

2013

Challenges and potential of technology integration in modern ship management practices

Bhardwaj, Suresh

<http://hdl.handle.net/10026.1/2840>

<http://dx.doi.org/10.24382/4076>

University of Plymouth

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Challenges and potential of technology integration in modern ship management practices

by

Suresh Bhardwaj

A thesis submitted to the Plymouth University

in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

International Logistics, Supply Chain and Shipping Management

Plymouth University, UK.

November 2013

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Abstract

Challenges and potential of technology integration in modern ship management practices

Suresh Bhardwaj

This thesis explores the challenges and potential of technology integration in current ship management practices. While technology advancements were designed to be contributing to minimising task complexity, issues such as fatigue, increased administrative burden and technology assisted accidents still plague the industry. In spite of the clearly recognisable benefits of using modern technology in the management of ships, in practice its application appears lacking by a considerable margin. The main driver of the study was to appreciate the cause of this disparity.

The study first reviewed a wide body of literature on issues involving the use of technology which included academic literature with empirical evidences and theoretical explanations of implementation of technology at work. With the help of the extant knowledge this research embarked on providing an explanation to the gap that existed in the application of technology in the shipping industry. By taking a case study approach the thesis looked into the induction and integration of technology in the management and operation of ships that primarily interfaced closely between the ship and its management unit on shore. Three companies with mutually diverse management setup were studied. The fourth case comprised of purposefully selected senior members of ships' staff.

The analysis of the data revealed that the manifestation of the gap in technology implementation is caused by deeper influences at work in the shipping industry. The unoptimised technology integration results in the seafarer, who is the keystone to the technology application, becoming a victim of the circumstances. The technology that was intended to ease operations and burdens ends up in controlling him, even leaving him under-resourced and causing fatigue. This was not an unintended outcome but the result of weak regulatory practices, short-term capital outlook and weakened labour practices in the shipping industry all caused by wider social and economic developments affecting not just this industry but businesses globally. The impact of such influences was however more acute in this industry resulting in such extreme consequence.

By bringing to light the limited application of some fundamental principles of human-systems integration, this study has attempted to expand the boundaries of research on the subject and contributed to the holistic understanding of the various underlying factors that influence technology integration in ship management processes.

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Acknowledgements

Firstly, I wish to thank my supervisors Professor Michael Roe and Dr Syamantak Bhattacharya for having initially accepted me with work-in-progress and then very patiently guiding it to completion. The blend of harsh critique and sincere encouragement provided a very stimulating and deep learning experience that will endure my remaining lifetime. The invaluable support rendered by The Plymouth Business School and Ms Cher Cressey, the Doctoral Training Centre Administrator, has been exemplary.

It was a chance meeting with Dr Lisa Froholdt that fructified my aspirations for research with her introducing me to the Department of Maritime Research and Innovation at the University of Southern Denmark. Dr Kristen Nedergaard the then head of this department left no stones unturned in ensuring my affiliation and even securing full funding for the project. Associate Professor Maria Anne Wagtmann as the principal supervisor facilitated a smooth commencement and imparted the crucial initial guidance and progress. Midway through the project this department was notified to be closed down and the head Dr Flemming Just facilitated the seamless transfer of the project to the Plymouth University. No words can describe the deep sense of gratitude that goes out to them and all the fellow researchers and staff at this department that radiated such invigorating energies and provided such ingenious and creative environment.

My wife Aprajita had raced me in her doctoral research work and had gone through it all. There could not have been a better and more realistic supporting environment at home. From nagging, nit-picking, castigating and outright censure to consoling, reassuring and

inspiring, whatever that seemed to work for her was adopted. Reaching the goal was all that mattered. Thank you so much for knowing me so well. This work is dedicated to you.

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

The study originally commenced at the University of Southern Denmark, Department of Maritime Research and Innovation under a PhD study agreement to carry out independent research work under their supervision and with all expenses related to research project being met by them. However, after completion of 22 months, the study was transferred to Plymouth University due to the closure of this department at the Danish University.

The following PhD programs were undertaken:

PhD Courses				
Course title	Type	Name of institution offering the course	ECTS	Completed and approved by the PhD Committee of University of Southern Denmark
Applied quantitative methods – Introduction to basic econometric techniques	PhD Course	Copenhagen Business School (CBS)	3.0	Nov 2009
Maritime economics and management - PhD Seminar	PhD Seminar	University of Southern Denmark & CBS	2.0	Dec 2009
Systems approach to management	PhD Course	AMET University, Chennai	4.0	July & Aug 2010
The Case Study: Fieldwork and qualitative methodology as a research strategy.	PhD Course	Aarhus School of Business, Aarhus University	5.0	Sept 2010

Papers were published and presented at relevant conferences. This study is the result of my own independent work/investigation, except where otherwise stated.

Word count: 72575 Signed: Suresh Bhardwaj Dated: 6th November 2013

Chapter 1: Introduction

1.1 The aim of the study

This research aims to study the challenges and potential of technology integration in modern ship management practices that is increasingly becoming available for deployment in the operation and management of ships.

The main task of shipping is to offer efficient transport services; and improvement in transport service quality is critical in achieving a differential advantage over competitors (Thai, 2008; Greve, 2009). Technology deployment through innovation is a great enabler that increases the possibility to improve operational performance, productivity and life cycle optimisation of the assets, as seen in other industries (Frankel, 1991; Nikitakos and Lambrou, 2007). In particular, information communication technology (ICT) has become a strategic asset which can help improve business processes and change the function of markets. Thus, it is necessary for organisations to continue their efforts in developing and implementing up-to-date technology (Yang *et al.* 2007). In the maritime field too, technology and ICT capabilities now exist to increase integration of vessel plant data with the business management systems ensuring optimised asset management and operation of each vessel in particular and the whole fleet at a corporate level (Lorange, 2001; Panayides, 2003; Lyridis *et al.* 2005).

1.2 An overview of the shipping industry service

1.2.1 A significant mode of transportation service

Shipping plays a very significant role in underpinning international commerce providing the most effective delivery mechanism for the vast majority of world trade (IMO, 2010).

More than 80% of international trade in goods is carried by sea, making maritime transportation the single most important transportation mode. As a matter of fact, the world seaborne trade mirrors the performance of the wider world economy, as reflected in figure

1. By the beginning of 2011, the total world merchant fleet (of size above 100 gross tons) had expanded by 8.6% over 2010 to reach 1.4 billion deadweight tons, numbering 103392 seagoing commercial ships in service (UNCTAD, 2011).

Indices for world GDP, the OECD Industrial Production Index, world merchandise trade and world seaborne trade (1977-2011) (1990=100).

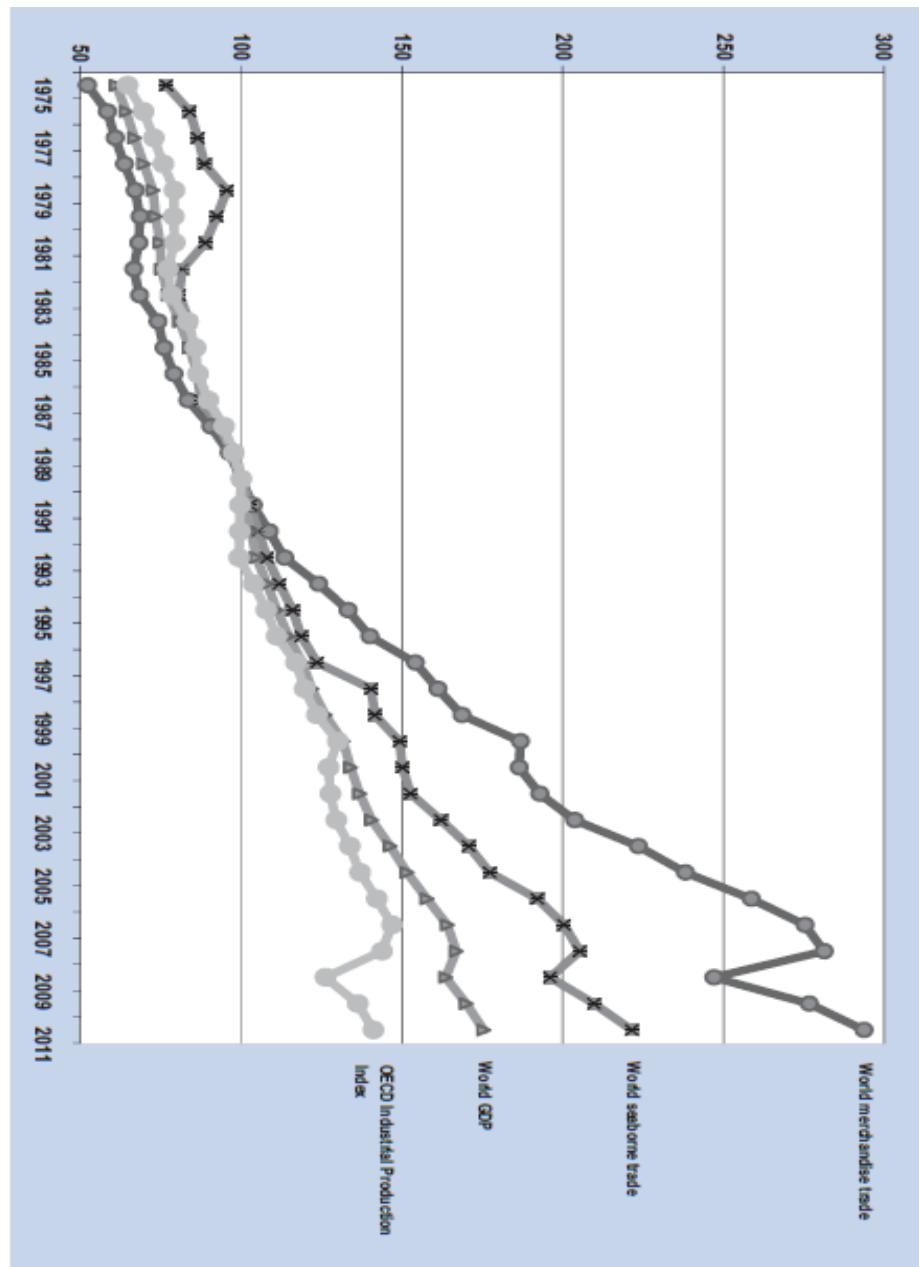


Figure 1: Significance of maritime transport. Source: UNCTAD, (2011).

1.2.2 Challenges in the service of shipping

The shipping industry like any other service industry grapples with the challenges of global competition and growing demands for efficiency. Along with the concerns for human safety and environmentally safe operations, the key dimensions of its service quality include operations and management efficiency which are characterised by the outcomes of service performance and enabled by technology applications for process efficiency. However, in the maritime field there is very little evidence of any academic research on management systems and the factors that make them or prevent them from working optimally (Lyridis *et al.* 2005; Barnett *et al.* 2006; Thai, 2008). Greve (2009) compares the shipping industry with other service industries and points out that the shipping firms deliver transportation services, and as in many other service industries the service delivery not only requires substantial investments in capital goods but also the service needs to be built for efficient operation, and customised to deliver specific transportation services. Furthermore, Cetin and Cerit (2010) who studied “organisation effectiveness” in seaports through a systems approach acknowledge it as a rather new concept in shipping which generally is a uniquely structured social and technical organisation. Its most important effective measures include productivity, efficiency, service quality, adaptability, information and communication management, profitability, human resource quality and customer satisfaction.

To be a truly world-class organisation, any company needs to work as a team and all the functional areas of the business need to be properly integrated, with each understanding the importance of cross functional processes. The advent of technology and connectivity now makes the remotest of ships at sea just another node in the corporate intranet. This assists

the ship board management to work closer as a team with the shore based management and thus could render ship management effective (O'Neil and Sohal, 1999). The available technologies are assisting in bridging the physical gap between land and sea by virtual means, making the crew of a ship as a node in a distributed network and as transnational teams. Customised personnel and technical management software for maritime markets are available and being employed to improve operational efficiency leveraging this connectivity and ease of data transfer. The effects of technological change and information technology are now changing the processes involved in ship operation and management, and are seen to be so dramatic that it can be compared to the effect brought about by change from sail to steam that changed the management structures, the technical aspects and the staff development needs of processes (Collins and Hogg, 2004).

Such a change is bound to bring with it its own challenges and issues. Besides the issues relating to human-machine interacting environment, there would be typical automation and technology related constraints like information integrity and security, and automation reliability, which too would need to be studied concurrently (Roumboutsos, Nikitakos and Gritzalis, 2005).

1.2.3 Can proper technology integration improve the services of shipping?

The development and deployment of technology is intimately bound with the notions of progress and a natural societal advance from a lower state to ever higher ones, a necessity characterised by integration or change from less coherent to more coherent forms. For example, the shipwrights and naval architects have over centuries created a variety of watercrafts exhibiting the same fundamental properties such as the hull proportions that we

see in the modern ships today (King, 2001). Lately, the shipping industry has also seen induction of technology as in other industries like electronics or process industries. Being a safety-critical industry, the deployment of technology focused more on its capability to enhance safety; and since safety management is an integral part of overall ship management, this area was *inter alia* partially addressed through technology interface, but lacked a holistic approach. Knudsen (2009) empirically finds that efforts to reduce accidents in seafaring have led to proliferation of procedures such as workplace assessments and checklists which not only increase avoidable work load but also are perceived by many seafarers as counteracting the use of common sense, experience, and professional knowledge epitomised in the concept of seamanship.

Cheng *et al.*'s (2011) review of cases found that technology, organisational structure and business processes impact one another, and in today's technology-intensive environment, organisational structures and business processes need to be developed in coordination with technological development. They claim that in doing so, organisations will gain the potential to harvest benefits from technology-organisation- process integration.

Furthermore, technological advances have now seen deployment of communication and information technology which has increasingly rendered obsolete the traditional operational environment with the lone ship at sea being a self-reliant unit due to its geographically distant location. Interconnectedness and ease of reporting allows shore management to monitor what is occurring on-board the ship. In theory this forces the shore management to share responsibility for important aspects of ship performance that have traditionally been seen as out of their control once a ship leaves port.

These advances are seen to have significant impacts in the way shipping operates as it alters the traditional pattern of operating and managing ships in as much as it threatens to displace many of the practices that have characterised the seaman's art through the ages. As Yang *et al.* (2007) state, technology often transforms the landscape of an industry and widely impacts processes. Mullins (2002) while conceptualising technology advocates Orlikowski's (1992) model of distinguishing the *scope* (what is defined as comprising technology) and the *role* of technology (how the interaction between technology and the organisation is defined). Orlikowski (1992) goes on to infer that the duality of technology allows us to see technology as enacted by human agency and as institutionalised in structure of the organisation. She concludes,

The on-going interaction of technology with organisations must be understood dialectically, as involving reciprocal causation, where the specific institutional context and the actions of the knowledgeable, reflexive humans always mediate the relationship. This view of technology encourages investigations of the interaction between technology and organisation that seek patterns across certain contexts and certain types of technology, rather than abstract, deterministic relationships that transcend settings, technologies and intentions. As the field of study shows, there are strong tendencies within institutionalised practices that constrain and facilitate certain developments and deployment of technology. In particular, understanding how different conditions influence the development, maintenance, and use of technologies would give insight into the limits and opportunities of human choice and organisational design (pp. 423,424).

The situation becomes more complex when automation designed to be used in high hazard domains like shipping proves detrimental when errors are introduced through its improper use without the holistic understanding and deployment of the technology – organisation –

process interactions. Macrae's (2009) analysis of common patterns of errors at sea finds influences of the organisational context and situational factors in provoking and shaping errors with situational factors such as inappropriate equipment or clumsy procedures providing error traps. Likewise, organisational factors, such as production pressures or lack of training that leave crew under-resourced. As automation and technology are decision support systems and are designed to assist human operators to reduce the risks, the human element remains a prevalent factor. Perrow (1983) in his discourse on human factors engineering in an organisational context specifically brings out the contrasts between what he describes as the “error-avoiding air transportation system and an error-inducing marine transportation system” (p.525). According to him, the air transportation system has high visibility, and performance failure affects profits and reputation immediately. There are stricter regulations and open investigations as well as various cross checks and balances. But in marine transportation, nations have conflicting interest and regulations are weaker. The human losses are restricted predominantly to crew as opposed to passengers in the air transport industry. Shipping remains largely a business-to-business activity and the consumers' interaction with the industry is minimal. The analyses of accidents are also impeded by national and other interests.

The reflections on factors underpinning ship operations and management raised many areas to be explored. Is the economics of robust technological change an impeding factor? Are there influences of the strong “community of practices” (Wenger and Snyder, 2000, p.141) of the very traditional and unique work environment of the shipping industry? How have the impacts of automation been experienced in other industries and are there any lessons to

be learnt? What are the benefits and challenges with technology and automation deployment in the maritime industry?

1.3 The objectives of the study

Against this background, this study seeks to understand the various challenges of automation and technology applications in ship operations and management along with their causal factors. It also seeks out the potential for optimisation through effectiveness of technologically integrated management processes. Importantly, it keeps one open to learning in research to the extent of refuting or falsifying what one seeks, and engages in a scientific study of technology integration in ship operation and ship management processes and practices.

Chary (2005) cautions that high-tech solutions are not the only panacea for the improvement of businesses particularly when advocated without proper domain knowledge. Anybody attempting process reengineering must have a thorough knowledge of the business. While the basis of competition still remains cost and quality but perhaps now includes flexibility and responsiveness, the value of process management is now being recognised as a tool that can help create sustainable competitive advantage. The redesign of management process and accompanying practice is a unique way to support the organisational performance via improving the effectiveness and adaptability of key managerial issues (Celik, 2009).

The principal aim of this study is to deepen understanding of challenges and potential of technology integration in modern ship management practices and explore opportunities for

process optimisation in alignment with contemporary management theory and practice, and fill the void in academic study conducted in this field. In order to achieve the objective effectively, the thesis delves into relevant literature, follows a qualitative methodology and presents and discusses extensive findings from empirical research before drawing conclusions and making recommendations. The layout of the thesis is described in detail below.

1.4 The thesis layout

The thesis has a further seven chapters.

Chapter 2 discusses the course of technology in shipping, from its economic perspectives to its inevitable advancement and then traces briefly the evolution of automation architecture in ship operations and its management. In the process it also delimits the boundary of the research project and provides the scope of coverage as the technical management processes within the modern ship management functions that have the greatest bearing on modern ship management practices. It then progresses to review the enabling technology in this specific area of technical management of ships that lies at the core of ship-shore interface thus making it the most contributing factor.

Chapter 3 then presents the thesis's theoretical foundation of technology-organisation-human interface and later delves into the skilling dilemma triggered by the technology integration. It then attempts to make out a case for the need to look at enhancing optimisation of the potential of technology application with its scientific integration into the shipping management practices.

Chapter 4 examines the challenges and limitations of automation and technology in ship operations and ship management. It then summarises the discussions, notes the lack of adequate research in the industry so far and goes on to enunciate the main and subsidiary research questions.

Chapter 5 then delineates the research methodology and presents the research strategy adopted as case-study. It includes a discussion of various data sources, the methods of collecting and analysing data and the limitations and challenges of the research design and fieldwork, including ethical considerations. It discusses the four case studies in the context of the research activity that explores alike situations across more than one entity, with constant cross-vetting, verification and comparison of facts. The explorative integration methodology helped generate facts in the field to create an integrative view of the enquiry response findings. This would enable formation of an opinion on the trustworthiness of the findings.

Chapter 6 presents the empirical field data with application of diligence and judgment and puts forth the various challenges with technology integration in ship operations and ship management. It shows overwhelming evidence of lack of any scientific integration backed by proper research. It reveals that the economic logic of low costs dominates the operations in the industry. The attitude of reactionary and minimal compliance to regulations leaves no room for proactive value creation in optimised operations with technology integration. It is these very issues that seem to become the root cause for all the challenges with technology integration encountered in various phases and circumstances of ship operation and

management enumerated in this chapter. This then leads logically to identifying the potential that exists to be harnessed for better practices.

Chapter 7 analyses the data and engages in locating and confirming the underlying causal factors of the persisting challenges and the tardy approach to optimisation in the shipping sector. It does so with the help of extant studies and relevant sociological theories and rationalises the debate. It further describes the optimisation potential with process reengineering of a specified process believed by case study participants to deliver maximum results from such an effort.

Chapter 8 finally presents the main assessment and conclusions of the research findings bringing together the theme of the empirical chapter and the analysed data in order to address the research question. It also makes policy recommendations on key issues challenging the optimised technology integration in ship management practices. Any research study is bound to have its own limitations and these are listed next, followed by suggested areas of scope for further research, and final concluding remarks.

Chapter 2: Technology induction in ship operations and ship management

Introduction

This chapter introduces the subject of application and integration of automation and technology in the areas of ship operations and ship management and traces the course that it has followed.

Maritime transport serves world trade. The driving force that guides the efforts of any transport system is the quest to win more business by providing cheaper transport and a better service (Stopford, 2009). Thus the economic considerations of technology up-gradation needs be first considered. The first section delves into shipping economics and its nuances before understanding the economics of technology change and up-gradation. With the objective to delimit the research project the architecture of ship management system is traced and the function having greatest influence on the ship management practice is scoped. The evolution of technology and its application in the delimited function of technical management is then discussed. With this base, the advancing technology specifically in the area of technical management in modern ship management practices is then reviewed.

2.1 The course of technology application in shipping

The shipping industry has not been very responsive to change. It tends to play safe and rely on a hands-on approach to management and operation, in spite of reliable technology

having made inroads into and been integrated with safe ship operations. Sharma (2008) in his study of the understanding of a service management framework in the ship management industry finds that it primarily runs on heuristics and rules of thumb. As the industry has some unique occupations set in a relatively isolated environment, it tends to believe that they are managing well by themselves and not requiring any external interventions. In spite of being a capital intensive industry, some basic management models are found to be conspicuous by their absence. Knudsen (2009) affirms that shipping and seafaring has the reputation for being conservative. In her empirical research on seafarers' reluctance against written procedures exemplified by the concept of seamanship, she finds that innovations are often met with much scepticism. The possible reasons for such feelings will be looked into in chapter 4 which discusses the challenges with technology and automation.

Technology application in shipping as a strategy follows the generic fundamental economic logic of how it will obtain its returns. A firm creates value for its customers and returns for itself by either achieving lower costs than its competitors, or offering better perceived quality in any differentiated feature for which customers are willing to pay a premium (Hambrick and Fredrickson, 2001). If value creation is the *raison d'être* for firms (Woiceshyn and Falkenberg, 2008), it calls for examining the economics of shipping and the economics of introducing technological change in shipping and see what manifests as the choice of economic logic in shipping.

2.1.1 The economics of shipping

Shipping economics exists as a separate branch of economics typically because of the relationship between globalisation and shipping industry dynamics. There are (a)

challenges and opportunities to the international shipping industry that follow from globalisation and changes in economic policies as well as maritime laws, and (b) the different positive and negative externalities of seaborne shipping. This throws up two specific characteristics of shipping: (a) the well-known cycles of the shipping markets, which also concerns the demand for shipping services and thus also freight rate fluctuations; and (b) the idiosyncratic nature of shipping investment itself. The two are inextricably linked. Investing in ships thus becomes classified as astute, a brave or an insane decision depending on the state and the prospects of the shipping markets which rarely - if ever - fulfil the promises they seem to give (Thanopoulou, 2002). Lorange (2001) affirms this and comments that shipping is largely a matter of judging the markets, and of timing in particular. While attempts are made to understand the various underlying factors that create supply and demand, however, with innumerable factors, events and issues likely to impact the shipping markets, it becomes impossible to accurately forecast the markets.

Stopford (2009) points out that the shipping markets have cycles of under and oversupply with a rough average of seven years per cycle. However, the cycle length is sufficiently variable to make a strategy of ordering ships ahead of an up-turn very difficult to implement. He further claims that ship owners are cost conscious because the return on investment (ROI) in shipping is lower than in most other industries, averaging less than 10 % per annum. He compares the returns from shipping with that of the all-companies index in the UK over a select period ranging from 1970 to 1990 where shipping gave an ROI of 9 % (of which only 4.4 % came from trading and balance from asset play), others gave an average of 11.2 %.

Stopford in his earlier work (2000) had highlighted that the cost reductions that shipping could achieve and contribute to the lower cost of freight was due to four major factors:

- (i) a revolution in international communications typified by electronic data interchange (EDI);
- (ii) economies of scale achieved by the growing size of ships;
- (iii) unitisation and containerisation with automation extensively used to reduce unit cost; and,
- (iv) deregulation of international shipping leading to flagging out¹ and change of control to third party managers.

The last factor was arguably the most significant contributor to cost reduction. Globalisation provided the opportunity to take advantage of all the economic benefits offered by new and more efficient market factors. While earlier the ship owner would register his ship in his own country of domicile and fly its flag, and crew it with people from his own country, today the ships fly the flags of foreign nations and are crewed by seafarers of different nationalities. There are typically three key players in the shipping industry today: asset owner (ship owner), asset user (charterer), and the asset operational manager (ship manager). The interest and motivation of these three key actors are different. The ship owner wants highest return on investment, while the charterer wants most the cost effective service with highest reliability. The ship manager makes efforts to integrate these diverse interests with efficient service management. He makes sure the ship has efficient

¹moving the ownership to countries and flags set up for the purpose to avoid tax, employment regulations , company regulations and disclosure

crew to man it, adequate quality standards to run the ship safely and meet international quality regimes, and that the asset value is maintained (Sharma, 2008). It is thus not hard to see that the choice of economic logic for value creation in shipping has been lowering of costs.

2.1.2 The economics of technological change

Technological change poses some of the most important concerns for shipping management in the current time. A shipping industry that was largely controlled by cargo shippers and shipping companies existed in closely controlled regimes and was carefully supervised by charterers. This elicited close interest in investments and operational performance. Now shipping has evolved into an aggressively competitive market driven regime. Charterers are often replaced by traders who take a short term view and prefer to hire ships they need from the spot market rather than charter long term (Stopford, 2000). This is also the case with ship owners who are more asset players and may sell their vessels and buy new ones or move them in and out of third party management, depending on fluctuating market situations, making it difficult to plan investment in technology (Shea, 2005).

Mitroussi (2004a) finds that third party ship management has now evolved into an industry in its own right and has made a critical contribution to a fundamental restructuring of the shipping business. It is estimated that more than one-third of the global shipping fleet is in the hands of third party managers. Professionals run assets they do not own and take decisions, while the owner has neither time nor information or commitment, and becomes more concerned with the dividends than the operation of their company. The basic objective for a third party ship manager becomes asset preservation for the owner offering

cost savings that he derives from economies of scale from technical support. Thus the fundamental nature of the business of shipping today, under severe pressure from the international shipping economic environment, lends volatility resulting in short term relationships between the ship owner, charterer and the manager, making technology change decisions more difficult.

Ship owners may also come from a conservative background which views technology with suspicion from the investment return optimisation perspective. However, as the technology keeps changing frequently, this inflicts a wait-and-watch approach in ship-owners' decision making, rendering the task more difficult. Vlachos and Nikolaidis (2002) have provided empirical evidence that ship owners' concern for quality is strongly related to the operating cost levels. This ranges over five levels, which they class as: optimum, good practice (high level of expense), standard practice (medium level of expense), common practice (minimum level of expense) and minimum (ship owner operates a sub-standard ship).

The highly competitive business environment of the shipping industry along with international regulations, directs the companies' strategies to operational cost reduction and to produce low cost services. Since manning expense represents as much as 50% of the operation costs, the owner tends to employ cheap labour at the cost of quality, who may not be able to handle the advanced technology (Progoulaki and Theotokas, 2010). With the slicing of the maritime value chain as discussed before and the activities such as crewing, technical and commercial operations being performed by separate entities it has influenced the incentive structure in the industry in many ways. The industry grapples with issues of split-incentives now well recognised as barriers to the diffusion of new and efficient

technology. The ship owner faces the dilemma between minimisation of operating costs with crewing costs to his account as against his capital costs of new or retrofit of equipment to existing tonnage where charterers or commercial operators draw the benefit.

Frankel (1991) points out that technology change decisions are usually made on the basis of economic and performance advantage, but the choice, timing, scale of introduction, and utilisation of old as well as new technology is becoming more difficult now as new technologies become increasingly available long before the expiration of the economic life of existing technologies.

The problem of technological change is also different whether one is an early or late adopter of existing technologies, in as much for large and financially powerful versus small and growing transport companies considering a new technology. Their perception of value and risk are quite different, which in turn affects their technology change decisions.

Jessen (2003) cautions that while there is a clear dependency between technology-led innovative practices and profitability in business it is not always profitable to invest in innovation. The failure rate is very high and many innovative initiatives never create profit. Therefore, the question always remains, as to what makes an innovation profitable.

Nikitakos and Lambrou (2007) reviewed current practices and emergent patterns regarding digital shipping in Greek owned tonnage. They observed that while Greek-owned shipping is financially robust, there is very low level of technology usage. They cite empirical evidence on e-readiness and maturity related to e-business models, as well as perceptions of key barriers and incentives in the Greek-owned shipping sector.

The Greek-owned ocean-going fleet in particular is ranked in the first place globally in terms of real ownership by country of domicile (ISL, 2010). However, in the field of communication and e-business applications, investments have not followed the same trend. The reasons accounting for the major obstacles in the adoption of electronic services are start-up costs or costs of acquisition, lack of reliability and efficient technical support, as well as the high cost of satellite communication services. Additional reasons have been compatibility and interoperability problems in the present framework of processes, the lack of standardisation in digital forms and documents that constrain the advantages stemming from the adoption of e-business applications. This study has further examined the perceived obstacles for the adoption of electronic applications by shipping companies, and found them to be primarily, (a) initial cost of acquisition, (b) lack of efficient technical support, (c) annual operational cost, (d) lack of compatibility with the present state of business cycles, (e) lack of standards, (f) need for expert employees, and (g) lack of sufficient data security.

While the above study was drawn from a Greek example, the concerns are likely to be similar across the industry.

2.2 The inescapable use of technology in advancement

Technology stems from the acquisition of new knowledge and is as a result of scientific enquiry. Aerospace, electronics and pharmaceuticals are all industries that depend heavily on scientific research for the creation of new product and their research and development costs are substantial (OECD, 1992). Just as in any other industry, an increased application of the latest technology and automation is also seen in the shipping industry.

While tracing the course of technology in shipping, King (2001) comments that technologies can be observed to proceed through three distinct stages: (1) *innovation* when a new means is first conceived but remains largely unacknowledged; (2) *intermediate* when its potential is clear and it becomes established at an increasing rate and (3) *mature* when the scope for further development is almost exhausted. The time gap that intervenes is getting reduced increasingly. While it took 70 years for the steam engine to get established, the evolution and establishment of the diesel engine in the 20th century has been much faster. Technology has created the means to do things that were inconceivable before and presently even in the traditionally conservative maritime field, technology change is now keeping apace. Advances in information communication technology (ICT) now pose the potential to fundamentally alter the course of shipping. Sophisticated systems and equipment with embedded software for fault diagnosis as well as multiple means for communication with shore-based units are being installed on newer sophisticated vessels.

Rensvik *et al.* (2003) have traced developments in maritime industrial information technology (IT). They report that in automation in industry, a shift in technology related to integration of real time control and monitoring systems for operation management was initiated in the mid 1990's mainly driven by process industries like chemical plants, oil and gas, pulp and paper. According to them, the use and availability of web technology as a means of communication increased significantly in the 1990's. This enabled e-business and remote monitoring and control capabilities of equipment, systems and ships and fuelled the desire to achieve online interactions. They provide the example of the Norwegian maritime cluster that has earnestly embarked on several research programs involving maritime industrial IT for ship operation and management.

Technological innovation has now underpinned transformation in the shipping industry. It is now possible to operate bigger, faster, safer, and more specialised ships with fewer people on-board. The last few decades has seen deployment of a range of new equipment developed as a result of technological innovation aboard ships, which includes automated engines and cargo control systems (Tang and Sampson, 2011).

The development and deployment of integrated automation systems with capability to monitor and control all the system parameters from the engine control room, bridge, cargo control room, day-rooms etc. is the order of the day, especially with the ship-owners who believe in technology led operations. Typical systems include alarm, main engine control, bilge-ballast, generator engines control and power management, hull stress monitoring, tank gauging and monitoring, bridge manoeuvring, fire monitoring, conning display and reefer monitoring.

Automation and IT now form an integral part of all new vessels, whether it is a small ship or a highly sophisticated LNG carrier, with on-board installation as complicated as a petro-chemical complex ashore; and with the added capability for transmitting ashore all the critical parameters for monitoring and advice purposes, if so desired (Jensen, 2009).

Allen (2009) concludes that the use of ICT is growing in the maritime industry as more systems become monitored remotely and new technologies are introduced to aid environmental awareness and increase safety.

The following section lays out the architecture of modern ship management systems in the context and also limits the scope for the research project.

2.3 The ship management system and scope of the project

In terms of scoping the challenges and potential of technology integration in modern ship management practices, it will first be necessary to examine the architecture of a ship management system and delimit the boundary for the research project that would have the greatest bearing on modern ship management practices.

Figure 2 with its key describes comprehensively the ship management system:

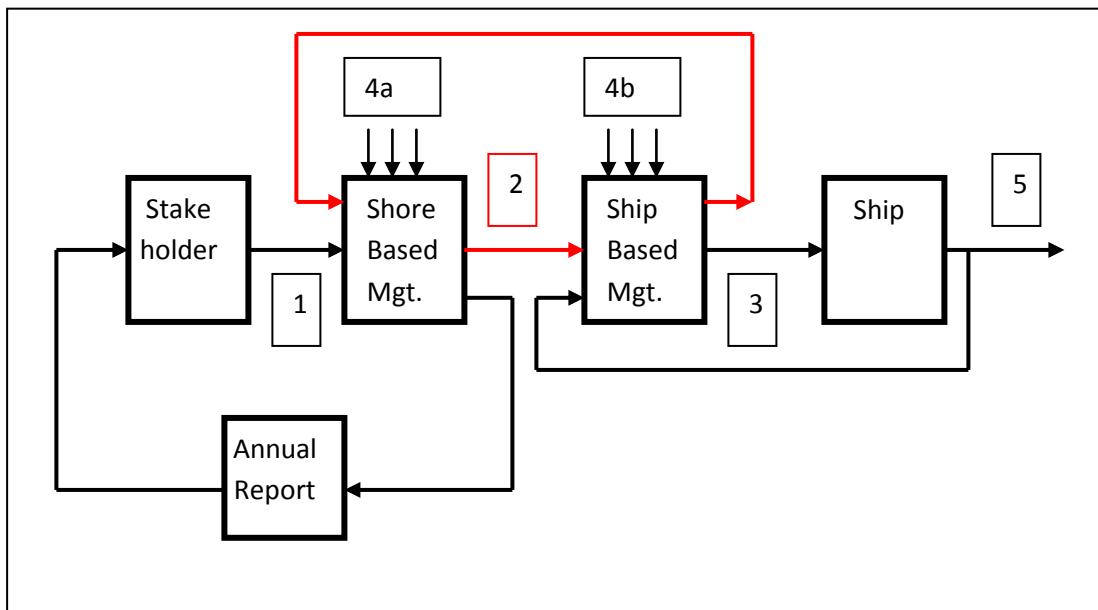


Figure 2: The ship management system.

Key to Figure 2: Ship management system

- [1] Expectations of the stake holders (that defines the objective functions for process control). Example: maximisation of sailing time (when the propeller turns the ship earns),

minimisation of turn-around time, minimisation of port stay, maximisation of safety on-board, etc.

[2] Technical Management Process (work flow, cooperation etc. between shore based management and ship board management).

[3] Management control strategy for the ship operation process; i.e. the strategy to achieve the desired stated objective function, derived from the stakeholder expectations.

[4a] Constraints, which for shore-based management may include (a) commercial constraints, like the contractual business commitments, (b) technical constraints such as budgets for repairs and maintenances, (c) constraints of supplying competent personnel, their availability, trade union agreements, (d) constraints imposed by compliance to regulatory requirements.

[4b] Constraints for ship-board management may be like (a) weather, (b) machinery/equipment limitations, (c) compliance with regulatory requirements.

[5] Performance of the ship

From figure 2 it can be seen that the ‘Ship Management System’ is made up of several subsystems, like the stake holder subsystem, the shore-based management subsystem, the ship -based management subsystem and the ship itself.

The technical management process comprising the shore based management subsystem and the ship based management subsystem which is shown in the figure with inter connections in stipple, is the scope of this research project, as it forms the core of ship management and

operations and links up the shore based management with its productive unit i.e. the ship, which is geographically remote.

It would now thus necessitate tracing briefly the advances in technology and automation over the years that have had greatest bearing in the scoped area of technical management and operation of ships.

2.4 The evolution of automation architecture in ship operation and management

Butera (2001) notes that the main components of technological advancements and automation in most industries are: (a) control systems based upon closed-loop control mechanism of feedback (on standards) and feed forward (on goals), performed by any kind of technological device; (b) integration of different devices, processes into a unitarian architecture at the level of a factory, firm, network, achieving continuity of processes and management control; and (c) system adaptation and innovation, through rapid detection both of the internal state of the system and of the environment (technical, economic, commercial, etc.). Application of the above in ship technical management and operations translates as below:

2.4.1 Advances in instrumentation and control

By the mid-1950s, pneumatic transmission of process data, pneumatic controllers and valve actuators had become highly developed forms of automated control. Most instrumentation was located in a unit control house, with significant savings in operating personnel achieved through these early process automation steps. The majority of such systems

employed automatic closed loop control systems, which, without human intervention, could control the actual value of the controlled condition, such as level, pressure, temperature, and flow, by comparing it with the desired set value representing the required operating condition, with corrective action being taken should a deviation or a difference occur between two values, this being called *Process Control* (Roy, 1987). Presenting the data to the operator though was elaborate with full graphic panel boards displaying the process pictorially in the control room with process indicators and controllers mounted at their appropriate locations on the display. During this period, process analysers for on-stream analysis became available, providing operators with more specific and timely information than just process flows, temperatures, pressures and levels. The classical control theory began to be developed by academic institutes and the major control companies.

From the late 1950's to the early 1960's, electronic instrumentation became more prevalent. Later some experimentation with digital control computers was initiated on select process units (Baillieul and Antsaklis, 2007). Through the joint efforts and through internal developments in large industrial organisations, computer control systems software began to evolve rapidly (Astrom, 1985). Computer control benefits gained recognition, and computer control became an established technology in many organisations; however significant organisational realignments in operating, technical, and mechanical areas were often necessary to take full advantage of computer control opportunities (Fragidis and Tarabanis, 2005). The *Microprocessor Era* then ushered in digital instrument systems. The advent of low-cost microprocessors spurred instrument companies to incorporate them into their products, thereby providing considerably improved functionality and flexibility. This development was made possible by the integrated circuit chip, and chip technology has

evolved to the point that today's chips contain the equivalent of millions of transistors (Bhattacharya and Chatterjee, 1995).

This era gave birth to the architecture of the modern control system, consisting of several major building blocks. These were the microprocessor-based digital controllers, the operator workstation, the host process control computer and a communication link that connects them all together. The operator's *looking glass* into the process became the cathode ray tube (CRT) at his workstation and the integration of instrumentation and control computers into a cohesive control system progressed rapidly.

This architecture also permitted extending the processing of information from many other systems, located in other parts of the plant. Integrated information systems were installed that extracted and archived data, permitted technical calculations and reporting on process units, utilities, machinery monitoring and laboratory systems. Many organisations now consider advanced process control as one of the best current opportunities for improving their profitability. With predictive capability, a controller can now make the moves necessary to prevent any constraint violation before it occurs, rather than reacting later (Gopinath, 2006). As the ability to precisely control the plant improved, interest shifted to optimisation as a control objective. The ability to apply rigorous optimisation techniques and carefully select the optimum solution from among the multiplicity of feasible alternatives provides the vital ingredient for excelling in highly competitive environments. One of the vital plant operational decisions is the selection of the most economic utilisation of process facilities. The industry leaders in advanced process control started installing on-line real-time optimisers to selected processes, which were successful and well accepted.

Rameback (2003) comments that as the boundaries between process control and optimisation blurs, such applications will increase together in a highly interrelated pattern.

2.4.2 Evolution of information systems

The systematic use of information to guide commercial and industrial decision making is as old as commerce itself. When written records became available in China, India, Persia, and the Middle East many centuries ago, they were used to track and inform on sales, production, inventories, accounts receivable and logistics. By using these records, people made decisions on how to manage their affairs to gain advantage and to minimise undesirable outcomes (Mukherji, 2002).

Over the centuries the sophistication and dependency on information systems may have increased but nothing as extensive as the dramatic changes that have taken place since the introduction of the computer. People are thinking more in terms of systems as a network of related data, information, and procedures that are organised to help accomplish the organisation's tasks (O'Brien, 2004). Many paper-based systems became well-structured and systematised using predefined forms and records and the computer began to automate many routine operations, particularly high volume, labour-intensive transaction processes in the financial and administrative areas, for example payroll accounting. These early efforts at automation emphasised the processing of data and the generation of reports that only summarised the transactions. But management reports needed for making non-routine decisions were still compiled manually.

As the power of computers became greater, the sophistication of their use increased. Systems were implemented to directly support operations in areas such as inventory

control, production planning and optimisation, and preventive maintenance. This concept of data warehousing with a single entry of data became the fundamental organising principle for many modern information systems. Later the concept of decision support systems (DSS) became increasingly accepted and a number of specialised systems were developed to provide decision information for management at different levels and for different functions (Shim *et al.* 2002). Since more systems were integrated, the timeliness of the information was also improved which allowed management teams to change the way business was being performed. With timely information, less errors, and more comprehensive decision information, managers were able to increase the efficiency of their operations, improve their service levels to customers, and reduce reaction time to competitors' actions. It was concluded that the key to sustainable performance improvement is better decisions. Mere data logging, monitoring, or reporting does not equate to profitability (McAfee and Brynjolfsson, 2008).

Enterprise Resource Planning (ERP) systems as business software packages that enabled organisations to integrate their business functions such as sales, production, human resources, financial, purchasing, etc. throughout the enterprise, using integrated application modules based on business processes of best-business practices then started appearing on the scene (Bingi, Sharma and Godla, 1999). Companies however learned that corporate implementation of ERP systems was not easy. They learned by experience that a high level of corporate readiness was required to conserve money, time and resources. Project success can be assessed by both usability and functionality. Without sufficient practical usability, a system will fall into disuse or certainly limited use that falls far short of the system's potential (Sarker and Lee, 1999). Continuous business performance monitoring methods

were evolving as performance benchmarks as the key performance indicators got updated on a management dashboard, and on employees' computer screens to keep a high visibility and focus on progress of the company towards the most important goals (Lebas, 1995). With the advanced process control and information systems converging, there is now great appeal in the idea of total enterprise optimisation (Shobrys and White, 2002). As technology becomes pervasive, how people use and sustain the technology and tools, would be the key success differentiator. The ability to marshal the talents, knowledge, and creativity of human resources would be the logical source of sustainable competitive advantage even in a technological, interconnected world. This truth may as well be a vital consideration in mapping all fundamental technology paths (Bingi, Sharma and Godla, 1999).

2.4.3 Marine communications – from semaphore to Sat-Com

Early ship-to-ship or ship-to-shore communications consisted of flag signals called semaphore and bells or foghorns. However, these had severe limitations such as requiring clear line-of-sight or having a limited audible range. The invention of marine radio radically improved communications on and over the water. The names of Marconi and Titanic are synonymous to marine radio. These radios did indeed use Morse code. Telegraphy is the long-distance transmission of messages without physical transport of written messages and radiotelegraphy or wireless telegraphy transmits messages using radio.

In 1912 the Titanic hit an iceberg and sent the first SOS signal which was heard by a nearby ship that came to the rescue of many survivors. It was later learned that another ship was

closer, which would have resulted in more lives being saved, but that ship only had one wireless operator on-board who happened to be off-watch at the time the Titanic went down. That resulted in the Radio Act of 1912, requiring that two operators be employed on all ships with constant watch (Rhoads, 1996).

In 1944, the first successful radio teletypewriter transmissions between ships were completed. Inevitably, the Second World War provided a spur to developments of radio technology in general, including VHF communications, marine radar and radio based position fixing systems. It is at this stage that we start to see how technology begins to serve seafarers and improve safety and operational efficiency on-board. The first successful use of radiophoto (facsimile) occurred in 1945 with the transmission of the surrender document signing that ended World War II (Naval Electrical and Engineering Training Series, Module 17, 2007).

On the commercial shipping front, the transatlantic liners provided a high volume of traffic, all using radiotelegraphy (Morse code) transmissions during the late 1940s and early 1950s. As automation increased telex became the absolute cheapest form of long-distance communication, and it was an advantage that telex directly produced written documents. As the U.S. space program grew in the 1960s, the Department of Defence began developing satellite communication systems that would address the special requirements of military operations. Collins and Hogg (2004) report that the new satellite communication technologies now applied in commercial shipping are providing an economical method of transferring data between ship and shore, with ship being another node in the corporate Intranet or wide area network (WAN), thus providing seamless connectivity. They inform

that there are satellites in geo-synchronous earth orbit (GEO), 35,785 kilometres above the earth. These appear to be stationary in relation to the earth, but in reality have an orbital period of exactly 24 hours and so rotate at exactly the same speed as earth. Due to their height above the earth, they have a wide coverage area and only a few are required to provide complete global coverage, but antennae must be very precisely located and focused to maintain contact. Inmarsat is the operator in a maritime context to provide such GEO coverage.

By contrast, low earth orbit (LEO) satellites, orbit the earth at between 100 and 1000 km and provide far smaller coverage than those in GEO, but it is far easier to maintain contact due to their reduced height, enabling even mobile telephones to access them. Iridium is the main provider of this in maritime sector.

Another satellite technology available in the maritime context is very small aperture terminals (VSAT) that allow reception to and transmission from ships at broadband capacities of up to 2 mb/s, but only over specific areas of the world and not globally. In order to use VSAT, a shipping company has to conclude a lease with a satellite service provider (Sorribas *et al.* 2009).

The recent introduction of mobile packet data (MPD) through Inmarsat Fleet 77 (a management support system designed to enable access to primary vessel data on-board and from ashore) is a vital addition to the satellite ICT infrastructure, as it at last makes Internet access from sea financially viable. Users only have to pay for the amount of data sent, rather than for the length of time connected and an *always on* connection is provided (Yong, 2010).

2.5 Review of advancing enabling technology concerning technical management of ships

It was seen in section 2.4 that the integration of instrumentation and control with computers into a cohesive system progressed rapidly which permitted processing of information from many other systems, located in other parts of the plant. Developing on the above, a review of technical literature was carried out of technology advances very specific within the scope of the project, of areas pertaining to technical management, as this lies at the heart of ship management practices and encompasses the vital ship-shore interface of operation and management. In the area of process automation it was found that the environmental push and the economy pull caused by high fuel costs had rendered technology advancement in vessel performance systems, where fuel performance *vis-à-vis* engine performance and energy management was now possible. Fuel performance monitoring rendered torque² measurement and improved information and understanding of total fuel consumptions. Continuous measurement of fuel consumption and engine power output was also measured. Engine performance monitoring provided the operator with guidance on engine tuning and maintenance planning. Generally it involved main engine and auxiliary engine cylinder performance monitoring. Energy management was another area where much advancement had taken place and systems existed that could measure, record and analyse the complete energy usage on the ship and provide decision support for reduced energy consumption.

With the help of distributed and modular automation technology, which is a system that connects together separate components and facilitates adding or replacing any one

² force acting causing the propeller to rotate

component without affecting the rest of the system, integration of the above three areas to local operator station and to centralised watch station with user friendly human-machine interface panels was now possible. Automated monitoring of relevant performance parameters, its analysis and taking of enabling corrective actions was now also possible for optimal operations. Additionally, advice could be available to the ship operator on enabling conditions that can further improve performance, if he so desires to adopt those conditions, for example trim³, draft⁴, speed, RPM⁵, ship's heading, etc.

Pomeroy and Tomlinson (2000) claim that things can now be done that would have been impossible without this technology, such as building of an engine that does not require a camshaft⁶, or optimise performance on a continuous basis to enhance overall fuel efficiency through a sophisticated power management system.

Section 2.4 also traced the advances in marine communications and noted that the new satellite communication technologies are providing an economical method of transferring data between ship and shore, thus providing seamless connectivity. This assists in effective management of the ship and the seafaring workforce as a virtual team (Collins and Hogg, 2004). Further to these tracings, it is now seen that the dial-up narrowband connection speeds of about 56 kbps has given way to broadband connectivity of greater than 1 Mbps between ship and shore communications. Thus increased bandwidth and transmission speeds and reduced cost of communications have now enabled vessels to communicate

³the incline by stern of the underwater part of the ship

⁴depth to which the ship is submerged

⁵revolutions per minute of the propeller

⁶used in internal combustion engines to operate the valves used to control the timing and quantity of gas flow into the engine

seamlessly and cost-effectively with their land based corporate networks across oceans (Yong, 2010).

It is further seen that advanced process control and information systems that have all developed along independent but complementary paths, have reached the point where these paths clearly seem to converge and intersect (Shobrys and White, 2002). Integration is now thus possible between process network and administrative network with firewall security measures enabling presentations in normal web browsers. The system architecture is based on distributed processing units (DPU – a parallel computing enabler that uses multiple processing elements simultaneously) that communicate with each other on redundant high capacity process bus (a subsystem that transfers data between components inside computers). While the DPUs carry out all monitoring and automation functions, the operator stations provide the human-machine interface. This enables display of automation data anywhere on ship and even on to shore based locations on-line and real-time, thus making it feasible to build a network management system enabling technical managers to view and provide up-to-date information on vessel location and its performance, fuel levels and consumption rates and engine performance in real-time.

Neef (2008) finds that it is possible to capture most of ship's performance data electronically and automatically from its original equipment source. On-board electronic systems these days can record exact real-time data in a multitude of areas: on engine performance, navigation, wind speed, fuel usage, tank-levels, valve openings and many other key indicators. The data can be now collected on ship's local area network (LAN) and stored in a server database. This data can be extracted and viewed through easy-to-use

software dashboards and sent from ship to shore using satellite communications and broadband technologies. The shore based management can be aware of every ship's performance – anytime, anywhere (Figure 3).

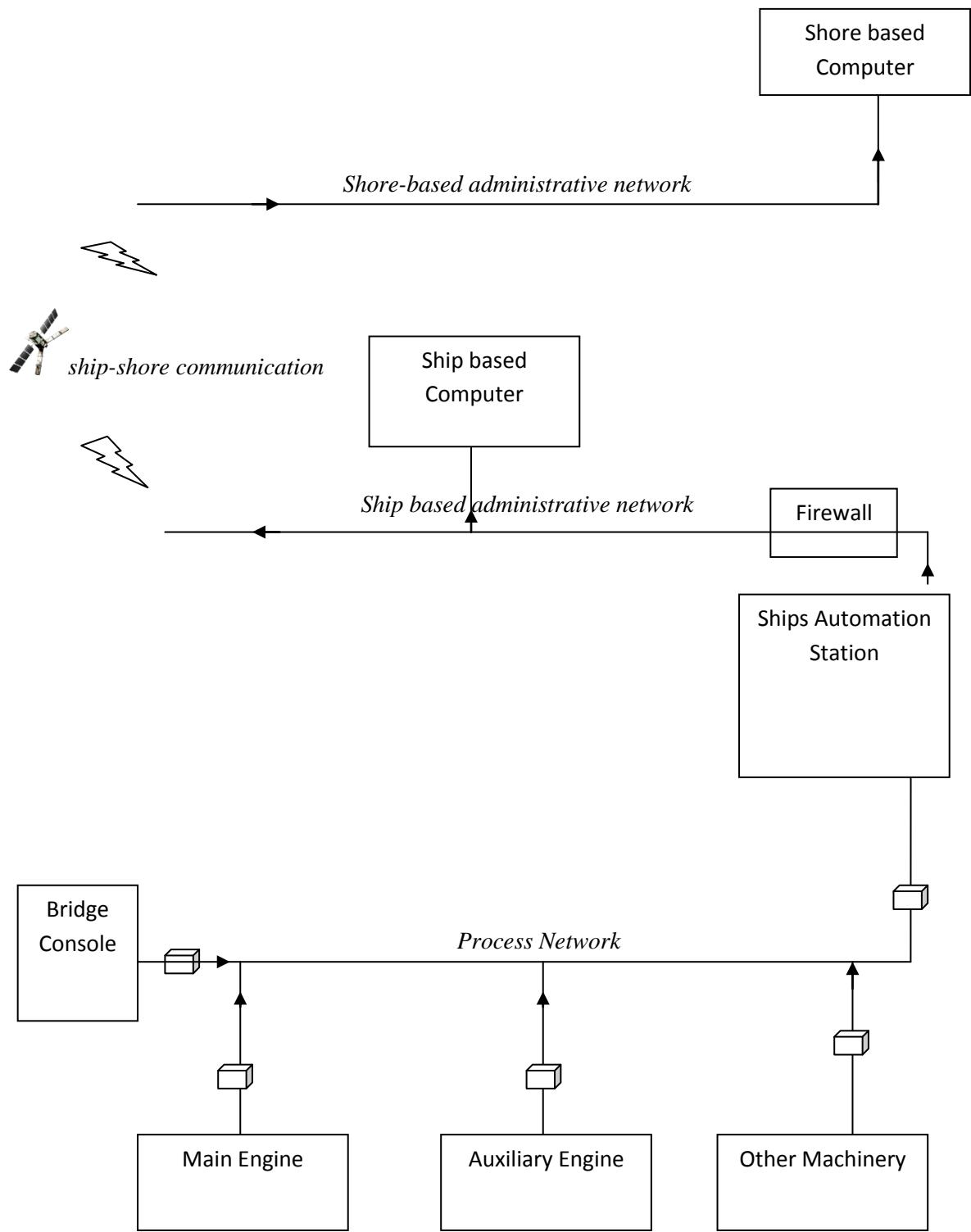


Figure 3: Ship-shore communication architecture.

Source: Yong, (2010); Sorribas *et al.* (2009).

Thus real-time monitoring including raw data normalisation (i.e., accounting for the effect of waves, wind and current) is possible. For example, minute-by-minute fuel consumption of vessels can be assessed against values in charter parties.

Charterers have often been frustrated by discrepancies between fuel consumption day rates included in charter party and the actual performance, given the higher fuel costs and lack of transparency. Real-time access to fuel consumptions by charterers directly will address transparency issues and help build healthy business environment.

Electronic logbooks for logging vital navigational, engine, radio and other operations are yet other developments where data recorded from ships instrumentations can be combined with manual inputs. They also comply with the specific reporting requirements as laid out in relevant statutes. The formats can be modified to the needs of various end users and can be accessed ashore.

Such automations designed for marine applications need to fulfil demonstratable Class and Flag requirements on safety, reliability and security, which are most stringent. It needs to support redundancy at all levels including communication, process controllers, serial lines and power supplies. Usually there are built-in self-diagnostic facilities that monitor the entire control system and include extensive monitoring of field circuits. Both the hardware and the software have to be type approved by major classification societies' requirements for periodically unmanned engine room operation. It was noted that the regulators have also geared up to certify these marine automation applications for ships in as much as users have started developing faith and trust in them, given these certifications and approvals (Pomeroy and Jones, 2002).

Summary

This chapter traces the course of technology application in shipping and finds that the economic logic of low costs as value addition dominates this form of transportation sector. The technology change decisions hitherto enforced mandatorily that aid enhancement of safety and environment protection, are more proactively being considered to make vessel operation more efficient. However the nature of shipping business due to its volatility increasingly makes the technology change decisions more difficult.

Be that is it may, as is in any other industry change in shipping technology has become all pervasive and inescapable. The review of the evolution of automation architecture in general and its deployment in the shipping industry environment that this chapter undertook, gives the perspective on technology inroads in shipping.

There is however a lack of scientific study on application and integration of technology in shipping, and appreciation of the potentials of such scientific integration of technology that can make ship operations and ship management services yet more effective and efficient. Chapter 3 attempts to investigate further these aspects and their relevance to the shipping industry.

Chapter 3: Theory and potential of scientific technology integration in shipping

Introduction

This chapter in its first section discusses the theory of interaction between technology and organisation to provide the fundamental basis for the deeper understanding of optimum technology applications in industry. This will provide the theoretical framework of reference and set a platform for addressing the aims of this research comprehensively. The second section looks at the skilling issues in the wake of the above discussion and further pursues theory to unravel the skilling dilemma triggered by the technology-human interface. The third section then attempts to make out the case for need to study the potential for optimisation leveraging technology application in the marine industry environment.

3.1 Theory of interaction between technology and organisation

Most rational decisions are based on some form of theory. Theory helps in building generalised models applicable to a range of organisations or situations. It further provides a conceptual framework and gives a perspective for the practical study of the subject. Thus theory and practice are inseparable. Together they lead to a better understanding of factors influencing patterns of behaviour in work organisations and application of the process of management (Billbsberry, 1996).

As technology has become pervasive within contemporary organisations, it is therefore essential to have an understanding of the nature of technology and organisational and human resource dimensions and circumstances of its use.

3.1.1 Technology and organisation

The theoretical models that examine the interaction between technology and organisation have evolved over a period of time. Nevertheless, technology has always been the central variable in organisational theory, guiding research and practice (Orlikowski, 1992).

Blau *et al.*'s (1976, p.21) definition of technology deployed in the factory and office is given as "the substitution of equipment for human labour". This set of studies that focused on technology as hardware emanated from the stream in the tradition that is represented by the Marxist account of technology and view on capitalism, such as those of Braverman (1974), where technology is devised and deployed to further the political and economic interests of powerful actors. Braverman draws his thesis from the scientific management principles of Fredrick W. Taylor an American mechanical engineer and a management consultant of early twentieth century, when capitalism organised new forms of labour management, among which Taylorism was a highlight. Around this period not only did capitalism come into a monopolistic phase, its dependence on live labour in manufacturing was an obstacle to the empire of capital (Heloani, 1994 as cited by Peci, 2009). Taylor proposed disassociating labour process and workers' specialty; separating conception and execution, using knowledge monopoly to control each phase of the labour process and the way it is carried out (Braverman, 1974). Taylor however attempted to minimise the contradiction between employer-employee interest, and in trying to conciliate stated that:

“Scientific management has for its very foundation, the firm conviction that the true interests of the two are one and the same; that the prosperity for the employer cannot exist over a long term unless it is accompanied by the prosperity for the employee, and vice versa; and that it is possible to give the workman what he most wants – high wages, and the employer what he wants – a low labour cost for his manufacture,” (Taylor, 1947).

Woodward's (1980) empirical study of 100 manufacturing firms and relationships between the application and principles of organisation and business success theorised that industrial organisations which design their formal organisation structures to fit the type of production technology they employ are likely to be commercially successful.

The work by Woodward was extended by Perrow (1983) who drew attention to human actions and interventions. He argued that the role played by technology in these early works assumed technology to be an external force that would impact the organisation properties such as structure. However, it had its limitations in the notion of application of human agents, where only managers or designers of technology had the power to shape it, and its viability only in organisations that employ machinery in their production activities

The technology concept was thus extended to social technologies which then included the generic tasks and knowledge utilised by humans, thus making it a meaningful variable in all types of organisations and acknowledging the fact that there was more to technology than just hardware. The focus got extended to human action and technology being seen as a rich mix of shared interpretations and interventions. The workers portrayed as relatively powerless, found recognition in their participation having implications for organisations. It

was recognised that technologies are socially constructed and can be changed by those using them (Perrow, 1983; Wynne, 1988).

Charsley (1989) also cautions about managing technical change in that failure to match technical change to concomitant human and social considerations means staff may become resentful, suspicious and defensive. People's cognitive limitations and their uncertainties and fears may result in a reluctance to accept change. Managers need to develop working practices based on integration of people's needs with organisational needs. He further points out that it is prudent to remember it is extremely dangerous to place more importance on the workers' tools than the workers themselves.

3.1.2 Process - centric theory

Further developments led to technology being incorporated into a strategic choice model suggesting technology as not immutable and a product of on-going human interaction, design and appropriation. It led to socio-technical studies of optimisation with the premise that outcomes such as job satisfaction and productivity can be addressed through re-examination of processes around the potential of information technology, thus taking a more process-centric approach (Markus, 1983; Markus and Bjorn-Andersen, 1987). Processes are a sequential flow of tasks that systematically complete organisational missions (Chandy and Lampert, 1985; Van de Ven, 1992). Zuboff (1988) distinguishes between the "automating" (the replacement of actions of the human body by the machine) and "informating" potential of IT (the simultaneous generation of new information about organisational activities). She suggests that because information technology can be designed with different intentions, for example to automate or to informate work, it will

have different implications for workers which in the first case would be “controlling and deskilling” and in the latter case “empowering and up-skilling” them. It is the latter which presents the transformative possibility to organisations through the transparency which it offers.

Porter’s (1998) model which includes technology and managerial processes in a value chain framework takes a process-centric view. Technology is positioned as a key supporting role facilitating processes creating value for operational system (Woiceshyn and Falkenburg, 2008). Research on value chain theory that is consistent with supply chain management concepts is taking a leading role in developing research in strategic management (Cheng and Grimm, 2006). However, Jayaraman and Luo (2007) suggest the limitations that such a linear view of operations in a sequential manner positions technology as a transitional factor and business processes evolve with minimal association with underlying technology. Narasimhan *et al.* (2010) confirm that linear thinking ignores simultaneity among other dimensions and hence lacks insight into the role that technology plays in developing and transforming business processes.

3.1.3 Organisation-centric theory

Another perspective provided by Barley (1986, 1990) portrays technology triggering structural changes such as increased decentralisation, thus leaning towards a more organisation-centric theory. Organisations are administrative structures that govern an entity with a hierarchy of authorities (Blau, 1968; Ouchi, 1998). While technology is considered as a social object defined by context of its use, its physical form and function remain fixed over time. Organisation-centric theory encourages a resource based view that

suggests firms need to develop strategic resources that sustain competitive advantages (Barney, 1991; Olvarrieta and Ellinger, 1997). Resource based view theorists state that to be qualified as a strategic resource, it needs to be scarce and difficult to imitate (Mata *et al.* 1995). Technology is considered as a key resource for competitive advantage and is distinguished as stand-alone construct (Stieglitz and Heine, 2007; Liang *et al.* 2010). New technology entails developing new procedures for bringing about interconnectedness of technology and business systems and possibly reengineering for operational processes (Valorinta, 2009).

However, there are limitations on the organisation-centric view relative to managing technology. Da Silveira (2002) points out that such a view considers organisation as a dominant factor in determining operations and performance, and technology remains a separable and non-integrative variable. Stabell and Fjeldstad (1998) confirm that technology once implemented becomes a dormant entity and such a view cannot precisely capture the dynamics between technology and organisation.

3.1.4 Technology-organisation-process integration

More recently Arvanitis and Loukis (2009) point out that while technology plays a key role in an organisation, extant literature in operations management still holds an organisation-centric or a process-centric view when studying business entities. Zammuto *et al.* (2007) and Helper and Sako (2010) also remark that despite the significant impacts of technology the three way technology-organisation-process interaction has largely been neglected in literature.

Technology, organisation structures and business processes are closely integrated and in any technology-intensive environment, organisation structures and business processes need to be developed or modified in simultaneity with technology development application (Cheng *et al.* 2011). The three do impact each other and these encounters do not necessarily take place in sequential manner (Hempell and Zwick, 2008). There is need for all these factors to be studied simultaneously (Pentland and Feldman, 2007; Zammuto *et al.* 2007). Figure 4 below shows the trinity view model that easily lends itself to simultaneity and dynamics where technology, organisation and processes co-exist and these dimensions are systematically integrated into an entity (Yang *et al.* 2007; Cheng *et al.* 2011).

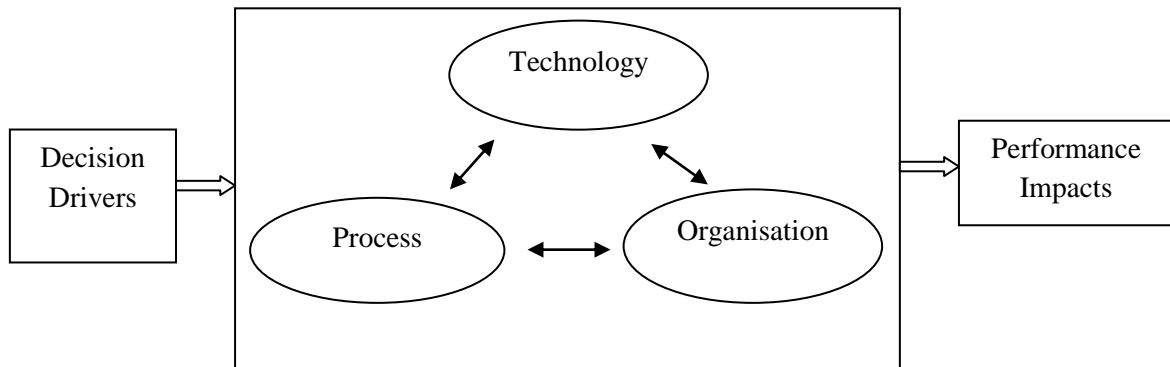


Figure 4: Technology Centric Framework with simultaneous technology-process-organisation view. Sources: Yang *et al.* (2007); Cheng *et al.* (2011).

Mullins (2002) conveys in typical textbook style that the main trends in the development of organisation behaviour and management theory categorise into approaches based on views. He suggests that there are three basic approaches; Classical, Human relations and Systems.

The Classical approach emphasised technical requirements of the organisation and its needs, while the Human relations approach emphasised the psychological and social aspects and the consideration of human needs. The Systems approach reconciles these two earlier approaches and focuses attention on the total work organisation and the interrelationships of structure and behaviour, and a range of variables within the organisation. The Systems approach encourages managers to view the organisation both as a whole and as part of a larger environment. The idea is that any part of an organisation's activities affects all parts.

3.1.5 Discussion

The study of interaction of technology and organisation highlights some key issues (Noble, 1984; Perrow, 1983; Zuboff, 1988; Powell, 1987):

Technologies are products of their time and organisational context. While it has flexibility in interpretation, design and use; it is a function of hardware, organisation context and human factors that can be summarised in the following maxims:

- a) The temporal and spatial distance between construction of technology and its application, affects its flexibility. The greater the distance, the lesser the flexibility.
- b) The workplace culture and interacting human element also plays a key role in deployment and application of technology.
- c) There is a simultaneous mutual impact among technology, organisation and process.
- d) Technology today is a driving force that stimulates changes within organisations.

A goal now exists for organisational managements to identify the optimal integration of technology, organisation and process.

3.2 The skilling dilemma

A key issue that comes to light in the evolving technology-organisation-process integration in shipping is about the skilling of people. While on the one hand it can be argued that merchant ships are now so automated and sufficiently reliable for little skill to be demanded of those who control them, on the other hand it can also be argued that today's merchant ships are so complicated that only those who fully comprehend their complexities should be entrusted with their operation.

At the heart of this conundrum lie the contrasting theories of technological change implications that support the notions of up-skilling and deskilling theses, both with equally strong convictions.

3.2.1 The deskilling theory

Arguments favouring the deskilling theory concern the notion that the seagoing personnel are no longer expected to possess high calibre diagnostic skills, as they can now rely on the automation, but they do need to be able to quickly assimilate information provided by the systems.

The engineering and brainwork involved in the design and construction of digital technologies facilitates task simplification and standardisation of work processes to the extent that less skilled workers with minimum training are able to perform the same jobs

earlier assigned to high skilled workers. There is thus actually deskilling of high skilled jobs which previously demanded educated workers and where work processes were difficult to capture because of the unpredictable and uncertain nature of work. The management strategy aimed at is - the codification and routinisation of knowledge work particularly in high skilled jobs. This is amply manifested in the 2010 revision of the International Convention on Standards for Training, Certification and Watch-keeping (STCW) that sets the standards for competency of seafarers internationally, where the education component for marine engineers is drastically reduced from earlier 30 months to just 6 months now.

The deskilling theory has its roots in the Scientific Management principles of Fredrick Winslow Taylor. Taylor's (1947) principles of scientific management consisted of a rigorous and scientific study of work, the use of scientific methods in the training and management of employees (rather than relying on intuitive knowledge of workers), fragmentation of work into discrete tasks through detailed instructions and supervision, and division of labour consisting of a clear distinction between those who manage work and those who actually perform the work (Anand, 2011).

According to Braverman (1977), Taylor proposed to dissociate labour process and workers' specialty, separating conception and execution, using knowledge monopoly to control each phase of the labour process and the way it is carried out. Taylorism related strongly to the dynamics of capitalism which came into a monopolistic phase, and the dependence of capital on live labour in manufacture was an obstacle to the empire of capital. The role of management was to relocate the knowledge of workers into machinery. Once the

knowledge and skills of workers can be reduced in the labour processes, less skilled workers can be employed at cheaper rates thus reducing costs for the employers.

However, be that as it may, it is acknowledged now that as the level of complexity of automated systems increases so the human element becomes more deeply embedded amongst the physical elements. As machinery and equipment are left to operate unattended, the monitoring systems detect warning signals and production control systems to take immediate action. The deskilling thesis thus gives due importance to just the knowledge gained through experience, observation and on-the-job training.

3.2.2 The up-skilling contradiction

The up-skilling thesis however considers this knowledge of marginal importance in post-industrial societies. The experiential and intuitive knowledge is rather replaced with the theoretical and scientific knowledge gained through formal education and training.

The up-skilling thesis suggests that the knowledge and skills of workers is a dominant source of productivity. It is argued that as work processes are fragmented into simplified tasks the machines take over the repetitive work while the workers should move towards furthering innovations. The passive-monitoring mode encourages deskilling, tedium, and low system comprehension, leading to low morale, low output, and lack of skills to cope with emergencies or even unexpected variations in system state. Designing operators out of the control system through automation reduces their system comprehension and ability to intervene in emergencies or when conditions are abnormal, which is more a norm than exception in the shipping industry.

Perrow (1983) and Charsley (1989), as discussed earlier in section 3.1.1 suggest perceiving technology as more than mere hardware; it being a rich mix with human actions and interventions, thus conceptualising *social technologies*, with shared interpretations and interventions, and further cautioning against placing more importance on the worker's tools than the workers themselves. Hence, it calls for exploring the cognitive underpinning of work and importantly decision-making under different conditions such as limited time, uncertainty and unstable conditions.

3.2.3 The tenable position through cognitive behaviour in decision making

Exploring and understanding the human cognitive behaviour in system operations in light of the skilling dilemma posed with handling of automation resolves the dichotomy.

Rasmussen's (1983) qualitative model describes the behavioural structure of human when working with control systems. He suggests that people perceive information (visual perception), then remember what is needed to carry out the task (memory), and then make decisions. Key elements of decision making are the skill-rule-knowledge (SRK) model – of human decision making as shown in table 1 below:

SBB	Skill based behaviour is a nearly automatic response of operator handling well known situations. This produces best performance in terms of speed, accuracy and error rate.
RBB	Rule based behaviour, where the operator follows a reasonably well known process and procedures. Performance is usually good although not as fluid as SBB.
KBB	Knowledge based behaviour, where operator must resort to his or her fundamental knowledge of the process to solve a problem. This is slowest and error prone, normally used in novel tasks, or abnormal / emergency situations.

Table 1: SRK Model of human decision making. Source: Rasmussen, (1983).

In novel cases, operators over time pass on to RBB and then SBB. Hence the idea to train operators in these two types of behaviours.

Typically, decision-making includes identifying known successful recipes that correspond most closely to the present situation, adapting the best-matching recipe, simulating it mentally, and then implementing it. That is where simulator training helps. Only when there is no existing recipe, one goes through KBB, with its associated difficulties and potential errors but it is the only resort in novel tasks or abnormal and emergency situations which is more a norm than exception in shipping environment.

Rasmussen's model appears rather grainy but is generally well accepted in human factors literature as it offers a good break down of cognitive functions and their interrelations, as in the figure 5:

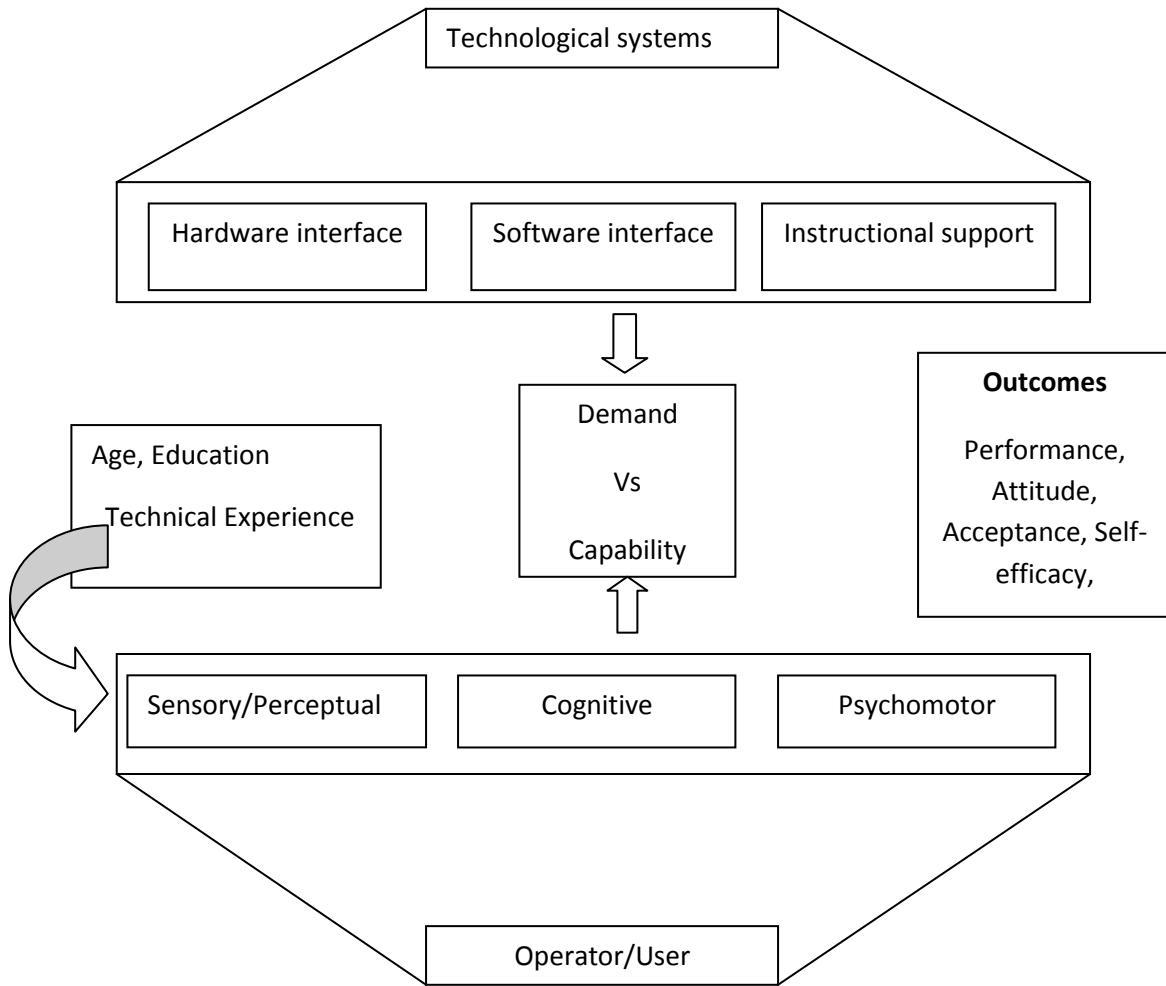


Figure5: Example of human – machine system. Source: Rasmussen, (1983).

Perrow's (1983) explanation partly clarifies this dichotomy of skilling. It notes that for merchant marine officers, higher skills requiring high cognitive complexities are required at

the times of high pressure and high workloads in the critical phases of the tour of duty, emergencies and maintenance. During the long routine phases of duty, passive monitoring reduces tasks and is characterised as deskilling even to the extent of automating functions (in engineering vernacular this is "removing the man from the loop"(p. 535).

Fewer control activities are required than in the past because most functions get carried out by the automatic systems, leaving a largely supervisory role for the watch-keeper during normal system operation. At other times, for example during high traffic density in confined waters or failures of automated systems, or when just the management of many sub-systems (navigation, engine control, cargo control) are allotted to a single operator, workloads and high skills demand increases. Polarising of such skills demand and workloads in itself constitutes a threat to performance (Sauer *et al.* 2002). Nonetheless both extremes need to be considered. For delivering high systems performance, it would be easily expected of the mariner to be altering the roles as the situation demands.

Hammond *et al.*'s (1987) cognitive continuum theory premises that cognitive activity is not a dichotomy between intuition (deskilling theory led) and analysis (up-skill theory led), but rather a continuum marked by intuition at one pole and analysis at the other.

Working separately in the same naturalistic decision (NDM) domain but reaching similar conclusion as Rasmussen was Klein's (2008) recognition-primed decision (RPD) model as depicted in figure 6. The NDM movement based on advances in cognitive psychology expanded decision-making process to include a prior stage of perception and recognition of situation as well as generation of appropriate responses as seen in Rasmussen's model. Klein's RPD model describes how people use their experience in the form of repository of

patterns. These patterns highlight the most relevant cues, plausible goals and suggest typical types of reactions. When people need to make decisions they can quickly match the situation to the pattern they have learnt. In newer situations mental simulation is analytically carried out to see how the decision will play out in current situation until a comfortable and satisfactory option is reached. Klein acknowledges that a purely intuitive strategy relying only on pattern matching would be too risky so also a completely analytical strategy too slow.

Hence, for all risks associated with marine operations, an integrated approach and consideration of totality of marine engineering systems, that includes technology as well as people and their behaviours, is fundamental to effective ship management.

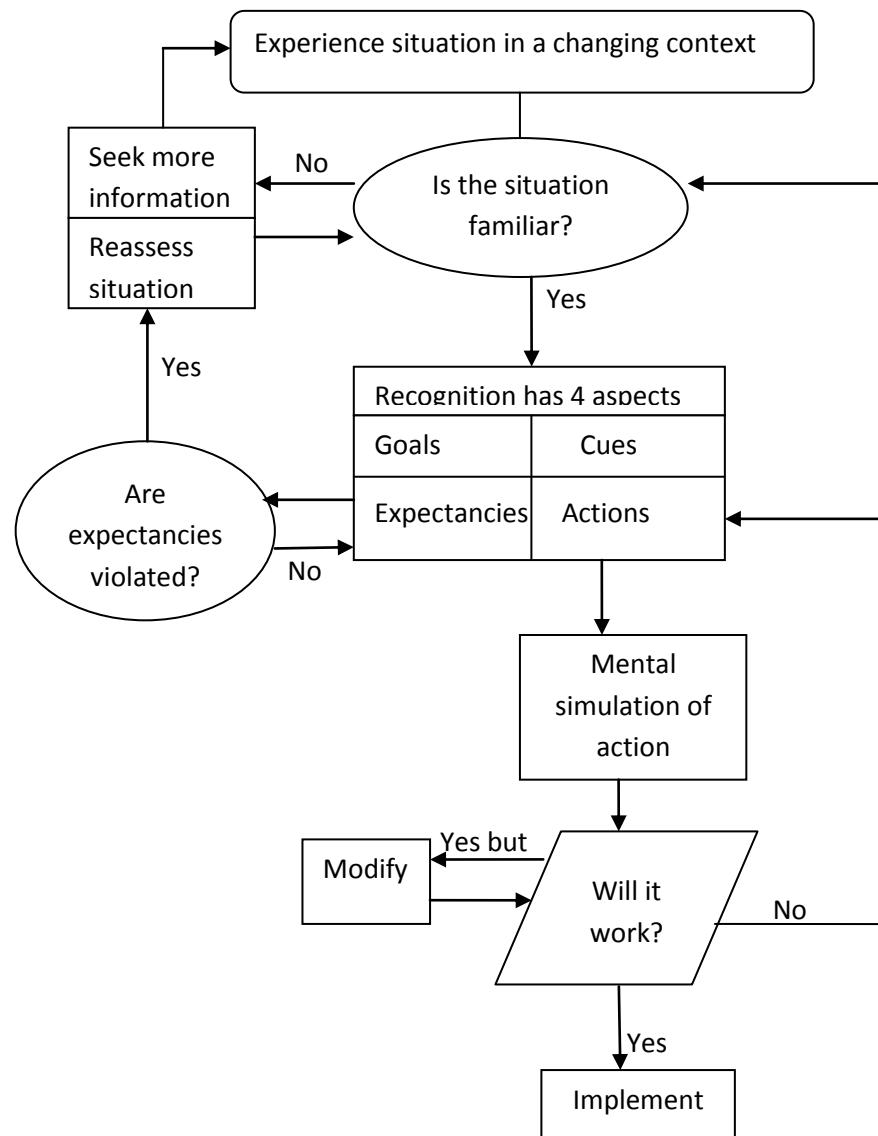


Figure 6: Model of recognition-primed decision making. Source: Klein, (2008).

3.3 An argument for favouring enhancement of optimisation potential of technology integration in shipping

3.3.1 Case for learning from other industries

A measure of the significance of a new technology is the extent to which it changes previous ways of doing things, or changes our ideas about how they ought to be done. Some maritime innovations can be described as highly significant because they have altered traditional patterns of operating ships, and in some cases, they can also be said to have contributed towards an essential change in the relationship between humankind and the sea (King, 2001). However, there is not very much evidence found in the literature on shipping management practices on any theory based scientific approaches to its integration, of the kind discussed in section 3.1; nor is much known of the metrics that enables the status of the shipping management system to be determined (Barnett, Gatfield and Pekcan, 2006).

In an enhanced and a broader view of the industry, Thai (2008) suggests that increasingly over past decades there has been recognition from marine transport operators that improvement in transport service quality is critical in achieving a differential advantage over competition, which includes safety management given the safety-critical nature of the industry. However, little literature directly addresses the dimensions or determinants of service quality in marine transport. Since there are very few studies conducted to investigate what constitutes service quality in this field, its managerial implication is that there has never been an approach to measuring service quality in the maritime sector.

In manufacturing industry, production tasks have been increasingly automated and thus processes can be more accurately controlled. Curry, Flett and Hollingsworth (2006) highlight that work can be coordinated by means of networking and communication systems that effectively eliminate time and distance restrictions. Teamwork is more widespread with data, information and skills being more extensively shared and exchanged as boundaries of organisations get less clearly defined with regard to where work is done, when and by whom. The shipping industry too is characterised by similar conditions. Nikitakos and Lambrou (2007) postulate that the main task in shipping is to offer transportation services whose stakeholders are located in different geographical areas. This characteristic results in the foundations of a distinctive virtual organisation where the personnel ashore and on-board may work in virtual teams. These teams support the productive unit which is the ship itself, and which can be considered as a node of a network that cooperates and interacts by gathering, diffusing and sharing information. A great contribution of the network-centric concept is that it exploits the use of information to suppress transaction costs and risk. Shipping companies do attempt to limit administrative and operational cost and risk by using management information systems (MIS) in most operating procedures.

Furthermore Curry *et al.* (2006) go on to say that to increase the performance of an organisation, reductionism and optimisation of the constituent parts leading to better performance is being adopted through a systems approach. The hierarchy of systems is useful in analysing the complexity of the problem - the lower the hierarchy the simpler the system. Organisations undertaking reengineering programs have to rely on process information which has to be systematically analysed and acted upon. ICT becomes a key

element when information systems and business strategy must be fully aligned and integrated to give the best strategic result. This concept can thus also be extended to the shipping industry. As a matter of fact Lyridis *et al.* (2005) have examined optimisation of shipping company operations using ‘business process modelling’ and report large time and cost savings after the application of the technology improvements. They claim that optimisation allowed the shipping company to even increase the number of round trips per year, thus indicating that very large benefits can be drawn by analysing and critically adjusting business processes in modern shipping companies.

Lyu (1996), professing process reengineering, contends that although Kaizen⁷ and automation are generally two different approaches to improve the performance of manufacturers, he proposed an integrated framework of Kaizen and automation to reengineer a manufacturing process in the shipbuilding industry. His study concluded that nearly 50% improvement in labour productivity was possible with the streamlined manufacturing process through process reengineering.

Communications and information technology have shifted the centre of gravity of the shipping enterprise away from the ship and from the people serving in it. Decision making by those who have authority to determine the end to which a ship is put - the cargo it should carry or the voyage it should make - has become increasingly remote, often in offices ashore. Modern shipping has come to depend for its day to day operation almost as much on communications and information as on more tangible inputs like fuel, comments King (2001).The new satellite communication technologies as described in section 2.4.3 are

⁷Japanese philosophy of continuous improvement of work practices that underlies total quality management and just-in-time business techniques.

providing an economical method of transferring data between ship and shore thus providing seamless connectivity which assists in effective management of the ship and the seafaring workforce as a virtual team (Collins and Hogg, 2004).

Pomeroy and Tomlinson (2000) claim, that the advance in automation technology and increased use of digital systems in place of traditional wired and pneumatic controls provide an opportunity to reduce through-life costs, which includes the larger operational cost components such as, fuels and crew.

Rensvik *et al.* (2003) address research efforts related to application of industrial IT in the marine industry and report that in shore based industries systems for operational management such as condition monitoring and diagnostic systems, enterprise management systems, have increased the possibility to improve operational performance, productivity and life cycle optimisation of the assets. The land-based industry sector has even started the next step to physically and functionally integrate real time control systems. However, the introduction of such an industrial IT architecture (figure 7), into marine applications is still in the area of research and development. They lay emphasis on aspects related to information flow between the real time systems ensuring on-line control and the management systems optimising the operations and the business processes. They envisage that as the cost of vessel-to-land satellite communication reduces and the maritime information technology architecture improves, this kind of information flow can be expected to be working seamlessly in real-time.

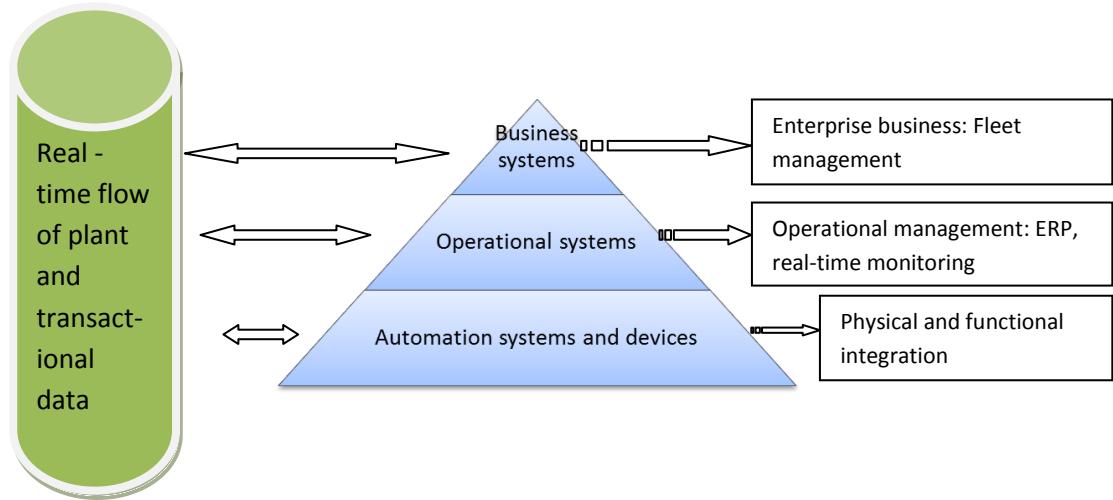


Figure 7: Industrial IT architecture. Source: Rensvik *et al.* (2003).

The shipping industry can now be viewed to be on a par with shore based industries in terms of technology advancement, connectivity and automation. It now calls for looking at optimisation opportunities where vast scope exists with the use of enabling technology, particularly in the ship-shore interface of shipping management which is the core of any shipping management operations and the scope of this research project.

3.3.2 The competitive edge – through low costs and differentiation

Technological change is among the most prominent of all things that can change the rules of competition. It has the ability to achieve low cost and differentiation through its value activities (Porter, 2004).

Panayides (2003) examined the competitive strategy-performance relationship in the context of ship management companies, and found a positive relationship between pursuing competitive strategies and company performance in ship management. The companies that

apply competitive strategies like differentiation through technology usage, market focus and competitor analysis are more likely to be high performers.

Furthermore, Lin and Chen (2000) state that in a highly competitive global economy, automation has been an important general approach to improve productivity, quality and customer satisfaction. Because shipping management today, must remain not only competitive, but also be able to meet the increasingly frequent challenges of users, regulators, and inter-modal interface suppliers to improve the quality, level, type, and technology of service (Frankel, 1991), it all the more makes the case for looking at low costs and differentiation through optimisation potentials of technology application.

Lee *et al.* (2005) have proposed internet based ship technical information management systems in order to better accumulate, manage, share and utilise various information and distributed application. While the application is in the context of ship design and building, it however incorporates the whole life cycle from concept design to construction, operation and maintenance. The information managed is the documents generated at various stages and database integration is also achieved in a concurrent engineering⁸ environment. The incorporation of information and communication technology into current shipbuilding technology is seen to increase the productivity and minimise redundancies in sharing and exchange of technical information thus leading to optimisation.

The benefits they envisaged are reduced management costs by systematic and integrated management of vast amounts of data, increased consistency and integrity between

⁸Concurrent engineering is a well-defined systems approach towards optimizing engineering design cycles.

departments and since the systems are on the internet, information can be used regardless of time and place, thus reducing the time for analysis and decision making.

According to Butera (2001), automation is a process towards integrated systems of processes, technology, organisation, roles and values where technology performs a large variety of existing and new tasks, while cooperation is designed among men and technical systems with the goal of achieving *optimal* products and services that then give the competitive edge. He further lists the essentials of automation as being, (a) the need for human work, (b) the need for collaboration among men and machines, and (c) the integration of technological, fiscal, organisational, and social systems adopted in any single case.

The Netherlands Organisation for Applied Scientific Research (TNO) Report (2005) strongly suggests that in a shipping context, the ICT developments on-board may additionally increase efficiency and reduce administrative burden, depending on how well it is developed.

Jenssen (2003) concludes that in the face of aggressive competition from low-cost economies in Asia, it is imperative for high-cost countries like Norway, to build their competitiveness in most industries, including shipping, on innovation and knowledge-intensive products to create distinctive competitive advantages that are difficult to imitate. Such a high degree of differentiation of service would imply that they focus on specialisation also in the segments of standard tonnage. He further claims that for the shipping industry to face major challenges in years to come, impetus would be needed in particularly the area of ICT.

The following section details how the high-cost countries of the West European regions have led innovation through technology in the shipping sector.

3.3.3 Innovation through technology – exemplified in West European countries

Innovation has been largely driven through technology, which, in the maritime context, has been led by the economically advanced nations like the West European countries.

Lorange (2001) when speaking of strategic re-thinking in shipping companies cites many examples of Nordic owned tonnage companies that embark on technological innovations as they move from pioneering a concept to rapid expansion and there-by be world leaders.

A typical case that has found consonance with this researcher's study is the MARSIKT (2000), an on-going research and development project funded by the Norwegian Ship Owners Association. Its main objective is that through innovative use of ICT, the Norwegian maritime cluster could strengthen their market position, and the ship owners would benefit from cooperation and development of ICT solutions for their business. This way they could also improve their capitalisation on their ICT investments. The project had the following principal objective:

“To improve the competitiveness of the Norwegian maritime sector by developing new technology and new forms of organisation, focusing on shipping companies' commercial and technical operations.”

The approach employed was -

- (a) To redefine business needs, and formulate relevant technology requirements in support of new and more efficient work processes at the shipping companies; and
- (b) The ability to understand the needs of the shipping companies and provide relevant products and solutions from software and system manufacturer point of view.

In this regard Rensvik *et al.* (2003) reported on the progress of the above in the following shipping organisations:

- (a) Hoegh Fleet Services implemented preliminary ICT structure on-board and ashore which included Fleetmaster (a management support system designed to enable access to primary vessel data on-board and from ashore) and electronic logbook from Kongsberg Maritime Ship Systems, which currently were being evaluated by the Norwegian Maritime Directorate and the IMO.
- (b) Odfjell was implementing a test module of integrated ICT structure for technical condition monitoring and management for vessels.
- (c) Barber International was developing BASS (Barber Software Solutions) for document handling and quality systems.
- (d) DNV's concept and software package titled Nauticus that was used for information exchange between databases of Classification Society and shipping company, and was forming the basis of standardisation of work in ISO/IEC for standardisation of integration of automation and communication systems.

They further saw future prospects of deployment of automation in the high end market segments of cruise vessels and LNG ships where complexity was on the higher side.

Utilisation of advanced navigational technologies in Scandinavia-owned large cruise ferries, operating between Finland and Sweden in the early 1980's has been reported by Gronberg (2007). The route incorporates 12 hours of navigation in one of the most difficult areas in the world and made more difficult by adverse weather and ice conditions.

Shea (2005) confirms that the European shipping companies who traditionally had high operating costs in maintaining modern fleets are increasingly coming under competing pressure from third world fleets and placing them in a more complex and demanding environment, who are increasingly resorting to technology to make that differentiation.

3.3.4 Performance through innovation

In their study of how innovation drives performance, Jenssen and Randoy (2006) define innovation as an effort to create something new, in order to create differentiation as an economic objective. They note that innovation had fuelled a rich and strong maritime cluster of the Norwegian shipping industry. They however caution that the urge seems to be waning for various reasons and that there is a need to reaffirm efforts in innovation again.

Their research strongly supports the hypothesis that there is a positive effect of innovation on performance in shipping firms. Also a positive relationship exists between product-process innovation and performance measured as financial results, market position and bargain power. They conclude that the most important factor for promoting product-process innovation is a deliberate strategy for innovation. Their study indicated that shipping sectors with high differentiation had shown high growth, for example in the offshore area, but argue that, innovation is of importance in low differentiating sectors too, for example dry bulk or liquid bulk shipping.

While innovations are sources of competitive advantage, research on the diffusion of innovations found that it is not just the capabilities of the firm that predicts early adoption of innovations, but also its centrality and social proximity to these innovations. Greve (2007) researched the role of technology in competition through diffusion of technologies. He based his hypothesis on cluster theory and network theory. Cluster theory predicts selective diffusion within a spatially bounded social system, while network theory predicts selective diffusion through pre-existing inter-firm relations.

He analysed the diffusion of two innovative ship designs. His study compared the diffusion of post-Panamax container ships⁹ and double-hull oil tankers¹⁰ which were two of the most important recent innovations in shipping at the time, as measured by the number of adoptions. As containers and oil are major markets in shipping, so innovations directed toward these markets affect the competitive advantage of many firms. Each of these innovations provided advantages to the owners, though there was sufficient uncertainty about their value to make the adoption risky. The buyers of post-Panamax container ships were sacrificing flexibility for efficiency, while the buyers of double-hull tankers were betting on nations maintaining or tightening their rules for preventing oil spills. Greve (2007) further acknowledges that both have proved right as can be seen today.

His findings confirm the hypotheses that: (a) adopters appear to build on their advantage by making additional orders, (b) that innovations have more rapid spread within nations, and

⁹ Post-Panamax ships are those whose sizes are beyond the dimensions that Panama Canal can accommodate. Economic and operational considerations are then the ultimate barriers on vessel size as there are no technical reasons preventing them from getting larger.

¹⁰ Double-hull oil tanker is a ship designed for carriage of oil in bulk where the cargo spaces are protected from the environment by a double hull on the sides and bottom thus reducing risk of pollution.

(c) firms are more likely to imitate the innovation adoptions of other firms in the same network cluster in the firm-supplier network.

Thus the prediction that the diffusion process is affected both by proximity in geographical and network space, is supported from each theoretical perspective as well as by prior experience with the innovation.

The slow and selective diffusion of these two innovations shows that technological innovations can be a source of competitive advantage over a strategically significant time span.

The advantage obtained by being an early adopter is cumulative because early adopters add to their advantage by making additional adoptions before many competitors have made their first adoption of the new technology. Hence, in order to study how a firm can be positioned to become an early adopter of a technological innovation, practices of the West European countries are studied.

The discussion so far affirms the view that the technology advancement agenda serves very well the economic logic that dominates the shipping industry operations. It does so through the effectiveness and efficiency of service offered and optimised operations. However it seems imperative and worth investigating further that the process of technology integration be backed by and based on well researched foundation and an up-skilled workforce who can leverage the technology and drive the innovations to render competitive advantages.

3.3.5 Technology advancement, safety and environment protection

Looking at optimisation issues in shipping operations, Goss (2002) postulates that, it was originally considered that the optimum ship was simply the most profitable one and that, in the long run, competitive markets would ensure that this would be that with the lowest costs. However, in maritime transport, as elsewhere, there has been an increasing concern with safety and the protection of the environment. Following a number of well publicised disasters, this economic approach has been extended to maritime safety in general, which has to be factored in beyond the lowest cost principle. Hence, the study on impact of automation on safety and environment protection cannot be overlooked.

Shipping is a high asset value industry. Failure of either a technological or a human kind, causing a single marine accident, carries the risk to cause damage to property, loss of life and pollution of the environment on a scale that is unlikely to be equalled in any other sector of industry and almost certainly in no other mode of cargo transport. Despite increased efforts to better safety at sea, seafaring is still a risky profession with a mortality rate considerably higher than in populations ashore (Hansen *et al.* 2002). However, even with regard to the analysis of human factors in causation of accidents, this analysis is relatively immature in the maritime world as little scientific analysis is undertaken to identify the trends and patterns. Even less analysis is attempted in assessing the significance or frequency of organisational factors such as incidence of commercial pressure or effects of organisation culture (Barnett, Gatfield and Pekcan, 2006).

Gronberg (2007) asserts that today more and more companies understand the benefits to safety by the proper application of new technologies. He however cautions that new

technology alone will not improve safety. Ship owners need to be responsible enough to ensure proper processes and training in the functionality and limitations of the equipment. Training has a crucial role in getting the maximum benefit from new technology as identified in section 3.2.3.

Allen (2009) states that, in parallel with safety advancements, technology at sea has been used to not only reduce crew numbers and reduce costs in an extremely competitive market, but also to increase efficiency at operational levels.

Quality shipping in practice is closely related to safety and environment protection issues and quality management in shipping can contribute immensely to safety management (Thai, 2008). The key dimensions and factors indicating quality in marine transportation is summarised with few examples, such as dimensions related to:-

- 1) Resources: infrastructure and availability of equipment and facilities.
- 2) Outcomes: speed and reliability of service performance (timeliness, accuracy, safety, and security), and competitive pricing.
- 3) Process: responsiveness and empathy, application of IT and EDI in customer service.
- 4) Management : application of technology in operations, efficiency in operations and management
- 5) Image-reputation: company's reputation for transparency and reliability.
- 6) Social responsibility: concern for human safety and environmentally safe operations.

Psaraftis *et al.* (1998) while analysing the risk factors in maritime transportation, also include ship's flag as a factor for marine accidents. The ship's flag factor is considered as a

proxy for other variables that cannot be easily measured, such as lack of commitment to responsible shipping. They report that the group consisting of a great number of developing countries around the world, exhibited the highest risk followed by the group – flags of convenience. The significant registers of DIS (Denmark's international register), NIS (Norway's international register), Norway, Spain, Netherlands, Sweden and Italy appear in the lowest risk region.

The “White list” of the Paris-MoU (2010) which is a key industry benchmark for quality shipping and a worldwide index for flag performance, has the top eight best performing flags as Bermuda (United Kingdom), Germany, Sweden, United Kingdom, Netherlands, France, Denmark and Finland (Table 2). These flags have consistently low detention record of their flagged ships by Port State Controls of various nations.

FLAG	Inspections 2008-2010	Detentions 2008-2010	Black to Grey limit	Grey to White limit	Excess Factor
Bermuda UK	270	0	26	12	-1.91
Germany	1388	14	113	81	-1.81
Sweden	984	9	83	55	-1.80
United Kingdom	2007	25	160	121	-1.76
Netherlands	3860	54	297	244	-1.75
France	355	2	33	16	-1.73
Denmark	1385	17	113	81	-1.73
Finland	624	6	55	33	-1.71

Table 2: The White list of the Paris-MoU.

Source: Annual report 2010, Paris MoU on Port State Control.

The above normative listing of Flags is based on binomial calculus. The performance of each flag is calculated using a standard formula for statistical calculations in which certain values have been fixed in accordance with agreed Paris MoU policy. Two limits have been included in the system, the “black to grey” and the “grey to white” limit, each with its own specific formula. A number of detentions above this “black to grey” limit means significantly worse than average, where a number of detentions below the “grey to white” limit means significantly better than average. To make the flags’ performance comparable, the excess factor (EF) is introduced (Paris-MoU, 2010).

The above comparative performance goes on to highlight that the West European countries who largely excel in performance through innovation using responsibly applied technology as pointed out in the preceding sections of this chapter, are also seen to perform well in the safety and environment protection dimensions of quality shipping, thus indicating the close relationships between technology advancement, safety and environment protection.

3.3.6 Technology falls short on expectation?

Innovation not only means product or market change, it also includes changes and optimisation of production or service delivery or administrative and management processes (Jessen, 2003).

Knudsen (2009) proves empirically that technological advancements, global competition and growing demand for efficiency have caused huge changes in seafaring. A growing amount of paper work has been implemented in a time where size of crew has been considerably declining. She claims that tight schedules, high workloads and long working days are conditions experienced by most seafarers. According to this study there remains a constant deficit in the reciprocal understanding across the traditional division of the ship and shore; and there is need for prioritising, rationalising and optimising the ship-shore management interface which has come to be so heavily dependent on excessive paperwork.

At the conference of the International Federation of Ship Masters Associations (IFSMA, 2009), the Director General of Danish Maritime Authority, commented, “Shipping has never been more regulated, inspected and controlled on safety issues than today and yet fatigue continues to be a problem!” He went on to explain that there is a need to analyse the actual workload on-board ships. For this purpose, the Danish Authorities commissioned a

study on Danish flag vessels by specialists not involved in the maritime industry (DMA, 2011). They created a simulation model consisting of a variety of criteria that control the task flow on a ship and concluded that (a) Captains had a lot of redundant paperwork, (b) there was input (typing) of identical data in 4-5 different formats according to recipients' specifications, (c) duplication of paperwork on arrival at different ports within same country, and (d) huge differences in total work load between crew members. The Danish Authorities had concluded that while shipping had seen tremendous advancement in technology as a result of the owners investing in meeting the challenges in this competitive world, however the process of operating this new technology on-board ships has not been adequately addressed. A resolution was adopted at the IFSMA conference to, (a) examine the process required for safe operations, (b) distribute the work load evenly where possible, (c) acknowledge that more new regulations are not wanted, the need was just to implement the existing ones, (d) this would require all Flag States and owners to study the process on-board and to take responsibility with regard to safe manning levels, and (e) to reduce the paperwork burden on-board ships today.

Thus, the key outcome of the conference was to urge the International Maritime Organisation to take into account the administrative burdens on-board and recommend reducing paperwork by (a) eliminating duplication, (b) driving for standardised international forms, and (c) development and use of internationally accepted form of documentation. The latest IMO guideline (IMO, 2012b) on development of Ship Energy Efficiency Management Plan is noted to have a very specific recommendation on limiting any additional administrative burden on ships staff to the minimum necessary.

The above discussion confirms the notion of unsatisfactory technology integration into modern ship management practices (even those of the West European fleet) that seem to fall woefully short on expectations thus leaving a large room for optimisation and improvement.

Summary, conclusion and way ahead

This chapter in its first section focused on the theory of technology and organisation interaction to provide a way of understanding and predicting the effects of this interaction. Maritime research is found to be lacking in explicit reference to such theory thereby hindering efforts to generalise findings from one context to the other. Theory not only enables better understanding but also helps guide development and evaluation of implementation and mechanism of action. The section concludes that when taking a technology-centric view for managing entities, a three way interaction of technology-organisation-process framework provides the holistic construct.

The second section examined the skilling dilemma initiated in the exploration of technology-human interaction process and debated the up-skilling versus deskilling positions. It again backs arguments on theory prepositions and arrives at a tenable position through cognitive behaviour in naturalistic decision making.

In the third section, the enhancement potential of technology application was discussed through provision of several perspectives; drawing on lessons from other industries, evidences of competitive edge through its proper application, and success stories from pockets of segments from the shipping industry itself. It concludes that despite the

investments in technology and automation in ship operation and ship management thus far, the industry is realising that its real impact on management styles and practices are actually well below expectations. There is thus a need for leveraging technology advancements in shipping for optimising operations, which seems to be underutilised and where a large scope exists. The lack of substantial research on process automation and optimisation, and the current level of business process achievements falling short on expectations suggest that, there is a potential for further enhancements of overall performance.

Samaranayake (2009) affirms that business process optimisation has its principles in waste elimination, simplification and integration, and automation seems a suitable option. This process has been suitably researched by Lyridis *et al.* (2005). In their exercise for optimising shipping company operations of a Greek liner company they developed and used process models of activities and integrated the organisation with ICT systems and resources to reengineer the process for delivering the defined strategic objective. Business processes were seen to find visibility through process models thus enabling reengineering, and the classical hierarchical model of macro to micro processes was followed with increasing level of detail. The specific application to a liner shipping service between Madrid and Athens in terms of cost and time was analysed, and technology including ICT leveraged with real time connectivity among interested parties, thus delivering improvements in a number of operational functions.

Pomeroy (2006) confirms that systems engineering methods provide an approach that permits the designers to select the best solution while ensuring that key requirements are satisfied within a given context. However, he states that there is actually very little evidence

to suggest that a systems engineering approach is being adopted when designing shipboard applications and operations methods. It may be noted that the theory as in section 3.1.4 also advocates a systems based approach to technology integration.

With the ship as its productive unit being geographically remotely located, for the ship manager the process interface between the shipboard management and the shore based management, which is the scope of this research project, thus becomes of prime importance. An objective for optimisation of this vital interfacing process leveraging technology application is envisaged to deliver enhanced value addition and business opportunities to ship owners through increased efficiency and effectiveness in management and operation, better safety and environment protection, and to improve the working environment.

There are however various challenges which need to be recognised with making the technology integration systems, especially those interfacing the ship and shore, robust, reliable and secure, in the ship operation and management with automated systems.

Chapter 4, details these challenges in technology integration in ship operation and its management practices.

Chapter 4: Challenges with technology integration in ship operation and management practices

Introduction

The June 1995 incident of the passenger vessel Royal Majesty running aground with 1509 passengers aboard near Nantucket Island on a voyage from Bermuda to Boston is widely referred to as the classic case of the automation induced accident. The incident is reproduced here briefly and forms the general basis for highlighting the various challenges with technology integration in ship operation and management practices.

Soon after the departure of vessel, with a straight course set for Boston, there was a cut-off in the signal from GPS¹¹ antenna to its receiver. The GPS, on losing the signal, defaulted to DR¹² mode, sounded a brief aural alarm and displayed the code. These alarms and codes were not noticed, in spite of the code being on plain view for 34 hours. The navigation command system and autopilot were thus using the inaccurate DR position inputs, without any warning. This was a system deficiency. The basic seamanship practice of cross-checking, in this case with Loran-C¹³ was not followed. Even when approaching landfall, the crew ignored and failed to recognise the warnings and indications that the vessel was not on its intended track, including not positively identifying the first buoy marking the entrance channel , ignoring the un-sighting of the second buoy, ignoring the reports of the lookout man and also the warning broadcast on VHF concerning their vessel.

¹¹ Global Positioning System which uses satellite data to calculate positions, course and speed.

¹² DR means that the position is estimated – deduced (ded.) reckoning, also known as dead reckoning.

¹³ Loran-C is a radio-based navigation system, which in this case provided more accurate positions closer to the US Coast.

When the vessel ran aground east of Nantucket, she was 17 nautical miles from the planned and presumed position on the course.

The accident, investigated by the U.S. National Transport Safety Board (NTSB, 1997), concluded that automation when designed properly and used by trained personnel, can be helpful in improving operational efficiency and safety. However, when designed poorly or misused by undertrained or untrained personnel, automated equipment can be a contributing cause to accidents.

Another analysis of the same accident was carried out by Lutzhof and Dekker (2002), from the perspective of the crew, with the aim to understand the role of automation in shaping crew assessments and actions. Using the local rationality principle of human factors which states that “people do reasonable things given their knowledge, their goals, and their limited resources” they converted the search for human failures into a hunt for human sense-making; why did the action or assessment make sense to people at that time and place, and tried to understand why they did what they did.

They suggest that accidents are the result of multiple factors that may all seem necessary and then become jointly sufficient to lead to the accident. According to them, focusing on a single point failure as labelled by the official accident report on Royal Majesty critically misses the evolving, building, escalating signature that lies at the heart of problems related to human-automation interaction. They claim that research shows that humans are not only poor monitors of automated systems, but also tend to rely on warning systems and not manual checks. Automation is often introduced because of quantitative promises that it will reduce human error and workload; and increase efficiency. But as demonstrated by the

Royal Majesty, automation has qualitative consequences for human work and safety, and does not simply replace human work with machine work.

They concluded that automation only changes the nature of human error. It creates new human weaknesses, and amplifies existing ones. They further noted that with increasing automation the error only gets displaced into the future, thus further compromising opportunities to recover. Finally Lutzhof and Dekker (2002) recommended that proper guidance is required to support the co-ordination between people and automation, not only in foreseeable standard situations, but also during novel, unexpected circumstances. The need is to find ways and means to turn automated systems into effective team players.

The Maritime and Coastguard Agency of UK initiated a research study and reported on “Development of guidance for the mitigation of human error in automated ship borne maritime systems” (MCA, 2006). This report identified a range of human related issues, like over-reliance on automated systems, its poor maintenance and calibration, lack of situational awareness, and poor ergonomic design as contributory factors.

While it is useful to differentiate between the safety and productivity implications of the use of technology on ships, it is inevitable that in a high risk work sector such as shipping the benefits of productivity cannot be considered if there is a minimal possibility that by bringing in new technology safety could be compromised.

This chapter examines the challenges of technology integration in the maritime domain with particular reference to ship operations and management practices which lies within the scope of the project. This it does comprehensively even at the design stage, in the operation

stage, in the management of, and with new technology, the influences of the unique work culture and work environment and its contributing factors, before summing up the limitations.

4.1 Issues involved at the design stage

4.1.1 Poor human factors consideration at design stage

The potential for error-causing behaviour related to automated systems has not been addressed adequately by the marine industry. The National Transport Safety Board (NTSB) Report (1997) on the grounding of Royal Majesty also stated that there have been little or no unifying efforts to integrate the human element into marine engineering or the manufacturing sector. The best place to do this is at the design stage. The human factors engineering concept (HFE) is about the comprehensive integration of human characteristics into the definition, design, development and evaluation of the ship to optimise human/machine performance under specified conditions. This concept of HFE is now being acknowledged as an essential component to meet the challenges of automation in many industries (Perrow, 1983). Pomeroy and Jones (2002), who also analysed the Royal Majesty, traced errors related to design, manufacture and installation of automation technology apart from operational errors.

A joint initiative of The Nautical Institute and Lloyds Register, the International Maritime Human Element Forum defines the human element concept as a critical feature of all aspects of ship or system design and operation. Poor ship design, bad ergonomics, equipment prone to failure, differing equipment designs and lack of proper training in the

operation of equipment, leads to fatigue, stress, boredom; all affect the way in which a ship is operated (Squire, 2004).

Lin and Chen (2002) empirically examined the effect of social factors on the success of automation and found that social factors played an essential role in the success or failure of automation. They suggest that although users may be psychologically ready to accept technical changes, system designers should adopt a socio-technical systems approach and familiarise themselves with the entire business process including its social factors in order to implement a successful automation program, and that it must not be solely a technical task.

Interestingly, with regard to the investigation of accidents and incidents, the school of thought that supports the deskilling preposition tends to back the idea of having more automation or computerisation than what exists. This arguably, is to design the “man out of the loop” (Perrow, 1983, p.535) and thereby compensate for the human error. Lutzhof and Dekker (2002) however caution that this could be a premature countermeasure as the qualitative implications of automation on human work particularly in the maritime domain is only lately being understood.

4.1.2 Design being technology-led rather than design-for- use

Pomeroy and Tomlinson (2000) noted that advances in technology which were technology-led rather than being designed-for-use, have a major influence on the frequency of occurrence of human error in ship operation. They suggest that the options available to systems designers have expanded as the capability of electronic systems has increased remarkably which is coupled with progressive reduction in the cost of the programmable

devices. This encourages the design and construction of more complex systems that offer the purchaser more options. However, the downside of this trend is that the user is left with a system that may possess unnecessary properties well beyond the understanding of an average well-trained user. The situation is made more complex by the interconnectedness of systems using networking, resulting in interactions and dependencies which become no longer obvious as with older systems.

It is important that the design-for-use principle is followed, that rationalises the information-intensity that the crew faces. Since human operators are unlikely to understand all of the characteristics of a total hybrid system such as the modern bridge or engine control room, the designers must ensure that the systems hardware is useable by an averagely competent operator.

Allen (2009) also raises concern about how technology is designed and introduced. He suggests that the processes of selecting and automating tasks are at risk of following machine-centred rather than user-centred principles. He cautions that as technology becomes increasingly more sophisticated, it is important that the understanding of how human-computer interaction takes place keeps apace. Technology developed without reference to key human factor principles has the potential to be counter-productive, particularly so in safety-critical industries like shipping, where mistakes can lead to disastrous consequences.

The problems are compounded when the system is procured from many suppliers of individual items of equipment. Suppliers of individual items use their own standards, so when it comes to user interfaces the system as a whole lacks consistency. Manuals and

instructions for component parts provide little assistance in understanding the complete installation. CHIRP¹⁴ (2006) reports emphasise that the style and presentation of operations and maintenance manuals should be subjected to review and a set of minimum standards should be agreed and imposed by classification societies, as the lack of it poses a potential safety related latent defect in the underlying processes. Integrated systems pose particular challenges which are not always met.

Lack of standardisation of equipment is another of the shipping industry's dilemmas. The equipment manufacturers in their effort to innovate incorporate new features and then maintain exclusivity for gaining inimitable competitive edge. These often contradict the seafarers' perception of how things should work. Although designing equipment that may be considered universally intuitive may be a challenging task, as Gronberg (2007) suggests, the IMO consider type rating of integrated navigation systems just as in the airline industry. The IMO (2008) has been engaged through its E-navigation Correspondence Group in discussions of potentially allowing innovation along with standardisation through an S-mode or standard mode. The concept behind S-mode is that different pieces of equipment from different manufacturers will have a default mode, which can be switched to at any time. This will allow manufacturers to continue innovating and adding new features to their equipment, whilst also maintaining a standard mode that seafarers will be able to revert to should they wish. The implementation of such a concept would also be likely to reduce training demands as it would bring in uniformity in operations.

¹⁴ Confidential Hazardous Incident Reporting Program; the aim is to contribute to enhancement of safety by providing a totally independent confidential reporting system.

Another factor that is often overlooked at the design stage is the shipboard operations environment where background noise, vibration and lighting levels do not provide an ideal working environment for the crew, particularly at times of abnormal or emergency operations. Osterman (2010) confirms that occupational ergonomics and the interface between humans and technology in shipping is an area of potential yet uncharted. Ergonomics produces and integrates knowledge from the human sciences to match jobs, systems, products and environments to the physical and mental abilities and limitations of people. In doing so it seeks to improve health, safety, well-being and performance (ISO, 1997). However, the operating procedures are rarely considered at the design stage, resulting in badly designed interfaces that encourage mistakes which no amount of training or management intervention can mitigate.

The user inputs must be solicited at the design stage to influence the design of component parts and also the whole system along with its documentation, standards, and codes of practices and rules that are referred by designers. It may be argued that the causal factors for the superior performance of the West European countries' flags, on a comparative scale, is because these countries are known to have a long tradition of cooperation between employers and employees towards a good working environment and employee participation in planning of new or altered work places is legally enforced, for example the Swedish Code of Statutes on Work environment (SFS, 1977:1160). However, it cannot be denied that when a West European owner flags out a ship to a flag of convenience, then such obligation is not mandated and may not be observed (Alderton and Winchester, 2002).

4.1.3 Limitations in assessments and type approvals

It is a well-established practice that ship systems are protected by strict design standards, redundancy and by a feedback process that will activate alarms or even take corrective action. However, as the systems get more complex with interconnected and interactive equipment, exhaustive assessment and testing gets unviable. Traditional type approval and certification examines a product against an agreed standard or set of rules, usually involving some form of demonstration through a test program. For a more complex system, it is likely to be too late to correct faults that are found, and even if rectified, the correction involves only temporary fixes or expensive rework. The assessment procedure also does not incorporate ergonomic factors or human consideration (Pomeroy and Tomlinson, 2000).

This aspect had also been commented upon earlier in a report from a Select Committee of the UK House of Lords (1992) which concluded that modern science and technology are not being adequately applied in many of the fields that affect the safety of ships, the lives of those who travel in them, and the marine environment; and that there are new developments in marine technology affecting the design, construction and operation of ships which the regulators constantly struggle to keep up with and constantly fall behind as technology develops.

Lutzhof (2004) further confirms this from her interviews with four representatives of major maritime technology manufacturers that most of their tests data relate to technical issues such as tolerance to vibrations and temperature, but when it comes to ergonomics and human factors it becomes difficult.

Standards for integrating human elements in design process exist as noted below from the ISO standards, and are being applied in other industries. This needs to be extended to marine applications as well. For example, some of the standards which can be used in the maritime sector are:

- (a) Human-centred design processes for interactive systems (ISO 13407); (b) Ergonomics of human-system interaction and life cycle process descriptions (ISO/TC159/SC4); (c) System lifecycle processes (ISO 15288).

What needs to be appreciated is the interconnectedness of an operation safety culture of shipboard operations and its working environment; and the complementary design and development process of the easily-usable advanced technologies. For safety to be improved further, ship design has to be looked at as a hybrid human-technical construction with active inclusion of the human element.

CHIRP (2006) highlights another area of inconsistency and limitations of assessment, which is in the area of operations and maintenance manuals. Other safety critical industries and transport modes have recognised the importance of technical/operational documentation and established controls to ensure adequate and consistent standards. While IMO has recognised its importance, it has not applied these principles more generally. As a result the determinant in manual production may not necessarily be end-users, but may be “defensive engineering and liability practices”. While port state control authorities have powers to audit this area, their effectiveness is constrained by the absence of an auditable standard. The absence of agreed standards means good quality documentation is a cost option invested in by a discrete sector, when it should be provided to all. The adoption of

standards for technical/operational documentation offers the potential to provide an element of consistency through a diverse equipment/personnel environment, thus reducing the risk of human error and promoting operational integrity and consistency.

4.2 Challenges in the management of information

4.2.1 Information clutter in management

This section highlights how the evolving information systems architecture has impacted adversely upon the ship management function.

Ships are no longer isolated and out of company control as soon as they leave the port. Interconnectedness and automated reporting allows shore management to monitor what is occurring on-board. This forces the shore management to share responsibility on the important aspects of ship's performances that traditionally have been seen as out of their control, once a ship leaves port.

However, more control begins to get exercised by the shore based management, making it necessary for them to be involved in managing information from the ship. In the process, too much information is required of, and is available to the shore side management today, rendered so by the ease of information communication technology. While application of computers, communication and software technology comprise for the management, processing and dissemination of information; the human element in the information management system gets neglected (Slesinger, 2009).

Jones (2007) comments that communications with the shore has improved dramatically in technical terms in the last few years, and this has turned the whole industry into a 24/7 operation, but the information flow with the (ever smaller) crew has not been managed in terms of distraction from the primary task.

Knudsen (2009) points out that the perceived distance between the ship and the company has become both greater and smaller. Due to the growing opacity in ownership and a growing disintegration between owner and flag, and between owners, operators and managers, the link between owners and those responsible for the crew is blurred. Thus the seafarer expresses a feeling of being a pawn in the game which they believe is more and more about money and less and less about their working conditions. The perceived distance seems smaller because of the enhanced means of communications, which, notwithstanding the improvements they have caused, have also resulted in loss of autonomy on-board. “Some seafarers claim they can hardly hit a nail without asking for a work instruction from an unskilled clerk ashore” (p.297). Thus while the shore administration has become more distant, it has developed a panoptic grasp on the vessel, operating outside its field with long-term planning and including the ship in its strategy. “The problem seems to be related to the form of control seamen are subjected to, and thereby the perceived need to “cover one’s back” or “wash one’s hand off”. This is an area where ethical considerations are sometimes mixed with tactical cunning. This form of control is perceived by the seafarer as having less to do with enhancing safety than with fixing legal accountability. Thus one of the most widespread and serious objections against paperwork has its root in a dilemma between legal and moral responsibility” (p.321).

The abuse of such disparate systems with little integration or coordination between them, runs the risk of proving detrimental to the ultimate objective, which is the safe conduct of the ship, and the safe and timely delivery of the cargo as identified in section 2.3, the performance of the ship being the goal of any ship management system.

It is vital that the data provided by the ship must be sorted, analysed and understood properly for it to be used optimally. Shipboard staff are often left wondering why they are being asked to provide certain pieces of information, and what is done with it. Such opaqueness in communications can lead to frustrations and resentment in the seafarers (Knudsen, 2009).

Slesinger (2009) also cautions against unnecessary use of the much eased process/information bridge between vessel and shore. It can increase information clutter as any amount of data transaction contracted for can be sent at a fixed price, so the attitude of “we have paid for it so let us use it” comes into play to justify the expense. Hence care is to be exercised to see that only required and appropriate data is sent from shore to vessel and vice versa.

Shipboard staff are also burdened with an overwhelming number of paper based logs, reporting forms and information requests from regulators, ports, agents, charterers, and other interested parties. If an on-board electronic systems that can record exact real-time data and be transmitted ashore and shared with relevant users can be used, then this will not only reduce the crew’s paperwork burden, but also will make logs accurate and unalterable, rendering improved transparency and behaviour. There is better compliance to the company’s policies. According to Neef (2008), seafarers feel protected against unfair

pressures to commit violations, in as much as company officers feel protected from their own prosecution or ending up costing the company money or damaged reputation. Such good behaviour has long been appreciated in commercial aviation or even monitoring of good laboratory practices in pharmaceutical companies.

The use of the mobile phones has also made communication between ship and shore so much easier, but at times it has resulted in excessive demands being placed on the master and his officers who have to deal with enquiries from a wide range of organisations and individuals who have business with the ship, such as ship owners, operators, charterers, chandlers, port officials and shipping agents (Nautical Institute, 2012).

4.2.2 Information clutter in operation

This section highlights the adverse effects of un-optimised overloads of information in ship operations.

E-Navigation deals with management of maritime information. IMO defines e-Navigation as: “the harmonised collection, integration, exchange, presentation and analysis of maritime information on-board and ashore by electronic means to enhance berth-to-berth navigation and related services, for safety and security at sea and protection of the marine environment” (Lemon, 2009).

The officer of the watch has to manage an ever-increasing amount of information, and has to take his decision after properly accessing, prioritising and analysing the same primarily because of lack of integration between navigation equipment.

There is also the risk of over-saturating the untrained seafarer with information that may be replicated through different means. The seafarer is presented with a plethora of information, from a variety of stand-alone systems having differing user interfaces, with the potential for confusion and information overload, particularly if he is not properly acquainted with the operational parameters of one or more of those systems.

Even in highly integrated systems, what the developers and manufacturers choose to integrate into screens or systems is not always what the seafarer would choose. Mariners are then left to perform integration work themselves and adapt to such mistakes (Lutzhof, 2004).

E-Navigation is a move to provide the benefit of optimum information to the officer of the watch. Much work is being spearheaded in this direction by the IMO and Nautical Institute (UK). IMO's decision to make Electronic Chart Display Information System (ECDIS) mandatory, with sensor information from radar and Automatic Identification System (AIS) shows great potential for enhancing the situational awareness of the watch-keeper, provided human engineering factors are taken into consideration adequately.

With the advent of Global Maritime Distress and Safety Systems (GMDSS) the presence of a radio operator is no longer a requirement on-board ship. The communication tasks get coupled with navigational responsibilities. The GMDSS system senses critical navigation situations and activates alarms on different consoles situated on the bridge causing communication information clutter and the officer of the watch grapples at consoles to cancel them. There is also a plethora of communication systems to be handled by the same

officer of the watch as compared to earlier times of 2-3 radios with a separate radio operator taking care of them.

Jones (2007) cautions that ships today have too many alarms. He also points out that external alarms are being generated more from traffic and more types of sensors – the relatively recent introduction of GMDSS and AIS having added dramatically to the number of spurious and distracting alarms. He professes the judicious use of alarms and highlights the Royal Majesty case as best known for alarm problems; the ship went from navigation by GPS to dead reckoning when the antenna cable got pulled off. This triggered aural chirps similar to those of a wristwatch alarm for a total duration of just one second and a display *DR* on a liquid crystal display (where visibility is not high) measuring just 3 inches high by 3.5 inches wide. Even its fathometer alarm was set at 0 meters, which was not reset from the position set in port to prevent alarm from being continuous.

While acknowledging the criticality of effective response to alarm indications for safe operation, Jones *et al.* (2006) also point out that particular problems do arise if the design, management and operation of alarm systems do not follow ergonomic principles. These include:

- Frequent spurious alarms, causing distraction to the watch-keepers (and risk of genuine alarm being ignored or discounted).
- Long standing alarm lists, where it can be hard to distinguish real problems from on-going issues of lower concern.
- Cascades of alarm when there is an incident, causing difficulty in diagnosis and excessive workload (e.g. cancelling alarms becomes a full time job during the incident)

- Alarms that are difficult for the operator to interpret, or where the correct course of action (or even the degree of urgency) is hard to determine.

Thus increased marine automation and modern instrumentation bring with them increasing numbers of alarm channels which can distract and confuse the ship's staff at critical junctures. Automation rather than freeing up resources is seen to create new vigilance demands, which may be extremely taxing. Allen (2009) contends that complex new automated systems may therefore give the illusion of reducing workload and introducing redundancy, in reality this may not necessarily be the case. Also, the task of controlling multiple remote systems may require high levels of cognitive ability and skill distinct from those originally learnt during qualification, even negating the deskilling argument that is based on the role of humans having changed from operator to monitor highlighted in chapter 3.

Pomeroy (2006) also suggests that as the level of complexity of automated systems increases so the human element becomes more deeply embedded amongst the physical elements. As machinery and equipment are left to operate unattended, the monitoring systems detect warning signals and prod control systems to take immediate action. The crew member that eventually gets called in to deal with any resulting major problem enters a situation which is part through. Without the time to gear up, it becomes easy to misjudge the situation in the confusion and to initiate action that exacerbates the situation. The tenable position of the skilling dilemma in section 3.2.3 proves right. In the new situation the seagoing engineers are no longer expected to possess high calibre diagnostic skills, as they can now rely on automation in routine situations, but they do need to be able to

quickly assimilate information provided by the systems and fall back on the knowledge base to handle the information clutter effectively and efficiently in abnormal, non-routine and emergency situations. This affirms Rasmussen's (1983) and Klein's (2008) models of naturalistic decision making in a technology integrated environment, as discussed in chapter 3.

The following section also reflects issues that have a bearing on the skilling of seafarers in the light of integrated technology.

4.3 Challenges in the operations with automation

4.3.1 Reduced and inexperienced crewing

Improvement in the reliability of equipment and extended intervals between routine overhauls has resulted in a significant change in the demand for and of the ships' staff.

- (a) The decrease in maintenance and repair work causes reduction in employment of number of crewmembers;
- (b) It significantly reduces the exposure of sea-going staff to the learning experience that is associated with these tasks, which reduce their effectiveness when dealing with abnormal or emergency situations. The familiarity with items of equipment gets reduced by the reduction in routine intervention.

The lack of opportunity to learn from precursor events may reduce skills required during handling a hazard. Pomeroy (2006) suggests that the environment that provided the experience for dealing competently with all manners of abnormal situations has been

changed by the advances in technology which has increased reliability and reduced maintenance. Allen (2009) also confirms that once the crew becomes used to working in an automated mode of operation there is concern about how they will respond should the requirement be made to switch back to manual operation in an emergency situation, which creates more complex consequences. Some maintenance tasks such as repairing machinery after failure, simply cannot be handled by the number of people available, who are also rendered inexperienced by the lack of learning opportunity, thereby presenting an additional potential hazard to the ship. Often the operator is faced with an increased dependence on marine electronics, generally with no specialist electronics engineer available on-board. Where repair is necessary the owner has to resort to servicing by specialists, usually from the original supplier which has implications of costs and delays.

Reduced and inexperienced crewing creates stressful work of operating a modern complex vessel that often leads to the growing problem of fatigue. Wrana (2007) confirms that this only adds to the other contributory factors of long hours of shift work without proper rest and administration tasks that pile up. Knudsen (2009) also reports that while physical conditions on-board as well as the means of communication have improved a lot, crew levels have declined and workload increased. Thus, in spite of technological advances, the seafarer has benefitted very little from the positive sides of globalisation due to increased connectivity and enhanced communication.

4.3.2 Suspension of traditional seafaring skills and reduced situational awareness

Barnett (2005), in searching for root causes of maritime casualties, identifies failures of situational awareness and situation assessment, as overwhelmingly dominating.

The reliability of automation has to some degree reversed roles. Rather than control and alarm systems assisting the human operator to identify malfunctions at an early stage, the operations get controlled automatically with human supervision. The reliance on the system, with the human relegated to monitoring the progress of the ship, encourages a suspension of the traditional seafaring skills of the crew. The officer of the watch tends to get so absorbed in technology that his awareness of the situation around him gets confined to the displays rather than looking out of the window on the bridge or sensing the machinery spaces. Awareness and observation of the environment that give vital clues, such as noise, vibration, touch, smell, appearance, weather changes, that are traditional seafaring skills used in making decisions gets dulled (Barnett, 2005).

King (2001) points out that in a ship an expert system might be used for fault diagnosis or collision avoidance where it could be described as an aid to operational decision making, but the more complex the context, the less freedom the human operator has to deviate from the advice or assistance offered by such technical aids. Today, knowledge-based information technology is limiting seafarers' scope to exercise initiative even in those areas where their sea-sense has traditionally rendered them qualified. The author concludes that technology challenges people to exercise moral judgment in the realisation of whatever is advantageous. In doing so, it limits the capacity of humankind to act freely. It symbolises human potency and power while simultaneously disguising the extent to which humankind is its subject.

Baker and McCafferty (2005) reviewed accident databases from the USA, UK, Canada, Australia and Norway, and confirmed that human error continues to be the dominant factor in maritime accidents and drew the following conclusions:

1. While the total number of accidents is declining, human error continues to be the dominant factor in 80 to 85% of maritime accidents.
2. Failures of situational awareness and situation assessment overwhelmingly dominate.
3. Human fatigue and task omission seem closely related to failures of situational awareness.

The effect of automation on airline pilot skills has been reported by Flottau (2011). An Associated Press release in Washington, USA, developing on this study noted that while federal regulations require greater reliance on computerised flying, the aviation industry is suffering from “automation addiction”. This study examined 46 accidents and major incidents, 734 voluntary reports by pilots and others as well as data from more than 9000 flights. It found that in more than 60 % of accidents, and 30% of major accidents, pilots had trouble in manually flying the plane or made mistakes with automated flight controls. Hundreds of people died over the last five years in “loss of control” accidents in which planes stalled during flight or got into unusual positions that the pilot could not correct. The Federal Aviation Administration Committee on pilot training warns that pilots use automated systems to fly airlines for all but three minutes of flight: which is the take-off and landing times. The pilots are mostly engaged in programming navigation directions into computers rather than using their hands-on controls to fly planes. They thus have few opportunities to maintain their skills by flying manually. Safety experts worry that they are seeing cases in which pilots who are suddenly confronted with loss of computerised flight

controls do not appear to know how to respond immediately, and they make errors – sometimes fatally.

For the shipping industry there could be parallels to draw from the well-documented studies conducted in the aviation sector. It shows that suspension of traditional skills and reduced situational awareness are potentially detrimental especially in safety-critical environments.

Hadnett (2008) argues that the relentless drive within the shipping community to introduce technology-aids to merchant ships had the principal stated objective of improving safety by enhancing situational awareness; however, it is proving counter-productive as reduction in core competencies has arisen due to the unforeseen effect of a human trait where the equipment engenders over-confidence in situational awareness. This encourages individuals to take far greater risks than in previous times. Ship staff tend to become more and more reliant on electronic systems with scant regard for the vulnerability of the systems in terms of their accuracy, reliability, availability and integrity.

Pyne and Koester (2005) in their analysis of the grounding of Royal Majesty also reported over reliance on technology. The crew on-board the fishing boats realised that the Royal Majesty was heading towards danger and tried to call it on Channel 16, referring to ‘cruise boat’ at a position in English. But the crew of Royal Majesty were convinced that they were in another position, so did not respond.

It is also alleged that the owner in a bid to cut costs, instead of investing in crew training substituted the fundamental skills of watch-keeping to a third party which in this case was the electronic aids. Alongside this, the introduction of electronic equipment has unwittingly

compromised safety with commensurate reduction in watch-keeping standards due to an over-reliance on navigational aids as the principal means of safely conning the ship.

4.4 Influences of the work culture and the work environment

While the benefits of automation may result in improved quality, efficiency, and flexibility, the failure rate of automation is also high. This is because social factors were ignored in the implementation of automation programs report Lin and Chen (2002). Their major findings suggest that a technical system with a high extent of automation is associated with an increased extent of complexity and flexibility of social factors, and that management support to these issues exhibit significant effect on the success of automation. They suggest a socio-technical systems (STS) approach must be adopted. They further state that in an era of immense competition, automation is a process en route to high productivity for manufacturing and the service industry alike. Hence concurrent change in both technical and social systems is crucial to the effective exploitation of the performance potential of new technologies.

In this context it is pertinent to study the United States Coast Guard (USCG, 2005) report that has identified the following endurance risk factors for maritime crew, which pertains to individuals and their work/rest environment:

- Individual risk factors as described in the decision support software tool:
sleep duration, sleep quality, sleep fragmentation, synchronisation with circadian rhythm¹⁵, change of work/rest schedule (irregular hours), extended work hours, opportunities to make

¹⁵ Pertaining to rhythmic biological cycles recurring at approximately 24-hour intervals

up sleep (nap), diet (type of food and eating times), workload, work-related stress, opportunities to exercise, sense of control, external environment (including motion sickness), family stress and isolation from the family.

- Environmental risk factors – Work environment that includes light intensity, noise intensity, temperature, air quality, vessel motion/ vibration; Sleep environment – that includes all the above factors again; and Vessel operating environment– temperature (humidity, extreme heat or cold), marine operating environment (wind, weather changes, sea state, tides, current, high low water), operational demands (down time, work load surges, routine vs. dynamic schedule), and operating policies (courtesy to crew sleeping off-watch, allowing napping, vessel manoeuvring, alternate meal and/or shower times).

Added to the above risk endurance factors, there are also the problems of occupational attractiveness. There is a present level of shortage of skilled crew and it is likely to only increase in the future. Occupational attractiveness is on the decline and the ability to recruit the required quality of fresh entrants is reduced even in the developing countries that are today in the most supplying the crew to the global shipping industry. Competition among the companies for qualified crew is intense and the labour market now operates almost on a spot market (BIMCO/ISF 2005, 2010). This throws up challenges for the companies – viz. how to attract, retain and build a committed and competent pool, and how to become a good service provider enabling handling of advanced technologies.

Often too much reliance is placed on a few highly skilled individuals in senior positions. Operational safety requires experience in depth from all individuals that form part of the ships' crew. The operations management is pre-dominantly dependent on quality of crew

and operating philosophy of the company. Crew turnover can thus encumber the application of any systems, and leads to frequent loss of resources and tacit knowledge. There remains very limited repair and maintenance knowledge on-board and crew computer literacy varies from enthusiastic hacker to absolute novice. The contractual employment pattern causing seafarers to move from one ship to another even in the same company, where each has different equipment fit, makes it impracticable for them to be properly trained in the use of different manufacturers' equipment. Furthermore, such contractual appointments, fluid labour markets, and high crew turnover, also result in lack of commitment by a transient workforce, in as much as employers being indifferent to them resulting in the workforce lacking adequate training, familiarisation and experience. Progoulaki and Theotokas (2010) confirm that in such special conditions of seafarers' occupation and employment relations the seafarers consider the agent or the third party manager that intervenes to secure his employment as employer rather than the principal that employs him.

CHIRP (2006) also notes that in the shipboard automation scenario, there are limitations on working with technology on account of the work culture and pattern. Seafarers move from ship to ship types with few restrictions and this flexibility is essential for the efficient management of human resources. As such, they are expected to assimilate different equipment quickly and perform to high operational standards, even when they encounter equipment on which they have not been specifically trained.

4.4.1 The ship-shore divide

Different objectives drive the ship and shore management, missing out on the ultimate objective of transportation of goods promptly from place A to B. While the ship works to this objective under its constraints of safety given the hostile environment, the shore management decisions get weighed heavily from an economic perspective. Technical decisions ashore get taken more with a financial point of view and maximisation of returns from the ship has become the prime focus now even in the ship owner managed companies. Insular mind-sets thus result in avoidable misunderstandings and fuel the classic ship-shore divide. Masters feel that their authority gets undermined by (a) increased interference from shore based management, and (b) increase in volume of management standards and procedures (Krishnamurthi, 2005).

MCA (2006) have reported that commercial pressures have become intense, and with minimum manning levels and increased demands for reporting and paperwork, the crew are led to putting in longer working hours and consequently being fatigued.

In this regard, Bielic (2008) states that when the communication from shore management is dominating in nature and against the belief system and at cross purposes to shipboard objectives, it casts a very negative influence among the ships' crew in inducing complacency, which can be detrimental to a healthy work environment. Thus, active knowledge, creativity and motivation are gradually suppressed, and the crew feels inhibited to use them.

Knudsen (2009) provides empirical evidence to show that there largely exists among seafarers, a feeling of being misunderstood, undervalued, or even forgotten by people

operating maritime business from the shore side, both, the administration of the company and the concerned Maritime Authorities. She suggests that the seaman's aversion to introduction of new rules and demand on written procedures has to be understood against *their* experience of enhanced control, mistrust and disrespect of their seamanship.

Krishnamurthi (2005) indicates that many times the situation even escalates to a "them and us", when each of the shore and ship side tries to take the credit when fleet operates efficiently and blame the other when things go wrong. It also creates a perception among the seafarers that while all the responsibility tends to rest with the ship, the authority gets snatched away to the shore side and this creates a wide chasm reflected in mutual distrust. He further suggests that modern shipping operations have become extremely complex and the sole responsibility thrust on the ship needs to be replaced by a shared chain of responsibility across teams that run the ship directly and remotely. In such a responsibility matrix the ultimate onus has to finally be that of the ship owner.

The underlying reasons for such a ship-shore divide can best be rationalised by examining the concept of a "community of practice". Wenger and Snyder (2000) define community of practice as a group of individuals that are held together by informal relationships through which they share identity, unity of purpose and meaning. Moreover, the people in these communities share experiences within a particular domain of knowledge, which allow them to develop perspectives, practices and particular approaches as a group. "Master under God" was a term used until relatively recent times to describe the role of a ship's captain, who retained both authority and responsibility from the age before instant communications. While maritime law still recognises the Master as the alter ego of the ship, the rapid

advances in information communication technology is somewhere along the way turning him from a commander to a technical expert, then to a manager and now even to an executioner of decisions made ashore. These developments are in complete conflict with the seamanship practices over ages that signified a blend of professional knowledge, professional pride and experience-based common sense. What creates aversion is the fact that whilst the ship and the master finds his authority abdicated, the responsibility and accountability is not allowed to be cast away. “Master’s overriding authority” even though mandated in the ISM Code (2010) remains an empty rhetoric.

The pervasive ICT is the new paradigm that has paved the way for better shore based management and needs to be accounted for in the evolving community of practice. This is however not simple because of the very strong influence of the community that relies upon practice based execution of tasks, and views ICT as encroachments. The reciprocal trust between the traditional division of the ship and shore can possibly be restored by giving more autonomy to the crew through goal setting and giving more space for local shipboard redesign, thereby providing sense of ownership.

4.4.2 Mariners’ readiness to uptake technology?

Lutzhof (2004) claims that mariners on their part want to use new technology. They want to have better control at their work stations and they want to be able to use tools they believe can provide them with this control. Mariners also feel that appropriate human-machine systems can relieve them of certain kinds of work and uncertainty, without technology being a burden on them. However, most of the time, they find there is a gross misfit between humans and machines, and mariners have no choice but to “reconstruct”

(p.75) the integration in terms and ways they understand. This entails only more work and effort and consequent disdain. Added to this is the fact that they get no or only on-the-job training for new technologies due to the constraining conditions of employment patterns noted earlier in this section.

The more recent work by Allen (2009) provides empirical results from a survey on British seafaring officers where he notes little generalised resistance to new technology. They however also feel that training is an area where not enough is being currently done to support them. Comparative analysis highlighted that resistance to technology may be related to age, number of crew and level of computer literacy.

Yet more recently, Tang and Sampson (2011) express encouragement that the majority of their respondents felt confident with shipboard equipment. They also express concern about the small percentage of respondents, whose answers indicated lack of confidence, considering the safety-critical nature of the shipping industry.

Hence, with the changing times and given the younger generations' affinity to technology, it may prove a myth that there is general reluctance to the adoption of technology. It is inappropriate implementation and the not so user-friendly deployment and application which could possibly be creating the barrier.

4.5 Technical limitations of automation

New technologies have improved efficiency and productivity in shipping. Yet, they also have limitations and may be prone to technical error, which has safety implications (Tang, 2009). The hostile and arduous marine environment, coupled with the peculiarities of

shipboard phenomena of vibration, movements due to wind and sea forces which could at times be violent, pose yet more limitations on the reliability and functionality of the automation equipment. Automation although capable is not infallible.

There are also information security risk factors in ICT as identified by Khidzir *et al.* (2010). Critical risk factors identified were systems error and ICT failures, unauthorised access, and information leakage.

Psaraftis *et al.* (1998) analysed marine accidents using Det Norske Veritas's "DAMA" database structure (a structure developed for both statistical analysis and fault tree analysis). He concluded that advanced technology systems if in place could have reduced the risk of accidents. However, this would not happen automatically just because these systems exist, but because of the assistance to the human operator that these systems would provide. So, again the human factor would be the prevalent factor, but in this case the ability of the human element would be enhanced due to these systems.

Pomeroy (2006) comments that the achievement of safety at sea depends on the availability of both dependable systems and competent people and the effective management of safety can only be achieved by considering these two aspects together. Dependability of hardware, and the embedded software, infers not only availability and reliability but also a measure of functional correctness in the context of the application.

The biggest advantage of machines over humans is that they can work at extraordinary speeds, perform repetitive tasks with ease, and not get tired and affected by fatigue as much as humans do. However, technology does not exist on its own. To deliver any value it must

be integrated and therein lies its biggest limitation. Automation supports humans with information, but it takes common sense, knowledge, and experience to make informed decisions. It is the humans that exercise decisions and are able to take calculated risks, particularly in abnormal and emergency conditions. Automation needs to be used as a decision support system and not allowed to dictate situations.

Hence, for all risks associated with marine operations, an integrated approach and consideration of the totality of the marine engineering system, that includes technology as well as people and their behaviours, is fundamental to effective ship management. Figure 8 aptly explains this integrated relationship in the marine business environment.

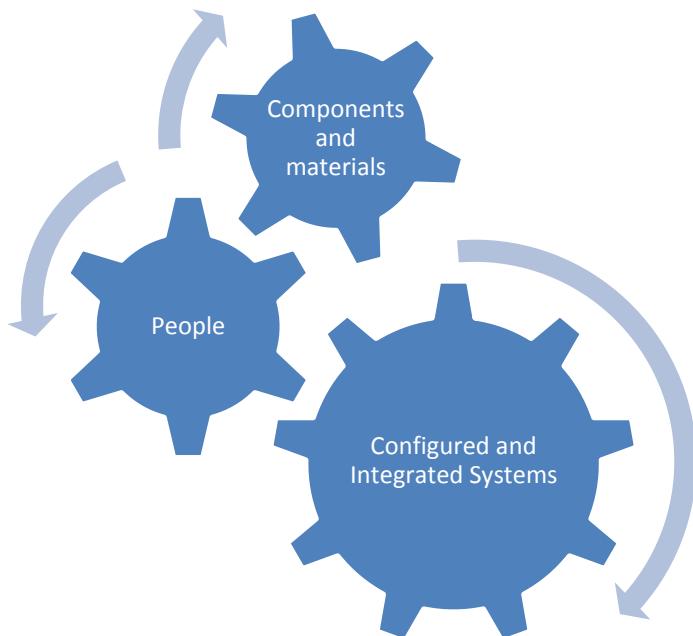


Figure 8: Maritime business environments.

The research carried out by Lutzhoff (2004) on Maritime Technology and Human Integration on the Ship's Bridge reports that several recent maritime accidents suggest that

modern technology sometimes can make it difficult for mariners to operate, and that technological remedies designed to prevent maritime accidents can be ineffective and counterproductive. When humans and technology have to work together, the humans have to coordinate resources, cooperate with devices and integrate to get work done, including representations of data and information, rules, regulations and practices. When technology is used to replace human work, this is not necessarily a straight-forward and simple process. It often means that mariners have to work hard to construct a co-operational human-machine system. She further claims that trying to fix human error by incremental improvements in technology or procedure tends to be largely ineffective due to “adaptive compensation by users” (p. iii). Hence she advocates that a systems approach is necessary to make changes to a work place. A systems approach is also advocated by Ropohl (1999) who claims that a systems model can be an effective tool to bring together both sides of social and technical phenomenon: “the technisation of society and the socialisation of technology”.

4.6 Discussion, summary and conclusion leading to research questions.

It is clear that when installing new technology in a new building or a retrofit, the ship owner should work hand in hand with the shipyard and supplier to ensure a layout of equipment that enhances and encourages its safe use.

IMO in Chapter V Regulation 15 (2000) of SOLAS, attempts to produce an integrated approach on the impact in design and operation of automated systems. Furthermore, with regard to safe use of automated control systems there are other circulars and guidelines issued by the International Maritime Organisation (IMO). Some prominent ones are:

(a) MSC/ Circ.1091 (2003) – Issues to be considered when introducing new technology on-board ships.

This circular alerts the stakeholders of the various aspects of how seafarers interact with technology and issues to be considered when assessing their training needs. Emphasis is given to the effects on non-standardisation of controls and displays, the challenges in training for technology, and the need to take the human element into account when introducing new technology.

(b) IMO Resolution A.947-23 (2003) - Human Element Vision, Principles and Goals for the Organisation.

(c) MSC/Circ.982 (2000) - Guidelines on Ergonomic Criteria for Bridge Equipment and Layout.

(d) MSC/Circ.1061 (2003) - Guidance for the Operational use of Integrated Bridge Systems

(e) Model Courses - Operational Use of Electronic Chart Display and Information Systems (ECDIS)

- Operational use of Integrated Bridge Systems (IBS)
- Operational use of AIS¹⁶.

The voice of the seafarer who is at the sharp end of working with technology must be heard. For instance, his objections to paperwork must be taken seriously, and not reject them as mere ignorance, conservatism, or indolence. The gap between procedures and practice, and the fact that sticking to procedures can lead to ineffective, unproductive or

¹⁶Automatic Identification System is a mandatory requirement whereby information about the ship gets provided automatically to other ships and to coastal authorities.

unsafe local action as for instance appears in the tactic of work-to-rule that appears to serve shore based control have to be acknowledged and understood well.

Allocation of matching resources must also be done. Fatigue is the most common factor found in accident investigation and stress levels are often amplified by constant exposure to noise, vibration, fumes, lighting, ship motion and temperature. Hence, the man-machine interface is another area of focus that must be addressed, specifically in the areas of:

- The effects on non-standardisation of controls and displays
- The challenges in training for technology, and
- The need to take the human element into account when introducing new technology.

Situational awareness is compromised due to over reliance on technology, and the feel for the work environment gets missing. This fact must be taken into account in designing and operating with automation. Good practices must be emulated from the airline industry that has matured with handling of computerised controls. Introduction of computer-controlled systems impose new demands on operators of safety-critical applications. It must be acknowledged that even the most professional person is capable of making the worst mistakes, and the most capable of machines cannot be 100% relied upon. The practice of team-based interactions rather than one watch-keeper alone with no redundancy needs be more widely taken up. It provides a barrier against individual human error and co-workers can monitor and intervene to support interaction between colleagues and increasingly complex systems. It aids in exercising caution against complacency and assumptions that colleagues or automated systems will perform tasks in a reliable manner.

The unique shipboard environment with nearly isolated occupational groupings, work sites, multinational crew resourcing, and changing composition of shipboard teams further throw up challenges and impediments to quality ship management and operations that benefit from technology investments.

This chapter hence underlines the fact that while automation and technology hold great promise in modern shipboard operations and management, it cannot be relied upon as the ultimate panacea without duly considering its many limitations in its design and deployment .

4.6.1 Enunciation of the research questions

This section now reflects on the discussions in all the four preceding chapters on issues related to technology interface in ship management and operations and arrives at the main research question.

Shipping as the principal service providing industry in transportation, with truly global context in all its dimensions, needs to be effective and efficient. It produces this service with the ship as its core constituent unit that operates geographically remotely and in a high risk environment. Technology including information communication technology (ICT) infrastructure is now seen to be increasingly rendering ship manager capable of holistically managing ship operations to this end. However, as noted in chapter 3, its impact in improving service performance is well below expectation. Contributing factors for this are noted to be the lack of adequate scientific approach to technology integration in the business process, in as much as lack of any lessons drawn from success in other industries that indicate large potential for optimisation for the further enhancement of performance.

Sharma (2008) concludes:

Shipping industry provides a relatively unexplored site and sample for searching for better services management practices. Its global and multinational nature coupled with technical dominance and manpower focus gives unique opportunities to explore services management from multifunctional angle. The literature within the industry is scant and industry had not generated or retained researchers over time to provide opportunity to make fundamental contribution in ship management in general and shipping services management in particular. Ship management industry in its totality integrates the art of managing HR, technical operations management, and supply chain management at global level. And therefore offers unique opportunity to compare, contrast and learn from it in managing services management (p.09).

In the wake of the above discussions, this thesis therefore seeks to answer the following question:

What are the challenges and potential of technological advancements for its application/integration in modern ship management practices?

This would typically involve examining the current ship management practices and eliciting the perceptions of the ship management team in shore based offices. At the same time, perceptions of shipboard staff involved in the operations of the ships that are geographically remotely located yet forming the productive unit for the ship management company would need to be examined. Inter-alia the experiences with the introduction of new technologies and the resulting changes in ship management and ship operation practices would need to be captured, giving due importance to the social factors of employment that underpin the shipping operations in the unique shipping industry's community of practices.

To be able to answer comprehensively the main research question, some key subsidiary questions were needed to be answered based on the discussions in the preceding chapters:

- a) What are the drivers for uptake of technology in the ship management industry?
- b) Is there any scientific approach adopted in the technology application/integration in ship management practices?
- c) How well is the human-machine interaction addressed in the application/integration of technology in ship management practices, and what are the gaps if any for it to meet the objectives of enhanced performance, safety and user satisfaction?
- d) What could be the underlying reasons for the challenges persisting yet and the tardy and decelerating progress on satisfactory technology integration in the shipping industry?

As noted in the discussions, vast potential apparently seems to exist to exploit technology to increase the added value to ship owners and managers through an increase in the efficiency in management and operation, without compromising or rather even enhancing safety and environment protection, and improving the working environment. Furthermore, as Graham (2004) notes that to apply any improvement procedure, it is first necessary to gather facts of the current system and challenge them with improvement indices in a holistic environment, hence a cautionary approach needs to be adopted taking due cognisance of the various constraints and challenges in making the system robust, reliable, secure and acceptable.

It is with these research questions that the thesis turns to the next chapter to discuss the methods of data collection and analysis. To be able to address these research questions

effectively it is important that this research took an appropriate methodological approach which is described in the next chapter.

Chapter 5: Research methodology

Introduction

The aim of the research was to study and present the challenges and potential of technology integration in ship operations and ship management and to enable to answer the research question: *What are the challenges and potential of technological advancements for its application/integration in modern ship management practices?*

On the basis of the discussions so far and the main and subsidiary research questions arrived at, a conceptual model that would be able to effectively answer these questions was formulated. This chapter enunciates the model and describes the research methods that were followed at different stages of the empirical work, while justifying the choice of research methods and the data analysis techniques.

Research being an organised endeavour, it requires proper planning of issues to be studied. To start with, a broad framework of approach needs to be planned to systematise the research work that will eliminate aimless intellectual wandering and give direction. The determination of the exact information needs through this specific focus prevents blind research and indiscriminate data gathering, thus saving the researcher from becoming lost in a welter of irrelevancies.

A qualitative, exploratory research approach with case study as strategy was considered appropriate to address the broad scope as will be adequately described in this chapter.

5.1 Strategy - Case Study

A case study is an appropriate research strategy of empirical enquiry to investigate a contemporary phenomenon within its real-life and natural context as demanded by the enquiry at hand. The focus is on in-depth understanding without involving explicit control or manipulation of variables. Case studies typically combine data collection techniques such as interviews, observation, questionnaires, and document analysis (Yin, 2009). These techniques are particularly suitable as the focus was on examining how the shore based managers and ship board staff at the two vital ends of the technical management process perceive and cope with the changing nature of work and skills as a result of the technology integration into the management and operation practices. A qualitative enquiry with such methods of research relies upon opinions, perceptions, interpretations and experience of the participants which was planned to be sought.

Benbasat *et al.* (1987) suggest that case study research is considered to be particularly useful where research and theory are at their early and formative stages. The literature review had revealed that this indeed was the case in the shipping industry. Furthermore as Gummesson (2000) comments, case study research is becoming increasingly accepted as a scientific tool in management research, particularly in areas where one wants an in-depth understanding of mechanisms of change, and one need not study a large number of cases. Hence, efforts were directed to first understand in-depth the current practices of ship management and the change experience of the technological advancements in its application/integration, followed by investigation of its optimisation potential.

Case study research is also a flexible approach and the flexibility provides for an inductive or deductive approach to theory or even an integrated one; one can focus on one case or many, can describe, explain or evaluate; and the methods used are pragmatically driven. Its use is well established in social sciences (Yin, 2009), and is most commonly applied in areas where the phenomenon of interest is complex and highly contextualised, with multiple variables unsuitable for control (Stake, 1995; Yin, 2009).

Macpherson, Brooker and Ainsworth (1999) add that case study research is capable of creating in-depth descriptions and rich understanding of social context that have relevance and resonance across sites, shore-based and ship board in this context. It also leads research participants to take a proactive role in shaping policies and to determine norms and values that direct their social practices. As envisaged this helped in finding enthusiastic engagement with the participants.

Schwandt (1997) summarises the conditions for case study research: "... a case study strategy is preferred when the inquirer seeks answers to how and why questions, when the inquirer has little control over events being studied, when the object of study is a contemporary phenomenon in a real-life context, when boundaries between the phenomenon and the context are not clear, and when it is desirable to use multiple sources of evidence" (p.13).

A disadvantage often cited is the difficulty of generalising from the single case. Simons (1996) revisits this problem in case study research and explores the paradox that is at the very heart of case study. She argues that by focusing in depth and from a holistic perspective, a case study can generate both unique and universal understandings. Flyvbjerg

(2006) examines and corrects some common misunderstandings about case study research and concludes that; (a) concrete (context-dependent) knowledge as is generated from a case study is more valuable than general theoretical (context-independent) knowledge with predictive theories and universals that do not seem to fit in the study of human affairs; (b) one can often generalise on the basis of a single case study and may be central to scientific development. Regrettably, formal generalisation is overvalued as a source of scientific development whereas “the force of example” is underestimated; (c) a case study contains no greater bias towards verification of researcher’s preconceived notions than other methods of inquiry. On the contrary, he says, “experience indicates that the case study contains a greater bias towards falsification of preconceived notions than towards verification” (p.237).

Surveys as opposed to case study are carried out generally on the conditions of the researcher. Informants have no choice but to react to the wording of the questions as they are put to them, however inadequate some of the terms may appear to them.

Likewise, subjects embarked on a classical experiment have to act within the confines set up by the researcher.

Drake, Shanks and Broadbent (1998) report that case study research is the most widely used qualitative research method in information systems research, and is well suited to understanding the interactions between information technology-related innovations and organisational contexts; which is predominantly the context in which this research undertakes to answer the research questions.

Stuart *et al.* (2002), further make a strong case for a number of case studies being of no relevance as any number would still be small. One single case study may be appropriate when it represents a critical case where it is extreme or a unique case: If this is (not) valid for this case, then it applies to all (no) cases. But it is very difficult to identify a critical case. Maaloe (2010) advocates a strategy of having more than one case study fearing that the longer one stays within an organisation the likelier one may (unknowingly) be to accept what they take for granted. Thus, at least one more supplementary site is needed, yet may not be studied in the same detail as the first. Hence for this project four case studies were selected, three of which were company settings undertaking technical management of ships in a mutually varied structure of constitution and the fourth case a set of interviews with on-board staff with sailing experience on ships of all the above three structured companies. Multiple case designs allow cross-case analysis and comparison, and the investigation of a particular phenomenon in diverse settings. Multiple cases may be selected to predict similar results or to produce contrasting results for predictable reasons (Yin, 2009). Multiple-case studies can strengthen research findings, however statistical generalisation to a population is not the goal of case study research as cases are not sampling units and rather a theoretical or analytical generalisation is appropriate (Benbasat *et al.* 1987).

With the context necessitating a strategy for an in situ in-depth methodology, which was well afforded by a case study strategy, this became the basis for careful design of the research project and defining its scope so that an appropriate unit of analysis and number of cases can be determined. The unit of analysis identifies what constitutes a case, and a complete collection of data for one study of the unit of analysis forms a single case. The unit of analysis may be an individual, a group, or an organisation (Yin, 2009). For a

thorough understanding of phenomena with respect to their presence or variance across groups or cases, a rich mix of four case studies was chosen, with specific focus on strategic selection of cases.

5.2 Selection rationale of case studies

Of the four case studies selected, the first (Case A) is an in situ examination and interaction with the management of a large third party management company that has in its basket the management of ships belonging to various ownership companies.

Third party ship management companies are defined as professional, independent organisations which, for a negotiated fee and with no shareholding ties with their clients, undertake responsibility for the management of vessels in which they have no financial stake. This sector has now been in existence for over 50 years and has evolved into an industry in its own right with a critical contribution to a fundamental restructuring of the shipping business by facilitating and promoting the division of labour between countries (Mitroussi, 2004a). The third party manager specialises in the operations involved in day-to-day running of the ship, which are tightly connected with cost control and thus with profit maximisation. The specific trends that had a positive effect on the growth of third party ship management as reviewed by Mitroussi (2004b) are: (a) the globalisation of shipping, rendering taking advantage of all the opportunities offered by the development of new, more efficient factor markets, especially the sources of manpower, (b) use of information technology with heavy investments in specialised equipment and skilled labour, (c) the quest for economies of scale, particularly in crewing and technical support, thus cost saving to owners that cannot enjoy such advantages on their own, (d) increased

legislation and difficulty to cope with the burden of stringent regulations, (e) shortage of manpower for timely supply of qualified crew, (f) increased liability in case of disastrous marine accidents and pollution, (g) provision of wide range of main and value-added services by the ship management companies.

The second case study (Case B) is a similar examination and interaction but with the management of a single ownership company that manages and operates its own ships and does not use the services of and divest managerial control to third party ship managers.

Such ship owners hold the view that cost savings and cost control in general are made possible only by retaining close relationship with the ship and its technical support. They would then hold abundant technical expertise. The commercial management of ships that directly connect to the basic income of the company like chartering are in general always retained with the owner. Mitroussi (2004b) in her empirical research lists the reasons for ship owners not using third party ship management as (a) availability of in-house expertise; (b) desire to retain overall control and personal contact with all markets and shipping organisations. Particularly noteworthy in the finding is the result shown that the lack of confidence in ship management scored low. This further establishes the justification for selecting a case A type of company as well in the study.

The third case study (Case C) has a profile completely different from that of cases A or B. Case C is a state owned company, and while fulfilling obligations for the various government departments, the company was noted to have maintained a strong presence in the international shipping business with a fleet profile of modern, young and diversified vessel types to serve different and specialised trades. The company was a profitable

commercial venture of the state. Since the company has had a track record of profitability since its inception about five decades ago, it enjoyed enhanced autonomy and delegation of powers towards capital expenditure.

Thus, while case A was that of a company undertaking the management of third party vessels, and case B was that of a company managing its own vessels; case C was a company that was partly managing its own fleet, partly that of the fleet of other government departments and was also giving out some of its own vessels to third party managers which enabled them to carry out peer review and benchmarking of its own services.

The fourth case study (Case D) comprises interviews with purposefully selected senior sailing staff who have had long sailing experience that included sailing on-board fairly modern ships that were equipped with modern technology to enable give a meaningful insight and inputs to the subject of research in context. While this would generally be the type of ships operated by the above types of business enterprises in case A, B or C, it was, for reasons explained later in the chapter, ensured that the sailing staff were not in the current employment of these companies. The on-board staffs who are at the core of operations in a shipping company would give vital input from their perspectives which may not be available from the staff ashore in the previous three cases.

To enable counter variations and obtain information about the significance of various circumstances for process activity and its outcome, the different dimensions of the case study chosen were on the nature of business operation as below:

- (a) Privately held third part ship management versus privately owned ownership company managing own business versus state owned company exercising both own as well as third party management. The structure and purpose of the three business models as elaborately described earlier in the chapter may influence the practices.
- (b) Interviews with people working on-board versus people working ashore in offices, however keeping to the market segments that appreciates the use of technology and its enabling innovation and also has the wherewithal to provide for it, yet are fraught with their own challenges of operating with new technology. Here again, the account of a shore based employer and the seafaring employee could give a biased perspective respectively on the common issues of process management that interfaces both the entities as has been highlighted in chapter four when discussing the challenges with automation and technology.

A comparative statement on the three case companies and their structure is noted below in table 3:-

	Case A	Case B	Case C
Ownership	Private	Private	Public
Type of operation	Management of Ships owned by third parties	Management of Ships owned by own company	Management of own as well as of third party ships.
Number of ships handled out of visited location	Close to 100	About half that of Case A	About three quarters of that of Case A
Types of ships handled	Tankers and General/Dry Bulk Carriers	Tankers	Tankers, Bulk carriers, Liners, Passenger , Offshore supply vessels
Total office Staff	Close to 200	About half that of Case A	About three times of Case A

Table 3: Comparative details of Case Companies A, B and C

The fourth (Case D) was mainly semi-structured interviews with ship's officers purposefully selected with rich and varied experiences on-board ships and were on leave

ashore. Given the clear division between the nautical and engineering departments on the ship and the fact that perspectives could be different in these divisions, interviews were conducted specifically with two sets of persons at the senior-most rank of Chief Engineers and Masters. Being at senior management levels on ship who direct and control the shipboard functions at its highest level and are the sole contacts for the shore based management team, they would have had a good overall management perspective balancing the shipboard operations with its various constraints and the shore-based directions, control and expectations; delivering on the ship performance that is at the core of the business enterprise function. They thus become the key informants who can also provide the *how* and *why* of what happens, selected for their first-hand knowledge about the topic of interest which is so essential for good qualitative interviews (USAID, 1996).

In choosing purposefully their profiles it was ensured that:

- (a) They were not in the current employment of any of the case companies because the employer-employee relationships in the first place and the differences fuelled by ship-shore divide as discussed in chapter four, would possibly render the responses restrained and biased.
- (b) They should either be in the employment of on-board ships or, have only recently given up on on-board duties and taken up shore based professions so that their sailing experiences were current and contemporary.
- (c) One set of Master and Chief Engineer would be relatively young bringing in the perspective of the younger generation, and the other set would be relatively senior in age

and have a long experience in sailing, who would have seen and experienced technology transformations on-board ships.

Furthermore, it was recognised and well considered that the age profile of the ships and the crew culture would have considerable impact on the findings. It was noted that all the four cases had in their experience a mix of ships with varying age profiles as well as exposure to various crew nationalities. It was ensured that the impact of both these aspects would be specifically queried during the course of interviews and data collection.

Such a strategy on the choice of the above four case studies would give enough breadth without compromising the depth of the study, and best help answer the research questions.

5.3 Profile of the four case studies

This section profiles the four case studies. It maps the ship management structure and profile of the three case companies A, B and C with particular reference to the technical management department that has the greatest bearing on the research undertaken and is the defined scope of the project. It also describes the profile of the ship's staffs in case D.

5.3.1 Case Company A

Company A was a privately held third party management company that belongs to a West European group which is in its fifth generation into shipping business. It offered highly integrated maritime services and had in its portfolio the management of a diversified and large fleet size that afforded versatility. Its infrastructure of offices is spread over many

countries around the globe that maintain operational and safety integrity over a managed fleet of more than 700 ships. It has over 17,000 employees on-board and ashore.

Its branch office, in the location visited provides the full spectrum of ship management services and solutions, including: crew recruitment, fleet management, loss prevention, new-building supervision, and safety and quality. This office employed about 200 staff and manages close to a 100 vessels. The office is headed by a CEO who had two General Managers one for the General/Dry Bulk Carrier fleet and other for the Tanker fleet reporting to him (Figure 9). The General Managers in turn had the Technical Superintendents, Marine Superintendents, Quality & Training Manager, Accounts Manager, and Crewing Manager reporting to them.

The Marine Superintendents were required to closely monitor the commercial performance of vessels and manage the commercial risks faced by their Principals during the course of employment of their vessels.

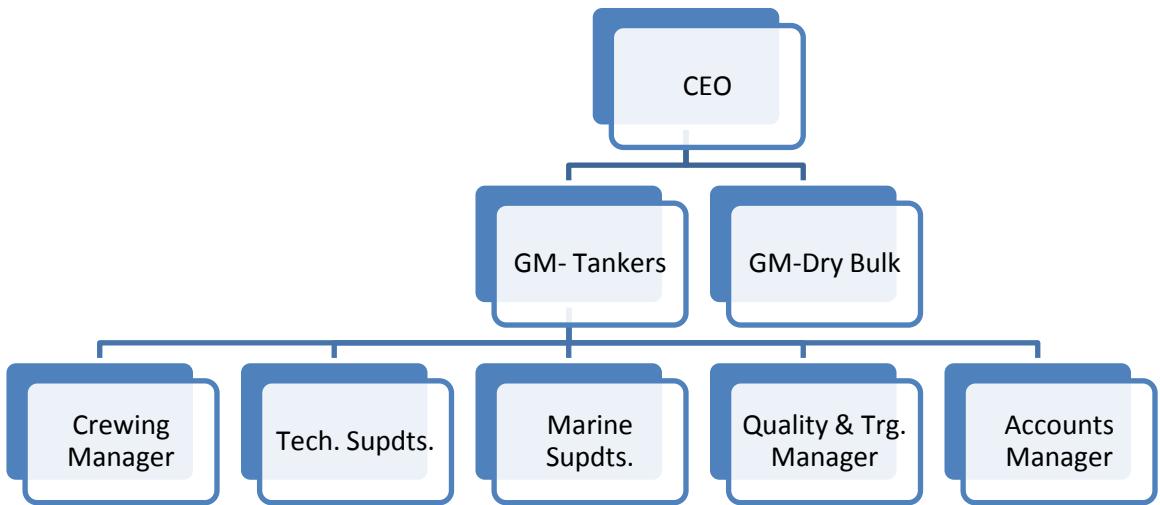


Figure 9: Organisation structure –Company A.

It was the Technical Management department directly under the supervision of Technical Superintendents that had the responsibility to ensure that all managed vessels operate in accordance with their principals' (the ship owners') requirements and also meeting optimally the design parameters. The department had to ensure that ships must at all times be complying with the requirements of the flag state where the ship was registered. They must also be complying with the requirements of the Classification Society that certifies its sea-worthiness; and additionally meet the requirements of its charterers' who paid the ship owners' for the optimum use of the vessel (Figure 10).

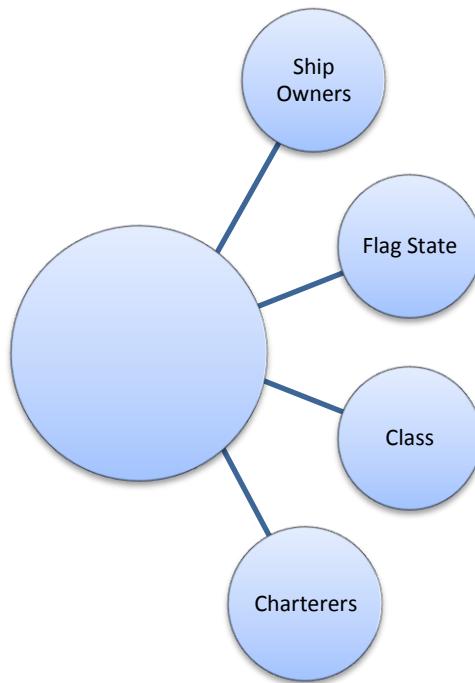


Figure 10: Compliance obligation of technical managers to stakeholder requirements.

Each set of Technical Superintendents were allocated a group of four to five vessels and were responsible for monitoring the vessels' condition and all aspects of their performance and operation, including:

- safe and efficient cargo handling and cargo conditioning.
- planned and project maintenance.
- regular condition assessment.
- dry-dock planning and supervision.
- budget control.
- certification and vetting by prospective charterers.

The department had to maintain relationships with suppliers, workshops and marine service providers to ensure that it is able to provide consistently reliable and high-quality service at the lowest possible price to its principals as part of its responsibilities.

5.3.2 Case Company B

Company B was the branch office of a privately held ship owning company based in Western Europe. This branch office carried out the crewing and technical management functions of about 50 ships owned and operated by the owners. The location afforded the advantage of equally competent skills albeit at much lower costs. The organisation structure was much the same as in case company A with a CEO heading the branch. The technical management department had two Fleet Managers dividing about 25 ships among them and each having set of Technical Superintendents handling about five to six ships. The Technical Superintendents had similar responsibilities as those of Company A. Although Company B was managing its own ships, its ship management division had to regard the head office as its principal who benchmarked the activities of this crewing and management division with that of any other established and reputed third party management organisation.

5.3.3 Case Company C

Company C is a State owned publically held limited company owning as well as managing a diversified fleet of ships including tankers, bulk carriers, general cargo ships, passenger-cum-cargo ships and off-shore supply vessels. While it managed the vessels of other government departments that depended on Company C for providing technical expertise, as a strategy to remain competitive, Company C also gave out few of its vessels to third party

ship managers to benchmark its own efficiencies. The Bulk carrier and Tanker division of this company was chosen for this research project to maintain the similar profile of vessel operation as that of Company A and B - yet provide the necessary variance of ownership structure to study if this variance mattered in the management and operation of ships operating in the similar global scenario.

While the technical management function in this division was found to have similar organisation structure as that of Company A and B, being a head office location its overall structure was in slight variance as below (Figure 11):

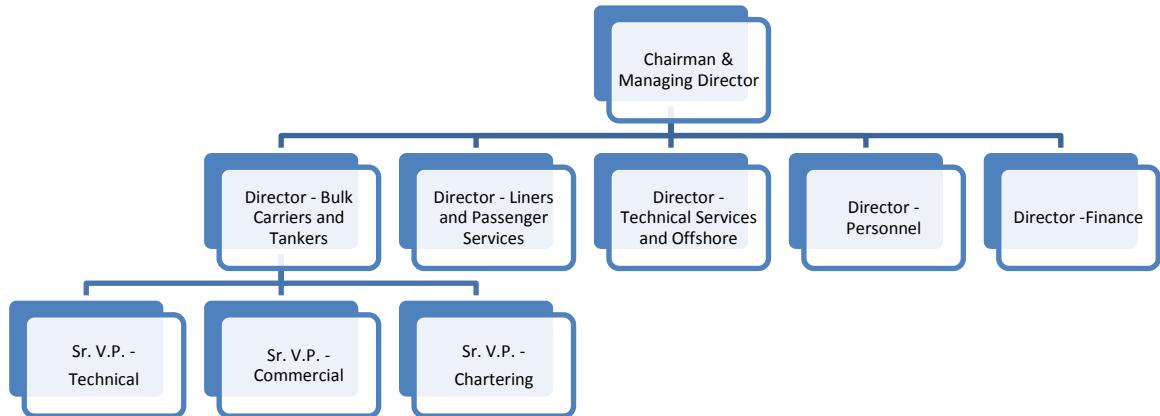


Figure 11: Organisation structure at Company C.

The difference with the previous cases were (a) the chartering function that in previous cases were handled by the head office at a different location, in this case, the head office location, the Director who was akin to the CEOs of previous cases also had to oversee the

front end chartering function, (b) his relationship with crewing, finance and quality function here were lateral rather than hierarchical.

5.3.4 Case D - Ships' staff

In accordance with the rationale explained about the methodology and profile desired of the ships staff in section 5.2, interviews were conducted with the following two Chief Engineers and two Masters:

Chief Engineer 1(CE1): A relatively young gentleman, who had served right through on all types of ships including bulk carriers and tankers owned by a major West European owner and only recently shifted to another major container ship owner of North America region, who charter their ships out to big liner service companies. He keenly pursues academic interests and has registered for part time doctoral research that keeps his analytical mind alert and open to developments giving him a wider and deeper perspective of the industry functioning.

Chief Engineer 2 (CE2): A faculty member at a maritime university who is very senior on age and with long experience at sea. He has just given up sailing and for last few years of his sailing career he had been sailing on the very modern tanker and container fleet of South Asia based owners. He too pursues his doctoral research in offshore wind energy and is easily regarded as most knowledgeable and learned faculty among his peers.

Captain 1(M1): A young Master, who is sailing on the modern tanker fleet of an Oil Major company from Western Europe. He has had the recent opportunity to actually experience some modern ICT technology as well as automated machinery operations. The company is

well known for its high levels of safety consciousness and modern processes in tanker operations and an exposure to such systems makes him well suited for giving the needed perspective.

Captain 2 (M2): A senior Master who until very recently, has been sailing with tanker owner companies in the South Asia region. More importantly, he holds a senior position at a renowned international professional association and interacts at global policy making level on technology applications. Such a combination of active sailing and representing the user (seafarer) interests into technology integration conceptualisation at global policy level who is privy to such proceedings is very rare to come by easily.

5.4 Data collection - an overview

Figure 12 below depicts the Explorative Integrative form of case study approach that was adopted in this project.

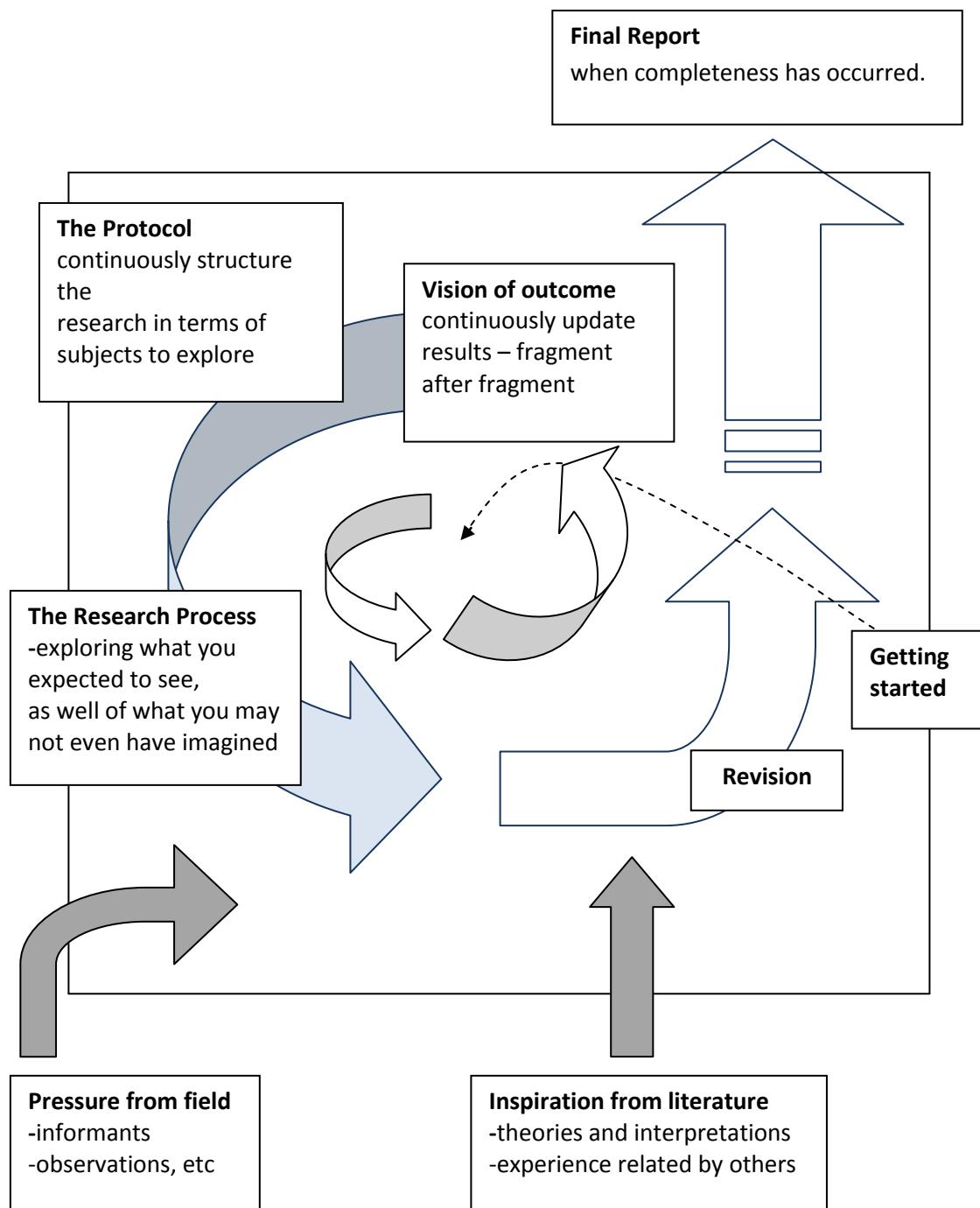


Figure 12: Explorative Integration as process. Source: Maaloe, (2010).

Explorative integration embraces both theory-driven research and an explanatory bottom up approach. It is an inherently cyclic design of several phases, explanatory, explorative, interpretative and understanding. As analytical endeavour it aims at generating facts in the field in order to create an integrative view of the case (Maaloe, 2010).

The practice of theory test that embraces top-down approach and typically works within the explanatory mode, often has too much invested in the belief, thus contra evidence is either brushed away as irrelevant or simply explained away. It excludes identification of relevance of events of dimension outside the theories initially embarked upon. Also, because of the uncertainties and impossibility to control the environment, theory testing remains a researcher-controlled affair and it is up to the case designer to determine what and how to measure, sticking to initially chosen theories. However, some features of this approach are incorporated in explorative integration as cases are excellent media to test mini-level theories, example validity of rival theories, and evaluating minute generalisations (Yin, 2009). Chapter 3 had provided the theory base for test in this research project highlighting the skilling dilemma and the trinity view of technology-organisation-process integration. Falsification that forms part of critical reflexivity is one of the most rigorous tests to which a scientific proposition can be subjected to (Flyvbjerg, 2006).

Grounded theory on the other hand emphasises internal validity with greater rigour. Being a bottom-up approach which may result in explanatory format, it is yet nested within the interpretive mode making sense of observances and interviews as text. The researcher thus can be more faithful to his data, rather than forcing it to fit a theory. Research becomes an explorative venture of discovery rather than one of verification (Glaser and Strauss, 1967).

However, grounded theory may not move much beyond the entity under study, as the investigation is grounded in the local, and so may be the theories derived from it. There is also the assumption of non-bias, and that the data from which the hypotheses emerge are indisputable. Corbin & Strauss (2007) amply demonstrate that intentionally or unintentionally we cannot help attributing meaning to what we see.

Explorative integration encourages the researcher to be able to question one's abilities as an observer and be able to play with different interpretations in situ. It facilitates a way both to explore reality and to test one's own initial assumption about it. It advises to approach the field with full awareness of preconceived ideas from theories or experience while consciously recognising how others may still be hidden from us. Thus the study is explicitly set up as a continued cyclic of tentative integrated drafts, nurtured by exploration of the field and the awareness of the people involved. Integration helps to identify biases, as well as benefit from them; and also identifies gaps due to lack of coherence between statements and thus issues which still need to be explored. Thus the main feature of the explorative-integrative choice of approach is an effort to sensitise us to question the limits of our own theoretical foundation and personal bias.

After several interchanges of phases of draft and continued fieldwork, a sense of wholeness to the research outcome occurs leading to the final report (Figure 13). Thus the explorative-integrative method is the cyclic integration of three approaches: deduction and theory testing, induction and theory building and the hermeneutics¹⁷ of creating a sense of wholeness (Maaloe, 2010).

¹⁷ the study of theory and practice of interpretations

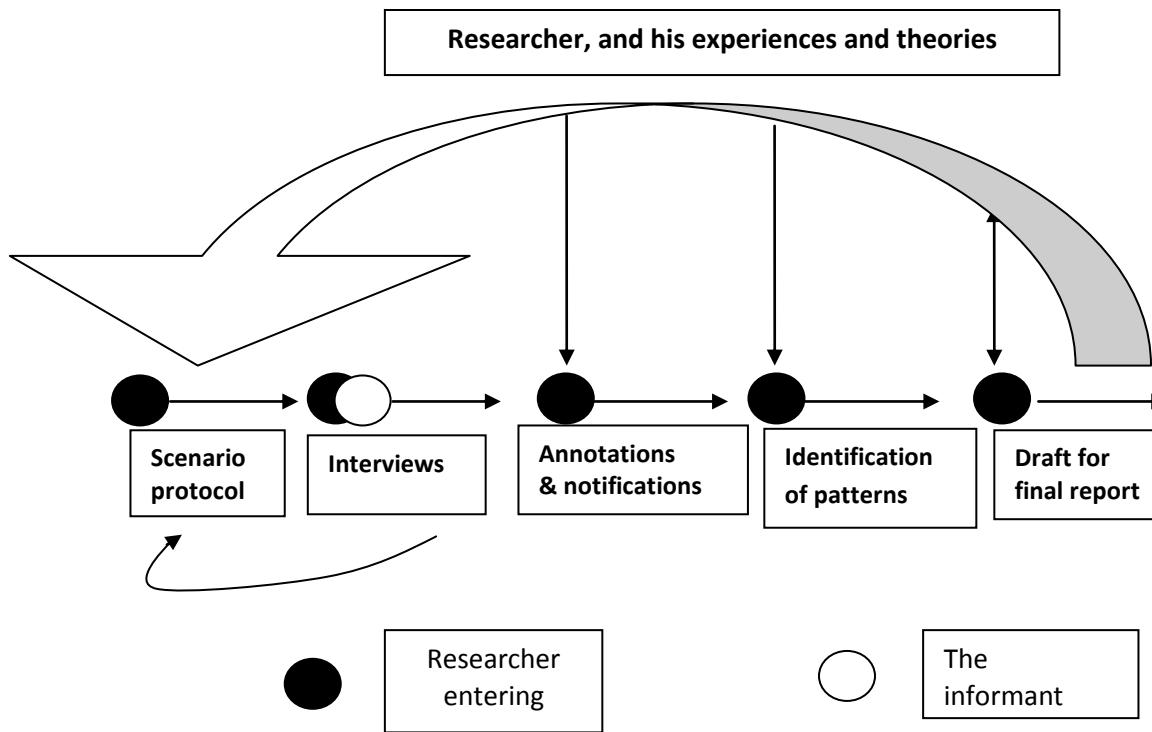


Figure 13: Researcher and his experiences and theories. Source: Maaloe,(2010).

5.4.1 Pre-visit preparations

Effective and efficient data collection for case study research requires careful planning and judicious use of both the case participants' and the researcher's time (Drake, Shanks and Broadbent, 1998). Preparations before on-site visits included understanding as much about the case companies as possible beforehand and developing a list of themes to be explored with prioritisation along a scale from 'need to know' to 'nice to know more about'.

Access is a main issue for the researcher (Gumesson, 2000). It was borne in mind that research questions indeed need to be interesting and important to the potential participants to gain their support. If the research is particularly relevant to an organisation and the

specific research question is one which the organisation needs or wishes to address, then it becomes more likely that they would provide access to their people and resources. It also takes a long time to create a reasonably open working relationship with staff to gain sufficient insight into a company's situation. With these preparatory cautions contact was established with the CEOs of companies in cases A and B, and with the Director (Bulk Carriers & Tankers) of case C (access letter format annexed as Appendix 6). A specific initial visit was made to the three case companies for this purpose. Appendix 5 details the timetable of all site visits. At the initial visit the CEOs called in the heads of technical departments for this meeting. The prime purpose of the study was explained to them as being purely academic in nature and that confidentiality and strict adherence to the basic ethics of research would be always maintained. It was also put to them that the process would give an opportunity for the staff to have a relook at the management practices which in itself would be value-adding to the organisation. Organisations need to be clear about the research outcomes and how their organisations would benefit from involvement. Reassured, they then readily agreed to render full cooperation. Thus gaining of their trust and acceptance by them paved the way for smooth data collection.

5.5 Interviews

Interviews are essential sources of information for case study research and are arguably the primary data source, as it is through interviews that researchers can best access case participants' views. Kvale (1996) describes the qualitative research interview as a conversation with a structure and purpose. Meeting people leads to conversations giving

insights and new understandings and it is possible that both researcher and informant may change when reflecting over what has previously been seen as obvious.

5.5.1 Semi - structured interviews

Individual semi-structured interviews were held with select staff in the three case companies as well as the ships' staff of case D. For the major part single face-to-face interviews were conducted that are characterised by synchronous communication, the answers are spontaneous and without an extended reflection. E-mails were followed up for any additional data missed out or specifically for situations needing to allow them more time to respond to the developing dialogue (Opdenakker, 2006). Considerable preparations had preceded these sessions including identification of the respondent population who were recognised as process experts and had a range of process management responsibilities. This was done at the initial on-site visit to the companies at the meetings with the CEO and General Manager - technical management. The timetable of the various interviews and site visits performed is annexed as Appendix 5 to the thesis. At the three case companies A, B and C typically participants from the technical department as well as the operations functions were requested. For instance, in company A, participants included the General Manager in-charge of Tankers, one Technical Superintendent, one Marine Superintendent, the Quality and Training Manager and the Technical Assistant. At company B, being smaller the CEO himself participated along with one Fleet Manager and his Technical Assistant. At company C, the Director responsible for Bulk Carrier and Tankers operation, Senior Vice President –Technical and Senior Vice President – Commercial were the participants. The interviews were followed up with the scrutiny of documents and records. Flow charts as graphic elicitation technique further assisted in understanding of the

processes. These are annexed as Appendix 1 to Appendix 4 which also served to get the respondents' confirmation on correct understanding. Copeland (2012) suggests graphic elicitation techniques are particularly useful in helping participants to express complex or abstract ideas and can greatly supplement interview data. It provides visual data representing personal understanding of concepts, experiences and beliefs and can be highly useful in qualitative research studies. Case D selected ship staff were also engaged in semi-structured interviews and followed up on e-mails.

With specific reference to semi-structured interviews the main advantages include effective time management and the fact that they are "structured" enough to provide a reasonably defined scope of exploration but "open" enough to allow a reasonable depth and breadth of exploration of the set topic (Denzin and Lincoln, 2007).

In a semi-structured interview, a thematic guide (see Appendix 7) was used as framework, allowing for flexibility to probe for details or further discuss issues (Williamson, 2002). Since the questions follow the flow of the informant rather than being asked in the order of the guide, it calls for being flexible and sensitive to the informant. By using semi-structured interviews, it is feasible to compare the answers from several interviews and, to a certain extent, make some generalisations.

After careful assessment of the other qualitative interview approaches, including in-depth and structured, the semi-structured interview offered the best option considering the need to balance reasonable structure and substantial flexibility.

The fieldwork was guided by the explorative method. The protocol served as a guide and not to confirm notions. After each interview the interviewees were asked if they were surprised that something was not asked or if they had something of greater importance for the researcher to be aware of. Analysis of interviews and observations, ranging from brief and ad hoc to exhaustive depending on the scenario, as a preparation for the next activity was always adopted, whether it was the next set of interviews or analysis of documents or sightings of records; thus each analysis serving as cross reference and even confirmation of work-in-progress with the company. The strategy adopted was to listen and let one be guided by the field as well as the interviewer's own reflections, thus making a tight-knitted web of cross interrelated well-substantiated facts and not merely stumbling around and waiting for something to turn up or be just satisfied to get the interviewee to talk.

Cautions in the process of interviewing were exercised, for example reading of the body language, noticing indications of tensions between what is said and what is expressed but not openly said, handling second hand information, etc. Furthermore, interviews were kept objective and not emotional.

Interviews were carried out in the small conference rooms and were digitally recorded with the permission of the participants. Also copious contemporaneous notes were taken of salient points noted during the interviews. There were only two instances when the interviews with the Technical Assistant in company A wished that it not be recorded, in which case notes were expanded immediately after the interview. Each interview lasted between forty five and ninety minutes. Posing open questions helped in the respondents being articulate and expansive in responses and shared their experiences, opinions and

views comfortably. It probably gave them an opportunity to reflect on their work process objectively which rarely comes by in the din of their daily routines, thus providing a therapeutic effect. The participants reflected that the whole exercise was found to be very value-adding to them. The subject was also contemporary and pertinent with issues that they themselves had been grappling with.

In the three case companies a total of three rounds of interviews each were conducted over a period of 12 months. The beginning was made with group interview as explained in the next section and this was followed with individual interviews with the same participants. The site visits to the three companies were made with a gap of approximately three months. This gave the opportunity to first understand the macro-level processes and slowly get down to micros of the processes and the interlaced issues with intervening time to reflect, assess, analyse, and validate the understandings on the next rounds of interviews and document scrutiny. Similar methodology was followed in an earlier case by Lyridis *et al.* (2005) as reported in the summary section of chapter 3. It also afforded the understanding of practices as they varied and matched amongst the three companies with different profiles.

With the carefully selected four ships staff in case D, only one round of interview was possible given their availability on leave; however the follow up was maintained on e-mail correspondence which proved effective as it gave them enough time to reflect on the enquiry and come up with responses.

5.5.2 Group interviews

As a support to the individual interviews in the company settings, ‘group’ meetings were used to commence the proceedings. This is because an understanding had to be obtained of various practices and processes that happen in an organisation, and in the delivery of process there is common interest and interactions that take place among individuals. Many researchers use group interviews as a means to generate information at the outset of the inquiry or to complement and support other data collection methods (Crabtree and Miller, 1999). This technique encouraged greater honesty, spontaneity, involvement and thoroughness of responses. It provided a situation for interaction among the participants who stimulate each other, discuss insights and experiences, comment or elaborate on the views expressed by previous speakers. It is also known that a group lowers respondents’ anxiety and provides a more comfortable setting (Kerr *et al.* 2000). Thus, while understanding of processes that involve many individuals cutting across departments greatly helped me in preparing further for personal interviews, it also helped the participants break ice with me and were more relaxed, cooperative and forthcoming in the individual interviews that followed. A comfortable environment was made available in a mid-sized conference room with as much of round table seating as possible. The basic objectives of the meeting were first explained.

The researcher assumed the role of the moderator exercising mild unobtrusive control. Checklists (Appendix 7), served as an aide memoire in framing suitable questions and keeping to the topic (Krueger and Casey, 2000). To support the interview and to triangulate the responses, the meeting was followed up with sighting of all records and documents which was assisted by the junior support staff. A one to one interview with the junior

support staff, with the prior permission of the seniors, was also conducted to gain more insight into the workings of the department not in the presence of his superiors. This is to overcome the perceived drawback of group interviews in which respondents may respond to please other members particularly seniors of the group. The documents and textual procedures manual as well as the records listed were sighted along with the actions taken by the company on reporting from the ships. A rough flow chart of processes was drawn out with inputs, outputs and interactions as a way of summarising and interpreting the content of group discussions. The group was thanked for their participation, and their cooperation sought for further interactions individually.

5.6 Data interpretation, analysis and synthesis

As expected, gradually as the project progressed and became increasingly focused on certain issues, the first outline of emerging outcomes began to take shape as one also begins to know of what is still missing.

Stake (1995) points out that there is no particular moment when data analysis begins and that analysis is a matter of giving meaning to first impressions as well as final completion. Case study relies on both direct interpretation of individual instances or categorical aggregation of instances until something can be said about them as a theme. Analysis of qualitative data is not purely an activity that happens on a conscious level after the data collection phase, but occurs also on an unconscious level throughout the research (Williamson, 2002). The conscious level of analysis and interpreting data is a process to bring structure, order and meaning to the data. Although techniques for analysing qualitative data vary with methods, theoretical positions or topic areas, three elements are

central: (a) a detailed description of the data, (b) the systematisation, reduction and categorisation of the data, and (c) the linking and connecting of the data to look for meanings and causes.

Furthermore, Miles and Huberman (1994) describe data analysis as consisting of three concurrent activities. (a) Data reduction refers to the process of selecting, simplifying, abstracting, and transforming the raw case data. (b) Data display refers to the organised assembly of information to enable the drawing of conclusions. (c) Conclusion drawing/verification involves drawing meaning from data and building a logical chain of evidence.

Every analysis requires a subsequent and complementing synthesis in order to verify and correct its results. Synthesis is generally defined as the opposite process to analysis and signifies a combination of the separate elements or components in order to form a coherent whole (Ritchey, 1991).

A general data analysis strategy as part of case design was formulated to indicate what to analyse and why, and to ensure data collection activities were appropriate and that would support the ways in which the evidence was to be analysed.

All interviews were transcribed for the purpose of analysis. Though time-consuming in spite of digital files allowing for data to be retrieved and examined in a more flexible manner (Tessier, 2012), it was comprehensive. Dissected and selected units from the interview transcript were assigned to the respective categories of themes and concepts. Although the initial orientation of empirical investigation was influenced by the theoretical framework based on literature review, the emerging themes of empirical findings were not

overlooked. Newer literature and theories offering fresh perspective were reviewed and tested against the findings at various stages. For example the domineering and defining influence of regulation and non-tariff trade barriers on the industry practices was one such area not estimated earlier. Cross-thematic examination and analysis in order to establish links and patterns of meaning was conducted (Corbin and Strauss, 2007). Similarities, meanings, inconsistencies and variances were also examined, for example in the group meetings at the companies, what the document and records analysis showed up and what the technical assistant stated in his single interview. Typically, the Technical Manager in the group says that preference is given to quality over price in purchasing products; however, the random selection of a record on receiving inspection of an electrical relay by the ship noted “Sparks flew off when the relay was tried out in the machinery”. On examining the tendering process for supply of the relay it was noted that out of the three quotes received, order was placed for the cheapest product, and the technical assistant confessing that unless known, it was really the price that mattered as long as the ship specified specifications were met.

It was thus also possible to analyse and compare what the companies said about certain themes and how the shipboard staff statements corroborated or contradicted the opinions. For example, on the subject of ship-shore interface while the companies asserted their endeavours on a “not them and us attitude”, the shipboard staff experiences were found to be not encouraging. Similarly when it came to the issue of reduction of crew due to proliferation of technology, the companies seemed to be guided by the economic constraint whereas the ship staff evaluated and decried it on compromising of safety.

Links between categories were identified, cross-referenced, and verified against the data before integrating the categories. For example, the companies when highlighting issues of technology integration touched upon themes of reduced crewing costs, ease of communication rendering detailed monitoring, and skill erosion. Such response could be grouped into at least three different categories such as economic pressures, domineering role of shore managers exacerbating the ship-shore divide and skilling issues. The use of special purpose software tools that are available with facilities for storage, indexing and analysis of qualitative data was considered but as Tessier (2012) comments these are still difficult to use, time consuming and not user-friendly. In view of familiarity with the standard Microsoft Excel program to manage data, the same was used. Also, the data analysis methodology was not the extensive coding and theoretical development but was interpretive data analysis for which data reduction and data display was crucial (Miles and Huberman, 1994). All the information from different sources of field notes, transcripts and recordings could be juxtaposed, corroborated and cross-examined easily. However, as Seidman (2006) notes, it is the craftsman skills of the researcher which counts more than any software when working with qualitative information as the latter is only a tool and an aide to the effort.

Tentative descriptions of findings were checked again at various stages to ascertain whether they represented the correct picture, and further adjustments made to the findings. For example, the macro-level processes that are annexed to this thesis as appendices 1 to 4 were modelled off-site in between on-site visits with the help of transcribed interviews and field notes. These were verified with the respondents on the next on-site visit. Appendix 5 shows the timetable of when the various interviews were conducted. It is important to produce the

researcher's propositional generalisation (assertions) to the respondents who know the case better and modify the generalisation. Thus data collection and data analysis overlapped allowing flexibility in data collection procedures and remaining open to new ideas or patterns which emerge (Miles and Huberman, 1994).

Multiple sources of evidence (triangulation of data) from the single and group interviews for the four case studies and document analysis strengthened the convergence of information providing multiple measures of the same phenomenon (Yin, 2009) and corroborating the information from different sources where there are conflicting accounts of events and actions. It also helped in counteracting the bias if any that may have been introduced by the researcher himself in the collection and analysis of data (Miles and Huberman, 1994). Confirmability is an important criterion to establish trustworthiness in research which is the degree of neutrality or the extent to which findings of study are shaped by the respondents and not researcher bias, motivation or interest (Lincoln and Guba, 1985). Throughout the research process the researcher has been aware of this and employed self-reflexivity and transparency as two valuable means towards sincerity in this qualitative research to achieve confirmability (Tracy, 2010).

The final picture thus slowly emerged with revisions and updated scenarios. This was facilitated by the 3 stage site visits and interviews with the cases, each following visit and interview commencing with confirmation of previous data and its correct understanding and analysis.

The change from analysis to synthesis was an iterative process with the direction of the process moving towards a creation of entirety and the fulfilment of the research purpose.

5.7 Paradigm – the basis of research

This research is based on the post-positivistic paradigm by Guba (1990).

The paradigm, which is the basic set of beliefs that guides actions in connection with a disciplined inquiry, is characterised by the responses to ontological, epistemological and methodological questions. These are the starting points that determine what inquiry is and how it is practiced. Positivism is rooted in “realist” ontology, which then constrains to practice in “objectivist epistemology” and adopt “empirical experimentalistic” methodology.

Post-positivism emerged as the modified version of conventional positivism that had its critic in inquiry bias and nature’s propensity to confound. However, prediction and control continue to be the aim. Ontologically post positivism moves from “naive” realist posture to “critical realism”, though realism remains the central concept. Epistemologically, post positivist counsels a modified objectivity, recognising that objectivity cannot be achieved in an absolute sense; and one strives to “come clean” on one’s own predispositions, so that the reader can make whatever adjustments to proffered interpretations by relying on “critical traditions”. Methodologically, emphasis is then placed on “critical multiplism”, thus relying on many different sources, which makes it less likely that distorted interpretations will be made at the same time redressing the imbalances that emerge from zeal for achieving realistic and objective inquiry by undertaking inquiry in more natural settings and using more qualitative methods while reintroducing discovery in the inquiry process (Guba, 1990).

Thus in post-positivist research, truth is constructed through dialogue on issues raised during interviews, participants' reactions and researcher's own interpretations of these interwoven ideas (Ryan, 2006).

Post positivism differentiates from interpretivism in the following way as we examine these perspectives on issues related to social scientific knowledge accumulation. In the conventional enquiry framework, theories are developed, tested, and refined through empirical research and the results take the form of generalised theoretical prepositions. While post positivism adjusts the conventional framework by embracing a social engineering view of role and purpose of science, interpretivism seeks not to adjust but replace this conventional framework. Interpretivist knowledge comprises the reconstruction of intersubjective meanings, the interpretive understanding of the meanings humans construct in a given context and how these meanings interrelate to form a whole. The interpretivist approach is based on an ontology in which reality is subjective. Thus any given interpretive reconstruct is idiographic, time-and-place bound; multiple reconstructs are pluralistic, divergent, and even conflictual. Hence, interpretivist knowledge resembles more a context-specific working hypothesis than generalisable prepositions warranting certainty or even probability (Greene, 1990). The evidence generated by interpretive research is much more likely to be of an evocative rather than a comprehensive kind, to be sustained, rejected or refined through future studies. The conclusions of one study merely provides a starting point in a continuing cycle of inquiry which may or may not over time serve to generate persuasive patterns of data from which further conclusions can be drawn (Morgan, 1983). Post-positivism's empirical quest for knowledge emphasises replicability across heterogeneous populations, settings, times, perspectives and deductive, critical

refutation. Scientific generalisations gain warrant only through such replication and criticism.

Gumesson (2000) affirms that in qualitative research it is important to account for the researcher's pre-understanding such as experience, knowledge and insights into particular problem areas and implies a certain attitude and commitment on the part of the researcher. This position is consistent with the character of social engineering in post positivism where the social scientist's main job is to participate in the community where his participation is marked by his own values and theoretical predispositions thereby generating a critical but not a normative warrant for the community's collective product of theory (Greene, 1990). Relevant experiences, beliefs and values that have shaped the author emanates from work experiences of more than fifteen years at sea in the nautical department including five years in command of ships. Subsequent shore job involvement in developing, implementing and auditing management systems related to quality, safety, environment, occupational health and social accountability for various shipping and non-shipping organisations for over ten years, enriched understandings of organisation management and its improvement. It also gave the opportunity for understanding how people construct and maintain perceptions of the world. Investigating one's own epistemologies and understanding how they affect one as a researcher is an essential part of the post-positivist approach (Ryan, 2006). Caution has been however exercised, in maintaining the role of an academic researcher and not to drift into a management consultancy mode (Gumesson, 2000).

5.8 Ethical considerations

Before commencing fieldwork at a case study site, it is essential to reach an agreement with the participating organisation concerning the confidentiality requirements relating to the case study data and findings, and any limitations on the disclosure of the identities of the case study participants and the organisation. Trust, integrity, confidentiality and discretion being essential to fieldwork, this was reiterated upon and assured. Data protection rules and research ethics policy of the university were adhered to. Ethical principles of informed consent, openness and honesty, right to withdraw and debriefing were meticulously followed. Every interview was preceded with clear definition of the objective, assurance on confidentiality and anonymity of the data. Before switching on the voice recorder the consent of the participants to the interview as well as to its being recorded was obtained. It was ensured that all the participants had a clear idea of what the research was about and how the data obtained will be handled and used. Before sighting the documents and records in the company settings, explicit prior permission was obtained from the person responsible for the process that generated the record. In case D which involved interviews with seafarers, the issue of anonymity and confidentiality becomes crucial because of their vulnerable position as employees and subordinate to the staff ashore. This was one of the main reasons besides solicitation of objective and unbiased views that the respondents chosen were not in the current employment of the case companies. They were also accorded the right to refuse participation if they wished to, at any time during the interview. The guidelines of the British Sociological Association (BSA) Ethical Procedures (BSA, 2002) and that of the Social Research Association (SRA) Ethical Guidelines (SRA, 2003)

were relied upon for the discharge of responsibility concerning ethics towards the participants, sources, data, and the affiliating institution.

In the case of the chosen case companies too, anonymity and confidentiality were of prime importance and caution had to be exercised in view of challenges of (a) headquarters of the companies in cases A and B that formulates policy decisions were being located remotely, and in that sense the employees at branch offices were subordinate to controlling head offices; (b) all companies being very sensitive to their corporate identity and image and the catching of public attention they can easily be vulnerable to.

Furthermore, protection against distortion and misrepresentation of data and intent gathered was ensured by always summarising the understandings and outcomes with the interviewed personnel.

The next chapter presents the findings of the fieldwork and also analyses and synthesises the findings based on information acquired from verbal and non-verbal dialogues and texts of written and spoken words as well as body language during interviews. The gained understanding from each research activity and empirical knowledge has been reflected upon using multiple levels of abstraction during the research process. Each individual study has contributed in the search for an understanding of the overall principle on how the parts interplay.

Chapter 6: The data: Challenges and potential of technology integration in modern ship management practices

Introduction

The research questions direct the project to explore the issues involved in the uptake of technology and its integration in the ship operation and management processes and practices - the challenges and shortfalls yet experienced, and, the potential that may exist towards further optimisation. As identified in earlier chapters, since technical management practices form the core of ship operations and ship management greatly influencing the vital ship-shore interface, the enquiry is scoped around this vital process.

In this chapter, data is presented, first on the technical management processes and later on the experiences with technology uptake and its integration from the perspective of both the ship managers ashore and ship operators on-board. The summary to the chapter synthesises the data and draws some key findings.

6.1 Technical management process

It was imperative to first fully understand the processes and practices constituting the technical management of ships.

The following were identified to be the core management processes and depicted sequentially in figure 14:

- Budgeting for vessel operations

- Maintenance of ships including supplies of spares and stores
- Certification and surveys, compliance requirements of Class and Flag
- Inspection and monitoring of vessel's performance

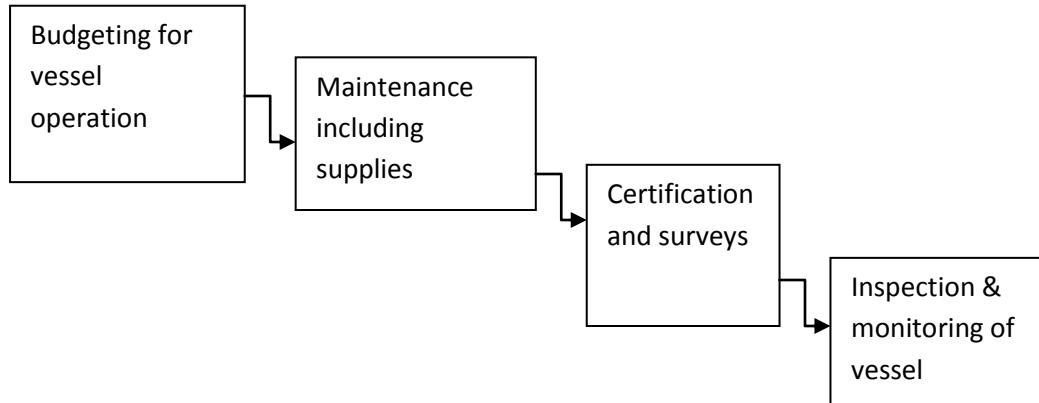


Figure 14: Technical management functions at macro level.

The detailed modelling of the above macro level processes was done off-site with the help of copious notes taken and data collected during the on-site visits. These are annexed to the thesis from Appendix 1 to Appendix 4.

The only variance of some significance noted among the three case companies was that while the process of 'budgeting for vessel operation' was done in all three case companies, company A being a third party management company additionally undertook an activity of risk assessment and checking out on the credentials of the ship owner before accepting the vessel for its management. This is not the case with company B being managers of their

own ships. Case company C too did not need to undertake this as it too was managing its own ships or at best those of other government departments. Again, while this process for company A formed the basis for negotiation of management fees with the ship owner, in the case of company B it was also done as more of an internal financial exercise and also served as its efficiency benchmark for its division. Company C too undertook the process for similar reasons and also to prescribe its management fee to other government department ship owners.

Notable was the view expressed across the companies that financial analysis and budget variance reporting are some key roles performed. As the technical management contracts are almost always on cost-plus basis, it was crucial to estimate accurately and perform closely. A manager from company A said:

Much in excess is not liked, so also, much lesser is not liked. Owners claim that managers have then not maintained the vessel well enough. (Company A)

This practice also was corroborated by the ship's staff and with appreciation. One of them, for instance, said:

Good companies like ours also questioned when the allocated budgets had not been spent out fully, leaving a doubt about adequate maintenance and upkeep of the asset. (CE1)

Commenting on the process of 'maintenance of ships including supplies of spares and stores', the ship's staff more-or-less agreed with the process at macro levels and commented that the planned maintenance system (PMS) may slightly vary in formats but essentially they met the same objectives.

They were also found to be appreciative of the companies being very prompt in supplies of spares and stores. One interviewee said:

The olden days of fifty % sanctions and lowest quotation supplies by Superintendents, is thankfully over. It was a good sign to see the Superintendents attach value to our requisitions. (CE2)

The changes in the management processes involving ship-shore interface over the period of time as experienced by Chief Engineer 2 come out strongly here, highlighting an increased sense of support from their counterparts ashore.

It can also be inferred that companies are now beginning to redefine their role appropriately of providing all shore based support for the ship to perform optimally.

On the process of ‘certification and surveys, compliance requirements of Class and Flag’, the ship’s staff agreed that this process is mapped adequately. They also commented that this was followed meticulously by all companies, given the importance attached to it and understood so by both the ship and shore staff. The consequences of non-compliance at any time may mean detention and delays, which was not only a revenue loss but also a credibility issue as well, which better companies could ill-afford.

The process of ‘inspection and monitoring of vessel’s performance’ was one area which came out to be the contentious one from the view of the ship’s staff, although generally being agreed that that was how the practices presently existed. They lamented that this process involved much paperwork, reports to be sent and demanded lots of their time. They even wondered what the efficacy of such exhaustive reporting was, and felt that this was one area where a large scope for rationalisation existed.

Chief Engineer 1 was able to show the reports on his personal computer that were part of their reporting to the Technical Managers ashore. This was matched with those of the case companies and found to be more-or-less consistent.

Captain 1 who had the experience on the most modern ships among the four interviewees of case D, also showed the reports from his computer, and this listing was decidedly much less than the one shown by Chief Engineer 1. As a result Captain 1 himself had experienced far more ease on this ship where the process was much rationalised and automated, rendering minimal reporting. His (M1) comment, “This ship is possibly the most modern in terms of technology and automation existent in the world today...,” illustrated the point.

In the understanding of the contemporary processes and practices of technical management what seemed to emerge was that:

- (a) The practices at macro levels were (i) closely conforming to the conceptualisations of the literature review in section 2.3 and (ii) fairly consistent across the types of companies, be it a third party management or ownership company and again whether it was privately owned or state owned. The ship's staff had in their sailing experience, been in the employment of all three above types of companies which made their experience accounting as much richer.
- (b) The respondents had experienced an overall improvement in the practices over time which did result in some areas of better ship-shore interface including shore based support.
- (c) Gaps however still seemed to exist, indicating much need for optimisation of the crucial ship-shore interface, for example, none of the shipboard staff could comment much on the

process of ‘budgeting for vessel operation’ as in their opinion this was a totally shore based activity and rarely if ever they were consulted on such issues. However they always seemed to come under pressure when the superintendents’ budgets started running in excess, as one Chief Engineer remarked:

The lack of experience shows up on some of these young superintendents who budget wrongly and then we have to suffer for their erroneous judgments. (CE2)

The alienation of shipboard staff from this vital management process in as much as lack of sea experience affecting competency of shore based superintendents is noticed.

(d) With regard to the paperwork involved in the ship-shore interface of the technical management process, only the form seemed to have changed from hard copy to soft copy enabling quicker transmission of data, but large scope seemed to exist in its rationalisation and also for better integration of technology as seen by the experience on a relatively modern ship.

Armed with the updated understanding of contemporary technical management process at its macro levels, the discussion now moves to upfront identifying what drivers are there for the industry to uptake and integrate technology in its technical management processes. It draws on the data captured from both the seafarers and the shore-based personnel.

6.2 Drivers for uptake of technology in the technical management process

Chapter 2 discussed the technology induction in ship operations and management. While acknowledging the inevitability of technological advancements it traced its uptake in shipping. It identified the drivers to be (a) new regulations in the aid of enhancement of

safety and environment protection and (b) the need to be competitive. However, the economic logic of low costs seemed to underpin every technology change decision, be it a reactive compliance ideology or a more proactive stance of value creation in enabling vessel operation to be more efficient. Additionally, the cyclical nature of shipping business and its volatility appeared to make the technology change decisions more difficult.

Empirical findings from this study also revealed that competitive performance efficiency and compliance with regulation for safety and environment protection were the themes that came out prominently from the companies as well as the seafaring staff. However, additionally from the data what emerged were the increasing pressures of the customers of the business that was pushing the agenda of better performance on safety and environment protection as well as on efficiency, possibly also enabled through technological advancements that aided in closer monitoring of ships by them. The ship's staffs were seen to be more candid in expressing this sentiment as noted by Chief Engineer 1 who said:

Customer pressure is the best pressure and if the oil majors for example make such focus into non-tariff trade barriers then where is the escape route for the companies? (CE1)

Again, the cost-efficiency of the technology itself was seen to be a critical deciding factor even as its inevitability was acknowledged by the managers in company B and C. They categorically pointed to the benefit of technology usage in their interviews. Two of the officers, for instance, said:

There are expectations that the industry will be ever greener, ever safer and ever more efficient and it is the role of innovative shipping company to satisfy them all and at the same time to remain economically viable. (Company B)

Whenever automation can be shown to give greatly improved safety and environmental protection at an affordable cost there will be inevitable pressure for its introduction. (Company C)

It has indeed been seen from the initiatives at the IMO such as that of a new chapter adopted in the MARPOL (International Convention for the Prevention of Pollution from Ships) Annex VI that includes a package of mandatory *technical* and *operational* measures to reduce Green House Gases (GHG) emissions from international shipping, with the aim of improving the energy efficiency for ships through improved design and propulsion techniques, as well as through improved operational practices. The Second IMO GHG Study (IMO, 2009) while estimating that international shipping would have contributed 2.7% of the global CO₂ emissions in 2007, emphasises that by together implementing the technical and operational measures even cost-effectively, it could be possible to increase the efficiency and reduce the emissions rate by 25% to 75% below current levels.

Furthermore, IMO adopts a flag-neutral system on the principle of a ‘level-playing field’ in international shipping given its nature of ship owners flagging out their ships to various flag states. This principle is contrary to the differentiated approach based on the United Nations Framework Convention on Climate Change (UNFCCC, 2012) principle of “common but differentiated responsibilities” of equitable justice in view of the different contributions to global environmental degradation and their capabilities. This yet again underlines the technology push by the regulatory regime irrespective of the flags they fly. However, IMO does emphasise the principle of cost-effectiveness in the adoption of technology here. This is seen to be much in line with the principle of “best available technology not entailing excessive costs” adopted successfully in other industries(Sorrell,

2002), which gives a comforting notion of much homework being done before pushing any regulation.

That a focus by an organisation on occupational health and safety and its environmental issues also contributes to the efficiency of the business of the organisation was found to be explicitly articulated by ship's staff. One, for example, said:

With the kind of awareness generated, it is today a well-known fact that what is good for EHS (Environment, Health and Safety) is good for business and vice versa, although returns may be not as tangible for companies to voluntarily adopt technologies contributing to it. (M2)

A focus on environment invariably draws organisation attention to resources *from* nature and waste streams *to* nature. Waste is a misplaced resource through inefficient product/service realisation process. The measure of efficiency is the product /service delivered with least resource and least waste – which is also the environment agenda. Hence it is not difficult to see the direct relationship between efficiency and environment.

Similar is the case with occupational health and safety, which although may not be as tangible for good health to be accounted for in ledger books of accounts, the costs of accidents are well known. Besides the visible costs of insurance related medication and compensation, the invisible costs could comprise product and material damage and downtime, production delays and interruptions, legal expenses, investigation time, and importantly loss of business, goodwill and reputation. As Peter Drucker (2007) the famous management guru puts it, “The first duty of business is to survive and the guiding principle of business economics is not the maximisation of profits, it is the avoidance of loss.”

The opinion of the companies though was more cautionary on the aspects of the technology push through regulatory implications. This is amply illustrated from the views of three interviewees from the three different companies who said:

Progress however gets hampered by the question of ‘who should pay’ for these investments and there was a need to provide evidence of payback from innovations. Perhaps, those offering devices or improvements to efficiency might consider financing these on a ‘no cure, no pay’ basis. (Company A)

Being a state owned organisation it is very difficult for us to convince our finance department and audit committees who are non-mariners on why we are not opting for cheaper technologies in our new ship buildings when they are shown to be equally compliant to regulations and serving the purpose. (Company C)

Regulatory changes were still not always clear and industry generally is anxious not to be taken down ‘a blind alley’ on a range of regulation based technical changes that owners have to be taking on-board. For example, where is there any proper impact assessment data to justify the regulation demand? (Company B)

The above statement warranted the need for regulatory agencies that if they be mandating such technology integration, then they must comprehensively evaluate and address all associated risks. Here it is encouraging to note the following trend on risk analysis and human element considerations adopted at the 58th session of the IMO Navigation Subcommittee recently (IMO, 2012a):

E-NAVIGATION

Progress made with regard to the development of detailed on-board e-navigation architecture was noted. Gap analysis has been completed and the final list of gaps of e-navigation approved. A preliminary list of potential e-navigation solutions will be used as the basis for further identification of Risk Control options in preparation for

the Formal Safety Assessment (FSA). A methodology for the Human Element Analysing Process (HEAP) in e-navigation was endorsed as well as that for FSA. Guidelines for usability evaluation of navigational equipment will be further developed as also will that for the harmonisation of test beds. Finally, it was decided to re-establish the Correspondence Group (CG) on e-navigation under the coordination of NORWAY.

The CG will give consideration to the issue of software quality assurance, especially important given the reported anomalies that are occurring with ECDIS.

What seemed to emerge was that while the ship's staff to an extent welcomed the considered increase in safety and environment protection, probably because it concerned their own selves more, the companies were seen to be reticent about its need and cost implications, even apprehending safety used as ploy to push in more technology.

The interviews therefore indicated that technology integration was largely because of a reactive stance to regulatory or customers' directive compliance rather than a proactive initiative, and the myopic view on cost-benefit analysis by the decision makers ashore. It thus becomes intriguing to unravel the process in which technology was being integrated – which is presented in the next section.

6.3 Lack of scientific approach to technology integration

The summary of chapter 2 that discussed the induction of technology into shipping had pointed out that the inadequate and unscientific integration of technology into the management practices and operations in shipping seemed to have been the cause of concern resulting in its improper evolution and throwing up areas of discontentment.

This aspect was further probed during the fieldwork. While there appeared no direct admission to the cause, probably because of the lack of relevant literature in the popular marine industry media explicitly highlighting the issue, the tacit approval was writ large as noted through the many ill effects of such poor integration on the operators and the evolved practices that has been highlighted in the later section of this chapter.

The interviews of the senior managers of the companies clearly pointed to their frustrating experience in the way in which technology was being introduced to the industry. One, for instance, said:

It must be so if you say so! One would wonder in spite of the technology advancements and automation supposedly introduced to ease the work load is ending up in more fatigue and well yes! I see that the work load is only now different, not seem to be reduced! (Company A)

Chapter 3 continued the debate and in section 3.1 dwelt on the theory of the technology-organisation-process interface to understand what enables scientific integration. Evidence was thus sought on where the shipping industry was in practicing the integration of technology into work environment *vis-à-vis* the theoretical models of the evolution seen in other industry domains. It was noted that the shipping industry is only just graduating to acknowledging the phenomenon of ‘social technologies’ and gradually moving towards driving practices of human factors engineering into the integration as a complete systems approach. So far the usual solution to improve work had been to add technology and/or automate, leaving the operator to adapt. Technology was often used to replace parts of or all of human work and theoretically to make work safer, more efficient or less costly.

However this replacement is not straightforward which presents itself as ‘substitution myth’ as expressed by a ship’s staffs among others who work with it:

Seafarers have no choice but to cope up with the situations of given technology, as they are bound to deliver on ships performance. This does take the toll. Well yes! It is probably time to question why is technology not integrated more scientifically? (M1)

The same sentiment was also echoed by the CE1 who said:

It is a part of seafarer culture to be able to ‘handle everything!’

Research by Lutzhoff and Nyce (2008) showed that a lot of effort is expended to get the new system to work if it is not well designed or integrated, and define the term “integration work” as process initiated and driven by the seafarer; in particular, towards working proactively to construct a workplace that “works” for them.

The data therefore conforms to the earlier studies and clearly identifies the challenges experienced by the managers and seafarers who are required to carry out the task of implementation.

There are trade-offs then in tailoring the tasks and adaptation by the seafarers to make the system compatible with the operators’ cognitive strategies (Cook and Woods, 1996). The seafarers adapt their strategies to carry out tasks so as to accommodate the constraints embedded in the new technology, which is not effective in the long run.

This leads to then seeing how the skilling issues are being taken care of by the industry for its staff to cope with these circumstances.

6.4 Skilling Issues

It seemed quite logical that if proper technology integration has been a challenge, mariners in order to get the work done still have to integrate data and information, rules and practices and their learnt and acquired skills themselves (Lutzhof, 2004). Skilling issues thus become corollary to the technology integration debate.

The companies were also seen to suggest the same, as can be made out from what an interviewee remarked:

The access to high quality professionals and their retention is a major issue for the industry. There is concern with accidents attributable to ‘stupidity’ and lack of professionalism. (Company A)

The companies further suggested that there needs to be healthy scepticism for what the machinery systems tell the operators and not take them as gospel. Those extracting information from the system need to always ask the question ‘does my engineering or nautical skill and common sense tell me that that is reasonable?’ Such a credibility check needs to be done in the head before any action is taken rather than just press some button because that is what the system tells them to do.

Even the ship staffs that were senior in ranks seemed to endorse this view, as is noted from what they said:

Technology cannot solve the problems created by technology. (CE1)

Likewise,

Monitoring systems only monitor problems; they don't predict them before they become problems. The younger generation seems to take technology for granted. (CE 2)

Whether the increasingly capable technology was compensating for the reduced requirement of up-skilled crews or was there a need for more capable crew to handle advanced technology as debated earlier in chapter 3, section 3.2 was thus an emerging dichotomy. The ship's staff at the operating end could also perceive this, which was evident from the interviews in which one Master, for instance, said:

It can of course be argued that with increased technology there is need for higher qualification and skill in navigation. This is certainly so when crossing Shanghai TSS, Dover straits, Singapore straits etc. On the other hand the ocean passages are a different cup of tea - yet we have almost the same level of watch-keeping for both modes. Perhaps the time has come to ask if during ocean passages, the Master may be permitted to place less qualified persons on the bridge. (M2)

The companies also believed that technology in harsh marine applications is getting to be most reliable and capable as in many shore applications. One company manager admitted:

I can see your apprehension that automation and technology can only postpone the inevitable and also hide the error chain from human detection. As a preventive measure, two independent information systems feeding into a human decision process is the future. Moreover, Professor Andy Norris, the past Chairman of the International Electro-Technical Commission has a different take. His strategy is as follows:

1. Development of Marine Technology tested to resilience and accuracy.
2. Adequate redundancies built into the system that the machine carries out the cross-check and self-test functions by itself.

3. All that the operator interacts with is a highly reliable ‘box’ that has an error probability in the range of 0.00001% or less.

His argument is that this is several multiples better at error elimination than the human operator. I too can see the possibilities of this strategy. (Company B)

The discussions based on the data so far suggest that the skills required of the mariners continue to evolve, not least because of advances in technology. It also shows that despite these changes, the Officer of the Watch (OOW) continues to be the central integrator of all navigational or machinery data. This human-gathered knowledge is then used to make the decisions to ensure safety.

However, when these findings are placed in the context of the literature it suggests that in the immediate future there will be a need to think more clearly about the options ahead, simply because the technology that is becoming feasible will steadily undermine the need for human involvement. An item of equipment making complex decisions on behalf of the watch-keeper effectively ceases to be an aid but becomes an essential item. The human watch-keeper is removed from the particular loop, effectively losing the skills to take over should the equipment fail, as has been noted in the previous chapter.

Such obvious concern was readily aired by the interviewees. They indicated that it is therefore only appropriate for the equipment to be fitted if the machine can perform consistently much better than a human at the specific task. Captain 2 (M2) said:

An example is the automatic position and motion integrity checking function of an INS (integrated navigation system). Such systems could become mandatory in the foreseeable future through IMO's eNavigation programme.

It appears evident that an INS and associated equipment could be designed to greatly outperform humans in the integrity checking of position, including reliably establishing whether satellite position is being compromised by interference, jamming or other problems. It would also be able to compare GPS position with any future alternative positional sensors such as eLoran and automatically make available the best position and motion data, with appropriate warnings, if accuracy has been degraded.

The INS will be taking continuous measurements, 24 hours a day. Unlike humans, it will not get tired or bored with the activity, will effect a greater accuracy and will react faster than even the most diligent officer in alerting a potential problem to the bridge team.

If this technology is proven, the OOW can be relieved of having to make positional integrity checks, enabling more time to be given to navigational tasks that benefit from being human-centred.

The result would surely be enhanced overall safety, especially because an increasing number of OOWs appear to neglect this onerous and generally non rewarding task – ‘it’s always right so I don’t need to be particularly careful.’

The companies in their considered opinion had a more restrained view. One of the officials from company A said:

We are encouraged to use the term ‘navigational aid’ for items of navigation-related equipment on-board a vessel. This helps to emphasise two important points concerning their use.

Firstly, that they are there to aid the bridge team in the safe navigation of the vessel. Secondly, that the loss of any one aid does not prevent safe navigation, even though it could result in it becoming a more demanding task.

As the range of technologies available to navigators continues to develop, and bridge officers increase their reliance on the information provided, and the potential consequences of a machine failure will grow in magnitude.

In the rather more distant future, the resultant limited human interaction needed may be best performed by shore-based personnel, perhaps culminating in the unmanned vessel.

On the route to greater automation, the increasing reliance on navigation technology will mean that equipment design and production techniques have to evolve. The equipment rather than an individual will be increasingly the cause of remaining accidents. We currently despair that 80 per cent of marine accidents are caused by human error, but what would we think if 80 per cent were caused by machine error, even if the total accident rate were lower?

In particular, equipment manufacturers would have to get to grips with the issues created by this greater liability.

It will be a different world, but it is the direction that technology is presently going in all transport sectors – road vehicles, trains and aircraft – with platforms for warfare, such as drones, unsurprisingly at the forefront.

The above discussion based on the analysis of the interviews leads to corroborate the skilling dilemma noted in section 3.2.3 that there will be many situations in the foreseeable future that will call for up skilled mariner to take control during times of emergencies and high stress and he will be required to alter roles as the situation demands.

Another noteworthy development that supports the concern raised by the interviewees in this study is that the STCW which had so far not included electrical engineering requirements has in its 2010 revision (implemented in 2012) acknowledged this important

skill requirement. With so much automation on-board ships and the move towards electric propulsion, electric drive systems, electrical steering etcetera, it is not only the marine engineering skilling requirement that is redefined to include enhanced electrical engineering skills, but also the requirement for a new position of electro-technical officer on-board ships.

The National Research Council (2007) study on Human-System Integration in System Development Process also identifies the problem that often automation actually creates more work because now the automation as well as the system itself must be monitored and controlled, thus calling for improved human-systems integration methods and tools.

The study furthermore states that other problems with poor human-system integration have been, (a) increase in automation is often due to pressures to reduce staff required to support the system, however not all automation actually reduces required staffing. (b) Sometimes automation changes the job requirements and takes away the hands-on knowledge that has proved to be so useful for maintaining ‘situational awareness’. (c) Sometimes it reduces reliability and trustworthiness of the overall system and increases the requirement for back-up personnel. (d) At other times people including designers can be subject to an ‘over-confidence’ bias, focusing on the potential benefits of new technology while failing to anticipate the complex interactions and new problems that may emerge.

All these issues can be seen as relevant to the concerns as found in this study and argued in the same way and in line with those already raised by the ships’ staffs and the shore-based officials.

The discussion so far first commenced with the appraisal of the technical management processes before recognising the skewed incentives of technology integration into these processes. It then led to the realisation of lack of any scientific approach in technology integration and debated upon the issues of skilling to deal comprehensively with the inept human-machine interface in the technology integrated operating environment.

The following sections now proceed to dwell exhaustively on the empirical findings of the challenges thrown up at each stage of the operations and management practice.

6.5 Issues involved at the design stage

A systematic approach needs to be taken in an integrated design of human-machine interaction that promote the perspective that system users should no longer be add-ons to the engineering design but should be an integrated part of the functional design. Usually interfaces are organised subsequent to the equipment design with the aim of matching them to the users' performance modes and mental models. Captain 2 who has been interacting at the global policy levels in nautical affairs expressed his view by saying:

The mandatory phase of induction and implementation of ECDIS (Electronic Chart Display and Information System) is just round the corner. This is a revolutionary change in the way ships are navigated as it heralds the transition from paper charts that have been familiar to mariners for centuries to ECDIS. It is not just a new technology to be retrofitted into the ship in an unthinking manner as so many pieces of kit have been put in the past. It is far more revolutionary and requires a new mind-set, revised bridge procedures, and substantial training for effective use. Moreover, while the company ashore can take the responsibility to organise implementation taking up issues of system assessment, purchasing, fitting and

training, but planning itself of such a major project needs to have inputs and involvement of sea staff. (M2)

His views carry many messages which require elaboration. They suggest that (a) technology is being driven by regulation (b) technology is bringing about a revolutionary change to the basic art and craft of seamanship (c) there is acknowledgement of poor and unscientific design and integration of technology related systems and calls for fundamental rethinking in the human performance and human-system integration which will never be effective unless it is seen by all its stakeholders as an integral part of the entire systems engineering process, from initial concept evaluation through to design and its operational use (d) identifies gaps in the process of systems assessment and calls for the companies to be particularly vigilant to these limitations on type approvals of a systems configuration by the classification societies that may lack in considering ergonomic and human factors (e) it suggests the need for vendor evaluation in the purchase of such highly integrated systems; and (f) it calls for stronger user interface at the design stage to make the development more user-led than mere technology-led.

Further emphasising his point of view, Captain 2 was engaged in discussion on the Royal Majesty grounding, the unique case of the passenger vessel running aground in broad daylight, when full complement was manning the ship's bridge. He commented:

Royal Majesty is a classic example to showcase the perils of automation without any process engineering. In fact, eNavigation strategy is more about process engineering than technology application. The Nav system designers at the IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) e-Nav discussion seem to think redundancy systems (be it position

fixing, course and speed indication or depth) is all about having a back-up in case the primary fails due to a technical hitch. I have been rather strenuous in my assertion that the secondary system is meant to cross check the primary as a matter of routine and diligent navigational practice to avoid the kind of false sense of security the officers on Royal Majesty operated in just prior the grounding. I have discussed this in the eNav strategy input paper for the IMO.

The S-mode is one aspect of eNav process engineering that will have a tremendous impact on safety. S-mode would require all navigation displays, regardless of manufacturer, to have a clearly identified button that, when pressed, brings the display into a standard format. (M2)

A positive affirmation is noted here with the S-Mode (Standard Mode) of the consideration of cognitive ergonomics¹⁸ and human factors in the conceptualisation, design and development of human-systems integrated technological systems. The younger Captain 1 from the view of the operating end of the new technology also indicated towards such need as he said:

If designers of marine equipment and software could achieve a common standard for basic operations such as operating the ECDIS (Electronic Chart Display and Information System) it would go a long way into making all our lives easier as we move from ship to ship. (M1)

The companies who in general are close to the trends of developments taking place within the industry resounded much the same views. One interviewee, for example, said:

¹⁸ Cognitive ergonomics studies cognition in work settings in order to optimize human well-being and system performance.

But it is not just the technology that is giving cause for concern. It is the systems themselves, because of a natural tendency for manufacturers to add their own features, in an attempt to make their equipment ‘user-friendly’ or made distinct within the market. For example, the seafarer can be faced with either: joystick, trackball or menu-driven controls, depending on the equipment fit in the vessel in which he is serving. (Company B)

The above highlights that (a) considering the design of individual interface workstations in isolation is no longer enough; today systems are complex and its holistic interaction with humans need to be taken into account, (b) acknowledgement of commercial pressures in the design of systems with little awareness of the tools and best practices in related fields.

The need for the S-Mode (Standard mode) as expressed by the ship staff was also seen to be emphasised by the companies from their point of view. One interviewee, for instance, said:

The different nationalities and cultures of seafarers dictate a need for commonality of symbols, switches and control keys, together with appropriate education in the basic principles of new technology. (Company A)

Early and proper planning with user-led inputs at design stage again was highlighted by the companies as well, as can be noted from the remarks of another interviewee from another company who said:

Firstly planning is the key. Understanding the ship’s staff, their capabilities, their needs, aspiration and complete familiarisation helps.

Another caution that needs to be exercised is the *early* planning for effective induction of new technology, particularly that which is mandated by regulation. Leaving it to the last moment is another well-trodden path within our industry, in

spite of IMO giving enough lead time that is envisaged necessary for fleet-wide implementation. (Company C)

The findings therefore strongly suggest the importance of incorporating accurate usability requirement at the design stage. This is not entirely new as the National Research Council (2007) study, for instance, had already identified inadequate integration of user requirements as the major contributor to project failures. It further attributes the main reasons for this to (a) inadequate understanding of the intended users and the context of use, and (b) vague usability requirements, such as ‘system must be intuitive to use’. Usability is defined to be in terms of understandability, learnability, operability, and attractiveness.

The lack of adherence to these fundamental principles including lack of consideration towards user perspective in the design stage results in a major challenge in the management and operations of today’s ships. The following sections present the related issues in more detail.

6.6 Information clutter in management and operation of ships

Empirical evidence corroborated the sentiments expressed in Section 4.2 of chapter 4 that pointed to the proliferation of information inadvertently caused in the effecting of practices through the eased technology. It showed that the ease of communication rendered by modern ICT was found to have resulted in much increased information exchange between the ship and the shore management. As noted in section 6.1 of this chapter while discussing the process of inspection and monitoring of ships, the paperwork which was now in electronic form had only increased. This was possibly effected by the apparent closure of

distance through communications, giving the shore management a closer comprehensive view of the shipboard operations and the consequent decision making. Such panoptic supervision by the shore management having an adverse effect on the behaviour of the ship's staff was amply discernible, as can be made out from the comment of Captain 1 who stated:

What effect does it (management from shore) have on ship captains? Increased inertia attitude - I can do nothing so better do not do anything, survive the assignment, change nothing, minimum communications...And, believe me: the office loves such attitude best! Until anything happens, then Master is simply dispensable scapegoat. (M1)

The apparent loss of autonomy is perceived by the ship's staff. The shore side involvement is taken as interference in the work leaving them frustrated even resentful and killing the drive to take their own initiatives. There is also apprehension that whether it is about efficient management or a more cunning agenda of washing their hands and fixing legal responsibility on the ship. The critique of "panopticism" in organisational theory draws attention to the inevitable interrelationship between power and resistance, and also to that between capital and control, which may not work when applied in much concentrated form (Boyne, 2000, p.288).

From the interviews of the seafarers it was evident that as the process/information bridge between the ship and shore is becoming quite a non-issue there probably is a need to exercise caution in the unnecessary use of this bridge. The abuse of the facility creating uncalled for clutter comes to light with disregard towards the shipboard objective function of the safe conduct of the voyage. What is sent from ship to shore or shore to ship must

add explicit value to those involved and with due regard to the complete understanding and appreciation of the objective functions of those at each end. This seemed to be the sentiment reflected in what Chief Engineer 1 had to say:

Ship is now being considered as a mere extension of the office. Unnecessary information, at any time (without considering the time differences between the ship and shore office), is called for with misplaced sense of urgency. (CE 1)

As for the information clutter in the *operation* of ships, there was an overwhelming affirmation of this fact. One Chief Engineer said:

Of course there is information overload and too many alarms. If there is going to be an alarm every thirty seconds then people just acknowledge it and do not even look at the screen to see what is there. Many alarms were unnecessary, and many we think is needed are not there! (CE2)

While another Chief Engineer expressed that:

If I had a wish list, it would be to ensure that the ship is delivered with easy-to-understand and operate systems and one selector switch to hide all non-critical alarms. (CE1)

The ship's captain using examples of navigation said:

On the deck side, ECDIS, e-navigation, integrated bridge systems is all about information management and unless there is focus on the proper collection, management and display of multiple sensor inputs in a coherent and user-friendly presentation, it does not achieve its desired purpose. (M2)

While the other mentioned that:

Today with automation, in the nautical environment the watch-keepers are increasingly made responsible for additional tasks of engine and cargo control besides the main task of safe navigation. (M1)

It is apparent from the tone of the interviewees that there is a shift of operator's role from direct control of systems to a more remote and supervisory relationship which then puts greater demand on cognitive resources if there is an overload or plethora of information to be dealt with. In addition, if there is a demand on increased monitoring of secondary controls thus stretching the operators' span of control, the resulting effect of automation is an increased workload rather than less. Research on this area suggests that there may be then undesirable consequences in terms of increased fatigue and work strain (Sauer *et al.* 2002). Smeaton *et al.* (1995) and Wickens (2000) also point out that visual scanning of separate and cluttered displays and mental integration of the overloaded information puts a heavy demand on cognitive resources resulting in greater difficulty for the operator.

The findings therefore point to the need for the integration of primary information sources in ship control. Studying this area Lee and Sanquist (1996) suggest that two aspects need to be considered, "perceptual augmentation" and "control integration". Perceptual augmentation is about improvement of the operators' perception of the ship's environment, i.e. 'situational awareness' and control integration aims to improve the operators' ability to control the ship operations.

6.7 Challenges in the operations with automation

Beyond the challenge of information clutter in operations with automation, there were other challenges noted to have resulted in reduced crewing, over-reliance on technology and reduced situational awareness. The companies however were seen to argue that rationalisation of crew strengths on-board was afforded by the increased technology and automation as a measure of economic policy to cut crewing costs. This argument was put forth by the companies because the costs of crewing had today become a major component of running expenses of ships. For instance, one company official said:

In these times of downturn with freight earnings at the lowest, crewing costs are the focus of attention as crewing is a major part of the costs. (Company C)

Likewise, an official from another company said:

A record delivery of new-buildings and low scrapping levels has contributed to freight rates ‘hitting the bottom’, and high volatility and challenging market conditions are continuing. The financial and economic realities are making degree of consolidation necessary. Anyway, the good news is that ‘the world is still turning and trade is growing! (Company B)

Another reason cited for cutting crew on-board was the non-availability of adequately skilled sailing staff coupled with the fact that the high automation levels were rendering the crew inexperienced in handling many situations, corroborating the noting in the literature review of ‘taking the man out of the loop.’ A manager from company A commented:

I can testify that there is a similar situation happening in the engine room, where many ‘modern’ engineers are becoming bus drivers that simply inform the shore office when something doesn’t work anymore. It is difficult for a company to see value in such an operating mentality, so it is natural that they start cutting the crew.
(Company A)

However, the ship’s staff (Case D), were seen to come out with some strong opposing views on the need for cutting crew. A Chief Engineer articulated this point of view and argued:

Regarding the highest cost to ship owners being crew wages...they are *not* the highest operating cost, but they are the highest *discretionary* cost. In other words, ship repair, dry-docking, fuel, etc. are all non-discretionary costs because they are overhead costs that are outside the ship owners’ area of control. They can't make the ships use less fuel, but they can cut the number of crew on-board and still make it to their destination. (CE1)

In the same way the other said:

For the most part, shipping companies "do" realise they need competent mariners, but they fail to realise that as their numbers are reduced, their cost of maintenance and repair goes up. Why? It is because those who count the beans for crew costs are usually not the same people who count the beans for repair costs. So while one part of the company bemoans the high cost of repairs and maintenance, another complains about the high cost of mariner wages. (CE2)

The lack of appropriate and adequate skills in the newer crews coming was also seen to be acknowledged by senior sailing staff and a reason cited for technology integration. For instance, the Chief Engineer 2 asserted:

The move to absolute minimum or no crew on ships in the future will most probably not stem from the activities of the bean counters but from the lack of suitably capable staff coming forward to do the work. Rather than accept lower qualified staff, I believe owners will opt for automation and a couple of multi-tasking riders that can keep a lookout, fix the PCs and actuators and assist the berthing or maintenance riders get on-board. These guys will earn very good salaries and have home leave of at least two to one. (CE2)

It also came out clearly from the responses of the ship's staff that the newer crew was tending to become over-reliant on the technology to the detriment of safety against the principles of good seamanship. For example the maxim that regards technology as mere 'aid to navigation' and not to be overly relied upon was overlooked. This came out clearly from one Captain's remark as he said:

A common thing in the young lads is that all are very skilful regarding the new technologies; because they are very good at hitting buttons they think they are good in their jobs!!! That's where the big problems start. They don't realise how limited their nautical, marine or seamanship skills are. Just as an example I had a 2nd Officer that never put the course in the log book since the first time I told him how to do it; as the problem persisted I asked him why he was not doing it, he just told me that wasn't necessary because we were using the ECDIS so why bother with that!!! Obviously was the first and only time he would sail with me...(M2)

However it was also pointed out how efforts to make this technology integrate with good practices of seamanship were being made, with another Captain citing the example said:

'Looking out of the window' is the fundamental rule of good navigation. I am aware that California Maritime Academy is in advanced stages of research where the bare

essential information of ECDIS are superimposed on the main bridge window in Head-up display thus dramatically improving 'situational awareness' and encouraging 'looking out of the window' to counter the syndrome of over-reliance on technology. (M1)

Likewise, the Chief Engineer corroborating on the need for good human-machine interface remarked:

The expert's behaviour goes beyond analytical rationality, and is situational, experience-based, and intuitive. (CE2)

While the other Chief Engineer, acknowledging that no technology was infallible, added:

The moral of the story is that no matter how ubiquitous or reliable a system, it will eventually fail, and do so at the most inopportune time. Without spare parts on-board, without a back-up system and the trained personnel to use it, the ship and those who expect certain performance will find themselves in serious trouble. (CE1)

The companies in turn were also found to concur on the absolute need of a proper and considered integration of technology into the practices of management and operation with exhaustive risk assessments carried out and the full involvement of all that are going to be part of the operating systems. It was pointed out that training too needs to be developed keeping the complete system integration in mind, of which trends are now being seen on specific training like crew resource management (CRM) on simulators with the bridge and the engine crew operating in unison in the respective but connected bridge and engine room simulators. Two interviewees, for instance suggested:

If the automation and tools are used correctly and the officers are *competent* not *certified* for their positions then we should not be having discussions such as this.
(Company C)

In answer to the original question, I would say that (a) technology must be developed to cope with the reduced numbers of suitable people available, and (b) newer methods of skills development must be adopted in the present scenario of increased human-machine interface environment. Some big cruise companies have already begun to adopt CRM trainings. CRM actually began as ‘cockpit’ resource management in the aviation sector. It is now coming as ‘crew’ resource management and will move to ‘corporate’ resource management. (Company A)

CRM training concerns with the cognitive and interpersonal skills needed to cope as part of team both in everyday work and in crisis in a high technology environment. As an instructional strategy it gives crew members the knowledge and good practice needed to apply non-technical abilities in the management of available resources (human, equipment and information), ensuring safety and efficiency. Cognitive skills are those mental processes used for gaining and maintaining situational awareness, for solving problems and taking decisions. Interpersonal skills are those related to teamwork, as communication and delegation of task.

The challenges in operations especially with regard to the increasing involvement of the shore-based personnel are seen to be further aggravated due to the relative isolation of the work environment that exists in the case of a typical merchant ship. The discussion in the following section draws on the interviewees’ views on this specific feature of the industry.

6.8 Influences of the work culture and work environment

The ship operations are characteristic of its uniqueness as a work culture and the work environment of seafaring. Guided by the discussions on this aspect in the literature review particular efforts were made to probe its influence in the technology integration with the established practices.

6.8.1 Traditional ship-shore divide persists

Modern communication systems have invariably resulted in drastically increased importance of shore-side management with shore managers seizing the decision-making functions traditionally associated with the ship's Master. One Captain lamented:

Particularly when it comes to commercial directions the shore based management is often represented by young talented graduates who have no idea about seafaring, have no experience of on-board life, and do not really care about or understand the needs of the seafarers. On the other hand, the ship's staffs usually have little knowledge about ship management and the commercial side of shipping. They do not study business matters in any depth in marine colleges and are not involved in them on-board ship. This alienation of senior ship staff from the management process can have costly consequences for the industry. (M2)

It can also be noted from the above that having sea-time is a veritable rite of passage and a *sine qua non* of having a say in any matter concerning seafarers. While generally the technical management departments in the case companies did have staff in the technical management division albeit with varied sea experiences, they did succumb to commercial pressures that seemed to play a domineering role, at times driving compromising practices

(Schroder-Hinrichs *et al.* 2012). The existence of the ship-shore divide appears accentuated with the followings remarks noted from the shore and the ship's staff respectively:

It is only wishful thinking to have our senior shipboard staff involved in management, economic and financial decisions. For this we need to train our people along those lines. But in the backdrop of popular crewing policies and the basic education and training infrastructure in non-established countries that supply most seafarers, this was impossible. Without the right tools, we cannot expect our people to make difficult management decisions. (Company A)

Almost all the Masters I have sailed with are much more capable managers than the jumped up accountants who are in charge. It is not the Masters who need the training in becoming effective managers. Management is a small part of the Masters job. A Master has to be capable and competent in many different areas. Way beyond the capabilities required of a shore administrator. No-one had the illusion that the accounts clerk could run the company. I have noticed a marked decrease in the capability of managers, when the myth that the general purpose accountant that could manage anything, became current wisdom. (M2)

In the companies a realisation of the need for better ship-shore interface and appreciation of each other's roles was discernible. They seemed to believe that ensuring both seafarers and managers were part of the same team was critical and moreover felt that this bond be emphasised. A strong comment noted was:

We don't want a 'them and us' attitude. We do try to give opportunities to our sailing staff to spend time in offices and appreciate our side of work. (Company B)

However, the ship staff were noticed to be sceptical in believing this attempt which aptly summed up the divide in an interview thus:

Oh! It's never windy behind his desk! (M1)

The ship-shore divide thus tends to exacerbate the level of trust at the very critical ship-shore interface of the ship management and ship operations. As identified in the literature review (sections 2.3 and 4.4.1) this inadvertently leads to conflicting objectives of the ship and shore, resulting in working cross-purposes with the technology integration agenda and leading to inefficiencies, ineffectiveness of ship management, and even jeopardising safety.

6.8.2 Crew conveniences and willingness all-around

Contrary to the generally established notion of greater reluctance from the ships staffs' in readiness for the uptake of technology, a general willingness was noted among them which confirmed the expressions in section 4.4.2 of Chapter 4. Furthermore, a pleasantly surprising revelation that came about from the interviewees of the companies was the tacit acknowledgment, at times even emphasis on the social considerations underpinning shipping operations, as noted below:

We are delivering communication convenience and flexibility to our crews who demand, and deserve reliable connectivity, easy-to-use software, dependable voice and consistent data. We have made sure that worldwide news and recreational content of the highest quality will be enjoyed, uninterrupted, by our crews around the world. (Company B)

The new satellite communications set-up will be used to run office communications and crew calling as well providing broadband internet access and television services to vessels. (Company C)

While such a strategy towards crew was a welcome finding it could also be argued that such a change of heart towards crew welfare was more a reactionary result of economic pressures. For instance, the non-tariff trade barriers of the Oil-majors whose Tanker management and self-assessment schemes (TMSA) which among other requirements dictated minimum 80% staff retention to meet the competency matrix requirements of certain ship type experience. It could even be in preparation towards the impending Maritime Labour Convention, but this was something the companies seemed shy of accepting.

Be that as it may, the willingness for technology integration towards simplifying operations for the ship's staff was also discernible in company responses:

Well, the tablets and mobile devices are getting very common nowadays, these can be directly connected to the ships PMS system and records the documents automatically. Also these devices are used for training purposes too. We have a project on these to enhance the pre-joining and familiarisation trainings by mobile devices and e-learning. I think we will see the implications in the very near future and this will be a very user friendly and beneficial way to cut down the paper generation. (Company A)

The ship's staffs were also seen to acknowledge the efforts of the companies in these directions:

Use of tablets about the ship is the wave of the future. I understand there are already some intrinsically safe tablet PCs. They probably already are in the offshore industry - the maritime industry should be encouraged to widely adopt them and get rid of the paper burden whenever possible. It should be a matter of time that there is common acceptance of electronic checklists. The hanging of the confined space

form at point of entry is a challenge I am sure we can find a way to properly manage. Class reports are now provided electronically with a digital signature. (M1)

Third-party inspectors will have to eventually accept computer based records of permits and checklists - they have no other choice as more and more vessel operators move to almost paperless systems - don't let them bully you into thinking otherwise. (CE2)

It just goes to establish that there is a general willingness all around, both ashore and on-board for embracing technology and that it really was the inadequate integration that was throwing up its many challenges that had to be dealt with. This was perhaps creating user dissatisfaction that erroneously translated to the myth of seafarers' reluctance.

Despite all the criticisms of the way in which implementation of technology was undertaken, in practice the findings from this empirical study provides strong evidence that there is much potential in optimisation of ship operations and its management. In order to provide an analysis of this, the discussion proceeds to exploring the views of the ships' staffs and managers especially on these potentials.

6.9 The potential of technology integration in modern ship management practices

The data collection and analysis logically progressed to the issue of exploration of optimisation opportunities, a theme noted to be vehemently articulated during the interviews given the rising awareness of shortfalls, gaps and strengths discussed in technology induction and its integration. Ideas were exchanged on the proper exploitation

of advancements and capabilities rendered by improved information communication technology application as well as advanced process control and automation developments on ship machinery as identified in chapter 2 section 2.4. Furthermore, chapter 3 in its section 3.3 had offered strong arguments in favour of enhancing the optimisation potential of technology in shipping, ranging from lessons from other industries to being competitive through low costs and differentiation. It had also highlighted similar emerging trends in the more resourceful shipping of Western European nations in as much as technology is becoming more capable and rendering safer and greener operations.

The participants were engaged in imaginative thinking on possibilities that may exist towards optimisation with increased capabilities due to technological advancements, however, never losing sight of constraints that accompanied every possibility. The companies were found to unanimously strongly acknowledge that ‘optimisation of resources’ was indeed another key theme which companies were pursuing in their proactive technology upgrade agenda. One interviewee from the company summed up:

In the times of economic downturn and knife-edge competition, optimised resource management is the key. (Company B)

6.9.1 Which process for optimisation will bear ‘low hanging fruits’?

Technology integration into ship operation and ship management has been happening in many fronts, but what specific process would it be that had the major concerns and bore maximum potential for delivering optimisation was the question. That it had to be in the area of ‘Inspections and monitoring of vessel performance’ which was at the core of

Technical Management functions and seemed to have the maximum irritants, was the unanimous choice.

Very specifically, the process of ‘Monitoring of fuel consumptions and vessel performance’ easily came out to be preferred area as could be inferred from one of the company managers’ remark:

Without doubt the machinery and fuel performance system. With the soaring bunker fuel prices making it the biggest cost element, it is but naturally a priority area. There are tremendous advancements happening in this area and reportedly it is now possible for information to be relayed directly from the machinery systems that have become highly advanced with self-diagnostic and rectification capabilities. This will ease a lot of work load on ship’s staff. Accuracy is also bound to become sharper and most of all it will encourage transparency. We operate some tankers in Tanker Pool, so the Pool operators in as much as the Oil companies who charter our vessels will have direct access to fuel information and promote trust. Shipping is a big relationship business and trust building is at the core. (Company C)

A manager from another company even provided statistics to prove the point:

Rising fuel costs have turned the shipping economics on its head. Today the capital cost is becoming cheaper, but the cost of operating ships is soaring into the stratosphere. I have actually seen more regular recessions and crises in this industry rather than the far fewer and shorter booms. Today we have a topsy-turvy world in which the capital costs of a ship might be USD 17000 per day and USD 25000 will have to be spent daily on bunkers! Today in Japan there is no less than a national effort being undertaken within the Japanese shipping and shipbuilding industry which focused on fuel consumption, with understandably no fewer than 22 different projects contributing to this research. (Company A)

Yet another manager from the third company was of the opinion that there was proliferation of technologies happening in the area of fuel consumption and its monitoring:

Matter-of-fact, I feel that owners and builders need to work more closely together if there was to be continuous improvement in ship efficiency, and more operational data shared about how ships performed. I would go on to say that production technology needs to be properly assessed and proper oversight provided on the issue of competitiveness and the risk of oversupply! There could be too many technologies being developed and more coordination is needed. (Company B)

Besides the stakeholders' concerns, the development of a regulatory regime towards energy efficiency was cited by another interviewee:

I must commend the progress being made by IMO in this respect, towards the adoption of Energy Efficiency Design Index and the Ship Energy Efficiency Management Plan. These standards will encourage ship designers and builders to develop more efficient ships and the ship owners to further optimise on their operations contributing towards energy efficiency. (Company C)

The ship's staffs' concerns also emphasised the need for looking into the ease of operations as an optimisation strategy. Their views were categorical and clearly portrayed the message. All four senior officers in Case D said:

There is so much time and effort being taken up in this process of 'Monitoring of fuel consumption and vessel performance'. There are daily reports, weekly reports, monthly reports, quarterly reports, half-yearly reports besides the special reporting that is not at fixed intervals. The master today is not a seaman anymore, he is a clerk. (M1)

P&I Clubs are reporting growing number of accidents in which fatigue was identified as a major contributor. There is a need to 'work smarter', perhaps through

task analysis that will assess the optimum manpower needed for tasks and voyages. I actually know of some encouraging results with manpower software being tested by a reputed maritime administration, in which manning levels can be simulated and overburdened personnel can be helped with additional manpower! (CE1)

As you said, convergence of Information Communication Technology, Advanced Process Control and Automation is indeed the new area of development enabling computerised monitoring of the engine with a direct feed to the office computer without any ship interface. Ships systems can be now accessed from any computer anywhere. (CE2)

Communication and trust between ship and shore are key to the success of the system. (M2)

The concerns from the perspective of the ships' staff provided ample support to Knudsen's (2009) research on paperwork in shipboard operation which revealed that a growing amount of paperwork has been implemented in a time where the size of the crew and its quality has been considerably declining. She concedes that it is undeniable that tight schedules, high workload and long working days are conditions most seafarers experience.

6.10 Key findings

The findings from this empirical study as discussed in this chapter thus provided a range of views from various perspectives to the practice of technology integration in the management of shipboard operations.

While there was consistency seen across the case companies and the shipboard staff in the similar understanding of the various processes involved, there were differences too. These were largely between the overall companies' approach to meet the objectives and the ships

staff's version of the approach to the same objectives in some areas. This contrast and at time contradictory points of view has provided a rich understanding of the complex issue of integration of technology in the operationalisation of management practices.

When it came to the compliance process there was no discord, and both the teams worked in unison, highlighting the effectiveness of the regulatory compliance regime in the shipping industry. However in the other processes of technical management, differences did manifest themselves in the process of operationalising the policies with the shipboard staffs' feeling being left alienated of their opinion and concerns.

In this summary the key message from the findings are reiterated against the original research questions raised in section 4.6.1. The first subsection read:

What are the drivers for uptake of technology in the ship management industry?

The answer seemed to suggest that enhanced regulatory compliance as well as customer created non-tariff trade barrier requirements both of which increasingly mandated the use of technology, were seen to be the main driving forces. There was however a need for a responsible compliance regime that would assess all risks and its cost-effectiveness prior mandating requirements. The data showed that the drive for better economics and optimisation were other reasons pushing the technology agenda. However, this enthusiasm when weighted against the economic logic of returns on investment seemed to result in only incremental advances of technology without giving consideration to a holistic approach.

There is thus a realisation of a lack of any scientific approach in integration of technology into shipping practices which consequently seemed to have resulted in its falling way short

on expectations. This concern was looked into in prior studies and featured in the discussion on the review of the literature in section 3.1. Thus the second question is there any scientific approach adopted in the technology application/integration in ship management practices, was answered as follows:

From the findings there was no direct admission noted of this possibly for want of lack of awareness. The interviews revealed that unlike some of the leading technology-driven industries, there was limited use of a scientific approach adopted in the uptake of technology.

Exploration of challenges in the management and operation with technology and automation was discussed as it was the next subsidiary enquiry which read:

How well is the human-machine interaction addressed in the application/integration of technology in ship management practices, and what are the gaps if any for it to meet the objectives of enhanced performance, safety and user satisfaction?

The findings from the study revealed striking gaps in cooperation and coordination, making the technology integration ineffective, even counter-productive. Technology being regarded by shore management as additional crew replacing humans did not find favour with the shipboard staff. Although it was acknowledged that the similar trend in future will be more determined by lack of availability of skilled staff and solutions worked around it.

In the opinion of the ship's staff it was the domineering role of the shore based management that was found to be even demeaning the strongly embedded practices of seamanship which define the shipboard team operations, became a bone of contention. The

acknowledgment of its existence by the shore based management and the directions of efforts to progressively close this gap, was however also seen to be existent.

Consideration of crew conveniences through enabled technology signified the advent of the integration of social factors which was a positive trend. A sense of general willingness all-around and the acceptance of the inevitable fact of technology integration into the practices of ship management and its operation were clearly discernible. It was no wonder then that the theme of bringing out improvements and optimisation of processes emerged strongly as a logical extension to the issues at hand which was then dealt with.

These main findings synthesise into the following five areas which address the main and its subsidiary research questions:

6.10.1 Reactionary technology uptake

The main drivers for uptake of technology emerge to be compliance to customer requirements as well as regulatory mandate. The findings revealed that uptake of technology largely followed a reactionary approach despite the shipping industry being safety-critical. The study showed that a proactive stance towards value creation though fairly appreciated was overwhelmed by the economic considerations. Unfortunately this resulted in a reactive and cautionary incremental initiative causing even more challenges of technology integration.

6.10.2 Limited scientific integration of technology

Technology becomes a key driver of organisational evolution. Understanding whether and how it affects firm performance is an important research issue as it allows the value of such

investment being delivered to be appreciated. Whilst chapter 3 had dealt with the theory of technology integration, the empirical findings reveal very limited if any such organised and concerted effort behind technology induction and integration decisions. Scanty literature on the subject in the maritime domain has already been identified in chapter 4. Consequences of poor integration then get amply reflected in shortfalls, gaps and uncalled for side-effects and may even be counterproductive.

6.10.3 Limited human factors engineering

Although the shipping literature has been acknowledging the role of humans in systems, the empirical data evidences continuing concern in its developmental phases with the human element not adequately being considered along with hardware and software elements. It was found that some of the fundamental principles of human factors engineering not considered were (a) description of human capacities, limitations, their needs, tasks and the environment they work in, and (b) characterising and evaluating alternative designs by trained human-systems design professionals. Particular attention needs to be paid to consideration of these factors in the system life cycle covering issues of manpower, personnel (aptitude and skills), training, safety, and health; the inadequacy getting reflected in the many challenges encountered in the operation and management of ships.

6.10.4 Limited usability perspective

The case study interviews amply demonstrated the failure to introduce usability perspectives early enough and the lack of effective methods and tools to predict its direct and ripple effects of envisioned future systems early in the design process. It was also found that there is even a tendency to focus on people as error-prone links in a system that

needs to be “automated away” rather than important contributors as its users. User analysis in early stages of design includes methods as contextual enquiry, scenarios, task analysis, cognitive task analysis, ethnography or participatory analysis (National Research Council, 2007). New technologies provide new capabilities, and these often generate new expectations, roles and ways of doing things that are not always anticipated ahead of time (Woods and Dekker, 2000). The following quote from the findings of Lutzhof (2004) on a related enquiry appropriately has noticeable parallels to the findings of this study. Her work revealed:

Many ostensibly technically integrated maritime systems are neither well integrated from a human cooperative point of view, nor from a technical point of view. Work cannot be broken into pieces and then put back together again. New ways of designing for and thinking about the workplace are already in use in other domains. We suggest that cognitive tasks and social tasks should be the focus, not engineering and devices (p.88).

6.10.5 Harnessing potential optimisation

Finally, the findings from the interviews also revealed that a large scope for optimisation exists in considering process reengineering leveraging technology in the process of monitoring of fuel consumption and vessel performance. The very capable information communication technology (ICT) that is increasingly becoming available for deployment in the operations and management of ships is rendering such a possibility waiting to be harnessed. The respondents believed that this was certainly an area when evaluated from a risk assessment perspective of effort to outcome, would rate very high in terms of ‘low hanging fruits’ given the current environment of high fuel costs and pressures for energy efficiency related greener operations.

The exhaustive list of challenges and potential of technology integration in modern ship management practices as revealed in this study is further analysed in light of theories and previous academic work to gain an in-depth understanding of the causal factors influencing the practice. The following chapter elaborates on these as discussions.

Chapter 7: Discussions

Introduction

The analysis of the challenges and potential of technology integration in ship management practices leads to an informed discussion on the underlying causal factors contributing to the persistence of such challenges and the reasons for the tardy and decelerating progress in harnessing the potential of optimised operations. This chapter further deliberates upon the empirical findings of this study and analyses the issues with the help of academic literature and through a theoretical frame of reference against which ship management practice can be evaluated. In the process it attempts to find convincing answers for the research questions.

Chapter 6 broadly summarised the challenges for reactionary technology uptake driven by a compliance culture, unscientific approach in executing technology integration, limited appreciation of human factors engineering in the industry and limited usability perspective in the early design stages itself.

Each of the issues is discussed further in this chapter.

7.1 Regulation driven compliance culture – pitfalls, theory and self-governance

The findings of the study indicated that the uptake of technology and its integration into ship operations was more a result of the dominant minimum compliance culture in a reactive stance rather than a proactive initiative. The myopic economic considerations of

low cost operations weighed heavily in any technology change decisions. The global industry environment proliferating varying degrees of quality standards in manning, technical management and operations was not conducive to support reliance on automated and technology integrated practices. The industry is thus driven by sets of regulations originating from the IMO or as non-tariff trade barriers imposed by the customers of its services. It thus calls for in-depth deliberations on the underlying factors influencing the current practice in the industry.

7.1.1 Pitfalls

By re-examining the shipping industry in the context of this study, one finds that while globalisation does affect industry functions, the impacts on the shipping industry are far more significant. Being a truly fully globalised industry it tends to take economic advantages offered by this globalisation, with greatest impact being that of flagging out of the ships to Flags of Convenience (FOC) that offered liberalised regulatory regimes. While IMO as the specialised agency of United Nations is entrusted with the responsibility for measures to improve safety and pollution prevention, it facilitates adoption of legislation which is then left to be implemented by the member Flag states of which by and large the FOCs (also called ‘open registers’) particularly tend to put enforcement fairly low in priority. Alderton and Winchester (2002) actually note this trend as “de-regulation” of the maritime industry. They however make a distinction between the established open registers and the new entrants and note that the *raison d'être* behind these new entrants and its existence is due to the regulatory free environment they offer for the ship owner, exercising its sovereign privilege and creating an unregulated environment where capital is left free to act as it pleases. Progoulaki and Roe (2011) further suggest that ship management

companies engage the services of specialist crewing agents who offer competitive services by engaging labour from the new labour supply countries and intensify their use through reduced crewing levels and extended working hours afforded by registering vessels under FOCs associated with lower regulatory cost, weak labour rights and lower wage levels. They quote studies pointing out that the world's largest fleets are attached to FOCs and over the last 25 years, 80% of the world merchant fleet has been manned with multicultural crew i.e. one ship having crew from different countries and different cultural backgrounds thus throwing up its own challenges.

It thus leads to a false sense of complacency that mandating technology through regulation will be a panacea because the implementation of these regulations is still in the hands of the flag states. Thus all the push of technology through regulations is seriously threatened when it comes to the implementation stage.

Discussions and deliberations in the IMO strongly suggests this and has enacted measures to control this trend through Port State Control (PSC) where government agencies inspect foreign ships that visit their ports and detain them if not meeting IMO standards. The primary responsibility for ships' standards rests with the flag State – but port State control provides the 'safety net' to catch substandard ships. Another initiative has been Voluntary Member State Audit Scheme (VMSAS) which presently is voluntary, but is likely to be made mandatory by the year 2015.

Key developments in PSC have been the adoption of a 'name and shame' policy of publishing detention lists and grading of flags in white, grey and black lists based on inspection and detention statistics as highlighted in section 3.3.5. It also provides useful

performance-measuring tools to flags themselves and the recognised organisations (ROs) delegated by flags to carry out statutory surveys, as well as to ship operators and charterers. One measure of the success of PSC might be in the fact that Liberia, the flag flown by the Amoco Cadiz, known for its oil spill off the coast of northern France, now regularly features on the main white list. Flying a white-list flag, a ship is less likely to be inspected, a fact that could influence a ship owner in the choice of register.

The benefit of voluntary auditing through VMSAS is seen in those flags that have gone through the process being rewarded for their commitment to improve standards by inclusion in a ‘whiter than white’ list that has two criteria: inclusion in the main white list and evidence of an IMO audit.

7.1.2 Regulation of technology - the theoretical framework

Technology and regulation are often looked upon as adversaries, with technology symbolising markets, enterprise and growth and regulation representing government, bureaucracy and limits to growth. Wiener (2004) concedes that to some extent this conflict is inevitable. Regulations do exercise considerable influence on the rate of technological change. However, it is also argued that newer products and devices are safer and less polluting so any regulation meant to reduce risk should not inhibit new technology. In this way regulations could contribute to conserving resources and giving innovative edge. In a global scenario like that of shipping, one fall-out is that if the technology move is costly, the economically advanced countries that regulate first take the lead in selling new technologies to countries that follow. It is often reported that it is this club of economically advanced countries and the body of technology suppliers who enjoy consultative status at

the IMO which dominate the proceedings in pushing the technology agenda. Often this is done behind the shield of safety enhancement that finds appeal and ready buy-in. This quite conforms to the leading theory of regulatory politics that concentrated industry groups could capture regulation and bend it to serve their own interests (Wiener, 2004). These suppliers put up a barrage of prominent eye-catching graphics extolling the virtues of technology and it takes a while to scratch beneath the surface to discover a slightly less enthusiastic take on the matter. In a bid for exclusivity on products supply the user's perspectives or need for standardisation are found to be overlooked with the self-serving objectives.

It thus calls for exercising care and caution in framing regulations. Indeed there can be more imaginative ways of rulemaking and it is not necessary to view its impact on technology integration as straightforward accelerating or retarding the initiative. Different regulatory mechanisms do exist like performance standards, management system requirements, taxes and incentives, tradable allowances, information disclosure etc. that can effect differently and influence consequences. Thus for example, a technology requirement approach may turn out to be less effective at stimulating technology change than a performance standard or tradable allowance as in carbon emissions. If say scrubbers were mandated for washing off the sulphur-di-oxide emissions prior to its release to atmosphere, firms would have lesser incentives to invent better methods. The Goal Based Standards (GBS) approach now being adopted by the IMO is one such example where the IMO would state what has to be achieved, leaving classification societies and ship designers the freedom to decide how best to employ their professional skills to meet the requirements.

Another major development is the regulatory impact assessments to forecast the impacts of new regulations before their enactment through Formal Safety Assessment (FSA) thus encouraging regulatory innovation in testing alternate designs of technology and regulation and selecting the best. The IMO is seen to be adopting this of late that promises enabling balance between various technical and operation issues, including the human element and between safety and costs. However, as yet there are few empirical investigations of actual impacts sighted.

A strategy much used particularly in the area of environment protection is “technology forcing” where the regulator specifies a standard that cannot be met with existing technology, or at least not at an acceptable cost (Gerard and Lave, 2005). The intent is to elicit advances in technology and force firms to invest in R&D, whereas firms want regulators to delay or relax standards. The outcome of such conflicts then determines the rate of technological innovation and its diffusion. This option may enjoy more political support than others like gasoline taxes. The IMO in its efforts towards mandatory energy efficiency measures for international shipping is seen to embrace this approach with its Energy Efficiency Design Index (EEDI) for new ships along with its set of guidelines. A more tempered approach is with the Ship Energy Efficiency Management Plan (SEEMP) that uses the management system approach and provides a mechanism for operators to improve their energy efficiency of ships over time.

7.1.3 Self-governance

The regulatory framework in the shipping industry in practice extends much beyond the IMO and flag states. The fragmentation of the industry and the range of organisations and

decision – making structures involved can be illustrated by the typical example of a German owned ship flying a Panama flag, manned by Indian officers and Filipino crew carrying Saudi crude oil to Japan. The ship may be classed with the Norwegian classification society, have her hull and machinery insurance placed in London and her cargo insurance in Paris.

With such a multitude of stakeholders of different nationalities, the regulation of the shipping industry is inevitably complex. There are then intra- and inter-organisational relationships within and among the various members of the global maritime community. These intermediary organisations also interact to form both systems of self-governance and private systems of governance. Examples are the International Association of Classification Societies (IACS), International Association of Independent Tanker Owners (INTERTANKO), International Association of Dry Cargo Ship Owners (INTERCARGO), etc. Porter (1995) points out that INTERTANKO is a good example of self-governance where membership is subject to a number of requirements, and members found not in compliance may be expelled from the association. Classification Societies, Marine Insurance companies and Protection and Indemnity (P&I Clubs, who are concerned with safety of crew and integrity of cargo), also have the ability to set standards of accountability among ship owners and ship operators (Fueger, 1997).

Social rules, practices and standards of accountability characterise an industry at any given time and have as significant an impact on safety and environmental protection as traditional command-and-control regulations by the State that rest on tacit assumption that government regulations are the only source of accountability. Self-regulation is in fact a notable trait of

professional organisations. The French sociologist Emile Durkheim's discussion of intermediary organisations analyses business groups and states:

Neither political society in its entirety, nor the state can take over function of rule-making as the economic life in its specialisation grows more specialised every day and escapes their competence and action. 'An occupational activity can be efficaciously regulated only by a group intimate enough with it to know its functioning....' (Durkheim, 1933:5)

In the maritime industry it was the insurance sector that created the classification societies as a way to reduce uncertainty and to manage marine risk. Many classification societies have now assumed statutory functions on behalf of flag states thus blurring the distinction between intermediary institution and a system of self-governance. Abrasions in as much as lowering of standards have been noticed though, because classification societies are not monopolistic and have competitive practices, a trend noted in times of sluggish demand for ships when ship owners in a bid to cut operating expenses engaged in 'class hopping'. Also a case in point was the use of high tensile steel and poor design produced by shipyards that led to a number of bulk carrier losses in the mid-80s (ABS, 1992; Intercargo, 1995). However it is notable that the marine system of governance has displayed a surprising ability to address its own institutional failures in a timely manner. Marine insurers being institutional counterparts to classification societies, could force ship owners to be registered with reputable classification societies to obtain adequate insurance and a superimposed system of self-governance in IACS came to be exercised (Furges, 1997). IACS adopted developing Common Structural Rules (CSR) to remove variations and achieve consistency, and further to be incompliance with IMO's Goal Based Standards. This changes the

century-long practice of independent classification rule making and also marks a significant step taken by IMO, as it has never been involved in the past in the detailed convention requirements for the structures of the ships (Kim, 2005). The IACS press release of 2nd July 2012 confirms the placing of draft IACS harmonised CSR on its website and states that the harmonisation project is also set out to achieve full compliance with the IMO's GBS which comes into force in the middle of 2016 (IACS, 2012).

There hence could be more such initiatives of self-governance in place of the ineffective regulatory regime.

In summary, in a global shipping environment with fragmented structures of organisation and split incentives for number of stakeholders in a venture, if regulation, as it strongly emerges, is to be the basic means of driving technology uptake, then it is calls for far more caution and imagination in its making and its implementation.

7.2 Unscientific approach

Another key finding of this study had noted that the root cause of many challenges with poorly integrated technology had been the very unscientific approach in its induction and integration into the operations and management practices. Reactionary compliance culture that so dominates the industry has the fall out that any progress is then driven largely by findings of accidents and incidents. It is here that one has a fleeting glimpse of the less orderly mix of technology and science. However, since it is seen this way only around accidents, one tends to believe that in normal cases the practices are more orderly, failing to see that the seafarer as operator makes a construct of workable technology alignments even

with malfunctions and deficiencies. In effect this becomes a reckless and irresponsible judgement call on the part of those in-charge taking failure within 'acceptable' bounds. Thus failure gets redefined and abnormality becomes the new normal and evolving practices then make operating rules which in time get recapitulated into updated formal codes of practice. It is least appreciated that evolution of such operating practices has resulted from the practical contextualisation of technology that the seafarer copes with and is a steady accumulation of empirical experience by precedent of the technology-social structure paradigm (Wynne, 1988).

Shipping has been seeing a conflict in the approach to technology with the policy field being dominated by the premise that treats technology as autonomous with the non-social domain. Technologies are evaluated by their external effects or risks alone and not by the relationships which are intrinsic to them. The concept of technology as social organisation has been far less influential, that examines the design needed to ensure technology's overall viability. These questions have at best been haphazard and vague and a better focus is accorded by examining the need to apply the sociology of scientific knowledge to a better understanding of technology for its application in shipping (Perrow, 1984).

The socio-technical system that constitutes and characterises the work in the shipping domain has ingredients in humans (e.g. crew members), groups (e.g. the crew), technology (ship, instruments, equipment), work practice (procedures, convention, traditions), organisation (management, company culture, pressures etc.) and work environment (light, noise, vibration etc.). A breakdown in the socio-technical system could be related to or caused by poor design of equipment (human-technology), inconsistency between work

practice and written procedure (work practice-organisation), crew stress caused by company pressure (human- organisation), poor communication between crew members (human-group) or fatigue caused by vibrations or noise (human-group-work environment) (Koester, 2005). The academic literature review and empirical findings of this thesis provide ample evidence of this fact. The network is illustrated in Figure 15.

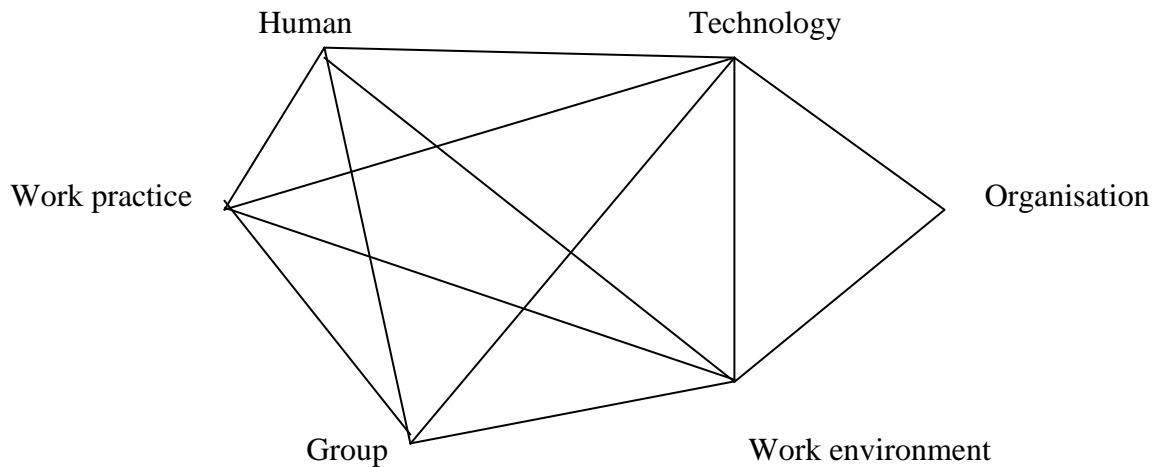


Figure 15: The socio-technical network. Source: Koester, T. (2005).

A typical case of optimisation recommended by Goulielmos and Tzannatos, (1997) for ship's bridge operations illustrates the application of above concept. The bridge operator's knowledge and skill together with his psychological and physiological capabilities get enhanced through measures on following three aspects:

1. Ergonomic aspect:

- physical optimisation of bridge environment, i.e. illumination, temperature, vibrations, odours, noise.
- design of controls, equipment, systems and work-stations based on analysis of anthropometrics

2. Organisational aspects:

- allocation, sequencing and scheduling of tasks, work and shift cycles,
- improvement of organisational attitudes and goals and practices concerning safety,

3. Personal aspects:

- improvement of psychological and psychological conditions like vision, audition, information processing, skill level, expertise and manual performance,
- compatibility of person and environment through safety motivation, high level of training and practice, optimisation of work-load, and control of types and level of stress.

The bridge operator's capability is critical to shipping safety because they still exercise judgement and decision making. However, the findings from this study showed no evidence of the practice of technology integration in the shipping industry taking into account ergonomics, organisational or indeed personal aspects involving the operation. Lack of any such scientific approach in technology integrated bridge operations as an example then manifests into its many challenges as identified in the findings.

What restricts the adoption and application of such a scientific approach is arguably the politics of regulation at IMO that gets so dominated by the group of technology manufacturers each proclaiming its many virtues, but seen to be evolved devoid of holistic scientific research into its ultimate application in the unique working environment of a ship. The fragmented structure of the globalised industry with many actors and stakeholders in a common venture of a typical sea voyage as seen in the findings, affords no real incentive to further the proper and scientific research and development agenda for the industry. The technology that gets pushed in with such a lack of concerted approach remains largely un-optimised even counter-productive as is seen with the many challenges in its operation and management.

As such verifying the ways in which regulation of technology uptake was introduced to the industry was beyond the scope of this research. Debate in the wider academic literature (Gereffi, 1999; Kaplinsky, 2010) however suggests that private commercial players involved in selling technology or indeed in other forms of business are driven by sales figures, which is a measure of penetration into the market and increasing their share of the market. Particularly in technology related markets the producer-driven commodity chains use barriers to generate returns from scarce assets that arise from asymmetrical access to key products and process technologies. Consultation on the usability of the product involving the end-user issues is seldom given top importance. Issues involving physical optimisation of the work environment, anthropometrics and psychological conditions demand a high degree of R&D involvement and commitment from the private company players. In the current market driven business environment such investment both in terms of commercial resource and long-term engagement with users are unlikely to be voluntarily

complied with. In view of this greater regulatory control is often seen as the only alternative.

Arguably in order to stem this route of ineffective implementation of technology on board ships there is a need for greater degree of regulatory control at the top level. The current arrangement and the level of supervision from the regulators expose lack of appreciation and/or involvement of the ways in which the commercial players influence the adaptation of technology. Perhaps what is required is to take into account the various usability concerns before manufacturing and selling their products to ship-owners.

This issue is further explored in the following subsection.

7.3 Why limited human factors engineering (HFE)

Another causal factor for the various challenges in technology integrated operations was found to be poor adoption of human factors engineering (HFE). HFE brings to design engineering concerns about anthropometric limits, visual and motor sensitivity, cognitive capacity and memory limits, and workload capacities. With this missing, the design engineers are unaware of the organisational context in which the operator functions.

The cause for neglect of HFE in design rests with the users and consumers of this design, who in shipping either make the design in-house or specify them to the vendors who produce them. The empirical data reveals that they do not want to be bothered with them and are also incapable of appreciating them. The influencing factors of low cost economic logic that dominates this sector of transportation industry coupled with the volatility of the shipping business restricts committed technology integration and many ship owners end up

as mere asset players playing the cyclic market with frequent buying and selling off of ships or moving them through third party managers and flags with the sole aim of profit making at any cost. The consequences are borne by the operator seafarer. Short of a well-publicised catastrophe, the design engineer will probably never know the consequences of his or her design, and the top management will hear of it faintly and not until the next project is already under construction. They do not hear because as is seen earlier, the costs are borne by those who must make the system work on a daily basis. The operators' argument that it is poorly designed is judged by everyone else as self-serving.

Traditionally the design and operating logic are to some degree contradictory. For instance, a good design is compact, but from an operator's view point there must be easy and logical access to controls and to system-state information as well as easy maintainability. A good design would favour a dedicated single-purpose information source and control, but a safe and flexible operation may require many entry points into the system for confirming information from different sources.

HFE as a discipline is fully engrained into other high risk industries like aviation, but rarely talked of in shipping, even in formal accident investigations. The prevailing view is that failures are the result of operators' errors rather than design engineers or top management. HFE on the other hand talks of design-induced errors or 'forced errors' due to circumstances. Assigning 'human error' as the cause is not only convenient from liability and insurance point of view but also wards off the despair in connection with systems which can have catastrophic potential. Otherwise it may lead to conclusion that if we cannot engineer safe systems then we should not build them. Furthermore, it is also argued

that managers largely subscribe to the human error theory that assumes workers behaving irrationally or wrongly applying the rule or plain being unmotivated as main cause for workplace accidents and incidents. As a result the corrective actions get directed to tackling seafarers' behavioural attributes rather than the root cause of accidents (Bhattacharya, 2009).

HFE is thus more tolerant towards operators than the design engineers or top management. It can identify deceptive error inducing control panel designs, task overloads and difficult system comprehension that produce forced errors. Coupled with operational pressures such poor designs encourage and necessitate overriding conceptualised procedural safeguards (Perrow, 1983). As technological systems increase in complexity, the gap between the human operator and technical system tends to increase as well. Occupational ergonomics as interplay of human, technology and organisation in the process of design and organisation of tasks and work environment is an area much neglected in the shipping industry and as Osterman (2012) suggests, it is an area of potential to develop in the effort to optimise maritime operations.

7.4 Why limited user perspective

Yet another causal factor resulting in many challenges of ship operation has been identified as inadequate user perspective in the design of technology integrated devices. In considering the drive for efficiency, it is important to understand both error and resilience, and to consider in greater depth, the role of human interaction in the socio-technical system of the ship operating in the global maritime complex.

Usability is now widely recognised as critical to the success of an interactive system or product. It renders increased productivity as it allows the user to concentrate on the task rather than the tool. The achievement of usability within system design requires a combination of the following (WMU, 2012) all of which have been the empirical findings of this thesis as discussed in chapter 6:

- a. Careful planning of the human-centred design process
- b. Understanding the context of use for the system as a basis for identifying requirements and evaluating the system
- c. Understanding and specifying user requirements in a clear manner which can be assessed for achievement.
- d. System and user interface development based on an iterative approach.
- e. Utility evaluation based on both expert and user testing at appropriate points.

In the compliance culture of shipping, the classification societies' requirements that dominate the industry always viewed the ship as a system and never focused on the seafarers or their operating environment. There are occasions where the operating environment makes it difficult for a ship's crew to achieve the desired compliance standard expected by a classification society (Goss, 1991).

The governing boards of classification societies do not have representation of seafarers or people who use their services. Rather it is the ship owners, ship builders and insurers that dominate the board. This may tend to bias the focus of the classification societies towards the interest of its constituent members. Furthermore, no system of feedback exists from seafarers direct to classification societies when they face undesirable outcomes. This results

in a situation that only takes into account the ship owner's view who is the prime customer for the services of the classification societies and procedures may get biased towards economy of operations rather than safety.

It is also noted that most of the interaction that the seafarers have with class surveyors is at the busiest times of operations in port and also the focus is on compliance lest seafarer be rewarded negatively, and this makes him take up a yet more defensive attitude.

Another reason for a lack of user perspective is the fragmentation of stakeholders in the industry as highlighted earlier in the chapter. With the flagging out of ships to FOCs and resorting to cheaper crew recruitment from crewing agencies, there is a sense of dislocation and distancing of the seafarer from the managing entity of the ship. This leads to dysfunctional communications between the two, further aggravated by their cultural differences. The perceived distance seems smaller rendered by advanced communication and results in excessive control by the shore staff and its related consequences as noted in the findings. There is a sense of loss of autonomy on-board, excessive paperwork leading to fatigue and worse still is the sense of mistrust, being used as a scapegoat in fixing accountability thus exacerbating the ship-shore divide. The empirical findings had suggested shore management exercising a panoptic control over the ship operations in the wake of advanced technologies. It may be reiterated that the origins of panopticism were as much in social architecture – in a concern for the criminal and the vulnerable – as they were in prison design, as a compact model of the disciplinary mechanism with the ever-visible inmate always the object of information, never a subject in communication (Foucault, 1977). It however evolved to a more generalised model as an expression in a pure form of a

realisable technology of power to maintain a general reign of docile subjectivities, doomed to fail (Boyne, 2000).

The Danish Maritime Authority (DMA, 2011) report on administrative burdens¹⁹ on seafarers, points out the lack of responsiveness on shore side to look into the consequences of new paperwork and procedures introduced on vessels with not enough channels for communication and also not much cognisance taken of them either. The result of such a dysfunctional feedback mechanism is a feeling of alienation to the rules and procedures especially those constructed in office and far from the reality of the seafarer.

With limited user perspective, the top driven technology application finds greater resistance and limited influence particularly in the shipboard environment that demonstrates a strong sense of a community of practices. Individuals in the community held together by informal relationships through which they share identity, unity of purpose and shared experiences within a particular domain of knowledge that develops perspectives, practices and approaches (Wenger, McDermott and Snyder, 2002) get much amplified given the ship's geographical isolation, tough work environment and further accentuated by the sense of alienation from own management ashore. The strength of communities of practise lies in providing the much needed psychosocial elements that make up the knowledge management (Rivera, 2011) and a perceived ship-shore divide does not particularly help in

¹⁹ In this study burdens are defined as administrative work which in the opinion of the seafarer is not adding value proportionate to the resources that the seafarer will have to put into the work to comply with specific rule and requirement. The burden is thus work that does not make any sense to the seafarer and which causes frustration and affects both efficiency and job satisfaction in a negative way.

effectively managing a knowledge base with a deficient cultural and behavioural dimension.

In view of the hardened community of practice matured over time in a unique work environment that is difficult to penetrate, there is possibly a need to reconsider the evolving framework of technology integration on a platform of an ‘emerging’ community of practice that embraces the technology enabled shore based organisation into the fold. As Lesser and Storck (2001) confirm it is indeed such a platform that will encourage creation of trust and mutual respect and the formation of another common language and context among members of the evolving community. Creating a newer community of practice as a paradigm to create and disseminate knowledge is also recommended by Easterby-Smith, Snell and Gherardi (1998) as such communities then have a clear understanding of the knowledge domain in their organisation and represent an excellent mechanism to help companies in transforming tacit knowledge to more explicit. It will be necessary to know how the human beings at both ends of the ship-shore communication construct knowledge in social and dynamic interaction that will create an environment which will lead to continuous learning in an organisation (Lave and Wenger, 1991). However, as Liedtka (1999) cautions, only communities operating on good value systems will encourage organisation learning and practices to be grounded on goal congruence basis among all members as a primary value, and keep them nimble to adapt to continuous change.

The above discussions highlight the underlying causal factors of the challenges to effective technology integration and accounts for the persisting gap in the intent and the outcomes of such integration.

The data findings in section 6.8.2 however showed that there is no dearth in technology appetite from a shipboard standpoint. So also it noted that the shore based management was convinced of the potential of proper technology integration delivering on value additions. The following section develops on the empirical findings of suggested potentials in specific areas and substantiates this view.

7.5 Optimisation potential and its value proposition

The data findings had exemplified substantial optimisation potential particularly in the process of monitoring of fuel consumption and vessel performance. As the review and analysis progressed interplaying the exchange of ideas within the case studies, a focus on reengineering of this process to eliminate, combine, change sequence, simplify and then apply the improvement strategy emerged. Process reengineering with its principles in a systems approach affords waste elimination, simplification, integration and automation, a theme found to be central to the perceived challenges in the empirical findings. Effective reengineering is seen to be enabled through modelling of processes that provides visibility to the process. Froholdt (2012) explains that in the academic disciplines of investigation in human factors, the role of design draws upon and contributes to engineering approaches for systems analysis and modelling. Furthermore, the representation of information flow between people and technology as used in process modelling draws upon and contributes to computer, communication and information science. In cognitive engineering, analysis and modelling techniques are applied to inform the overall design of human-technology systems.

Jackson (2000) draws on the respective strengths of the social sciences and systems traditions to further enhance their working together and argues that in the area of practical task of managing problems and bringing about change, this approach is very strong. Such an approach encourages analysis of the needs and expectations, in this case of the charterers and ship owners, definition of the processes to enable contribution to the outputs, and also keeps the processes under control. It thus provides a good framework for driving improvements and optimisation and increases the probability of enhancing the satisfaction levels of the interested parties. It is a powerful way of organising and managing activities to create value for the stakeholders.

Another major advantage of this approach is in the management and control of the interactions between these processes and the interfaces between functional hierarchies of the organisation, typified in this case as shipboard functions and shore based organisation. It introduces horizontal management, crossing the barriers between different functional units and unifying their focus to the main goals of the organisation. It also improves the management of process interfaces.

Reengineering of the process of ‘Monitoring of fuel consumption and vessel performance’ on the above principles is thus envisaged to render the following advantages:

- (a) It would establish transparency. The charterer who normally pays for the fuel costs can directly access real-time fuel consumption from the machinery and there is no need for reporting on the same either by the ship’s staff or more conventionally by the technical managers ashore, giving rise to doubts on covering up for inefficient excess fuel consumptions.

This in turn would afford excellent relationship building between the charterers and ship owners / ship managers, which is a key component of shipping business. This business is not a one-time transaction but a continuous interaction upon which stable, long term relationships are built. ‘Trust’ being inherent to relationships, comprises perceived integrity, willingness to reduce uncertainty, expertise, congeniality and timeliness (Panayides and Gray, 1997).

Furthermore, Jessen (2003) researching on the innovation led competitiveness of the Norwegian shipping industry, reports that a strong relationship with demanding customers is important for driving innovation, and that experts ranked this as the most important factor for innovation in the shipping industry. Many services created by the company were in response to and with close cooperation with customers, which then creates crucial value for the business.

(b) Elimination of paperwork and avoidance of duplication of paperwork. The daily, monthly, and voyage reporting need not take place between ship and shore thus much reducing the workloads on ship staff thus lessening the administrative burden as the findings had conveyed.

The ship staff would get more time at hand to focus on tasks demanded of efficient watch-keeping that otherwise would go wasted in manual checking of fuel consumption, analysis of performances and reporting of data to shore based managers. Data management becomes easier with utilities like on-line entry of data, single point of storage, automatic logging of all technical data and data being conveniently available in remote offices for usage. The whole process of information exchange becomes more efficient, reliable and accurate. The

ship operation and management as well as the ship-shore cooperation would become much more efficient in timely, reliable and accurate data and information exchange with the shore based management and other interested parties.

It would render easy application of data analysis tools for driving efficiency, in as much as making available data archive for decision support systems. It would also afford compatibility for data transfer to other systems for usage and it also could provide truthful evidence in case of disputes.

All the above factors are seen to contribute immensely to the employee well-being on the ships. Although there is no generally agreed definition of employee well-being, theory and research has focused on topics such as physical and mental health, job satisfaction, employee morale, stress, motivation, organisational commitment and climate (Grawitch, Gottschalk and Munz, 2006).

(c) Definitive cost advantage would accrue because of:

(i) Savings in fuel consumption.

(ii) Reduction in off-hires and charter disputes. Charter disputes frequently occur on account of causes attributed to discrepancies in fuel consumptions against as agreed in the charter party document.

(iii) Reduced communication costs

(iv) Time savings that accrue in the process of data collecting and reporting.

(d) Improved compliance to energy efficient operations requirement and greenhouse gases emission.

All these above factors are seen to be readily addressed by this reengineered process and opined so by the case study participants who confirmed that, that was the way forward, in some form or other.

Furthermore, recent relevant literature too has been found to report advancements in similar directions using similar methodology. The World Maritime University (WMU, 2012) notes the Vessel Performance Management Service (VPMS), which is a decision support service for monitoring and controlling fuel efficiency recently introduced by Maersk line. This service is based on the ship's daily reporting of operational data, and is designed to optimise the operation and technical management of hull, propeller and main engine performance and voyage efficiency. The system provides daily reporting on a range of performance metrics including hull and propeller performance, lubrication oil performance, voyage abstracts and statistics and the vessel's operational efficiency. Some key metrics such as main engine SFOC (specific fuel oil consumption) performance, main engine load profile, and emissions are calculated dynamically and in real-time.

Relevant to this context is an important study by Liang *et al.* (2010) who conducted a meta-analysis of 42 published empirical studies to examine how different factors from the resource-based view affect firm performance. They contend that it is unclear whether a direct relationship exists between IT resources in organisations (as those that could be used in the above process reengineering) and their performance; hence they adopt an indirect model using a third construct -organisational capabilities as a mediator between resources

and performance. Organisational capabilities refer to the ability that an organisation assembles, integrates, and deploys its valued resources to build unique competencies, deal with environmental changes and management challenges. The major argument is that IT resources can enhance organisational capabilities through integration and synergy, which can then improve firm performance.

The distinction between resources and their capabilities is that: a resource is an observable (not necessarily tangible e.g. software) asset that can be independently valued and traded, while capability is unobservable and hence necessarily intangible, cannot be independently valued, and changes hands only as part of its entire unit (Makadok, 2001).

Liang *et al.* (2010) further state that technological resources can significantly improve organisational capabilities. Its impact on both internal capabilities, i.e. ability to utilise resources that can enhance internal control, strengthen cooperation, improve capacity of system and deployment; and external capabilities, i.e. ability to adapt to external environment, facing the market and customer needs; are again positively significant and affect firm performance. Furthermore, organisation resources positively affect organisational efficiency through its impact on internal capabilities.

This distinction helps the appreciation of the optimisation potential that is envisaged in this section and shows that there is scope for optimisation of management processes through proper deployment and integration of technology in the critical ship-shore interface process.

The next chapter now draws out the conclusions of this research.

Chapter 8: Conclusions

After discussing the causal factors of the challenges with technology integration in modern ship management practices and elucidating the optimisation potential, this chapter sums up the overall findings of the study and rationalises the gap in light of prevailing theories and framework generally applicable across industry sectors. It then makes policy recommendations towards addressing these gaps as a way forward for the shipping industry. Finally, it reflects on the methods and contribution of the study before acknowledging its limitations and suggesting further work.

The pace of technology invasion in shipping operations had picked up significantly since the early 1990s. Unmanned machinery spaces (UMS), as a Class notation was already existent for many ships even then, precluding the necessity for a qualified engineer to man the machinery spaces 24 hours in constant attendance. Global Positioning Systems (GPS) had revolutionised the conduct of navigation since then. Satellite communication systems had made the position of Radio Officer on-board ships redundant. Planned Maintenance Systems (PMS) as a software based system greatly aiding technical management was already making inroads. Yet the industry was plagued with issues such as fatigue, administrative burdens and technology assisted accidents. While technology advancements were designed to be contributing to minimising task complexity and in mitigating human errors, it had created new problems in human-machine misfits. The user system interfaces were not aligned with actual usage or need in specific contexts. Clearly the process of technology induction and integration into modern shipping practices was wanting, that was leaving a large gap in its intent and delivery on performance. Questions were raised guided

by the review of the literature which led to the development of the main enquiry - *What are the challenges and potential of the technological advancements and its application/integration in modern ship management practices?*

To be able to answer the research enquiry comprehensively, a case study approach was adopted using semi-structured interviews, group interviews, observations, analysis of documents as basic research tools as described in chapter 5. The research studied the induction and integration of technology in the technical management systems of the company that primarily interfaced closely with the ship and was central to management practices. Three companies of mutually diverse ownership and operation structures impacting technical management were the cases studied. The fourth case comprised of interviews using purposeful selection technique of senior ships staff that enriched the study with the important shipboard perspectives. The analysis and synthesis of data has led to the key findings constituting the challenges and potential of technology integration into modern ship management practices along with their underlying causal factors. The following sections provide the concluding perspective.

8.1 The technology integration gap

This research has shown that the seafarers who are at the cutting edge of delivering on ship's performance for the shipping industry are not in the least averse to technology integration. There is no vacuum towards this initiative from the shipboard standpoint. For example during the fieldwork of this study the enthusiasm towards handling the latest technology that in particular reduced their administrative burden or made operations easy for them was amply discernible. So also their vehement assertion of the existence of large

potential for optimised operations through enabling technology that could also enhance their own safety further affirms the notion.

However the evolving structure of the industry under the influence of forces of globalisation in which it exists, are seen to create failures and barriers in its holistic and well founded implementation. The main challenges thrown up due to this scenario were seen to be as below:

The main drivers for technology uptake were seen to be more as a reactionary stance of compliance to the requirements of regulations and customer directives rather than a proactive initiative as a value proposition guiding organisations towards satisfied constituents and sustainable value creation.

The economic logic of low cost operation underpins every technology change decision and the cost-benefit analysis remains myopic to short term financial returns on investment. The ship manager, in keeping to business objectives fails to undertake any initiative on technology implementation and is driven by the regulatory demands. As a result such implementation takes the shape of mere incremental advancement without considering its design, operational constraint or impact. The regulatory drive in turn originates from the business initiatives taken by the private entrepreneurial organisations promoting such technology without any in-depth understanding of usage circumstances. This technology push is largely proposed keeping in mind the need for greater safety in industry operations. Thus the need for enhancing safety in the industry is made to take the centre stage, which being a safety critical industry cannot ignore. The concept and the scope of technology integration are largely drawn from similar forms of technology already in use in other

industries. The literature review showed evidences of a far greater degree of technology interventions in industries such as aviation, medical sciences and process industries, but as compared to shipping industry the interventions in such industries were based on a much more robust fundamental research application (Perrow, 1983).

Some of the features of the shipping industry which are not directly connected to the implementation process of shipboard technology nonetheless have a profound impact on the final outcome. The industry's fragmented structure fails to encourage any such holistic and concerted approach to technology integration. It is seen that in the globalised shipping environment there are a myriad of actors in a common enterprise. This gives rise to a split-incentives phenomenon. The ship owner, particularly if he himself is a mere asset player who finds himself not reaping the full benefits, with the ultimate beneficiaries of technology change being many other actors in the business. The fragmentation and lack of genuine interest in the value of technology implementation is then reflected in the way in which it is implemented and operated in practice. Not much attention is paid to whether such implementation benefits the operators or not but what was evident from the study was that such implementation was seen as a cost and the management were keen to see that its immediate benefits were realised. The reduction in crew size is thus considered as a natural and inevitable corollary as it is equated with the cost that needed to be recovered due to implementation of 'expensive' technology on ships. Arguably in some cases the implementation of technology in this way is seen as a good return on investment and the implementation of technology itself is a ploy to reduce expenses on manpower.

Technology excuse thus gets pushed to reduce on-board crew numbers below the optimum. This gets coupled with a lack of learning opportunity and experience in an automated environment which then proves risky in situations of abnormality or emergency. Also often the seafarer who is not an electronics expert is ill-equipped to handle automation faults. Thus reduced and inexperienced crewing only adds a layer of complexity adding to seafarers' stress and fatigue. Skilling issues prevail within the industry which is left grappling with the up-skilling/deskilling dilemma in light of poor technology integration. It is seen that while technology intervention incentivises crew reduction and allows for a cheaper deskilled workforce, in reality poorly integrated technology integration demands placing up-skilled and not down-skilled shipboard workforce. In practice abnormality and emergency, even occasional technology failure demands highly skilled crew to be able to adequately respond to out of the normal operational needs.

What was also evident from the study was the technology aided panopticism of the shore based management which proves detrimental to independent and trustworthy work environment on-board ships, thus exacerbating the traditional ship-shore divide. The study showed that the application of technology was interpreted to the advantage of the management to the extent that it was felt that in practice the usage of technology is skewed to work largely for the managers. It was used for improved flow of instruction from the managers to the ships and for monitoring work output of seafarers. The work environment of the ship in itself is considered challenging enough, and on top the poor considerations of socio-technical systems in the technology integration process involving ship-shore interface only exacerbated such divisive feeling. The dominating and controlling stance of the shore management engendered a sense of apathy and reluctance among the seafarers. The critique

of panopticism in organisational theory draws attention to the inevitable interrelationship between power and resistance, and also to that between capital and control, which may not work when applied in a much concentrated form (Boyne, 2000). The seafarers thus felt undervalued and mistrusted and tended to perceive shore management as cunning even immoral that tried to fix liability on them. This again was largely a consequence of poor consideration of social factors in technology integration process that eroded mutual trust and respect. The underlying reason for why seafarers were not considered as a key player in the introduction of technology arguably relates back to the fact that technology adoption was a reflection of mere regulatory compliance and an act that only had to satisfy immediate economic rationality.

The design of technology remained alienated from the operation function. It is acknowledged that the design stage itself is the most crucial stage to address the functional requirements direct from the user perspective and all the principles of human factors engineering can if at all, find its most worthwhile application at this very stage. However, as evidenced from the findings, this aspect did not find visibility in the shipping domain, where design was seen as technology-led rather than design-for-use (Allen, 2009). It led to non-standardisation and poor integration of equipment into work systems but without integrating human characteristics into its definition, design or development. Even the quality of assessment, type approval and certification of such interconnected systems by the approving authorities like classification societies was found to be inadequate and wanting. With operability hardly being considered at the design stage, it resulted in stress and fatigue for the operator even encouraging mistakes which no amount of training or management intervention can mitigate.

This research has further established that often over-reliance on technology crept into operation functions leading to reduced situational awareness, suspension of traditional seafaring skills and consequential enhancement of risk of accident. Although no direct evidence of a technology initiated accident was noted in this study it is not hard to see that the operator could be getting absorbed into technology overlooking its vulnerability and the need to treat it with healthy scepticism. It could be argued that such technology spawns a sense of over-confidence about the situational awareness inducing the seafarer to forego his core-competency skills, which in some scenarios could prove counter-productive.

Furthermore, this study shows that the investment in appropriate training of crew in handling integrated technology finds no ownership in the growing disintegration between the owner, flag, operators, managers thus blurring the link between owners and those responsible for the crew. The short-term contracts afforded minimal obligations towards the seafarer and the economic logic in a split-incentive scenario afforded the evasion of anyone baring the costs of any such training (ILO, 2001; Alderton *et al.* 2004).

Another discernible outcome of such blinkered application of technology led to information clutter in the management and operation of ships. In the management function of the ship-shore interface, the ease of communication afforded shore management to exercise excessive control by demanding documentary evidence from the seafarers resulting in the production of a plethora of paperwork. It is no surprise that the ship's staffs question the value of such exercises that adds to the administrative burden and diverts them from the main objective of running the ship safely. Many seafarers also perceived such top-down implementation practice as countering the use of their professional skills and experiences

embraced in proven good practice of seamanship (Knudsen, 2009). The study showed that in the operation of ships the un-optimised overload of information through poorly integrated operating systems puts greater demand on cognitive resources over-saturating the operator. The premise that automation reduces the workload thus remained an illusion.

Such forced implementation not only increased avoidable work load but was also perceived by many seafarers as countering the use of common sense, experience, and professional knowledge epitomised in the concept of seamanship. The strong community of practice established over a long period of time in a relatively secluded working environment made it harder to penetrate into and bring about any change with ease. It requires deft handling and as discussed, through a paradigm of an inclusive new practice with technology integration rather than such imposition.

In summation, the seafarers' attitude to technology integration is unequivocal. However, the economic short-sightedness of the split-incentivised industry operation totally ignores the seafarers. Bhattacharya's (2012) seminal findings reveal that ineffective regulatory infrastructure, weak employment practices, the absence of trade union support and lack of organisational trust in the shipping context manifests deeper sociological issues and organisational weaknesses in the shipping industry. Such concerns were the underpinning concerns in this study too. The seafarers' antipathy to un-optimised technology integration in the wake of his experience of enhanced control, mistrust and disrespect towards his seamanship, even his genuine concerns for safety were construed as rejections by the maritime business operating from ashore.

8.2 Technology integration gap rationalised

The above interpretation of the research is further analysed below. This section reviews and explains the gap in technology integration in the light of prevailing theories and framework of globalisation, neo-liberal capitalism, principal-agent theory, regulation of technology, socio-technical theory and community of practice. While these generalise across industry sectors however in the shipping industry due to its unique nature and structure, they are found to be highly accentuated. This creates the paradox of immense potential of technology integration failing to be taken up and manifesting as the gap.

It is seen that the globalised shipping industry environment affords no real incentive to the ship-owner directly for technology uptake beyond remaining compliant for business to run. The highly fragmented structure of the industry that is seen to give rise to split-incentive problem is akin to the principal-agent problem that is accompanied by a rich stream of theory and empirical research. Principal-agent theory premises that where parties have partly differing long-term goals, for example that they aim for profit maximisation in their respective companies, then market failure occurs (Johnson, 2013). There is then economising on bounded rationality while simultaneously safeguarding the terms of contract against the hazards of opportunism (Williamson, 1979).

The ship-owner only minimally complies with the technology that gets pushed through regulation imposed for safety, security and environment reasons, conforming to the reactive compliance culture that dominates the industry. This in turn is exacerbated when the globalisation affords the ship owner to *choose* his regulator in terms of the flag of the state he wishes the ship to fly. Guttal (2007) among many others has argued that globalisation is

a form of capitalist expansion that entails the integration of local and national economies into a global, unregulated market. Although economic in its structure, globalisation is equally a political phenomenon, shaped by negotiations and interactions between institutions of transnational capital, nation states, and international institutions. Its main driving forces are institutions of global capitalism, but it also needs the firm hand of states to create enabling environments for it to take root. Globalisation is always accompanied by liberal democracy, which facilitates the establishment of a neo-liberal state and policies that permit globalisation to flourish. Contrary to the development theories, be they ‘conservative, modernisation, or dependency theory’ that conceived development as ‘national development’, present notions underlying neo-liberal economic development being pushed through globalisation, re-conceives development as global competitiveness within the global market place (Onder, 1998). The neo-liberal freedom as a concept gets tied down to free markets where people are free so long as they submit to the dictates of deregulated free markets. Significantly, the race to the bottom hypothesis argues that states in their competition to attract mobile capital must converge to the lowest common denominator.

The extra-ordinary element for the shipping industry is the fact that the law of the seas is grounded in the notions of freedom of the seas with underlying principles of navigation of the oceans freely, a ship’s national state having exclusive dominion over that ship and no other nation can exercise dominion over that ship. The Flag of Convenience (FOC) phenomenon and later mimicked by the international registries that is encouraged in such an environment, shows the veracity of de-regulation of the marine industry. This conforms to the notion of globalisation theory put forth earlier and explains the minimalistic attitude

adopted by the industry regulators. The fact that an international regulation is enacted upon a nation by nation basis who remain keen to make their states an attractive choice as regulators, the sovereign privilege creates an unregulated environment where capital is free to act as it pleases (Alderton and Winchester, 2002).

In the global context, the policy making is seen to get politicised with a self-serving agenda of the constituent members of policy making bodies belaying the notions of any common good for the industry. The issue, particularly in safety-critical industry like shipping becomes that the dividing line between *social* regulation on health, safety, environment and *economic* regulation of technology gets blurred when technology is passed off as enhancing safety. The regulation of technology follows the leading theory of interests lobbying to shield business profits. The theory that it is the subgroups of the industry that drive technology in the garb of social regulation on safety, health and environment, do so to serve their own parochial advantage by raising rival firms' cost, endures (Wiener, 2004).

Munck (2002) had contended that globalisation combines several strands, such as the consensus among global economic policy makers who favour market-based development strategies over state-managed ones, the control of G7 states over global market rules, and the control of financial power in the hands of transnational corporations and banks to facilitate its implementation. Seen in this light, even the monopoly rights such as patents and copyright are strengthened to encourage innovation arguably become counter-productive. They not only become barriers to shared common ideas of standardised operation that plague the shipping industry as seen in this study, but also with powerful state actors pushing the policy making in favour of their own technology suppliers wards

off any competition. Stiglitz (2006) has argued that the developed world has carefully crafted laws which give innovators the exclusive right to their innovations and the profits that flow from them. In cases like pharmaceutical industries the costs go beyond money when access is denied to affordable lifesaving drugs and highly profiteering companies researching on lifestyle drugs rather than lifesaving drugs simply because the poor cannot afford to pay for the drugs. R&D intensity defined as the ratio of R&D expenditure to GDP is an important determinant of innovation. This is in excess of 4% in OECD countries with USA alone accounting for 41% in the OECD area gross domestic expenditure in 2009 (Dumont et al. 2011, OECD, 2011).

The discussion thus in part explains the lack of control from the flag states in the case of regulating technology implementation in the shipping industry. As flag states remain competitive in acquiring business of ship registration – especially those which are not so scrupulous and renowned for being under-resourced– a flag-state based control for the implementation of shipboard technology is unlikely to be effective. But what is equally striking is that the maritime states where such technology is being developed also fail to control the adoption and implementation practices of such technology. They refrain from interfering because by giving the freedom they are better able to promote home-grown technology manufacturers corroborating the arguments presented above.

Another causal factor for the technology gap is identified as lack of fundamental research into the technology integration in the shipping environment and paucity of appreciation of the fact that technology has always been the central variable in organisational theory guiding research and practice so evident in other safety-critical industries. Being an

extreme case of a globalised industry, the ship and the seafarer lie in the centre of a complex constellation of multiple interests. The contractual employment of the seafarer, his non-existent relationship with owner, mixed nationality crewing, and dysfunctional communication with managers find no support for him. What comes out glaringly is that the seafarer, who manages technology for optimum performance of the sole productive unit – the ship, and on whose performance the profiteering of the myriad of actors in the industry hinge, finds himself as the lowest priority.

The explanation once again lies in the outcome of economic globalisation that underpins the state–capital–labour relationship. The increasing dependence of national economies on the global economic flow of investments sees financial capital play off one territorial jurisdiction against another to gain optimum return including labour that is cheaper, more flexible and more easily subjected to hard work. As nations compete amongst themselves the content of their labour laws are watered down to the detriment of their workers including those that protect their rights (Servais, 2004). Even ILO (2004) has conceded that while there is improvement in global production systems, globalisation has impacted work and worker relations, compromising the observance of core labour standards. A growing amount of literature on social dimensions of globalisation shows that many are wary of the so-called benefits of globalisation (Jenkins, 2004; Servais, 2004; ILO, 2004). Labour fortunes are undermined by an ideological discourse that upholds profit as a sign of efficiency that will generate the required levels of productivity to sustain economic growth for national development. To succumb to labour demands or interests would render an economy inefficient and directed towards failure, thus making out labour ‘standing in the way’ of national progress if it insists that its interests should be considered. In this way,

while globalisation is about removing state restrictions on capital, it seeks also to control labour by making believe that social protection and job security are uneconomic and inimical to economic growth (Jenkins, 2004). Stiglitz (2002) asserts that such economic policies that purport to separate efficiency issues from equity treat labour as a commodity and runs counter to the interest of workers. ‘Labour market flexibility’ and ‘capital market flexibility’ appear as symmetric policies but they have very asymmetric consequences – and both serve to enhance the welfare of capital at the expense of workers. Lack of consultation with seafarers in the use of shipboard technology, discarding the user perspective in the development of such products and requiring seafarers to merely adapt and comply once the technology is implemented as this study reveals, can all be explained by the wider developments discussed above. It corresponds to the statements made earlier (Bhattacharya, 2012) of the shipping industry where a widespread *laissez-faire* approach has resulted in significant restructuring of its labour market to the detriment of the seafarer.

There is thus no concerted effort or interest or ownership towards long term and organised development. Any development is then left to be driven by reactionary situations of accidents and incidents which in the maritime industry have severe limitations in getting to the root of the causal factors to drive meaningful change. Worse still, there is a failure to see the seafarer coping with abnormalities and evolving practices that get built on this ‘new normal’ that even start defining *rule-making* practices. In complex systems, there are ‘latent pathogens’ normally tolerated in the system but ‘awakened’ by a specific situation and then create a causal link leading to an accident. The seafaring culture of ‘making everything work,’ as highlighted in this thesis and seen to be accepted by the organisation is a potent ground for harbouring such latent pathogens. As Wynne (1988) has argued, contextual

normalisation of working technologies takes place according to local rationalities but this fragments the overall social nature of technology while evolving its informal practical rules. A general perception remains that just before the accident everything was perfectly normal. Thus a holistic application of sociology of scientific knowledge in better understanding of technology remains stunted. Technologies get evaluated by their external effects or risks alone but not by the relationships that may be intrinsic to them. As science becomes an increasingly economic resource in industrial competition, the rush to exploit scientific knowledge as commercial technologies allows less time and social access in pilot phases. Thus wider systems problems arise often more acutely during the commercial lifetime of technologies.

Related to the above is the causal factor of limited end-user participation in the design and development of technology integrated functions. This effectively means that the knowledge and experience of the seafarer is scarcely entered into the information networks which inform the design process. There also is a lack of appreciation that end-users contribute important workplace knowledge on processes, tasks, equipment and potential risks. Ethnography with participatory user analysis of contextual enquiry does not find a place in the design considerations, which is a critical factor in the success of any interactive systems function. The most important objective is to achieve usability which is defined by Fiset (2009) as, "...the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a special context of use..."

Limited application of human factors engineering is then evidenced in the design and operations of technology integrated practice. The focus remains technology, engineering

and equipment rather than cognitive and social ability of operation in an integrated environment with due regard to human characteristics, limitations and the ergonomics. This thesis has investigated that the socio-technical theory as a systems approach focuses on the interdependencies between and among people, technology and organisational environment that provided the holistic construct. Clearly then, the socio-technical theory remains as valid today as it was in the 1950s. We continue to live in a world greatly affected by technology; so much so that we take for granted the choices made for us by the technical system designers. Today as in the past, the socio-technical paradigm calls on us to question the design assumptions underlying technical systems to ask, “Is this the best way to design and utilise technology for people and society?” So also, when attempting optimisation, to question “Have we assessed the degree of joint optimisation of social and technical systems in light of the demanding external environment?” Both the technical and the social systems must produce positive outcomes. This method contrasts with the traditional that first designs the technical component and then fits it to people, as is seen to be widely practiced in the shipping industry. The traditional method as seen often leads to mediocre performance at high social costs (Cherns, 1986). The cause lies in the organisational context of rewards and sanctions in case of high technology systems. The shore based management finds appeals of speed, power and manoeuvrability in current sophisticated design winning over concerns of ease of operation or maintenance. The costs in excessive fatigue and workload are borne by the seafarers who make the systems work on a daily basis as their feedback on poor design is judged as self-serving (Perrow, 1983).

This section has analysed the technology potential gap in terms of theoretical frameworks generally applicable in other sectors. But it is exacerbated in the shipping industry

environment due to its unique structure and disposition, which is why the un-optimised technology integration results in the seafarer who is the driver of technology, becoming a victim of the circumstances. The technology that was intended to ease the seafarer's operations and burdens ends up in controlling him, even leaving him under-resourced with fewer crews and causing fatigue. Influences of a strong community of practice then manifest his frustrations as resistance and hindrances to technology integration from the ship standpoint. There is a large gap in what seems technically rational in concept and intent and what actually gets implemented in the shipping industry.

8.3 Policy recommendations

It is seen that the uptake of technology in the first place is merely a reactionary response to compulsions of compliance rather than a proactive stance for driving efficiency. Hence, a responsible and risk-assessed regime of regulatory and customer requirements is thus seen to be the key driver in enhanced technology integration in modern ship management practices. If the potentials are there as seen to be, then it needs the attention of the policy makers' like the IMO, Maritime Administrations, Classification societies and industry organisations like Oil Companies International Marine Forum (OCIMF) and Society of International Gas Tankers and Terminal Operators(SIGTTO).What is fundamentally lacking is policy entrepreneurship that will encourage policy innovators who will develop and test new forms and approaches to regulation for greater effectiveness, less caustic side-effects, even less cost and promote other desirable attributes. Regulatory design should be about consequences – what works, how much, with what costs and side effects compared to the available alternatives. The influence of regulation on technology is complex and as

Wiener (2004) puts it, depends on the “technology of regulation” that aids governance - the actual design of instruments of enforcement.

There is thus a need for the rules to become more performance based with defined outcomes, rather than set technological solutions in a prescriptive format. This would also allay the view that it tacitly supports influence of commercial players in the adaptation of technology. Prescriptive regulations tend to be a distillation of past experience and as such become less and less relevant over time. It is the innovator that is best placed to ensure the safety of design rather than the regulator. Care should also be taken to see that the additional regulations do not add to the administrative burdens on the ships’ crew and calls for a user-centric approach in even designing of regulation in as much as the design and implementation of technology integrated practices. The user-centric approach puts employees in the centre where they play an active role in identifying potentials for rethinking of business regulation and how burdensome experiences can be reduced (DMA, 2011).

Furthermore, the industry needs to link humanism and effectiveness together in the design of work and work systems. This is best achieved if the specific design of human-machine interface (HMI) is incorporated and used by design engineers, given that a system’s architecture is driven by the design of its interfaces. A major component of many systems is people, who act as either users or operators or maintainers. Even a highly automated system requires people – at the least to start, stop and monitor the system. Often users and operators also perform service and maintenance on the machines. The term socio-technical system refers to the interrelatedness of social and technical aspects. Engineers are said to

ignore the social concerns of the work and social scientists to ignore technology. As Ropohl (1999) puts it, what is needed is the “technisation of the society and the socialisation of technology”, and a systems model is a tool that brings both sides together.

All of the above gaps stem from a lack of synergy between research and practice that results in the practitioners insufficiently aware of relevant research and at the same time research tends to be not sufficiently informed by the body of knowledge gained from practices. In the shipping domain particularly, there is a need to develop methods and tools to more effectively leverage the knowledge and insights gained from practice and improve the cross-dialogue between research (be it in other domains if it is lacking in shipping) and practice.

As has been seen, the large potential for the optimisation of processes that exists, needs to be harnessed by appropriately leveraging the technology integration in ship management practices. Companies need to take further steps beyond simply ‘going digital’. They need to improve the employees’ skills as well as to integrate technology into their business process and actually conduct business electronically. It has the potential to change the work processes significantly both within and between organisations, with very positive impacts. It may be reiterated that along with the concerns for human safety and environmentally safe operations the key dimensions of service quality for the shipping industry include operations and management efficiency. These are characterised by the outcomes of service performance and enabled by technology applications for process efficiency.

8.4 Overall reflections

It needs to be appreciated that the challenges and potential of technology integration into management practices ultimately translate into human performances. Human performances and human-system integration will never be effective unless it is seen by all stake-holders as an integral part of the entire systems engineering process, from initial exploration and concept evaluation through operational use, even reengineering; and be responsive to users' needs.

By bringing to light the limited application of some fundamental principles of human-systems integration and discussing the broad underlying optimisation potential of ship operations and ship management, this study has attempted to expand the boundaries of research on the subject in the maritime industry, in a way that both contributes to academic knowledge and has significance for those in the industry. It thus achieves the objectives that the study set out for itself.

Credibility of a study involves the level of truth value that it achieves by investigating the level of engagement which allows an analyst to build trust and learn about the setting under investigation. Adequate engagement was achieved in the settings of the three companies and the ships staffs' interviews. Verification of correct understanding and analysis was achieved from the respondents, for example on the process maps annexed in the appendices 1 to 4.

Due to the rigour applied in the application of appropriate methodology it can be claimed that the findings while emerging from the study of three specific companies do relate to the wider context in the maritime sector.

This study thus contributes to the better and holistic understanding of the impacts of technology integration in ship management processes and its productivity, thus providing a better picture of this take up in the shipping industry.

8.5 Limitations of this study

Nonetheless it must also be acknowledged that the study suffered from a few limitations.

As discussed in the chapter on methodology, primarily, it is acknowledged that the research approach and tools to some extent have been influenced by the researcher's pre-understanding. On a general side, a certain amount of pre-understanding entering a research project can be timesaving since the researcher does not have to read up on structures, procedures and other peculiarities of the industry which is being studied. It is also said to simplify acquisition of institutional knowledge, such as informal hierarchies, cultural values, social interactions and patterns that can otherwise be difficult to access (Gummesson, 2000). However, there is a risk that pre-understanding leads to preconceptions that can block new information, create bias and hamper creativity and innovation. This has been thoroughly acknowledged. Throughout the present thesis, the researcher has been aware of, and reflected on the subject of preconceptions, the risk for selective perception and personal defence mechanisms, values and beliefs.

By explicitly accounting for relevant experiences significant for the pre-understanding, and striving for a detailed documentation of the analysis process and line of argument, the researcher has aimed for a transparent research process and believes that it has compensated for any negative consequences of the prior knowledge.

Availing one or more research voyages on ships and undertaking on-board studies to know first-hand the shipboard aspects of cooperation with shore clearly would have enriched the account of the seafarers. Getting access on-board ship for a research voyage does not come by easily. It is ridden with complexities such as security considerations, accommodation and lifeboat capacity, insurance requirements, maritime regulations permitting a non-crew member to sail on-board. All these issues dissuade even a half willing company from going through the ordeal. This shortcoming was however anticipated in advance and data collection methodology was adequately strengthened with good selection of shipboard staff for interviews while they were ashore and through review of shipboard communications data in the shore based offices.

Another weakness of the present research is the lack of complementary quantitative study to test the potential of the proposed optimisation with external validity. However, that is seen as the natural next step where the present thesis work constitutes a robust base for the design of future studies in knowing what to measure and how.

Furthermore, generalisability or applicability problem arises with all forms of social research. As Guba (1990) comments, while qualitative studies have their own special ways of dealing with the problem none of which are perfectly adequate, but all of which add confidence to the conclusions.

8.6 Scope for further research

New technology deployment always carries the risk for the first time users and the industry normally waits and watches closely the developments before self-deployment. As further work to this research, ways can be formulated to subject the optimisation potential of holistic technology integration to further tests of validation and falsification. A complementary quantitative study using a model shipping company that shows the least traits of the vulnerabilities of the unique sector as a prototype can investigate the availability of data on optimised operations and empirically validate the suggested potential.

In today's world of competing financial priorities, the value proposition of improved technology integration and positioning the potential core values that can be delivered to employees, customers and other stakeholders within and outside the marine transport system needs to be further studied. Value propositions as part of operational strategy guiding organisations towards satisfied constituents and establishing relationship between commercial value generation and optimised technology enabled operations towards business performance should be the aim of such further work. Fine balancing of apparently mutually incompatible and divergent issues of cost, safety, regulation and efficiency within a sociological framework would need to be studied in the fast evolving technology enabled industry. There is an obvious risk of sub-optimisation if decisions are made and measures are taken unilaterally, instead of adopting a wider perspective that takes more than one aspect into account. As the technological systems increase in complexity and automation, it reduces transparency of work operation and the gap between human operator and

technological systems is found to be widening. Suggestive research design and data collection would entail specific methods to give precise and testable expression on various value propositions of optimisation from a wider base of seafarers' and shore based managers' using structured and validated data-collection instruments. This confirmatory approach will help test hypothesis as well as remain open to inductive input from practising mariners. Within the ethical parameters of social research, data may be sourced from serving seafarers returning to maritime universities for post sea competency related courses. While at the same time perspectives of the ship management companies in global shipping hubs such as Mumbai, Singapore and Hong Kong may be necessitated. First a model, theory and hypothesis need to be developed followed by the instrument and method of measurement. This can be followed by the collection of empirical data. Thematic analysis of data collected can be done using eclectic approaches by combining both methods to capitalize on the respective strengths of quantitative and qualitative research techniques. Mixed methods research as an approach draws upon the strengths and perspectives of each method, recognising the existence and importance of the physical, natural world as well as the importance of reality and influence of human experience (Johnson and Onquegbuzie, 2004). Triangulation will then help interpret data towards successfully balanced safety with technology integration and commerce leading to the main assessments and conclusions of the research.

Funded study involving more qualitative data as well as a large-scale quantitative study involving global shipping should be the next research for a better understanding of the interplay of humans, technology and organisation in the process of design and organisation of tasks and technology integrated work environments. Furthermore, these studies need to

be cognisant of the socio-technical system within which they operate and may be tested out in simulation facilities. Safety monitoring cannot be based only on historical data but needs to proactive and lessons from best practices. Complementary studies are thus needed to investigate this feasibility as well.

Since the industry is predominantly compliance driven, further study on how to make the compliance regime more effective and performance driven in the very challenging maze of globalised operation is called for. Additionally, since shipping is a safety-critical industry and all technology intervention has its bearing on safety, the balancing of apparently mutually incompatible and divergent issues of cost-safety and risk- regulation- efficiency- sociology would make an interesting and meaningful study for the fast evolving technology enabled industry. There is an obvious risk of sub-optimisation if decisions are made and measures are taken unilaterally, instead of adopting a wider perspective that takes more than one aspect into account. Moreover, as the technological systems increase in complexity and automation it reduces transparency of work operation and the gap between human operator and technological systems actually increases.

Lastly, while this study contributes to the studies within maritime human factors, it needs to be recognised that the amount of research in this area is not vast. Hence it should continue to be a research focus, particularly in the continued identification of poor integration between technology and humans whose consequences can be dire in the least. As more and more technology gets pushed into the industry it is the practice of its implementation that needs to have a better understanding.

Bibliography

- ABS, (1992). American Bureau of Shipping – A guide to combating fatigue, *Surveyor*, 23 (4), 24-31.
- Alderton, T. and Winchester, N. (2002). Globalisation and de-regulation in the maritime industry, *Marine Policy*, 26, 35-43.
- Alderton, T., Bloor, M., Kahveci, E., Lane, T., Sampson, H., Thomas, M., Winchester, N., Wu, B. and Zhao, M. (2004). *The global seafarer: living and working conditions in a globalised industry*, International Labour Office, Geneva.
- Allen, P. (2009). Perceptions of technology at sea amongst British seafaring officers, *Ergonomics*, 52 (10): 1206-1214. Doi: 10.1080/00140130902971924.
- Anand, N. (2011). *New Technologies, Work, Skills and Identity -The Case of Maritime Industry*, PhD Thesis, School of Social Sciences, Cardiff University, UK.
- Arvanitis, S. and Loukis, E.N. (2009). Information and communication technologies, human capital, workplace organisation and labour productivity: a comparative study based on firm-level data for Greece and Switzerland, *Information Economics and Policy*, 21 (1), 43-61.
- Astrom, K.J. (1985). Process Control–Past, Present and Future, *IEEE Control System Magazine*, 5(3), 3-10. Doi: 10.1109/MCS.1985.1104958.

Baillieul, J. and Antsaklis, P.J. (2007). Challenges in networked real-time systems, *Proceedings of the IEEE*, 95(1), 9-28. Doi: 10.1109/JPROC2006.887290.

Baker, C.C. and McCafferty, D.B. (2005). Accident database review of human element concerns: What do the results mean for classification? *Proceedings from the conference on 'Human Factors in Ship Design and Operation' of the Royal Institution of Naval Architects, UK.*

Barley, S. (1986). Technology as an occasion for structuring: evidence from observation of CT scanners and the social order of radiology departments, *Administrative Science Quarterly*, 31 (1), 78-108.

Barley, S. (1990). The alignment of technology and structure through roles and networks, *Administrative Science Quarterly*, 35 (1), 61-103.

Barnett, M.(2005).Searching for the root causes of maritime casualties, *WMU Journal of Maritime Affairs*, 4(2), 131-145.

Barnett, M., David, G. and Pekcan, C. (2006). *Non-technical skills: the vital ingredient in world maritime technology?* Paper of IMarEST, downloadable from the Nautical Institute's website at: <http://www.he-alert.org/documents/published/he00515.pdf>

Barney, J.B. (1991). Firm resources and sustained competitive advantage, *Journal of Management*, 17 (1), 99-120.

Benbasat, I., Goldstein, D.K. and Mead, M. (1987). The case research strategy in studies of information systems, *MIS Quarterly*, 11, 369-386.

Bettis, R. and Hitt, M. (1995). The new competitive landscape, *Strategic Management Journal*, 16(7), 7–20.

Bhattacharya, S. (2009). *The Impact of the ISM Code on the management of occupational health and safety in the marine industry*, PhD thesis, School of Social Sciences, Cardiff University, UK.

Bhattacharya, S. (2012). Sociological factors influencing the practice of incident reporting: the case of the shipping industry, *Employee Relations*, 34 (1), 4-21. Doi: 10.1108/01425451211183237.

Bhattacharya, S.K. and Chatterjee, S. (1995). *Industrial Electronics and Control*, New Delhi, India: Tata McGraw-Hill. ISBN-13: 978 0 07 462477 6.

Bielíc, T. (2008). *Complacency as element of maritime accidents*, Paper available from the Nautical Institute website at: <http://www.he-alert.org/documents/published/he00665.pdf>.

Billbsberry, J. (1996). *There is nothing so practical as a good theory: How can theory help managers become more effective*, The Effective Manager: perspectives and illustrations, Sage publications.

BIMCO/ISF, (1995, 2000, 2005, 2010). *Worldwide demand for and supply of seafarers*, Institute of Employment Research, University of Warwick, UK.

Bingi, P., Sharma, M.K. and Godla, J.K. (1999). Critical issues affecting an ERP implementation, *Information Systems Management*, 16(3), 7-14. DOI: 10.1201/1078/43197.16.3.19990601/31310.2.

Blau, P.M. (1968). The hierarchy of authority in organisations, *The American Journal of Sociology*, 73 (4), 453-467.

Blau, P. M., Fable, C.M., McKinley, W. and Tracy, P.K. (1976). Technology and organisation in manufacturing, *Administrative Science Quarterly*, 21 (1), 20-40.

Boyne, R. (2000). Post-Panopticism, *Economy and Society*, 29 (2), 285-307.

Braverman, H. (1974). *Labour and Monopoly Capital: The degradation of work in the twentieth century*, Monthly Review Press, New York.

BSA, (2002). *Statement of Ethical Practice for the British Sociological Association*,
<http://www.britsoc.co.uk/about/equality/statement-of-ethical-practice.aspx>

Butera, F. (2001). Automation: organisational studies, *International Encyclopaedia of the Social & Behavioural Sciences*, 993-998. ISBN: 0-08-043076-7.

Celik, M. (2009). Establishing an integrated process management system in ship management companies, *Expert Systems and Applications*, 36, 8152-8171. Doi: 10.1016/j.eswa.2008.10.022

Cetin, C.K. and Cerit, A.G. (2010). Organisational effectiveness at seaports: a systems approach, *Maritime Policy and Management*, 37 (3), 195-219. Doi: 10.1080/03088831003700611.

Chandy, K.M. and Lamport, L. (1985). Distributed snapshots: determining global states of distributed systems, *ACM Transactions on Computer Systems*, 3 (1), 63-75. Doi: 10.1145/214451.214456.

Charsley, W.F. (1989).The human factor in office automation, *Office and Information Management International*, 2 (9),21.

Chary, L. R. (2005).*Corporate transformation without tears*, Mumbai: Institute of Marine Engineers (India). ISBN 81-902330-2-5.

Cheng, L.C. and Grimm, C.M. (2006). The application of empirical strategic management research to supply chain management, *Journal of Business Logistics*, 27 (1), 1-56.

Cheng, L.C., Gibson, M.L., Carrilo, E.E. and Fitch, G. (2011). A technology-centric framework for investigating business operations, *Industrial Management & Data Systems*, 111 (4), 509-530. DOI : 0.1108/02635571111133524.

Cherns, A. (1986). Principles of socio-technical designs revisited, *Human Relations*, 40, 153-162.

CHIRP,(2006). Marine operating and maintenance manuals – are they good enough? *Report from the UK CHIRP (Confidential Incident Reporting Program)*

Collins, P. and Hogg, J. M. (2004). The Ultimate Distributed Workforce: the use of ICT for seafarers, *AI & Society*, 18, 209-241.Doi: 10.1007/s00 146-003-0287-5.

Cook, R.I. and Woods, D.D. (1996). Adapting to new technology in the operating room, *Human Factors*, 38, 593-613.

Copeland, A.J. (2012). Diagrams and relational maps: the use of graphic elicitation techniques with interviewing for data collection, analysis and display, *International Journal of Qualitative Methods*, 11 (5), 513–533.

Corbin, J. and Strauss, A. (2007). *The basics of Qualitative Research*, New Delhi, India: Sage.ISBN-13: 978-1412906449.

Crabtree, B. F. and Miller, W. L. (1999). *Doing Qualitative Research*, Thousand Oaks, California, USA: Sage. ISBN 0-7619-1497-8.

Curry, A., Flett, P. and Hollingsworth, I. (2006).*Managing information and systems: the business perspective*. London: Routledge. ISBN 0415355869.

Da Silveira, G.J.C. (2002). Improvement trajectories in operations and technology management: concept, process and current issues, *Technology Analysis and Strategic Management*, 14 (2), 227-240. Doi: 10.1080/09537320220133884.

Denzin, N.K. & Lincoln, Y.S. (2007). *Collecting and interpreting qualitative materials*, Thousand Oaks, California, USA: Sage. ISBN-13: 9781412957571.

DMA, (2011). *From Crafts to Control?* Danish seafarers' perception of administrative burdens in maritime sector. Draft summary report of the Danish Maritime Authority, December 2011.

Drake, P., Shanks, G. and Broadbent, M. (1998). Successfully completing case study research: combining rigor, relevance and pragmatism, *Information Systems Journal*, 8, 273-289.

Drucker, P. (2007).*The Practice of Management*, Butterworth-Heinemann, Burlington, USA: ISBN 978-0-7506-8504-7.

Dumont, M., Stojanovska, N. and Cuyvers, L. (2011). World inequality, globalisation, technology and labour market institutions, *International Journal of Manpower*, 32 (3), 257-272. Doi: 10.1108/01437721111136750.

Durkheim, E. (1933).*The Division of Labour in Society*, New York: The Free Press.

Easterby-Smith, M., Snell, R. and Gherardi, S. (1998). Organisational learning: diverging communities of practice? *Management Learning*, 29 (3), 259-272.

Eisenhardt, K.M. (1989). Building theories from case study research, *Academy of Management Review*, 14 (4), 532-550.

Foucault, M. (1977).*Discipline and Punish*, London: Allen Lane.

Fiset, J. Y. (2009).*Human – Machine Interface Design for Process Control Applications*, Research Triangle Park, NC 27709, USA. ISBN 978-1-934394-35-9.

Flottau, J. (2011). Regaining control, *Aviation Week and Space Technology*, 173 (38), 87-88.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research, *Qualitative Enquiry*, 12 (2), 219-245. Doi: 10.1177/1077800405284363.

Fragidis, G. and Tarabanis, K. (2005). The business strategy perspective on the development of decision support systems, *Proceedings of the International Conference on Computational Intelligence for Modelling, Control and Automation, Intelligent Agents, Web technologies, and Internet Commerce*.

Frankel, E.G. (1991). The economics of technological change in shipping, *Maritime Policy and Management*, 18-1, 43-53. Doi: 10.1080/03088839100000005.

Froholdt, L.L. (2012). The Communicative Blue, *Mercator, March-June 2012*, 460-466. Report on her Ph. D. dissertation: The Communicative Blue. Human Factors in technologically mediate routine and non-routine interaction in the maritime industry. Available at <http://mercatorinfo.dk/page/66>.

Fruger, F. (1997). Accountability and system of self-governance: the case of the maritime industry, *Law & Policy*, 19(4), 445-476.

Geertz, C. (1995). *After the fact: Two countries, four decades, one anthropologist*, Cambridge, MA: Harvard University Press.

Gerard, D. and Lave, L.B. (2005). Implementing technology – forcing policies: The 1970 Clean Air Act amendments and the introduction of advanced automotive emission controls in the United States, *Technology Forecasting and Social Change*, 72, 761-778. Doi: 10.1016/j.techfore.2004.08.003.

Gereffi, G. (1999). International trade and industrial upgrading in the apparel commodity chain, *Journal of International Economics*, 48 (1), 37-70.

Gersch, M., Hewing, M. and Scholer, B. (2011). Business Process blueprinting – an enhanced view on process performance, *Business Process Management Journal*, 17 (5), 732-747. Doi: 10.1108/14637151111166169.

Glaser, B. G. and Strauss, A.L. (1967).*The discovery of grounded theory: strategies of qualitative research*, London, UK: Wiedenfeld and Nicholson. ISBN-13: 9780202302607.

Gopinath, C. (2006). Condition monitoring enhances revenue earning, *Ferry Technology*, 47-48.

Goss, O. R. (2002). The future of maritime economics. In Grammenos, C. Th. (Ed.),*The Handbook of Maritime Economics and Business*, London, UK: Lloyds of London Press. ISBN 1-84311-195-0.

Goss, R. (1991). Evidence presented to the House of Lords Select committee on science and technology, *Safety aspects of ship design and technology*, University of Wales, Cardiff, U.K.

Goulielmos, A. and Tzannatos, E. (1997). The man-machine interface and its impact on shipping safety, *Disaster Prevention and Management*, 6(2), 107-117.

Graham, B. (2004).*Detail Process Charting: Speaking the language of Process*, Hoboken, N.J. :Wiley. ISBN 9780471653943.

Grawitch, M.J., Gottschalk, M. and Munz, D.C. (2006). The path to a healthy workplace, a critical review linking healthy workplace practices, employee well-being, and organisational improvements, *Consulting Psychology Journal: Practice and Research*, 58 (3), 129-147.

Greve, H. R. (2009). Bigger and Safer: The diffusion of competitive advantage, *Strategic Management Journal*, 30, 1-23, Doi: 10.1002/smj.721.

Greene, J.C., (1990). *Three views on the Nature and Role of Knowledge in Social Science*, in *The Paradigm Dialogue*, New Delhi: Sage. ISBN 0-8039-3823-3.

Gronberg, G. (2007). High tech bridge equipment promise increased safety, *The Swedish Club Letter*, 1-2007, 8-9.

Guba, E.G. (1990). *The Paradigm Dialog*, New Delhi: Sage. ISBN 0-8039-3823-3.

Gummesson, E. (2000). *Qualitative methods in management research*, Thousand Oaks, California, USA, Sage publications. ISBN 0-7619-2014-5.

Guttal, S. (2007). Globalisation, *Development in practice*, 17 (4-5), 523-531. Doi: 10.1080/09614520701469492.

Hadnett, E. (2008). A Bridge too far? *The Journal of Navigation*, 61, 283-289. Doi: 10.1017/S0373463307004675.

Hambrick, D. and Fredrickson, J. (2001). Are you sure you have a strategy? *Academy of Management Executive*, 15 (4), 48-59.

Hammond, K.R., Hamm, R.M., Grassia, J. and Pearson, T. (1987). Direct comparison of the efficacy of intuitive and analytical cognition in expert judgement, *Proceedings of IEEE Transactions on Systems, Man and Cybernetics, SMS -17*, 753-770.

Hansen, H.L., Nielsen, D. and Frydenberg, M. (2002). Occupational accidents aboard merchant ships, *Occupational and Environmental Medicine*, 59 (2), 85-91. Doi: 10.1136/oem.59.2.85.

Helper, S. and Sako, M. (2010). Management innovation in supply chain: appreciating chandler in the twenty-first century, *Industrial and Corporate Chang*, 19 (2), 399-429.

Hempell, T. and Zwick, T. (2008). New technology, work organisation and innovation, *Economics of Innovation and New Technology*, 17 (4), 331-354.Doi: 10.1080/10438590701279649.

House of Lords, (1992).House of Lords: Select Committee on Science and Technology, *Safety Aspects of Ship Design and Technology*, HL Paper 30-I,Carver Report.

IACS, (2012). IACS press release – 2nd July 2012, available from <http://www.iacs.org.uk/news/article.aspx?newsid=164>.

IFSMA, (2009). International Federation of Ship Masters Association: *Report on Workshop held at Manila, IFSMA Newsletter No. 59, November*, London.

ILO, (2001). *Impact on seafarer's living and working conditions of changes in the structure of the shipping industry*, ILO, Geneva.

ILO, (2004). *A fair globalisation: The role of the ILO*, Report of the Director-General on the World Commission on the social dimension of globalisation, Geneva.

IMO, (2000). International Convention for Safety of Life at Sea (SOLAS) Chapter V Regulation 15 '*Principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures.*'

IMO, (2008). International Maritime Organisation: E-navigation Correspondence Group, 2008, *Development of an E-navigation strategy*.

IMO, (2009). Second IMO GHG Study 2009, Available at [http://www.seas-at-risk.org/Images/MEPC%2059-NF.10%20\(The%20Second%20IMO%20GHG%20Study%202009\).pdf](http://www.seas-at-risk.org/Images/MEPC%2059-NF.10%20(The%20Second%20IMO%20GHG%20Study%202009).pdf)

IMO, (2012a). International Maritime Organisation: Summary of the meeting of the Sub-Committee on Safety of Navigation, 58th session, Available at <http://www.imo.org/MediaCentre/MeetingSummaries/NAV/Pages/NAV-58th-session.aspx>.

IMO, (2012b). Resolution MEPC.(213)-6, 2012 Guidelines for development of Ship Energy Efficiency Management Plan (SEEMP).
[http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Technical%20and%20Operational%20Measures/MEPC.213\(63\).pdf](http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Technical%20and%20Operational%20Measures/MEPC.213(63).pdf)

INTERCARGO, (1995). *Analysis of Total Loss and Fatality Statistics, Bulk Carriers, Ore Carriers and OBOs 1990-1994*, London: INTERCARGO.

ISL, (2010). *Shipping Statistics and Market Review 2010*, Vol. 54 No.1/2, Bremen: Institute of Shipping Economics and Logistics.

ISM Code, (2010). *International Safety Management Code, 2010*. Available from <http://www.imo.org/ourwork/humanelement/safetymanagement/pages/ismcode.aspx>.

ISO, (1997). International Organisation for Standardisation: *ISO/TC159/SC1/WG1 Principles of the design of work systems*, Vienna, Austria.

ISO, (2005).International Organisation for Standardisation: *BS EN ISO 9000:2005*, Geneva, Switzerland, ISO Central Secretariat.

Jackson, M. (2000).*Systems Approaches to Management*, New York: Kluwer Academic/Plenum Publishers. ISBN 0-306-46500-0.

Jayaraman, M.S., Natarajan, G. and Rangaramanujan, A. V. (1994). *Business Process Reengineering*, New Delhi : Tata McGraw-Hill Publishing Company. ISBN 0-07-462169-6.

Jayaraman, V. and Luo, Y. (2007). Creating competitive advantages through new value creation: a reverse logic perspective, *Academy of Management Perspectives*, 21 (2), 56-73. Doi: 10.5465/AMP.2007.25356512.

Jenkins, R. (2004). Globalisation, production, employment and poverty: debates and evidence, *Journal of International Development*, 16, 1-12.

Jensen, C.W. (2009). Hands-on education with maritime IT and automation, *Proceedings at the World Maritime Technology Conference*, Mumbai, India: Institute of Marine Engineers.

Jenssen, J.I. (2003). Innovation, capabilities and competitive advantage in Norwegian shipping, *Maritime Policy and Management*, 30, (2), 93-106. Doi: 10.1080/0308883032000084841.

Jenssen, J. I. and Randoy, T. (2006). The performance effect of innovation in shipping companies, *Maritime Policy and Management*, 33-4, 327-343. Doi: 10.1080/03088830600895485.

Johnson, H. (2013). *Towards understanding energy efficiency in shipping*, PhD thesis, Department of Shipping and Maritime Technology, Chalmers University of Technology, Gothenburg, Sweden.

Johnson, R.B. and Onquegbuzie, A.J. (2004). Mixed methods research: a paradigm whose time has come, *Educational Researcher*, 33 (7), 14–26.

Jones, B.S. (2007). Working with alarms on ships, *Presentation made at 'Work with Computer Systems' Symposium*, Stockholm, Sweden.

Jones, B.S., Earthy, J.V., Fort, E. and Gould, D. (2006). Improving the design and management of alarm systems, *Proceedings from the World Maritime Technology Conference, hosted by The Institute of Marine Engineering, Science and Technology (IMarEST)*, London, UK.

Kaplinsky, R. (2010). Globalisation and Unequalisation: What can be learned from value chain analysis? *The Journal of Development Studies*, 37 (2), 117-146.

Kerr, N.L., Aronoff, J. and Messe, L.A. (2000). *Methods of Group Research*, In: Handbook of Research Methods in Social and Personality Psychology, Cambridge University Press, UK.

Khidzir, N.Z., Mohamed, A. and Arshad, N.H. (2010). Information security risk factors, 2010 International Conference on Information Retrieval and Knowledge Management (CAMP), 194-199. Doi: 10.1109/INFRKM.2010.5466918.

Kim, T. (2005). Human factors and regulatory regime in design and construction of safe and robust ships and maintaining them for their lifetime, *Presentation at the RINA Conference*.

King, J. (2001). Technology and the course of Shipping, *Ocean and Coastal Management*, 44, 567-577.

Klein, G. (2008). Naturalistic decision making, *Human Factors*, 50 (3), 456-460. Doi: 10.1518/001872008X288385.

Knudsen, F. (2009). Paperwork at the service of safety? Workers' reluctance against written procedures exemplified by the concept of 'seamanship', *Safety Science*, (47), 295-303. Doi: 10.1016/j.ssci.2008.04.004.

Koester, T. (2005). *Human Factors in the Maritime Domain*, Ph.D. dissertation, Aarhus University, Denmark.

Krishnamurthi, S. (2005). Building bridges, breaking barriers. *Alert! The International Maritime Human Element Bulletin*, 09, Page 6. ISSN 1747-5015.

Krueger, R.A. and Casey, M.A. (2000). *Focus groups: A practical guide for applied research*, Thousand Oaks, California, USA, Sage.

Kvale, S. (1996). *Interviews: an introduction to qualitative research interviewing*, Thousand Oaks, California. USA, Sage publications.

Lave, J. and Wenger, G. (1991). *Situated learning: Legitimate peripheral participation*, Cambridge University Press, UK.

Lebas, M. J. (1995). Performance measurement and performance management, *International Journal of Production Economics*, 41, 23-35.

Lee, J.D. and Sanquist, T.F. (1996). *Maritime Automation in Automation and Human Performance: Theory and Application*, 365-384, Mahwah, NJ: Lawrence Erlbaum.

Lee, S.S., Lee, J.K., Park, B.J., Lee, D.K., Kim, S.Y. and Lee, K.H. (2006). Development of internet-based ship technical information management system, *Ocean Engineering*, 33, 1814-1828. Doi:10.1016/j.oceaneng.2005.10.019.

Lemon, N. (2009). Will e-navigation help the officer of the watch manage information? *Alert! The International Maritime Human Element Bulletin*, 21, Page 6. ISSN 1747-5015.

Lesser, E. and Storck, J. (2001). Communities of practice and organisational performance, *IBM Systems Journal*, 40 (4), 831-841.

Liang, T.P., You, J.J. and Liu, C.C. (2010). A resource-based perspective on information technology and firm performance: a meta-analysis, *Industrial Management and Data Systems*, 110 (8), 1138-1158.

Liedtka, J. (1999). Linking competitive advantage with communities of practice, *Journal of Management Inquiry*, 8 (1), 5-16.

Lin, C. Y. and Chen, W.H.(2002). The effect of social factors on the implementation of automation: an empirical study in Taiwan, *Journal of Engineering and Technology Management*, 17, 39-58.

Lincoln, Y. and Guba, C. (1985). *Naturalistic inquiry*, Beverly Hills, California, USA: Sage.

Lorange, P. (2001). Strategic re-thinking in shipping companies, *Maritime Policy and Management*, 28 (1), 23-32.

Lutzhof, M. H. and Dekker, S. W. A. (2002). On Your Watch: Automation on the Bridge, *Journal of Navigation*, 55(1), 83-96.

Lutzhof, M. (2004). “The Technology is great when it works” – Maritime Technology and Human Integration on the Ship’s Bridge, *Dissertation No. 907, Linkoping Studies in Science and Technology*, Linkoping, Sweden. ISBN 91-85295-78-7 ISSN 0345-7524.

Lutzhof, M. and Nyce, J.M. (2008), Integration work on the ship’s bridge, *Journal of Maritime Research*, 5-2, 59-74.

Lyridis, D.V., Fyrvik, T., Kapetanis, G.N., Ventikos, N., Anaxagorou, P., Uthaug, E. and Psaraftis, H.N. (2005). Optimising shipping company operations using business process modelling, *Maritime Policy and Management*, 32(4), 403-420. Doi: 0.1080/03088830500300636.

Lyu, J.J. (1996). Applying kaizen and automation to process reengineering, *Journal of Manufacturing Systems*, 15(2), 123-132.

Macpherson, I., Brooker R. and Ainsworth, P.(2000). Case study in the contemporary world of research: using notions of purpose, place, process and product to develop some principles for practice, *International Journal of Social Research Methodology*, 3 (1), 49-61.ISSN 1364-5579 print/ISSN 1464-5300 online Taylor & Francis Ltd.

Macrae, C. (2009). Human factors at sea: common patterns of error in groundings and collisions, *Maritime Policy and Management* 36(1): 21-38. Doi: 10.1080/03088830802652262 .

Maaloe, E. (2010). Explorative Integration – the expansive cyclic, multi-theoretical approach to case research, course notes, The School of Business at Aarhus University, Aarhus, Denmark.

Makadok, R. (2001). Towards a synthesis of the resource-based and dynamic-capability view of rent creation, *Strategic Management Journal*, 22 (5), 387-401.

Marine Propulsion and Auxiliary Machinery, (2011). *The Journal of Ships' Engineering Systems*, June/July 2011. Riviera Maritime Media Ltd., Enfield UK. ISSN 1742-2825.

Markus, M.L. (1983). Power, politics and MIS implementation, *Communications of the ACM*, 26, 430-444.

Markus, M.L. and Bjorn-Andersen, N. (1987). Power over users: its exercise by system professionals, *Communications of the ACM*, 30(6), 498-504. Doi: 10.1145/214762.214764.

MARSIKT, (2000). On-going project on ICT (Information and Communication Technology) of The Norwegian Ship Owners Association.
<http://prosjekt.marintek.sintef.no/marsikt/>.

MCA, (2006). *Leading for Safety*, Maritime and Coastguard Agency, UK.

MCA, (2006). MCA RP545: *Development of guidance for the mitigation of human error in automated ship borne maritime systems*, Maritime and Coastguard Agency, UK.

McAfee, A. and Brynjolfsson, E. (2008). Investing in the IT that makes a competitive difference, *Harvard Business Review*, 86 (7/8), 98-107.

Miles, M.B. and Huberman, A.M. (1994). *Qualitative Data Analysis: A Sourcebook of new methods*, Thousand Oaks, California. Sage Publications.

Mitroussi, K. (2004a). The role of organisational characteristics of ship owning in the use of third party ship management, *Marine Policy*, 28, 325-333. Doi: 10.1016/j.marpol.2003.07.002.

Mitroussi, K. (2004b). The ship owners' stance on third party ship management: an empirical study, *Maritime Policy and Management*, 31 (1), 31-45. Doi: 10.1080/03088830310001642030

Morgan, G. (1983). *Beyond method: Strategies for social research*, Beverly Hills, CA: Sage.

Mukherji, A. (2002). The Evolution of information systems: their impact on organisations and structures, *Management Decisions*, 40 (5), 497-507. Doi: 10.1108/00251740210430498.

Mullins, L.J. (2002). *Management and Organisational Behaviour*, Pearson Education Limited, Essex, UK. ISBN 0 273 65147 1.

Munck, R. (2002). *Globalisation and labour: the new 'Great Transformation'*, Zed Books, London.

Narasimhan, R., Swink, M. and Viswanathan, S. (2010). On decisions for integration implementation: an examination of complementarities between product-process technology integration and supply chain integration, *Decision Sciences*, 41 (2), 355-372. Doi: 10.1111/j.1540-5915.2010.00267.x.

National Research Council, (2007). *Human-System Integration in the System Development Process*, Washington D.C.: The National Academies Press. Available at http://www.nap.edu/openbook.php?record_id=11893&page=R2.

Nautical Institute, (2012). *Automation and Technology: Dulling Mariner skills?* A ‘members only’ discussion group supported by LinkedIn. Available at <http://www.linkedin.com>.

Naval Electrical and Engineering Training Series, Module 17, (2007).*Chapter 1 Introduction To Radio-Frequency Communications*, Integrated Publishing, Inc.

Neef, D. (2008). Electronic monitoring and reporting comes to the maritime industry, *Safe Voyage*, (2), QSE Publishing, Woodinville, USA.

Nikitakos, N. and Lambrou M. A. (2007). Digital Shipping: The Greek experience, *Research in Transport Economics*, 21, 383-417. Doi: 10.1016/S0739-8859(07)21012-1.

Noble, D. F. (1984). *Forces of Production: A Social History of Industrial Automation*, New York, Knopf.

NTSB, (1997). *Grounding of the Panamanian Passenger Ship Royal Majesty on Rose and Crown Shoal near Nantucket, Massachusetts*, Marine Accident Report. National Transportation Safety Board, Washington, D.C., USA.

O'Brien, J.A. (2004). *Management Information System: Managing Information Technology in the E-Business Enterprise*, New Delhi: Tata McGraw-Hill. ISBN 0-07-058739-6.

OECD,(1992). Technology and the economy: the key relationship, *R&D expenditure as a %age of output*, *Organisation for Economic Cooperation and Development*, OECD, Paris.

OECD, (2011), *OECD Science, Technology and Industry Scoreboard*, OECD, Paris.

Onder, N. (1998). Integrating with the global market: The State and the crisis of political representation, *International Journal of Political Economy*, 28 (2), 44-84.

O'Neill, P. and Sohal, A.S. (1999). Business Process Reengineering – A review of recent literature, *Technovation*, 19, 571-581.

Olavarrieta, S. and Ellinger, A.E. (1997). Resource-based theory and strategic logistics research, *International Journal of Physical Distribution and Logistics Management*, 27 (9/10), 559-587.

Opdenakker, R. (2006). Advantages and Disadvantages of Four Interview Techniques in Qualitative Research, *Forum: Qualitative Social Research*, 7 (4), Art. 11. On-line journal, available at <http://www.qualitative-research.net/index.php/fqs/article/view/175/391>

Orlikowski, W.J. (1992). The duality of technology: rethinking the concept of technology in organisations, *Organisation Science*, 3 (3), 398-427.

Osterman, C. (2010). *Ergonomics: an unchartered route to improved overall systems performance in shipping*, Report No. 10.119, Division of Ship Work Environment, Safety and Human factors, Department of Shipping and Maritime Technology, Chalmers University of Technology, Goteborg, Sweden.

Osterman, C. (2012). *Developing a value preposition of maritime ergonomics*, PhD thesis, Department of Shipping and Maritime Technology, Chalmers University of Technology, Gothenburg, Sweden.

Ouchi, W.G. (1980). Markets, bureaucracies and clans, *Administrative Science Quarterly*, 25(1), 129-141.

Panayides, P.M. (2003). Competitive strategies and organisational performance in ship Management, *Maritime Policy and Management*, 30(2), 123-140.Doi: 10.1080/0308883032000084850.

Panayides, P.M. and Gray, R. (1997). Marketing the professional ship management services, *Maritime Policy and Management*, 24(3), 233-244.Doi: 10.1080/03088839700000028.

Paris MoU, (2010). Annual Report 2010 of the Paris MoU on Port State Control. Available from:www.parismou.org.

Patton, M.Q. (1990). *Qualitative evaluation and research methods*, Newbury Park, California, USA, Sage Publications.

Peci, A. (2009). Taylorism in the socialism that really existed, *Organisation*, 16(2), 289-301. Doi: 10.1177/1350508408100479.

Pentland, B.T. and Feldman, M.S. (2007). Narrative networks: patterns of technology and organisation, *Organisation Science*, 18 (5), 781-795. Doi: 10.1287/orsc.1070.0283.

Perrow, C. (1983). The organisational context of human factors engineering, *Administrative Science Quarterly*, 28 (4), 521-541.

Perrow, C. (1984). *Normal Accidents: Living with High Risk Technologies*, New York: Basic Books.

Pomeroy, R.V. and Jones, B.M.S.(2002). Managing the human element in modern ship design and operation, *Proceedings from the conference on 'Human Factors in Ship Design and Operation' of the Royal Institution of Naval Architects*, UK.

Pomeroy, R.V. and Tomlinson, C.M. (2000). A Systems approach to integrating the Human Element into Marine Engineering Systems, *Proceedings from the conference on 'Human Factors in Ship Design and Operation' of the Royal Institution of Naval Architects*, UK.

Pomeroy, V. (2006). Perception and management of risk – dependence on people and systems, *Proceedings from the World Maritime Technology Conference, hosted by The Institute of Marine Engineering, Science and Technology (IMarEST)*, London, UK.

Porter, J. (1995). 'Intertanko expels Greek tanker owner,' *Journal of Commerce and Commercial*, May 24:8B.

Porter, M.E. (1998). *Competitive Advantage: Creating and Sustaining Superior Performance*, The Free Press, New York.

Porter, M. E. (2004). *Competitive Advantage*, New York: Free Press, ISBN 0-7432-6087-2 .

Powell, W.W. (1987). Review essay: explaining technological change, *American Journal of Sociology*, 93 (1), 185-197.

Power, T. (2004). *Best practice in Ship-management software*, Digital Ship Ltd., London, UK.

Progoulaki, M. and Theotokas, I. (2010). Human resource management and competitive advantage: an application of resource-based view in the shipping industry, *Marine Policy*, 34, (3), 575-582. Doi: 10.1016/j.marpol.2009.11.004.

Progoulaki, M. and Roe, M. (2011). Dealing with multicultural human resources in a socially responsible manner: a focus on the maritime industry, *WMU Journal of Maritime Affairs*, 10, 7-23. Doi: 10.1007/s13437-011-0003-0

Psaraftis, H.N., Caridis, P., Desypris, N., Panagakos, G. and Ventikos, N. (1998). The human element as a factor in marine accidents, *Proceedings from the IMLA -10 Conference of the International Association of Maritime Lecturers*, St. Malo, France.
<http://www.martrans.org/lmsf.htm>.

Psaraftis, H.N., N., Panagakos, G., P., Desypris and Ventikos, N. (1998). An analysis of maritime transportation risk factors, *Proceedings from the ISOPE -1998 Conference of the International Society of Offshore and Polar Engineers*, Montreal, Quebec, Canada.
<http://www.martrans.org/lmsf.htm>.

Pyne, R. and Koester, T. (2005). Method and means of analysis of crew communication in the maritime domain, *The Archives of Transport*, Vol. XVII, 3-4.

Qian, Y., Joshi, J., Tipper, D. and Krishnamurthy, P. (2007). *Information Assurance: Dependability and Security in Networked Systems*, USA, Morgan Kaufmann Publishers.

Rameback, C. (2003). Process Automation System – history and future, *Emerging Technologies and Factory Automation, 2003, Proceedings ETFA '03. IEEE Conference*.
Doi: 10.1109/ETFA.2003.1247680.

Rasmussen, J. (1983). Skills, rules and knowledge: signals, signs and symbols and other distinctions in human performance, *IEEE Transactions on systems, Man and Cybernetics*, 13, 257-266.

Rasmussen, J. (1999). Ecological interface design for reliable human-machine systems, *International Journal of Aviation Psychology*, 9(3), 203-223. Doi: 10.1207/s15327108ijap0903_2.

Renvik, E., Sorensen, A.J. and Rasmussen, M. (2003). Maritime industrial IT, *Proceedings from the 9th International Conference on Marine Engineering Systems – International Cooperation on Marine Engineering Systems 2003*, Helsinki University of Technology, Finland.

Rhoads, E.B. (1996). Just who invented the Radio, *Blast from the past: A 75 years photo history of the radio*. Available from <http://www.qsl.net/n7jy/radiohist.html>.

Ritchey, T. (1991). Analysis and synthesis. on scientific method – based on a study by Bernhard Riemann, *Systems research*, 8 (4), 21-41.

Rivera, J.C.A. (2011). Communities of practice: Improving knowledge management in business, *Business Education and Accreditation*, 3 (1), 101 – 111.

Rosenberg J.P. and Yates P.M. (2007). Schematic representation of case study research designs, *Journal of Advanced Nursing* 60 (4), 447–452.Doi: 10.1111/j.1365-2648.2007.04385.x.

Roumboutsos, A., Nikitakos, N. and Gritzalis, S. (2005). Information technology network security risk assessment and management framework for shipping companies, *Maritime Policy and Management*, 32-4, 421-432.Doi: 10.1080/03088830500301501

Ropohl, G. (1999). Philosophy of socio-technical systems, *Society for Philosophy and Technology*, 4 (3).

Roy, G.J. (1987). *Instrumentation and Control*, London, UK, Stanford Maritime Press, ISBN 0504 07344 X.

Ryan, A.B. (2006).*Post-Positivist Approaches to Research*, In: Researching and Writing your thesis: a guide for postgraduate students, MACE: Maynooth Adult and Community Education, pp. 12-26. <http://adulteducation.nuim.ie/documents/Thesis.pdf>.

Samaranayake, P. (2009). Business process integration, automation, and optimisation in ERP; Integrated approach using enhanced process models, *Business Process Management Journal*, 15 (4), 504-526.Doi:10.1108/14637150910975516.

Sarker, S. and Lee, A. S. (1999). IT-enabled organisational transformation: a case study of BPR failure at TELECO, *Journal of Strategic Information Systems*, 8, 83-103.

Sauer, J., Wastell, D.G., Hockey, R.J., Crawshaw, C.M., Ishak, M. and Dowling, J.C. (2002). Effects of display design on performance in a simulated ship navigation environment, *Ergonomics*, 45-5, 329-347. Doi: 10.1080/0014013011011612 8.

Schroder-Hinrichs, J.U., Hollnagel, E. and Baldauf, M. (2012). From Titanic to Costa Concordia – a century of lessons not learned, *WMU Journal of Maritime Affairs*, (11),151-167. Doi: 10.1007/s13437-012-0032-3.

Schwandt, T. (1997).*Qualitative Inquiry: A Dictionary of Terms*, Thousand Oaks, California, USA, Sage publications.ISBN-13: 978-0761902539.

Seidman, I. (2006). *Interviewing as Qualitative Research: A guide for Researchers in Education and the Social Sciences*, New York: Teachers College Press.

Servais, J.M. (2004). Globalisation and decent work policy: reflections upon a new legal approach, *International Labour Review*, 143 (1-2), 185-207.

SFS, (1977). Swedish Code of Statutes: Work Environment 1977:1160.

Sharma, K. K. (2008). Integrative approach to services management: A study of global ship management, paper presented at the *10th International Research Seminar in Service Management* in La Londe, France. Available from: http://www.cerog.org/lalondeCB/SM/2008_lalonde_seminar/Papers/S2-3-2_SHARMA_Integrative_approach_to_sces_management.pdf.

Shea, I.P. (2005). *The organisational culture of a ship: A description and some possible effects it has on accidents and lessons for seafaring leadership*, Thesis PhD. University of Tasmania. Australia.

Shim, J.P., Warkentin, M., Courtney, J.F., Power, D.J., Sharda, R. and Carlsson, C. (2002). Past, present and future of decision support technology, *Decision Support Systems* 931 0167-9236/02/\$ - see front matter D 2002 Published by Elsevier Science B.V PII: S0167-9236(01)00139-7.

Shobrys, D.E. and White, D.C. (2002). Planning, scheduling and control systems: why cannot they work together, *Computers and Chemical Engineering*, 26, 149–160. PII: S0098-1354(01)00737-2.

Simons, H. (1996). The paradox of case study, *Cambridge Journal of Education*; 26-2, 225-241.

Slesinger, P.E. (2009). Making information work, *Alert! The International Maritime Human Element Bulletin*, 21, Page 2. ISSN 1747-5015.

Smart, P.A., Maddern, H. and Maull, R.S. (2009). Understanding Business Process Management: Implications for theory and practice, *British Journal of Management*, 20, 491-507. Doi: 10.1111/j.1467-8551.2008.00594.x.

Smeaton, G.P., Dineley, W.O. and Tucker, S.M. (1995). Display requirements for ECDIS/ARPA overlay systems, *Journal of Navigation*, 48-1, 13-28.

Sorrell, S. (2002). The meaning of BATNEEC: interpreting excessive costs in UK industrial pollution regulation, *Journal of Environmental Policy and Planning*, 4-1, 23-40. Doi: 10.1002/jepp.102.

Sorribas, J., Afonso, D., Arilla, E., Garcia, O., Hernandez, A., Olive, J., Ruiz, J.L., Romero, X., Sandoval, A. and Serrano, J.A. (2009). Real time Fleet monitoring system using Satellite Broadband Communications and Google Earth, *First International Conference on Advances in Satellite and Space Communications*, IEEE. Doi: 10.1109/SPACOMM.2009.44.

Squire, D. (2004). *Alert!* Available from <http://www.he-alert.org>

SRA 2003. SRA Ethical Guidelines, Social Research Association, <http://www.the-sra.org.uk/guidelines.htm>

Stabell, C.B. and Fjeldstad, O.D. (1998). Configuring value for competitive advantage: on chains, shops and networks, *Strategic Management Journal*, 19 (5), 413-437.

Stake R.E. (1995). *The art of case study research*, Thousand Oaks, California, USA, Sage publications. ISBN-13: 978-0803957664.

Stake R.E. (2005). Case studies, In *The Sage Handbook of Qualitative Research*, (Denzin N. and Lincoln Y. Eds.), Thousand Oaks, California, USA, Sage publications. ISBN 0-7619-2757-3.

Stiglitz, J. (2002). Employment, social justice, and societal well-being, *International Labour Review*, 141 (1-2), 9-29. Doi: 10.1111/j.1564-913x.2002.tb00229.x

- Stiglitz, J. (2006). Innovation: a better way than patents, *New Scientist*, 191, 20.
- Stieglitz, N. and Heine, K. (2007). Innovations and the role of complementarities in a strategic theory of the firm, *Strategic Management Journal*, 28 (1), 1-15.
- Stopford, M. (2000). Defining the future of shipping markets, *Presentation at the ITIC Forum 2000: Innovative Thinking is Crucial*, London, UK.
- Stopford, M. (2009). *Maritime Economics*, (3rd ed.), Oxon, UK, Routledge.
- Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R. and Samson, D. (2002). Effective case research in operations management: a process perspective, *Journal of Operations Management*, 20, 419-433.
- Tang, L. (2009). Training and technology: potential issues for shipping, *Seafarers International Research Centre Symposium Proceedings*. ISBN: 1-900174-36-7.
- Tang, L. and Sampson, H. (2011). Training and technology: findings from the Questionnaire Study, *Seafarers International Research Centre Symposium Proceedings*. ISBN: 1-900174-39-1.
- Taylor, F.W. (1947). *Scientific Management*, Harper and Brothers, New York.
- Tessier, S. (2012). From field notes, to transcripts, to tape recordings: evolution or combination, *International Journal of Qualitative Methods*, 11 (4), 446-460.

Thai, V.V. (2008). Service quality in maritime transport: conceptual model and empirical evidence, *Asia Pacific Journal of Marketing and Logistics*, 20, (4), 493-518. Doi: 10.1108/13555850810909777.

Thanopoulou, H. (2002). Investing in ships: an essay on constraints, risk and attitudes, in Grammenos, C. Th. (Ed.) *The Handbook of Maritime Economics and Business*, London, UK: Lloyds of London Press. ISBN 1-84311-195-0.

TNO – Report, (2005). Fatigue in the shipping industry, *Report No. 20834/11353, TNO Quality of Life, Work and Employment*, The Netherlands. www.tno.nl/arbeid

Tracy, S. J. (2010). Qualitative quality: eight ‘big-tent’ criteria for excellent qualitative research, *Qualitative Inquiry*, 16, 837-851.

UNCTAD, (2011). *Review of Maritime Transport 2011*. ISSN: 0566-7682. Available from <http://www.unctad.org>.

UNFCCC, (2012). United Nations Framework Convention on Climate Change, Article 3: Principles. Available at http://unfccc.int/essential_background/convention/background/items/1355.php.

USAID, (1996). *Conducting Key Informant Interviews*, United States Agency for International Development’s Centre for Development Information and Evaluation, Performance Monitoring and Evaluation TIPS, Available at http://www.usaid.gov/pubs/usaid_eval/pdf_docs/pnabs541.pdf

USCG, (2005). United States Coast Guard: Crew Endurance Management Practices – A Guide for Maritime Operations, *USCG Human Element and Ship Design Division*, Washington, USA.

Valorinta, M. (2009). Information Technology and mindfulness in organisations, *Industrial and Corporate Change*, 18 (5), 963-967. Doi:n10.1093/icc/dtp027.

Van De Ven, A.H. (1992). Suggestions for studying strategy process: a research note, *Strategic Management Journal*, 13 (S1), 169-188. Doi: 10.1002/smj.4250131013.

Vlachos, G.P. and Nikolaidis, E. (2002). Analysis of primary causes concerning shipping safety – owner's and ship master's point of view, *Proceedings from the International Association of Maritime Economists (IAME) Conference*, Panama.http://www.eclac.cl/transporte/perfil/iame_papers/proceedings/AgendaProceedings.html

Wenger, E. (1998).*Communities of Practice: Learning, Meaning and Identity*, Cambridge: Cambridge University Press.

Wenger, E. and Snyder, W. (2000). Communities of Practice: The organisational frontier, *Harvard Business Review*, 78 (1), 139-145.

Wenger, E., McDermott, R. and Snyder, W. (2002). *Cultivating communities of practices*, Boston: Harvard Business School Press.

Wickens, C.D. (2000). Human factors in vector map design: the importance of task-display dependence, *Journal of Navigation*, 53-1, 54-67.

Wiener, J.B. (2004). The regulation of technology and the technology of regulation, *Technology in Society*, 26, 483-500. Doi: 10.1016/j.techsoc.2004.01.033.

Williamson, O. (1979). Transaction-cost economics: the governance of contractual relations, *Journal of law and economics* 22 (2), 233-261.

Williamson, K. (2002). *Research methods for students, academics and professionals*, (Vol. 20), Wagga Wagga, NSW: Centre for Information Studies, Charles Stuart University.

WMU, (2012). *Simulation-based training module to promote green energy-efficient ship operation*, IAMU 2011 Research Project by World Maritime University (WMU), International Association of Maritime Universities, Tokyo, Japan.

Woiceshyn, J. and Falkenberg, L. (2008). Value creation in knowledge-based firms: aligning problems and resources, *Academy of Management Perspectives*, 22 (2), 85-99. Doi: 10.5465/AMP.2008.32739761.

Woods, D.D. and Dekker, S. (2000). Anticipating the effects of technological change: A new era of dynamics for human factors, *Theoretical Issues in Ergonomic Science*, 1-3, 272-278.

Woodward, J. (1980). *Industrial Organization: Theory and Practice*, 2nd ed. New York: Oxford University Press.

Wrana, A. (2007). Fatigue – a contributor to fatal accidents, *The Swedish Club Letter*, 1-2007, 10-11.

Wynne, B. (1988). Unruly technology: Practical Rules, Impractical Discourses and Public Understanding, *Social Studies of Science*, 18 (1), 147-167.

Yang, K.H., Lee, S.M. and Lee, S.G. (2007). Adoption of information and communication technology: impact of technology types, organisation resources and management style, *Industrial Management and Data Systems*, 107 (9), 1257-1275. Doi: 10.1108/02635570710833956.

Yin, R.K. (2009). *Case Study Research: Design and Methods*, New Delhi, India, Sage publications. ISBN-13: 978-1412960991.

Yong, T. (2010). *Surfing the IP Broadband Highway across Oceans*. Available from <http://business.singtel.com/satellite/SatCom/Article.pdf> on 10th March 2010.

Zammuto, R.F., Griffith, T.L., Majchrzak, A., Dougherty, D.J. and Faraj, S. (2007). Information Technology and the changing fabric of organisation, *Organisation Science*, 18 (5), 749-762. Doi: 10.1287/orsc.1070.0307.

Zuboff, S. (1998). *In the age of Smart Machines*, Basic Books, USA.

Appendix 1: Budgeting for vessel operations

(Process map sketched by researcher used for respondent verification). This process is performed prior to the taking on acceptance of the ship for its management. It involves the review of own capabilities as well as to budget out the activities involved.

Process Flow	Dept.	Resp.	Document	Objective	Record
Collate requirements	Technical	Tech.Supdt.	Checklist		Input Record
Prepare Budget with explanations	Technical	Tech.Supdt.	Format		
Review and Amend	Technical	G.M.			Input Record
Submit to Client	Technical	G.M.			
Make agreed amendments	Technical	Tech.Supdt.			
Final Budget to Client, Accounts and others	Technical	G.M.		% Budget Overruns	Final Budget
Monitor Performance, however budgetary constraints do not override safety	Technical	Tech.Supdt.	Procedure		Perf. Record

Appendix 2: Maintenance including supplies of spares and stores

(Process map sketched by researcher used for respondent verification). The core function of the Technical department, this process outlines the maintenances and supplies activities to ensure optimal operation of the vessel to the regulatory and contractual requirements

Process Flow	Dept.	Resp.	Document	Objective	Record
Collate all requirements, Statutory, Client, others	Technical	Tech. Supdt.	Checklist		Input Record
Plan out all the Maintenance, viz. Planned, Breakdown, Replacement, Repairs	Technical	Tech. Supdt.	Planned Maintenance System (PMS)		
Sanction and Provide external assistance through approved Service Providers	Technical	Tech. Supdt.	Approved list		Defect list
Sanction and arrange spares and stores supplies through approved Suppliers	Technical	Tech. Supdt.	Approved list	No. of break-downs and jobs overdue	Indent
Monitor Performance.	Technical	Tech. Supdt.	Procedure		PMS Record

Appendix 3: Compliance requirements of class and flag

(Process map sketched by researcher used for respondent verification). This process details out the activities involved in the process of inspections, audits and certifications and ensures that the vessel remains in compliance to all regulatory and own requirements.

Process Flow	Dept.	Resp.	Document	Objective	Record
Inventories of all certificates	Technical	Tech. Supdt.	Format		Master list of Certs.
Receive survey status from shin	Ship	Master	Format		Status Report
Review with Class records	Technical	Tech. Supdt.			Class Record
Arrange certification survey, inspection, audit	Technical	Tech. Supdt.	Procedure		
Receive completion report from shin	Ship	Master	Procedure	Overdue Surveys	Survey Report
Receive and Send original Cert. to ship, retain copy in office	Technical	Tech. Supdt.			Cert. copy
Monitor Renewal of Certificates	Technical	Tech. Supdt.	Procedure		

Appendix 4: Inspection and monitoring of vessel's performance

(Process map sketched by researcher used for respondent verification). This process lays out the methodology adopted to physically inspect and to regularly monitor the performance of the vessel to ensure optimal operations meeting the contractual requirements.

Process Flow	Dept.	Resp.	Document	Objective	Record
Identify all monitoring stages and plan out inspections	Technical	Tech. Supdt.	Procedure		
Receive all periodical and voyage reports from the ships and advise ships on variances	Ship / Technical	Master / Tech. Supdt.	Procedure		Ship reports
Carry out physical inspection of the ship and report to the clients	Technical	Tech. Supdt.	Checklist		Insp. Record
Monitor Regular Performance.	Technical	Tech. Supdt.	Procedure	% sub-optimal performance	Perf. Monitoring records

Appendix 5: Schedule of interviews and project work

Presentation of Project Plan at PhD Seminar in Copenhagen	30 th November 2009
Initial visit to Companies A, B & C	7 th December 2009
1 st on-site visit to Companies A & B	12 th February 2010
1 st on-site visit to Company C	13 th February 2010
1 st Interview with Captain 2 & Chief Engineer 2	6 th March 2010
2 nd on-site visit to Companies A & B	7 th May 2010
2 nd on-site visit to Company C	8 th May 2010
1 st interview with Captain 1 and Chief Engineer 1 (on - leave)	5 th June 2010
2 nd interview with Captain 2 & Chief Engineer 2	12 th June 2010
Evaluation at University of Southern Denmark	10 th September 2010
Project presentation at IAMU AGA at Korea	16 th October 2010
3 rd on-site visit to Companies A & B	10 th December 2010
3 rd on-site visit to Company C	11 th December 2010
2 nd Interview with Captain 1 and Chief Engineer 1 (on - leave)	27 th December 2010
3 rd Interview with Captain 2 & Chief Engineer 2	28 th December 2010

Note

Contact on e-mail continued with all three case companies as well as the seafarers of case 4 right through and beyond until the end of the year 2011.

Appendix 6: Access letter

Date:

From:

Capt. S. Bhardwaj

AMET University, Chennai.

To:

The CEO/MD/Director

Shipping Company....

.....
Dear Sir,

Subject: Request for research facilitation at your organization

As part of my PhD study I am undertaking research on the subject concerning challenges and potential of technology integration in modern ship management practices. A contract concerning this PhD study that is registered with University of Southern Denmark exists between AMET University Chennai where I am employed fulltime and the Faculty of Social Sciences, Department of Maritime Research and Innovation at the University of Southern Denmark.

The nature of my research entails study of ship management practices and interviews with relevant staff particularly that of technical management in at least three companies' settings that have mutually different structure of operation and management. After a careful consideration of various company profiles I find that your company operations ideally suit the purpose of my research.

Since this study is registered with a Danish university, it has to comply with the requirements of the Danish Data Protection Agency. Hence I offer full anonymity, confidentiality and discretion to all research participants and even the Danish university will not have access to confidential information. It will not be possible to connect specific and confidential information to individuals or organizations in my dissertation or other scientific articles. These are basic norms of ethical conduct of any research.

Sir, you will appreciate that this is only for academic purposes and bears no commercial significance. Furthermore, I firmly believe that the opportunity afforded to your staff in the participation of such study to objectively relook at own systems and processes in itself would be found very much value-adding.

I look forward to meeting you in person at your convenient time and date to explain the context in more detail.

Sincerely yours,

Capt. S. Bhardwaj

Appendix 7: Interview schedule

Part 1 - COMPANIES

Understanding processes

1. Please define the processes involved at macro-level in the Technical management function?
2. Please describe each of the macro-level processes step-by-step from its start to finish; with
 - (a) Who takes the step?
 - (b) Other department or ship interfaces at each step?
 - (c) Document used for reference if any to take that step, and
 - (d) Record if any generated at each step?
3. What is the performance indicator for that process to measure how well that process is done?
4. Do you have a documented management system of the functions and can I sight them?
5. What is your filing system of various records?
6. May I sight the records generated and the documents used at each step of the process?
7. How is the interface with ship effected?
8. What sort of reporting is required of the ship?
9. How are these reports from ship dealt with?
10. To whom are you answerable to?
11. Please define your:
 - (a) Role?
 - (b) Responsibility?
 - (c) Authority?
12. Please verify the rough process map that I generate and confirm if the map correctly represents the activities as done?

Drivers for technology

13. What kind of technology exists that is deployed in the operation of your ships?
14. On the deck for navigation, cargo operations and ship-shore communications?
15. In the machinery spaces?
16. What kind of technology exists that is deployed in the facilitation of management of these ships?
17. With respect to ship-shore communication and exchange of data?
18. With respect to deployment of software for process integration?
19. On a scale of 1 to 10 where will you rate your fleet in terms of technology integration in operation and management of your ships?
20. Please provide an overview of the advancing technology deployed in technical management of ships that you are aware of?
21. What is the average age of your fleet of ships?
22. Whether in new-building or in existing fleet, what in your opinion are the drivers to uptake/ upgrade of technology?
23. How do you perceive the technology push in the industry?
24. Is it proactively adopted to optimise operations?
25. Is it adopted to comply with regulatory requirements?
26. What part do the technology manufacturers play in pushing their technology?
27. How does the cyclic nature of shipping industry influence technology uptake/upgrade decision?
28. What returns on investment are expected from investments in technology?
29. How are the values and risks perceived in investments in technology?
30. What flag do your ships fly?
 - (a) Why?

Overview of technology integration and its impact

31. Is the technology integration meeting your expectations on its performance?
32. How has your experience been with technology integration?
33. What sort of challenges do you encounter in working with technology?

34. What sort of challenges does your crew report to encounter in working with technology?
35. Why do you think the crew reports that way about technology?
36. Do you see enough of fundamental research in technology integration processes?
37. What are your guiding parameters in selection of technology?
38. What in your opinion are the reasons for challenges in handling technology in present forms?
39. How do you think the challenges can be addressed in the shipping industry?

Crewing Issues

40. Where do you predominantly source your crew from?
41. Why do you source your crew from these locations?
42. Does technology influence your decisions on crewing?
 - (a) How?
43. Is technology capable and reliable enough to allow for cheaper deskilled operations?
44. Do you find crew capable of handling technology efficiently and effectively?
45. What do you think are the reasons of challenges posed in ineffective handling of technology by the crew?
46. Do you find age of persons as a defining factor in ease of handling technology?
47. Are there changed skilling requirements for crew to handle shipboard technology?
48. How often do you have to rely on shore assistance to handle technology related issues on board ships?
49. How do you train your crew in handling technology integrated operations?
50. What mandated skilling requirements would you recommend in light of technology integrated practices?
51. Is there broadband facility on-board for crew to use for personal communications and usage?
52. Are there any restrictions on such usage by the crew?

Specific issues in technology integration

53. In your opinion are there issues in proper designing of technology?
54. What sort of issues do you see?
55. Do you find sufficient user input in the design of technology?
56. More and more technology is seen to operate as a system rather than stand-alone add-on approach, with operators as integrated part of the system. Would you agree? If so, then how well do you think human element integration is considered at the design stage itself for example with respect to:
 - (a) Ergonomics
 - (b) Cognitive limitations
 - (c) Information overload
 - (d) Ease of operation
 - (e) Human factors engineering in general
57. Normally Class certifies all equipment for usage on-board that gives user the assurance, but how competent do you think is the Class itself in testing and certifying a hybrid human-technological integrated system?
58. Would you agree when it is said that humans are the main cause of incidents and accidents?
59. Would automation and keeping the man out of the loop be a good answer to improve safety?

Technology application in management

60. What technology applications do you utilise to assist you in management of ships under your charge?
61. Do you use any customised software in technical management processes?
62. How frequent is your interaction with the ships' staff given the ease of ship-shore communications?
 - (a) On what issues do these communications take place?
63. How often do you visit the ship and interact with the ships' crew?

64. Do senior ships' officers meet you before and after they sign on / sign off from the ship?

Part 2 - SHIPS STAFF

65. Please verify the rough process map that I have generated out of my interaction with companies on technical management process and confirm if the map correctly represents the activities as done?

- (a) On the interfaces that happen with the ship
- (b) The documents and records exchanged with the shore based management
- (c) Do practices differ in various companies?
- (d) What changes do you perceive have take place over the period of your sailing career?
- (e) Is there any scope for improvement in any practices?
- (f) Any other comments

66. What latest technology have you handled in ship operations in

- (a) Navigation/machinery spaces
- (b) Cargo operations
- (c) Communications

67. You have sailed on ships of various owners/managers. What in your opinion drives the technology agenda in shipping?

- (a) Is it enhanced performance?
- (b) Is it safety related?
- (c) Is it regulation driven?
- (d) Is it customers' requirements like the oil majors?

68. Why, in your view, such large disparity exists in technology application among various companies?

69. What have your overall experiences been with the various technology applications?

- (a) Why good experience?
- (b) Why bad experience?

70. Do you think there is a gap between the users expectation and the designers of technology?
- (a) And why?
71. How do you cope with
- (a) Deficient technology integration?
- (b) Non-standardised equipment?
72. In your opinion, is there enough research carried out in the shipping industry to base the technology integration as seen in other sectors like aviation?
73. In your opinion, is the technology reliable enough to allow deskilling of human handling them or do the seafarers need to know the fundamentals yet and remain up-skilled?
74. Is there a need to re-skill in light of technology invasion happening in shipping?
75. Is the move to reduce crew in light of technology advancement justified?
76. How do you view the ease of communication with shore based management?
- (a) Why is good?
- (b) Why is it bad?
77. How do you handle the information overload in automation systems?
78. Is there a tendency of over-reliance on the technology?
79. Does technology spawn suspension of traditional seafaring skills?
80. Does technology enhance situational awareness?
81. How frequent are situations of emergency and abnormality?
- (a) How are these handled?
82. What challenges do you face with crewing issues?
- (a) Contractual employment and transient work force?
- (b) Multi-cultural environment?
- (c) Alienation from the ship owner?
83. Would you favour greater technology integration if the gaps were addressed?
84. Is there potential for optimisation of processes through enabling technology?
85. Which process in your opinion has the maximum potential for optimisation and can give large benefits with least effort?

Appendix 8: Matrix matching issues discussed in literature review with its empirical findings

	Literature Review		Empirical Findings
Section	Topic	Section	Topic
2.1	Economics of shipping, economics of technological change	6.2	Drivers for uptake of technology
2.2	Inescapability of technological advancements	6.2	Drivers for uptake of technology
2.4	Technical advances–ship management	6.1	Technical management process
		6.2	Drivers for uptake of technology
2.5	Technical advances – technical management	6.2	Drivers for uptake of technology
3.1	Theory of technology interface	6.3	Lack of scientific approach to technology integration
3.2	Skilling dilemma	6.4	Skilling issues
3.3	Enhancing optimisation potential	6.9	Which process for optimisation will bear ‘low hanging fruits’?
4.1	Issues in design stage	6.5	Issues involved at design stage
4.2	Challenges of management of information in management and operations	6.6	Information clutter in management and operation of ships
4.3	Challenges of operation with automation	6.7	Challenges in the operations with automation
4.4	Influence of work culture and work environment	6.8	Influence of work culture and work environment
4.5	Technological limitations	6.2/6.4/6.7	As above