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Monitoring real time data of the seafarer work and rest hours onboard merchant ships &stakeholder utilization of the data to manage operations risk in merchant shipping.

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MSc INTERNATIONAL OPERATIONS AND SUPPLY CHAIN MANAGEMENT

Abstract
Resilient supply chains are made possible due to the existence of merchant ships which ply from coast-to-coastcrossing seas and oceans, thus carrying large volumes of energy, raw materials and finished goods. The shipping industry transports 350 million tonnes of grain, 1 billion tonnes of iron ore, and about 2 billion tonnes of crude oil annually. By land, rail, or air, these shipments would not be conceivable. Prosperity is fuelled by the capacity to contribute value, which also enables emerging nations to grow.
Merchant ships interact with the marine ecology which can be severely harmed by a commercial ship accident.While accidents in shipping can be caused due to a culmination of non-conformities, the issue of seafarer fatigue is closely linked to accidents and incidents that occur at sea. The violations of work and rest hours (W&RH) in merchant shipping is a contentious issue which is closely monitored by ship and shore personnel. Commercial pressures due to globalization, have made it difficult for shipping companies and regulatory bodies to address the issue of seafarer fatigue. This research aims to device a means to resolve the issue, thereby contributing to the theory and practice of operations risk management in merchant shipping.

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I. Introduction

Due to exponential rise in economies of scale and consumption patterns of consumers globally the size and number of merchant ship(s)(MS's) has expanded, however, the number of personnel running these ships has decreased, for example, 20-26 crew onboard a MS carrying a load of 20000TEU containers, and similarly, 20-26 crew on very large Oil, Gas, and Bulk carriers, while crew sizes on Transocean ships ranged form 30-40 crew onboard prior to the year 2000 (Ellis & Sampson, 2008). According to Grech and Horberry, (2002), technological advancements have contributed to reduced personnel, with some vessels having as few as 22 sailors on board a Very Large Crude Carrier (VLCC). Improvements in ship design and navigational aids along with a decline in technological failures have exposed how much of accidents are caused by human error(Rothblum, 2000).Esbensen, et al. (1985), describes, human error is the leading cause of 43 percent of incidents reported, the actual number of occurrences involving human mistake could be as high as 80%. Repeated research articles since 1985 until date reiterates, Sánchez-Beaskoetxeaet al., (2021) have highlighted human error caused due to fatigue as the cause in shipping accidents.

The following are some recent occurrences causing operation failure in supply chains& environmental pollution:In an accident initially blamed on strong winds on the beam, the 20,124 TEU (Twenty Equivalent Unit) container vessel, Ever Given ran aground and blocked the Suez Canal for nearly a week. The 203,130 tonneWakashio, a cape size bulk ship, collided with a reef, causing oil pollution and sank off the coast of Mauritius, a fragile ecosystem, (www.seatrade-maritime.com). Maritime business is characterised by a variety of demands, and weariness is one of the potential causes of accidents that happen aboard ships, posits McNamara et al., (2000).

Primarily this research proposal endeavours to address the issue of seafarer fatigue in the maritime industry, being a cause to shipping operation incidents /accidents &attempts to highlight the opportunity which exist in monitoring the accurate real time data (RTD) of seafarer Work & Rest Hours (WRH) which is presently not known to the stakeholders. Fatigue has been shown in previous research studies to have potentially disastrous consequences in terms of bad health and performance posits, Josten et al., (2003). Ship managers install a software on board vessels to allow officers & crew to record WRHD &plan their work and rest hours in

advance of operations e.g. The ISF Watchkeeper software (Mitroussi&Notteboom, 2015). The effectiveness of this planning tool for work and rest hours of seafarer will be reviewed in this dissertation.

1.1Research Aim:

To examine perception of stakeholders in the shipping industry with regards to the effective monitoring of real time data of Work and Rest Hours of the seafarer onboard merchant ships & the use of this data as a tool for risk management in international ship operations.

1.2 Research Objectives based on pragmatism:

2. Literature review of past research papers on initiatives to automate the recording of fatigue risk management systems in various industries including shipping and offshore industry (including seaports and terminals) and utility of this data as part of a risk management tool in the respective industry/ organisation.
3. Critical review of the major & minor incidents/ accidents in merchant shipping and evaluate the extent to which fatigue of seafarer, contributed to the accidents in merchant shipping.
4. To explore a sample of stakeholders(Seafarer, Ship Owner, Ship managers, ship inspectors, ship surveyors) perceptionin merchant shipping regarding automated recording of work and rest hours (WRH's)& the utilization of the work rest hours data (WRHD)as a tool for risk management in merchant ship operations.
5. To examine the seafarer's view on the positive/negative impact of having work and rest hours recorded via appropriate indoor localisation technology such as a wearable tracking device or biometric reading device while seafarer is onboard the merchant ship.

This research will not discuss the details of localisation technologies and their layout (as various technologies are available for use in hazardous & non-hazardous areas of a merchant ship). Table 1 lists these commercially available systems along with their name, manufacturer, technology, and accuracy. by Zare et al., (2021).

System name	Maker	Technology	Accuracy
Underground Global Positioning System (UGPS)	ApoSys Technologies	RFID/ Wi-Fi	Centimeters-level
RealTrac Positioning	RealTrac	BLE/UWB	0.1–3 m
Mobilaris Onboard	Mobilaris	Sensors and Wi-Fi	5–10 m
Widefind WISPR	Widefind	UWB radio	Centimeter-level
Minestar Solutions	Caterpillar	Wireless ad hoc system (WASP)	Centimeters-level
Trax + Tags II	Minetec	Wireless ad hoc system (WASP)	Centimeters-level
Asset Tracking System	Mine Site Technologies	RFID and Wi-Fi	N/A
MineSuite FleetManager	Maptek	Nanotron Swarm Bee	~1 m
StataConnect Wireless	Strata	Wi-Fi	Up to 60 m
DISPATCH Underground System	Modular	RFID	N/A
SENTINEL System	IWT	Wi-Fi	N/A
Miner and Equipment Tracking System (METS)	Carroll Technologies group	RFID	N/A
HxGN MineOperate UG Foundation	Hexagon AB	N/A	N/A
TrackSphere	Tracktio	BLE	10 cm
Pitram	Micromine	RFID	N/A
Real-Time Resource Location Solutions	Becker Mining Systems	RFID	N/A
Personnel and Equipment Positioning System	Newtrax	Wi-Fi, BLE, LTE	N/A
Mine Net Mesh	AMR PEMCO	Wi-Fi	1–2 m
People and Personnel Tracking	Infotek Software & Systems (P) Limited	RFID	N/A
GuardIAN Personnel Tracking	MineARC systems	LTE	N/A

Table 1: Commercial tracking systems for personnel and equipment (Zare et al., 2021)

1.3 Critical evaluation of research objectives

A researcher requires to be critical at every stage& distant from biases, which occur either due to the researcher's connection with the industry or due to the structure of a questionnaire which leads participants to giving positive, non-critical responses(Stahl et al., 2011), a mixed method research (MMR) approach isadopted(Greene, 2007). Primary contributors to mariners' psychological issues is social isolation (Sampson & Thomas, 2003). For more than four months, seafarers who do not step ashore or have social connections tend to overvalue trivial incidents/items (Exarchopoulos et al., 2018). The implications of having technologies installed to monitor the WRHD of a seafarer,could lead to monitoring movement of the seafarer within the accommodation area of the ship and the views expressed by seafarers to this aspect are given an equal importance in the research. The research takes a large step towards encouraging ship managers& ship owners to evaluate the monitoring of WRHD, with a transparency which will assist in determining the operational risk in

merchant shipping due to a crew which maybe stressed due to repeated violations of WRH'srather than accepting the existing exploitative scenario which presently persist in the merchant shipping industry(Iversen, 2012).The existing solutions provided to the seafarer and the Ship Manager are to record Work and Rest Hour data and then if the recorded WRHD displays violations than work to be stopped or compensatory rest to be given to seafarer. However, the qualitative data reveals that ship operations cannot be stopped when ship is in port (24-48 hours) or in a 12–24-hour river/ channel transit. Besides compensatory rest or 'stop work for rest' being done after an unsafe operation where the senior ranks (Master, Chief officer, Chief Engineer) are fatigued does not justify the period when the operation was unsafe. Coincidentally any equipment installed onboard to satisfy a regulation involves the seafarer maintaining the equipment and filling up a checklist, and since the implementation of STCW1978, amended in 1995, numerous regulations and equipment's installed on a merchant ship have increased the seafarer workload with the advent of globalisation, however number of crew onboard have reduced subsequently(Kristiansen, 2019; Heij et al., 2011).

II. Literature Review

2.1 Introduction

Merchant shipping (MS) carries 90% of the worlds goods, its operations are a part of a supply chain and the drivers which initiate and formulate the entire supply chain are the suppliers and end consumers (Crang et al., 2013),MS's being in between these drivers tends to face several pressures from suppliers and consumers and therefore several challenges for the international MS sector to address the violation in Work &Rest Hours (WRH) of seafarer's(Smith, 2007).

A review of various incidents and accidents in merchant shipping and the causes of these accidents are examined to gain an unbiased understanding of the causes and the contribution of seafarer fatigue towards these accidents. The literature review attempts to identify if the factual data related to seafarer (WRH), is given importance in merchant shipping. Research articles studying the social fabric of a seafarer's life and the benefits and stressors that come along with the jobare evaluated critically as this information forms the basis of designing the survey questionnaire.

A review of various other industries using automated localisation techniques for monitoring the occupational health and safety of workers has been examined to identify the gap, between existing automated localisation techniques usedin industries other than shipping and the existing conceptual framework of fatigue management systems in maritime operations.

2.2 Difficulties of operations risk management in merchant shipping.

A general principle in risk management suggests that operations associated to certain risk should be coupled with precautionary actions to mitigate or prevent the riskhowever, if the risk cannot be mitigated or eliminated by installing precautionary measures then the activity should not be carried outAven, (2016).Sparrow, (2000) points, whatever the strategy chosen, organizations must make investment choices when deciding the best course of action to lessen risk exposure or take advantage of possibilities. A correct definition of supply chain risk is the likelihood of an incident wherein the company loses money, because of not recognizing opportunities accompanying inbound supplies (Zsidisin& Smith, 2005).

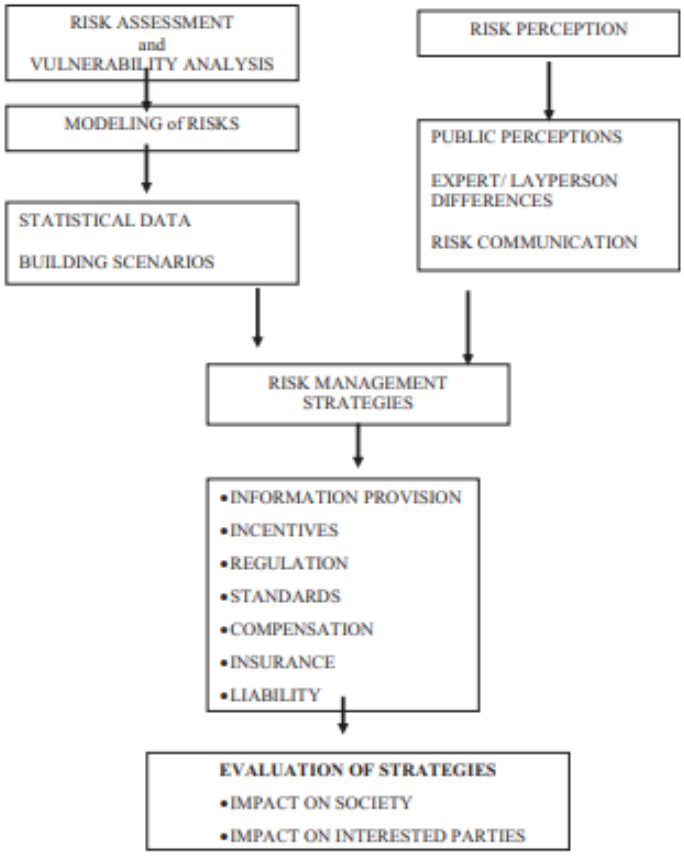


Figure. 1 Conceptual framework of Risk Analysis (Cohen &Kunreuther, (2007) pg. 526)

Fig. 1 depicts the conceptual framework of risk analysis, which highlights the requirement of statistical data and industry experts to formulate the necessary risk management strategies. Cohen and Kunreuther, (2007) highlights, the key element required to be considered in linking risk assessment (i.e. likelihood of occurrence and potential consequences(Khan & Abbasi,2001), risk perception (which depends on the view of the prevailing situation, business environment and the experience of the persons involved managing the risk (Wachinger et al., 2013)) and risk management (creating, taking into consideration, and evaluating the effects of many scenarios and solutions on the results of company performance (Zsidisin & Ritchie, 2009))are issues dependingon each other (Hart & Milstein, 2003). In the evaluation of strategies towards risk management Warhurst, (2002) highlights theexistences of a questionable doubt regarding organizations investing in operations risk management to a degree that is adequate from an environmental perspective upholding the values of sustainability (Warhurst, 2002).

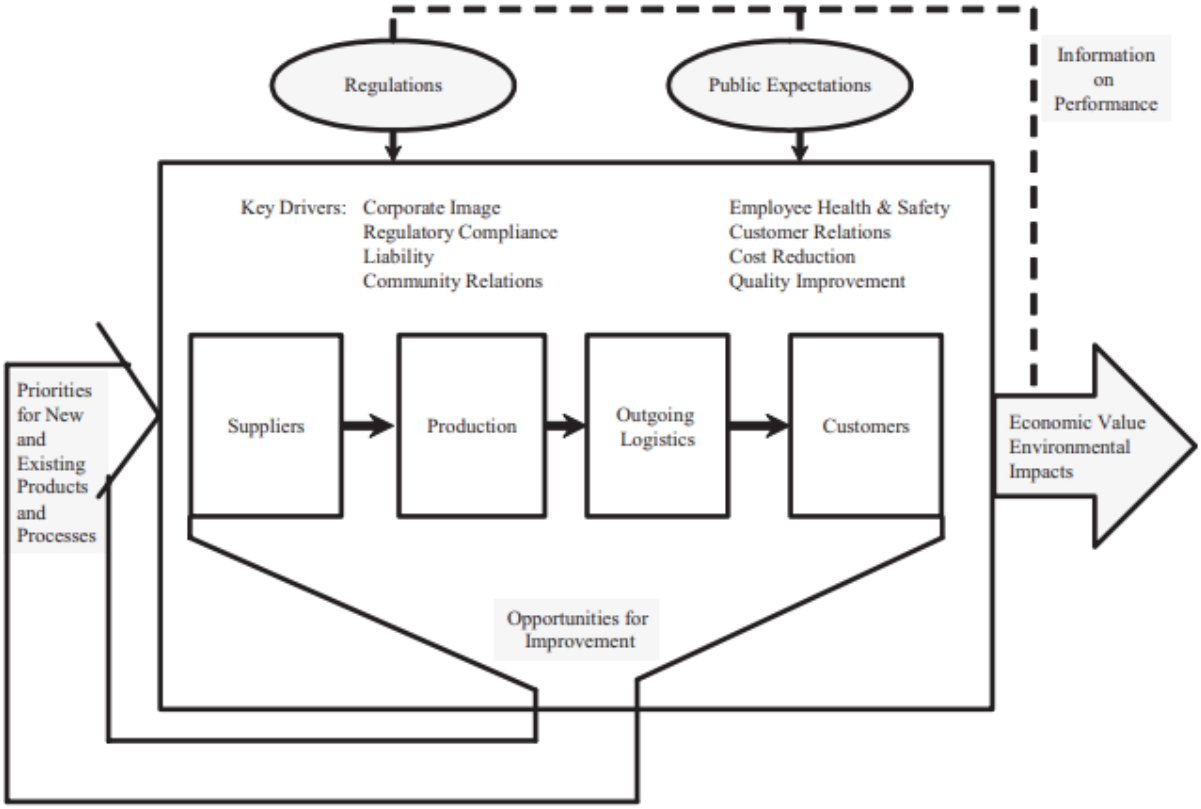


Figure 2:Environmental risk management and extended supply chain (Cohen&Kunreuther,(2007) pg.527)

Figure2 depicts the supply chains guided by regulations and public expectations. Corporate image, regulatory compliance, liability, and community relations are important supply chain drivers for regulators, and health and safety, customer relations, cost reduction, and quality improvement are important supply chain drivers for employees. Merchant shipping forms an integral partof the incoming and outgoing logistics of supply chain, between suppliers and consumers depicted in Fig.2.The Maritime Coast Guard Agency (UK) reveals that reduced crew and increased workload in merchant shipping, plays a vital role in many maritime accidents (Exarchopoulos et al., 2018). Changes in organisational structures related to the marine industry have a significant impact on seafarers' general well-being, as noted by MacLachlan et al., (2012),influencing variables include globalisation, technical advancements on ships that make jobs more complex, crew reductions and short-term contracts that make jobs more precarious, multicultural crewing, and ships registered under Flags of Convenience (FOC)(Slišković&Penezić, 2015) making the industry highly exploitative.

A flag of convenience (FOC) is the official nationality for a ship that is registered for a fee in a country where it is not actually owned to benefit from tax or commercial advantages, Van Fossen, (2016) highlights, most of the rules governing taxation, labour practises, safety, licencing, inspection, and management are dependent on the flag that a ship is flying. (Glen, 2008)highlights, Norway, once a registry to many ships has led to ships being registered outside Norway to gain from tax benefits in registering a ship under a FOC administration leading to a decline in the number of Norwegian seafarers (Benito et al., 2003).

2.3 Accidents in merchant shipping affectingmarine environment &causes of accidents.

The ship Torey Canyon was implicated in the first significant oil spill in the English Channel, which occurred in 1967, Hetherington et al., (2006)highlighted the releasing of 100,000 tons of oil in the water along the southwestern coastline of England. Lazarev, (2021) discusses an oil spill from the tanker Exxon Valdeze in Prince William Sound, Alaska caused direct damage of USD 287 million in 1989, besides the damage to the marine life can barely be measured. The 21,000-ton container ship Bunga Teratai Satu ran aground on the Great Barrier Reef in the year 2000, according to Haynes et al., (2002). In the approach channel to the River Neath in Wales, on March 27, 2018, the general cargo vessel CelticaHav, registered in the Bahamas, grounded on a breakwater wall (www.gov.uk/maib-reports). The bulk carrier Shen Neng 1 grounded on Douglas Shoal on April 3, 2010, according to Grech (2016), who also points out that the Chief Mate's lack of rest caused a series of mistakes that ultimately caused the grounding. According to Phillips et al. (2015), multiple marine accidents

show that seafarer are led to their own device to manage their fatigue levels, though they continue to display WRH incompliance with regulations to not reflect negatively on themselves.

Wu et al, (2015), in his study of maritime accident reports, issued by Maritime Safety Administration (MSA) China from 2000 to 2010, concluded that many ship crews did not make their safety training actionable as a safety barrier in an emergency leading to an accident and insisted for safety culture to be improved, by increased trainings using simulators and frequent drills. Baker & McCafferty, (2005) reviewed maritime accident and near miss data for a period of three years from the data bases of Maritime authorities of various countries,the research findings reveal, human error accounts for 80 percent of maritime accidents, failures in situational awareness and assessment account for most accidents, and fatigue is closely related to both failures in situational awareness and the accidents that result.Roberts et al., (2014) posits most serious incidents were caused by human factors as opposed to mechanical ones. Unsafe work practices, carelessness, an incorrect understanding of risk, and insufficient training were among the major contributors to the fatalities.

A tool to expect mariner fatigue over the length of a voyage and tools to test for fatigue to find and confirm mariner fitness for duty are two areas where Baker & McCafferty, (2005)decided that more research was required. According to Roberts et al. (2014), the fatal accident rate in British merchant shipping between 2003 and 2012 was 21 times greater than the rate for the entire British workforce.According to Roberts & Carter, (2018) analysis of casualties in British merchant shipping during a 92-year period (1925-2017), saw a large percentage of deaths among merchant seafarers, these being attributed to ship-related incidents. 108 of the 363 deaths caused by fires and explosions in the past 70 years were on tanker vessels, either in the engine rooms or mechanical spaces, or in ports during the loading or unloading of cargo, (Roberts & Carter, 2018).Training and certification of seafarer by maritime regulatory bodies has been defined as a large step towards preventing accidents and incidents (Mazhari, 2018). Slišković&Penezić, (2015) recommendation for reducing stress and lowering the occupational health risk of seafaring include reducing on-board stay (i.e., efforts to shorten separations from home), respect for the work contract, minimising high workload and fatigue, improving the quality of life on board, and protecting seafarers' rights. As a result of an enhanced safety culture and short-term employment contracts on tanker ships, Norwegian registered ships experienced fewer accidents than ships registered under Flags of Convenience, according to research by Håvold&Nesset(2009).

2.4 Existing regulation and technology to prevent fatigue on merchant ships.

The maritime industry has made efforts in regulating the work & rest hours of seafarers, through maritime conventions including International Labour Organisations (ILO), Maritime Labour Convention (MLC) and the International Maritime Organisations, Standards of Training Certification& Watchkeeping Regulation VIII/1 (Fitness for Duty), which regulates work and rest hours for sailors on merchant and cruise ships(Zhang et al., (2020) ;Jepsen et al. (2015)). The seafarer reports and logs, his/her WRH using computer software placed on ship, the systems can and are manipulated, according to research states, Baumler et al., (2020). The bureaucratization of management and safety, affects record keeping(Graeber, 2015),& in limited resource environments such as ships, the true workload is not reflected owing to manipulation (Baumler et al., 2021; Phillips et al., 2015).

Convention	Work / rest in any 24 hour period	Work / Rest in 7 days	Rest period amount and duration	Notes and exceptions
MLC 2006	A maximum 14 h of work A minimum 10 h of rest	A maximum 72 h of work A minimum 77 h of rest	Not more than 2 rest periods, one of which shall be at least 6 h. The interval between rest periods of less than 14 h	The records Shall be made each day. Exceptions are allowed, by means of Collective Agreements.
STCW 2010 (Manila annex)	A minimum 10 h of rest	A minimum 77 h of rest	Not more than 2 rest 2 rest periods, one of The interval between rest periods of less than 14 h	The records Shall be made each day. Exceptions are allowed.

Table 2: Working and rest time regulation in shipping (www.ilo.org&www.imo.org)

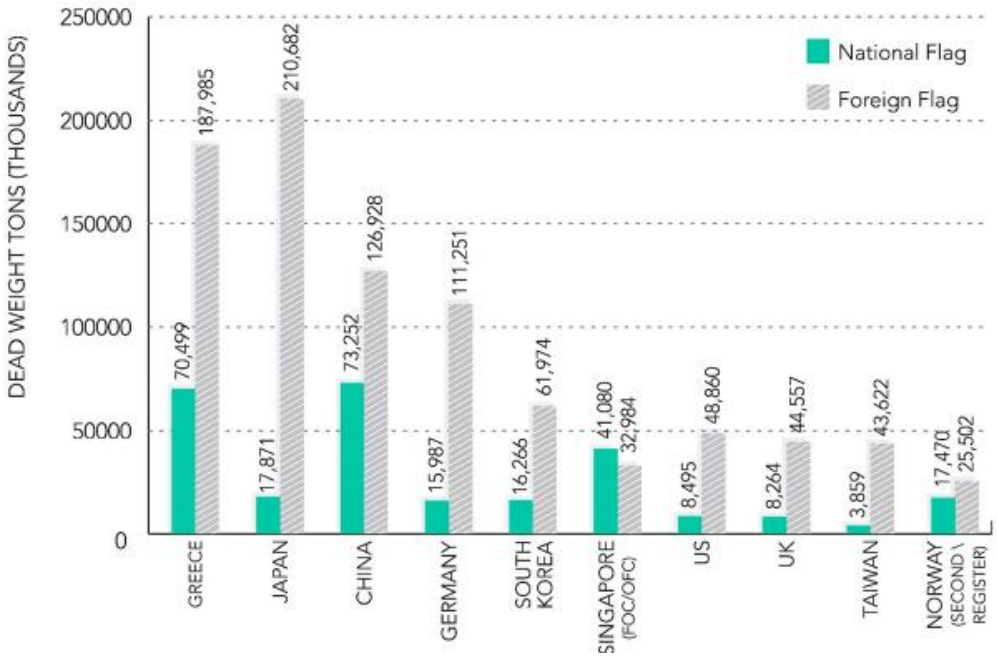
Baumler, (2020)explains (Table 2) should a state being a member to the Maritime Labour Convention (2006) comply with the hours of work standard of 72 hours in a 7-day period would be agreeing to a rest of 96 hoursinthe same 7-day period. However, if member states follow the hours of rest standard as per (Standards of training, certifications and watchkeeping 2010) STCW 2010 than 77 hours of rest, would mean 91 hours of work which is a difference of 19 hours of work in a week as compared to the MLC 2006 Convention.Chae, (2011) highlights the computer software allowing seafarer to record WRH are programmed to raise a red flag

when STCW 2010, specified hours of rest are violated, the MLC regulations for seafarer's apply mainly to working and living conditions. The manual entry of WRH by the seafarer is the only means available to regulate WRH, however these entries are allegedlyfalsified or adjusted if a red flag is observed, and this is considered a norm in merchant shipping (Baumler et al., 2020). Fatigue was considered as an underlying factor causing task deviation leading to dangerous situations at sea (Rajapakse & Emad, 2020).

Lamvik, (2012)highlights, that the ship is always on the move and seafarers must remain oriented towards this movement, though unpredictable.((Lamvik, 2012; Knudsen, 2009)i.e.the ship staff is unaware as to which is the next port, or if the vessel will go in port or wait at anchorage). Besides on entering port there is an anxiety of inspections that could be carried out by Port State Control or terminal vetting inspectionsLamvik, (2012).Exarchopoulos et al., (2018) reiterates it is the responsibility of Company, Flag states, Port states and labour supply states who are jointly responsible for the implementation and enforcement of the STCW 2010 & MLC 2006 regulations. The companies must attempt to improve on MLC standards, rather than simply adhere to them (MacLachlan, 2017).

According to international regulations all ships must be safely manned in compliance with, the Minimum Safe Manning Document (www.imo.org).Alapetite&Kozine, (2017)state the document defines the minimum number of qualified seafarers required onboard for the safe functioning of the ship.The low levels of risk perception by the FOC administrationsis a key reason that safe manning levels mentioned for a ship in its Minimum Safe manning Document issued by Flag administration have reduced (Alapetite&Kozine, 2017) encouraging transnational corporations to draw labour from countries, offering low wages and living conditions,(Broeze, 2002). Even though work and rest hours of seafarer is an important aspect checked by the Port State Control Inspectors, when a ship comes to port, seafarers are asked more than often by their companies to record false hours compliant with MLC 2006, (Zhang et al., 2020).

Seafarer's working onboard the vessel are responsible for managing daily risk, (Ghosh &Daszuta, 2019), the ability to carry out effective risk assessments, help to identify hazards (De Rossi, 2011). Although violation of work and rest hours is a hazard to the seafarer safety (Zhang et al., 2020), seafarers accept certain risks if some benefits can compensate for the risk, overlooking the hazard caused due to fatigue (Ghosh &Daszuta, 2019),most commonly seafarers are willing to work even though fatigued because it is considered as competent to do so (Grech, 2016).Complaining crew fear the risk of being dismissed (MacLachlan, 2017), whilea ship Captain fear being told by Company to improve his management skills (Baulmer et al., 2021). The reason for individuals in the age group of 20-25 years opting for a life at sea revealed, monetary rewards & promotions in the shipping industry were comparatively higher as compared to other industries (Li et al., 2014), however Kohn, (1993) states monetary incentives can reduce job satisfaction and motivation at the workplace, while Kim (2002) highlights participative management between employees to improve the working and living conditions enhances employee job satisfaction.



Graph 1: Top ten ship owning nations, comparing ships registered under foreign and national flags(Van Frossen, (2016) pg.367)

Van Fossen, (2016) highlights shipping nations and ship owners registering their ships under (FOC) enables systems of outsourcing, sub-contracting, partnerships, and alliances that are essential to the strategies of transnational corporations. Fig. 3 reveals the ship owning nations which have adopted to register their ships under Flag of convenience administrations. Owners gain from registering their ships under a FOC because it allows them to avoid paying expensive domestic salaries and taxes and complying with onerous rules governing safety, manning, employment, and other obligations, (Ademun-Odeke, 2005).

2.5 Technology used in high-risk industries for improvement of occupational health and safety.

Personnel tracking technology has been implemented by numerous businesses and is considered one of the technologies that contributed to the twenty-first century (Sun, Jiang, & Jiang, 2013). Additionally, it is employed in the logistics, shipbuilding, oil and gas, and mining and construction industries. On the other hand, MS's do not deploy personnel tracking or monitoring devices. A location-tracking wearable device is used by Equinor's offshore facility in the North Sea as a system for disaster preparedness. When personnel arrive at the muster station, the system immediately reads their unique tag and recognises them (Offshore Technology,2011).The adoption of wearable technology by workers in construction enterprises to support occupational health and safety management was studied by Kangari & Yoshida (1990). Construction companies have gotten used to having employees wear smart vests with built-in indoor GPS, thus workers real-time location at the workplace is tracked sending location information to a manger. Bauk et al., (2018) points port workers of the Port of Bar (Montenegro) wear personal protective equipment (PPE) which is embedded with UHF RFID tags. A signal alarm notifies of a harmful scenario if a worker is not wearing the proper PPE or if he or she is in an exceedingly dangerous zone. The system guards against accidents and makes port employees and managers more aware of the dangers of their jobs.In 2017, Idaho National Laboratory (INL) collaborated with Xcel Energy Inc. described by St. Germain et al., (2017)and identified three technologies for the nuclear power industry. These include video surveillance and recording, ultra-high frequency (UHF) radio frequency identification (RFID), Bluetooth low energy (BLE) beacons, and RFID. The technologies were used in combination to find employees and equipment and increase productivity. The Mine Improvement and New Emergency Response (MINER) Act of 2006 led to the development of several localization and tracking systems for employees and equipment in underground mines, as highlighted by Zare et al., (2021). These are based on a single technology or a combination, including Wi-Fi, Bluetooth Low Energy, Swarm Bee, Long Term Evolution (LTE), and Ultra-Wideband.The following factors were listed as group drawbacks: RFID reading error, privacy/security concerns, computing bottleneck, long-term cost-benefit considerations, risk of obsolescence, and compliance with international norms during usage (StGermain et al., 2017; Bauk et al., 2018). To assure organisational support for the ethical exploitation of data sent by wearable technology and training for perceived ease of use, Kangari & Yoshida, (1990) concluded that additional research was required.

2.6Existing Research Limitations in maritime shipping and gap identification:

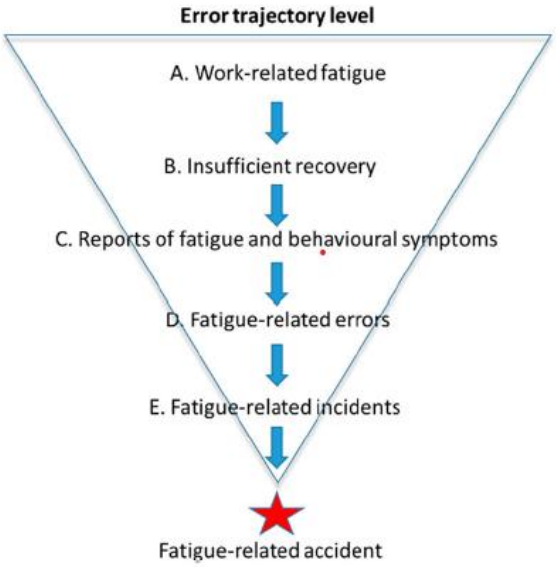


Figure.3Dawson and McCulloch's (2005) pg. 370. Fatigue-risk trajectory (FRT)

Effective fatigue-risk management, according to Phillips et al., (2017), will need the control of hazards at each of the levels of the fatigue risk trajectory (FRT), but the void of detection of (A) Work Related Fatigue (Figure 3) &absence of subsequent control mechanism, lead to fatigue related accidents,Friswell& Williamson (2013).Control measures are also discussed by Anund et al. (2015) in the context ofdecisions that must be made to limit fatigue-related collision risks in various transportation sectors. Despite the availability of several evaluations, there is a significant disconnect between what is investigated and how risk is managed, at least in some transport branches, particularly merchant shipping reiterates Phillips et al., (2015). A framework that merely aims to prove compliance for the sake of inspections could make matters worse, instead communicating risks and measures in a way that is compatible with risk management principles may help (Anund et al. 2015). As a result, there is tremendous room for improvement in the framework offered to mariners to precisely quantify their WRHD.

According to Jonglertmontree et al., (2022), 51.5 to 66.5 percent of seafarers reported experiencing work-related psychosocial stress, with concerns about their families, finances, ship safety, sea piracy, port state control, and their jobs among them. One of the most major sources of stress for sailors has been discovered to be being apart from a partner and family (Thomas et al., 2003). Crew are forced into a compliance trap because they feel pressured to manage their own exhaustion the same way they handle any shipboard danger due to the commonly held view that weariness is a part of the job (Grech, 2016) and the comparatively high compensation for crew, especially senior ranks (Phillips, 2014; Phillips et al., 2015). According to Slikovi and Penezi (2015), financial stability, time spent at home, the nature and dynamics of the job, as well as salary benefits, the working environment, promotions, feelings of status, and satisfaction with wealth management, all contribute to merchant seafarers' job satisfaction (Li et al., 2014).Shipping companies and major, oil and gas companies promote high standards of safety onboard ships via inspections and a continuously upgraded safety culture enhanced with seafarer training (Phillips, 2014),but reducing onboard crew and demanding high standards via inspections have been causes of seafarer stress (Grech, 2016).Globalization, has forced the marine sector to put finances first and maximise economic outputs, which has resulted in violations of seafarers' rights and norms, compromising their dignity, performance, safety, and general well-being (McVeigh et al., 2016).

Exarchopoulos et al. (2018),emphasises, that because more than 75% of the world's tonnage is currently registered under a FOC, several indicators in the shipping industry suggest that low seafarer welfare and subpar conditions have nothing to do with the Flag under which a ship is registered. Focusing on a risk-based approach to fatigue management at sea is now viewed as essential, according to Anund et al., (2015) given that there are approximately 1.2 million seafarers employed in merchant shipping and the potential environmental impact of a shipping accident, as suggested by Phillips et al. (2015). The MLC 2006 has been approved by over 75 percent of the world's gross tonnage, and during port visits, ships are inspected by Port State Control authorities, according toAkyuz et al (2018). Ironically, most rest hour breaches occur when the ship is in port because of cargo operations, receiving supplies or stores, and unforeseen PSC or terminal safety inspections, as these operations call for the presence of ship crew (Allen et al., 2007), thus recurrent violation of WRH along with reduced number of crew onboard seems to be the recognised norm, as observed from the literature review.

2. 7 Summary

The previous literatures have provided psychological theories to address the perception of fatigue and its effect on seafarer. Irrespective of the psychological interventions that maritime psychologist develops, implementing these models in an exploitive working environment, can be counterproductive (MacLachlan, 2017). The literature review highlights the problem of seafarer fatigue caused due to various factors leading to accidents and incidents, however there is no remedypreviously recommendedwhich has guided regulators to encourage the recording of real time WRHD to address thecatastrophic consequences of seafarer fatigue.The findings in this research will attempt to bridge the gap between WRH regulation (STCW 2010 & MLC 2006)requirements and the deviations from these regulations which could be used as part of an operations risk management tool in merchant shipping.

III. Analysis summary of qualitative and quantitative data:

Through the mixed methods research approach,a thorough evaluation of all aspects to investigate, if the solution provided(with regards to automation of WRHD) is practical and can be utilized in the merchant shipping industry, via a method of triangulation (Mertens, 2003).

The open-ended survey questions reveal (n=65) shortage of manpower, (n=35) extended contracts, (n=64) inability to address fatigue & (n=55) dissatisfaction with regulatory framework, this data aligns with the data obtained from quantitative and qualitative interviews, though cannot be directly compared. The responses

also make n= 28 references regarding lack of trust in governments and commercial operators, and this is similar to quantitative data where SF prefer to allow a Third party to manage the WRHD of automated.

Objective 1: Officers can spend everyday filling safety related forms (Størkersen, 2018). Investigating accidents has revealed human error to be the cause to accidents(Bhattacharya & Tang, 2013). The most likely cause of human error is fatigue which reduces situational awareness Robert et al., (2014). Literature review, qualitative research interviews and survey questionnaire has led to a confirmation of seafarer's work and rest hours being violated, and a triangulation of data confirms repeated violation in WRH leads to accumulated fatigue which causes lack of situational awareness, leading to accidents. Several accidents in merchant shipping has revealed fatigue to be the cause of accidents in MS. Confirming Objective 1 we are able to highlight the need to improvise the system of recording WRHD of seafarer.

Objective 2: From evaluation of past research papers, it has been observed that the use of localization techniques has been utilized in high-risk industries like construction, nuclear, off shore oil and gas platforms and is used to track goods, personal protective equipment and persons too via a wearable device. The past research papers have stated, there is yet more research to be carried out on these technologies and the measures to take to obtain organizational support in order to increase comfort level of the users and to ensure the data of the users is ethically exploited, states Kangari & Yoshida, (1990). The localization technologies are used on construction sites and nuclear power plants to enhance occupational safety, however there is no specific mention of the technology being used as part of a operations risk management tool.

Objective 3 Part 1 of this objective, suggest the automation of recording WRHD and gauges seafarer perception via a MMR. The response obtained in quantitative data averages to 68% agreement towards automation of WRHD. The open-ended questions in the survey questionnaire haveled to an equal number of advantages and disadvantages being pointed out. However,the responses cannot confirm the necessity of automation of WRHD, most of the participants have looked at it as an idea which they have not heard before. A more effective measure to confirm the need to automate WRHD would be the response of seafarer perceptionabout the effect of reduced manpower on ships. The quantitative data revealed that 87% seafarers revealed, reduced manpower leads to violation of WRH, thus the need for having WRHD automated (as the collective MMR reveals crew supplied are in the range of 20-25 persons). 55 times disadvantages have been highlighted in the survey open ended questionnaire towards the present-day method of recording WRH.

Part 2, of the Objective 3 on the aspect of WRHD being used as a risk management tool, an average of 80% agreement across quantitative and qualitative data is seen. During the qualitative interviews the concern expressed by Ship Manager's was the possibility of ships business being stalled due to the mis-use or mis-interpretation of WRHD which could lead to interruption of ships business, thus defeating the purpose of making supply chains resilient. Thus, the suggestions are in favor of using WRHD mainly for the purpose of operations risk management.

Objective 4 has addressed the most critical aspect of the research, relating to seafarer comfort in having his location monitored if the automation of WRHD becomes a reality. A mixed response was observed towards automation of WRHD if the device is wearable and monitors location. To look deeper into this, the last question of survey was to gain seafarer perception as to 'Who should manage the automated WRHD if the technology to manage SF, WRH automation becomes a reality?' The SF has given preference to a 'third party manager' while the SM has given preference to a collective management of the WRHD between 'Ship master & Ship manager'. Ironically it is seen that only 4% of SM have opted to select SM to manage the automated WRHD.

IV. Limitations:

Labels	Count of SF_SM	Average
Seafarer	63	4.3
Operational	11	4.5
Management	52	4.2
Ship Manager	24	4.2
Management	24	4.2
Grand Total	87	4.3

1. The research participants were n=87 mainly management level SM (24) and SF (63), with only 11 operational crew among SF's. In order to have a thoroughly homogenized target group a preferable ratio of seafarer would be Management: Operational ; 1:2, the reason being that operational level crew are the ground staff on a ship directly managing daily maintenance. A perspective of the operational level crew onboard the ship is important, if the automation of WRHD concept is to be researched further.

2. The data for this research has been collected within 15 days due to time constraints. In future more time to be given for data collection.

V. Recommendations:

Past research has identified,Flag of convenience to be acause of expanding shipping fleets and reducing number of crews onboard ships due to their slack standard of regulations and low taxes, however as 75% of the world's shipping fleets are registered under FOC administrations it is needed to engage the FOC administration in taking complete responsibility for the crews on a vessel flying their flag. The last question in the questionnaire is 'Who will be the ethical owner of the automated WRHD if this technology is made mandatory by the regulator International Maritime Organization (IMO)? 35% of seafarer's and 29% of ship managers have opted for a Third party to handle the WRHD. The proper third party, should be an organization recognized by the FOC& such is the recommendation of this research. Further research should be carried out in deciding how to engage the FOC, in being directly responsible for crew WRHD and participate in mitigating risk that comes along with ship operations.

The recommendation highlights the need for a change to be encouraged by regulators as technology alone may not be a solution(though it is a bottom-up approach to initiate change) if the FOC under which vessel is registered is not taking responsibility of operational risk accompanying a vessel.

The use of a wearable location monitoring device could have several uses in a shipboard environment e.g. assist in accident investigation, prevent harassment at work place due to monitoring or reduce time for maintenance of equipment's via behavior based observations. These added uses can be explored only after the ethical concerns of the user are fully addressed.

VI. Conclusions:

This research confirms, privacy and data protection are the primary concerns expressed by the participants in the qualitative interviews and in the survey questionnaires. Due to nature of a seafarer's work, one of the primary contributors to mariners' psychological issues is social isolation,states Exarchopoulos et al., (2018).Thus, irrespective of the viability of the technology used to record seafarer WRHD, care has to be taken to ensure the compatibility of the technology with the environment on board the ship. A secondary concern is the mis-use or mis-interpretation of WRHD which could lead to the arrest of a ship by PSC inspectors and this would affect supply chains and increase cost of ship operations. This research has highlighted the importance of the use of the factual WRHD along with additional factors such as, period the seafarer (SF) is onboard and the number of crew onboard the vessel (i.e., correct WRHD x period SF onboard x number of crew onboard). The highlighted factors were clearly identified as the stress causing elements to the seafarer. Thus, the learning gained from the research can be used effectively by merchant shipping companies to address operation risk management.A merchant ship operated by 20-25 crew members interacts with various uncertain ecological and commercial entities e.g. Uncertain weather conditions, coastal navigation hazards & coastal regulations governing ship movement in coastal waters, ports and terminal interfaces which apply several uncertain commercial pressures on the ship when a ship is in anchorage or port. To expect that Work and Rest Hours (WRH) recorded by seafarers on a daily basis and checked and rechecked by company and inspectors (internal and external) would by itself give seafarer sufficient rest, makes the process of complying with STCW Work and Rest Hour regulations incomplete and redundant. Thus, the use of technology to have the Work and Rest hour data recorded in real time without distracting the seafarer from his job/ duties and utilized effectively to at least recognize the risk in the shipping operation with a fatigued crew, is a suggestion by which the STCW work and rest hour regulation can be made viable to an extent which does not effect profitability of mercantile ship operations. The recommendations in this research are of legislative value for the merchant shipping industry and if further researched can lead to ethical management of supply chains, safer ships, and cleaner oceans.

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Appendix 1

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