addressee's details and researcher's signature, including the signatures from the supervisory team, providing a personal touch. In addition, the researcher's and the supervisory team's email addresses were also provided in order to increase the confidence of respondents in completing and returning the questionnaire.

The questionnaire of the current research was prepared with a personalised cover letter, a set of two means of follow-ups (the reminder letter and the postcard) and a stamped addressed return envelope. In all, the questionnaire documentation to be sent to each participant consisted of a cover letter (see Appendix D1), the participant information sheet (see Appendix E1), the questionnaire (see Appendix B1), a reminder letter (see Appendix F1), a reminder postcard (see Appendix G1) and a stamped addressed return envelope. The, documentation was then ready to be distributed as explained in the following section.

5.8.2 The outgoing and the returning postage

With regard to the international postage involvement throughout the data collection, a careful trade-off was conducted between cost and time in administering the data collection. Using the casual international postage service may allow this research to obtain lowest total cost, but incurs lengthy posting days that could jeopardise the completion of the research. In contrast, using a premium mail service could reduce the posting days significantly, but it would become expensive if the questionnaire documentation was sent directly using international postage service from Australia to Indonesia. Furthermore, for the return postage, using a pre-printed business envelope provided by the Australian Post Office may not be effective in obtaining satisfactory response rates (Kanso 2000; Osler et al. 2009).

Furthermore, the physical weight of each returning questionnaire exceeds the maximum weight that can be accommodated by the Australian reply paid postage services (*Reply Paid Service Guide* 2010). Even though several compromises were made in designing the questionnaire, the inclusion of numerous necessary exploratory questions made the total questionnaire size eleven pages including its cover and introduction pages. In addition, in order to maintain the quality of the questionnaire's presentation, it was printed on paper of 80 grams per square metre. As a result, the total weight per returning questionnaire was 105 grams, which exceeds the maximum weight of 50 grams as per Australian reply paid postage services guidance.

A local professional courier agency in Jakarta was employed as a trade-off solution between the time and cost in executing the data collection for the current research. The agency was utilised as a proxy address in administering the distribution and collection of the questionnaire documentation in Indonesia. Furthermore, the employment of a professional courier agency may provide additional credibility to the survey which in turn influences the response rates (Kasprzyk et al. 2001). All of the questionnaire documentation was sent to a proxy address in Jakarta, Indonesia, for distribution to the participants' addresses. A stamped addressed return envelope with the proxy address in Jakarta was inserted into each package of questionnaires. The proxy address was printed on the stamped addressed return envelopes to accommodate the return of questionnaires before they were collected in bulk to be sent back to the researcher in Australia. All the preparation processes were undertaken by the researcher in Australia in order to ensure the consistency and quality of the questionnaire documentation. The local agent was responsible only for distributing the questionnaires and compiling the returning questionnaires into one parcel to be sent back to the researcher's address in Australia.

5.8.3 Executing the data collection

At this point, the questionnaire and other survey documentation were ready to be dispatched for executing the data collection. However, with regard to the involvement of a professional courier agency in Indonesia, a detailed plan for managing the outgoing and returning questionnaire is necessary. First, the questionnaires and other survey documentation were assembled into one mailing package, which might take three to four working days to arrive in Jakarta, Indonesia. Once the package was received in Jakarta, the questionnaires were prepared by putting a domestic stamp on each of the return envelopes and enclosing one in each survey package. It was estimated that one working day would be needed to carry out these preparations prior to sending off to the participants' addresses. Using the Indonesian premium one-day postage service, the questionnaires were estimated to arrive at the participants' addresses within five to six working days after mailing from Australia.

The reminder letter was then prepared to be sent two weeks (14 days) after the first mailing. The reminder letter also provided the researcher's contact details which allowed the participants to have further communication whenever necessary, for example if they required an additional copy of the questionnaire or enquired about the roles of the local agency. Next, the reminder postcard was to be sent two weeks (14 days) after the mailing of the reminder letter, or four weeks (28 days) after the first mailing of the questionnaire document. It was decided that the cut-off date for the data collection project would be two weeks after sending the reminder postcard. Then, one to two working days were allocated for compiling the returning questionnaires and sending them back to the researcher's address in Australia. Following this, another three to four working days were allocated as the waiting period before the expected receipt date of the package in Australia. These outgoing and returning postages are summarised in Table 5.4. Having discussed the administration of the postal survey, the next section will describe the error control process in order to address the perceived total survey error which may influence the quality of the current research.

Table 5.4: Outgoing and returning postage plan

Activities	Estimated duration	
	Earliest	Latest
Questionnaire documentation ready to be dispatched	D-day	D-day
Sending packages to Indonesia	D-day + 3	D-day + 4
Questionnaire documentation preparation (stamping return-envelopes)	D-day + 4	D-day + 5
Dispatch questionnaire documentation packages	D-day + 6	D-day + 7
Dispatch reminder letters	D-day + 20	D-day + 21
Dispatch reminder postcards	D-day + 34	D-day + 35
Cut-off date	D-day + 48	D-day + 49
Compiling the returning questionnaires	D-day + 49	D-day + 51
Sending the questionnaire packages to Australia	D-day + 50	D-day + 52
Receiving the questionnaire packages at the researcher's address in Australia	D-day + 53	D-day + 56

Source: Author

5.9 Error control processes

An error control process involves understanding the sources, the measures and the steps undertaken to diminish these perceived errors. Cooper and Schindler (2011) classify sources of errors in research which consist of measurement questions and survey-instrument-based errors, interviewer-based errors and participant-based errors. How these errors are addressed will be discussed in the following in order to enable the current research to produce reliable and valid information from the insights gained from the shipping companies.

5.9.1 Measurement error and questionnaire-based error

A measurement error may result from the inability of respondents to provide an accurate answer due to the questionnaire-related construction (Dillman, Smyth & Christian 2009, p. 18). Swain, Weathers and Niedrich (2008) found that the use of inconsistent and reversed Likert scales produce a higher level of measurement error. To address these Likert scale issues, the questionnaire has been arranged so that the scale is provided consistently. As discussed, the five-point Likert scales in the questionnaire have been arranged in a positive direction where the lowest number of the scale (one) represents the most negative response and the highest number (five) represents the most positive response. The scale is also designed so that the mid-value '3' provides a neutral response; and, it also provides 'Don't Know' or 'Not Applicable' responses, when appropriate, to accommodate genuine response rather than force the participants to provide a guessing response (Agrawal et al. 2009).

The design of the questionnaire may also generate a measurement error due to ambiguous questions or complex words beyond participants' comprehension (Cooper & Schindler 2011 , p. 280). As discussed earlier, the questionnaire has undergone two pre-testing procedures that assessed the validity of the questions and their responses, including type of measurement applied. Based on the feedback from the pre-tests, some revisions were undertaken to adjust the questionnaire and address the comments and suggestions in order to minimise the perceived ambiguities. The pre-testing procedures also function as an internal validity measure of the questionnaire, by which the questionnaire is measuring what it purports to do (Cooper & Schindler 2011; Rattray & Jones 2007). The reliability of the questionnaire will be measured in terms of Cronbach alpha coefficient based on collected data, which is discussed in the analysis chapter of this thesis, Chapter Six.

5.9.2 Interviewer-based error

Interviewer-based error consists of sampling error, data entry error and process errors (interview inconsistency, interview environment, influencing behaviours and physical presence bias) (Cooper & Schindler 2011). Since the questionnaire itself assumes the role of the interviewer in the postal survey, the interviewer-based error is only concerned with the sampling error, whilst the data entry error and the process errors have been addressed during the development of the questionnaire. Sampling error involves the chance of variation in the selection of sampling units (Zikmund 2010). The variation may be attributed to incomplete data about the population which results in the presence of coverage error where not all members of the population are included in the research survey (Dillman, Smyth & Christian 2009).

At the beginning of the current research, there were found to be inconsistent databases providing lists of shipping companies in Indonesia. As discussed in the population and sampling section (see section 5.4), a cross-referencing procedure was undertaken to frame the population. The cross-referencing procedure enables this study to establish the required population for the research as complete as possible. With regard to the availability of detailed databases about shipping companies in Indonesia and other underpinning circumstances to the current research, the questionnaire-based postal survey was considered to be the most suitable and viable method to undertake the survey research. The decision was made to minimise potential bias due to coverage error.

The samples were then determined using a quota sampling method which determined the number of shipping companies from each of the cities to be included in the sample population (see Table 5.1). Even though quota sampling is not a probability sampling method, this method is still capable of providing a confidence level with regard to the representativeness of the sample towards the population (Cooper & Schindler 2011). The equation, which resulted in the number of samples from each city, also provides a higher level of confidence about the sampling method (see Figure 5.2). The equation provided 95 per cent confidence with the interval of $\pm$ 5 per cent, which provided confidence that the sampling error has been sufficiently addressed, as suggested by Bonett (2008). The perceived sampling error has been sufficiently addressed to ensure the quality and the research findings.

5.9.3 Participant-based error

Participant-based error includes the lack of knowledge of the participants, misinterpretation in relation to the questionnaire, incomplete participation (item nonresponse) and total nonresponse (Cooper & Schindler 2011). The lack of participant knowledge has been addressed via the selection of the participants' characteristics. The targeted participants were selected from the sample population whose expertise and experience are relevant to the research topic. The possibilities of misinterpretation about the items and items' instructions in the questionnaire have been addressed via the two-step pre-testing process. Accordingly, these types of error have been anticipated.

The occurrence of nonresponse error which results in low response rates that influences the quality of findings of a survey research has been widely discussed in the literature (see Borkan 2010; Dennis 2003; Díaz de Rada 2005b; Dillman et al. 2009; Dillman, Smyth & Christian 2009; Fauth et al. 2013; Groves & Peytcheva 2008; Hager et al. 2003; Helgeson, Voss & Terpening 2002; Kawash & Aleamoni 1971; McAuliffe et al. 1998; Reio 2007; Thomsen 2000). Both total nonresponse error and item nonresponse error should be properly addressed in a postal survey (Sax, Gilmartin & Bryant 2003). The total nonresponse error refers to any failure to return the mailed survey and the latter refers to incomplete returned mail surveys (Platek 1985; Reio 2007; Sax, Gilmartin & Bryant 2003).

To address the issue of total nonresponse error, several strategies have been applied for the current research. Larson and Poist (2004) and Schirmer (2009) suggest that, in order to increase response rates in a survey, the topic of the questionnaire should be interesting and relevant to the interests of the intended participants. Schirmer (2009) and Ford and Bammer (2009) suggest that the use of multiple reminders with ethical considerations such as persuasion, ensuring confidentiality, representativeness and not putting a burden on the participant can be useful in order to increase the response rates. The use of stamped addressed return envelopes may also have the effect of increasing response rates (Cook, Dickinson & Eccles 2009; Levy et al. 2012).

The necessary efforts to anticipate the item nonresponse issue in the questionnaire-based postal survey due to the absence of the interviewer have been addressed. Scott et al. (2011) found that item nonresponse rate relates to sensitive questions which impose upon participants' reluctances or uncertainties. The questionnaire has been designed to make it easier for the respondents to answer all items based on provided responses by filling in the answer to the corresponding box. Furthermore, sensitive questions were moderated by providing a set of responses in Likert-type scales in order to encourage the participants to answer the questions. Some questions encompass 'Don't Know' or 'Not Applicable' responses in order to minimise the item nonresponse, and provide a range of responses. Riphahn and Serfling (2005) suggest that these types of responses could accommodate the respondents when they refuse to answer whilst maintaining the nonresponse error at a low level. In all, the questionnaire has been carefully developed in order to address the total survey error issues, which may influence the validity and the reliability of the research findings resulting from the data collection processes.

5.10 Summary

The detailed research design and methodology in undertaking the current research has been discussed throughout this chapter. The research is designed to enable this thesis to achieve its objectives by addressing the primary research question that is constructed with two subsidiary research questions. The nature of the research and the availability of databases about the population have been considered in the process to select the most suitable and viable data collection method for the research survey.

The generation of the population resulted in 604 shipping companies in Indonesia, from which a sample of 230 were needed in order to obtain survey results with 95 per cent confidence with $\pm$ 5 per cent. Various survey methods have been reviewed which resulted the questionnaire-based postal survey being determined as the most viable method to accomplish the objective of the research. As the best use of any method can provide optimum results, the inherent weaknesses of questionnaire-based postal surveys have been addressed in order to capitalise on the benefits of such method. In terms of the error control process, several strategies have been applied to diminish the perceived total survey error which influences the quality of the research findings. In the next chapter, the results of the survey are presented and discussed to address the research objectives.

Chapter Six

RESEARCH FINDINGS

AND

DISCUSSION

6.1 Introduction

This chapter provides a discussion of the results and analysis of the data collection to address the research objectives. The chapter first provides an overview of the demographic information about the participants of the survey to obtain the context of the discussion. The data analysis investigates current ship maintenance management from the perspective of supply chain management which includes internal readiness of the shipping companies, the external relationship conditions and the supply chain service processes. This analysis should reveal whether supply chain management is applicable in improving ship maintenance performance while at the same time enabling this research to identify the key elements for successful implementation of such an approach to ship maintenance. This research also investigates the benefits that can be attained by undertaking a supply chain management approach to ship maintenance.

6.2 Overview of the postal survey results

This section discusses the results of the survey for which preparations were described in Chapter Five. The achieved response rate and demographic information about the shipping companies and the survey participants is also discussed.

6.2.1 The response rates

After the initial sending of the questionnaires, only ten questionnaires were returned within the first two-week period, which is equal to a 4.35 per cent response rate. The low response rate was expected due to the participants' job positions in the shipping companies. As middle management, they were likely to be fully occupied with their daily responsibilities which makes it difficult for the postal mail survey to gain their attention (Klasnic 2005). This low response rate had also been anticipated as several researchers in the literature had noted lowering trends with regard to survey responses (see Dennis 2003; Fincham 2008; Rovai, Baker & Ponton 2013; Sax, Gilmartin & Bryant 2003; Tuckel & O'Neill 2002). Thus, a series of reminders were pre-planned to be dispatched to all participants two weeks after the initial sending, and the reminder postcard if necessary to be dispatched two weeks after dispatching the reminder letter.

The pre-planned reminders proved to be prudent. In total, 55 questionnaires were returned via either mail or email. From these participants, seven questionnaires were not useable due to total nonresponse. As a result, the effective responses for further data analysis were 48 questionnaires, which is equal to a 20.87 per cent response rate. The achieved response rate compares favourably with other research in supply chain management and maintenance management foci which used questionnaire-based postal mail surveys for data collection purposes (see: Bhatnagar, Sohal & Millen 1999; Bichou & Bell 2007; Carter et al. 2008; Casaca & Marlow 2005; Handfield et al. 2009; Knemeyer & Murphy 2004; Lockamy & McCormack 2004). Furthermore, for a sample size of 230, gaining 48 useable data/cases is sufficient for conducting several statistical tests to yield meaningful results for drawing conclusions about the population (Rovai, Baker & Ponton 2013).

6.2.2 Benefits from using local contact address

The use of a local professional courier agency increased flexibility in administering the distribution of the questionnaire. The benefit of such flexibility was revealed when, having received 35 questionnaires that were returned due to the addresses not being found, a local agent was engaged, resulting in quick responses to these unsuccessful returned questionnaires. The 35 companies' data were updated and the questionnaires were re-sent via the same one-day postage service. A total of 21–30 working days would have been incurred if the questionnaires were sent directly from Australia individually to the addressees. Comparing the postage days to the method outlined in the previous chapter, which was seven days to reach the addressees (see Table 5.5), the use of a local agent significantly reduces the amount of time for distributing the mail survey.

A cost-efficient benefit was also gained from using the local agent. By using the local agent, the total average cost of sending the survey, including the reminder letter, reminder postcard and returning the questionnaire to the Australian Maritime College was 7.55 AUD. In contrast, the total cost for administering the mail surveys directly from Australia to individual addressees in Indonesia would cost 11.10 AUD per questionnaire. Accordingly, in addition to the reduction of time and the increased flexibility for handling the distribution and collection of the questionnaire, using the local agent enabled this research to attain a lower total average cost for administering the mail survey.

6.2.3 The shipping companies

As discussed in Chapter Four, the shipping companies in the current research provide inter-island shipping services to deliver cargoes and passengers. The shipping companies may operate a single ship, multiple ships of a single type or multiple ships of multiple types. Item H1 of the questionnaire (see Appendix B1) asked the participant to provide information with regard to size and types of their fleet (see Table 6.1). In general, Table 6.1 shows there are two types of shipping company in the sample population, those that focus on a certain shipping segment and others that offer various shipping services requiring various types of ship. Subsequently, shipping companies that operate one ship can be categorised into the first group. As a result, 34 shipping companies (80.8 per cent) offer a shipping service for specific cargo and the other 14 shipping companies (29.2 per cent) offer shipping services for several types of cargo related to the types of ship.

Table 6.1: Shipping companies sample population

Fleet types		**Companies**	**Per cent**
1 ship		4	8.3
>1 ship	General cargo	5	10.4
	Container ship	2	4.2
	Dry-bulker	3	6.3
	Liquefied bulk tanker	2	4.2
	Chemical product tanker	2	4.2
	Landing craft transportation	3	6.25
	Tug and barge	13	27.1
>1 ship; >1 type		14	29.2
Total		**48**	**100.0**

Source: Appendix I item H1

Percentages may not add to 100 due to rounding

This research focuses on the supply chain management of ship maintenance in general. As discussed in Chapter Four, there was very little information known about shipping companies in Indonesia. The available list of information about shipping companies in Indonesia, registered as Indonesian shipping companies, was obtained from the Lloyds' Directory (Lloyds 2012). However, this list was provided without sufficient information about the shipping companies' services or the types of ships they operate. Very little information about these shipping companies was able to be verified; even though various open sources such as websites and group blog archives have been used to cross-referenced the data. Only after the analysis of the survey findings, it was revealed that the shipping companies operate various types and sizes of ships, as shown in Table 6.1.

A random pattern of the number of the ships and their types has hindered this research drawing a general conclusion about the shipping companies and their fleet. Implementation of the findings of this research might require an adjustment at the operational level of the companies in relation to their fleet size and types of ships. This limitation will be addressed in the conclusions chapter of this thesis. Nevertheless, the findings of this research remain valuable in revealing the importance of developing an approach for managing the ship maintenance at the strategic level in companies. This research has revealed the contemporary awareness of the senior managers regarding the importance of strategic maintenance management and the need to integrate maintenance management activities at the strategic level, as explained in section 6.3.

There are 808 ships in the sample population (see Table 6.2). These data may be related to various commodities that are transported in the Indonesian archipelagos. Espada, Kumazawa and Tambunan (2005) reported that among various commodities of Indonesian sea freight, the largest group are petroleum, general cargo and coal. In terms of petroleum, although the volume is large, most tanker ships possess a high volume capacity that affects the number of ships required to transport the cargo. The second largest number of ships in is general cargo ships, which is followed by landing craft transportation. The number may relate to the archipelagic nature of Indonesia which requires general marine transportation able to accommodate diverse cargoes on-board in small volumes (Plomaritou, Plomaritou & Giziakis 2011). Furthermore, landing craft transportations are capable of beaching in any shallow water beaches across islands in Indonesia. This type of ship can provide logistics services to remote areas where an established seaport is still absent.

Table 6.2: Data of ships from the sample population

Ships			**Average DWT (x 1,000)**	
Types	**Number**	**Percentage**	**Min.**	**Max.**
General cargo	114	14.11	3.3	13.2
Container ship	77	9.53	2.6	12.5
Dry-bulker	84	10.40	3.0	72.4
Liquefied bulk tanker	17	2.10	1.2	17.5
Chemical product tanker	43	5.32	1.7	30.0
Landing craft transport	94	11.63	0.4	5.0
Tug and barge	379	46.91	0.5	8.0
Total	**808**	**100.00**	**n/a**	**n/a**

Source: Appendix I item H1

DWT: Dead Weight Tonnage

Percentages may not add to 100 due to rounding

The questionnaire asked the participants to provide information about the number of shore-based maintenance personnel in their companies (item F1 Appendix B1). The data were crossed-tabulated to the range of companies' ship number, as seen in Table 6.3, to stratify the sample. One case of item nonresponse occurred from item F1 which caused 2.1 per cent missing data out of 48 cases. However, these missing data are low which allows the data to be considered as missing completely at random (SPSS 2007); and thereby no data intervention is required.

Table 6.3 shows that 33 (19+14) shipping companies employ up to ten shore-based personnel for managing ship maintenance, which is equal to 70.2 per cent of the sample population. This number represents the biggest group of the total maintenance personnel in the shipping companies. Among these 33 shipping companies, 15 of them possess five to nine ships in their fleet. These data show that the shipping companies of less than ten shore-based maintenance personnel and five to nine ships represent the biggest group of the sample population.

Table 6.3: Cross tabulation – number of ships and maintenance personnel

		Number of maintenance personnel					**Total**
		1–5	6–10	11–20	21–40	>40	
Number of ships	1	4	0	0	0	0	4 (8.5%)
	2–4	3	2	0	0	0	5 (10.6%)
	5–9	8	7	1	0	0	16 (34.0%)
	10–19	3	2	2	2	0	9 (19.1%)
	20–49	1	2	3	1	5	12 (25.5%)
	≥50	0	1	0	0	0	1 (2.1%)
Total		19 (40.4%)	14 (29.8%)	6 (12.8%)	3 (6.4%)	5 (10.6%)	47 (100%)

Source: Appendix I item F1

Percentages may not add to 100 due to rounding

Table 6.3 also indicates that the size of fleet might influence shipping company's decision on the total number of shore-based maintenance personnel to be employed, for example, companies that operate only one ship tend to employ not more than five shore-based maintenance personnel. Whilst companies that operate 2–4 ships and 5–9 ships tend to employ either less or more than five shore-based maintenance personnel but rarely employ more than ten. An interesting pattern appears from companies with 20–49 ships of their fleet. The data indicates that various approaches are used in determining the number of shore-based maintenance personnel in these companies. Some companies that employ a large number of maintenance personnel (more than fifty) might use an in-house maintenance management approach, whilst the other companies with small number of maintenance personnel apparently out-sourced maintenance services in managing maintenance for their ships. These data provides an indication to a correlation between size of fleet and decision making in managing maintenance for ships, which is valuable for future research in understanding the complexity of ship maintenance management holistically.

6.2.4 The survey participants

The survey participants come from various job positions in the shipping companies; even though the survey was addressed to the maintenance manager (see Table 6.4). These data indicate that the title of maintenance manager varies from one company to another. Table 6.4 shows the profile of the participants, consisting of senior managers (22.9 per cent) and middle managers such as maintenance managers, operations managers, superintendents and general affair managers (64.6 per cent). Only 8.3 per cent of the participants were from operations level staff. As suggested by Pinjala, Pintelon and Vereecke (2006), obtaining data from participants of higher management levels can provide some levels of confidence about the collected data. Accordingly, some confidence about the data is obtained, with regard to the managerial levels of the participants of this survey, to undertake data analysis of this research.

There were two participants (4.2 per cent) who declined to respond to their position in the companies which generated an item nonresponse. Since the survey is a self-administered type, no further question can be prompted to explore the reason. However, this item nonresponse is less than five per cent of the sample population which allows the data to be considered as missing completely at random (SPSS 2007); and thereby no action was required in order to be able to perform further statistical data analysis.

Table 6.4 also includes the experiences of the survey participants in the shipping industry and the current job positions. The majority of the participants have an extended period of experiences within the shipping industry. Almost half of them, 45.8 per cent, indicated that they have been more than 15 years in the shipping industry, whilst the other 50.0 per cent has from six to fifteen years' experience (H2). In relation to the current job position, 12.5 per cent of participants have been in their position for more than 15 years, and 41.7 per cent for more than six up to fifteen years (H5). Furthermore, 79.2 per cent of the participants indicated that they are directly responsible for the management of ship maintenance (H4). These data suggest the participants possess a significant role in the decision-making process for managing the ship maintenance, and have the experience and expertise to provide relevant and valuable insights from the industry.

Table 6.4: Participants' profile

No	Statement	Number	Percentage(%)
H2	**Experience in shipping**		
	Less than 2 years	0	0
	2–5 years	1	2.1
	6–10 years	17	35.4
	11–15 years	7	14.6
	More than 15 years	22	45.8
	No Answer	1	2.1
	Total	**48**	**100.0**
H3	**Job positions**		
	Senior managers (such as director, general manager and president director)	11	22.9
	Operations manager	8	16.7
	Maintenance manager	9	18.8
	General affairs manager	2	4.2
	Superintendent	11	22.9
	Marketing manager	1	2.1
	Technical operations staff	4	8.3
	No response	2	4.2
	Total	**48**	**100.0**
H4	**Responsibility to ship maintenance management**		
	Direct	38	79.2
	In-direct	10	20.8
	Total	**48**	**100.0**
H5	**Experience in the current job positions**		
	Less than 2 years	4	8.3
	2–5 years	18	37.5
	6–10 years	18	37.5
	11–15 years	2	4.2
	More than 15 years	6	12.5
	Total	**48**	**100.0**
H6	**Education background in maintenance management**		
	Certified Practitioner of Maintenance Management	5	10.4
	Certified Senior Practitioner of Maintenance Management	3	6.3
	Maritime Engineer	10	20.8
	Naval Architect	15	31.3
	Other	2	4.2
	No Degree	13	27.1
	Total	**48**	**100.0**
H7	**Education underpin carrier experience**		
	Yes	38	79.2
	No	1	2.1
	Unsure	9	18.8
	Total	**48**	**100.0**

Source: Appendix I

Percentages may not add to 100 due to rounding

Another issue that might be drawn from Table 6.4 is related to the participants' education background and their perspective upon formal education in maintenance management. A total of 79.2 per cent of the participants believe that education background might underpin those who want to undertake carrier in shipping industry, particularly in ship maintenance related jobs. However, only 16.7 per cent of the participants possess a formal education in maintenance management. Most of them undertake their carrier as Naval Architect or Maritime Engineer, which do not specifically equip them with management skill in relation to ship maintenance. The data indicates that there might be challenges to enhance awareness to the important of ship maintenance through a formal education.

6.3 Ship maintenance management activities

This section explores how ship maintenance management is undertaken in the shipping companies. The ship maintenance management was investigated through the lens of a supply chain management approach that includes the internal readiness conditions for supply chain management orientation, the external relationship conditions and the supply chain service processes. Each of these elements is discussed in the following sections.

6.3.1 The internal readiness conditions

The internal readiness conditions of the shipping companies relates to the availability of dedicated personnel for managing the supply chains of ship maintenance, the commitment and support from the top management, the integration behaviour within the companies and the internal use of information and communication technology for managing the supply chains.

6.3.1.1 Dedicated personnel for managing the supply chain

The title of procurement manager and maintenance manager can vary among shipping companies (items A1, A5). Item A1 asked the participants to indicate the person who is responsible for managing the maintenance for the ships, and item A5 asked for the person who is responsible for managing the supply chains of ship maintenance. The maintenance manager is the person who deals with the operational activities of ship maintenance and who knows the detailed conditions of the ships, including the technical capability of the maintenance suppliers. The involvement of the maintenance manager in the management of supply chains of ship maintenance is important for providing necessary technical assessment in relation to maintenance requirements (Lee & Scott 2009; Trent 2004).

The data suggest that the majority of the personnel were appointed from middle-level management of the shipping companies. The job positions of the procurement manager and the maintenance manager are provided in Table 6.5. Based on the reporting line data from the survey (items A1–A3 and A5–A7), in descending order, the management level in shipping companies comprises the board of directors as the highest management level and then levels one to three. Level-one management consists of the chief executive officer or president director as the immediate level under the board of directors. Level-two management includes the operations manager, maintenance manager, procurement manager or finance manager. The field staff or operator comprises level three of the management.

Table 6.5: Management levels of maintenance and procurement managers

Levels in management	Example of titles in the shipping companies	Number	%
Procurement Manager			
Level one	Material manager, logistics manager	5	10.4
Level two	Procurement manager, fleet logistics manager, chief of supply	35	72.9
Level three	Supply section purchasing staff	7	14.6
	(Nonresponse)	1	2.1
	Total	**48**	**100.0**
Maintenance Manager			
Level one	Technical director, operations and fleet general manager	6	12.5
Level two	Maintenance manager, superintendent, technical manager, operations manager	36	75.0
Level three	Technical staff	4	8.3
	(Nonresponse)	2	4.8
	Total	**48**	**100.0**

Source: Appendix I

Percentages may not add to 100 due to rounding

The data in Table 6.5 show that the majority of procurement and maintenance managers, more than 70 per cent, are assigned from personnel who are in level two of the companies' managerial structures. This information suggests that the shipping companies delegate the responsibility of procurement and maintenance managers to those who have sufficient access to the corporate-level business strategies. As suggested by Marquez (2007) and Bengtsson (2008), personnel with sufficient access to the corporate-level business strategy should be able to develop a tactical strategy aligned with the business strategy of the company to provide profits for the companies. The data indicate that the shipping companies satisfy one element of the internal readiness conditions in order to assume a supply chain management approach for managing their ship maintenance, which requires the companies to allocate their resources to master the supply chain management (Kotzab et al. 2011).

6.3.1.2 Top management commitment and support

Commitment and support from top management is acknowledged as an important element for developing strategy driven maintenance management (Coetzee 1999; Garg & Deshmukh 2006; Ingalls 2010; Kodali, Mishra & Anand 2009; Marquez 2007; Tsang 2002). The participants were asked to indicate their perception toward the commitment and support from the top management for improving purchasing for ship maintenance requirements. The results, as seen in Table 6.6, indicate that the measurement scale has a high internal reliability with a Cronbach alpha (α) coefficient of 0.859. The survey was seeking participants' level of agreement to the provided statements (items C14–C16) by using a five-point Likert scale, where "1" is equal to strongly disagree and "5" is strongly agree. The mean values in Table 6.6 suggest that the participants agree with the provided statements. This result indicates the existence of commitment and support from the top management of the shipping companies to implement a supply chain management approach for ship maintenance.

Table 6.6: Top management commitment and support

Item	Statement	μ	σ	α
C14	Support to improve purchasing for maintenance	4.26	0.820	0.859
C15	Consider purchasing for maintenance as a vital part of business strategy	4.22	0.841	
C16	Acknowledge the role of purchasing for maintenance in improving company's competitiveness	4.17	0.973	

Source: Appendix I

μ: mean; σ: standard deviation; α: Cronbach alpha coefficient

6.3.1.3 Internal integration behaviour

The companies' internal integration behaviours were assessed through measuring the horizontal and vertical relationships between departments in the shipping companies across management activities of the ship maintenance. Whilst coordination between operations manager, maintenance manager, procurement manager and finance manager reflect the horizontal relationships at a tactical level, their communication with the chief executive officer and the board of directors reflects the vertical relationship within shipping companies. The participants were asked to provide information about the involvement of these personnel in the planning of maintenance, organisation of spare parts inventory, evaluation of maintenance performance, setting of specification of the required maintenance and allocating of the ship maintenance budget (see Appendix B1 items A9–A14).

A Pearson product-moment correlation test was undertaken as it reflects the extent of the linear relationship between two sets of data; and it provides a dimensionless summary with correlation coefficients (r) from -1 to +1 (Iuga 2010; Pallant 2011). The negative coefficient indicates that as one variable increases, the other decreases; and the positive coefficient indicates both variables move towards the same direction (Pallant 2011). In this instance, a Pearson product-moment correlation test was undertaken to investigate the linear relationships between the managers, the chief executive officer and the board of directors. The compound scale to measure the internal integration behaviour was reported with a Cronbach alpha coefficient of 0.899 which indicated a high reliability of the scale. The outputs of the Pearson product-moment correlation test are provided in Appendix I.

The significant correlation coefficients at the confidence level of 0.01, provided in Appendix I, are summarised in Table 6.7. The coefficients were obtained from the survey data regarding the involvement of the personnel in the maintenance management activities, which may reflect the contemporary intra-organisation linkages of the shipping companies. The solid lines in the table represent the significant correlation coefficients between personnel in the shipping companies. The lines in the table may also represent the complexity of maintenance management in shipping companies.

As seen in Table 6.7, the involvement of the board of directors in maintenance management activities correlate more with the chief executive officer, the operation manager and the finance manager; whilst there is no significant correlation with the maintenance manager who undertakes maintenance action directly. In contrast, the maintenance manager's involvement throughout maintenance management activities only significantly correlates with the finance manager's and the procurement manager's involvements. The correlation appears in the maintenance planning of the maintenance managers when allocating the maintenance budget of the finance manager; and in the specification settings of maintenance of the maintenance manager when allocating the maintenance budget of the procurement manager. Specification settings of maintenance may include decision on repairing or replacing wear-off parts, undertaking a full set of general overhaul or selecting only the critical items, undertaking general overhaul or top-head overhaul, and others. The correlations suggest that the necessary information and required strategic approach to maintenance management be discussed in a budget driven environment at the tactical level of the shipping companies; it does not appear at the strategic level.

Table 6.7: Summary of intra-organisation correlations

No	Entities	Maintenance management activities				
		Planning	Organising spare parts	Evaluating	Specification settings	Allocating budget
A9	Board of directors	*	*	*	*	*
A10	Chief executive officer	*	*	*	*	*
A11	Operations manager	*	*	*	*	
A12	Maintenance manager	*			*	
A13	Procurement manager	*		*		*
A14	Finance manager	*	*	*	*	*

Source: Appendix I

*: correlated personnel; —: correlation lines

The results provide insights about the internal integration behaviour relating to the management of ship maintenance of shipping companies. Firstly, the results suggest that the board of directors, the chief executive officer and the finance manager are involved intensively in maintenance management activities, but little (if no) correlation with maintenance managers who are supposed to be directly responsible for the ship maintenance management. Their involvement is more in controlling the spare parts and making decisions on the ship maintenance specification to be undertaken. The findings suggest that shipping companies implement a budget driven ship maintenance management; and the involvement of the board of directors directly influence all personnel in the shipping companies but the maintenance manager. The correlation between the board of directors and the maintenance manager appears indirectly through the finance manager. Secondly, the shipping companies appear to assume a hierarchical relationship in the management of the ship maintenance. Thirdly, whilst significant correlation coefficients resulted from the Pearson product-moment correlation test between the board of directors, chief executive officer, operations manager, procurement manager and finance manager, no significant coefficient resulted from the test with the maintenance manager, which indicates a weak or very weak correlation (between 0 and ±0.4) (see Appendix I pp. 337-338). These results indicated a 'silo' approach is currently applied in the ship maintenance management where the maintenance manager is absent from most of the activities.

Pivotal roles of the chief executive officer can be seen from the solid lines in Table 6.7, which depicts his/her involvement in the relationships within upper-level management and with the other managers at the middle level. At the upper level of management, there are correlated relationships between the chief executive officer and the board of directors across all maintenance management activities. The correlations involve a vertical relationship with the finance manager in middle-level management, except in the activity relating to the allocation of maintenance budget. These data suggest that budgeting for ship maintenance is exclusively managed by the chief executive officer and the board of directors of the shipping companies.

In terms of correlated relationships with middle-level management of the shipping companies, Table 6.7 indicates that decisions emanating from upper-level management are delegated to the finance manager who then interprets the decisions into budget-driven operational activities. The interpretations correlate operational activities of ship maintenance between the finance manager with the operations manager and the procurement manager. These flows suggest a hierarchical approach in managing maintenance activities for the ships of the companies' fleet as depicted in Figure 6.1.

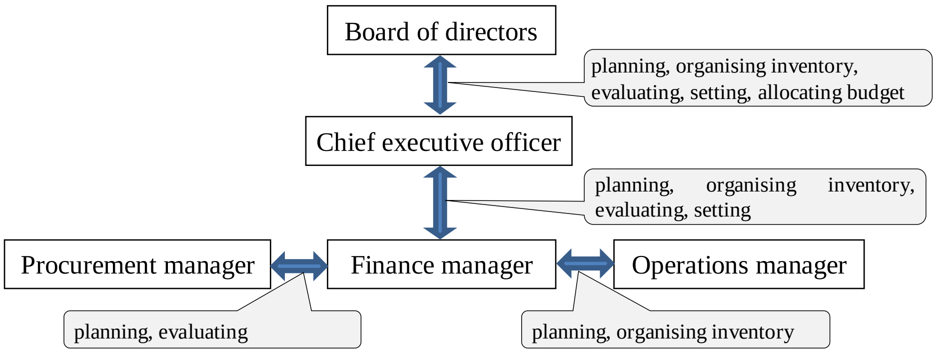


Figure 6.1: Hierarchical relationships in shipping companies

Source: Author

A further investigation was carried out in relation to the non-involvement of the maintenance manager at the strategic level of management. A Spearman rank order correlation test was carried out to assess the maintenance manager responsibilities data from item A4. The results are presented in Table 6.8. The Spearman rank order correlation test is useful to estimate the direction and the strength of ordinal or binary variables (Rovai, Baker & Ponton 2013). Throughout the survey, the participants were asked to indicate the maintenance manager's responsibilities in maintenance management activities. To undertake this test, data from item A4 (see Appendix I) were assigned with "1" when the response was ticked and "0" when the response was not ticked.

Table 6.8: Correlation coefficients of maintenance manager's responsibilities

Spearman's rho		**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
On-the-spot guidance for undertaking maintenance (1)	Correlation Coef.	1.000						
	Sig. (2-tailed)	.						
	N	48						
Analyse cause and/or effect of failure (2)	Correlation Coef.	.582**	1.000					
	Sig. (2-tailed)	.000	.					
	N	48	48					
Developing maintenance plan (3)	Correlation Coef.	.075	-.386**	1.000				
	Sig. (2-tailed)	.613	.007	.				
	N	48	48	48				
Intra-departments coordination for maintenance strategies (4)	Correlation Coef.	.348*	.450**	-.227	1.000			
	Sig. (2-tailed)	.015	.001	.120	.			
	N	48	48	48	48			
Intra-departments coordination for maintenance operations (5)	Correlation Coef.	.348*	.450**	-.227	.496**	1.000		
	Sig. (2-tailed)	.015	.001	.120	.000	.		
	N	48	48	48	48	48		
Supervise materials and/or services purchase (6)	Correlation Coef.	.533**	.655**	-.253	.370**	.159	1.000	
	Sig. (2-tailed)	.000	.000	.083	.010	.281	.	
	N	48	48	48	48	48	48	
Evaluate maintenance expenses **(7)**	Correlation Coef.	.116	.427**	-.284	.348*	.235	.178	1.000
	Sig. (2-tailed)	.433	.003	.050	.015	.108	.227	.
	N	48	48	48	48	48	48	48

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

The results in Table 6.8 show that there is no significant correlation coefficient resulting from the responsibilities pertaining to developing the maintenance plan (see column (3) of the table). This result underpins the result from the previous test that indicated weak correlation across maintenance management activities involving the maintenance manager. The data suggest that the internal integration behaviour of the shipping companies need to involve the maintenance managers at the strategic level of the companies.

6.3.1.4 Internal communication

The use of a computerised maintenance management system (CMMS) in shipping companies was investigated to measure the extent of internal communication (see Appendix I item F8). The result was reported with a high internal reliability with the Cronbach alpha coefficient reported as 0.892. A binomial test was executed to investigate the proportion of the participants who use a CMMS, which can be used for assessing the direction towards internal integration for managing the ship maintenance. The test was taken with an assumption that fifty per cent of participants use CMMS and the other fifty per cent does not use CMMS.

As seen in Table 6.9, two groups of answers resulted significant values that smaller than 0.05 ($p<0.05$). The first group is resulted from the items of planning and scheduling and recording maintenance time. The significant values of this group are resulted from the participants who indicated that they are using CMMS. The other group is resulted from storing maintenance reports and recording inventory on-board, which resulted from the participants who indicated that they are not using CMMS. The rest of the table shows that the significant values are greater than 0.05, which are evident in the use of CMMS for recording actual downtime, updating maintenance records and performing analytical functions to underpin decision making for ship maintenance. The results show that CMMS in shipping companies is mostly used in maintenance management activities such as planning and scheduling and recording actual maintenance time but not in storing maintenance reports and recording inventory on-board. And the participants who use CMMS for recording actual down-time, updating maintenance record and underpinning decision making process for ship maintenance are almost equal to those who do not use it.

Table 6.9: Binomial test for the use of CMMS

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)*
CMMS for planning and scheduling	Group 1	No	14	0.29	0.50	0.006
	Group 2	Yes	34	0.71		
	Total		48	1.00		
CMMS for recording actual down-time	Group 1	No	21	0.44	0.50	0.471
	Group 2	Yes	27	0.56		
	Total		48	1.00		
CMMS for actual maintenance time	Group 1	No	15	0.31	0.50	0.013
	Group 2	Yes	33	0.69		
	Total		48	1.00		
CMMS for storing maintenance reports	Group 1	No	36	0.75	0.50	0.001
	Group 2	Yes	12	0.25		
	Total		48	1.00		
CMMS for updating maintenance records	Group 1	No	29	0.60	0.50	0.193
	Group 2	Yes	19	0.40		
	Total		48	1.00		
CMMS for recording inventory on-board	Group 1	No	35	0.73	0.50	0.002
	Group 2	Yes	13	0.27		
	Total		48	1.00		
CMMS for analytical functions for decision making	Group 1	No	27	0.56	0.50	0.471
	Group 2	Yes	21	0.44		
	Total		48	1.00		

* $p<0.05$

In terms of the use of CMMS to underpin decision making for ship maintenance, the data indicate that the internal communication of the shipping companies has not capitalised on the use of integrated communication technology. The companies may have used computerised technology in planning and scheduling ship maintenance and recording the actual maintenance time. However, the use of this technology might be still in silo functions, which is evident in the majority non-user for storing maintenance history and recording inventory on-board, which hinder the shipping companies capitalising on CMMS for performing analytical analysis in decision making for ship maintenance. This information suggests that the internal communication in the shipping companies is yet to be integrated.

6.3.2 External relationship conditions

The research investigates the relationships between the shipping companies and the suppliers of materials and/or services in undertaking the ship maintenance activities. The investigation assesses the network configuration, relationships across maintenance management activities, strategic relationships and information sharing. The results provide insights from the structure of the ship maintenance supply chains.

6.3.2.1 Supply chain network configuration

The supply chain network configuration of ship maintenance was investigated by exploring the relationships between the shipping companies and their suppliers. The investigation provides information about the behaviour of the shipping companies in managing their supply chain network in order to ensure their ship maintenance can be undertaken in profitable manner. The research seeks the extent of the participants' agreements on the statements about their companies' relationships with the suppliers (items B1–B5). The data were assessed using a one-sample *t*-test to determine the differences between the sample mean and the test value (Rovai, Baker & Ponton 2013). Results of the test are provided in Table 6.10. The data were found to have a moderate compound reliability in which the Cronbach alpha coefficient was reported at 0.653. Although this coefficient is smaller than 0.700, the reliability test suggests that deletion in one of the variables causes weaker reliability. The inter-item correlation was reported with positive values in all correlated variables. Accordingly, it is still acceptable for conducting an analysis of the test of the supply chain configuration.

The one-sample *t*-test was undertaken with test values equalling three (undecided) and four (agree) to assess the significance of the relationships. As seen in Table 6.10, with the test value equalling four, the results show that the shipping companies have a significant direct link with their suppliers. In particular, substantial responses were perceived in relation to the linkage with spare parts suppliers, repair vendors and dry-dock providers, in which *p* values are less than 0.05 when the test value equalled four. These results indicate that stronger direct linkages appear in the relationships between the shipping companies with these suppliers.

Table 6.10: One-sample *t*-test supply chain configuration

No	**Item statement**	**Min**	**Max**	**μ**	**df**	**Sig. (2-tailed)***	
						Test value	
	Indicator ("The company always ….")					3	4
B1	has direct linkages with spare parts suppliers	1	5	4.38	46	.000	0.041
B2	has direct linkages with consumables suppliers	1	5	4.11	43	.000	0.222
B3	has direct linkages with repair vendors	1	5	4.38	46	.000	0.002
B4	has direct linkages with equipment manufacturers	1	5	3.82	45	.000	0.377
B5	has direct linkages with dry-dock providers	1	5	4.51	45	.000	0.002

Source: Appendix I

μ: mean; df: degree of freedom;*: $p<.05$

With regard to the different perceived strength about the relationships above, further investigation was undertaken to determine the strength by conducting a

Pearson product-moment correlation test. As seen in Table 6.11, there is a significant correlation between spare parts suppliers (B1) with consumables suppliers (B2), and repair vendors (B3) and equipment manufacturers (B4) with dry-dock providers (B5). These results show a similar pattern with the previous information that the shipping companies have a strong direct relationship with spare parts suppliers, repair vendors and dry-dock providers. In addition, the relationship with spare part suppliers correlates to the relationship with consumables suppliers and the relationship with repair vendors and dry-dock providers correlate to the relationship with equipment manufacturers. These results lead to the configuration of the supply chain network of ship maintenance in the following discussion.

Table 6.11: Direct linkages correlations between ship maintenance suppliers

No			B1	B2	B3	B4	B5
B1	Spare parts suppliers	Pearson Correlation	1				
		Sig. (2-tailed)					
		N	47				
B2	Consumables suppliers	Pearson Correlation	.797**	1			
		Sig. (2-tailed)	.000				
		N	44	44			
B3	Repair vendors	Pearson Correlation	-.003	.065	1		
		Sig. (2-tailed)	.983	.676			
		N	47	44	47		
B4	Equipment manufacturers	Pearson Correlation	.137	.285	.231	1	
		Sig. (2-tailed)	.365	.064	.123		
		N	46	43	46	46	
B5	Dry-dock providers	Pearson Correlation	.186	.195	.555**	.393**	1
		Sig. (2-tailed)	.215	.210	.000	.007	
		N	46	43	46	46	46

Source: Appendix I

** Correlation is significant at the 0.01 level (2-tailed).

In relation to the monitoring of the suppliers of the shipping companies' suppliers, 24 participants (50 per cent) agree and 14 participants (29.2 per cent) strongly agree that their companies monitor these suppliers (see Appendix I item D10). The results of the statistical tests above suggest that the shipping companies managed direct relationships with all Tier-1 suppliers and monitor the relationship of Tier-1 suppliers with their respective suppliers which may influence the supply of materials and/or services items into the shipping companies. Based on the strength of the relationship (see Table 6.11), the first-tier suppliers comprise of the spare parts suppliers, the consumables suppliers and the dry dock providers; and the repair vendors and the equipment manufacturers are recognised as second-tier suppliers whose relationships with the dry dock providers are monitored by the shipping companies. Accordingly, the supply chain network of ship maintenance management can be depicted as seen in Figure 6.2.

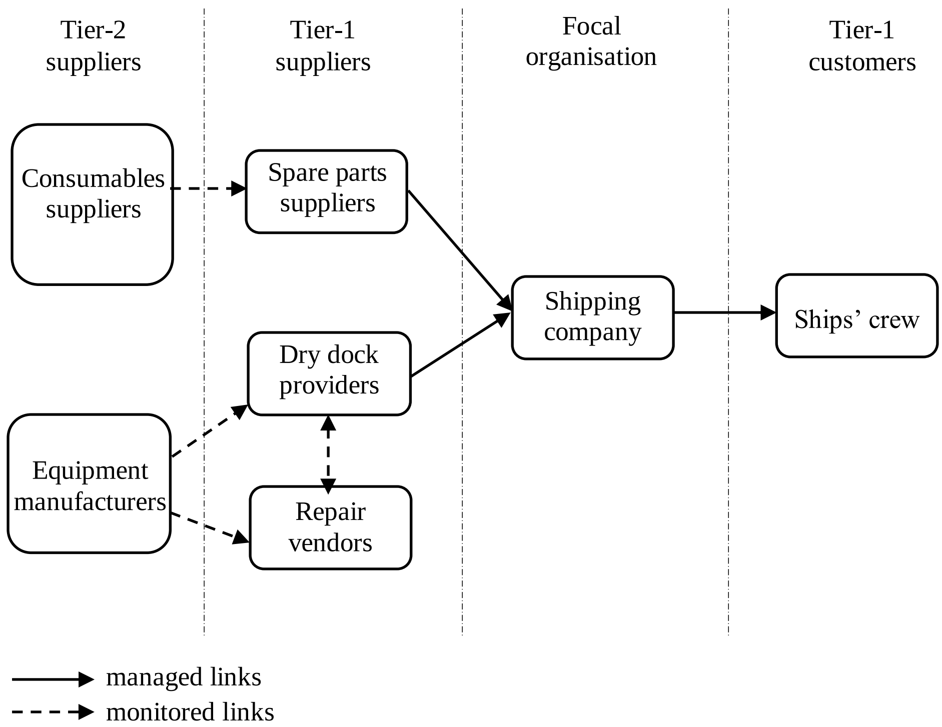


Figure 6.2: The ship maintenance supply chain network

6.3.2.2 Joint actions in maintenance management

The following discussion describes the investigation of the relationships between the shipping companies and the suppliers in planning, organising spare part inventory, evaluating maintenance performance, developing service level agreements and solving maintenance problems. The investigation provides insights from the involvement of the suppliers across these maintenance management activities, which was sought through items C9–C13 (see Appendix B1). The participants were asked to indicate the frequency of involvement of the suppliers. The frequency was measured using a 5-point Likert scale where “1” is equal to never and “5” is always. A Pearson product-moment was then carried out to assess the extent of the relationships. The results were reported with a very high internal reliability of the scale, with a Cronbach alpha coefficient of 0.983. The very high internal reliability implies that some confidence can be gained from this construct of the items (random error free) and the participants providing truthful answers (Cooper & Schindler 2011; Zikmund 2010).

The results of the Pearson product-moment test on items C9–C13 indicate a statistically significant relationship in a positive direction between the suppliers across all maintenance management activities (see Appendix I). For example, in maintenance planning the involvement of spare parts suppliers correlate with the involvement of consumables suppliers, repair vendors, equipment manufacturers and dry-dock providers. Similar results are evident in other maintenance management activities. These results suggest that the shipping companies might not develop a unique approach for different type of suppliers, by which the shipping companies involve all of their suppliers in all maintenance activities. However, the data suggest that the relationships tend to be arbitrary rather than strategic. The extent of the relationships with the suppliers was assessed by evaluating the means of the data (see Appendix I items C9–C13). In general, the means were reported in a range of 2.36 to 3.63 out of 5.00, which indicates that the suppliers' involvements were 'rare' to 'sometimes'.

6.3.2.3 Strategic relationships

In terms of strategic relationships, the occurrence of long-term contracts with the suppliers was investigated (items C1–C5). Table 6.12 shows the participants' responses to the formal relationship between their companies and the suppliers. The data show that the majority of shipping companies do not sign any contracts with the suppliers; or are in favour for a less than one-year contract (77.1–89.6 per cent). Only a small number of respondents (2.1–8.3 per cent) indicated that their companies have more than four-year contracts, which represent a long-term relationship with the suppliers. These data suggest that the relationships between shipping companies and the suppliers in the ship maintenance supply chain align with one of the characteristics of service-oriented supply chains, and extreme fragmentation of numerous suppliers with short-term relationship (Marosszeky 2005).

Qualitative data in relation to the above information were collected by asking the respondents to indicate the reasons their companies have a contract with the suppliers (items C7, C8). The preference for having a "No contract" relationship was reported due to the shipping companies' intention to sustain their flexibility for choosing the best price of materials and/or services items at the time they are required for undertaking ship maintenance. In addition, a less than one-year contract relationship was taken in order to ensure the availability of specific materials and/or services items at the best price and quality. This information suggests that the shipping companies are in favour of a short-term relationship in managing their ship maintenance supply chains, which indicates a traditional approach to the management of supply chains (Larsen, Thernoe & Andresen 2003).

Table 6.12: Questions of duration of contract

No	**Item statement**	**No contract (%)**	**Contract duration (%)**			
			<1 year	1–2 years	3–4 years	>4 years
C1	Spare parts suppliers	66.7	16.7	12.5	0	4.2
C2	Consumables suppliers	70.8	16.7	8.3	0	4.2
C3	Repair vendors	62.5	25.0	8.3	0	4.2
C4	Equipment manufacturers	72.9	16.7	4.2	0	2.1
C5	Dry-dock providers	64.6	12.5	10.4	4.2	8.3

Source: Appendix I

6.3.2.4 Information sharing between shipping companies and their suppliers

The quantity and quality of information sharing being investigated have been recognised as important aspects for the practice of the supply chain management approach (Li et al. 2006). In terms of the quantity of the information sharing, almost all of the participants (97.9 per cent, μ = 4.21 (agree), 0.459 standard deviation) indicated that their companies share proprietary information about ship maintenance requirements such as the condition of on-board ship's equipment, the maintenance schedule and maintenance historical data (item E2). In addition, more than 75 per cent of the participants indicated their companies utilise email

(97.9 per cent), telephone (93.8 per cent), facsimile (81.2 per cent) and site visits (79.2 per cent) as a communication media for sharing the information with the suppliers (item E1). Only 58.3 per cent of the participants indicated their companies have web-based communication media to accommodate the information sharing purposes. These results appear to corroborate the concerns about obtaining a sufficient level of internet connection in Indonesia (Elliot 2012; Hermana & Silfianti 2011), and highlight the concern about the lack of available information about Indonesian shipping companies' websites as discussed in Chapter Four. This lack might hinder the Indonesian shipping companies to capitalise on global supply chain management in sourcing supplies for ship maintenance.

The quality of the information sharing was investigated by asking the participants' perception in relation to the timeliness (E3), accuracy (E4), completeness (E5) and credibility of information exchanged (E6). The internal reliability of the scale for items E3–E6 was reported with the Cronbach alpha coefficient of 0.809. The items' mean, standard deviation and standard error are provided in Table 6.13. A one-sample *t*-test was conducted with test values equalling three (undecided) and four (agree), and the significance value 0.05. As seen in Table 6.13, with the test value equalling four, the results' significant values were reported as being greater than 0.05 on accuracy, completeness and reliability. The results indicate that the information exchanged between the shipping companies and the suppliers is accurate, complete and reliable. The undecided result in timely information exchanges (item E3) might be influenced by the condition where the shipping companies and suppliers update the information at any time to keep both parties informed about the changes. This can be seen in the data collected from item E7 (see Appendix I).

Table 6.13: One-sample *t*-test on the quality of information exchanges

No	**Statement**	**df**	**μ**	**σ**	**Std. Error μ**	**Sig. (2-tailed)***	
						Test value	
						3	4
E3	Timely information exchanges	46	3.28	0.949	0.138	0.052	0.000
E4	Information exchanged accurate	47	4.10	0.627	0.091	0.000	0.256
E5	Information exchanged complete	47	4.04	0.683	0.099	0.000	0.674
E6	Information exchanged reliable	47	4.13	0.606	0.087	0.000	0.159

Source: Appendix I

df: degree of freedom; μ: mean; σ: standard deviation

* p<0.05

With regard to the arbitrary relationships and the pattern of short-term relationships in the previous two sub-sections, it appears that the information sharing takes place at the operational level of ship maintenance. It is evident in the limited use of CMMS in decision making for maintenance as discussed in section 6.3.1.4. Regardless of the quantity and quality of the information exchanged, un-integrated data hinders the use of CMMS for analytical data analysis that is required in the decision making process. This result suggests the necessity of using web-based communication, which allows a real-time communication between parties (Karim & Candell 2009), however many of the companies do not do this.

6.3.3 Supply chain service processes

As discussed in Chapter Three, Ellram, Tate and Billington (2004) suggested particular processes for managing a service supply chain. The processes consist of capacity management, demand management, supplier relationship management and service delivery management of the shipping companies. Data from the survey were analysed based on these processes to reveal how shipping companies manage the supply chain for their ship maintenance.

6.3.3.1 Capacity management

Capacity management relating to shipping companies' investments to enable them to undertake ship maintenance tasks involving the availability of maintenance personnel and spare parts inventory. The companies' investments in maintenance personnel have been discussed earlier in relation to the number of maintenance personnel (see Table 6.3) and the dedicated personnel for managing supply chains of ship maintenance (see section 6.3.1.1). Accordingly, this section now discusses companies' investments in managing the spare parts inventory (items F4–F7). The inventories being investigated are the spare parts for the main engines, power generators and auxiliary equipment on board the ships. Spare parts for this equipment were classified based on their monetary value (Rupiah in Indonesia) and levels of criticality when the system failed (see Huiskonen 2001). Items F4-F7 of the questionnaire asked the participants to indicate the availability of the spare parts in their companies using a 5-point Likert scale, where "1" indicates never and "5" indicates always available.

Data resulting from items F4–F7 is presented in Table 6.14. In general, the highest percentage of participants indicates the availability of the spare parts as "often" resulted from low-value critical type (see F5). However, the large standard deviations from all items indicate the various policies of shipping companies in managing spare parts inventory for the ship maintenance. A Pearson product-moment correlation test was conducted to investigate the correlation of the availability of the spare parts. The test results suggest the availability of all spare parts is correlated with each other (see Appendix I). However, some coefficients suggest a significant correlation between the spare parts, which is illustrated by the dashed lines in Figure 6.3. All the correlations were reported in a positive direction with a high internal reliability (Cronbach alpha coefficient of 0.851) which indicates a random error free data.

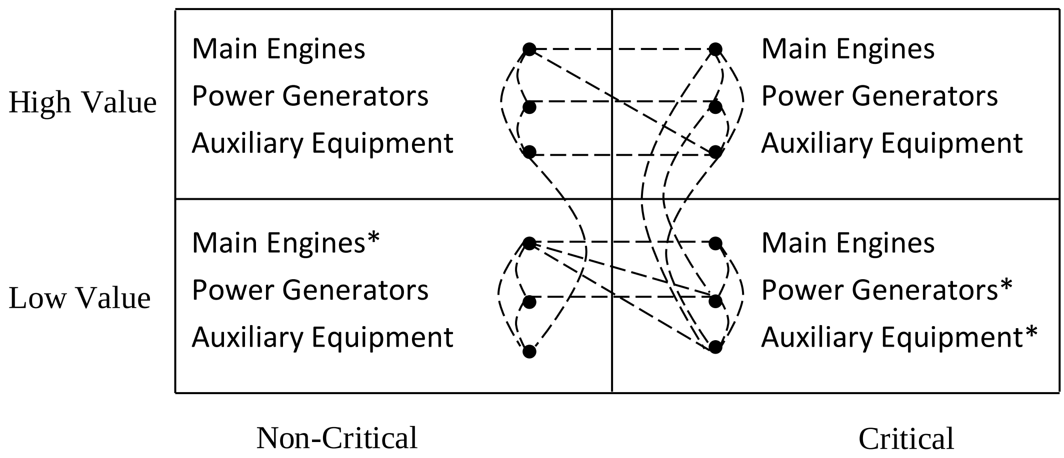
Table 6.14: Questions on the management of spare part availability

No	Types of spare parts	Main engines			Power generators			Auxiliaries		
		Often (%)	μ	σ	Often (%)	μ	σ	Often (%)	μ	σ
F4	Low-value non-critical	50.0	3.56	1.01	35.5	3.38	1.04	45.8	3.43	1.02
F5	Low-value critical	58.4	3.98	1.10	52.0	3.79	1.14	62.4	3.91	1.03
F6	High-value non-critical	23.0	2.67	1.11	12.5	2.56	1.01	20.9	2.68	1.05
F7	High-value critical	47.9	3.58	1.10	39.6	3.43	1.04	48.0	3.51	1.04

Source: Appendix I

μ: mean; σ: standard deviation

As seen in Figure 6.3, there are intense significant correlations among the availability of low-value non-critical main engines spare parts, low-value critical power generators and auxiliary spare parts. The frequent availability and the intense significant correlations of these spare parts, as indicated in Table 6.14, may indicate the shipping companies' policies in managing their ship maintenance capacity. The low-value critical spare parts of main engines comprise of materials such as lubricant, grease, gasket and cleaner. Maintenance tasks that require these spare parts are likely to be done by maintenance personnel on-board the ships, all of which relates to maintenance level one (see Chapter Three). Furthermore, the higher levels of maintenance for ships' main engines require special tools and skills that are usually available at equipment manufacturers or maintenance service providers' workshops. Whilst the frequent availability policy is for low-value critical spare parts of main engines, the policy is directed at low-value critical power generators and auxiliary spare parts. The data suggest that higher levels of maintenance tasks for power generators and auxiliaries equipment can be performed by maintenance personnel on-board the ships.



* Spare parts with most intense significant correlation coefficients

Source: AppendixI item F4-F7

Figure 6.3: The correlation of spare parts availability

Based on these discussions, it appears that shipping companies manage their ship maintenance capacity for undertaking level-one maintenance for the main engines and level-two, and possibly level-three maintenance for power generators and auxiliary equipment. In relation to the correlation of the availability of the spare parts, the data imply the shipping companies emphasise the availability of certain types of spare parts in managing their maintenance capacity, low-value non-critical main engines spare parts, low-value critical power generators and auxiliary spare parts. The data shows that, for ship maintenance in shipping companies, dollar-value governs the availability of main engines spare parts, whilst criticality governs the availability of spare parts for power generator and auxiliary equipment. The policy might be influenced by historical downtime data of main engines, power generators and auxiliary equipment, and by the capability of ships' crew to undertake necessary maintenance actions. The requirements on availability of main engines might be not as high as the requirements on power generator and auxiliary equipment due to its criticality to generate and supply electricity power for sustaining the operations of navigational equipment of the ships and the quality of the cargo. Further investigations on the drivers of the availability of these spare parts in relations to maintenance capability of ships' crew might be valuable in managing spare parts inventory for the supply chain of ship maintenance.

Shipping companies' policies in purchasing materials and/or services for ship maintenance also influence their capability to undertake maintenance tasks. Items C17–C19 sought the participants' views to the statements about the policies. The collected data were collapsed into three categories (disagree, undecided and agree) in order to allow better statistical analysis on items C17–C19. As seen in Table 6.15, 77.1 per cent of participants indicate that purchasing is not assigned to the chief engineer of each ship, and 68.7 per cent agreeing that purchasing is assigned to the procurement manager. In relation to item C19, 52.1 per cent of participants indicate procurement managers are not only purchasing high-dollar value materials and/or services but also all other requirements for undertaking maintenance. A one-sample *t*-test was conducted on the data from item C19 to obtain confidence about the result on this item. The result suggests that the mean of the survey of item C19 ($\mu = 2.91$) has no difference to the test value equalling two (disagree), where $t\ (46) = 1.679$, $p<0.05$, $\alpha = 0.05$. These data provide consistent indications that the purchasing of materials and/or services is centralised to the procurement managers.

Table 6.15: Strategies for purchasing MRO items

No	Item questions	Percentages				
		Disagree	Undecided	Agree	Not applicable	Total
C17	All purchases are by the Chief Engineer of each ship	77.1	2.1	20.8	0	100.0
C18	All purchases are by the Procurement Manager	25.0	4.2	68.7	2.1	100.0
C19	Only high value dollar purchases are by the Procurement Manager	52.1	10.4	35.4	2.1	100.0

Source: Appendix I

6.3.3.2 Demand fluctuations

From the suppliers' perspective, demand management focuses on managing the impact of demand variations (Ellram, Tate & Billington 2004). A reflective image of this process is how the shipping companies manage their demand for maintenance materials and/or services to lower the variations. To measure this variable, the participants were asked to indicate fluctuations in the dispatched demands from their companies (item B10). A one-sample *t*-test was conducted to compare the value of the means of collected data on item B10 against test value three (undecided) and four (agree).

As seen in Table 6.16, data on item B10 were reported with a high internal reliability (0.908) which provides confidence for undertaking further statistical analysis. The results from the one-sample *t*-test indicate that there are fluctuations of demands for materials and/or services from spare parts suppliers, repair vendors and dry-dock providers ($p>0.05$, test value = 4). Whilst fluctuations of demand are evident on the requirements above, the result indicates indifferent responses on demand for materials and/or services from consumable suppliers and equipment manufacturers. Demand for consumables comprises lubricant oil, grease, gasket and cleaner are relatively simple, and involving daily activities of ship maintenance (level one), whilst demand for spare parts, equipment repair and dry-dock facilities involves higher level, maintenance levels two and three. Demand on equipment from the manufacturer can be very rare since purchasing on equipment on board the ship usually take place when the ship was built or replacing with new equipment. In addition, to lower these demand variations shipping companies might need to involve maintenance personnel in the management processes (planning, organising, evaluating, specification setting and allocating budget) particularly for decision making process on spare parts suppliers, repair vendors and dry-docking providers (Lee & Scott 2009; Trent

2004). However, the current research encounters some constraints such as limited availability of time, fund and facilities for collecting further information on the applied strategy to overcome these fluctuations. A future research on this topic might be valuable for scholars and (shipping) industry in developing a holistic strategy for managing the supply chains of ship maintenance.

Table 6.16: Questions on demand management

No	Statement	*p*-sig. (2-tailed)*			μ	α
		df	Test Value			
			3	4		
B10	Fluctuate demands on materials and/or services from spare parts suppliers	47	0.000	0.241	3.85	0.908
	Fluctuate demands on materials and/or services from consumables suppliers	45	0.000	0.011	3.62	
	Fluctuate demands on materials and/or services from repair vendors	46	0.000	0.404	3.90	
	Fluctuate demands on materials and/or services from equipment manufacturers	46	0.000	0.019	3.66	
	Fluctuate demands on materials and/or services from dry dock providers	45	0.000	0.142	3.78	

Source: Appendix I

μ: mean; α: Cronbach alpha coefficient; *: $p<.05$

6.3.3.3 Supplier relationship management

The supplier relationship management involves a selection of suppliers of materials and/or services for the shipping companies. This study assesses the factors that underline the shipping companies' relationships with the suppliers. In the questionnaire, the participants were asked to indicate the importance of a set of suppliers' attributes to be selected by their companies, where "1" is equal to very unimportant and "5" is very important (item D1-D6). The suppliers' attributes include the lowest price, long-term, quality assurance, information sharing willingness, providing training for maintenance and availability of qualified technicians. The means of the data were reported in the range of

3.478–4.708 (see Appendix I). Then, a one-sample *t*-test with a value equalling four (important) was conducted on these means to assess any differences. The result is summarised in Table 6.17 that shows the attributes with *p*-values less than 0.05, which indicate the attributes as very important. These results suggest that the shipping companies put more emphasis on suppliers that are capable of providing quality assurance, qualified personnel, information sharing and training.

Table 6.17: One-sample *t*-test on suppliers' characteristics

Attributes	**Test Value = 4**		
	df	*p*-sig. (2-tailed)	μ
Quality assurance of spare parts suppliers*	47	0.000	4.708
Quality assurance of repair vendors*	47	0.000	4.708
Quality assurance of equipment manufacturers*	47	0.000	4.708
Quality assurance of dry dock providers*	46	0.000	4.596
Repair vendors with qualified personnel*	46	0.000	4.511
Equipment manufacturers with qualified personnel*	46	0.000	4.468
Quality assurance of consumables suppliers*	45	0.000	4.457
Dry dock providers with qualified personnel*	44	0.000	4.444
Information sharing repair vendors*	47	0.005	4.292
Information sharing equipment manufacturers*	47	0.007	4.292
Training providing spare parts suppliers*	47	0.029	3.708
Training providing consumables suppliers*	45	0.001	3.478

Source: Appendix I

df: degree of freedom; μ: mean; * : $p<0.05$

Based on the mean values in Table 6.17, it appears that shipping companies place highest priority on quality assurance of spare parts suppliers, consumables suppliers, repair vendors and dry-dock providers. Even though the shipping companies emphasise on the assurance of quality, they prioritise qualified personnel of repair vendors and equipment manufacturers higher than quality assurance that is provided by consumables suppliers. This prioritation might correlate to the abundant availability of consumables in open market that allows shipping companies to procure them from any suppliers in relatively short time. Following these priorities, the shipping companies consider information sharing capacity of repair vendors and equipment manufacturers as characteristic to be looked at. The data shows that the lowest priority for selecting maintenance suppliers is training from spare parts suppliers and consumables suppliers. The least attention on training for maintenance personnel could indicate a lack of internal communication to understand a requirement to maintain their employees' capability with up-dated maintenance skills.

An exploratory factor analysis was conducted on data collected from items D8–D14 of the questionnaire. This analysis was taken to investigate the factors that underline the shipping companies' relationships with the suppliers. The internal reliability test on these items was reported with a Cronbach alpha coefficient of 0.496. This low internal reliability coefficient indicates that the items D8–D14 may possess some different underlining factors, which led to the utilisation of an exploratory analysis. The Kaise-Meyer-Olkin (KMO) coefficient on items D8–D14 was 0.595, which indicates that the sample size was adequate for conducting the factor analysis test. The result is presented in Table 6.18, which shows three components (quality improvement, long-term relationship and mutual benefit) that underline the shipping companies' relationship with the suppliers.

The results suggest that the shipping companies understand the need for a long-term relationship for managing their ship maintenance. However, they only manage short-term relationships with the suppliers (see 6.3.2.3). Both results corroborate the notion which suggests the need for developing an internal readiness of companies before engaging in external relationships in order to benefit from the supply chain management (Kotzab et al. 2011).

Table 6.18: Rotated component matrix of supplier relationship management

No	Item questions	Component		
		1	2	3
D8	Based relationships on mutual needs	0.081	-0.042	0.575*
D9	Support the suppliers for a quality improvement	0.905*	-0.082	-0.068
D10	Monitor the suppliers' suppliers	0.488	0.485	0.536*
D11	Select a small number of high quality suppliers	-0.279	-0.027	0.811*
D12	Expect a long-term relationship	0.241	0.740*	-0.104
D13	Consider suppliers' activities as part of companies'	0.738*	0.414	-0.016
D14	Expect supplier to consider a long-term relationship	-0.066	0.881*	0.038

Source: Appendix I

*: components with similar background

6.3.3.4 Service delivery management

The service delivery management from the shipping companies' perspective involves detailed service level agreements where expectations on ship maintenance are articulated. It is not possible to measure whether a service level agreement is detailed enough in delivering shipping companies' expectations. However, the impact of a service level agreement can be measured by assessing the materials and/or services provided by the suppliers. Accordingly, the participants of the survey were asked to indicate the suppliers' performance in providing materials and/or services for the ship maintenance. Table 6.19 shows the results of one-sample *t*-test which was conducted to compare the means of the data from items B7–B9 of the questionnaire to test values three (undecided) and four (agree). The internal reliability coefficient of the construct was reported high with Cronbach alpha equal to 0.845 (see Table 6.19). This result provides confidence to proceed with the one-sample *t*-test to assess the value of means of each item.

Table 6.19: Questions on service delivery management

No	Statement	*p*-sig. (2-tailed)*					μ	α
		df	Test Value					
			3	∂ μ	4	∂ μ		
B7	Spare parts suppliers consistently meet company's requirements	47	0.000	0.688	0.027	-.313	3.69	0.845
	Consumables suppliers consistently meet company's requirements	45	0.000	0.739	0.038	-.261	3.74	
	Repair vendors consistently meet company's requirements	46	0.000	0.596	0.012	-.404	3.60	
	Equipment manufacturers consistently meet company's requirements	46	0.000	0.681	0.015	-.319	3.68	
	Dry dock providers consistently meet company's requirements	45	0.000	0.826	0.221	-.174	3.83	
B8	Extensive inspections on supplies from spare parts suppliers	47	0.000	1.438	0.001	0.438	4.44	
	Extensive inspections on supplies from consumables suppliers	45	0.000	1.283	0.026	0.283	4.28	
	Extensive inspections on supplies from repair vendors	45	0.000	1.370	0.002	0.370	4.37	
	Extensive inspections on supplies from equipment manufacturers	46	0.000	1.447	0.000	0.447	4.45	
	Extensive inspections on supplies from dry-dock providers	46	0.000	1.362	0.001	0.362	4.36	
B9	Much rework on supplies from spare parts suppliers	45	0.000	-.543	0.000	-1.543	2.46	
	Much rework on supplies from consumables suppliers	44	0.001	-.533	0.000	-1.533	2.47	
	Much rework on supplies from repair vendors	44	0.125	-.244	0.000	-1.244	2.76	
	Much rework on supplies from equipment manufacturers	46	0.211	-.191	0.000	-1.191	2.81	
	Much rework on supplies from dry-dock providers	43	0.038	-.341	0.000	-1.341	2.66	

Source: Appendix I

μ: mean; α: Cronbach alpha coefficient;*: $p<.05$

Based on the results in Table 6.19, in general the participants agree with the statements on items B7–B8. The results from item B7 indicate that most suppliers consistently satisfy ship companies' requirements on materials and/or services for ship maintenance. This is supported by the results on item B9 that indicates that the participants tend to disagree with the statements. However, the participants' agreement on item B8 indicates a negative perspective on the suppliers' performance; which indicates that extensive inspections have to be conducted by the shipping companies on the purchased materials and/or services in order to assure the supplies will satisfy their requirements. This result indicates that the service level agreement might not be sufficiently detailed and, consequently, cause shipping companies to conduct extensive inspections to attain satisfaction on the supplies.

6.4 Addressing subsidiary research question 1 (SRQ1)

The SRQ1 states "*How is the management of ship maintenance currently undertaken?".* As discussed in Chapter Two, the supply chain management approach being discussed consists of the management components, the network structures and the service processes. This research found that the management of ship maintenance in Indonesia lacks internal readiness, which hinders the implementation of the supply chain management approach (Kotzab et al. 2011). The default might be due to less internal integration behaviour at the corporate level across ship maintenance management activities, specifically regarding the involvement of the maintenance managers. The data suggest that the maintenance managers carry out their responsibilities in a silo mentality. Even though coordination with other managers is part of the maintenance managers' responsibilities (see item A4), the non-strategic involvement across maintenance management activities only places the maintenance managers as the executors of the given strategy of the companies' business.

The non-involvement of maintenance managers in the ship maintenance management at the corporate level hinders their visibility to align maintenance strategy to the shipping companies' business strategy. Without a clear vision towards companies' business strategy, it will be difficult for the maintenance managers to develop a strategy driven management for the ship maintenance which enables compliance towards the stringent rules and regulations in the shipping industry whilst maintaining a profit margin for the shipping companies. The result might appear in the on-going conflicts between departments in the shipping companies in improving the reliability of the ships and increasing the organisational efficiency.

The non-involvement of maintenance managers in the management of ship maintenance at the corporate level also introduces difficulty for shipping companies to develop a strategic approach via supply chain management of ship maintenance. Without detailed information from maintenance managers, it will be difficult to evaluate technical capabilities of their suppliers and hinders the vision towards the benefits of long-term relationships with the suppliers (Lee & Scott 2009; Spens & Bask 2002). The data analysis suggests that the shipping companies consider quality assurance as the most important characteristic of the suppliers, and they look for a long-term relationship. However, it appears that they experience difficulties in assessing suppliers' capabilities to provide the required quality assurance for the companies. As a result, there is evidence that some shipping companies are in favour of having a short-term relationship and involve the suppliers in all maintenance management activities without strategic segregating to the core capabilities of the suppliers. More evidence can be seen from the extensive inspections of supplies that are undertaken to assure the quality of the purchased materials and/or services items. The observed data of the supply chain management elements in discussing the maturity of the management of ship maintenance supply chains is summarised in Table 6.20.

Table 6.20: Ship maintenance supply chain management maturity summary

Supply chain management elements	Observed data
Internal readiness conditions	
Dedicated personnel for managing the ship maintenance supply chains	Available (assigned from middle-level management of the shipping companies)
Top management commitment and support	Available
Internal integration behaviour	Lack of maintenance manager involvement
Internal communication	Involve manual data interfaces
External relationships conditions	
Supply chain network configuration	Short-term transactional and fragmented relationships with numerous suppliers
Relationship across maintenance management activities	No differentiation approach for managing relationships with various types of suppliers
Strategic relationships	No or less than one year contract
Information sharing	Involve manual data interface caused by lack of web-based data exchanges
Supply chain service processes	
Capacity management	Spare part inventory categorisation
Demand management	Centralised purchasing system; Demands for maintenance materials and/or services fluctuate significantly
Supplier relationship management	No suppliers differentiation; Expect quality improvement, long-term relationship and mutual benefits; Supplier selection based on quality and mutual trust
Service delivery management	Fluctuate demand for materials and/or services caused by inadequacy in assessing service level agreement from the suppliers
Cash flow management	No cash flow management

As shown in Table 6.20, the shipping companies' supply chain management lacks internal readiness, which is attributed to the lack of internal integration behaviours. As emphasised by Mentzer et al. (2001), Lambert (2004) and Kotzab et al. (2011) that developing companies' own internal readiness is essential before entering a supply chain management approach, the shipping companies need to improve their internal readiness in order to assume such an approach. In particular, the shipping companies need to address the roles of the maintenance manager that enable their involvement at the corporate level of management, and the use of web-based communication in conducting information exchanges across the supply chains related to the ship maintenance management activities.

6.5 The performance of ship maintenance

After assessing the management of ship maintenance, this section discusses the performance of the ship maintenance. This involves investigating the achieved maintenance tasks and the compliance of ship maintenance with their planned maintenance.

6.5.1 Performance of ship maintenance tasks

The horizon of maintenance management has been discussed in Chapter Three. From the literature, it has been identified that maintenance tasks are classified into corrective (run-to-failure maintenance) and preventive (time-based maintenance) or preventive and predictive (condition-based maintenance) (Dhillon 2006; Khazraei & Deuse 2011). The targeted ratio for these maintenance tasks is not-more than 20 per cent for reactive maintenance and 80 per cent or more for the combined preventive and predictive maintenance (Frampton 2011; Wireman 2004). Frampton (2011) suggests the best practiced maintenance should achieve a ratio of 20:45:35 for the reactive, preventive and predictive respectively. This ratio was taken as the target measure to assess the performance of ship maintenance tasks in the shipping companies. The rule of thumb for this ratio is the lowest possible of the reactive maintenance and the highest possible of the preventive maintenance and predictive maintenance.

Item F3 of the questionnaire (see Appendix B1) asked the participants to complete the percentage ratio of reactive, preventive and predictive maintenance of the ship maintenance undertaken in their companies. Based on Table 6.21, the mean of the reactive maintenance is 27.05, preventive maintenance is 49.77 and predictive maintenance is 23.30. Further, to assess whether these means differ from the targeted ratio (20:45:35), a one-sample *t*-test was undertaken to compare each mean of the maintenance task of the sample against the corresponding targeted ratio.

Table 6.21: Percentage of reactive, preventive and predictive maintenance

No	Maintenance tasks	N	μ	Std. Error μ	σ	Test value	p-sig. (2-tailed)*
F3	Reactive maintenance	44	27.05	2.872	19.053	20	0.018
	Preventive maintenance	44	49.77	2.798	18.135	45	0.117
	Predictive maintenance	44	23.30	1.657	10.741	35	0.000

Source: Appendix I

μ: mean; σ: standard deviation; ∗: $p<.05$

The results in Table 6.21 show that the *p* values of reactive maintenance and predictive maintenance are less than 0.05, whilst the *p* value of preventive maintenance is greater than 0.05. The data suggest there is sufficient statistical evidence to accept that the means of the reactive and the predictive maintenance differ from the targeted values of 20 and 35, whilst the *p* value resulting from the mean of the preventive maintenance suggests there is no difference between the mean and the targeted value of 45. These results indicate that ship maintenance is characterised by excessive reactive maintenance and a less predictive one, whilst the preventive maintenance has been undertaken at the level that enables the ship maintenance to achieve best practice status. The results suggest that although shipping companies appear to perform at best-practice level for preventive maintenance, the overall performance of ship maintenance needs to be improved to lower the reactive maintenance.

6.5.2 Planned ship maintenance

Another measure of ship maintenance performance is the compliance with the planned ship maintenance budget (excluding docking maintenance) (G7), ship-docking budget (G8) and ship docking duration (G9). The three measures have a high level of internal reliability with a reported Cronbach alpha coefficient of 0.777. The high internal reliability provides confidence that items G7–G9 measure a single construct of ship maintenance performance. A one-sample *t*-test was conducted to determine the value of means of the data collected from items G7–G9. The test was undertaken with test values of two and three to estimate the significant means of the data collected from each item which indicates the percentage range of compliance with the planned maintenance. The test value two represents the value of 50–69 per cent, whilst the test value three represents the value of 70–89 per cent.

As seen in Table 6.22, the *p* value of each mean are smaller than 0.05 at test value two, and greater than 0.05 at test value three. The results from the above test suggest there are no differences between the means of the sample with the test value three. These results indicate that 70–89 per cent of the planned ship maintenance budget, scheduled dry dock duration and dry dock budget were achieved. This result suggests that maintenance performance in the shipping companies is still below the best practice maintenance which requires the compliance towards planned maintenance by 95 per cent (Wireman 2004, p. 202).

Table 6.22: Compliance to planned ship maintenance

No	Statement	df	μ	Test value	*p*-sig. (2-tailed)*
G7	Compliance to maintenance budget (excluding dry dock)	41	2.90	2 (50–69%)	0.000
				3 (70–89%)	0.456
G8	Compliance to scheduled dry dock duration	41	2.93	2 (50–69%)	0.000
				3 (70–89%)	0.618
G9	Compliance to dry dock maintenance budget	41	2.77	2 (50–69%)	0.000
				3 (70–89%)	0.105

Source: Appendix I

df: degree of freedom; μ: mean; * : $p<0.05$

6.6 Shipping performance

As discussed in Chapter Two (see section 4.3.1), shipping performance, which is influenced by the performance of ship maintenance, includes the availability of shipping services, the availability of ships in accordance with shipping companies' plans and reliability of ships to undergo its planned voyages. Thus, this section investigates the effects of materials and/or services items' unavailability on the shipping services (G1–G6), compliance with the planned ship's availability (G10), ship's reliability to undergo the planned voyages (G11) and the other performance aspects such as improved customer satisfaction, lowered ship's total operating expenses and increased companies' profits, which are collected from items G12–G16.

The participants were asked to indicate the effects of materials and/or services unavailability on the shipping services of their companies by answering items G1–G6 of the questionnaire. The data collected were then analysed using one-sample *t*-test to compare the means of the sample against the test values in order to enable this research to draw some inferential results. Before undertaking the one-sample *t*-test, the internal reliability of the questions used in items G1–G6 were assessed in order to ensure that the items have the same underlining construct. The compound Cronbach alpha coefficient of the items was 0.819, which indicated that the questions possessed a high internal reliability for conducting a further statistical test.

A one-sample *t*-test was conducted to infer the mean of each variable measured in items G1–G6. The results of the one-sample *t*-test on items G1–G6 are summarised in Table 6.23. The means of the data collected were compared to test values of two (little effect), three (moderate effect) and four (significant effect). The test values were selected from the closest value to the means of the sample. The results show that almost all measures were reported as significant at test values three (moderate effect) except for item G5 which was significant at test value four (significant effect). The results suggest that all shipping companies experienced materials and/or services unavailability which affected their shipping services to various levels of severity.

Table 6.23: Effects of materials and/or services unavailability questions

No	Statement	df	μ	Test value	*p*-sig. (2-tailed)*
G1	Spare parts unavailability impact on shipping services	46	3.30	2 (little effect)	0.000
				3 (moderate effect)	0.065
				4 (significant effect)	-
G2	Consumables unavailability impact on shipping services	46	2.79	2 (little effect)	0.000
				3 (moderate effect)	0.229
				4 (significant effect)	-
G3	Maintenance experts unavailability impact on shipping services	46	3.06	2 (little effect)	0.000
				3 (moderate effect)	0.718
				4 (significant effect)	-
G4	Suppliers' technicians unavailability impact on shipping services	46	2.87	2 (little effect)	0.000
				3 (moderate effect)	0.479
				4 (significant effect)	-
G5	Dock space unavailability impact on shipping services	45	3.59	2 (little effect)	0.000
				3 (moderate effect)	0.012
				4 (significant effect)	0.71
G6	Ship unavailability for docking impact on shipping services	44	3.09	2 (little effect)	0.000
				3 (moderate effect)	0.628
				4 (significant effect)	-

Source: Appendix I

df: degree of freedom; μ: mean; * : $p<0.05$

Based on the results in Table 6.23, the unavailability of spare parts (G1), consumable items (G2), maintenance expert (G3) and suppliers' technician (G4) and the ship due to operational requirement (G5) cause a moderate-level impact to the availability of shipping services. The moderate-level impact implies that the shipping services are still available but in a lower capacity, such as lower speed and loading spaces. In contrast, the unavailability of a docking space (G5) may create a significant impact on the shipping services. The unavailability of docking space at the time a ship has to undergo the compulsory survey may cause detention due to an invalid sailing certificate. This suggests that shipping companies need to provide more attention to ensure the availability of dry-dock facilities.

As discussed earlier (see section 6.3.2.2), shipping companies tend to have a similar approach to all their suppliers. The data also showed that the relationships with the suppliers could be attributed as being arbitrary or based on a transactional approach. With regard to the impact of the unavailability of dock space on the shipping services, the management of ship maintenance supply chains needs to develop a strategic relationship with the dry-dock providers. This approach may enable the shipping companies to deal with this challenge to improve shipping performance in term of service availability.

To assess the availability and reliability of the ship, the participants were asked to indicate the percentages of ships' compliances with the companies' plan for one year (items G10, G11). As shown in Table 6.24, for the planned ship's availability, 73 per cent of the participants indicate the ships of their companies achieved more than 70 per cent of the planned availability. For the planned ship's reliability, the data show that 81.2 per cent of the participants indicate their ships perform more than 70 per cent of the scheduled voyages. Based on the available key performance indicator in ship operations, the target availability and reliability of a ship is set to 97 per cent (Sleire et al. 2008, p. 75). The current performance of the shipping companies is still below the target of the key performance indicators.

Table 6.24: Planned ship availability and reliability

No	Statement	Number	Percentage (%)
G10	**Compliance to planned ship's availability**		
	Less than 50%	0	0
	50–69%	9	18.8
	70–89%	14	29.2
	More than 90%	21	43.8
	Not applicable	4	8.3
	Total	**48**	**100.0**
G11	**Compliance to scheduled ship's voyages**		
	Less than 50%	1	2.1
	50–69%	6	12.5
	70–89%	16	33.3
	More than 90%	23	47.9
	Not applicable	2	4.2
	Total	**48**	**100.0**

Source: Appendix I

Percentages may not add to 100 due to rounding

In addition to the performance measurement, participants' perceptions of the contribution of ship maintenance to their companies were included. Table 6.25 shows that more than 90 per cent of the participants agree that ship maintenance could improve ships' availability and reliability, and customer satisfaction on shipping services. Almost 90 per cent agree that ship maintenance can improve company's profits. These profits reflect the technical benefits that can be attained from ship maintenance. Only 81.3 per cent of the participants see a reduction in total operating expenses as a result of ship maintenance. The results suggest that the technical benefits of ship maintenance tend to be more understood than the economic benefits. However, these results suggest a positive perception on undertaking ship maintenance. This perception can be valuable when developing a strategic approach to ship maintenance management.

Table 6.25: Participants' perceptions of ship maintenance

No	Statement	Agree (%)	μ	σ
G12	Ship maintenance improves availability of ships	93.8	4.33	0.663
G13	Ship maintenance improves reliability of ships	97.9	4.69	0.512
G14	Ship maintenance improves customer satisfaction on shipping services	95.8	4.56	0.580
G15	Ship maintenance reduces total operational expenses	81.3	4.17	0.883
G16	Ship maintenance increases company's profits	89.6	4.38	0.644

Source: Appendix I

μ: mean; σ: standard deviation

6.7 Addressing subsidiary research question 2 (SRQ2)

The SRQ2 states "*What benefits can shipping companies attain by undertaking a supply chain management approach to ship maintenance?*". Throughout the previous section, some deficiencies of the supply chains and the performance of ship maintenance were identified that include:

- the short-term transactional and fragmented relationships,
- inadequacy to develop approaches for different types of suppliers,
- fluctuating demand and supply of materials and/or service for undertaking ship maintenance actions,
- excessive inspections on maintenance materials and/or services,
- inadequacy to scrutinise service level agreements offered by the suppliers,
- difficulty in arranging cash flow to finance the purchased materials and/or services,
- excessive reactive maintenance actions, and
- low-level compliance to the maintenance plan.

The deficiencies above have been identified through the lens of a supply chain management approach. As discussed, the shipping companies need to improve their internal readiness by providing more access for the maintenance manager to get involved in the ship maintenance management activities at the corporate strategy level. By using this process, the maintenance manager could provide detailed information that enables the shipping companies to scrutinise the service level agreements offered by the suppliers and assessing the suppliers' capacity and capability. This enhanced capability of shipping companies might instigate the development of a long-term relationship with the suppliers.

The long-term relationships within supply chain management should provide both the shipping companies and the suppliers with the capability and capacity to evaluate their performance in order to improve the quality of supply and service level agreements. From the shipping companies' side, the long-term relationship might allow a lowered fluctuation of demand on materials and/or services, reduced inspections on supplies, and a scheduled cash flow to finance the purchased ship maintenance requirements. From the suppliers' side, this arrangement might allow them to understand their customers, which lead to improved quality of materials and/or services as required by the shipping companies.

The data analysis of the results from the survey showed excessive reactive maintenance has been performed by the shipping companies. Whilst best practice suggests reactive maintenance be at a maximum of 20 per cent of the total maintenance tasks, the ship maintenance was reported with 27.05 per cent of total maintenance. Reactive maintenance could be caused by postponed preventive maintenance actions that are rooted in the unavailability of materials and/or services for undertaking the scheduled maintenance. Pearson product-moment correlation tests were conducted to assess the relationship between demand fluctuations (item B10), supply fluctuations (item B7) and unavailability incidents (items G1–G5) indicating significant correlation coefficients in a positive direction between the above tested items (see Appendix I). The results indicate that the demand fluctuations correlate to the unavailability incidents. The same results occur from the test between the supply fluctuation and the unavailability incidents. The fluctuation of supply correlates to the unavailability incidents. Accordingly, managing these fluctuations might help shipping companies to control these unavailability incidents to enhance the availability of shipping services.

The results of the data analysis suggest that if shipping companies provide better demand management, the unavailability incidents may be controllable, thus lowering the amount of postponed scheduled maintenance tasks. Subsequently, this could lead to a lower reactive maintenance, which leads towards lower maintenance costs (Smith & Hinchcliffe 2005). By undertaking a supply chain management approach to ship maintenance, shipping companies and the suppliers can obtain benefits resulting from strategy driven maintenance management. The benefits encompass improved performance of ship maintenance and supply chain performances.

6.8 The ship maintenance – addressing the primary research question (PRQ)

This section addresses the primary research question (PRQ) which states "*Is a supply chain management approach applicable to improve ship maintenance performance?*". To address the PRQ, the insights from the ship maintenance management is discussed initially through the first subsidiary research question (SRQ1). Then, the research analysed the possible benefits by undertaking supply chain management as a strategic approach to ship maintenance as stated in the second subsidiary research question (SRQ2). The discussions on SRQ1 and SRQ2 then led this research to address the PRQ.

Based on the discussions on ship maintenance management in addressing the SRQ1 (see sections 6.3 and 6.4) and the possible benefits in addressing the SRQ2 (see section 6.7), it appears that supply chain management is applicable as a strategic approach to improving the performance of ship maintenance. The service processes suggested by Ellram, Tate and Bilington (2004) have been used to substitute the business processes in the supply chain management approach suggested by Lambert, Cooper and Pagh (1998). The ship maintenance management was assessed based on this framework, by which the supply chain management approach includes the internal readiness of companies, the external relationships conditions and the service processes. Of these three elements, the internal readiness of companies determines the success in adopting the supply chain management approach (Kotzab et al. 2011).

As explained throughout this chapter, it was evident that using the supply chain management framework enables this research to reveal the lack of strategic approach in the ship maintenance management. Although most of the participants indicated the commitment and support from top-level management of the shipping companies, this lack is still apparent. Evidence of this is to be found in the silo mentality in managing the ship maintenance, limited use of web-based communication, tendency towards a short-term transactional relationship, dealing with all suppliers with a similar approach, fluctuating demand and incidents of unavailability of materials and/or services for undertaking ship maintenance. Most importantly, the silo mentality prevents maintenance managers from being involved in the ship maintenance management at the corporate level, which can be attributed to the lack of internal readiness of the shipping companies to adopting a supply chain management approach.

By adopting supply chain management as a strategic approach, shipping companies could improve the performance of ship maintenance. Several benefits can be capitalised on through this adoption, such as increased availability and reliability of ships. These benefits can be linked to the involvement of maintenance managers in management activities at the corporate level, which enables the shipping companies to both develop and scrutinise a detailed service level agreement. These capabilities should enhance shipping companies' capacity in managing their ship maintenance resources, including planning the cash flow for financing the purchased materials and/or services. Furthermore, adopting this approach could lead to shipping companies achieving successful ship maintenance, which would then enable them to attain lower ship-operating expenses and increase the availability and reliability of their ships.

With regard to the maintenance flow model depicted in Figure 3.1 and the maintenance chain model in Figure 3.5, it appears that discussion on maintenance management in the literature has overlooked the importance of seamless flow of materials, services, information and finances across the chain. Within these models, maintenance has been recognised as consisting of maintenance level one to level three. Although this approach accommodates the management to deal with the complexity of maintenance, it fails to address the lack of strategic approach in order to develop a holistic maintenance management, which is essential for achieving a successful maintenance (Coetzee 1999; Parkinson 1991). It appears that directing the ship maintenance towards a supply chain management approach might overcome this deficiency. Accordingly, this research proposes a model to accommodate the supply chain management approach to (ship) maintenance as depicted in Figure 6.4.

Figure 6.4 is the result of synthesising the maintenance management and the service supply chain management approaches from the literature. The figure depicts three elements of supply chain management: the supply chain network structure, the supply chain service processes and the supply chain management components. The maintenance level one, level two and level three in the figure indicate contemporary maintenance management as discussed in the literature (Blanchard 1998; MacDonnell & Clegg 2007; Trappey, Hsiao & Lin 2011). These maintenance levels combined together constitute the maintenance supply chain management components. These components underpin the internal readiness of an organisation to be able to develop its supply chain structure and service processes. These elements represent the development of maintenance management toward level four, which is the maintenance supply chain management. This model is the proposed model of a supply chain management approach for (ship) maintenance, which accommodates the gap in the literature.

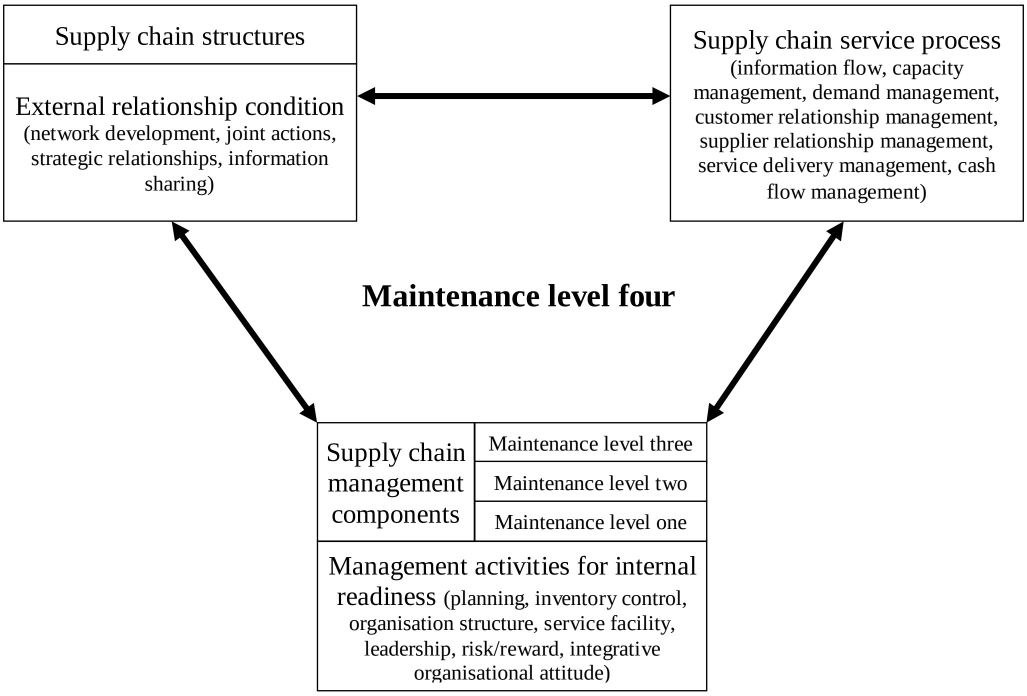


Figure 6.4: A supply chain management approach to maintenance

Maintenance level one, two and three in Figure 6.4 depict a contemporary maintenance management. Although maintenance level one, two and three were recognised as a correlated process, this research found that the involvements of maintenance managers in the management activities do not clearly correlate to the other managers in the shipping companies. There were evident that a silo mentality exists in the ship maintenance management. By introducing a supply chain management approach to ship maintenance, maintenance level one, two and three will not be a sole business of maintenance managers any longer. By managing these activities as an integral process that involve necessary entities, shipping companies might develop their internal readiness for implementing supply chain management (see internal integration in Figure 6.4). Whilst developing the prerequisite internal readiness, shipping companies might develop their capability to capitalise on this approach in order to provide shipping services that satisfy customers' requirements (the Maintenance level-four).

As mentioned earlier, the model in Figure 6.4 was used in this research and it enabled the identification of the lack of strategic approach within ship maintenance management. As emphasised by Mentzer et al. (2001), Lambert (2004) and Kotzab et al. (2011) regarding the importance of companies' own internal readiness, implementation of this model into ship maintenance management will require the shipping companies to address their internal integration behaviour in order to be able to attain benefits from the supply chain management approach.

6.9 Summary

A postal survey was adopted to collect data from the shipping companies in Indonesia. Suggestions from the literature review on how to conduct a postal survey were followed, which proved to be prudent as it led to success in obtaining the required response rate. In addition, this research has experienced some benefits of using a local professional agency to assist the distribution of the survey in Indonesia, which included a lowered total survey cost, reduced posting days and increased flexibility in managing the postal surveys.

This chapter has addressed the SRQ1 and SRQ2, which provided foundations in addressing the PRQ. Discussion in addressing the SRQ1 indicated that the ship maintenance management in the shipping companies in Indonesia was characterised by a silo mentality, budget driven management and low utilisation of a computerised maintenance management system and web-based communication. These characteristics appear to hinder the shipping companies in attaining benefits from the maintenance supply chains. If the supply chain management approach was implemented (SRQ2), the shipping companies might be able to develop a strategic relationship with entities in the ship maintenance supply chains, and allow the maintenance managers to align their strategy towards the companies' business strategy.

Based on the model in Figure 6.4, ship maintenance can be strategically approached via supply chain management. The research has found that the elements of the service supply chain management exist in the ship maintenance. However, to enable the shipping companies to capitalise on the approach, they need to address their internal readiness for such an approach by involving the maintenance managers at the corporate level of management of ship maintenance. If the supply chain management approach is holistically applied, shipping companies might be able to gain benefits from the increased availability and reliability of their ships without increasing the ship operations expenses, or even reducing the expenses. To conclude, this research found that the supply chain management approach is applicable to ship maintenance in improving ship maintenance performance.

Chapter Seven

CONCLUSION

7.1 Introduction

This chapter highlights the research objective, values, limitations and potential areas for future research. Starting with a summary of how the research objective was accomplished, a discussion of the research values then follows to identify the contributions of this research to the body of knowledge and to industry practice. The limitations of this research are then addressed to ensure that the research objective was accomplished within its set parameters and to identify selected potential issues and recommendations for future research.

7.2 Summary of the findings

The main objective of this research was to investigate the implementation of supply chain management as a strategic approach to ship maintenance. To address the research objective, a primary research question (PRQ) and two subsidiary research questions (SRQs) have been developed. These research questions were addressed in Chapter Six; thus, the discussion in this section is only to provide a summary of the findings. This research was undertaken as an empirical study based on shipping companies in Indonesia. A quantitative non-experimental research method was followed to enable a systematic investigation to gain insights from the shipping companies without making any attempt to exert control over their normal activities (Rovai, Baker & Ponton 2013). A questionnaire-based postal survey was sent to the shipping companies as a data collection tool. Data analysis of the results of this survey was explained in Chapter Six to address the research objective.

This research has argued that the strategic value of ship maintenance in underpinning the success of ship operations has been overlooked, and ship maintenance tends to be considered as a source of companies' ad-hoc expenses. Ship maintenance appears to be managed at the operational level of the shipping companies mostly in relation to ensuring compliances against the stringent rules and regulations such as those in the International Safety Management Code that include, for example, gas emitting pollutant limitations on ship emissions. Several available maintenance concepts from literature have been reviewed in this thesis, such as reliability centred maintenance, total productive maintenance and computerised maintenance management system (Amari, McLaughlin & Pham 2006; Dhillon 2006; Fore & Msipha 2010; Peimbert-García et al. 2012). However, these maintenance concepts are not sufficient for shipping as they were developed for assets of the manufacturing industry, aviation industry, power generating industry and nuclear plants. In addition, these maintenance concepts are criticised as having fragmented technical solutions (Al-Turki 2011; Coetzee 1999; Tsang 2002) and are resources demanding (Salonen & Bengtsson 2011; Zhang, Li & Huo 2006). Strategic management for ship maintenance is required to reveal the true value of ship maintenance in providing profits.

To achieve the research objective, this thesis explained and replicated the input-output model of maintenance systems (Al-Turki 2011) in Chapters One and Three. The model shows that undertaking maintenance is also influenced by external entities that supply inputs of labour, materials, spare parts, tools, information, budget and external services. A strategic management approach for maintenance needs to consider the influence of these externalities in achieving successful maintenance. The supply chain management approach appears to be relevant for managing these inputs, as well as being relevant for introducing strategic management for ship maintenance and thus became the focus of this thesis. This required adopting a service-oriented supply chain framework that consists of the supply chain management components, the supply chain network configuration, and the supply chain service processes.

Three research questions were developed consisting of one primary and two subsidiary research questions. Subsidiary research question one (SRQ1) asked '*How is the management of ship maintenance currently undertaken?*'. SRQ1 was developed to assess the current management of ship maintenance through the lens of the above framework. The management element of the framework assessed the internal readiness of shipping companies to assume supply chain management as a strategic approach for managing their ship maintenance. It became evident that the Indonesian shipping companies implement a budget driven maintenance management and they do not adequately possess the necessary internal readiness such as the internal integration behaviour and web-based communication. The research also found that the shipping companies do not involve their maintenance managers across ship maintenance management processes at the corporate level (planning, organising, maintenance performance evaluation, specifications setting and budgeting). The non-involvement of the maintenance managers appears to preclude the shipping companies' capability to manage their ship maintenance supply chains strategically as highlighted in the following paragraphs.

The supply chain network configuration relates to the external relationship conditions of the shipping companies with their suppliers. Similar to maintenance supply chains in other industries, the shipping companies are the end customer of the chain since there are no ship maintenance outputs to be delivered to the customers of the shipping companies — the shippers. However, the shippers might receive the output residue of the strategic management of ship maintenance supply chain in terms of the availability and reliability of shipping services at a competitive cost. The results of the data analysis suggested that the supply chain network configuration of ship maintenance is characterised by many suppliers with transactional and fragmented relationships with fluctuating demand for maintenance materials and/or services lodged by the shipping companies. The relationships were evident at the operational level of ship maintenance but lack web-based communication. These conditions indicate that the supply chain network of ship maintenance is at the early stage of developing collaborative relationships, of which further development is essential to benefit from the supply chain management. In addition, the fluctuating demand from shipping companies and the tendency toward short-term relationships appear to correlate with the non-involvement of the maintenance managers in the ship maintenance at the corporate level of management of shipping companies.

The supply chain service processes include capacity management, demand management, supplier relationship management, customer relationship management, service delivery management and cash flow management (Ellram, Tate & Billington 2004). The non-involvement of maintenance managers across ship maintenance management at the corporate level might hinder shipping companies in clearly assessing their maintenance capacity as well as the capacity of their suppliers. The overall findings appear to indicate a lack of strategic approach to ship maintenance management.

In relation to SRQ1, it was evident that the management of ship maintenance was undertaken in a silo mentality, which is attributed to the non-involvement of the maintenance managers, a lack of web-based communication and transactional relationship with the suppliers. The limited use of web-based communication indicates a less efficient flow of information due to manual data being used as the interface to accommodate information exchanges.

Subsidiary research question two (SRQ2) asked '*What benefits can shipping companies attain by undertaking a supply chain management approach to ship maintenance?*'. By addressing SRQ2, this thesis found that shipping companies could capitalise on leveraging competitive advantage by implementing supply chain management as a strategic approach to ship maintenance. These benefits include lower fluctuations in ship maintenance demand, increased reliability and availability, and the quality of inputs for undertaking ship maintenance. Most importantly, applying supply chain management can overcome the silo mentality approach to develop an integrated approach to maintenance management. These benefits may lead towards maintenance providing greater profits to shipping companies through increased ship availability and reliability to carry out the planned voyages in a cost-efficient manner.

Indonesian shipping companies experience intense fluctuations in demand of materials and/or services for ship maintenance. These fluctuations appear to postpone the execution of maintenance tasks, which decreases the reliability of the ship and may incur excessive reactive maintenance. These fluctuations could also jeopardise the shipping companies, the shipping services they provide and the suppliers of maintenance requirements. In addition, the thesis found that the shipping companies conduct extensive inspections on the supplies they receive. This could be minimised if a supply chain management approach is fully implemented for ship maintenance. Finally, with the implementation of a strategic approach via supply chain management in place, shipping companies can continually improve the quality from the suppliers, which leads toward cost effective and efficient ship maintenance.

Discussions in addressing the SRQ1 and SRQ2 enable this thesis to address the PRQ which asked '*Is a supply chain management approach applicable to improve ship maintenance performance?*'. By addressing the SRQ1 and the SRQ2, it became evident that a supply chain management approach (for service-oriented supply chains) is applicable to ship maintenance to improve ship maintenance performance. By using a framework of the supply chain management approach, the research was able to identify the lack of strategic approach in the management of ship maintenance. The findings suggest the need for the shipping companies to address their internal readiness and the utilisation of web-based communication.

As ship maintenance could significantly affect the availability of ships to undertake their scheduled voyages reliably, it is necessary for the shipping companies to develop a strategic approach that could provide cost-effective ship maintenance. However, in order to adopt supply chain management as a strategic approach, shipping companies need to address their lack of internal readiness by involving their maintenance managers and enabling web-based communication, and to instigate external relationship development with the suppliers toward a long-term relationship. The roles of the maintenance managers need to be adjusted to enable them to get involved in the management of ship maintenance at the corporate level.

In addition, this thesis found that the models of maintenance management and maintenance chain (see Chapter Three) overlooked the importance of the seamless flow of services, information and finances across the supply chains. By incorporating the supply chain management framework (for service-oriented supply chains), this thesis proposes a model of supply chain management approach to (ship) maintenance as depicted in Figure 6.4. This thesis has addressed the research objective as stated in SRQ1, SRQ2 and PRQ based on this model.

This research also found empirical benefits resulting from the data collection processes. In terms of geographical coverage, it was evident that the postal survey is suitable for collecting primary data from a research population that is distributed across an area such as Indonesia. Postal surveys can be distributed in a relatively short period, and reach all participants within the same period. This method underpins the research process to collect data within a similar timeframe to prevent bias due to changes in the business environment. The expected cost and complexity due to international mailing system were anticipated by using a local agent, which was useful when undertaking the survey of this research. The employment of the local agent during this research reduced the total cost by 30 per cent and increased the speed for distributing and collecting the survey by 65–75 per cent. It was evident that this method did not only lower the total cost of posting the surveys but also improved flexibility in terms of time in conducting international postal surveys.

Providing several modes of contact to enable the participants to reach the researcher appears to have influenced the achieved response rate of this research. The questionnaire was provided with a stamped return envelope and researcher's email address. The result showed that whilst 60 per cent of the responses were returned using the stamped return envelope, the remaining 40 per cent were returned via email. In all, the combination of the employment of a local professional agent and providing the flexibility to contact the researcher might be necessary to underpin research projects using mail surveys to obtain appropriate response rates.

7.3 Contributions of the research

This research has contributed to the literature and the practical implementation of maintenance management and supply chain management. Firstly, the contribution of this research is discussed in terms of the review of literature in maintenance management and supply chain management. In undertaking a review of the literature, this research identified there are limited studies both on ship maintenance management and on the management of service-oriented supply chains. Identification of these gaps is necessary for undertaking this research and for recommending further research directions. Of interest, the extant literature often appears to deal with maintenance management, in particular in ship maintenance, and supply chain management in separation. Accordingly, this thesis has contributed by synthesising these into one study to extend the applicability of one to the other.

Secondly, this research explores the implementation of supply chain management to enable the development of a strategic approach to the management of ship maintenance. Within the research, it was evident that limited studies in ship maintenance management were available. Most of these studies were conducted with a focus on how to carry out maintenance actions effectively and efficiently. These past studies seem to overlook the influence of the suppliers of the maintenance parts and services. In this context, the literature on supply chain management of service-oriented supply chains, although appearing to be emergent, is applicable for addressing ship maintenance supply chains strategically. Thus, the current research has broadened the perspective on ship maintenance management to suggest the development of a strategic approach to the management of the supply chains of ship maintenance. This research also adds empirical results to the literature of ship maintenance management.

In terms of the supply chain management focus, this research has added empirical research results with regard to the supply chain management of service-oriented supply chains. The research on the supply chain management of service-oriented supply chains has been noted as lagging behind the manufacturing-oriented supply chains (Ellram, Tate & Billington 2004; Giannakis 2011). Thus, this research has contributed empirical results to the studies of the supply chain management of service-oriented supply chains. Furthermore, this research revealed the need to incorporate the value chain perspective to enable necessary investigation into the transfer of the value of undertaking ship maintenance management to the shippers as the customers of shipping companies.

Thirdly, this research proposes a model of supply chain management approach to maintenance (see Figure 6.4). This model synthesises the maintenance management and supply chain management framework from the literature into one model that enables decision making on maintenance to include the importance of the seamless flow of materials, services, information and finances.

Fourthly, this research contributes to the managerial practice of ship maintenance management. The use of the supply chain management as a strategic approach in this research has revealed the silo mentality approach in currently undertaken ship maintenance management. This finding should be interesting to the shipping companies in order to develop a strategic approach for the management of ship maintenance. The research found that the maintenance managers of shipping companies have not been included in the management of ship maintenance at the corporate level. There is a need to address the role of the maintenance managers to enable them to align their maintenance strategies with the corporate business strategies.

In addition, the research found short-term and fragmented relationships with the suppliers of maintenance materials and/or services. Shipping companies need to instigate a strategic relationship development program to address this issue. The involvement of the maintenance managers in management of the ship maintenance might help the companies in assessing the performance and the capacity of the suppliers, which is essential for developing a strategic relationship. Thus, this research has made its contribution to the shipping industry in terms of providing insights into currently undertaken ship maintenance management. These insights should provide an important foundation to develop a strategic approach for management of ship maintenance.

Fifthly, this research contributes to the shipping companies in developing countries such as Indonesia. The limited logistics and infrastructure that characterises the management of supply chains in developing countries do not provide any reason to compromise the safety requirement of ship operations. Accordingly, shipping companies need to manage their ship maintenance strategically. As indicated via the results of the research, internal readiness by involving maintenance managers at the corporate level need to be addressed. In addition, the companies need to develop a roadmap in order to obtain web-based communication that enables them to source logistics for ship maintenance globally in order to gain benefits from the supply chain management.

Finally, this research also contributes insights to the research design and methodology focus by conducting international mail surveys. This research achieved a cost and time effective data collection process when conducting the postal surveys from Australia to the shipping companies in Indonesia. This research also benefited from the employment of a professional local agent to manage the distribution of the research instrument documentation. This employment has increased the flexibility of the research in terms of time and cost for handling unexpected outcomes of the distribution and overcome the limitation in the international mailing system between Australia and Indonesia. This research has also found that providing the researcher's email address might be useful for increasing the response rate as almost fifty per cent of the response rate of this research was obtained from the returned questionnaire via email. This research has proved that some suggestions from the literature, such as limiting questionnaire size, developing topics that are relevant to the interests of the targeted population, pre-testing, enclosing a stamped return envelope, sending a reminder letter and postcard and providing university logos in conducting postal survey are prudent.

7.4 Limitations

Research limitations are inherent in research which should be properly addressed to identify potential improvements for future research and ensure that the objectives of the current research have been attained within its parameters. A limitation was perceived in relation to the exploratory nature as this prevents this research from measuring the magnitude of the variables of supply chain management. The primary data were collected from a cross-section of participants. In addition, the time, funding and facilities constraint prevented this research from undertaking longitudinal data collection. Therefore, these conditions prevented this research from concluding any causal relationships between the measured variables such as performance of the ship maintenance and the shipping companies before and after the implementation of a supply chain management approach.

Some participants' responses might contain biased points of view and/or be reluctant to provide a correct answer. The participants might have been cautious in their responses to maintain their own or the shipping companies' reputations as being successful. This research could not control the selection of the participants who completed the questionnaire as the participants were self-selected by the shipping companies where they work, which may not have always been the most appropriate maintenance person. In addition, various participants' experiences might influence the answers provided in the questionnaire. Moreover, a higher response rate would have enabled this thesis to analyse any differences or similarities between sub-samples of participants. Initial telephone contact, if possible, might be useful to overcome this limitation in future research.

In terms of asking further investigative questions, the use of a mail survey prevents this research from prompting more questions to explore further insights from the participants. Even though the questionnaire was provided with some open-ended options, it appears that only a few participants used this opportunity. The maximum length of the questionnaire also limited the possibility of extending the investigation within the current research. A lengthy questionnaire could have resulted in resistance to completing the survey. Another data collection method such as telephone interviews may have overcome this limitation, and therefore it should be considered in future research.

In terms of generalisability, the low response rate achieved in this research affects the capability to generalise the findings to a larger population. The sample of the research was shipping companies in Indonesia. Even though the selection of the population of the research was justified, it may be arguable whether the research only fits the Indonesian shipping industry due to different business practices and contexts in other countries. Also, this research does not differentiate the shipping companies based on the types of ships and the size of their fleet. Some adjustment might be required in implementing the findings of this research to address the uniqueness of the shipping companies. It is recommended that future research includes a broader population and/or differentiation of types of ships and size of the fleet to underpin the generalisability of the results of that research. In sum, the limitations of the current research have been acknowledged to provide platforms for future research.

7.5 Future research

This research has found that the current ship maintenance management is undertaken within a silo mentality approach. This approach appears to prevent the visibility of the strategic values of ship maintenance from the corporate level management of shipping companies. Whilst this study found supply chain management is applicable as a strategic approach to ship maintenance, this research was exploratory where in-depth assessment on the magnitude and the causal relationships of the variables of supply chain management cannot be established. Therefore, some areas would merit further investigation in future research.

In terms of the implementation of supply chain management as a strategic approach to ship maintenance, there is potential to investigate the reasons for the non-involvement of maintenance managers at the corporate level of ship maintenance management. In-depth interviews with the senior-level managers of shipping companies should provide valuable insights from the industry due to their strategic level in the decision making process, and the method could provide flexibility to prompt interrogative questions. Revealing these reasons might provide insights into how and to what extent the maintenance managers should be involved in management. Furthermore, in-depth investigations about inter-organisational relationships between entities of the supply chains of ship maintenance should provide interesting topics for future research.

This research was conducted with shipping companies as the focal point of the maintenance supply chain. Within the research, it was evident that shipping companies are the end customer of the supply chain of ship maintenance. To configure a better picture of the supply chain of ship maintenance, it would be important to investigate supply chain management from the suppliers' point of view. This different point of view could provide better information about supply chain management of ship maintenance. Furthermore, putting the suppliers as the focal point might enable the investigation of the whole service processes of the framework of service-oriented supply chain management. Another research topic that can be developed from this research is the value chain discussion which involves transfer of value of ship maintenance to the customer of shipping companies, the shippers.

In terms of the effective response rate achieved, 20.87 per cent, this thesis suggests this achievement was relatively acceptable due to the possibility of providing statistical results with a sufficient level of significance. This response rate is also argued to be acceptable in relation to the commonality of achieved response rates in the supply chain management and the maintenance management literature, which is about 20.00 per cent. Nonetheless, future research by using different data collection methods, if necessary resources are adequately available, might be useful in triangulating the findings and the proposed model resulting from the current research.

This research has studied shipping companies of various types, such as liner, tramp or coastal services during the data analysis process. As discussed in Chapter Six, whilst some shipping companies offer services in specific shipping markets, the others offer mixed services. Even though ship maintenance is mandatory for all ships of shipping companies, different types of shipping companies might suggest the need for varying strategies to manage their ship maintenance supply chains. The small sample of the current research prevented this research from cross-tabulating these shipping companies. Future research, which focuses on different types of shipping companies, should enable a better understanding about the supply chain management of ship maintenance.

This thesis provides a parallel approach to both supply chain management and ship maintenance management that extends the boundaries of the body of relevant knowledge. It has explored the implementation of supply chain management as a strategic approach in the context of ship maintenance that has not been done before. The implication of the findings for practising managers is that it is important to involve the maintenance managers across the ship maintenance management at the corporate level. This policy is a necessity to enable the shipping companies to achieve better control regarding maintenance of the ships, which may provide better performance by the shipping companies in the long term and to contribute profits. Finally, this research has found that the supply chains of ship maintenance are still developing in terms of a supply chain management approach. These findings indicate that supply chain management of ship maintenance is rich with potential for future research.

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Appendix A

DISTANCES OF CITY LOCATIONS

Table of distances of city locations

km / nm	Batam	Palembang	Jakarta	Surabaya	Pontianak	Samarinda	Makassar
Batam		245	467	723	325	793	997
Palembang	452		233	545	325	756	891
Jakarta	864	430		359	399	707	756
Surabaya	1338	1009	665		479	483	419
Pontianak	601	602	738	887		467	679
Samarinda	1468	1405	1308	895	871		311
Makassar	1845	1649	1400	776	1259	576	

km: kilometre
nm: nautical mile

Appendix B1

THE QUESTIONNAIRE

(ENGLISH)

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone + 61 3 6324 9750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

AUSTRALIAN MARITIME COLLEGE

A STUDY OF SUPPLY CHAIN MANAGEMENT FOR SHIP MAINTENANCE

CONFIDENTIAL

Once completed, please return this questionnaire by [dd-mm-yyyy].

Please return by one of the following methods:

- Use the provided stamped envelope to mail back to the Student Investigator; or
- Scan and email to idindin@amc.edu.au.

Introduction

Thank you for agreeing to participate in this important study. You have been selected as a professional in the shipping industry whose experience and knowledge is significant to our research for ensuring relevant and useful findings to the shipping industry.

This questionnaire should only take approximately 25 minutes to complete. Please note that there are no right or wrong answers to this questionnaire, only your personal experience and knowledge matter. Most of the questions require only completing matrices or ticking of the responses provided. Only a small number of questions ask for a brief written answer.

Throughout the questionnaire, the word "**supplier**" refers to spare parts suppliers, consumables suppliers, maintenance vendors, original equipment manufacturers and dry-dock providers. The word "**customer**" refers to shippers and/or ship charterers. The term "**maintenance materials**" refers to spare parts and consumables such as cleaners, gaskets, lubricating oil, O-rings and paint.

Your responses are voluntary and will remain confidential. This questionnaire has been approved by the Ethics Committee of the University of Tasmania. The approval number is H13039.

If you would like to receive a copy of the summary of the findings, please provide your name and email address at the end of this questionnaire, or alternatively email idindin@amc.edu.au.

Should you have questions relating to any aspect of this questionnaire, please do not hesitate to contact the Student Investigator on (+61) 3 6324 9750 or email idindin@amc.edu.au.

With thanks

Imanuel Dindin

A. Maintenance organisation

This section focuses on the organisation of ship maintenance in your company.

A1. What is the job position in your company that manages the maintenance of the company's ships?

____

For the rest of the questionnaire, this manager will be referred to as the *Maintenance Manager*.

A2. What job position does the Maintenance Manager directly report to?

____

A3. What job position does the person in the answer to question A2 report to?

____

A4. Some responsibilities of a Maintenance Manager are listed as follows.

Please tick the boxes to indicate the responsibilities that apply to the Maintenance Manager in your company.

- ☐ 1 Provide on-the-spot guidance for undertaking maintenance actions.
- ☐ 2 Analyse the causes and/or effects of equipment failure.
- ☐ 3 Develop maintenance plans for the ships.
- ☐ 4 Co-ordinate with other managers to develop maintenance strategies.
- ☐ 5 Co-ordinate with other managers to develop maintenance procedures.
- ☐ 6 Supervise the purchase of new equipment and/or spare parts for the ships.
- ☐ 7 Evaluate the expenditures of undertaking maintenance on the ships.
- ☐ 8 Other, *(please specify)* _______________

____

A5. What is the job position in your company that manages the procurement of materials and/or services for maintenance of the company's ships?

____

For the rest of the questionnaire, this manager will be referred to as the *Procurement Manager*

A6. What job position does the Procurement Manager directly report to?

____

A7. What job position does the person in the answer to question A6 report to?

____

A8. Some responsibilities of a Procurement Manager are listed as follows.
Please tick the boxes to indicate the responsibilities that apply to the Procurement Manager in your company.

☐1 Secure the availability of required maintenance materials and/or services.
☐2 Ensure the purchased maintenance materials and/or services are at the lowest price.
☐3 Ensure the quality of purchased maintenance materials and/or services.
☐4 Evaluate the dollar value of maintenance materials in the inventory.
☐5 Evaluate the expenditures for purchasing the maintenance materials and/or services.
☐6 Other, *(please specify)* ____________________

____

For each of the job positions listed below, please indicate from 1 – 5 the involvement of each position in the maintenance management activities listed, where1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always, and 0 if the activity is not applicable to your company.

	Maintenance planning	Organising spare parts inventory	Evaluating maintenance performance	Setting the specification of the required maintenance materials and/or services	Allocating the maintenance budget
A9. CEO					
A10. Board of Directors					
A11. Operations Manager					
A12. Maintenance Manager					
A13. Procurement Manager					
A14. Finance Manager					

B. Maintenance supply chains

This section focuses on your company's maintenance supply chain networks.

The following statements relate to the linkages that your company has with the suppliers, in particular for the purchasing of materials and/or services for ship maintenance.
Please tick one response for each statement to indicate whether your company <u>*always has a direct link*</u> *to each of the following suppliers.*

	Strongly disagree (1)	Disagree (2)	Undecided (3)	Agree (4)	Strongly agree (5)	Not applicable (0)
B1. Spare parts suppliers.	☐	☐	☐	☐	☐	☐
B2. Consumables suppliers.	☐	☐	☐	☐	☐	☐
B3. Repair vendors.	☐	☐	☐	☐	☐	☐
B4. Equipment manufacturers.	☐	☐	☐	☐	☐	☐
B5. Dry-dock providers.	☐	☐	☐	☐	☐	☐
B6. Other, *(please specify)* ____________________	☐	☐	☐	☐	☐	☐

Each of the statements below address the degree of uncertainty of supply and demand in your company's ship maintenance supply chains. Please indicate from 1 – 5 to what extent do you agree/disagree with the statements listed, where 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree, and 0 if the activity is not applicable to your company.

Maintenance supply and demand	Suppliers					
	Spare parts suppliers	Consumables suppliers	Repair vendors	Equipment manufacturers	Dry-dock providers	Other (as indicated in B6)
B7. The suppliers consistently meet our requirements.						
B8. Our company has to conduct extensive inspections of the material and/or services from the suppliers.						
B9. Much rework has to be done on the materials and/or services from the suppliers						
B10. Our demand for materials and/or services fluctuates drastically from time to time						

C. Purchasing management

This section focuses on how your company manages the purchasing of maintenance materials and/or services for the ships.

Does your company have any contract with the suppliers below for purchasing maintenance materials and/or services of the ships?
Please tick one response for each type of the suppliers.

	No contract at all (1)	Yes: <1 year (2)	Yes: 1-2 years (3)	Yes: 3-4 years (4)	Yes: >4 years (5)	Don't know (0)
C1. Spare parts suppliers.	☐	☐	☐	☐	☐	☐
C2. Consumables suppliers.	☐	☐	☐	☐	☐	☐
C3. Repair vendors.	☐	☐	☐	☐	☐	☐
C4. Equipment manufacturers.	☐	☐	☐	☐	☐	☐
C5. Dry-dock providers.	☐	☐	☐	☐	☐	☐
C6. Other, *(as indicated in B6)* ______	☐	☐	☐	☐	☐	☐

C7. If your company has 'No contract at all' with any of the above suppliers (C1 to C6), please explain the reasons why.

____

____

____

C8. If your company has a contract with any of the above suppliers, please explain the reasons why.

____

____

____

For each of the maintenance management activities listed below, please indicate from 1 – 5 the involvement of these suppliers with your company for purchasing maintenance materials and/or services for the ships, where 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always, and 0 if the activity is not applicable to your company.

Maintenance management activities	Suppliers					
	Spare parts suppliers	Consumables suppliers	Repair vendors	Equipment manufacturers	Dry-dock providers	Other (as indicated in B6)
C9. Maintenance planning						
C10. Organising spare parts inventory						
C11. Evaluating maintenance performance						
C12. Setting the specification of the required maintenance materials and/or services						
C13. Solving maintenance problems						

To what extent do you agree/disagree with the following statements about your company's top management support for the strategic purchase of ship maintenance materials and/or services?
Please tick one response for each statement.

	Strongly disagree (1)	Disagree (2)	Undecided (3)	Agree (4)	Strongly agree (5)	Not applicable (0)
C14. Supportive of improving the purchase of maintenance materials and/or services.	☐	☐	☐	☐	☐	☐
C15. Considers the purchase of maintenance materials and/or services as a vital part of the business strategy.	☐	☐	☐	☐	☐	☐
C16. Emphasises the strategic role of purchasing maintenance requirements in improving the company's competitiveness.	☐	☐	☐	☐	☐	☐

To what extent do you agree/disagree with the following statements about your company's purchasing strategy for ship maintenance materials and services?
Please tick one response for each statement.

	Strongly disagree (1)	Disagree (2)	Undecided (3)	Agree (4)	Strongly agree (5)	Not applicable (0)
C17. All ship maintenance materials and services are purchased by the Chief Engineer of each ship.	☐	☐	☐	☐	☐	☐
C18. All ship maintenance materials and services are purchased by the Procurement Manager.	☐	☐	☐	☐	☐	☐
C19. Only ship maintenance materials and services with a high-dollar value are purchased by the Procurement Manager.	☐	☐	☐	☐	☐	☐
C20. Purchase of maintenance materials and/or services is included in our company's business strategy.	☐	☐	☐	☐	☐	☐

C21. Is there any other department in your company responsible for the purchase of ship maintenance materials and/or services?

Please tick the box that applies.

☐1 Yes, *(please specify)* ____________________

☐2 No

D. Supply management

This section focuses on the management of the supply of ship maintenance materials and/or services for your company's ships.

For each of the characteristics of suppliers listed below, please indicate from 1 – 5 the level of importance of these characteristics to your company's selection of ship maintenance suppliers, where 1 = very unimportant, 2 = unimportant, 3 = moderately important, 4 = important, 5 = very important, and 0 if the characteristic is not applicable.

Suppliers' characteristics	Suppliers					
	Spare parts suppliers	Consumables suppliers	Repair vendors	Equipment manufacturers	Dry-dock providers	Other (as indicated in B6)
D1. Lowest price						
D2. Long-term availability						
D3. Assured quality of supply						
D4. Willingness to share information						
D5. Willingness to provide training to our maintenance personnel						
D6. Willingness to commit qualified personnel						
D7. Other (*please specify*)						

To what extent do you agree/disagree with the following statements about your company's relationships with the suppliers?
Please tick one response for each statement.

	Strongly disagree (1)	Disagree (2)	Undecided (3)	Agree (4)	Strongly agree (5)	Not applicable (0)
D8. Our company's relationships with suppliers are based on mutual need.	☐	☐	☐	☐	☐	☐
D9. Our company supports the suppliers in improving the quality of their supply.	☐	☐	☐	☐	☐	☐
D10. Our company monitors whether the suppliers of our suppliers may affect the supply of maintenance materials and/or services.	☐	☐	☐	☐	☐	☐
D11. Our company maintains a close relationship with a small number of high-quality suppliers.	☐	☐	☐	☐	☐	☐
D12. Our company expects the relationships with suppliers to last for a long time.	☐	☐	☐	☐	☐	☐
D13. Our company considers suppliers' activities as part of the company's activities.	☐	☐	☐	☐	☐	☐
D14. The suppliers consider their relationships with us as a long-term alliance.	☐	☐	☐	☐	☐	☐

E. Communication

This section focuses on the information-sharing practices in your company for ship maintenance management.

E1. Please indicate the platforms that your company uses to communicate with suppliers.
Please tick the boxes that apply.

☐1 Phone

☐2 Facsimile

☐3 Email

☐4 Company's website

☐5 Suppliers' site visits

☐6 Other *(please specify)* ____________________

To what extent do you agree/disagree with the following statements about your company's information exchange with the suppliers?
Please tick one response for each statement.

		Strongly disagree (1)	Disagree (2)	Undecided (3)	Agree (4)	Strongly agree (5)	Not applicable (0)
E2.	Our company shares proprietary information with our suppliers about maintenance requirements.	☐	☐	☐	☐	☐	☐
E3.	The exchange of information is made in a timely manner.	☐	☐	☐	☐	☐	☐
E4.	The information exchanged is accurate.	☐	☐	☐	☐	☐	☐
E5.	The information exchanged is complete.	☐	☐	☐	☐	☐	☐
E6.	The information exchanged is reliable.	☐	☐	☐	☐	☐	☐
E7.	The suppliers and our company keep each other informed about changes that may affect the other party.	☐	☐	☐	☐	☐	☐

F. Maintenance operations

This section focuses on the maintenance operations of your company's ships.

F1. How many shore-based maintenance personnel are employed in your company?

____

F2. Does your company set a target amount, out of 100 per cent, for each the following maintenance tasks over the last year?
Please tick the boxes to indicate the maintenance tasks that apply to your company and provide the percentage respectively.

	Maintenance tasks	Set Target (%)
☐1	Emergency maintenance (Run-to-failure) ……………………	
☐2	Time-based maintenance (Preventive maintenance) ………..	
☐3	Condition-based maintenance (Predictive maintenance) ……	
	Total ……………………………	100

F3. Of the maintenance tasks you indicated in question F2 above, please indicate, as a percentage, the actual maintenance tasks undertaken over the last year.

Maintenance tasks	Actual tasks undertaken (%)
☐1 Emergency maintenance (Run-to-failure) …………………	
☐2 Time-based maintenance (Preventive maintenance) ………	
☐3 Condition-based maintenance (Predictive maintenance) …	
Total ………………………	100

For each classification of the spare parts listed below, please indicate from 1 – 5 the availability in your company's inventory for each type of equipment listed, where 1 = never , 2 = rarely,3 = sometimes, 4 = often, 5 = always, and 0 if the activity is not applicable to your company.

Category of spare parts	Equipment		
	Main Engines	Power Generators	Auxiliary Equipment
F4. Low dollar value – non-critical			
F5. Low dollar value – critical			
F6. High dollar value – non-critical			
F7. High dollar value – critical			

F8. Does your company use a computerised maintenance management systems for the following activities? *Please tick the boxes that apply*.

☐1 Planning and scheduling maintenance tasks.
☐2 Recording of the actual down time of equipment on-board.
☐3 Recording of the actual maintenance time.
☐4 Storing information of maintenance reports.
☐5 Updating of maintenance records of equipment on-board.
☐6 Recording of the inventory on-board of the maintenance spare parts.
☐7 Providing analytical functions for decision making for maintenance management.
☐8 Other, *(please specify)* ____________________

G. Maintenance performance

This section focuses on the performance of your company's ship maintenance.

Several types of unavailability incidents may cause disruptions to the scheduled dry dock maintenance which in turn influence the availability of shipping services. To what extent does each of the unavailability incidents listed below affect the shipping services of your company?
Please tick one response for each statement.

	Very little effect (1)	Little effect (2)	Moderate effect (3)	Significant effect (4)	Very significant effect (5)	Not applicable (0)
G1. Unavailability of spare parts.	☐	☐	☐	☐	☐	☐
G2. Unavailability of consumables.	☐	☐	☐	☐	☐	☐
G3. Unavailability of maintenance specialists.	☐	☐	☐	☐	☐	☐
G4. Unavailability of technicians from suppliers.	☐	☐	☐	☐	☐	☐
G5. Unavailability of docking space.	☐	☐	☐	☐	☐	☐
G6. Unavailability of the ship for dry-docking due to operational requirements.	☐	☐	☐	☐	☐	☐

The following statements relate to the performance of ship maintenance in your company. Please indicate how much of the target performance of the followings were achieved over the last year. *Please tick one response for each statement.*

	<50% (1)	50-69% (2)	70-89% (3)	≥90% (4)	Not applicable (0)
G7. Compliance to maintenance budget (excluding dry-dock maintenance).	☐	☐	☐	☐	☐
G8. Compliance to dry-docking maintenance durations.	☐	☐	☐	☐	☐
G9. Compliance to dry-docking maintenance costs.	☐	☐	☐	☐	☐
G10. Ships' availability.	☐	☐	☐	☐	☐
G11. Ships' voyage time.	☐	☐	☐	☐	☐

To what extent do you agree/disagree with the following statements about contributions of ship maintenance in your company?
Please tick one response for each statement.

	Strongly disagree (1)	Disagree (2)	Undecided (3)	Agree (4)	Strongly agree (5)	Not applicable (0)
G12. Ship maintenance improves the availability of the company's ships.	☐	☐	☐	☐	☐	☐
G13. Ship maintenance improves the reliability of the company's ships in undertaking the planned voyages.	☐	☐	☐	☐	☐	☐
G14. Ship maintenance improves customer satisfaction with shipping services.	☐	☐	☐	☐	☐	☐
G15. Ship maintenance reduces the total operating expenses of the ships.	☐	☐	☐	☐	☐	☐
G16. Ship maintenance increases the company's profits.	☐	☐	☐	☐	☐	☐

H. General

This questionnaire is almost finished. However, there are a few more general questions that relate to you and your company.

H1. Listed below are types of ship. Please indicate the fleet size of your company.

Type of ships	Number of ships	Total DWT
General cargo		
Container		
Dry-bulk cargo		
Liquefied-bulk cargo		
Chemical tanker		
Liquefied gas		
Other *(please specify)* ______		

H2. How many years in total have you worked in the shipping industry?
Please tick the box that applies.

☐1 Less than 2 ☐3 6 – 10 ☐5 More than 15

☐2 2 – 5 ☐4 11 – 15

H3. What is your position in the company?

____

H4. Are you directly responsible for overseeing the maintenance management of your company's ships?
Please tick the box that applies.

☐1 Yes ☐2 No

H5. How many years have you held this position?
Please tick the box that applies.

☐1 Less than 2 ☐3 6 – 10 ☐5 More than 15

☐2 2 – 5 ☐4 11 – 15

H6. What is the highest educational qualification in maintenance management that you have completed?
Please tick the boxes that apply.

☐1 Diploma of maintenance management.

☐2 Diploma of asset management.

☐3 Certified practitioner in asset management.

☐4 Certified senior practitioner in asset management.

☐5 No educational qualification in maintenance management → *go to* **Concluding remark**

☐6 Other (*Please specify*) ______________________________

H7. Have you found this qualification of importance to your career in the shipping industry?
Please tick the box that applies.

☐1 Yes ☐2 No ☐3 Unsure

Concluding remark

A copy of the summary of the findings will be provided to you upon request. If you would like to receive a copy when it becomes available, please provide your details.

Name: ______________________________

Email address: ______________________________

This is the end of this questionnaire.

We would like to thank you and convey our deep appreciation of your time and willingness to participate in this important research.

Appendix B2

THE QUESTIONNAIRE

(INDONESIAN)

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Email: idindin@amc.edu.au
www.amc.edu.au

STUDI MANAJEMEN RANTAI SUPLAI PEMELIHARAAN KAPAL

R A H A S I A

Mohon mengembalikan dengan salah satu cara berikut ini:

- Kirimkan melalui Pos menggunakan amplop berperangko yang telah disediakan;atau
- *Scan*dan *email*-kankeidindin@amc.edu.au.

Nomor dokumen: _____________

Prakata

Terima kasih atas kesediaan Anda untuk berpartisipasi dalam penelitian ini. Pengalaman dan pengetahuan Anda dalam industri pelayaran sangat penting bagi penelitian ini untuk dapat menghasilkan temuan yang relevan dan berhasil-guna untuk meningkatkan kinerja industri pelayaran.

Untuk menjawab seluruh pertanyaan dalam kuesioner ini diperlukan waktu sekitar 25 menit. Tidak ada jawaban yang benar maupun salah, hanya pengalaman dan pengetahuan Anda yang menjadi hal utama dalam menjawab pertanyaan-pertanyaan kuisioner ini. Sebagian besar pertanyaan meminta Anda untuk mengisikan angka 0 – 5 ke dalam tabel atau mencentang salah satu pilihan yang tersedia. Hanya beberapa pertanyaan memerlukan uraian singkat jawaban Anda.

Ada beberapa kata dan istilah yang perlu kami definisikan untuk menyederhanakan penggunaannya di dalam kuesioner ini. Kata dan istilah tersebut kami tabelkan sebagai berikut:

Kata/Istilah	Pengertian
penyedia	penyedia suku cadang, penyedia barang-habis, penyedia jasa perbaikan, pabrikan perlengkapan dan permesinan kapal, dan galangan kapal penyedia fasilitas dok-kering.
pelanggan	pemilik barang dan/atau penyewa kapal.
material pemeliharaan	suku cadang peralatan dan permesinan kapal, dan barang-habis seperti pembersih, gasket, minyak pelumas, O-ring dan cat.

Partisipasi Anda bersifat sukarela dan rahasia. Kuesioner ini telah disetujui oleh Komite Etik Universitas Tasmania dengan nomor kode persetujuan H13039.

Bila Anda berkenan menerima salinan rangkuman hasil penelitian ini, mohon mencantumkan nama dan alamat email Anda pada bagian akhir kuesioner ini, atau kirimkan email ke idindin@amc.edu.au.

Bila Anda ingin menanyakan lebih lanjut tentang berbagai aspek dari kuesioner ini, mohon untuk mengubungi kami selaku Peneliti di nomor (+61) 3 6324 9750 atau *email*idindin@amc.edu.au.

Hormat kami

Imanuel Dindin

Kandidat Peneliti

A. Organisasi pemeliharaan

Bagian ini fokus pada pengorganisasian pemeliharaan kapal di perusahaan Anda.

A1. Jabatan apa dalam perusahaan Anda yang bertanggung jawab terhadap manajemen pemeliharan kapal?

____

Dalam kuesioner ini, jabatan tersebut akan kami sebut sebagai Manajer Pemeliharaan.

A2. Jabatan apa yang menjadi atasan langsung dari Manajer Pemeliharaan tersebut?

____

A3. Jabatan apa yang menjadi atasan langsung dari pejabat dalam jawaban pertanyaan A2?

____

A4. Apakah tugas dan tanggung jawab Manajer Pemeliharaan di perusahaan Anda?

Untuk menjawab,mohon mencentang kotak-kotak yang sesuai.

- ☐1 Memberikan petunjuk langsung di kapal tentang cara melaksanakan pemeliharaan.
- ☐2 Menganalisa sebab dan/atau akibat permesinan kapal yang rusak.
- ☐3 Menyusun rencana pemeliharaan kapal milik perusahaan.
- ☐4 Berkoordinasi dengan manajer-manajer lain untuk menyusun strategi pemeliharaan.
- ☐5 Berkoordinasi dengan manajer-manajer lain untuk menyusun prosedur pemeliharaan.
- ☐6 Melaksanakan supervisi dalam pembelian peralatan baru dan/atau suku cadang kapal.
- ☐7 Mengevaluasi biaya pelaksanaan pemeliharaan kapal.
- ☐8 Lainnya, *(mohon disebutkan)* _______________

____

A5. Jabatan apa dalam perusahaan Anda yang bertanggung jawab terhadap manajemen pengadaan material dan/atau jasa pemeliharaan kapal?

____

Dalam kuesioner ini, jabatan tersebut akan kami sebut sebagai ManajerPengadaan.

A6. Jabatan apa yang menjadi atasan langsung dari Manajer Pengadaan tersebut?

____

A7. Jabatan apa yang menjadi atasan langsung dari pejabat dalam jawaban pertanyaan A6?

____

A8. Apakah tugas dan tanggung jawab Manajer Pengadaan di perusahaan Anda?

Untuk menjawab,mohon mencentang kotak-kotak yang sesuai.

- ☐ 1 Menjamin ketersediaan material dan/atau jasapemeliharaan yang diperlukan.
- ☐ 2 Menjamin material dan/atau jasa pemeliharaan diperoleh dengan harga terendah.
- ☐ 3 Menjamin kualitas material dan/atau jasa pemeliharaan yang dipesan.
- ☐ 4 Mengevaluasi nilai rupiah atas inventori material pemeliharaan.
- ☐ 5 Mengevaluasi biaya pengadaan material dan/atau jasa pemeliharaan.
- ☐ 6 Lainnya, *(mohon disebutkan)* ____________________

Apakah para Pejabat di bawah ini (atau yang setingkat di perusahaan Anda) dilibatkan dalam aktifitas manajemen pemeliharaan kapal?

Untuk menjawab, mohon melengkapi tabel berikut dengan angka **0 – 5**, *dimana:* **1** *= tidak pernah,* **2** *= jarang,* **3** *= kadang-kadang,* **4** *= sering,* **5** *= selalu, dan* **0** *bila aktifitas itu tidak diterapkan.*

Jabatan	**Aktifitas manajemen pemeliharaan kapal**				
	Perencanaan pemeliharaan	Penyusunan inventori suku cadang	Evaluasi kinerja pemeliharaan	Penetapan spesifikasi material dan/atau jasa pemeliharan	Pengalokasian anggaran pemeliharaan
A9. CEO					
A10. Dewan Direksi					
A11. Manajer Operasional					
A12. Manajer Pemeliharaan					
A13. Manajer Pengadaan					
A14. Manajer Keuangan					

B. Rantai suplai pemeliharaan

Bagian ini fokus pada jaringan rantai suplai pemeliharaan perusahaan Anda.

Apakah perusahaan Anda <u>selalu memesan langsung</u>kepada para penyedia di bawah ini untuk pengadaan material dan/atau jasa pemeliharaan kapal?

Mohon mencentang satu jawaban yang sesuai.

	Tidak pernah (1)	Jarang (2)	Kadang (3)	Sering (4)	Selalu (5)	Tidak dapat diterapkan (0)
B1. Penyedia suku cadang.	☐	☐	☐	☐	☐	☐
B2. Penyedia barang-habis.	☐	☐	☐	☐	☐	☐
B3. Penyedia jasa perbaikan.	☐	☐	☐	☐	☐	☐
B4. Pabrikan peralatan dan permesinan.	☐	☐	☐	☐	☐	☐
B5. Penyedia dok-kering.	☐	☐	☐	☐	☐	☐
B6. Lainnya, *(mohon disebutkan)* ____________	☐	☐	☐	☐	☐	☐

Setujukah Anda dengan pernyataan tentang tingkat ketidakpastian sediaan dan permintaan dalam rantai suplai pemeliharaan kapal di perusahaan Anda?
Untuk menjawab, mohon melengkapi tabel berikut dengan angka **0 – 5**, *dimana:* **1** *= sangat tidak setuju,* **2** *= tidak setuju,* **3** *= ragu-ragu,* **4** *= setuju,* **5** *= sangat setuju, dan* **0** *bila pernyataan tersebut tidak berlaku di perusahaan Anda.*

Kondisi sediaan dan permintaan	**Penyedia:**					
	Suku cadang	Barang-habis	Jasa perbaikan	Peralatan dan permesinan	Dok-kering	Lainnya (*lihat B6*)
B7. Para penyedia selalu memenuhi kebutuhan material dan/atau jasa pemeliharaan dengan memuaskan.						
B8. Kami harus melaksanakan pemeriksaan secara teliti setiap material dan/atau jasa dari para penyedia.						
B9. Banyak material dan/atau jasa dari para penyedia harus di-'*re-work*'.						
B10. Permintaan kami terhadap material dan/atau jasa pemeliharaan sangat berfluktuasi setiap saat.						

C. Manajemen pengadaan

Bagian ini membahas manajemen pengadaan material dan/atau jasa pemeliharaan kapal di perusahaan Anda.

Apakah perusahaan Anda mengikat kontrak pengadaan material dan/atau jasa pemeliharaan kapal dengan para penyedia berikut ini?
Mohon mencentang satu jawaban untuk setiap tipe penyedia.

	Tidak ada kontrak (1)	Ya, <1 tahun (2)	Ya, 1-2 tahun (3)	Ya, 3-4 tahun (4)	Ya, >4 tahun (5)	Tidak tahu (0)
C1. Penyedia suku cadang.	☐	☐	☐	☐	☐	☐
C2. Penyedia barang-habis.	☐	☐	☐	☐	☐	☐
C3. Penyedia jasa perbaikan.	☐	☐	☐	☐	☐	☐
C4. Pabrikan peralatan dan permesinan.	☐	☐	☐	☐	☐	☐
C5. Penyedia dok-kering.	☐	☐	☐	☐	☐	☐
C6. Lainnya, *(lihat B6)* ______	☐	☐	☐	☐	☐	☐

C7. Bila perusahaan Anda memilih 'Tidak ada kontrak' dengan salah satu dan/atau para penyedia di atas (C1 - C6), mohon berkenan menjelaskan alasannya.

______

______

______

C8. Bila perusahaan Anda memilih mengikat kontrak dengan salah satu dan/atau para penyedia di atas (C1 - C6), mohon berkenan menjelaskan alasannya.

______

______

______

Apakah para penyedia berikut ini dilibatkan dalam aktifitas manajemen pemeliharaan untuk pengadaan material dan/atau jasa pemeliharaan kapal di perusahaan Anda?

Untuk menjawab, mohon melengkapi tabel berikut dengan **0 – 5**, *dimana:* **1** = *tidak pernah,* **2** = *jarang,* **3** = *kadang-kadang,* **4** = *sering,* **5** = *selalu, dan* **0** *bila aktifitas tersebut tidak diterapkan.*

Aktifitas manajemen pemeliharaan	**Penyedia:**					
	Suku cadang	Barang-habis	Jasa perbaikan	Peralatan dan permesinan	Dok-kering	Lainnya (*lihat B6*)
C9. Perencanaan pemeliharaan						
C10. Penyusunan inventori suku cadang						
C11. Evaluasi kinerja pemeliharaan						
C12. Penetapan spesifikasi material dan/atau jasa pemeliharaan						
C13. Pemecahan masalah pemeliharaan						

Apakah pernyataan di bawah inimenggambarkan tentang dukungan dari Senior Manajemen di perusahaan Anda terhadap strategi pengadaan material dan/atau jasa pemeliharaan kapal?
Mohon mencentang satu jawaban untuk setiap pernyataan.

	Sangat tidaksetuju (1)	Tidak setuju (2)	Ragu-ragu (3)	Setuju (4)	Sangat setuju (5)	Tidak tahu (0)
C14. Mendukung peningkatan strategi pengadaan material dan/atau jasa pemeliharaan kapal.	☐	☐	☐	☐	☐	☐
C15. Menempatkan pengadaan material dan/atau jasa pemeliharaan kapalsebagai bagian vital strategi perusahaan.	☐	☐	☐	☐	☐	☐
C16. Menekankan fungsi strategis pengadaan material dan/atau jasa pemeliharaan kapaluntuk meningkatkan daya saing perusahaan.	☐	☐	☐	☐	☐	☐

Apakah pernyataan di bawah ini menggambarkan tentang strategi pengadaan material dan/atau jasa pemeliharaan kapal di perusahaan Anda?
Mohon mencentang satu jawaban untuk setiap pernyataan.

	Sangat tidaksetuju (1)	Tidak setuju (2)	Ragu-ragu (3)	Setuju (4)	Sangat setuju (5)	Tidak dapat diterapkan (0)
C17. Semua pengadaan dilakukan oleh Kepala Kamar Mesin setiap kapal.	☐	☐	☐	☐	☐	☐
C18. Semua pengadaan hanya dilakukan oleh Manajer Pengadaan.	☐	☐	☐	☐	☐	☐
C19. Hanya pengadaan dengan nilai rupiah tinggi dilakukan oleh Manajer Pengadaan.	☐	☐	☐	☐	☐	☐
C20. Pengadaan tersebut termasuk dalam strategi bisnis perusahaan.	☐	☐	☐	☐	☐	☐

C21. Apakah ada departemen lain di perusahaan Anda yang bertanggung jawab terhadap pengadaan material dan/atau jasa pemeliharaan kapal?

Mohon mencentang jawaban yang sesuai.

☐ 1 Ya, *(mohon disebutkan)* ______________________

☐ 2 Tidak

D. Manajemen sediaan

Bagian ini membahas manajemen sediaan material dan/atau jasa pemeliharaan kapal di perusahaan Anda.

Seberapa pentingkah karakteristik berikut ini untuk menentukan penyedia material dan/atau jasa pemeliharaan kapal bagi perusahaan Anda?
Untuk menjawab, mohon mengisi tabel berikut dengan angka **0 – 5***dimana:* **1** *= sangat tidak penting,* **2** *= tidak penting,* **3** *= cukup penting,* **4** *= penting,* **5** *= sangat penting, dan* **0** *bila karakteristik tersebut tidak dapat diterapkan*.

Karakteristik Penyedia	**Penyedia:**					
	Suku cadang	Barang-habis	Jasa perbaikan	Peralatan dan permesinan	Dok-kering	Lainnya (*lihat B6*)
D1. Memberikan harga terendah						
D2. Menjamin sediaan dalam waktulama						
D3. Menjamin kualitas material dan/atau jasa						
D4. Berbagi informasi penting						
D5. Memberikan pelatihan kepada personel pemeliharaan kami						
D6. Menyediakan personel berkualitas						
D7. Lainnya (*mohon disebutkan*) ____________ ____________						

Apakah pernyataan berikut ini dapat menggambarkan hubungan perusahaan Anda dengan para penyedia?
Mohon mencentang satu jawaban pada setiap pernyataan.

	Sangat tidak setuju (1)	Tidak setuju (2)	Ragu-ragu (3)	Setuju (4)	Sangat setuju (5)	Tidak tahu (0)
D8. Hubungan kami berdasarkan asas saling membutuhkan.	☐	☐	☐	☐	☐	☐
D9. Perusahaan kami mendukung para penyedia untuk meningkatan kualitas suplainya.	☐	☐	☐	☐	☐	☐
D10. Perusahaan kami memantau penyedia dari para penyedia kami yang dapat mempengaruhi suplai kepada kami.	☐	☐	☐	☐	☐	☐
D11. Perusahaan kami menjaga hubungan dekat hanya dengan sejumlah kecil penyediayang berkualitas tinggi.	☐	☐	☐	☐	☐	☐
D12. Perusahaan kami mengharapkan hubungan jangka panjang dengan para penyedia.	☐	☐	☐	☐	☐	☐
D13. Perusahaan kami memperhitungkan aktifitas produksi para penyedia sebagai bagian dari aktifitas perusahaan.	☐	☐	☐	☐	☐	☐
D14. Para penyedia memperhitungkan hubungan dengan perusahaan kami sebagai aliansi jangka panjang.	☐	☐	☐	☐	☐	☐

E. Komunikasi

Bagian ini fokus pada praktek pertukaran informasi dalam perusahaan Anda dalam pelaksanaan manajemen pemeliharaan kapal.

E1. Apakah media yang digunakan perusahaan Anda untuk berkomunikasi dengan para penyedia material dan/atau jasa pemeliharaan kapal?

Mohon mencentang media yang digunakan.

☐1 Telepon	☐4 Website perusahaan
☐2 Faksimili	☐5 Mengunjungi lokasi penyedia
☐3 *Email*	☐6 Lainnya (*mohon disebutkan)* ____________

Bagaimanakah kualitas pertukaran informasi perusahaan Anda dengan para penyedia tersebut? *Mohon mencentang satu jawaban untuk setiap pernyataan*.

		Sangat tidaksetuju (1)	Tidak setuju (2)	Ragu-ragu (3)	Setuju (4)	Sangat setuju (5)	Tidak dapat diterapkan (0)
E2.	Perusahaan kami saling bertukar informasi penting tentang material dan/atau jasa pemeliharaan kapal.	☐	☐	☐	☐	☐	☐
E3.	Pertukaran informasi dilakukan secara terjadwal.	☐	☐	☐	☐	☐	☐
E4.	Informasi yang diberikan akurat.	☐	☐	☐	☐	☐	☐
E5.	Informasi yang diberikan lengkap.	☐	☐	☐	☐	☐	☐
E6.	Informasi yang diberikan dapat dipercaya.	☐	☐	☐	☐	☐	☐
E7.	Kami dan para penyedia segera saling memberikan informasi bila ada perubahan yang dapat mempengaruhi pihak lain.	☐	☐	☐	☐	☐	☐

F. Operasional pemeliharan

Bagian ini membahas operasional pemeliharaan kapal di perusahaan Anda.

F1. Berapa jumlah staf/karyawan pemeliharaan kapal di perusahaan Anda?

____

F2. Selama setahun yang lalu, apakah perusahaan Anda menetapkan target, dalam perbandingan prosentasi dari total 100%, terhadaptiap jenis pemeliharaan berikut ini?

Mohon mencentang jenis pemeliharaan yang ditetapkan dan memberikan perbandingan prosentasinya.

Jenis pemeliharaan	Target (%)
☐1 Pemeliharaan darurat (*Emergency maintenance*) ………………	
☐2 Pemeliharaan terencana/terjadwal (*Time-based maintenance*) …	
☐3 Pemeliharaan terkondisi (*Condition-based maintenance*) ………	
Total ……………………………	100

F3. Berapakah prosentasi pemeliharaan di F2 yang telah dilakukan dalam setahun tersebut?

Jenis pemeliharaan	Pelaksanaan pemeliharaan (%)
Pemeliharaan darurat (*Emergency maintenance*) ………………	
Pemeliharaan terencana/terjadwal (*Time-based maintenance*) …	
Pemeliharaan terkondisi (*Condition-based maintenance*) ………	
Total ………………………	100

Apakah suku cadang permesinan berikut ini selalu tersedia dalam inventori perusahaan Anda?
Untuk menjawab, mohon melengkapi tabel berikut dengan angka **0 – 5**, *dimana:* **1** *= tidak pernah,* **2** *= jarang,* **3** *= kadang-kadang,* **4** *= sering,* **5** *= selalu, dan* **0** *bila tidak dapat diterapkan.*

Kategori suku cadang	**Permesinan**		
	Mesin Pokok	Pembangkit Listrik	Mesin Bantu
F4. Murah – non-kritis			
F5. Murah – kritis			
F6. Mahal – non-kritis			
F7. Mahal – kritis			

F8. Apakah perusahaan Anda menggunakan sistem komputerisasi manajemen pemeliharaan untuk aktifitas berikut ini?
Mohon mencentang kotak-kotak yang sesuai.

- ☐1 Perencanaan dan penjadwalan jenis-jenis pemeliharaan.
- ☐2 Pencatatan waktu kerusakan pada permesinan kapal.
- ☐3 Pencatatan waktu pelaksanaan pemeliharaan.
- ☐4 Penyimpanan informasi laporan-laporan pemeliharaan.
- ☐5 Pemutakhiran catatan pemeliharaan permesinanan kapal.
- ☐6 Pencatatan inventori suku cadang yang ada di kapal.
- ☐7 Melakukan analisa untuk pengambilan keputusan terhadap manajemen pemeliharaan.
- ☐8 Lainnya, *(mohon disebutkan)* ____________________

G. Kinerja pemeliharaan

Bagian ini membahas kinerja pemeliharaan kapal di perusahaan Anda.

Kejadian di bawah ini dapat mengganggu jadwal pelaksanaan doking pemeliharaan kapal yang berakibat pada ketersediaan jasa pengapalan. Seberapa besar akibat kekosongan suplai tersebut mempengaruhi ketersediaan jasa pengapalan perusahaan Anda?
Mohon mencentang satu jawaban untuk setiap pernyataan.

		Sangat kecil (1)	Kecil (2)	Cukup (3)	Besar (4)	Sangat besar (5)	Tidak berkaitan (0)
G1.	Kekosongan suku cadang.	☐	☐	☐	☐	☐	☐
G2.	Kekosongan barang-habis.	☐	☐	☐	☐	☐	☐
G3.	Tidak ada tenaga ahli pemeliharaan.	☐	☐	☐	☐	☐	☐
G4.	Tidak ada teknisi dari penyedia.	☐	☐	☐	☐	☐	☐
G5.	Tidak ada tempat untuk pelaksanaan dok.	☐	☐	☐	☐	☐	☐
G6.	Kapal tidak siap doking karena masih berlayar	☐	☐	☐	☐	☐	☐

Dalam setahun yang lalu, berapakah prosentasi satuan kinerja di bawah ini yang dicapai perusahaan Anda?
Mohon mencentang satu jawaban untuk setiap pernyataan.

		<50% (1)	50-69% (2)	70-89% (3)	≥90% (4)	Tidak diterapkan (0)
G7.	Kesesuaian rencana biaya pemeliharaan kapal (selain dok).	☐	☐	☐	☐	☐
G8.	Kesesuaian rencana waktu pelaksanaan dok.	☐	☐	☐	☐	☐
G9.	Kesesuaian rencana biaya pelaksanaan dok.	☐	☐	☐	☐	☐
G10.	Ketersediaan kapal melaksanakan pelayaran.	☐	☐	☐	☐	☐
G11.	Kehandalan kapal melaksanakan pelayaran.	☐	☐	☐	☐	☐

Setujukah Anda dengan pernyataan tentang manfaat pemeliharaan kapal di perusahaan Anda?
Mohon mencentang satu jawaban untuk setiap pernyataan.

		Sangat tidak setuju (1)	Tidak setuju (2)	Ragu-ragu (3)	Setuju (4)	Sangat setuju (5)	Tidak berkaitan (0)
G12.	Meningkatkan ketersediaan kapal.	☐	☐	☐	☐	☐	☐
G13.	Meningkatkan kehandalan kapal untuk melaksanakan pelayaran yang direncanakan.	☐	☐	☐	☐	☐	☐
G14.	Meningkatkan kepuasan pelanggan atas layanan pengapalan.	☐	☐	☐	☐	☐	☐
G15.	Menurunkan total biaya operasional kapal.	☐	☐	☐	☐	☐	☐
G16.	Meningkatkan keuntungan perusahaan.	☐	☐	☐	☐	☐	☐

H. Umum

Kuesioner ini hampir selesai. Namun sejumlah pertanyaan berikut sangat diperlukan untuk melakukan analisa demografi industri pelayaran yang ada.

H1. Mohon melengkapi tabel berikut sesuai dengan armada kapal di perusahaan Anda.

Jenis Kapal	Jumlah	Total DWT
General cargo		
Container		
Dry-bulk cargo		
Liquefied-bulk cargo		
Chemical tanker		
Liquefied gas		
Lainnya *(mohon disebutkan)* ________		

H2. Berapa tahun Anda telah bekerja di industri pelayaran?

Mohon mencentang kotak yang sesuai.

☐1 kurang dari 2 ☐3 6 – 10 ☐5 Lebih dari 15

☐2 2 – 5 ☐4 11 – 15

H3. Apakah jabatan Anda di perusahaan?

H4. Apakah Anda bertanggung jawab langsung terhadap manajemen pemeliharaan kapal?

Mohon mencentang kotak yang sesuai.

☐1 Ya ☐2 Tidak

H5. Berapa tahun Anda telah memegang jabatan tersebut?

Mohon mencentang kotak yang sesuai.

☐1 Kurang dari 2 ☐3 6 – 10 ☐5 Lebih dari 15

☐2 2 – 5 ☐4 11 – 15

H6. Apakah jenjang pendidikan tertinggi di bidang manajemen pemeliharaan kapal yang telah Anda miliki?

Mohon mencentang kotak yang sesuai.

☐1 Diploma manajemen pemeliharaan.

☐2 Diploma manajemen asset.

☐3 Sertifikat praktisi manajemen aset.

☐4 Sertifikat praktisi senior manajemen aset.

☐5 Gelar lainnya (*mohon disebutkan*)

☐6 Tanpa jenjang pendidikan di manajemen pemeliharaan → *silahkan ke* **Penutup**

H7. Apakah jenjang pendidikan tersebut mendukung karier Anda di industri pelayaran?

Mohon mencentang kotak yang sesuai.

☐1 Ya ☐2 Tidak ☐3 Ragu-ragu

Penutup

Salinan rangkuman hasil penelitian ini akan disediakan. Bila berkenan menerima salinan tersebut, mohon membubuhkan detail Anda di bawah ini.

Nama:

Alamat *Email*:

Kuesioner ini telah selesai.

Kami haturkan terima kasih yang sangat mendalam atas waktu dan kesediaan Anda untuk berpartisipasi didalamnya.

Appendix C

PRE-TESTING LETTER

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone + 61 3 63249750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

Click here to enter a date.

Dear …………………..

I would like to invite you to participate in the pre-testing of my data collection for my PhD study. I am a PhD candidate at the Department of Maritime and Logistics Management, Australian Maritime College at the University of Tasmania. Your comments will significantly assist in improving the quality of the survey.

Please pre-test the following documents:

- The cover letter
- The questionnaire labeled "confidential"
- The two follow-ups:
    - follow-up one: the reminder letter
    - follow-up two: the reminder postcard
- The participant information sheet
- The participant consent form

The objectives of the research

The main objective of the research is to investigate the application of supply chain management in the context of ship maintenance. The use of supply chain management is shown to be widely practised and studied in manufacturing-oriented industry. Research on supply chain management suggests that a service-oriented industry such as maintenance lags behind manufacturing. The research also suggests that maintenance supply chains can capitalise on the best practice of manufacturing-oriented supply chain management. Furthermore, research on maintenance management suggests the need for strategy-driven management to improve the performance of the maintenance function in an industry which involves a large amount of capital investment such as shipping. Thus, the primary research question (PQ) and two subsidiary research questions (SQ) are formulated as follow:

PQ: *Is a supply chain management approach applicable to improve ship maintenance performance?*

SQ1: *How is the management of ship maintenance currently undertaken?*

SQ2: *What benefits can shipping companies attain by undertaking a supply chain management approach to ship maintenance?*

To address these questions, the research involves a mail survey to 250 technical managers, marine superintendents or other managers responsible for the management of ship maintenance from shipping organisations in Indonesia. It is intended that information from these participants will provide valuable insights into the business processes and the supply chain management elements in a ship maintenance context.

The processes for conducting the mail survey are:

1. Pre-test all documents related to the mail survey (the current phase).
2. Submit all documents for ethics approval.
3. Send the mail survey packages to the selected sample. The packages will include:
   a. The cover letter;
   b. The participant information sheet;
   c. The participant consent form;
   d. The questionnaire; and
   e. A stamped return envelope.
4. Send a reminder letter to the non-response participants three weeks (21 days) after the first sending. Please note that postage to or from Indonesia takes about one week.
5. Send a reminder postcard to the non-response participants two weeks (14 days) after the follow-up packages.
6. The cut-off date for the returned surveys to be received by the researcher is two weeks (14 days) after the sending of the reminder postcard, that is seven weeks after the first sending.
7. There are eight item sections (A – H) of questions in the survey. Most of the questions require the filling or ticking of the responses. Only a small number of questions ask for a brief written answer. Any sentences in *italics* are guidance for the participants on how to answer the question.

Major issues for pre-testing

During pre-testing, please consider the following issues:

- Is the layout of the survey convenient to read?
- Are there any spelling or grammatical errors?
- Is there any ambiguity in the questions?
- Are the instructions clear?
- How long did the survey take to read through and potentially answer?
- Will the survey questions enable the research questions to be addressed?

Please feel free to write any further comments on the questionnaire or send me an email. If you have any questions when pre-testing this survey, please either call me on (03) 63249750 or email idindin@amc.edu.au.

Please returned your comments to me byWednesday, 30 January 2013.

I appreciate your valuable assistance in improving this survey and look forward to assisting you when you require any pre-testing of survey documents.

Kind regards

Imanuel Dindin

Appendix D

FULL ETHICS APPLICATION APPROVAL

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
Fax: (03) 6226 7148
Katherine.Shaw@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

UTAS

5 March 2013

Dr Stephen Cahoon
National Centre for Ports and Shipping
Australian Maritime College
Locked Bag 1397

Student Researcher: Imanuel Dindin

Sent via email

Dear Dr Cahoon

Re: FULL ETHICS APPLICATION APPROVAL
Ethics Ref: **H0013039 - A Study of Supply Chain Management for Ship Maintenance**

We are pleased to advise that the Tasmania Social Sciences Human Research Ethics Committee approved the above project on 4 March 2013.

This approval constitutes ethical clearance by the Tasmania Social Sciences Human Research Ethics Committee. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approval of other bodies or authorities is required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

Please note that this approval is for four years and is conditional upon receipt of an annual Progress Report. Ethics approval for this project will lapse if a Progress Report is not submitted.

The following conditions apply to this approval. Failure to abide by these conditions may result in suspension or discontinuation of approval.

1. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval, to ensure the project is conducted as approved by the Ethics Committee, and to notify the Committee if any investigators are added to, or cease involvement with, the project.

2. Complaints: If any complaints are received or ethical issues arise during the course of the project, investigators should advise the Executive Officer of the Ethics Committee on 03 6226 7479 or human.ethics@utas.edu.au.

3. Incidents or adverse effects: Investigators should notify the Ethics Committee immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Amendments to Project: Modifications to the project must not proceed until approval is obtained from the Ethics Committee. Please submit an Amendment Form (available on our website) to notify the Ethics Committee of the proposed modifications.

5. Annual Report: Continued approval for this project is dependent on the submission of a Progress Report by the anniversary date of your approval. You will be sent a courtesy reminder closer to this date. **Failure to submit a Progress Report will mean that ethics approval for this project will lapse.**

6. Final Report: A Final Report and a copy of any published material arising from the project, either in full or abstract, must be provided at the end of the project.

Yours sincerely

Katherine Shaw
Ethics Officer
Tasmania Social Sciences HREC

Appendix E1

COVER LETTER

(ENGLISH)

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone + 61 3 6324 9750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

AMC AUSTRALIAN MARITIME COLLEGE | UTAS

Click here to enter a date.

«Title»«First_Name»«Last_Name»
«Company_Name»
«Address_Line_1»
«City»«ZIP_Code»

«GreetingLine»

Re: A study of supply chain management for ship maintenance

We are writing to request your support for a study being conducted by the Department of Maritime and Logistics Management, Australian Maritime College, University of Tasmania, Australia. This study investigates the application of supply chain management in the context of ship maintenance. The study is being conducted by Mr Imanuel Dindin, a PhD Candidate, under the supervision of Dr Stephen Cahoon and Dr Jiangang Fei.

You have been specifically selected to participate in this study due to your industry knowledge and experience in ship maintenance. You participation involves completion of the attached questionnaire. In return for your participation, a summary of the findings of this study will be made available for you upon request. The summary should enable you to assess your company's ship maintenance activities against those carried out by other similar organisations. It will also enable you to formulate a strategy-driven ship maintenance capitalising on the supply chain management approach for gaining a sustainable source of competitive advantage.

All information collected from this study will be treated carefully to guarantee its confidentiality. Enclosed with this letter is the Questionnaire and the Participant Information Sheet that explains how the study is being conducted. Details on how to return the Questionnaire is provided on the cover page of the Questionnaire. Please complete the Questionnaire and return it by XXXX 2013.

Should you have any questions, please do not hesitate to contact Imanuel Dindin by email at idindin@amc.edu.au or by phone at +61 3 6324 9750.

Thank you for your cooperation.

Yours sincerely

Imanuel Dindin
Student Investigator

Dr Stephen Cahoon
Chief Investigator,
Head, Department of Maritime
and Logistics Management

Dr Jiangang Fei
Co-Investigator

Appendix E2

COVER LETTER

(INDONESIAN)

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone + 61 3 63249750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

AUSTRALIAN MARITIME COLLEGE

Click here to enter a date.

«Title»«First_Name»«Last_Name»
«Company_Name»
«Address_Line_1»
«City»«ZIP_Code»

«GreetingLine»

Ref: Studi manajemen rantai suplai pemeliharaan kapal

Kami mohon dukungan Anda dalam studi yang dilaksanakan oleh Departemen Maritim dan Manajemen Logistik, Australian Maritime College, Universitas Tasmania.Studi ini meneliti penerapan manajemen rantai suplai di bidang pemeliharaan kapal.Studi ini dilaksanakan oleh Imanuel Dindin, seorang Kandidat PhD, di bawah supervisi Dr Stephen Cahoon dan Dr Jiangang Fei.

Anda secara khusus dimohon untuk berpartisipasi dalam studi ini berdasarkan pengetahuan dan pengalaman Anda dalam pemeliharaan kapal. Anda dimohon untuk berpartisipasi dengan cara menjawab setiap pertanyaan dalam kuesioner terlampir. Sebagai ungkapan terima kasih kami, rangkuman hasil studi ini akan disediakan bagi Anda. Rangkuman tersebut dapat digunakan untuk membanding kinerja pemeliharaan kapal di perusahaan Anda terhadap perusahaan lain yang sejenis. Rangkuman tersebut juga dapat digunakan untuk menyusun strategi pemeliharaan kapal dengan mengambil manfaat dari manajemen rantai suplai untuk memperoleh sumber keunggulan perusahaan yang berkelanjutan.

Seluruh informasi dari studi ini akan diperlakukan secara hati-hati untuk menjamin kerahasiaannya. Bersama surat ini kami lampirkan bundel Kuesioner dan Lembar Informasi Relawan dimana detail pelaksanaan studi dijelaskan. Cara pengembalian Kuesioner dapat dibaca di halaman depan bundel Kuesioner. Mohon berkenan menjawab seluruh pertanyaan Kuesioner dan mengembalikannya paling lambat hari Jumat, 22 Maret 2013.

Bila Anda ingin menanyakan lebih lanjut, mohon untuk mengubungi Imanuel Dindin selaku Peneliti di nomor (+61) 3 6324 9750 atau *email*idindin@amc.edu.au.

Terima kasih atas kerja sama Anda.

Hormat kami

Imanuel Dindin
Kandidat Peneliti

Dr Stephen Cahoon
Kepala Peneliti,
Kepala Departemen
Maritim dan Manajemen
Logistik

Dr Jiangang Fei
Pendamping Peneliti

Appendix F1

PARTICIPANT INFORMATION SHEET

(ENGLISH)

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone + 61 3 6324 9750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

Participant Information Sheet

A Study of Supply Chain Management for Ship Maintenance

1. Invitation

You are invited to participate in the research of a supply chain management approach for ship maintenance. The study is being conducted by Mr. Imanuel Dindin, a PhD Candidate, under the supervision of Dr Stephen Cahoon and Dr Jiangang Fei from the Department of Maritime and Logistics Management, Australian Maritime College, University of Tasmania, Australia.

2. The purpose of the research

The purpose of the research is to investigate the application of supply chain management in the context of ship maintenance in the shipping industry in Indonesia. The survey is being conducted to collect data that provides valuable insights into the business processes and the supply chain management elements in a ship maintenance context. Some parts of the survey also asks for demographic questions in order to make comparisons between shipping organisations in relation to their application of the supply chain management approach for maintaining their ships.

3. Reason for the invitation to participate

You have been invited to participate in the study due to your professional experience and knowledge in ship maintenance in the shipping industry. Your participation is important to our research to ensure we find relevant and useful findings to the shipping industry.

4. Details of participants' involvement

Your participation in this study involves completion of the attached questionnaire. You will be asked to answer a number of questions that relate to your professional responsibilities, knowledge and experience in relation to ship maintenance management. The questionnaire will take approximately 25 minutes of your time to complete. Once the questionnaire is completed, please return it using one of the following options:

a. Use the provided stamped envelope to mail back to the Student Investigator; or
b. Scan and email to Student Investigator's email address (idindin@amc.edu.au).

5. Possible benefits from participation in this research

As your organisation is involved in the shipping business, your participation will be of great value to this study and the shipping industry. The findings of this research should enable shipping organisations on how to better manage ship maintenance to effectively and efficiently enhance the availability and reliability of ships in performing shipping services. Further, the findings should enable you to assess your organisation's ship maintenance activities against those carried out by other similar organisations. It will also enable you to formulate a strategy-driven ship maintenance capitalising on the supply chain management approach for gaining a sustainable source of competitive advantage.

6. Possible risks from participation in this research

There are no particular risks to you by participating in this research.

7. Alteration during or after this research

It is important that you understand that your involvement in this study is voluntary. While we are pleased to have your participation, we respect your right to decline. There will be no consequences to you if you decide not to participate. If you decide to discontinue participation at this time, you may do so without providing any explanation.

If you decide to alter your participation after this research, please contact the Student Investigator before 6 May, 2013 and all the data that you have provided during your participation will be destroyed.

8. Data collection and confidentiality

All information will be treated in a confidential manner, and you and your organisation's name will not be used in any publication arising out of the research. In the final report, you and your organisation will be referred to by a pseudonym. We will remove any references to personal information that might allow someone else to guess your identity or that of your organisation. The researcher will de-identify the data prior to the data analyses process. This means that your name and contact details will be kept in a separate, password-protected computer then stored on CD and held by the Australian Maritime College, University of Tasmania for five years and then destroyed.

9. Publication of the results of the study

This study constitutes the main source of primary data for the Student Investigator's doctoral thesis. The results may later be presented or published at conferences and in other academic forums, including journals. A copy of such publications can be supplied upon request to all participants in this study. Participants are invited at the end of the questionnaire to request a copy of any publications and/or summary of the study by providing their email address by either writing it on their returned questionnaire or emailing the request to the investigators directly.

10. Contact information

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have any concerns or complains about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (+61 3) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H13039.

Should you have questions relating to any aspect of this study, please feel free to contact the Student Investigator and/or the Supervisors:

Student Investigator:
Imanuel Dindin
Department of Maritime and Logistics Management
Ph: +61 3 6324 9750
email: idindin@amc.edu.au

Chief Investigator:
Dr. Stephen Cahoon
Head, Department of Maritime and Logistics Management
Ph: +61 3 6324 9769
email: S.Cahoon@amc.edu.au

Co-Investigator:
Dr. Jiangang Fei
Lecturer, Department of Maritime and Logistics Management
Ph: +61 3 6324 9877
email: J.Fei@amc.edu.au

Thank you for taking the time to consider this study.
This information sheet is for you to keep.
If you wish to take part in this study, please complete the questionnaire and return it.

Appendix F2

PARTICIPANT INFORMATION SHEET

(INDONESIAN)

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone + 61 3 6324 9750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

AUSTRALIAN MARITIME COLLEGE

Lembar Informasi Relawan

Studi Manajemen Rantai Suplai Pemeliharaan Kapal

1. Undangan

Kami mengundang Anda untuk berpartisipasi dalam penelitian tentang manajemen rantai suplai pemeliharaan kapal. Studi ini dilaksanakan oleh Imanuel Dindin, Kandidat PhD, di bawah supervisi Dr Stephen Cahoon dan Dr Jiangang Fei dari Departemen Maritim dan Manajemen Logistik, Australian Maritime College, Universitas Tasmania, Australia.

2. Tujuan studi

Studi ini bertujuan untuk meneliti penerapan manajemen rantai suplai di bidang pemeliharaan kapal di industri pelayaran di Indonesia. Pengumpulan data melalui survei ini dilaksanakan untuk memperoleh informasi tentang proses bisnis dan elemen manajemen rantai suplai di bidang pemeliharaan kapal. Survei ini juga mengumpulkan data demografi untuk dapat mengenali kelompok-kelompok organisasi pelayaran berdasarkan penerapan manajemen rantai suplai yang digunakan untuk pemeliharaan kapal-kapal mereka.

3. Latar belakang undangan untuk berpartisipasi

Anda diundang untuk berpartisipasi dalam studi ini karena pengalaman dan pengetahuan profesional Anda di bidang pemeliharaan kapal dalam industri pelayaran.Partisipasi Anda sangat penting bagi studi ini agar temuannya relefan dan berguna bagi industri pelayaran.

4. Detail keikutsertaan Anda

Partisipasi Anda dalam studi ini berupa melengkapi kuesioner terlampir. Anda akan diminta menjawab sejumlah pertanyaan berkaitan dengan tanggung jawab, pengetahuan dan pengalaman profesional Anda di bidang manajemen pemeliharaan kapal. Kuesioner ini akan membutuhkan waktu sekitar 25 menit. Bila Anda telah menjawab seluruh pertanyaan kuesioner ini, mohon mengembalikannya paling lambat hari Jumat, 22 Maret 2013, dengan salah satu cara berikut ini:

a. Gunakan amplop berperangko yang tersedia dan kirimkan ke Kandidat Peneliti; atau
b. *Scan* dan *email*-kan ke alamat email Kandidat Peneliti (idindin@amc.edu.au).

5. Manfaat dari berpartisipasi dalam studi ini

Karena perusahaan Anda bergerak dalam bisnis pelayaran, partisipasi Anda sangat berharga bagi studi ini dan industri pelayaran.Temuan studi ini memungkinkan perusahaan pelayaran untuk dapat mengatur pemeliharaan kapalnya dengan lebih baik, yang secara efektif dan efisien dapat meningkatkan ketersediaan dan kehandalan kapal memberikan layanan pengapalan. Temuan studi ini dapat digunakan untuk membandingkan kinerja pemeliharaan kapal di perusahaan Anda terhadap perusahaan lain yang sejenis. Temuan studi ini juga dapat digunakan untuk menyusun strategi pemeliharaan kapal dengan mengambil manfaat dari manajemen rantai suplai untuk memperoleh sumber keunggulan perusahaan yang berkelanjutan.

6. Kemungkinan resiko karena berpartisipasi dalam studi ini

Tidak ada resiko bagi Anda yang disebabkan oleh keikutsertaan di dalam studi ini.

7. Perubahan keputusan selama atau setelah studi

Sangat penting untuk Anda ketahui bahwa partisipasi Anda dalam studi ini bersifat suka rela.Kami sangat bersyukur bila Anda memutuskan untuk berpartisipasi, namun kami tetap menghormati keputusan Anda untuk tidak berpartisipasi.Anda dapat memutuskan untuk tidak berpartisipasi sekarang tanpa memberikan penjelasan kepada kami.

Bila sekarang Anda memutuskan untuk berpartisipasi, namun ingin membatalkannya setelah mengembalikan kuesioner ini, mohon menghubungi Imanuel Dindin sebelum tanggal 6 Mei 2013 agar informasi yang Anda berikan dapat kami hapuskan.

8. Pengumpulan data dan kerahasiaannya

Setiap informasi yang diperoleh akan diperlakukan secara rahasia, dimana identitas Anda dan perusahaan Anda tidak akan digunakan dalam semua publikasi yang dihasilkan dari studi ini. Dalam laporan akhir studi, identitas tersebut akan disamarkan. Kami akan mengkodekan dan merahasiakan seluruh identitas tersebut sebelum proses analisa data. Hal ini bertujuan agar identitas tersebut tidak dapat ditelusuri oleh orang lain. Identitas tersebut akan disimpan secara terpisah di dalam komputer dan CD dengan kata sandi rahasia, dan disimpan di Australian Maritime College, Universitas Tasmania selama lima tahun dan selanjutnya akan dimusnahkan.

9. Publikasi hasil studi

Studi ini merupakan sumber utama data primer yang digunakan dalam tesis doktoral Kandidat Peneliti. Temuan studi akan disajikan atau dipublikasikan dalam konferensi dan forum akademis lain termasuk jurnal. Apabila berkenan menerima salinan publikasi tersebut, pada bagian akhir kuesioner Anda akan diminta untuk mengisikan nama dan alamat email Anda, atau mengirimkan email permintaan salinan publikasi kepada para peneliti.

10. Kontak informasi

Studi ini telah disetujui oleh Komite Etik Riset Ilmu Sosial Humaniora Tasmania.Bila Anda prihatin atau memiliki keluhan atas pelaksanaan studi ini, mohon menghubungi petugas Jaringan Komite Etik Tasmania di (+61 3) 6226 7479 atau *email* human.ethics@utas.edu.au. Petugas tersebut ditunjuk untuk menerima seluruh keluhan dari para relawan studi. Nomer etik referensi studi ini adalah H13039.

Bila Anda ingin menanyakan lebih lanjut tentang berbagai aspek penelitian ini, mohon menghubungi Kandidat Peneliti dan/atau para Supervisi.

Kandidat Peneliti:
Imanuel Dindin
Departemen Maritim dan Manajemen Logistik
Telp: +61 3 6324 9750
email: idindin@amc.edu.au

Kepala Peneliti:
Dr Stephen Cahoon
Kepala Departemen Maritim dan Manajemen Logistik
Telp.: +61 3 6324 9769
email: S.Cahoon@amc.edu.au

Pendamping Peneliti:
Dr Jiangang Fei
Dosen, Departemen Maritim dan Manajemen Logistik
Telp.: +61 3 6324 9877
email: J.Fei@amc.edu.au

Terima kasih atas perhatian Anda untuk mempertimbangkan studi ini.
Lembar informasi ini untuk Anda simpan.
Bila Anda memutuskan untuk berpartisipasi, mohon melengkapi kuesioner terlampir dan mengembalikannya.

Appendix G1

REMINDER LETTER

(ENGLISH)

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone + 61 3 6324 9750 Fax + 61 3 6326 9720
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www.amc.edu.au

AMC AUSTRALIAN MARITIME COLLEGE

UTAS

Click here to enter a date.

«Title»«First_Name»«Last_Name»
«Company_Name»
«Address_Line_1»
«City»«ZIP_Code»

«GreetingLine»

Re: A study of supply chain management for ship maintenance

We are writing this letter as a friendly reminder about the questionnaire that you should have received in the last three weeks. The questionnaire relates to a study of a supply chain management for ship maintenance.

If you have not yet had a chance to complete the questionnaire, please consider the value you may gain from the findings of the study. In return for your participation, a summary of the findings of this study will be made available for you upon request. The summary should enable you to assess your company's ship maintenance activities against those carried out by other similar organisations. It will also enable you to formulate a strategy-driven ship maintenance capitalising on the supply chain management approach for gaining a sustainable source of competitive advantage.

If you have completed the questionnaire and already returned it to the Investigators, we would like to take this opportunity to convey our deep appreciation on your contribution.

Should you have any questions or require another copy of the questionnaire, please do not hesitate to contact Imanuel Dindin by email at idindin@amc.edu.au or by phone at +61 3 6324 9750.

Thank you for your cooperation.

Yours sincerely

Imanuel Dindin
Student Investigator

Dr Stephen Cahoon
Chief Investigator,
Head, Department of Maritime and Logistics Management

Dr Jiangang Fei
Co-Investigator

Appendix G2

REMINDER LETTER

(INDONESIAN)

Locked Bag 1397
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Phone + 61 3 63249750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

AUSTRALIAN MARITIME COLLEGE

Click here to enter a date.

«Title»«First_Name»«Last_Name»
«Company_Name»
«Address_Line_1»
«City»«ZIP_Code»

«GreetingLine»

Re: Studi manajemen rantai suplai pemeliharaan kapal

Surat ini merupakan tindak lanjut dari kuesioner yang seharusnya telah Anda terima dalam tiga minggu yang lalu. Kuesioner tersebut berkaitan dengan studi tentang manajemen rantai suplai pemeliharaan kapal.

Bila Anda belum berkesempatan menyelesaikan kuesioner tersebut, mohon dipertimbangkan manfaat yang dapat diperoleh. Sebagai ungkapan terima kasih kami, rangkuman hasil studi ini akan disediakan bagi Anda. Rangkuman studi ini dapat membantu Anda untuk membandingkan kinerja pemeliharaan kapal di perusahaan Anda terhadap perusahaan lain yang sejenis. Rangkuman tersebut juga dapat digunakan untuk menyusun strategi pemeliharaan kapal dengan mengambil manfaat dari manajemen rantai suplai untuk memperoleh sumber keunggulan perusahaan yang berkelanjutan.

Bila Anda telah menyelesaikan kuesioner tersebut dan mengembalikannya kepada kami, terima kasih yang sangat mendalam kami haturkan atas sumbangsih Anda dalam studi ini.

Bila Anda ingin menanyakan lebih lanjut atau memerlukan salinan kuesioner tersebut, mohon mengubungi Imanuel Dindin selaku Peneliti di nomor (+61) 3 6324 9750 atau *email* idindin@amc.edu.au.

Terima kasih atas kerja sama Anda.

Hormat kami

Imanuel Dindin
Peneliti Kandidat

Dr Stephen Cahoon
Kepala Peneliti,
Kepala Departemen Maritim
dan Manajemen Logistik

Dr Jiangang Fei
Peneliti Pendamping

Appendix H1

REMINDER POSTCARD

(ENGLISH)

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www.amc.edu.au

AUSTRALIAN MARITIME COLLEGE

UTAS

Reminder postcard (sample)

«GreetingLine»

In the last five weeks you should have received a questionnaire about a study of ship maintenance management. We thank you if you have already completed the questionnaire and returned it to the researcher.

However, if you have not yet had a chance to complete it, please consider the value you may gain from its findings. In return for your participation, asummary of the findings will be made available for you upon request. The summary should enable you to assess your company's ship maintenance activities against those carried out by other similar organisations. It will also enable you to formulate a strategy-driven ship maintenance capitalising on the supply chain management approach for gaining a sustainable source of competitive advantage.

Should you have any questions or require another copy of the questionnaire, please contact Imanuel Dindin by email at idindin@amc.edu.au or by phone at +61 3 6324 9750.

Yours sincerely

Imanuel Dindin
Student Investigator

Dr Stephen Cahoon
Chief Investigator,
Head, Department of Maritime and Logistics Management

Dr Jiangang Fei
Co-Investigator

Locked Bag 1397
Launceston Tasmania 7250 Australia

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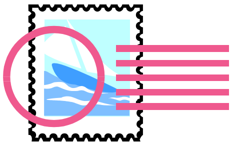
Web: www.amc.edu.auEmail: idindin@amc.edu.au



«Title»«First_Name»
«Last_Name»

«Company_Name»

«Address_Line_1»

«City»«ZIP_Code»

Appendix H2

REMINDER POSTCARD

(INDONESIAN)

Locked Bag 1397
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Phone + 61 3 63249750 Fax + 61 3 6326 9720
Email: idindin@amc.edu.au
www.amc.edu.au

AUSTRALIAN MARITIME COLLEGE

UTAS

Reminder postcard (sample)

«GreetingLine»

Dalam lima minggu ini semoga Anda telah menerima kuesioner tentang studi manajemen pemeliharaan kapal. Terima kasih bila Anda telah melengkapi dan mengirimkannya kembali kepada kami.

Namun, bila Anda belum sempat melengkapinya, mohon dipertimbangkan manfaat yang bisa diperoleh dari temuannya. Rangkuman studi ini berguna untuk membandingkan kinerja pemeliharaan kapal di perusahaan-perusahaan sejenis dan untuk menyusun strategi pemeliharaan kapal untuk memperoleh sumber keunggulan perusahaan yang berkelanjutan.

Bila Anda ingin menanyakan lebih lanjut atau memerlukan salinan kuesioner ini, mohon menghubungi Imanuel Dindin di nomor (+61) 3 6324 9750 atau *email* idindin@amc.edu.au.

Hormat kami

Imanuel Dindin Peneliti Kandidat	Dr Stephen Cahoon Kepala Peneliti, Kepala Departemen Maritim dan Manajemen Logistik	Dr Jiangang Fei Peneliti Pendamping

Locked Bag 1397
Launceston Tasmania 7250

Phone + 61 3 6324 9750 Fax + 61 3 6326 9720
Web: www.amc.edu.au Email: idindin@amc.edu.au

Yth. Direktur Teknik/ Pemeliharaan Kapal
PT. ….«NAME»

Appendix I

DATA ANALYSIS

Companies' fleet types and sizes (item H1)

Companies' shore based maintenance personnel (item F1)

ID	H1																F1
	General Cargo		Container		Dry bulk		Liquefied bulk		Chemical		Landing craft		Tug boat		Total Ship/ID	Category	Maintenance Personnel
	Fleet	DWT x 1,000	Fleet	DWT x 1,000	Fleet	DWT x 1,000	Fleet	DWT x 1,000	Fleet	DWT x 1,000	Fleet	DWT x 1,000	Fleet	DWT x 1,000			
1													2	1.6	2	>1 ship, 1 type	10
2					19	72.4							4	1.8	23	>1 ship, >1 type	10
3					3	140.0			3	40.0					6	>1 ship, >1 type	9
4													7		7	>1 ship, 1 type	3
5					9	648.0			1	30.0			53	130.8	63	>1 ship, >1 type	-
6									1		18				19	>1 ship, >1 type	7
7													44		44	>1 ship, 1 type	26
8											5	15.0			5	>1 ship, 1 type	2
9					1	3.0	1	1.2			3	1.3			5	>1 ship, >1 type	3
10	10	78.0			7	323.2			1	1.7			14	105.0	32	>1 ship, >1 type	14
11							4	38.0							4	>1 ship, 1 type	4
12					7										7	>1 ship, 1 type	10
13									8	50.0					8	>1 ship, 1 type	5
14													11		11	>1 ship, 1 type	4
15													2		2	>1 ship, 1 type	4
16									7	45.0					7	>1 ship, 1 type	10
17					1	72.4	3	23.5	1	6.0			10	80.0	15	>1 ship, >1 type	20
18					10	80.0									10	>1 ship, 1 type	3
19	21	277.3													21	>1 ship, 1 type	2
20											38				38	>1 ship, 1 type	30
21			2	8.0					6	50.0					8	>1 ship, >1 type	6
22					9										9	>1 ship, 1 type	20
23													8		8	>1 ship, 1 type	4
24			1	5.0											1	One ship	5
25	6	19.8													6	>1 ship, 1 type	4
26	26	130.0													26	>1 ship, 1 type	100
27													5		5	>1 ship, 1 type	10
28													17		17	>1 ship, 1 type	18
29			25	312.5											25	>1 ship, 1 type	50
30	2	14.0			2	16.0									4	>1 ship, >1 type	6
31													5	10.0	5	>1 ship, 1 type	4
32									1	18.2					1	One ship	4
33							5	20.0							5	>1 ship, 1 type	10
34	1	10.0													1	One ship	3
35	1	6.0			11	87.5									12	>1 ship, >1 type	20

36	17	110.0	21	150.0											38	>1 ship, >1 type	90
37									1	17.7					1	One ship	4
38													25		25	>1 ship, 1 type	6
39	2	12.9			2	15.7									4	>1 ship, >1 type	2
40	1	9.0	16	42.0	2	116.0	4	35.0	13	50.0					36	>1 ship, >1 type	60
41													11		11	>1 ship, 1 type	10
42	15	90.0													15	>1 ship, 1 type	40
43	10	95.0													10	>1 ship, 1 type	26
44													150	250.0	150	>1 ship, 1 type	8
45			12	55.1											12	>1 ship, 1 type	5
46													8		8	>1 ship, 1 type	5
47											30	150.0			30	>1 ship, 1 type	50
48	2				1								3		6	>1 ship, >1 type	9

Summary

Total															
-	114	-	77	-	84	-	17	-	43	-	94	-	379	-	808

Min - Max DWT Average (x 1,000)														
Min	-	3.3	-	2.6	-	3.0	-	1.2	-	1.7	-	0.4	-	0.5
Max	-	13.2	-	12.5	-	72.4	-	17.5	-	30.0	-	5.0	-	8.0

ID: Participants' identification number
DWT: Dead Weight Tonnage

Participants' profiles (items H2, H3, H5)

ID	Experience in Shipping	Job's Title	Exp. in the Job Position
	H2	H3	H5
1	more than 15 years	Operation Manager	6 - 10 years
2	more than 15 years	Technical Manager	2 - 5 years
3	11 - 15 years	-	11 - 15 years
4	more than 15 years	Operations Manager	6 - 10 years
5	no answer	-	more than 15 years
6	more than 15 years	Technical Manager	more than 15 years
7	more than 15 years	Maintenance Staff	2 - 5 years
8	11 - 15 years	Technical Manager	6 - 10 years
9	11 - 15 years	Technical Staff	6 - 10 years
10	11 - 15 years	Fleet Manager	2 - 5 years
11	more than 15 years	Fleet Operations General Manager	6 - 10 years
12	6 - 10 years	Marketing Manager	2 - 5 years
13	more than 15 years	Operations General Affair	2 - 5 years
14	more than 15 years	Senior Manager	2 - 5 years
15	more than 15 years	Director	2 - 5 years
16	more than 15 years	Executive Director	2 - 5 years
17	more than 15 years	Director	2 - 5 years
18	2 - 5 years	Technical Superintendent	2 - 5 years
19	2 - 5 years	Unit Fleet	2 - 5 years
20	6 - 10 years	Owner Surveyor	less than 2 years
21	more than 15 years	Senior Manager Ship Technique	6 - 10 years
22	more than 15 years	Senior Manager Logistics and Production Facilities	6 - 10 years
23	more than 15 years	Operations Manager	2 - 5 years
24	more than 15 years	Technical Superintendent	2 - 5 years
25	more than 15 years	Maintenance Manager	less than 2 years
26	more than 15 years	Operations and Technical Staff	2 - 5 years
27	6 - 10 years	Designated Person Ashore	2 - 5 years
28	more than 15 years	Technical Superintendent	6 - 10 years
29	6 - 10 years	Maintenance Manager	less than 2 years
30	more than 15 years	Operations Manager	2 - 5 years
31	6 - 10 years	Operations Staff	6 - 10 years
32	more than 15 years	Technical Superintendent	6 - 10 years
33	more than 15 years	Maintenance Manager	2 - 5 years
34	11 - 15 years	Operations Manager	6 - 10 years
35	6 - 10 years	Technical Manager	less than 2 years
36	6 - 10 years	Chief Fleet Division	6 - 10 years
37	more than 15 years	Technical Superintendent	6 - 10 years
38	11 - 15 years	HSE Officer	6 - 10 years
39	6 - 10 years	Manager	2 - 5 years
40	11 - 15 years	Designated Person Ashore	6 - 10 years

41	6 - 10 years	Fleet General Manager	6 - 10 years
42	more than 15 years	Superintendent	more than 15 years
43	more than 15 years	Fleet Operations Director	6 - 10 years
44	6 - 10 years	Superintendent	2 - 5 years
45	more than 15 years	Maintenance Staff	2 - 5 years
46	6 - 10 years	Operations Manager	6 - 10 years
47	more than 15 years	President Director	6 - 10 years
48	more than 15 years	Technical Superintendent	6 - 10 years

ID: Participants' identification number

Participants' profiles (items H6 – H7)

ID	Ed. Background	Other Degree	Carrier Supporting
	H6		H7
1	Certified Practitioner in Asset Management	-	Yes
2	Certified Practitioner in Asset Management	-	Yes
3	Other	Marine Engineer	Yes
4	Certified Practitioner in Asset Management	-	Yes
5	Other	Naval Architech	Yes
6	-	-	-
7	Other	Naval Architech	Yes
8	Other	Marine Engineer	Yes
9	-	-	-
10	Other	Marine Engineer	Yes
11	Other	Marine Engineer	Yes
12	-	-	-
13	-	-	-
14	Other	Naval Architech	Yes
15	-	-	-
16	Other	-	Yes
17	Diplome of Maintenance Management	Naval Architech	Yes
18	-	-	-
19	Certified Senior Practitioner in Asset Mgt	-	Yes
20	Other	Naval Architech	Yes
21	Other	-	Yes
22	Certified Senior Practitioner in Asset Mgt	-	Yes
23	Other	Naval Architech	Yes
24	Certified Practitioner in Asset Management	-	Yes
25	Diplome of Maintenance Managemetn	-	Yes
26	Certified Practitioner in Asset Management	-	Yes
27	-	-	No
28	Diplome of Maintenance Management	-	Yes
29	Other	Naval Architech	Yes
30	Other	Marine Engineer	Yes
31	Other	BE	Yes
32	Other	Marine Engineer	Yes
33	Other	Naval Architech	Yes
34	Other	Naval Architech	Unsure
35	-	-	-
36	Other	Naval Architech	Unsure
37	Other	Naval Architech	Yes
38	-	-	Yes
39	Other	Naval Architech	Yes
40	Other	Mariner	Yes
41	Other	Naval Architech	Yes

42	Certified Senior Practitioner in Asset Mgt	-	Yes
43	Other	Naval Architech	Yes
44	-	-	-
45	Other	Master of Management	Yes
46	-	-	Yes
47	-	-	Yes
48	-	-	Yes

ID: Participants’ identification number

Top management commitment and support (items C14-C16)

		Top management support for improving MRO purchase (C14)	Top management recognises MRO purchase as vital (C15)	MRO purchase as a strategy to company's competitiveness (C16)
N	Valid	47	46	46
	Missing	1	2	2
Mean		4.26	4.22	4.17
Std. Deviation		.820	.841	.973
Range		4	4	4

Summary of item C14: Top management support for improving MRO purchase

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	1	2.1	2.1	2.1
	disagree	1	2.1	2.1	4.3
	undecided	2	4.2	4.3	8.5
	agree	24	50.0	51.1	59.6
	strongly agree	19	39.6	40.4	100.0
	Total	47	97.9	100.0	
Missing	No answer	1	2.1		
Total		48	100.0		

Summary of item C15: Top management recognises MRO purchase as vital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	1	2.1	2.2	2.2
	disagree	1	2.1	2.2	4.3
	undecided	3	6.3	6.5	10.9
	agree	23	47.9	50.0	60.9
	strongly agree	18	37.5	39.1	100.0
	Total	46	95.8	100.0	
Missing	not applicable	1	2.1		
	no answer	1	2.1		
	Total	2	4.2		
Total		48	100.0		

MRO purchase as a strategy to company's competitiveness

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	1	2.1	2.2	2.2
	disagree	3	6.3	6.5	8.7
	undecided	3	6.3	6.5	15.2
	agree	19	39.6	41.3	56.5
	strongly agree	20	41.7	43.5	100.0
	Total	46	95.8	100.0	
Missing	not applicable	1	2.1		
	no answer	1	2.1		
	Total	2	4.2		
Total		48	100.0		

Internal integration behaviour (Pearson product-moment correlation test item A9-A14)

CORRS
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/PRINT=TWOTAIL NOSIG
/MISSING=PAIRWISE.

Correlations of Chief Executive Officer's involvement in maintenance management activities

		CEO involv in mtc plan'g	CEO involv in inv'y control	CEO involv in mtc eval	CEO involv in specs settings	CEO involv in alloc mtc $
CEO involv in mtc plan'g	Pearson Corr	1.000**	.673**	.834**	.701**	.665**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	37	36	37	37	35
CEO involv in inv'y control	Pearson Corr	.673**	1.000**	.572**	.718**	.500**
	Sig. (2-tailed)	.000	.000	.000	.000	.003
	N	36	36	36	36	34
CEO involv in mtc eval	Pearson Corr	.834**	.572**	1.000**	.702**	.559**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	37	36	38	37	35
CEO involv in specs settings	Pearson Corr	.701**	.718**	.702**	1.000**	.506**
	Sig. (2-tailed)	.000	.000	.000	.000	.002
	N	37	36	37	37	35
CEO involv in alloc mtc $	Pearson Corr	.665**	.500**	.559**	.506**	1.000**
	Sig. (2-tailed)	.000	.003	.000	.002	.000
	N	35	34	35	35	35
BOD involv in mtc plan'g	Pearson Corr	.444**	.255	.342*	.255	.370*
	Sig. (2-tailed)	.007	.140	.041	.133	.031
	N	36	35	36	36	34
BOD involv in inv'y control	Pearson Corr	.461**	.514**	.378*	.342*	.446**
	Sig. (2-tailed)	.005	.002	.025	.045	.009
	N	35	35	35	35	33
BOD involv in mtc eval	Pearson Corr	.168	.186	.332*	.169	.089
	Sig. (2-tailed)	.327	.286	.048	.324	.618
	N	36	35	36	36	34
BOD involv in specs settings	Pearson Corr	.550**	.503**	.451**	.539**	.467**
	Sig. (2-tailed)	.001	.002	.006	.001	.005
	N	36	35	36	36	34
BOD involv in alloc mtc $	Pearson Corr	.265	.076	.162	-.011	.459**
	Sig. (2-tailed)	.119	.663	.344	.948	.006
	N	36	35	36	36	34
Ops Mgr involv in mtc plan'g	Pearson Corr	.118	.091	-.028	-.151	.234
	Sig. (2-tailed)	.494	.603	.869	.379	.183
	N	36	35	36	36	34
Ops Mgr involv in inv'y control	Pearson Corr	.057	.154	.100	-.037	-.002
	Sig. (2-tailed)	.744	.376	.570	.832	.989
	N	35	35	35	35	33
Ops Mgr involv in mtc eval	Pearson Corr	.043	-.030	.145	-.166	-.025
	Sig. (2-tailed)	.805	.863	.405	.339	.891
	N	35	35	35	35	33
Ops Mgr involv in specs settings	Pearson Corr	.034	.123	.100	-.039	-.016
	Sig. (2-tailed)	.848	.482	.567	.824	.928
	N	35	35	35	35	33
Ops Mgr involv in alloc mtc $	Pearson Corr	-.067	-.125	-.053	-.188	-.016
	Sig. (2-tailed)	.705	.480	.767	.288	.931
	N	34	34	34	34	33
Mtc Mgr involv in mtc plan'g	Pearson Corr	.224	.124	.262	.190	.216
	Sig. (2-tailed)	.183	.472	.112	.261	.213
	N	37	36	38	37	35

Mtc Mgr involv in inv'y control	Pearson Corr	-.059	-.142	-.050	-.137	.203
	Sig. (2-tailed)	.731	.409	.767	.420	.243
	N	37	36	38	37	35
Mtc Mgr involv in mtc eval	Pearson Corr	.241	.114	.291	.196	.042
	Sig. (2-tailed)	.151	.509	.076	.246	.809
	N	37	36	38	37	35
Mtc Mgr involv in specs settings	Pearson Corr	-.130	-.212	-.033	-.100	.022
	Sig. (2-tailed)	.442	.214	.843	.557	.900
	N	37	36	38	37	35
Mtc Mgr involv in alloc mtc $	Pearson Corr	.300	.166	.320	.158	.211
	Sig. (2-tailed)	.080	.349	.057	.366	.231
	N	35	34	36	35	34
Proc Mgr involv in mtc plan'g	Pearson Corr	.147	.228	.010	.185	.071
	Sig. (2-tailed)	.392	.188	.956	.279	.689
	N	36	35	36	36	34
Proc Mgr involv in inv'y control	Pearson Corr	.028	-.041	-.072	.054	-.019
	Sig. (2-tailed)	.869	.817	.677	.754	.917
	N	36	35	36	36	34
Proc Mgr involv in mtc eval	Pearson Corr	.318	.220	.262	.278	.236
	Sig. (2-tailed)	.059	.205	.123	.100	.179
	N	36	35	36	36	34
Proc Mgr involv in specs settings	Pearson Corr	.053	-.027	.076	.085	-.213
	Sig. (2-tailed)	.758	.877	.660	.623	.227
	N	36	35	36	36	34
Proc Mgr involv in alloc mtc $	Pearson Corr	.140	.092	.177	.233	.143
	Sig. (2-tailed)	.422	.604	.310	.178	.421
	N	35	34	35	35	34
Fin Mgr involv in mtc plan'g	Pearson Corr	.415*	.545**	.280	.405*	.410*
	Sig. (2-tailed)	.011	.001	.093	.013	.014
	N	37	36	37	37	35
Fin Mgr involv in inv'y control	Pearson Corr	.402*	.523**	.289	.246	.274
	Sig. (2-tailed)	.014	.001	.083	.143	.111
	N	37	36	37	37	35
Fin Mgr involv in mtc eval	Pearson Corr	.334*	.450**	.372*	.226	.168
	Sig. (2-tailed)	.043	.006	.024	.178	.334
	N	37	36	37	37	35
Fin Mgr involv in specs settings	Pearson Corr	.344*	.515**	.205	.331*	.212
	Sig. (2-tailed)	.040	.002	.231	.048	.229
	N	36	35	36	36	34
Fin Mgr involv in alloc mtc $	Pearson Corr	.117	-.072	.164	.108	.211
	Sig. (2-tailed)	.499	.680	.339	.529	.225
	N	36	35	36	36	35

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Correlations of Board of Directors' involvement in maintenance management activities

		BOD involv in mtc plan'g	BOD involv in inv'y control	BOD involv in mtc eval	BOD involv in specs settings	BOD involv in alloc mtc $
CEO involv in mtc plan'g	Pearson Corr	.444**	.461**	.168	.550**	.265
	Sig. (2-tailed)	.007	.005	.327	.001	.119
	N	36	35	36	36	36
CEO involv in inv'y control	Pearson Corr	.255	.514**	.186	.503**	.076
	Sig. (2-tailed)	.140	.002	.286	.002	.663
	N	35	35	35	35	35
CEO involv in mtc eval	Pearson Corr	.342*	.378*	.332*	.451**	.162
	Sig. (2-tailed)	.041	.025	.048	.006	.344
	N	36	35	36	36	36

CEO involv in specs settings	Pearson Corr	.255	.342*	.169	.539**	-.011
	Sig. (2-tailed)	.133	.045	.324	.001	.948
	N	36	35	36	36	36
CEO involv in alloc mtc $	Pearson Corr	.370*	.446**	.089	.467**	.459**
	Sig. (2-tailed)	.031	.009	.618	.005	.006
	N	34	33	34	34	34
BOD involv in mtc plan'g	Pearson Corr	1.000	.764**	.533**	.761**	.527**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	44	43	44	43	44
BOD involv in inv'y control	Pearson Corr	.764**	1.000**	.407**	.773**	.490**
	Sig. (2-tailed)	.000	.000	.007	.000	.001
	N	43	43	43	42	43
BOD involv in mtc eval	Pearson Corr	.533**	.407**	1.000**	.542**	.389**
	Sig. (2-tailed)	.000	.007	.000	.000	.009
	N	44	43	44	43	44
BOD involv in specs settings	Pearson Corr	.761**	.773**	.542**	1.000**	.395**
	Sig. (2-tailed)	.000	.000	.000	.000	.009
	N	43	42	43	43	43
BOD involv in alloc mtc $	Pearson Corr	.527**	.490**	.389**	.395**	1.000**
	Sig. (2-tailed)	.000	.001	.009	.009	.000
	N	44	43	44	43	44
Ops Mgr involv in mtc plan'g	Pearson Corr	.537**	.436**	.226	.308*	.282
	Sig. (2-tailed)	.000	.004	.146	.047	.067
	N	43	42	43	42	43
Ops Mgr involv in inv'y control	Pearson Corr	.295	.428**	.179	.266	.016
	Sig. (2-tailed)	.058	.005	.257	.093	.921
	N	42	42	42	41	42
Ops Mgr involv in mtc eval	Pearson Corr	.395**	.306*	.575**	.263	.208
	Sig. (2-tailed)	.010	.049	.000	.097	.187
	N	42	42	42	41	42
Ops Mgr involv in specs settings	Pearson Corr	.356*	.480**	.238	.378*	.079
	Sig. (2-tailed)	.021	.001	.129	.015	.617
	N	42	42	42	41	42
Ops Mgr involv in alloc mtc $	Pearson Corr	.200	.257	.206	.184	.248
	Sig. (2-tailed)	.210	.105	.197	.256	.118
	N	41	41	41	40	41
Mtc Mgr involv in mtc plan'g	Pearson Corr	.135	.041	.219	.112	.234
	Sig. (2-tailed)	.388	.798	.158	.482	.131
	N	43	42	43	42	43
Mtc Mgr involv in inv'y control	Pearson Corr	-.048	.153	-.139	-.160	.251
	Sig. (2-tailed)	.758	.332	.376	.312	.104
	N	43	42	43	42	43
Mtc Mgr involv in mtc eval	Pearson Corr	.038	.051	.206	-.005	.095
	Sig. (2-tailed)	.810	.750	.185	.974	.543
	N	43	42	43	42	43
Mtc Mgr involv in specs settings	Pearson Corr	-.040	.022	-.037	-.166	.188
	Sig. (2-tailed)	.799	.888	.812	.293	.228
	N	43	42	43	42	43
Mtc Mgr involv in alloc mtc $	Pearson Corr	-.127	-.095	-.037	-.044	-.102
	Sig. (2-tailed)	.430	.560	.819	.787	.525
	N	41	40	41	40	41
Proc Mgr involv in mtc plan'g	Pearson Corr	.055	.235	-.252	.069	-.193
	Sig. (2-tailed)	.728	.139	.108	.666	.221
	N	42	41	42	41	42
Proc Mgr involv in inv'y control	Pearson Corr	.293	.171	.227	.149	-.084
	Sig. (2-tailed)	.060	.284	.148	.352	.596
	N	42	41	42	41	42
Proc Mgr involv in mtc eval	Pearson Corr	.098	.222	-.174	.117	-.090
	Sig. (2-tailed)	.536	.164	.272	.468	.571
	N	42	41	42	41	42
Proc Mgr involv in specs settings	Pearson Corr	.232	.116	-.009	.191	-.087
	Sig. (2-tailed)	.139	.470	.955	.232	.582
	N	42	41	42	41	42

Proc Mgr involv in alloc mtc $	Pearson Corr	-.116	.149	-.287	-.039	-.069
	Sig. (2-tailed)	.468	.359	.069	.812	.666
	N	41	40	41	40	41
Fin Mgr involv in mtc plan'g	Pearson Corr	.384*	.450**	.239	.499**	.047
	Sig. (2-tailed)	.010	.002	.119	.001	.762
	N	44	43	44	43	44
Fin Mgr involv in inv'y control	Pearson Corr	.327*	.474**	.298*	.456**	.117
	Sig. (2-tailed)	.030	.001	.050	.002	.451
	N	44	43	44	43	44
Fin Mgr involv in mtc eval	Pearson Corr	.065	.192	.224	.119	.013
	Sig. (2-tailed)	.674	.216	.143	.448	.934
	N	44	43	44	43	44
Fin Mgr involv in specs settings	Pearson Corr	.067	.213	-.099	.235	-.115
	Sig. (2-tailed)	.667	.171	.524	.129	.459
	N	44	43	44	43	44
Fin Mgr involv in alloc mtc $	Pearson Corr	-.086	.068	.029	.162	.089
	Sig. (2-tailed)	.583	.667	.855	.305	.570
	N	43	42	43	42	43

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Correlations of operations managers' involvement in maintenance management activities

		Ops Mgr involv in mtc plan'g	Ops Mgr involv in inv'y control	Ops Mgr involv in mtc eval	Ops Mgr involv in specs settings	Ops Mgr involv in alloc mtc $
CEO involv in mtc plan'g	Pearson Corr	.118	.057	.043	.034	-.067
	Sig. (2-tailed)	.494	.744	.805	.848	.705
	N	36	35	35	35	34
CEO involv in inv'y control	Pearson Corr	.091	.154	-.030	.123	-.125
	Sig. (2-tailed)	.603	.376	.863	.482	.480
	N	35	35	35	35	34
CEO involv in mtc eval	Pearson Corr	-.028	.100	.145	.100	-.053
	Sig. (2-tailed)	.869	.570	.405	.567	.767
	N	36	35	35	35	34
CEO involv in specs settings	Pearson Corr	-.151	-.037	-.166	-.039	-.188
	Sig. (2-tailed)	.379	.832	.339	.824	.288
	N	36	35	35	35	34
CEO involv in alloc mtc $	Pearson Corr	.234	-.002	-.025	-.016	-.016
	Sig. (2-tailed)	.183	.989	.891	.928	.931
	N	34	33	33	33	33
BOD involv in mtc plan'g	Pearson Corr	.537**	.295	.395**	.356*	.200
	Sig. (2-tailed)	.000	.058	.010	.021	.210
	N	43	42	42	42	41
BOD involv in inv'y control	Pearson Corr	.436**	.428**	.306*	.480**	.257
	Sig. (2-tailed)	.004	.005	.049	.001	.105
	N	42	42	42	42	41
BOD involv in mtc eval	Pearson Corr	.226	.179	.575**	.238	.206
	Sig. (2-tailed)	.146	.257	.000	.129	.197
	N	43	42	42	42	41
BOD involv in specs settings	Pearson Corr	.308*	.266	.263	.378*	.184
	Sig. (2-tailed)	.047	.093	.097	.015	.256
	N	42	41	41	41	40
BOD involv in alloc mtc $	Pearson Corr	.282	.016	.208	.079	.248
	Sig. (2-tailed)	.067	.921	.187	.617	.118
	N	43	42	42	42	41

Ops Mgr involv in mtc plan'g	Pearson Corr	1.000**	.480**	.528**	.487**	.256
	Sig. (2-tailed)	.000	.001	.000	.001	.093
	N	46	45	45	45	44
Ops Mgr involv in inv'y control	Pearson Corr	.480**	1.000**	.621**	.806**	.480**
	Sig. (2-tailed)	.001	.000	.000	.000	.001
	N	45	45	45	45	44
Ops Mgr involv in mtc eval	Pearson Corr	.528**	.621**	1.000**	.702**	.476**
	Sig. (2-tailed)	.000	.000	.000	.000	.001
	N	45	45	45	45	44
Ops Mgr involv in specs settings	Pearson Corr	.487**	.806**	.702**	1.000**	.614**
	Sig. (2-tailed)	.001	.000	.000	.000	.000
	N	45	45	45	45	44
Ops Mgr involv in alloc mtc $	Pearson Corr	.256	.480**	.476**	.614**	1.000**
	Sig. (2-tailed)	.093	.001	.001	.000	.000
	N	44	44	44	44	44
Mtc Mgr involv in mtc plan'g	Pearson Corr	.069	-.017	.015	-.028	-.075
	Sig. (2-tailed)	.653	.911	.925	.855	.635
	N	45	44	44	44	43
Mtc Mgr involv in inv'y control	Pearson Corr	.171	.137	-.204	-.104	-.143
	Sig. (2-tailed)	.260	.375	.185	.502	.360
	N	45	44	44	44	43
Mtc Mgr involv in mtc eval	Pearson Corr	.047	-.021	.051	-.035	-.153
	Sig. (2-tailed)	.761	.890	.740	.821	.328
	N	45	44	44	44	43
Mtc Mgr involv in specs settings	Pearson Corr	-.046	-.031	-.169	-.240	-.092
	Sig. (2-tailed)	.766	.839	.273	.116	.559
	N	45	44	44	44	43
Mtc Mgr involv in alloc mtc $	Pearson Corr	.034	.029	.203	.051	-.035
	Sig. (2-tailed)	.827	.856	.198	.750	.825
	N	43	42	42	42	42
Proc Mgr involv in mtc plan'g	Pearson Corr	.199	.428**	-.039	.367*	.078
	Sig. (2-tailed)	.194	.004	.803	.016	.622
	N	44	43	43	43	42
Proc Mgr involv in inv'y control	Pearson Corr	.253	.135	.270	.149	-.038
	Sig. (2-tailed)	.098	.389	.080	.342	.811
	N	44	43	43	43	42
Proc Mgr involv in mtc eval	Pearson Corr	.198	.426**	.044	.172	.117
	Sig. (2-tailed)	.199	.004	.778	.271	.459
	N	44	43	43	43	42
Proc Mgr involv in specs settings	Pearson Corr	.146	-.005	.081	.075	-.148
	Sig. (2-tailed)	.345	.974	.606	.634	.349
	N	44	43	43	43	42
Proc Mgr involv in alloc mtc $	Pearson Corr	-.080	.238	-.100	.176	.088
	Sig. (2-tailed)	.608	.129	.528	.264	.578
	N	43	42	42	42	42
Fin Mgr involv in mtc plan'g	Pearson Corr	.363*	.342*	.271	.434**	.215
	Sig. (2-tailed)	.013	.022	.072	.003	.162
	N	46	45	45	45	44
Fin Mgr involv in inv'y control	Pearson Corr	.403**	.468**	.334*	.389**	.314*
	Sig. (2-tailed)	.006	.001	.025	.008	.038
	N	46	45	45	45	44
Fin Mgr involv in mtc eval	Pearson Corr	.165	.404**	.293	.298*	.310*
	Sig. (2-tailed)	.274	.006	.051	.047	.040
	N	46	45	45	45	44
Fin Mgr involv in specs settings	Pearson Corr	.014	.116	-.132	.146	.031
	Sig. (2-tailed)	.926	.455	.394	.343	.846
	N	45	44	44	44	43
Fin Mgr involv in alloc mtc $	Pearson Corr	.011	.090	-.061	.100	.188
	Sig. (2-tailed)	.941	.561	.694	.517	.221
	N	45	44	44	44	44

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Correlations of maintenance managers' involvement in maintenance management activities

		Mtc Mgr involv in mtc plan'g	Mtc Mgr involv in inv'y control	Mtc Mgr involv in mtc eval	Mtc Mgr involv in specs settings	Mtc Mgr involv in alloc mtc $
CEO involv in mtc plan'g	Pearson Corr	.224	-.059	.241	-.130	.300
	Sig. (2-tailed)	.183	.731	.151	.442	.080
	N	37	37	37	37	35
CEO involv in inv'y control	Pearson Corr	.124	-.142	.114	-.212	.166
	Sig. (2-tailed)	.472	.409	.509	.214	.349
	N	36	36	36	36	34
CEO involv in mtc eval	Pearson Corr	.262	-.050	.291	-.033	.320
	Sig. (2-tailed)	.112	.767	.076	.843	.057
	N	38	38	38	38	36
CEO involv in specs settings	Pearson Corr	.190	-.137	.196	-.100	.158
	Sig. (2-tailed)	.261	.420	.246	.557	.366
	N	37	37	37	37	35
CEO involv in alloc mtc $	Pearson Corr	.216	.203	.042	.022	.211
	Sig. (2-tailed)	.213	.243	.809	.900	.231
	N	35	35	35	35	34
BOD involv in mtc plan'g	Pearson Corr	.135	-.048	.038	-.040	-.127
	Sig. (2-tailed)	.388	.758	.810	.799	.430
	N	43	43	43	43	41
BOD involv in inv'y control	Pearson Corr	.041	.153	.051	.022	-.095
	Sig. (2-tailed)	.798	.332	.750	.888	.560
	N	42	42	42	42	40
BOD involv in mtc eval	Pearson Corr	.219	-.139	.206	-.037	-.037
	Sig. (2-tailed)	.158	.376	.185	.812	.819
	N	43	43	43	43	41
BOD involv in specs settings	Pearson Corr	.112	-.160	-.005	-.166	-.044
	Sig. (2-tailed)	.482	.312	.974	.293	.787
	N	42	42	42	42	40
BOD involv in alloc mtc $	Pearson Corr	.234	.251	.095	.188	-.102
	Sig. (2-tailed)	.131	.104	.543	.228	.525
	N	43	43	43	43	41
Ops Mgr involv in mtc plan'g	Pearson Corr	.069	.171	.047	-.046	.034
	Sig. (2-tailed)	.653	.260	.761	.766	.827
	N	45	45	45	45	43
Ops Mgr involv in inv'y control	Pearson Corr	-.017	.137	-.021	-.031	.029
	Sig. (2-tailed)	.911	.375	.890	.839	.856
	N	44	44	44	44	42
Ops Mgr involv in mtc eval	Pearson Corr	.015	-.204	.051	-.169	.203
	Sig. (2-tailed)	.925	.185	.740	.273	.198
	N	44	44	44	44	42
Ops Mgr involv in specs settings	Pearson Corr	-.028	-.104	-.035	-.240	.051
	Sig. (2-tailed)	.855	.502	.821	.116	.750
	N	44	44	44	44	42
Ops Mgr involv in alloc mtc $	Pearson Corr	-.075	-.143	-.153	-.092	-.035
	Sig. (2-tailed)	.635	.360	.328	.559	.825
	N	43	43	43	43	42
Mtc Mgr involv in mtc plan'g	Pearson Corr	1.000**	.037	.807**	.208	.200
	Sig. (2-tailed)	.000	.804	.000	.161	.188
	N	47	47	47	47	45
Mtc Mgr involv in inv'y control	Pearson Corr	.037	1.000**	.102	.646**	.060
	Sig. (2-tailed)	.804	.000	.497	.000	.694
	N	47	47	47	47	45
Mtc Mgr involv in mtc eval	Pearson Corr	.807**	.102	1.000**	.135	.122
	Sig. (2-tailed)	.000	.497	.000	.365	.423
	N	47	47	47	47	45
Mtc Mgr involv in specs settings	Pearson Corr	.208	.646**	.135	1.000**	.197
	Sig. (2-tailed)	.161	.000	.365	.000	.195
	N	47	47	47	47	45
Mtc Mgr involv in alloc mtc $	Pearson Corr	.200	.060	.122	.197	1.000**
	Sig. (2-tailed)	.188	.694	.423	.195	.000
	N	45	45	45	45	45

Proc Mgr involv in mtc plan'g	Pearson Corr	.078	.324*	.036	.114	-.006
	Sig. (2-tailed)	.609	.030	.813	.456	.967
	N	45	45	45	45	44
Proc Mgr involv in inv'y control	Pearson Corr	.364*	-.029	.353*	.049	-.022
	Sig. (2-tailed)	.014	.852	.017	.747	.887
	N	45	45	45	45	44
Proc Mgr involv in mtc eval	Pearson Corr	.151	.298*	.083	.228	.294
	Sig. (2-tailed)	.324	.046	.588	.132	.052
	N	45	45	45	45	44
Proc Mgr involv in specs settings	Pearson Corr	-.052	-.071	-.018	.054	.105
	Sig. (2-tailed)	.736	.645	.905	.722	.499
	N	45	45	45	45	44
Proc Mgr involv in alloc mtc $	Pearson Corr	.037	.358*	.015	.431**	.275
	Sig. (2-tailed)	.812	.017	.922	.004	.071
	N	44	44	44	44	44
Fin Mgr involv in mtc plan'g	Pearson Corr	.096	-.248	.060	-.333*	.136
	Sig. (2-tailed)	.528	.097	.693	.024	.379
	N	46	46	46	46	44
Fin Mgr involv in inv'y control	Pearson Corr	.072	.042	.090	-.243	.208
	Sig. (2-tailed)	.633	.784	.554	.104	.175
	N	46	46	46	46	44
Fin Mgr involv in mtc eval	Pearson Corr	.104	-.042	.067	-.133	.313*
	Sig. (2-tailed)	.492	.782	.658	.379	.038
	N	46	46	46	46	44
Fin Mgr involv in specs settings	Pearson Corr	-.005	-.022	.026	-.106	.242
	Sig. (2-tailed)	.973	.887	.864	.489	.118
	N	45	45	45	45	43
Fin Mgr involv in alloc mtc $	Pearson Corr	.476**	.013	.350*	.190	-.033
	Sig. (2-tailed)	.001	.931	.018	.211	.833
	N	45	45	45	45	44

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Correlations of procurement managers' involvement in maintenance management activities

		Proc Mgr involv in mtc plan'g	Proc Mgr involv in inv'y control	Proc Mgr involv in mtc eval	Proc Mgr involv in specs settings	Proc Mgr involv in alloc mtc $
CEO involv in mtc plan'g	Pearson Corr	.147	.028	.318	.053	.140
	Sig. (2-tailed)	.392	.869	.059	.758	.422
	N	36	36	36	36	35
CEO involv in inv'y control	Pearson Corr	.228	-.041	.220	-.027	.092
	Sig. (2-tailed)	.188	.817	.205	.877	.604
	N	35	35	35	35	34
CEO involv in mtc eval	Pearson Corr	.010	-.072	.262	.076	.177
	Sig. (2-tailed)	.956	.677	.123	.660	.310
	N	36	36	36	36	35
CEO involv in specs settings	Pearson Corr	.185	.054	.278	.085	.233
	Sig. (2-tailed)	.279	.754	.100	.623	.178
	N	36	36	36	36	35
CEO involv in alloc mtc $	Pearson Corr	.071	-.019	.236	-.213	.143
	Sig. (2-tailed)	.689	.917	.179	.227	.421
	N	34	34	34	34	34
BOD involv in mtc plan'g	Pearson Corr	.055	.293	.098	.232	-.116
	Sig. (2-tailed)	.728	.060	.536	.139	.468
	N	42	42	42	42	41
BOD involv in inv'y control	Pearson Corr	.235	.171	.222	.116	.149
	Sig. (2-tailed)	.139	.284	.164	.470	.359
	N	41	41	41	41	40
BOD involv in mtc eval	Pearson Corr	-.252	.227	-.174	-.009	-.287
	Sig. (2-tailed)	.108	.148	.272	.955	.069
	N	42	42	42	42	41

BOD involv in specs settings	Pearson Corr	.069	.149	.117	.191	-.039
	Sig. (2-tailed)	.666	.352	.468	.232	.812
	N	41	41	41	41	40
BOD involv in alloc mtc $	Pearson Corr	-.193	-.084	-.090	-.087	-.069
	Sig. (2-tailed)	.221	.596	.571	.582	.666
	N	42	42	42	42	41
Ops Mgr involv in mtc plan'g	Pearson Corr	.199	.253	.198	.146	-.080
	Sig. (2-tailed)	.194	.098	.199	.345	.608
	N	44	44	44	44	43
Ops Mgr involv in inv'y control	Pearson Corr	.428**	.135	.426**	-.005	.238
	Sig. (2-tailed)	.004	.389	.004	.974	.129
	N	43	43	43	43	42
Ops Mgr involv in mtc eval	Pearson Corr	-.039	.270	.044	.081	-.100
	Sig. (2-tailed)	.803	.080	.778	.606	.528
	N	43	43	43	43	42
Ops Mgr involv in specs settings	Pearson Corr	.367*	.149	.172	.075	.176
	Sig. (2-tailed)	.016	.342	.271	.634	.264
	N	43	43	43	43	42
Ops Mgr involv in alloc mtc $	Pearson Corr	.078	-.038	.117	-.148	.088
	Sig. (2-tailed)	.622	.811	.459	.349	.578
	N	42	42	42	42	42
Mtc Mgr involv in mtc plan'g	Pearson Corr	.078	.364*	.151	-.052	.037
	Sig. (2-tailed)	.609	.014	.324	.736	.812
	N	45	45	45	45	44
Mtc Mgr involv in inv'y control	Pearson Corr	.324*	-.029	.298*	-.071	.358*
	Sig. (2-tailed)	.030	.852	.046	.645	.017
	N	45	45	45	45	44
Mtc Mgr involv in mtc eval	Pearson Corr	.036	.353*	.083	-.018	.015
	Sig. (2-tailed)	.813	.017	.588	.905	.922
	N	45	45	45	45	44
Mtc Mgr involv in specs settings	Pearson Corr	.114	.049	.228	.054	.431**
	Sig. (2-tailed)	.456	.747	.132	.722	.004
	N	45	45	45	45	44
Mtc Mgr involv in alloc mtc $	Pearson Corr	-.006	-.022	.294	.105	.275
	Sig. (2-tailed)	.967	.887	.052	.499	.071
	N	44	44	44	44	44
Proc Mgr involv in mtc plan'g	Pearson Corr	1.000**	.452**	.579**	.118	.445**
	Sig. (2-tailed)	.000	.002	.000	.441	.002
	N	45	45	45	45	44
Proc Mgr involv in inv'y control	Pearson Corr	.452**	1.000**	.235	.090	-.048
	Sig. (2-tailed)	.002	.000	.120	.556	.759
	N	45	45	45	45	44
Proc Mgr involv in mtc eval	Pearson Corr	.579**	.235	1.000**	.269	.606**
	Sig. (2-tailed)	.000	.120	.000	.074	.000
	N	45	45	45	45	44
Proc Mgr involv in specs settings	Pearson Corr	.118	.090	.269	1.000**	.290
	Sig. (2-tailed)	.441	.556	.074	.000	.056
	N	45	45	45	45	44
Proc Mgr involv in alloc mtc $	Pearson Corr	.445**	-.048	.606**	.290	1.000**
	Sig. (2-tailed)	.002	.759	.000	.056	.000
	N	44	44	44	44	44
Fin Mgr involv in mtc plan'g	Pearson Corr	.312*	.146	.198	-.023	.026
	Sig. (2-tailed)	.037	.340	.193	.879	.869
	N	45	45	45	45	44
Fin Mgr involv in inv'y control	Pearson Corr	.212	.117	.389**	-.035	.051
	Sig. (2-tailed)	.162	.445	.008	.822	.741
	N	45	45	45	45	44
Fin Mgr involv in mtc eval	Pearson Corr	.111	-.028	.386**	-.205	.131
	Sig. (2-tailed)	.469	.858	.009	.176	.395
	N	45	45	45	45	44
Fin Mgr involv in specs settings	Pearson Corr	.328*	.011	.352*	.139	.369*
	Sig. (2-tailed)	.030	.943	.019	.369	.015
	N	44	44	44	44	43

Fin Mgr involv in alloc mtc $	Pearson Corr	.194	.119	.350*	-.077	.278
	Sig. (2-tailed)	.207	.443	.020	.618	.068
	N	44	44	44	44	44

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Correlations of finance managers' involvement in maintenance management activities

		Fin Mgr involv in mtc plan'g	Fin Mgr involv in inv'y control	Fin Mgr involv in mtc eval	Fin Mgr involv in specs settings	Fin Mgr involv in alloc mtc $
CEO involv in mtc plan'g	Pearson Corr	.415*	.402*	.334*	.344*	.117
	Sig. (2-tailed)	.011	.014	.043	.040	.499
	N	37	37	37	36	36
CEO involv in inv'y control	Pearson Corr	.545**	.523**	.450**	.515**	-.072
	Sig. (2-tailed)	.001	.001	.006	.002	.680
	N	36	36	36	35	35
CEO involv in mtc eval	Pearson Corr	.280	.289	.372*	.205	.164
	Sig. (2-tailed)	.093	.083	.024	.231	.339
	N	37	37	37	36	36
CEO involv in specs settings	Pearson Corr	.405*	.246	.226	.331*	.108
	Sig. (2-tailed)	.013	.143	.178	.048	.529
	N	37	37	37	36	36
CEO involv in alloc mtc $	Pearson Corr	.410*	.274	.168	.212	.211
	Sig. (2-tailed)	.014	.111	.334	.229	.225
	N	35	35	35	34	35
BOD involv in mtc plan'g	Pearson Corr	.384*	.327*	.065	.067	-.086
	Sig. (2-tailed)	.010	.030	.674	.667	.583
	N	44	44	44	44	43
BOD involv in inv'y control	Pearson Corr	.450**	.474**	.192	.213	.068
	Sig. (2-tailed)	.002	.001	.216	.171	.667
	N	43	43	43	43	42
BOD involv in mtc eval	Pearson Corr	.239	.298*	.224	-.099	.029
	Sig. (2-tailed)	.119	.050	.143	.524	.855
	N	44	44	44	44	43
BOD involv in specs settings	Pearson Corr	.499**	.456**	.119	.235	.162
	Sig. (2-tailed)	.001	.002	.448	.129	.305
	N	43	43	43	43	42
BOD involv in alloc mtc $	Pearson Corr	.047	.117	.013	-.115	.089
	Sig. (2-tailed)	.762	.451	.934	.459	.570
	N	44	44	44	44	43
Ops Mgr involv in mtc plan'g	Pearson Corr	.363*	.403**	.165	.014	.011
	Sig. (2-tailed)	.013	.006	.274	.926	.941
	N	46	46	46	45	45
Ops Mgr involv in inv'y control	Pearson Corr	.342*	.468**	.404**	.116	.090
	Sig. (2-tailed)	.022	.001	.006	.455	.561
	N	45	45	45	44	44
Ops Mgr involv in mtc eval	Pearson Corr	.271	.334*	.293	-.132	-.061
	Sig. (2-tailed)	.072	.025	.051	.394	.694
	N	45	45	45	44	44
Ops Mgr involv in specs settings	Pearson Corr	.434**	.389**	.298*	.146	.100
	Sig. (2-tailed)	.003	.008	.047	.343	.517
	N	45	45	45	44	44
Ops Mgr involv in alloc mtc $	Pearson Corr	.215	.314*	.310*	.031	.188
	Sig. (2-tailed)	.162	.038	.040	.846	.221
	N	44	44	44	43	44
Mtc Mgr involv in mtc plan'g	Pearson Corr	.096	.072	.104	-.005	.476**
	Sig. (2-tailed)	.528	.633	.492	.973	.001
	N	46	46	46	45	45
Mtc Mgr involv in inv'y control	Pearson Corr	-.248	.042	-.042	-.022	.013
	Sig. (2-tailed)	.097	.784	.782	.887	.931
	N	46	46	46	45	45

Mtc Mgr involv in mtc eval	Pearson Corr	.060	.090	.067	.026	.350*
	Sig. (2-tailed)	.693	.554	.658	.864	.018
	N	46	46	46	45	45
Mtc Mgr involv in specs settings	Pearson Corr	-.333*	-.243	-.133	-.106	.190
	Sig. (2-tailed)	.024	.104	.379	.489	.211
	N	46	46	46	45	45
Mtc Mgr involv in alloc mtc $	Pearson Corr	.136	.208	.313*	.242	-.033
	Sig. (2-tailed)	.379	.175	.038	.118	.833
	N	44	44	44	43	44
Proc Mgr involv in mtc plan'g	Pearson Corr	.312*	.212	.111	.328*	.194
	Sig. (2-tailed)	.037	.162	.469	.030	.207
	N	45	45	45	44	44
Proc Mgr involv in inv'y control	Pearson Corr	.146	.117	-.028	.011	.119
	Sig. (2-tailed)	.340	.445	.858	.943	.443
	N	45	45	45	44	44
Proc Mgr involv in mtc eval	Pearson Corr	.198	.389**	.386**	.352*	.350*
	Sig. (2-tailed)	.193	.008	.009	.019	.020
	N	45	45	45	44	44
Proc Mgr involv in specs settings	Pearson Corr	-.023	-.035	-.205	.139	-.077
	Sig. (2-tailed)	.879	.822	.176	.369	.618
	N	45	45	45	44	44
Proc Mgr involv in alloc mtc $	Pearson Corr	.026	.051	.131	.369*	.278
	Sig. (2-tailed)	.869	.741	.395	.015	.068
	N	44	44	44	43	44
Fin Mgr involv in mtc plan'g	Pearson Corr	1.000**	.658**	.450**	.541**	.174
	Sig. (2-tailed)	.000	.000	.001	.000	.247
	N	47	47	47	46	46
Fin Mgr involv in inv'y control	Pearson Corr	.658**	1.000**	.721**	.503**	.097
	Sig. (2-tailed)	.000	.000	.000	.000	.520
	N	47	47	47	46	46
Fin Mgr involv in mtc eval	Pearson Corr	.450**	.721**	1.000**	.496**	.205
	Sig. (2-tailed)	.001	.000	.000	.000	.171
	N	47	47	47	46	46
Fin Mgr involv in specs settings	Pearson Corr	.541**	.503**	.496**	1.000**	.149
	Sig. (2-tailed)	.000	.000	.000	.000	.327
	N	46	46	46	46	45
Fin Mgr involv in alloc mtc $	Pearson Corr	.174	.097	.205	.149	1.000**
	Sig. (2-tailed)	.247	.520	.171	.327	.000
	N	46	46	46	45	46

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Responsibilities of maintenance managers (item A4)

Statistics of responsibilities of maintenance managers

		On-the-spot guidance for undertaking maintenance	Analyse cause and/or effect of failure	Develo-ping maintenan ce plan	Intra-departments coordination for maintenance strategies	Intra-departments coordination for maintenance operations	Supervise MRO purchase	Evaluate maintenance expenses
N	Valid	48	48	48	48	48	48	48
	Missing	0	0	0	0	0	0	0
Mean		.79	.88	.98	.71	.71	.75	.79
Std. Deviation		.410	.334	.144	.459	.459	.438	.410
Range		1	1	1	1	1	1	1

On-the-spot guidance for undertaking maintenance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	10	20.8	20.8	20.8
	Yes	38	79.2	79.2	100.0
	Total	48	100.0	100.0	

Analyse cause and/or effect of failure

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	6	12.5	12.5	12.5
	Yes	42	87.5	87.5	100.0
	Total	48	100.0	100.0	

Developing maintenance plan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1	2.1	2.1	2.1
	Yes	47	97.9	97.9	100.0
	Total	48	100.0	100.0	

Intra-departments coordination for maintenance strategies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	14	29.2	29.2	29.2
	Yes	34	70.8	70.8	100.0
	Total	48	100.0	100.0	

Intra-departments coordination for maintenance operations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	14	29.2	29.2	29.2
	Yes	34	70.8	70.8	100.0
	Total	48	100.0	100.0	

Supervise MRO purchase

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	12	25.0	25.0	25.0
	Yes	36	75.0	75.0	100.0
	Total	48	100.0	100.0	

Evaluate maintenance expenses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	10	20.8	20.8	20.8
	Yes	38	79.2	79.2	100.0
	Total	48	100.0	100.0	

CMMS usage internally (item F8)

		CMMS for planning and scheduling	CMMS for recording actual down-time	CMMS for actual maintenance time	CMMS for storing maintenance reports	CMMS for updating maintenance records	CMMS for recording inventory on-board	CMMS for analytical functions for decision making	Other uses of CMMS
N	Valid	48	48	48	48	48	48	48	48
	Missing	0	0	0	0	0	0	0	0

CMMS for planning and scheduling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	14	29.2	29.2	29.2
	Yes	34	70.8	70.8	100.0
	Total	48	100.0	100.0	

CMMS for recording actual down-time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	21	43.8	43.8	43.8
	Yes	27	56.3	56.3	100.0
	Total	48	100.0	100.0	

CMMS for actual maintenance time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	15	31.3	31.3	31.3
	Yes	33	68.8	68.8	100.0
	Total	48	100.0	100.0	

CMMS for storing maintenance reports

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	12	25.0	25.0	25.0
	Yes	36	75.0	75.0	100.0
	Total	48	100.0	100.0	

CMMS for updating maintenance records

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	19	39.6	39.6	39.6
	Yes	29	60.4	60.4	100.0
	Total	48	100.0	100.0	

CMMS for recording inventory on-board

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	13	27.1	27.1	27.1
	Yes	35	72.9	72.9	100.0
	Total	48	100.0	100.0	

CMMS for analytical functions for decision making

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	21	43.8	43.8	43.8
	Yes	27	56.3	56.3	100.0
	Total	48	100.0	100.0	

Other uses of CMMS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	45	93.8	93.8	93.8
	1	3	6.3	6.3	100.0
	Total	48	100.0	100.0	

Supply chain network configuration (items B1-B6)

Statistics summary

		The company always has direct linkages with …					
		spare parts suppliers	consumables suppliers	repair vendors	EMs	dry-dock providers	other suppliers
N	Valid	47	46	47	46	46	5
	Missing	1	2	1	2	2	43

The company always has direct linkages with spare parts suppliers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	1	2.1	2.1	2.1
	disagree	4	8.3	8.5	10.6
	undecided	5	10.4	10.6	21.3
	agree	5	10.4	10.6	31.9
	strongly agree	32	66.7	68.1	100.0
	Total	47	97.9	100.0	
Missing	no answer	1	2.1		
Total		48	100.0		

The company always has direct linkages with consumables suppliers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	2	4.2	4.3	4.3
	disagree	5	10.4	10.9	15.2
	undecided	7	14.6	15.2	30.4
	agree	3	6.3	6.5	37.0
	strongly agree	29	60.4	63.0	100.0
	Total	46	95.8	100.0	
Missing	not applicable	1	2.1		
	no answer	1	2.1		
	Total	2	4.2		
Total		48	100.0		

The company always has direct linkages with repair vendors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	undecided	9	18.8	19.1	19.1
	agree	11	22.9	23.4	42.6
	strongly agree	27	56.3	57.4	100.0
	Total	47	97.9	100.0	
Missing	no answer	1	2.1		
Total		48	100.0		

The company always has direct linkages with EMs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	3	6.3	6.5	6.5
	disagree	6	12.5	13.0	19.6
	undecided	8	16.7	17.4	37.0
	agree	8	16.7	17.4	54.3
	strongly agree	21	43.8	45.7	100.0
	Total	46	95.8	100.0	
Missing	not applicable	1	2.1		
	no answer	1	2.1		
	Total	2	4.2		
Total		48	100.0		

The company always has direct linkages with dry-dock providers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	1	2.1	2.2	2.2
	disagree	3	6.3	6.5	8.7
	undecided	3	6.3	6.5	15.2
	agree	4	8.3	8.7	23.9
	strongly agree	35	72.9	76.1	100.0
	Total	46	95.8	100.0	
Missing	not applicable	1	2.1		
	no answer	1	2.1		
	Total	2	4.2		
Total		48	100.0		

The company always has direct linkages with the other suppliers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	undecided	1	2.1	20.0	20.0
	agree	2	4.2	40.0	60.0
	strongly agree	2	4.2	40.0	100.0
	Total	5	10.4	100.0	
Missing	not applicable	1	2.1		
	no answer	42	87.5		
	Total	43	89.6		
Total		48	100.0		

Joint actions in maintenance management (items C9-C13)

```
CORRELATIONS
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  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations of spare parts suppliers' involvements

		Spare parts suppliers involvement in maintenance planning	Spare parts suppliers involvement in inventory control	Spare parts suppliers involvement in maintenance evaluation	Spare parts suppliers involvement in specifications settings	Spare parts suppliers involvement in problem solvings
Spare parts suppliers involvement in maintenance planning	Pearson Corr	1	.786**	.809**	.679**	.477**
	Sig. (2-tailed)		.000	.000	.000	.001
	N	44	44	44	44	44
Spare parts suppliers involvement in inventory control	Pearson Corr	.786**	1	.855**	.711**	.677**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	44	44	44	44	44
Spare parts suppliers involvement in maintenance evaluation	Pearson Corr	.809**	.855**	1	.607**	.601**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	44	44	44	44	44
Spare parts suppliers involvement in specifications settings	Pearson Corr	.679**	.711**	.607**	1	.620**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	44	44	44	45	45
Spare parts suppliers involvement in problem solvings	Pearson Corr	.477**	.677**	.601**	.620**	1
	Sig. (2-tailed)	.001	.000	.000	.000	
	N	44	44	44	45	45

**. Corr is significant at the 0.01 level (2-tailed).

```
CORRELATIONS
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  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations of consumables suppliers' involvements

		Consumables suppliers involvement in maintenance planning	Consumables suppliers involvement in inventory control	Consumables suppliers involvement in maintenance evaluation	Consumables suppliers involvement in specifications settings	Consumables suppliers involvement in problem solvings
Consumables suppliers involvement in maintenance planning	Pearson Corr	1	.841**	.839**	.721**	.584**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	42	42	42	42	40
Consumables suppliers involvement in inventory control	Pearson Corr	.841**	1	.911**	.706**	.616**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	42	42	42	42	40
Consumables suppliers involvement in maintenance evaluation	Pearson Corr	.839**	.911**	1	.740**	.688**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	42	42	42	42	40
Consumables suppliers involvement in specifications settings	Pearson Corr	.721**	.706**	.740**	1	.685**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	42	42	42	42	40
Consumables suppliers involvement in problem solvings	Pearson Corr	.584**	.616**	.688**	.685**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	40	40	40	40	41

**. Corr is significant at the 0.01 level (2-tailed).

CORRELATIONS
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/PRINT=TWOTAIL NOSIG
/STATISTICS DESCRIPTIVES
/MISSING=PAIRWISE.

Correlations of repair vendors' involvements

		Repair vendors involvement in maintenance planning	Repair vendors involvement in inventory control	Repair vendors involvement in maintenance evaluation	Repair vendors involvement in specifications settings	Repair vendors involvement in problem solvings
Repair vendors involvement in maintenance planning	Pearson Corr	1	.697**	.727**	.617**	.513**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	44	43	44	44	44
Repair vendors involvement in inventory control	Pearson Corr	.697**	1	.755**	.637**	.555**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	43	43	43	43	43
Repair vendors involvement in maintenance evaluation	Pearson Corr	.727**	.755**	1	.746**	.664**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	44	43	44	44	44
Repair vendors involvement in specifications settings	Pearson Corr	.617**	.637**	.746**	1	.807**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	44	43	44	44	44
Repair vendors involvement in problem solvings	Pearson Corr	.513**	.555**	.664**	.807**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	44	43	44	44	45

**. Corr is significant at the 0.01 level (2-tailed).

CORRELATIONS
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/PRINT=TWOTAIL NOSIG
/STATISTICS DESCRIPTIVES
/MISSING=PAIRWISE.

Correlations of equipment manufacturers' involvements

		Equipment manufacturers involvement in maintenance planning	Equipment manufacturers involvement in inventory control	Equipment manufacturers involvement in maintenance evaluation	Equipment manufacturers involvement in specifications settings	Equipment manufacturers involvement in problem solvings
Equipment manufacturers involvement in maintenance planning	Pearson Corr	1	.831**	.813**	.733**	.609**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	43	43	43	43	43
Equipment manufacturers involvement in inventory control	Pearson Corr	.831**	1	.851**	.698**	.725**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	43	43	43	43	43
Equipment manufacturers involvement in maintenance evaluation	Pearson Corr	.813**	.851**	1	.710**	.763**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	43	43	43	43	43
Equipment manufacturers involvement in specifications settings	Pearson Corr	.733**	.698**	.710**	1	.750**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	43	43	43	43	43
Equipment manufacturers involvement in problem solvings	Pearson Corr	.609**	.725**	.763**	.750**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	43	43	43	43	44

**. Corr is significant at the 0.01 level (2-tailed).

```
CORRELATIONS
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  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Correlations of dry dock providers' involvement

		Dry dock providers involvement in maintenance planning	Dry dock providers involvement in inventory control	Dry dock providers involvement in maintenance evaluation	Dry dock providers involvement in specifications settings	Dry dock providers involvement in problem solvings
Dry dock providers involvement in maintenance planning	Pearson Corr	1	.610**	.679**	.602**	.571**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	43	43	43	43	43
Dry dock providers involvement in inventory control	Pearson Corr	.610**	1	.819**	.609**	.735**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	43	44	43	43	43
Dry dock providers involvement in maintenance evaluation	Pearson Corr	.679**	.819**	1	.655**	.742**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	43	43	43	43	43
Dry dock providers involvement in specifications settings	Pearson Corr	.602**	.609**	.655**	1	.648**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	43	43	43	43	43
Dry dock providers involvement in problem solvings	Pearson Corr	.571**	.735**	.742**	.648**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	43	43	43	43	45

**. Corr is significant at the 0.01 level (2-tailed).

One-Sample Statistics (items C9-C13)

Item		N	Mean	Std. Deviation	Std. Error Mean
C9	Spare parts suppliers involvement in maintenance planning	44	2.82	1.544	.233
	Consumables suppliers involvement in maintenance planning	42	2.64	1.650	.255
	Repair vendors involvement in maintenance planning	44	3.16	1.554	.234
	Equipment manufacturers involvement in maintenance planning	43	2.93	1.595	.243
	Dry dock providers involvement in maintenance planning	43	3.37	1.512	.231
C10	Spare parts suppliers involvement in inventory control	44	2.77	1.612	.243
	Consumables suppliers involvement in inventory control	42	2.57	1.610	.248
	Repair vendors involvement in inventory control	43	2.42	1.516	.231
	Equipment manufacturers involvement in inventory control	43	2.47	1.517	.231
	Dry dock providers involvement in inventory control	44	2.36	1.571	.237
C11	Spare parts suppliers involvement in maintenance evaluation	44	2.75	1.527	.230
	Consumables suppliers involvement in maintenance evaluation	42	2.76	1.559	.241
	Repair vendors involvement in maintenance evaluation	44	2.98	1.548	.233
	Equipment manufacturers involvement in maintenance evaluation	43	2.88	1.499	.229
	Dry dock providers involvement in maintenance evaluation	43	2.70	1.597	.243
C12	Spare parts suppliers involvement in specifications settings	45	3.31	1.328	.198
	Consumables suppliers involvement in specifications settings	42	2.86	1.555	.240
	Repair vendors involvement in specifications settings	44	3.34	1.397	.211
	Equipment manufacturers involvement in specifications settings	43	3.26	1.482	.226
	Dry dock providers involvement in specifications settings	43	2.95	1.511	.230
	Spare parts suppliers involvement in problem solvings	45	3.13	1.440	.215
	Consumables suppliers involvement in problem solvings	41	2.93	1.634	.255
	Repair vendors involvement in problem solvings	45	3.56	1.358	.202
	Equipment manufacturers involvement in problem solvings	44	3.18	1.419	.214
	Dry dock providers involvement in problem solvings	45	3.18	1.482	.221

One-Sample Test (items C9-C13)

Item		Test Value = 2 (rarely)				
		df	Sig. (2-tailed)*	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
C9	Spare parts suppliers involvement in maintenance planning	43	.001	.818	.35	1.29
	Consumables suppliers involvement in maintenance planning	41	.016	.643	.13	1.16
	Repair vendors involvement in maintenance planning	43	.000	1.159	.69	1.63
	Equipment manufacturers involvement in maintenance planning	42	.000	.930	.44	1.42
	Dry dock providers involvement in maintenance planning	42	.000	1.372	.91	1.84
C10	Spare parts suppliers involvement in inventory control	43	.003	.773	.28	1.26
	Consumables suppliers involvement in inventory control	41	.027	.571	.07	1.07
	Repair vendors involvement in inventory control	42	.077	.419	-.05	.89
	Equipment manufacturers involvement in inventory control	42	.051	.465	.00	.93
	Dry dock providers involvement in inventory control	43	.132	.364	-.11	.84
C11	Spare parts suppliers involvement in maintenance evaluation	43	.002	.750	.29	1.21
	Consumables suppliers involvement in maintenance evaluation	41	.003	.762	.28	1.25
	Repair vendors involvement in maintenance evaluation	43	.000	.977	.51	1.45
	Equipment manufacturers involvement in maintenance evaluation	42	.000	.884	.42	1.35
	Dry dock providers involvement in maintenance evaluation	42	.006	.698	.21	1.19
C12	Spare parts suppliers involvement in specifications settings	44	.000	1.311	.91	1.71
	Consumables suppliers involvement in specifications settings	41	.001	.857	.37	1.34
	Repair vendors involvement in specifications settings	43	.000	1.341	.92	1.77
	Equipment manufacturers involvement in specifications settings	42	.000	1.256	.80	1.71
	Dry dock providers involvement in specifications settings	42	.000	.953	.49	1.42
C13	Spare parts suppliers involvement in problem solvings	44	.000	1.133	.70	1.57
	Consumables suppliers involvement in problem solvings	40	.001	.927	.41	1.44
	Repair vendors involvement in problem solvings	44	.000	1.556	1.15	1.96
	Equipment manufacturers involvement in problem solvings	43	.000	1.182	.75	1.61
	Dry dock providers involvement in problem solvings	44	.000	1.178	.73	1.62

* reject *H*o if *p*<.05

One-Sample Test (items C9-C13)

Item		Test Value = 3				
		df	Sig. (2-tailed)*	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
C9	Spare parts suppliers involvement in maintenance planning	43	.439	-.182	-.65	.29
	Consumables suppliers involvement in maintenance planning	41	.168	-.357	-.87	.16
	Repair vendors involvement in maintenance planning	43	.501	.159	-.31	.63
	Equipment manufacturers involvement in maintenance planning	42	.776	-.070	-.56	.42
	Dry dock providers involvement in maintenance planning	42	.114	.372	-.09	.84
C10	Spare parts suppliers involvement in inventory control	43	.355	-.227	-.72	.26
	Consumables suppliers involvement in inventory control	41	.092	-.429	-.93	.07
	Repair vendors involvement in inventory control	42	.016	-.581	-1.05	-.11
	Equipment manufacturers involvement in inventory control	42	.026	-.535	-1.00	-.07
	Dry dock providers involvement in inventory control	43	.010	-.636	-1.11	-.16
C11	Spare parts suppliers involvement in maintenance evaluation	43	.283	-.250	-.71	.21
	Consumables suppliers involvement in maintenance evaluation	41	.328	-.238	-.72	.25
	Repair vendors involvement in maintenance evaluation	43	.923	-.023	-.49	.45
	Equipment manufacturers involvement in maintenance evaluation	42	.614	-.116	-.58	.35
	Dry dock providers involvement in maintenance evaluation	42	.221	-.302	-.79	.19
C12	Spare parts suppliers involvement in specifications settings	44	.123	.311	-.09	.71
	Consumables suppliers involvement in specifications settings	41	.555	-.143	-.63	.34
	Repair vendors involvement in specifications settings	43	.113	.341	-.08	.77
	Equipment manufacturers involvement in specifications settings	42	.264	.256	-.20	.71
	Dry dock providers involvement in specifications settings	42	.841	-.047	-.51	.42
C13	Spare parts suppliers involvement in problem solvings	44	.538	.133	-.30	.57
	Consumables suppliers involvement in problem solvings	40	.776	-.073	-.59	.44
	Repair vendors involvement in problem solvings	44	.009	.556	.15	.96
	Equipment manufacturers involvement in problem solvings	43	.400	.182	-.25	.61
	Dry dock providers involvement in problem solvings	44	.425	.178	-.27	.62

* reject *H*o if *p*<.05

Strategic relationships with suppliers (items C1-C6)

Summary of statistics

		Contract with spare parts suppliers	Contract with consumables suppliers	Contract with repair vendors	Contract with equipment manufacturers	Contract with dry dock providers	Contract with other suppliers
N	Valid	48	48	48	46	48	6
	Missing	0	0	0	2	0	42

Contract with spare parts suppliers (item C1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No contract at all	32	66.7	66.7	66.7
	less than 1 year contract	8	16.7	16.7	83.3
	1 - 2 years contract	6	12.5	12.5	95.8
	more than 4 years contract	2	4.2	4.2	100.0
	Total	48	100.0	100.0	

Contract with consumables suppliers (item C2)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No contract at all	34	70.8	70.8	70.8
	less than 1 year contract	8	16.7	16.7	87.5
	1 - 2 years contract	4	8.3	8.3	95.8
	more than 4 years contract	2	4.2	4.2	100.0
	Total	48	100.0	100.0	

Contract with repair vendors (item C3)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No contract at all	30	62.5	62.5	62.5
	less than 1 year contract	12	25.0	25.0	87.5
	1 - 2 years contract	4	8.3	8.3	95.8
	more than 4 years contract	2	4.2	4.2	100.0
	Total	48	100.0	100.0	

Contract with equipment manufacturers (item C4)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No contract at all	35	72.9	76.1	76.1
	less than 1 year contract	8	16.7	17.4	93.5
	1 - 2 years contract	2	4.2	4.3	97.8
	more than 4 years contract	1	2.1	2.2	100.0
	Total	46	95.8	100.0	
Missing	do not know	2	4.2		
Total		48	100.0		

Contract with dry dock providers (item C5)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No contract at all	31	64.6	64.6	64.6
	less than 1 year contract	6	12.5	12.5	77.1
	1 - 2 years contract	5	10.4	10.4	87.5
	3 - 4 years contract	2	4.2	4.2	91.7
	more than 4 years contract	4	8.3	8.3	100.0
	Total	48	100.0	100.0	

Contract with other suppliers (item C6)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No contract at all	5	10.4	83.3	83.3
	less than 1 year contract	1	2.1	16.7	100.0
	Total	6	12.5	100.0	
Missing	do not know	2	4.2		
	no answer	40	83.3		
	Total	42	87.5		
Total		48	100.0		

Shipping – suppliers information sharing (item E2-E7)

Summary of Statistics

		Sharing proprietary information	Timely information exchanges	Information exchanged accurate	Information exchanged complete	Information exchanged reliable	Keep each other with up-dated information
N	Valid	48	47	48	48	48	46
	Missing	0	1	0	0	0	2

Sharing proprietary information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	undecided	1	2.1	2.1	2.1
	agree	36	75.0	75.0	77.1
	strongly agree	11	22.9	22.9	100.0
	Total	48	100.0	100.0	

Timely information exchanges

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree	13	27.1	27.7	27.7
	undecided	11	22.9	23.4	51.1
	agree	20	41.7	42.6	93.6
	strongly agree	3	6.3	6.4	100.0
	Total	47	97.9	100.0	
Missing	not applicable	1	2.1		
Total		48	100.0		

Information exchanged accurate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	undecided	7	14.6	14.6	14.6
	agree	29	60.4	60.4	75.0
	strongly agree	12	25.0	25.0	100.0
	Total	48	100.0	100.0	

Information exchanged complete (item E5)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree	1	2.1	2.1	2.1
	undecided	7	14.6	14.6	16.7
	agree	29	60.4	60.4	77.1
	strongly agree	11	22.9	22.9	100.0
	Total	48	100.0	100.0	

Information exchanged reliable (item E6)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	undecided	6	12.5	12.5	12.5
	agree	30	62.5	62.5	75.0
	strongly agree	12	25.0	25.0	100.0
	Total	48	100.0	100.0	

Keep each other with up-dated information (item E7)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	undecided	3	6.3	6.5	6.5
	agree	31	64.6	67.4	73.9
	strongly agree	12	25.0	26.1	100.0
	Total	46	95.8	100.0	
Missing	not applicable	1	2.1		
	no answer	1	2.1		
	Total	2	4.2		
Total		48	100.0		

Capacity management: Spare part inventory management (items F4-F7)

```
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  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL CORR.
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Reliability
Scale: F4-F7_ME

Case Processing Summary

		N	%
Cases	Valid	43	89.6
	Excluded[a]	5	10.4
	Total	48	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.0.851	.539	4

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CORRS
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F7_Aux with F4_ME F4_PG F4_Aux
  /PRINT=TWOTAIL NOSIG
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
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Correlations

[DataSet1] C:\Users\idindin\Documents\data\Thesis\Survey\Data processing\Data entry\130610 - Raw data MV_9n0.sav

Descriptive Statistics

	Mean	Std. Deviation	N
Availability of LV NC main-engines s'parts	3.56	1.013	45
Availability of LV NC power-generators s'parts	3.38	1.035	42
Availability of LV NC aux-equipment s'parts	3.43	1.021	44
Availability of LV C main-engines s'parts	3.98	1.102	43
Availability of LV C power-generators s'parts	3.79	1.138	42
Availability of LV C aux-equipment s'parts	3.91	1.030	44
Availability of HV NC main-engines s'parts	2.67	1.108	45
Availability of HV NC power-generators s'parts	2.56	1.007	43
Availability of HV NC aux-equipment s'parts	2.68	1.052	44
Availability of HV C main-engines s'parts	3.58	1.097	45
Availability of HV C power-generators s'parts	3.43	1.039	42
Availability of HV C aux-equipment s'parts	3.51	1.036	45

Correlations of availabity of low-value non-critical spare parts

		Availability of LV NC main-engines s'parts	Availability of LV NC power-generators s'parts	Availability of LV NC aux-equipment s'parts
Availability of LV NC main-engines s'parts	Pearson Corr	1.000**	.904**	.831**
	Sig. (2-tailed)	.000	.000	.000
	N	45	42	44
Availability of LV NC power-generators s'parts	Pearson Corr	.904**	1.000**	.875**
	Sig. (2-tailed)	.000	.000	.000
	N	42	42	42
Availability of LV NC aux-equipment s'parts	Pearson Corr	.831**	.875**	1.000**
	Sig. (2-tailed)	.000	.000	.000
	N	44	42	44
Availability of LV C main-engines s'parts	Pearson Corr	.354*	.286	.138
	Sig. (2-tailed)	.020	.070	.378
	N	43	41	43
Availability of LV C power-generators s'parts	Pearson Corr	.310*	.322*	.155
	Sig. (2-tailed)	.046	.040	.332
	N	42	41	41
Availability of LV C aux-equipment s'parts	Pearson Corr	.363*	.280	.257
	Sig. (2-tailed)	.015	.076	.096
	N	44	41	43
Availability of HV NC main-engines s'parts	Pearson Corr	.194	.181	.232
	Sig. (2-tailed)	.206	.257	.134
	N	44	41	43
Availability of HV NC power-generators s'parts	Pearson Corr	.128	.220	.205
	Sig. (2-tailed)	.419	.168	.198
	N	42	41	41
Availability of HV NC aux-equipment s'parts	Pearson Corr	.155	.180	.317*
	Sig. (2-tailed)	.321	.260	.038
	N	43	41	43
Availability of HV C main-engines s'parts	Pearson Corr	.236	.212	.133
	Sig. (2-tailed)	.118	.177	.388
	N	45	42	44
Availability of HV C power-generators s'parts	Pearson Corr	.197	.321*	.175
	Sig. (2-tailed)	.212	.038	.269
	N	42	42	42
Availability of HV C aux-equipment s'parts	Pearson Corr	.221	.232	.215
	Sig. (2-tailed)	.144	.140	.161
	N	45	42	44

**. Corr is significant at the 0.01 level (2-tailed).
*. Corr is significant at the 0.05 level (2-tailed).

Correlations of availability of low-value critical spare parts

		Availability of LV C main-engines s'parts	Availability of LV C power-generators s'parts	Availability of LV C aux-equipment s'parts
Availability of LV NC main-engines s'parts	Pearson Corr	.354*	.310*	.363*
	Sig. (2-tailed)	.020	.046	.015
	N	43	42	44
Availability of LV NC power-generators s'parts	Pearson Corr	.286	.322*	.280
	Sig. (2-tailed)	.070	.040	.076
	N	41	41	41
Availability of LV NC aux-equipment s'parts	Pearson Corr	.138	.155	.257
	Sig. (2-tailed)	.378	.332	.096
	N	43	41	43

Availability of LV C main-engines s'parts	Pearson Corr	1.000**	.913**	.898**
	Sig. (2-tailed)	.000	.000	.000
	N	43	41	43
Availability of LV C power-generators s'parts	Pearson Corr	.913**	1.000**	.897**
	Sig. (2-tailed)	.000	.000	.000
	N	41	42	42
Availability of LV C aux-equipment s'parts	Pearson Corr	.898**	.897**	1.000**
	Sig. (2-tailed)	.000	.000	.000
	N	43	42	44
Availability of HV NC main-engines s'parts	Pearson Corr	-.025	-.038	.015
	Sig. (2-tailed)	.873	.810	.924
	N	43	42	44
Availability of HV NC power-generators s'parts	Pearson Corr	-.044	.003	-.039
	Sig. (2-tailed)	.787	.985	.806
	N	41	42	42
Availability of HV NC aux-equipment s'parts	Pearson Corr	-.067	-.042	.046
	Sig. (2-tailed)	.668	.793	.772
	N	43	41	43
Availability of HV C main-engines s'parts	Pearson Corr	.293	.279	.315*
	Sig. (2-tailed)	.056	.073	.037
	N	43	42	44
Availability of HV C power-generators s'parts	Pearson Corr	.241	.351*	.235
	Sig. (2-tailed)	.129	.024	.139
	N	41	41	41
Availability of HV C aux-equipment s'parts	Pearson Corr	.268	.253	.351*
	Sig. (2-tailed)	.082	.106	.019
	N	43	42	44

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Correlations of availability of high-value non-critical spare parts

		Availability of HV NC main-engines s'parts	Availability of HV NC power-generators s'parts	Availability of HV NC aux-equipment s'parts
Availability of LV NC main-engines s'parts	Pearson Corr	.194	.128	.155
	Sig. (2-tailed)	.206	.419	.321
	N	44	42	43
Availability of LV NC power-generators s'parts	Pearson Corr	.181	.220	.180
	Sig. (2-tailed)	.257	.168	.260
	N	41	41	41
Availability of LV NC aux-equipment s'parts	Pearson Corr	.232	.205	.317*
	Sig. (2-tailed)	.134	.198	.038
	N	43	41	43
Availability of LV C main-engines s'parts	Pearson Corr	-.025	-.044	-.067
	Sig. (2-tailed)	.873	.787	.668
	N	43	41	43
Availability of LV C power-generators s'parts	Pearson Corr	-.038	.003	-.042
	Sig. (2-tailed)	.810	.985	.793
	N	42	42	41
Availability of LV C aux-equipment s'parts	Pearson Corr	.015	-.039	.046
	Sig. (2-tailed)	.924	.806	.772
	N	44	42	43
Availability of HV NC main-engines s'parts	Pearson Corr	1.000**	.860**	.930**
	Sig. (2-tailed)	.000	.000	.000
	N	45	43	44
Availability of HV NC power-generators s'parts	Pearson Corr	.860**	1.000**	.891**
	Sig. (2-tailed)	.000	.000	.000
	N	43	43	42
Availability of HV NC aux-equipment s'parts	Pearson Corr	.930**	.891**	1.000**
	Sig. (2-tailed)	.000	.000	.000
	N	44	42	44

Availability of HV C main-engines s'parts	Pearson Corr	.395**	.228	.284
	Sig. (2-tailed)	.008	.147	.065
	N	44	42	43
Availability of HV C power-generators s'parts	Pearson Corr	.304	.311*	.241
	Sig. (2-tailed)	.053	.048	.129
	N	41	41	41
Availability of HV C aux-equipment s'parts	Pearson Corr	.340*	.198	.304*
	Sig. (2-tailed)	.024	.210	.047
	N	44	42	43

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Correlations of availability of high value critical spare parts

		Availability of HV C main-engines s'parts	Availability of HV C power-generators s'parts	Availability of HV C aux-equipment s'parts
Availability of LV NC main-engines s'parts	Pearson Corr	.236	.197	.221
	Sig. (2-tailed)	.118	.212	.144
	N	45	42	45
Availability of LV NC power-generators s'parts	Pearson Corr	.212	.321*	.232
	Sig. (2-tailed)	.177	.038	.140
	N	42	42	42
Availability of LV NC aux-equipment s'parts	Pearson Corr	.133	.175	.215
	Sig. (2-tailed)	.388	.269	.161
	N	44	42	44
Availability of LV C main-engines s'parts	Pearson Corr	.293	.241	.268
	Sig. (2-tailed)	.056	.129	.082
	N	43	41	43
Availability of LV C power-generators s'parts	Pearson Corr	.279	.351*	.253
	Sig. (2-tailed)	.073	.024	.106
	N	42	41	42
Availability of LV C aux-equipment s'parts	Pearson Corr	.315*	.235	.351*
	Sig. (2-tailed)	.037	.139	.019
	N	44	41	44
Availability of HV NC main-engines s'parts	Pearson Corr	.395**	.304	.340*
	Sig. (2-tailed)	.008	.053	.024
	N	44	41	44
Availability of HV NC power-generators s'parts	Pearson Corr	.228	.311*	.198
	Sig. (2-tailed)	.147	.048	.210
	N	42	41	42
Availability of HV NC aux-equipment s'parts	Pearson Corr	.284	.241	.304*
	Sig. (2-tailed)	.065	.129	.047
	N	43	41	43
Availability of HV C main-engines s'parts	Pearson Corr	1.000**	.902**	.934**
	Sig. (2-tailed)	.000	.000	.000
	N	45	42	45
Availability of HV C power-generators s'parts	Pearson Corr	.902**	1.000**	.860**
	Sig. (2-tailed)	.000	.000	.000
	N	42	42	42
Availability of HV C aux-equipment s'parts	Pearson Corr	.934**	.860**	1.000**
	Sig. (2-tailed)	.000	.000	.000
	N	45	42	45

*. Corr is significant at the 0.05 level (2-tailed).
**. Corr is significant at the 0.01 level (2-tailed).

Capacity management: Purchasing policies (items C17-C19)

Summary of statistics

		Chief engineers purchase (de-centralised)	Procurement manager purchase (centralised)	Mixed purchase
N	Valid	48	47	47
	Missing	0	1	1

Chief engineers purchase (de-centralised) (item C17)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	7	14.6	14.6	14.6
	disagree	30	62.5	62.5	77.1
	undecided	1	2.1	2.1	79.2
	agree	4	8.3	8.3	87.5
	strongly agree	6	12.5	12.5	100.0
	Total	48	100.0	100.0	

Procurement manager purchase (centralised) (item C18)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	2	4.2	4.3	4.3
	disagree	10	20.8	21.3	25.5
	undecided	2	4.2	4.3	29.8
	agree	27	56.3	57.4	87.2
	strongly agree	6	12.5	12.8	100.0
	Total	47	97.9	100.0	
Missing	not applicable	1	2.1		
Total		48	100.0		

Mixed purchase (item C19)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	2	4.2	4.3	4.3
	disagree	23	47.9	48.9	53.2
	undecided	5	10.4	10.6	63.8
	agree	11	22.9	23.4	87.2
	strongly agree	6	12.5	12.8	100.0
	Total	47	97.9	100.0	
Missing	not applicable	1	2.1		
Total		48	100.0		

Demand management (item B10)

Scale: B10

Case Processing Summary

		N	%
Cases	Valid	45	93.8
	Excluded[a]	3	6.3
	Total	48	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.908	.909	5

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Fluctuate demand on supplies from spare parts suppliers	48	3.85	.850	.123
Fluctuate demand on supplies from consumables suppliers	47	3.62	.990	.144
Fluctuate demand on supplies from repair vendors	48	3.90	.857	.124
Fluctuate demand on supplies from equipment manufacturers	47	3.66	.962	.140
Fluctuate demand on supplies from dry dock providers	45	3.78	.997	.149

One-Sample Test

	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fluctuate demand on supplies from spare parts suppliers	6.960	47	.000	.854	.61	1.10
Fluctuate demand on supplies from consumables suppliers	4.272	46	.000	.617	.33	.91
Fluctuate demand on supplies from repair vendors	7.246	47	.000	.896	.65	1.14
Fluctuate demand on supplies from equipment manufacturers	4.701	46	.000	.660	.38	.94
Fluctuate demand on supplies from dry dock providers	5.231	44	.000	.778	.48	1.08

One-Sample Test

	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Fluctuate demand on supplies from spare parts suppliers	-1.188	47	.241	-.146	-.39	.10
Fluctuate demand on supplies from consumables suppliers	-2.651	46	.011	-.383	-.67	-.09
Fluctuate demand on supplies from repair vendors	-.843	47	.404	-.104	-.35	.14
Fluctuate demand on supplies from equipment manufacturers	-2.427	46	.019	-.340	-.62	-.06
Fluctuate demand on supplies from dry dock providers	-1.494	44	.142	-.222	-.52	.08

Supplier relationship management: Suppliers' characteristics (item D1-D6)

Notes

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One-Sample Statistics

Item		N	Mean	Std. Deviation	Std. Error Mean
D1	Lowest price spare parts suppliers	48	4.00	.899	.130
	Lowest price consumables suppliers	46	4.04	1.095	.161
	Lowest price repair vendors	48	4.04	.798	.115
	Lowest price equipment manufacturers	48	4.02	.812	.117
	Lowest price dry dock providers	47	4.02	.821	.120
D2	Long-term availability of spare parts suppliers	46	3.98	1.022	.151
	Long-term availability of consumables suppliers	44	3.84	1.055	.159
	Long-term availability of repair vendors	46	3.76	1.119	.165
	Long-term availability of equipment manufacturers	46	3.91	1.029	.152
	Long-term availability of dry dock providers	45	3.78	1.085	.162
D3	Quality assurance of spare parts suppliers	48	4.71	.459	.066
	Quality assurance of consumables suppliers	46	4.46	.721	.106
	Quality assurance of repair vendors	48	4.71	.459	.066
	Quality assurance of equipment manufacturers	48	4.71	.459	.066
	Quality assurance of dry dock providers	47	4.60	.538	.078
D4	Information sharing spare parts suppliers	48	3.96	.898	.130
	Information sharing consumables suppliers	46	3.89	.948	.140
	Information sharing repair vendors	48	4.29	.683	.099
	Information sharing equipment manufacturers	48	4.29	.713	.103
	Information sharing dry dock providers	47	4.21	.750	.109
D5	Training providing spare parts suppliers	48	3.71	.898	.130
	Training providing consumables suppliers	46	3.48	1.027	.151
	Training providing repair vendors	48	3.92	.895	.129
	Training providing equipment manufacturers	48	4.15	.743	.107
	Training providing dry dock providers	47	3.81	.876	.128
D6	Spare parts suppliers with qualified personnel	47	4.06	.965	.141
	Consumables suppliers with qualified personnel	46	3.93	.975	.144
	Repair vendors with qualified personnel	47	4.51	.621	.091
	Equipment manufacturers with qualified personnel	47	4.47	.620	.090
	Dry dock providers with qualified personnel	45	4.44	.693	.103

One-Sample Test

		Test Value = 4					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
D1	Lowest price spare parts suppliers	.000	47	1.000	.000	-.26	.26
	Lowest price consumables suppliers	.269	45	.789	.043	-.28	.37
	Lowest price repair vendors	.362	47	.719	.042	-.19	.27
	Lowest price equipment manufacturers	.178	47	.860	.021	-.21	.26
	Lowest price dry dock providers	.178	46	.860	.021	-.22	.26
D2	Long-term availability of spare parts suppliers	-.144	45	.886	-.022	-.33	.28
	Long-term availability of consumables suppliers	-1.000	43	.323	-.159	-.48	.16
	Long-term availability of repair vendors	-1.449	45	.154	-.239	-.57	.09
	Long-term availability of equipment manufacturers	-.573	45	.569	-.087	-.39	.22
	Long-term availability of dry dock providers	-1.374	44	.176	-.222	-.55	.10
D3	Quality assurance of spare parts suppliers	10.684	47	.000	.708	.57	.84
	Quality assurance of consumables suppliers	4.293	45	.000	.457	.24	.67
	Quality assurance of repair vendors	10.684	47	.000	.708	.57	.84
	Quality assurance of equipment manufacturers	10.684	47	.000	.708	.57	.84
	Quality assurance of dry dock providers	7.590	46	.000	.596	.44	.75
D4	Information sharing spare parts suppliers	-.321	47	.749	-.042	-.30	.22
	Information sharing consumables suppliers	-.778	45	.441	-.109	-.39	.17
	Information sharing repair vendors	2.959	47	.005	.292	.09	.49
	Information sharing equipment manufacturers	2.833	47	.007	.292	.08	.50
	Information sharing dry dock providers	1.945	46	.058	.213	-.01	.43
D5	Training providing spare parts suppliers	-2.250	47	.029	-.292	-.55	-.03
	Training providing consumables suppliers	-3.445	45	.001	-.522	-.83	-.22
	Training providing repair vendors	-.645	47	.522	-.083	-.34	.18
	Training providing equipment manufacturers	1.359	47	.181	.146	-.07	.36
	Training providing dry dock providers	-1.499	46	.141	-.191	-.45	.07
D6	Spare parts suppliers with qualified personnel	.454	46	.652	.064	-.22	.35
	Consumables suppliers with qualified personnel	-.454	45	.652	-.065	-.35	.22
	Repair vendors with qualified personnel	5.636	46	.000	.511	.33	.69
	Equipment manufacturers with qualified personnel	5.173	46	.000	.468	.29	.65
	Dry dock providers with qualified personnel	4.304	44	.000	.444	.24	.65

Supplier relationship management: Exploratory factor analysis (items D8-D14)

```
FACTOR
  /VARIABLES D8 D9 D10 D11 D12 D13 D14
  /MISSING PAIRWISE
  /ANALYSIS D8 D9 D10 D11 D12 D13 D14
  /PRINT UNIVARIATE INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
  /PLOT EIGEN
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
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Descriptive Statistics

Item		Mean	Std. Deviation	Analysis N	Missing N
D8	Mutual need based relationships	4.08	.794	48	0
D9	Support the suppliers to improve quality of supplies	4.40	.536	48	0
D10	Monitor the suppliers' suppliers	4.02	.872	47	1
D11	Close relationships with limited number of high quality suppliers	3.44	1.201	48	0
D12	Long-term relationships initiative	4.35	.635	48	0
D13	Suppliers' activities inclusion	3.77	.928	48	0
D14	Long-term relationship initiative from suppliers	4.19	.537	47	1

Correlation Matrix[a]

		Mutual need based relationships	Support the suppliers to improve quality of supplies	Monitor the suppliers' suppliers	Close relationships with limited number of high quality suppliers	Long-term relationships initiative	Suppliers' activities inclusion	Long-term relationship initiative from suppliers
Correlation	Mutual need based relationships	1.000	.021	.122	.117	.025	-.031	.062
	Support the suppliers to improve quality of supplies	.021	1.000	.306	-.242	.204	.486	-.048
	Monitor the suppliers' suppliers	.122	.306	1.000	.259	.336	.504	.362
	Close relationships with limited number of high quality suppliers	.117	-.242	.259	1.000	-.124	-.175	-.028
	Long-term relationships initiative	.025	.204	.336	-.124	1.000	.357	.426
	Suppliers' activities inclusion	-.031	.486	.504	-.175	.357	1.000	.302
	Long-term relationship initiative from suppliers	.062	-.048	.362	-.028	.426	.302	1.000
Sig. (1-tailed)	Mutual need based relationships		.444	.208	.214	.434	.416	.339
	Support the suppliers to improve quality of supplies	.444		.018	.049	.082	.000	.374
	Monitor the suppliers' suppliers	.208	.018		.039	.010	.000	.006
	Close relationships with limited number of high quality suppliers	.214	.049	.039		.201	.117	.427
	Long-term relationships initiative	.434	.082	.010	.201		.006	.001
	Suppliers' activities inclusion	.416	.000	.000	.117	.006		.019
	Long-term relationship initiative from suppliers	.339	.374	.006	.427	.001	.019	

a. Determinant = .235

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.595
Bartlett's Test of Sphericity	Approx. Chi-Square	62.080
	df	21
	Sig.	.000

Communalities

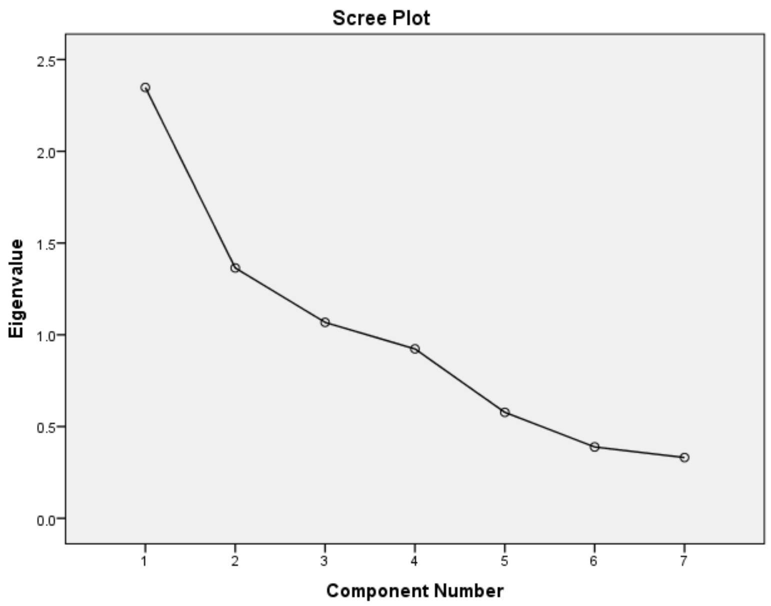
Item		Initial	Extraction
D8	Mutual need based relationships	1.000	.338
D9	Support the suppliers to improve quality of supplies	1.000	.830
D10	Monitor the suppliers' suppliers	1.000	.762
D11	Close relationships with limited number of high quality suppliers	1.000	.735
D12	Long-term relationships initiative	1.000	.616
D13	Suppliers' activities inclusion	1.000	.717
D14	Long-term relationship initiative from suppliers	1.000	.782

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.348	33.538	33.538	2.348	33.538	33.538	1.749	24.979	24.979
2	1.364	19.489	53.026	1.364	19.489	53.026	1.739	24.846	49.824
3	1.068	15.250	68.276	1.068	15.250	68.276	1.292	18.452	68.276
4	.923	13.187	81.464						
5	.578	8.250	89.714						
6	.389	5.554	95.268						
7	.331	4.732	100.000						

Extraction Method: Principal Component Analysis.



Component Matrix[a]

Item		Component		
		1	2	3
D8	Mutual need based relationships	.085	.436	.375
D9	Support the suppliers to improve quality of supplies	.567	-.479	.528
D10	Monitor the suppliers' suppliers	.739	.389	.252
D11	Close relationships with limited number of high quality suppliers	-.132	.797	.287
D12	Long-term relationships initiative	.682	.037	-.386
D13	Suppliers' activities inclusion	.807	-.208	.147
D14	Long-term relationship initiative from suppliers	.582	.335	-.575

Extraction Method: Principal Component Analysis.[a]
a. 3 components extracted.

Rotated Component Matrix[a]

Item		Component		
		1	2	3
D8	Mutual need based relationships	.081	-.042	.575
D9	Support the suppliers to improve quality of supplies	.905	-.082	-.068
D10	Monitor the suppliers' suppliers	.488	.485	.536
D11	Close relationships with limited number of high quality suppliers	-.279	-.027	.811
D12	Long-term relationships initiative	.241	.740	-.104
D13	Suppliers' activities inclusion	.738	.414	-.016
D14	Long-term relationship initiative from suppliers	-.066	.881	.038

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 5 iterations.

Component Transformation Matrix

Component	1	2	3
1	.698	.709	.101
2	-.438	.311	.843
3	.566	-.633	.528

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Service delivery management (items B7-B10)

Reliability
Scale: B7 – B10

Case Processing Summary

		N	%
Cases	Valid	41	85.4
	Excluded[a]	7	14.6
	Total	48	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.845	.851	20

Item Statistics

Item		Mean	Std. Deviation	N
B7	Spare parts suppliers consistently meet company's requirements	3.66	.938	41
	Consumables suppliers consistently meet company's requirements	3.68	.850	41
	Repair vendors consistently meet company's requirements	3.59	1.072	41
	Equipment manufacturers consistently meet company's requirements	3.61	.891	41
	Dry dock providers consistently meet company's requirements	3.76	.943	41
B8	Extensive inspections on supplies from spare parts suppliers	4.44	.838	41
	Extensive inspections on supplies from consumables suppliers	4.24	.860	41
	Extensive inspections on supplies from repair vendors	4.39	.703	41
	Extensive inspections on supplies from equipment manufacturers	4.41	.591	41
	Extensive inspections on supplies from dry dock providers	4.39	.586	41
B9	Much rework on supplies from spare parts suppliers	2.49	1.003	41
	Much rework on supplies from consumables suppliers	2.51	1.003	41
	Much rework on supplies from repair vendors	2.78	1.084	41
	Much rework on supplies from equipment manufacturers	2.85	1.038	41
	Much rework on supplies from dry dock providers	2.71	1.055	41
B10	Fluctuate demand on supplies from spare parts suppliers	3.90	.860	41
	Fluctuate demand on supplies from consumables suppliers	3.63	1.019	41
	Fluctuate demand on supplies from repair vendors	3.95	.865	41
	Fluctuate demand on supplies from equipment manufacturers	3.71	.955	41
	Fluctuate demand on supplies from dry dock providers	3.83	.998	41

```
T-TEST
  /TESTVAL=2
  /MISSING=ANALYSIS
  /VARIABLES=B7_SPs B7_Cons B7_RepVs B7_EMs B7_DdFs B8_SPs B8_Cons B8_RepVs B8_EMs
B8_DdFs B9_SPs B9_Cons B9_RepVs B9_EMs B9_DdFs B10_SPs B10_Cons B10_RepVs B10_EMs
B10_DdFs
  /CRITERIA=CI(.95).
```

T-Test

One-Sample Statistics

Item		N	Mean	Std. Deviation	Std. Error Mean
B7	Spare parts suppliers consistently meet company's requirements	48	3.69	.949	.137
	Consumables suppliers consistently meet company's requirements	46	3.74	.828	.122
	Repair vendors consistently meet company's requirements	47	3.60	1.056	.154
	Equipment manufacturers consistently meet company's requirements	47	3.68	.862	.126
	Dry dock providers consistently meet company's requirements	46	3.83	.950	.140
B8	Extensive inspections on supplies from spare parts suppliers	48	4.44	.873	.126
	Extensive inspections on supplies from consumables suppliers	46	4.28	.834	.123
	Extensive inspections on supplies from repair vendors	46	4.37	.771	.114
	Extensive inspections on supplies from equipment manufacturers	47	4.45	.583	.085
	Extensive inspections on supplies from dry dock providers	47	4.36	.673	.098
B9	Much rework on supplies from spare parts suppliers	46	2.46	.982	.145
	Much rework on supplies from consumables suppliers	45	2.47	.991	.148
	Much rework on supplies from repair vendors	45	2.76	1.048	.156
	Much rework on supplies from equipment manufacturers	47	2.81	1.035	.151
	Much rework on supplies from dry dock providers	44	2.66	1.055	.159
B10	Fluctuate demand on supplies from spare parts suppliers	48	3.85	.850	.123
	Fluctuate demand on supplies from consumables suppliers	47	3.62	.990	.144
	Fluctuate demand on supplies from repair vendors	48	3.90	.857	.124
	Fluctuate demand on supplies from equipment manufacturers	47	3.66	.962	.140
	Fluctuate demand on supplies from dry dock providers	45	3.78	.997	.149

One-Sample Test

Item		Test Value = 3					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
B7	Spare parts suppliers consistently meet company's requirements	5.020	47	.000	.688	.41	.96
	Consumables suppliers consistently meet company's requirements	6.053	45	.000	.739	.49	.99
	Repair vendors consistently meet company's requirements	3.867	46	.000	.596	.29	.91
	Equipment manufacturers consistently meet company's requirements	5.412	46	.000	.681	.43	.93
	Dry dock providers consistently meet company's requirements	5.898	45	.000	.826	.54	1.11
B8	Extensive inspections on supplies from spare parts suppliers	11.409	47	.000	1.438	1.18	1.69
	Extensive inspections on supplies from consumables suppliers	10.426	45	.000	1.283	1.03	1.53
	Extensive inspections on supplies from repair vendors	12.055	45	.000	1.370	1.14	1.60
	Extensive inspections on supplies from equipment manufacturers	17.023	46	.000	1.447	1.28	1.62
	Extensive inspections on supplies from dry dock providers	13.866	46	.000	1.362	1.16	1.56
B9	Much rework on supplies from spare parts suppliers	-3.753	45	.000	-.543	-.84	-.25
	Much rework on supplies from consumables suppliers	-3.611	44	.001	-.533	-.83	-.24
	Much rework on supplies from repair vendors	-1.565	44	.125	-.244	-.56	.07
	Much rework on supplies from equipment manufacturers	-1.268	46	.211	-.191	-.50	.11
	Much rework on supplies from dry dock providers	-2.143	43	.038	-.341	-.66	-.02
B10	Fluctuate demand on supplies from spare parts suppliers	6.960	47	.000	.854	.61	1.10
	Fluctuate demand on supplies from consumables suppliers	4.272	46	.000	.617	.33	.91
	Fluctuate demand on supplies from repair vendors	7.246	47	.000	.896	.65	1.14
	Fluctuate demand on supplies from equipment manufacturers	4.701	46	.000	.660	.38	.94
	Fluctuate demand on supplies from dry dock providers	5.231	44	.000	.778	.48	1.08

One-Sample Test

Item		Test Value = 4 t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
B7	Spare parts suppliers consistently meet company's requirements	-2.282	47	.027	-.313	-.59	-.04
	Consumables suppliers consistently meet company's requirements	-2.136	45	.038	-.261	-.51	-.01
	Repair vendors consistently meet company's requirements	-2.624	46	.012	-.404	-.71	-.09
	Equipment manufacturers consistently meet company's requirements	-2.537	46	.015	-.319	-.57	-.07
	Dry dock providers consistently meet company's requirements	-1.242	45	.221	-.174	-.46	.11
B8	Extensive inspections on supplies from spare parts suppliers	3.472	47	.001	.438	.18	.69
	Extensive inspections on supplies from consumables suppliers	2.297	45	.026	.283	.03	.53
	Extensive inspections on supplies from repair vendors	3.253	45	.002	.370	.14	.60
	Extensive inspections on supplies from equipment manufacturers	5.257	46	.000	.447	.28	.62
	Extensive inspections on supplies from dry dock providers	3.683	46	.001	.362	.16	.56
B9	Much rework on supplies from spare parts suppliers	-10.658	45	.000	-1.543	-1.84	-1.25
	Much rework on supplies from consumables suppliers	-10.381	44	.000	-1.533	-1.83	-1.24
	Much rework on supplies from repair vendors	-7.967	44	.000	-1.244	-1.56	-.93
	Much rework on supplies from equipment manufacturers	-7.892	46	.000	-1.191	-1.50	-.89
	Much rework on supplies from dry dock providers	-8.429	43	.000	-1.341	-1.66	-1.02
B10	Fluctuate demand on supplies from spare parts suppliers	-1.188	47	.241	-.146	-.39	.10
	Fluctuate demand on supplies from consumables suppliers	-2.651	46	.011	-.383	-.67	-.09
	Fluctuate demand on supplies from repair vendors	-.843	47	.404	-.104	-.35	.14
	Fluctuate demand on supplies from equipment manufacturers	-2.427	46	.019	-.340	-.62	-.06
	Fluctuate demand on supplies from dry dock providers	-1.494	44	.142	-.222	-.52	.08

Ship maintenance performance (item F3)

```
T-TEST
  /TESTVAL=20
  /MISSING=ANALYSIS
  /VARIABLES=F3_RTF
  /CRITERIA=CI(.95).
```

One-Sample Statistics (Emergency maintenance)

	N	Mean	Std. Deviation	Std. Error Mean
Performed emergency maintenance	44	27.05	19.053	2.872

One-Sample Test (Emergency maintenance)

	Test Value = 20					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Performed emergency maintenance	2.453	43	.018	7.045	1.25	12.84

One-Sample Statistics (Preventive maintenance)

	N	Mean	Std. Deviation	Std. Error Mean
Performed preventive maintenance	44	49.77	19.794	2.984

One-Sample Test (Preventive maintenance)

	Test Value = 45					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Performed preventive maintenance	1.599	43	.117	4.773	-1.25	10.79

One-Sample Statistics (Predictive maintenance)

	N	Mean	Std. Deviation	Std. Error Mean
Performed predictive maintenance	44	23.30	11.290	1.702

One-Sample Test (Predictive maintenance)

	Test Value = 35					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Performed predictive maintenance	-6.877	43	.000	-11.705	-15.14	-8.27

Planned ship maintenance performance (items G7-G9)

```
T-TEST
  /TESTVAL=2
  /MISSING=ANALYSIS
  /VARIABLES=G7 G8 G9
  /CRITERIA=CI(.95).
```

One-Sample Statistics

Item		N	Mean	Std. Deviation	Std. Error Mean
G7	Compliance to maintenance budget (excluding dry dock)	42	2.90	.821	.127
G8	Compliance to scheduled dry dock duration	45	2.93	.889	.133
G9	Compliance to dry dock maintenance budget	44	2.77	.912	.137

One-Sample Test

Item		Test Value = 2					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
G7	Compliance to maintenance budget (excluding dry dock)	7.144	41	.000	.905	.65	1.16
G8	Compliance to scheduled dry dock duration	7.040	44	.000	.933	.67	1.20
G9	Compliance to dry dock maintenance budget	5.623	43	.000	.773	.50	1.05

One-Sample Statistics

Item		N	Mean	Std. Deviation	Std. Error Mean
G7	Compliance to maintenance budget (excluding dry dock)	42	2.90	.821	.127
G8	Compliance to scheduled dry dock duration	45	2.93	.889	.133
G9	Compliance to dry dock maintenance budget	44	2.77	.912	.137

One-Sample Test

Item		Test Value = 3					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
G7	Compliance to maintenance budget (excluding dry dock)	-.752	41	.456	-.095	-.35	.16
G8	Compliance to scheduled dry dock duration	-.503	44	.618	-.067	-.33	.20
G9	Compliance to dry dock maintenance budget	-1.654	43	.105	-.227	-.50	.05

Shipping performance (items G1-G6)

```
RELIABILITY
  /VARIABLES=G1 G2 G3 G4 G5 G6
  /SCALE('G1 - G6') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE
  /SUMMARY=TOTAL MEANS.
```

Case Processing Summary

		N	%
Cases	Valid	45	93.8
	Excluded[a]	3	6.3
	Total	48	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.819	.823	6

```
T-TEST
  /TESTVAL=2
  /MISSING=ANALYSIS
  /VARIABLES=G1 G2 G3 G4 G5 G6
  /CRITERIA=CI(.95).
```

One-Sample Statistics

Item		N	Mean	Std. Deviation	Std. Error Mean
G1	Spare parts unavailability impact on shipping services	47	3.30	1.082	.158
G2	Consumables unavailability impact on shipping services	47	2.79	1.197	.175
G3	Maintenance experts unavailability impact on shipping services	47	3.06	1.205	.176
G4	Suppliers' technicians unavailability impact on shipping services	47	2.87	1.227	.179
G5	Dock space unavailability impact on shipping services	46	3.59	1.514	.223
G6	Ship unavailability for docking impact on shipping services	45	3.09	1.221	.182

One-Sample Test

Item		Test Value = 2					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
G1	Spare parts unavailability impact on shipping services	8.225	46	.000	1.298	.98	1.62
G2	Consumables unavailability impact on shipping services	4.510	46	.000	.787	.44	1.14
G3	Maintenance experts unavailability impact on shipping services	6.052	46	.000	1.064	.71	1.42
G4	Suppliers' technicians unavailability impact on shipping services	4.875	46	.000	.872	.51	1.23
G5	Dock space unavailability impact on shipping services	7.109	45	.000	1.587	1.14	2.04
G6	Ship unavailability for docking impact on shipping services	5.980	44	.000	1.089	.72	1.46

One-Sample Test

Item		Test Value = 3					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
G1	Spare parts unavailability impact on shipping services	1.888	46	.065	.298	-.02	.62
G2	Consumables unavailability impact on shipping services	-1.219	46	.229	-.213	-.56	.14
G3	Maintenance experts unavailability impact on shipping services	.363	46	.718	.064	-.29	.42
G4	Suppliers' technicians unavailability impact on shipping services	-.713	46	.479	-.128	-.49	.23
G5	Dock space unavailability impact on shipping services	2.629	45	.012	.587	.14	1.04
G6	Ship unavailability for docking impact on shipping services	.488	44	.628	.089	-.28	.46

One-Sample Test

Item		Test Value = 4					
		t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
G1	Spare parts unavailability impact on shipping services	-4.450	46	.000	-.702	-1.02	-.38
G2	Consumables unavailability impact on shipping services	-6.948	46	.000	-1.213	-1.56	-.86
G3	Maintenance experts unavailability impact on shipping services	-5.326	46	.000	-.936	-1.29	-.58
G4	Suppliers' technicians unavailability impact on shipping services	-6.302	46	.000	-1.128	-1.49	-.77
G5	Dock space unavailability impact on shipping services	-1.850	45	.071	-.413	-.86	.04
G6	Ship unavailability for docking impact on shipping services	-5.004	44	.000	-.911	-1.28	-.54

Shipping performance: compliances to planned availability (items G10-G11)

```
FREQUENCIES VARIABLES=G10 G11
  /STATISTICS=STDDEV
  /ORDER=ANALYSIS.
```

Statistics

		Compliance to scheduled ships' availability	Compliance to scheduled ships vayages' reliability
N	Valid	44	46
	Missing	4	2
Std. Deviation		.788	.790

Compliance to scheduled ships' availability (item G10)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	50-69%	9	18.8	20.5	20.5
	70-89%	14	29.2	31.8	52.3
	more than 90%	21	43.8	47.7	100.0
	Total	44	91.7	100.0	
Missing	not applicable	3	6.3		
	no answer	1	2.1		
	Total	4	8.3		
Total		48	100.0		

Compliance to scheduled ships vayages' reliability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 50%	1	2.1	2.2	2.2
	50-69%	6	12.5	13.0	15.2
	70-89%	16	33.3	34.8	50.0
	more than 90%	23	47.9	50.0	100.0
	Total	46	95.8	100.0	
Missing	not applicable	1	2.1		
	no answer	1	2.1		
	Total	2	4.2		
Total		48	100.0		

Shipping performance: Participants' perceptions of ship maintenance (items G12-G16)

```
DESCRIPTIVES VARIABLES=G12 G13 G14 G15 G16
  /STATISTICS=MEAN STDDEV MIN MAX.
```

Descriptive Statistics

Item		N	Minimum	Maximum	Mean	Std. Deviation
G12	Ship maintenance improves availability of ships	48	2	5	4.33	.663
G13	Ship maintenance improves reliability of ships	48	3	5	4.69	.512
G14	Ship maintenance improves customer satisfaction on shipping services	48	3	5	4.56	.580
G15	Ship maintenance reduces total OPEX	48	2	5	4.17	.883
G16	Ship maintenance increases company's profits	47	3	5	4.38	.644
	Valid N (listwise)	47				

Potential benefits from adopting supply chain management approach (items B7, B10, G1-G5)

```
RELIABILITY
  /VARIABLES=B7_SPs B7_Cons B7_RepVs B7_EMs B7_DdFs G1 G2 G3 G4 G5
  /SCALE('B7 - G1-G5') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE CORR
  /SUMMARY=MEANS.
```

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.703	.585	10

Item Statistics

	Mean	Std. Deviation	N
Spare parts suppliers consistently meet company's requirements	3.67	.928	42
Consumables suppliers consistently meet company's requirements	3.69	.841	42
Repair vendors consistently meet company's requirements	3.62	1.035	42
Equipment manufacturers consistently meet company's requirements	3.64	.879	42
Dry dock providers consistently meet company's requirements	3.76	.958	42
Spare parts unavailability impact on shipping services	3.33	1.074	42
Consumables unavailability impact on shipping services	2.83	1.167	42
Maintenance experts unavailability impact on shipping services	3.07	1.177	42
Suppliers' technicians unavailability impact on shipping services	2.88	1.194	42
Dock space unavailability impact on shipping services	3.67	1.493	42

```
DATASET ACTIVATE DataSet1.
CORRELATIONS
  /VARIABLES=B7_SPs B7_Cons B7_RepVs B7_EMs B7_DdFs with G1 G2 G3 G4 G5
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

Correlations

		Spare parts unavailability impact on shipping services	Consumables unavailability impact on shipping services	Maintenance experts unavailability impact on shipping services	Suppliers' technicians unavailability impact on shipping services	Dock space unavailability impact on shipping services
Spare parts suppliers consistently meet company's requirements	Pearson Correlation	.439**	.209	.399**	.004	.286
	Sig. (2-tailed)	.002	.158	.005	.979	.054
	N	47	47	47	47	46
Consumables suppliers consistently meet company's requirements	Pearson Correlation	.225	.295*	.139	.086	.187
	Sig. (2-tailed)	.137	.049	.363	.574	.225
	N	45	45	45	45	44
Repair vendors consistently meet company's requirements	Pearson Correlation	.158	.055	.116	.144	.135
	Sig. (2-tailed)	.295	.719	.442	.338	.377
	N	46	46	46	46	45
Equipment manufacturers consistently meet company's requirements	Pearson Correlation	.337*	.186	.282	.241	.095
	Sig. (2-tailed)	.022	.215	.058	.107	.534
	N	46	46	46	46	45
Dry dock providers consistently meet company's requirements	Pearson Correlation	.203	.035	.046	.030	.197
	Sig. (2-tailed)	.181	.819	.765	.845	.200
	N	45	45	45	45	44

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

```
RELIABILITY
  /VARIABLES=B10_SPs B10_Cons B10_RepVs B10_EMs B10_DdFs G1 G2 G3 G4 G5
  /SCALE('B10 - G1-G5') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE CORR
  /SUMMARY=MEANS.
```

Scale: B10 - G1-G5

Case Processing Summary

		N	%
Cases	Valid	43	89.6
	Excluded[a]	5	10.4
	Total	48	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.788	.700	10

Item Statistics

	Mean	Std. Deviation	N
Fluctuate demand on supplies from spare parts suppliers	3.84	.898	43
Fluctuate demand on supplies from consumables suppliers	3.60	1.027	43
Fluctuate demand on supplies from repair vendors	3.88	.905	43
Fluctuate demand on supplies from equipment manufacturers	3.63	1.001	43
Fluctuate demand on supplies from dry dock providers	3.77	1.020	43
Spare parts unavailability impact on shipping services	3.33	1.107	43
Consumables unavailability impact on shipping services	2.88	1.199	43
Maintenance experts unavailability impact on shipping services	3.07	1.203	43
Suppliers' technicians unavailability impact on shipping services	2.91	1.231	43
Dock space unavailability impact on shipping services	3.65	1.510	43

```
CORRELATIONS
  /VARIABLES=B10_SPs B10_Cons B10_RepVs B10_EMs B10_DdFs with G1 G2 G3 G4 G5
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

Correlations

		Spare parts unavailability impact on shipping services	Consumables unavailability impact on shipping services	Maintenance experts unavailability impact on shipping services	Suppliers' technicians unavailability impact on shipping services	Dock space unavailability impact on shipping services
Fluctuate demand on supplies from spare parts suppliers	Pearson Correlation	.279	.264	.054	.039	.167
	Sig. (2-tailed)	.058	.073	.720	.794	.267
	N	47	47	47	47	46
Fluctuate demand on supplies from consumables suppliers	Pearson Correlation	.234	.097	.059	.145	.136
	Sig. (2-tailed)	.117	.523	.696	.336	.375
	N	46	46	46	46	45
Fluctuate demand on supplies from repair vendors	Pearson Correlation	.128	.001	.264	.279	.032
	Sig. (2-tailed)	.391	.993	.073	.057	.830
	N	47	47	47	47	46
Fluctuate demand on supplies from equipment manufacturers	Pearson Correlation	.170	.035	.195	.181	.024
	Sig. (2-tailed)	.258	.820	.194	.229	.874
	N	46	46	46	46	45
Fluctuate demand on supplies from dry dock providers	Pearson Correlation	.123	.128	.258	.144	.085
	Sig. (2-tailed)	.428	.407	.090	.350	.588
	N	44	44	44	44	43