CHALLENGES AND POTENTIAL OF TECHNOLOGY INTEGRATION IN MODERN SHIP MANAGEMENT PRACTICES

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ABSTRACT

This paper is based on the research project that 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 un-optimised 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.

Keywords: *human-machine interface, optimisation, technology integration*

1. INTRODUCTION

Along with the concerns for human safety and environmentally safe operations, the key dimensions of service quality of shipping industry 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 proper research on technology integration and management systems and the factors that make them or prevent them from working optimally [25], [5], [42]. Sharma [36], in his study of the understanding of a service management framework in the ship management industry, finds that it primarily runs on heuristics and thumb rules.

While technology advancements were designed to contribute to minimising task complexity and to mitigating human errors, issues of fatigue, increased administrative burden, technology assisted accidents etc. still plagued the industry. Shipping as the principal service providing industry within transportation, produces this service with the ship as its core constituent unit that operates geographically remotely and in a high risk environment. Yet, technology including information communication technology infrastructure is now seen to be increasingly rendering the ship manager capable of holistically managing ship operations effectively [24], [31], [25].

How is the technology being inducted and integrated into the modern shipping practices? What has been the impact of it so far? Is there scope and potential for optimisation? These were the drivers of the study. 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 [11].

The principal aim of this study was to deepen understandings 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 in 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.

With the objective to delimit the research project in the architecture of ship management system, the function of 'technical management' that has greatest influence on the ship management practice is scoped.

2. THE ECONOMICS OF TECHNOLOGICAL CHANGE

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 [41]. Thus it is not hard to see that the choice of economic logic for value creation in shipping has always been lowering of costs.

Technological change poses some of the most important concerns for shipping management in the current time. 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 operation performance. Now shipping has evolved into an aggressively competitive market driven regime. Charterers are often replaced by traders who take short term view and prefer to hire ships they need from the spot market rather than charter long term [40]. This is also the case with ship owners who are more of 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 [37].

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. With the slicing of the maritime value chain 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 barrier to the diffusion of new and efficient technology. The ship owner faces the dilemma between minimization of operation 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 [14] 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 utilization 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 is quite different, which in turn affects their technology change decisions.

However, 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 [22]. The evolution of technology integration and automation architecture in ship operations and management has been through three main areas: (a) advances in instrumentation and control, (b) evolution of information systems and (c) advances in maritime communications. 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 then *inter alia* got partially addressed with technology interface, but lacked in holistic approach. Knudsen [23] 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.

This points out to the lack of any scientific approach in the practice of technology integration in ship operations and management.

3. THEORY OF TECHNOLOGY INTEGRATION

Most rational decisions are based on some form of theory. It 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 [7].

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 [30].

Arvanitis and Loukis [4] point out that, while technology plays a key role in an organisation, existing literature in operations management still holds an organisation-centric or a process-centric view when studying business entities. Despite the significant impacts of technology, the three way technology-organisation-process interaction has largely been neglected in literature [48], [17]. 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 [9].

Figure 1 below shows the trinity view model that easily lends to simultaneity and dynamics where technology, organisation and processes co-exist and

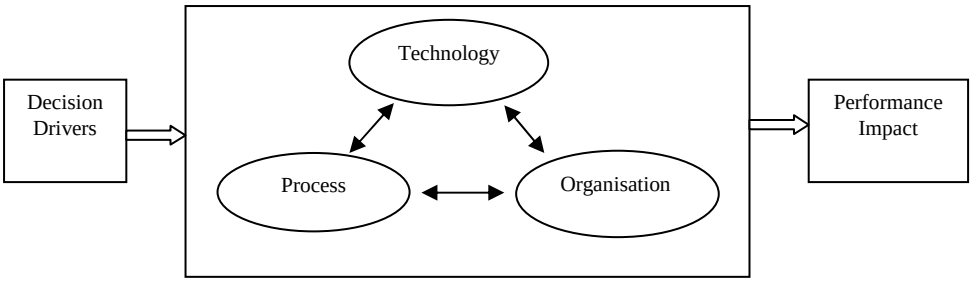

Figure 1 Technology Centric Framework with simultaneous technology-process-organisation view.

these dimensions are systematically integrated into an entity [46], [9].

The study of interaction between technology and organisation highlights some key issues [32], [49], [33]:

Technologies are products of their time and organisational context. While they have flexibility in interpretation, design and use, they are 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 the 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.

4. RESEARCH METHODOLOGY

A qualitative, exploratory research approach with case study as strategy was considered appropriate. The focus was on examining how the shore based managers and ship board staff who are 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. 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 that corroborates the intent of 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 which were all used as research tools [47].

Four case studies were selected, three of which were company settings undertaking technical management of ships in a mutually varied structure of constitution. (Case A) was 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. 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. The third case study (Case C) has a profile completely different from that of case 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 fleet profile of modern, young and diversified vessel types to serve different and specialized 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.

The fourth case study (Case D) consisted of interviews with senior sailing staff that have had long sailing experience including sailing on-board fairly modern ships that were equipped with modern technology to enable giving 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 ensured that the sailing staffs 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.

Multiple case designs allow cross-case analysis and comparison, and the investigation of a particular phenomenon in diverse settings.

Furthermore, an ‘Explorative Integrative’ form of case study approach was adopted in this project. ‘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 an analytical endeavour, it aims at generating facts in the field in order to create an integrative view of the case, depicted in figure 2 below [26]:

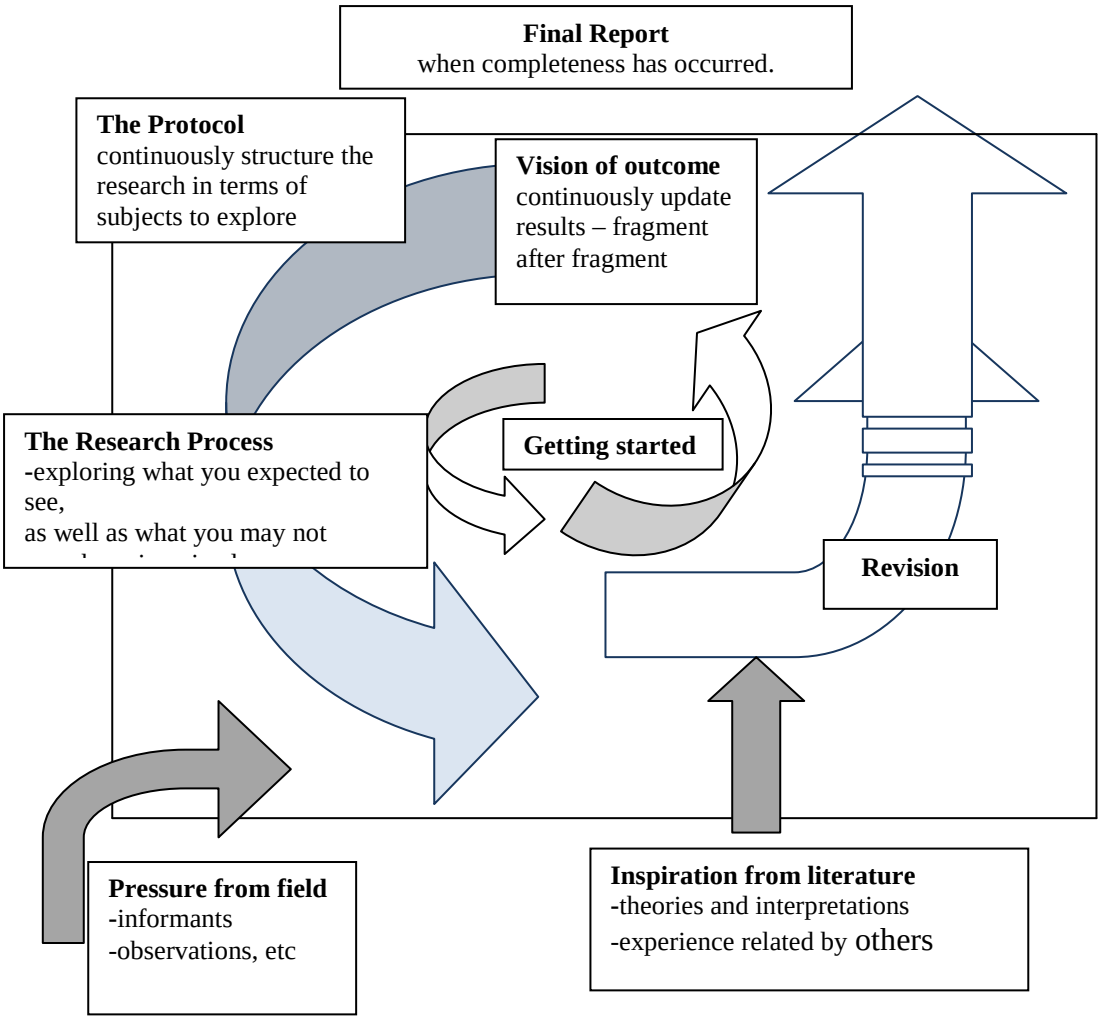

Figure 2 'Explorative Integration' as process

This research was based on the 'post positivistic' paradigm by Guba [15]. 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. 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 [34]. Post positivism's empirical quest for knowledge emphasizes replicability across heterogeneous populations, settings, times, perspectives and deductive, critical refutation. Scientific generalisations gain warrant only through such replication and criticism.

5. 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 as is suggested by some. There is no vacuum towards this initiative from the shipboard standpoint. For example during the fieldwork of this study the enthusiasm towards handling of latest technology that in particular rendered reduced their administrative burden or made operations easy for them was amply discernible. So also their vehement assertion of 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 preposition guiding organisation 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 form of technology already in use in other industries. The literature review showed evidences of 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 much more robust fundamental research application [32].

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 myriad of actors in a common enterprise. This gives rise to split-incentives phenomenon. The ship owner, particularly if he himself is a mere asset player finds him 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 that such implementation was seen as a cost and the management were keen to see 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 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 lack of learning opportunity and experience in an automated environment which then proves risky in situations of abnormality or emergency. Also many a times 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 much concentrated form [8].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 [3]. It led to non-standardisation and poor integration of equipment into work system 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 into 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 many a times 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 technology initiated accident was

noted in this study it is not hard to determine how 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 evading bearing of costs towards any such training [18], [2].

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 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 veracity of such exercise 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 [23]. 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 [6] 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.

6. 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 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, 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 [21]. There is then economising on bounded rationality while simultaneously safeguarding the terms of contract against the hazards of opportunism [44].

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 [16] 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 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 as are being pushed through globalisation, re-conceives development as global competitiveness within the global market place [29]. 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 shipping industry is the fact that the law of the seas is grounded in the notions of freedom of the seas with underlying principle of navigation of the oceans freely, 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 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 attractive choice as regulators, the sovereign privilege creates an unregulated environment where capital is free to act as it pleases [1].

In the global context, the policy making is seen to get politicised with 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 own parochial advantage by raising rival firms' cost, endures [43].

Munck [27] 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 those 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 [39] 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 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 [12], [28].

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 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 at the bottom of 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 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 [35]. Even ILO [19] 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. Growing amount of literature on social dimensions of globalisation shows that many are wary of the so-called benefits of globalisation [20], [35], [19]. Labour fortunes are undermined by an ideological discourse that upholds profit as 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 [20]. Stiglitz [38] asserts that such economic policies that purport to separate efficiency issues from equity treats labour as commodity and runs counter to the interest of workers. 'Labour market flexibility' and 'capital market flexibility' appears 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 [6] of the shipping industry where 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 failure to see the seafarer coping with abnormalities and evolving practices then 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 [45] 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 problem arise often more acutely during commercial lifetime of technologies.

Related 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 seafarer is scarcely entered into the information networks which inform the design process. There also is 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 [13] 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 "Whether we have 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 [10]. 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 daily basis as their feedback on poor design is judged as self-serving [32].

This section has analysed the technology potential gap in terms of theoretical framework generally applicable in other sectors. Exacerbated in the shipping industry environment due to its unique structure and disposition, the un-optimised technology integration results in the seafarer who is the driver of technology, become 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 strong community of practices 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.

7. 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. Respondent validation was achieved in all analyses.

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.

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