



Original article

Simultaneous tasks as a contributory factor to maritime accidents: A socio-cultural approach

Asanka Rajapakse^{a,*}, Gholam Reza Emad^a, Margareta Lützhöft^b, Michelle Grech^c

^a Australian Maritime College, University of Tasmania, Launceston, Australia

^b Department of Maritime Studies, Western Norway University of Applied Sciences, Haugesund, Norway

^c Ship Operations, Australian Maritime Safety Authority, Canberra, Australia

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ABSTRACT

Analyses of accident investigation reports show that attempting to simultaneously perform tasks onboard ships to manage workload has led to many accidents at sea. These accident reports point out that seafarers fail to follow procedures as expected by shipping companies when conducting tasks simultaneously. Only a handful of studies that examined such discrepancies between work as imagined by shipping companies and work as actually done by seafarers exist. This study aims to examine why seafarers engage in simultaneous tasks, which may lead to accidents. In an exploratory qualitative study, face-to-face interviews were conducted with selective and targeted seafarers previously involved in maritime accidents. The collected data were analysed using interpretive and descriptive qualitative methods with a socio-cultural approach. The findings of this study show that the substantial regulatory changes over the years in the maritime industry have resulted in increased occupational workload for seafarers. Some of these regulatory barriers designed to improve safety at sea prompted seafarers to engage in simultaneous tasks to perform excessive paperwork and compensate for insufficient crewing. The research also revealed how a poor speak-up culture onboard might encourage simultaneous tasks leading to accidents at sea. The analysis shows that reasons for engaging in simultaneous tasks at sea are varied and complex. Therefore, complex intervention efforts to discourage seafarers from engaging in simultaneous tasks is needed to mitigate accidents at sea.

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1. Introduction

Despite the harmonised international effort, maritime accidents keep occurring at an alarming rate (Allianz, 2020, 2021; EMSA, 2016, 2017, 2018, 2021; IUMI, 2017). Recent maritime accident figures (Fig. 1) indicate that the current barriers established by the maritime industry to prevent maritime accidents are insufficient. Postaccident investigations consistently highlight the human element as the major contributing factor to maritime mishaps (Allianz, 2020; EMSA, 2018; MCA, 2016; Allianz, 2012). Among these factors, multitasking has not been explored adequately (ATSB, 2017). Thus, the objective of this study is to examine why seafarers engage in simultaneous tasks, which may lead to accidents at sea.

International Maritime Organisation (IMO) is the international regulatory body that attempts to regulate and resolve complex maritime issues. IMO (2019a), (2019b)) continuously introduces and

amends regulations such as the International Safety Management Code (ISM) and Standards of Training, Certification, and Watch-keeping for Seafarers Convention (STCW) to curb accidents and improve safety at sea. To manage safety, these regulations demand shipping companies implement stringent safety mechanisms and develop a ship safety management system (SMS) that provides seafarers with a set of procedures and checklists for every ship operation. However, despite these efforts, studies show that the maritime industry is not substantially improving its safety records (EMSA, 2021; Batalden & Sydnes, 2014; Knudsen & Hassler, 2011).

Previous studies show that these regulations and standards perceive shipping operations as a linear process, wherein, in reality, most work onboard ships are dynamic and complex (Oltedal & Lützhöft, 2018). Uncertainties may quickly escalate during shipping operations (Caschili & Medda, 2012). Our earlier study shows that 'work as done' (WAD) by seafarers can be different from 'work as imagined' (WAI) by shipping companies who design the procedures and checklists (Rajapakse et al., 2019). It is improbable for onshore designers of work task procedures to predict all intricacies which

* Correspondence to: 58, Warmbrunn Cres, Berwick VIC 3806 Australia.
E-mail address: asanka.rajakapse@utas.edu.au (A. Rajapakse).

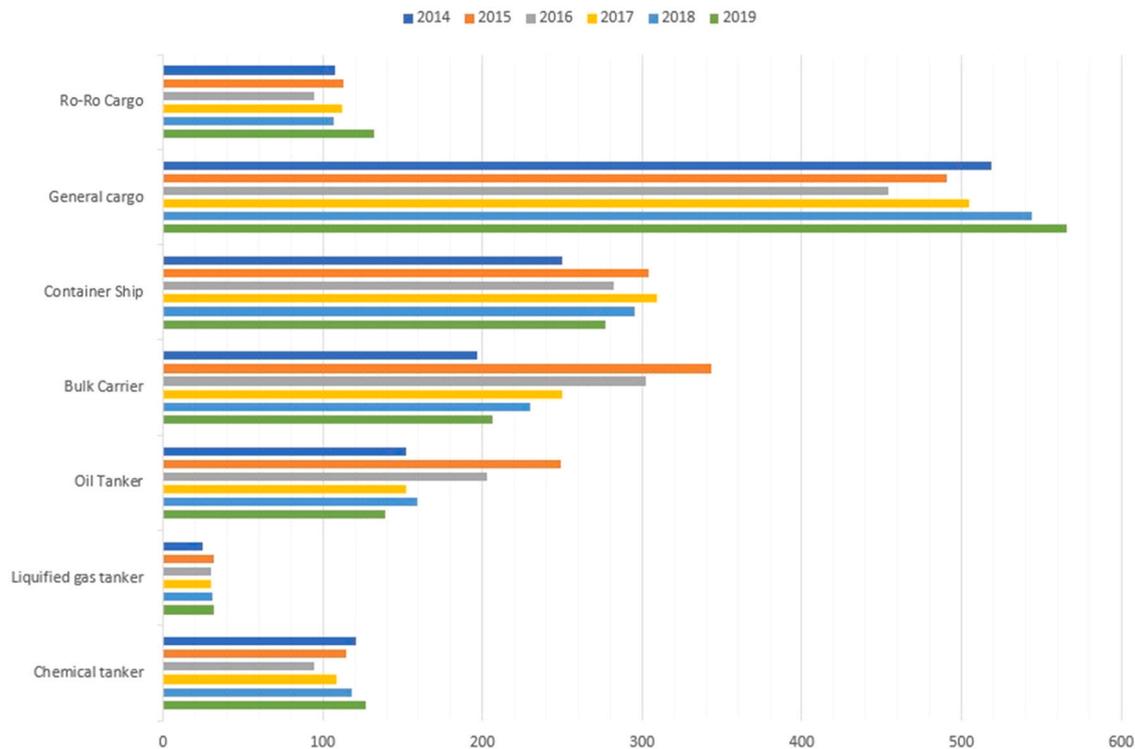


Fig. 1. Distribution of Cargo ships involved in accidents (EMSA, 2021).

may occur while working onboard ships (Hollnagel, 2013; Rajapakse & Emad, 2021). This has led to the design of less than perfect procedures and checklists that may provoke task deviations (Loukopoulos et al., 2009). In this context, we defined the task deviation as a departure from the specified task sequence in a procedure provided by the work task designers (WAI), which may lead to accidents (Rajapakse & Emad, 2021). Frequently, engaging in simultaneous tasks during work execution (WAD) leads to task deviation (Spink et al., 2008).

Research exploring the concept of WAI and WAD at sea is limited (de Vries 2017; Praetorius, Hollnagel, & Dahlman, 2015; van Westrenen, 2014; Praetorius & Lundh, 2013; Lützhöft et al., 2007; Morel and Chauvin, 2006). Although a considerable amount of research into accidents at sea exists (Chang & Park, 2018; Jinxian, Dong, & Gang, 2018; Mou et al., 2018; Meifeng, Sung-ho, & Young-Tae, 2017), however, no other study examines how simultaneous tasks may lead to accidents at sea due to discrepancies between WAI and WAD.

Research examining socio-cultural aspects of workplaces shows that workers deviate from prescribed procedures due to social, historical, and cultural issues in the workplace (Waring and Rowley, 2011; Woods, 2010). Therefore, in this study, the Cultural Historical Activity Theory (CHAT), also referred to as Activity Theory, is utilised as a lens to investigate this complex issue. CHAT's ability to facilitate comprehension of multi-medial processes (Engeström, 1999) is instrumental in understanding why seafarers engage in simultaneous tasks, leading to accidents at sea.

2. Background

Studies on the effects of engaging in simultaneous tasks exist in various disciplines and industries such as healthcare (Wahlström et al., 2018), transportation (Nguyen-Phuoc et al., 2020; Truong & Nguyen, 2019; Wahlström et al., 2013), nuclear power plants (Norros, Savioja, & Koskinen, 2015; Savioja, Norros, Salo, & Aaltonen, 2014), education (Dzubak, 2008), and airline industry (Loukopoulos et al., 2009). However, there is only a limited number of research

that have explored this concept in the maritime domain (Sandhaland, Oltedal, Hystad, & Eid, 2017; Uchino and Kobayashi, 2012; MCA, 2010; Grech, Horberry, & Koester, 2008). There is a plethora of literature that supports performing simultaneous tasks poses a significant safety risk resulting in task deviation (Kalisch & Aebersold, 2010; Laxmisan et al., 2007; Loukopoulos et al., 2009; Rivera-Rodriguez & Karsh, 2010). However, literature is silent in the understanding of why people decide to engage in simultaneous tasks leading to task deviation.

Many investigations into maritime accidents show that seafarers' task deviations due to simultaneous tasks contribute to many maritime mishaps (ATSB, 2019; MAIB, 2015a, 2015b, 2016, 2020; Hetherington et al., 2006). These investigations found that although shipping companies had provided operating procedures for each task, seafarers involved in these accidents had to deviate from the procedures due to multitasking. In response, the maritime industry introduced tighter procedures, improved designs and technology, and required further training (Dekker, 2018; Emad & Roth, 2008). Further investigations show that this approach did not bring about much success (Batalden & Sydnes, 2014). Understanding why seafarers engage in simultaneous tasks due to discrepancies between work as imagined (WAI) and work as done (WAD) may assist in developing knowledge that potentially enhances maritime safety.

2.1. WAI, WAD, and task deviation

Studies show seafarers struggle to align WAD with WAI due to the dynamic nature of shipping operations (Vries, 2017; Praetorius et al., 2015; Hollnagel et al., 2013). A review of accident investigations shows seafarers at the sharp end are usually blamed as the leading cause of accidents. The primary responsibility might be on the personnel at the blunt end (Hollnagel, 2014).

Completed and signed checklists show that seafarers follow procedures the ship operator provides. However, hindrances such as time and resource limitations may force workers to undertake more than one task at a time (Dekker, 2006). The ship operators are

unaware that their seafarers frequently need to involve simultaneous tasks at sea, which may lead to task deviation (Sandhaland et al., 2017).

Task deviation is a divergence from a specified sequence of tasks in a procedure which could lead to adverse events (Rajapakse & Emad, 2021). When the actual sequence of tasks conducted by a seafarer at sea (WAD) is different to the prescribed sequence of tasks in a procedure (WAI) provided by the ship operator, task deviation occurs. Although task deviation due to discrepancies between WAI and WAD does not always lead to mishaps, Kontogiannis (1999) shows that an unfavourable event is unavoidable only if the resultant deviation is not rectified before it is too late.

Rajapakse and Emad (2021) pointed out that one of the underlying factors which cause discrepancies between WAI and WAD is multitasking, and socio-cultural attributes of the shipping industry may have a part to play in this misalignment between WAI and WAD at sea, leading to task deviations (Corrigan et al., 2018).

To have a clear understanding of why seafarers involve in multitasking on board ships from a socio-cultural perspective, in this study, we utilised Cultural-historical activity theory (CHAT) to analyse seafarers' accounts of their involvement in simultaneous tasks that led to accidents (Devane & Squire, 2012; Engeström, 1987).

2.2. CHAT as a theoretical framework

One way to understand human behaviour is by viewing humans as part of an activity system such as shipping (Rajapakse & Emad, 2021; Vygotsky, 1978). CHAT facilitates this by providing a lens to examine dialectical relationships between humans and their objectives. These relationships are influenced by social structures in their environment (Devane & Squire, 2012).

An activity system is the minimum unit of analysis in CHAT (Engeström, 2000, 1987). An activity system consists of elements in a social structure that influence an individual to behave in a certain way towards achieving a goal. It is illustrated in a triangular model developed by Engeström (1987), as portrayed in Fig. 2. In this model, the *subject* is the individual(s) involved in the activity (Jonassen & Rohrer-Murphy, 1999). *Tools* include artefacts that can be conceptual or material that mediate human behaviour to achieve the *object*. Material tools are physical items, while conceptual tools are reasoning strategies (Kozulin, 1998). The *object* is the goal of the activity, which gives purpose to the activity system to generate the anticipated *outcome* (Kaptelinin & Nardi, 2006). The *rules* are meant to govern how the activity takes place. They attempt to control the behaviour of *subjects* and the *community* (Jonassen & Rohrer-Murphy, 1999). The social group that the subject belongs to is the *community* and consists of the other humans who interact with the *subject* while engaged in an activity. *Division of labour* is how various tasks within the community are distributed (Tolman, 1999).

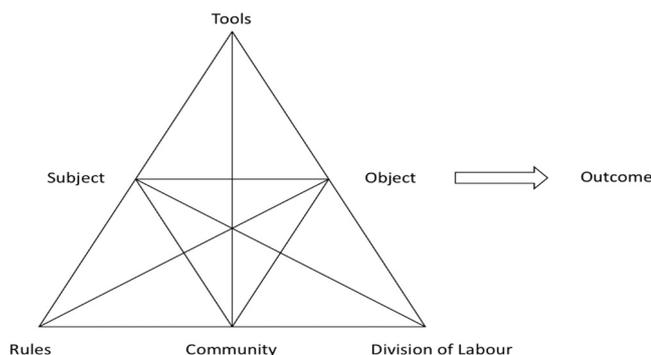


Fig. 2. Activity System (Engeström, 2000).

Shipping can be perceived as an activity system because it has the necessary characteristics under CHAT. The outcome of the *seafarers' activity system* is to conduct safe and efficient maritime operations (Rajapakse et al., 2019). Fig. 3.

All activity systems consist of internal and external conflicts called *contradictions*. Contradictions cause changes within activity systems due to structural tensions over time (Engeström & Miettinen, 1999). For example, seafarers perform several tasks simultaneously to complete jobs efficiently on time with the available resources. However, as investigation reports show, multitasking may lead to accidents. This situation generates a structural contradiction within the *activity system*. Through examining contradictions in the seafarers' activity system, this study aims to establish why seafarers engage in performing simultaneous tasks.

3. Research method

To explore why seafarers involve in multitasking on ships, this research took a qualitative approach using the seafarers' activity system (Rajapakse et al., 2019) to analyse discrepancies between WAI and WAD onboard ships. This approach has two primary benefits for this study. First, it facilitates the comprehension of complex real-world data collected from research participants and second, it provides a clear framework for use as a guide for managing interpretations of the data. A qualitative approach facilitates rich and in-depth accounts of human behaviour in various circumstances at sea (Berg, 2007; Rubin & Rubin, 2005; Silverman, 2010; Yin, 2011).

In this study, events narrated by the interviewees involved consequential outcomes such as collisions, groundings, capsizing, fire and explosions, flooding, oil spills, and accidents onboard commercial ships, which lead to fatal and/or serious injuries. Our analysis shows that a contributing factor to these accidents is seafarers engaging in simultaneous tasks. The study follows the ethical standards required by the University of Tasmania.

3.1. Data collection

One-to-one qualitative semi-structured interviews form the data collection strategy of this study. Interviews facilitate the capturing of in-depth perspectives of research participants (Devane & Squire, 2012). These also enable building reports of detailed research participants' views by encouraging interviewees to express their thoughts and feelings (Berg, 2007; Bryman, 2016). Also, one-to-one interviews allow for analysing nonverbal portions of a conversation, such as people's tone of voice, interruptions, pauses, and other mannerisms that add to the depth and quality of the collected data (Drew, 2009; Yin, 2011).

3.2. Participants

Seafarers are employed onboard commercial ships in three departments, namely deck, engine, and catering. Senior officers, junior officers, and ratings make up of personnel of both deck and engine departments. Ratings are seafarers with lower levels of seafaring qualifications compared to the officers (Glen, 2008). Officers and ratings in the deck department are responsible for navigating the ship and managing cargo in ports. Those in the engine department are responsible for the operation and upkeep of the machinery on ships. Seafarers in the catering department are ratings taking care of services such as cooking, serving, and cleaning.

This study used data from sixty-one, one-to-one interviews with experienced and qualified seafarers involved in maritime accidents. Research participants were purposefully selected to represent all ranks on ships. Most interviewees selected were ashore at the time of interviews, attending revalidation programs or pursuing programs to acquire higher qualifications to serve at higher maritime ranks in

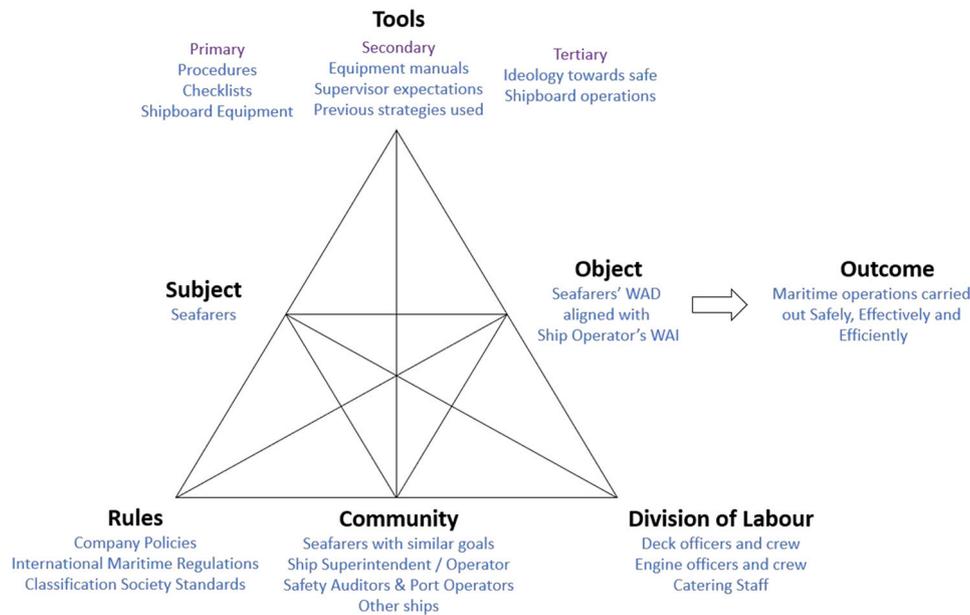


Fig. 3. Seafarers' activity system (Rajapakse et al., 2019).

a renowned maritime education institution in Australia. Interviews also comprised onboard interviews conducted under permission on two cargo ships registered in Australia and Panama, respectively. Sixty interviewees are male, and one is female between 24 and 68 years of age. The gender disparity of the interviewees is due to female seafarers only accounting for 2% of the total workforce (ITF, 2019). The interviewees represent a wide geographical distribution, including Australia, New Zealand, Nigeria, India, Sri Lanka, Bangladesh, Singapore, Philippines, United Kingdom, Spain, Belgium, and Ukraine. Their work experience at sea ranged from oil and chemical tankers, container ships, bulk carriers, general cargo and offshore support vessels trading on worldwide shipping routes.

The authors of this research project rely on Guba and Lincoln (1989) fourth-generation evaluation to confirm the trustworthiness of the research findings. According to the fourth-generation evaluation, the study's trustworthiness is measured in terms of credibility, transferability, dependability and confirmability.

3.3. Procedure

Interviewees were requested to elaborate on the circumstances surrounding the seafarers' behaviour before the maritime accident they were involved in or observed. These one-to-one interviews, which lasted from thirty minutes to three hours, were audio-recorded and transcribed verbatim. Table 1.

Table 1
Example of crewing on a commercial ship.

| Deck Department | Engine Department | Catering Department |
|-----------------|------------------------|---------------------|
| Officers | | Chief Cook |
| Master | Chief Engineer Officer | Messman |
| Chief Officer | 2nd Engineer Officer | |
| 2nd Officer | 3rd Engineer Officer | |
| 3rd Officer | 4th Engineer Officer | |
| Ratings | | |
| Bosun | Motorman 1 | |
| Able Seaman 1 | Motorman 2 | |
| Able Seaman 2 | | |
| Able Seaman 3 | | |
| Ordinary Seaman | | |

3.4. Data analysis

Theoretical thematic analysis, which identifies patterns or themes within the collected qualitative data, was conducted initially (Javadi & Zarea, 2016; Braun & Clarke, 2006). Braun and Clarke (2006) 6-step framework used in this study led to identifying sociocultural contexts that influenced seafarers to engage in more than a single task at a time at sea.

Initial and major codes were first established through theoretical saturation of data (Bernard, 2000; Creswell, 1994; Kuzel, 1992). The conceptualisation of comparisons of patterns was continued until no new properties of patterns emerge (Charmaz, 2006; Glaser, 2001).

The next phase of analysis constructed dialectical connections between these major codes to obtain a broader understanding of the seafarers' activity system. Relationship codes between each element in the activity system facilitated this. For example, subject to object, subject to tools, subject to rules and alike. Analysis of these relationship codes led to the identification of contradictions within the activity system. Thereby, practices and mediators in the seafarers' activity system that cause discrepancies between work as done (WAD) and work as imagined (WAI) due to simultaneous tasks were identified. Thus, giving rise to themes and categories.

4. Findings

Three categories emerged that contradict the object of aligned WAD (by seafarers) and WAI (by shipping companies), as shown in Table 2.

Table 3 depicts how CHAT analysis was conducted to identify contradictions between the object of WAD (by seafarers) aligned with WAI (by shipping companies).

The first category is 'administrative burden', commonly referred to as paperwork at sea. Paperwork requires checklists and forms enforced by shipping companies to be completed by seafarers to comply with international regulations. Seafarers perceive the act of performing the paperwork related to a task as a task in itself. Paperwork needs to be performed at the same time as work tasks. Our data shows that this can cause distraction and interruptions to the safe execution of the main task at hand. The primary task has to be interleaved to correctly complete paperwork, which otherwise would be observed as a deficiency during safety audits if found

Table 2
Categories and themes.

| Categories and their themes | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Administrative Burden Inaccurate Procedures No flexibility using procedures Unnecessary paperwork involved in correcting procedures Not practical to follow step by step because of nature of task | Lack of speak-up culture Afraid to call senior officer for assistance Unsuitable equipment / wheelhouse design Can't say NO to supervisor / senior officers Warnings / requests ignored by senior officers | Insufficient Crew Not practical for one person to manage Abrupt escalation of workload Homeport job rush Safe crewing certificate is an excuse to save money |
| Back and forth to work and ticking away boxes | Requests by senior officers ignored by company | Safe crewing certificate does not have sufficient people |
| Using checklists in bad weather on deck / dirty hands Company needs only paperwork in order to pass audits | Unexpected break-in emergency work Don't get checklists / procedures corrected by shore | Workload stress to the level of burnout Less people more work |
| Falsifying records | Scared to speak up in unsafe conditions due to blame | Technology hasn't reduced the workload much, but crewing has reduced a lot |
| Checklists are good but a source of distraction Chasing people to sign paperwork / permit renewal | Unnecessary telephone calls to wheelhouse Unnecessary interruptions by others while working | Crew reduced, paperwork increased Companies save money with less crewing but lose more in accidents |
| Procedures written by non-mariners | Abuse by senior officers | Open and Second registry is the cause of decreasing manpower |
| No real benefit | Tight ship schedules – lack of time for maintenance | |
| Too much paperwork than really required Lack of supervision from Senior officers because they are busy with paperwork | Has accepted his fate Office doesn't care | |
| Large volumes of procedures and instructions difficult to read | Multiple ship inspections and audits in port | |
| | To save face / to avoid embarrassments Above my pay grade to fix issues on board Manage somehow Diverse cross-cultural values against speaking up Frequent new crew changes | |

incomplete. On other occasions, the sequence of tasks in procedures or checklists cannot be executed in the prescribed order due to unexpected events such as changes in weather or breakdowns in machinery (Kalisch & Aebersold, 2010; Österman & Hult, 2016).

The second category is the lack of speak-up culture that is also prevalent in the maritime industry (ATSB, 2015a; Biggs et al., 2008). Some accidents occur due to seafarers attempting to manage overwhelming situations without requesting assistance (ATSB, 2015b). Seafarers are reluctant to ask for assistance due to previous experiences of rejected requests and cultural power imbalance (Moreby, 1990). They take up the challenge and sometimes fail to execute two or more simultaneous tasks safely. Further, this study found that seafarers who observe others engaging in unsafe simultaneous tasks do not discourage or attempt to stop them due to the lack of speak-up culture, resulting in unfavourable events that could be easily averted (ATSB, 2019).

The third category is *insufficient crewing* onboard ships. International conventions, SOLAS (Safety of Life At Sea), and STCW govern minimum safe crewing levels on commercial ships. However, it is evident from this study that in certain circumstances, these crewing levels of ships may be insufficient to carry out tasks without engaging in multitasking.

These categories are further elaborated below.

4.1. Administrative burden

There are task procedures and compliance documents (*tools*) provided to seafarers by shipping companies to prevent accidents. This research shows that involving with these documents sometimes resulted in performing multiple tasks simultaneously. Shipping companies perceive paperwork as evidence of compliance with international regulations. Paperwork is time-consuming and demands considerable attention (Størkersen et al., 2017). This practice has become an administrative burden on ships contradicting the object of aligned WAD and WAI. Shipping companies view paperwork as

part of the job, whereas seafarers at the sharp end consider it a separate task (Österman & Hult, 2016).

The paperwork associated with each task may include; completion of job risk assessments (JRAs); obtaining a variety of work permits; reading and following procedures and equipment manuals; signing off checklists; obtaining receipts and port entry papers, performing after-action reviews and cargo records during cargo operations; entering data in deck & engine logbooks and PMS (Planned Maintenance Systems) software (*tools*). These may result in seafarers (*subject*) engaging in simultaneous tasks leading to task deviation due to contradictions in the activity system. For example, a chief engineer (R47) explained:

All types of paperwork can be a reason for multitasking. A classic example is permit to work. After a 12-hour shift, a new permit or a permit renewal is required for the next shift persons to take over and continue the work from the previous shift. Once the handover is complete at the worksite, the new shift guys have to chase down at least three management level persons to sign off the permit rather than continuing with the job. The management level guys are always involved in other jobs. They suspend that and have to go through the permit before they sign their life away. In this situation, both the work team and the managers are doing multiple work at the same time and mistakes happen on both levels always affecting safety performance.

This is a common issue that may lead to poor handovers at shift changes where critical information is not correctly passed on to incoming shift workers (Enya, 2016). Further, seafarers overlook corrections and essential amendments to procedures because of the perceived extra workload associated with paperwork. For instance, an engineer (R52) stated:

Today's paperwork culture has no time for amending paperwork but only to get administrative bits right for inspections to show compliance. There is too much paperwork to do to comply. Important things like if a simple modification is done on an equipment during

Table 3
Example of CHAT analysis.

| Category | Theme | Relationship | Quotes from Interviews |
|---------------------------------|---------------------------------------------------------------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Administrative Burden | Not practical to follow checklist step by step because of nature of task | Subject - Tools | All jobs on ships cannot be done sequentially as per a checklist. For example, if I'm doing a service on the separator (purifier) and I see water under the bowl, I need to skip some steps in the procedure and come back to the top later. It can't be done without. It is against policy to go out of sequence, but need to if I'm to do the job. |
| | Procedures written by non-mariners | Subject - Community | There are many engineers in the office who have never worked on a ship who are given the responsibility of prepping procedures. They don't realise that the same job can take different approaches because of changing circumstances. A good example is the yearly service of the lift. The procedure is written for a lift in a building, but not a ship. Sometimes the ship is rolling, or sometimes we need to suspend the job because of port calls. We come back to job later. X band (radar) is on the port side and S band (radar) is on the starboard side of the bridge. The ECDIS is towards the auto pilot and helm (centre console). In traffic I need to move all around the bridge if I'm to get a full appraisal of a situation. By the time I come back to the short range (X band) it is a total different picture especially in places like Shanghai. I doubt whether it is possible to change the setup of the bridge. It was the same in my last couple of ships. We need to work rather than complain. |
| | Unsuitable equipment / wheelhouse design | Subject - Tools | It is OK to call the wheelhouse to get information like seawater temperatures and to check whether we are in a special area to throw garbage overboard when there's no traffic. It is a huge distraction when you are taking action to prevent a close quarters situation. You can't tell them to call later because they'll get angry with you which is not a good thing. You have only so many people on ships. |
| Lack of Speak-up culture | Unnecessary telephone calls to wheelhouse | Subject - Division of Labour | When I ask the company / fleet manager about this issue of more people required in some ports, they simply avoid the conversation saying that their hands are tied because they are only obliged to comply with the safe manning certificate. This is pathetic excuse by companies to save money but dump a lot of pressure on the senior as well as junior guys to manage work. |
| | Safe manning certificate is an excuse to save money | Subject - Community | Ever since I joined ships I've seen that crew sizes have decreased by as many as thirty to forty people. Yes, newer technology has made some jobs easier but what about paperwork. Computers don't do paperwork themselves. Someone has to do them. Paper work has increased so much now I feel that we only do paperwork on board, not work. |
| Insufficient Crewing | Manning reduced, paperwork increased | Subject - Rules | |

the job and the procedure's not amended, the next time the job is done people can get hurt because the procedure doesn't include the details of the modification and it will be a surprise.

These conditions at sea indicate that the paperwork (*tools*) imposed by shipping companies as a method of complying with international regulations (*rules*) also contradict the objective of safe execution of work tasks because of the cumbersome processes involving paperwork during a job. In particular, paperwork on the wheelhouse can compromise the safety of the ship's navigation. A junior officer's (R37) thoughts on the issue were:

Thirty minutes or so before the end of every watch (wheelhouse) we need to start completing the handover form for the taking over officer which takes a long time. Since you cannot be in the chart room, like at night, doing this, you need to go out time to time to make sure everything is ok. But every time you go out it takes about 5 – 10 min for my eyes to adjust to the darkness. Then come into the chart room again to fill the checklist. This is a recipe for disaster like in high traffic areas or you are taking action for another vessel, but you need to do this as per ISM. It is the law.

Mistakes in procedures and checklists (*tools*) interrupt work. When mistakes in procedures are found, seafarers need to stop the job, leave the worksite and take the procedure to their supervisor for correction and approval. If the procedure is for critical equipment, the correction may need official approval from the ship operator to continue the task. Seafarers are assigned other tasks while the corrected paperwork is approved by shore personnel. As an example, a master (R36) pointed out:

We ensure that we have our ducks in a row with paperwork because this is xxx (well-known company name). We can't work on a job with wrong information and need to correct it before we go further but it takes time. I see that this type of interruption to work as very dangerous because now the job is stopped halfway and there is no instructions to monitor the worksite or stop the work completely. Work is only suspended until senior officers make corrections. In the meantime, the work team is assigned another job until the suspended job goes online to manage time. New permits, new jobs and resumption of suspended jobs suspending the new jobs are concurrent work tasks leading to human error. Lapses and slips are very common.

Tasks laid out in procedures and checklists (*tools*) are meant to be followed sequentially. However, work tasks in these procedures and checklists cannot always be followed sequentially as expected by shipping companies due to the dynamic nature of ship operations, such as weather changes or ship movements (Loukopoulos et al., 2009). Certain tasks in the checklist are left out to be completed later by seafarers. These left-out items may be missed out and forgotten, resulting in incomplete tasks affecting safety. An example is moving the ship while moored using mooring winches. The exact sequence of the work tasks involved in the operation cannot be foreseen when designing the procedure or checklist for such tasks. Therefore, while some paperwork assists in improving safety, others can be a distraction leading to safety issues.

Contradictions between seafarers (*subject*) and other staff on board (*division of labour*) may also take place in these situations leading to unsafe multitasking at sea due to paperwork. Another master (R35) mentioned:

Paperwork like checklists are good for some jobs. But not all jobs can be done one by one using a procedure. For example, hazards and the mitigation measures for a job before ISM were in our heads, now it is on a nice clean piece of paper. After every stage of the job we need to look at the piece of paper (job risk assessment) and see who's assigned to the control measures, and actually ask them whether it is done before proceeding. Then tick off on the JRA. This is a distraction

on the job. Distractions cause accidents.

Using procedures and checklists (*tools*) in a workplace such as a ship can be inconvenient. Seafarers are distracted by carrying papers around the main deck during high winds and rain. On other occasions, the papers get dirty to illegible levels, for example, during engine room maintenance because of greasy hands. It was also a distraction to remove hand gloves from time to time to do paperwork at the workplace. For example, a junior officer (R22) explained his frustrations:

It is such a pain to carry paperwork with you all the time. The instructions from the management is to carry checklists with you so that you don't miss starting any items. In good weather it is fine, but in bad weather you need to protect the checklist because once you finish the job we need to scan it to attach it to the 1SAP (PMS) software. So now you have two jobs. One to safeguard the papers and one to do the actual job. Mistakes happen this way. This is a huge distraction. Engineers also complain of doing paperwork with dirty hands and gloves. If you see a signed but clean checklist, it is most probably a tick and flick (smiles).

Paperwork causes conflicts within the components of the *subject* and *tools* in the seafarers' activity system, contradicting the object of conducting WAD by seafarers aligned with WAI by ship companies. It is improbable for procedure designers to be aware of the work context when the job is actually carried out. Therefore, administrative work introduced by shipping companies to comply with regulatory requirements on ships forces seafarers to deviate from the prescribed tasks due to the demand for engaging in simultaneous tasks.

4.2. Lack of speak-up culture

This research found a lack of *speak-up culture* in the maritime industry. Seafarers are aware that their work as done (WAD) is not always aligned with work as imagined (WAI) by the shipping companies, which sometimes leads to unsafe situations at sea. Nonetheless, they proceed with jobs in an unsafe manner because they do not assume that changing the circumstances to align WAD with WAI is the expected behaviour by the shipping companies. Seafarers mentioned that *task tailoring* to achieve goals using available resources, with or without following procedures (Hollnagel & Woods, 2005; Woods & Cook, 1999), is their best option. As a junior officer (R3) mentioned:

Looking at how previous guys were treated for reporting unsafe issues on the ship, I want to keep a low profile. Safety is mainly only talk and paperwork. Everyone in this field knows it and it is the same (at) every company I worked. You make noise about unsafe multitasking you will be branded a troublemaker or a person who doesn't help others. The people who are in the good books of the company are the people who keep quiet and somehow run the ship whether safe or unsafe. As per procedure or no procedure. We have a motto we-somehow-manage with zero accidents. But accidents happen.

International regulations (*rules*) may require multiple ship inspections during port calls. They constantly interrupt and distract seafarers (*subject*). This situation, on many occasions, creates a contradiction in the seafarers' activity system, which sometimes leads to accidents. However, accident investigations involved in these cases show that seafarers are usually blamed for not following company procedures. Seafarers do not attempt to challenge these reports but accept them as their fate. In particular, a junior officer (R16) stated:

The inspectors are doing their job as do we. They have no choice but to disturb us to get through their inspections. Without the inspections signed off the ship cannot run. Everyone knows it is not safe.

This is our fate. But attending to them is part of our job and there is no way around it. It is a matter of two to three days and we usually do well to get the inspections out of the way and get everything right with cargo operations. Sometimes things go wrong because of simultaneous jobs, but the following investigations never talk about the audit inspectors. They are long gone when the accident investigators arrive. We have to be ready to face these if we want to make this our living. If something goes wrong it is your bad luck.

Junior seafarers frequently engage in simultaneous tasks due to an unrealistic daily list of job tasks assigned to them by senior officers. Most of these daily jobs are generated by the company planned maintenance system (PMS), an enterprise resource planning software most shipping companies use to create and keep track of ship operations. Planned maintenance coordinators and ship superintendents (*community*) based ashore populate the PMS without consulting ship personnel. As a result, the workload is not spread out evenly throughout the year due to poor PMS schedules. These work schedules result in a high workload during certain periods, which demand multitasking by seafarers to complete these jobs within the given time. Seafarers (*subject*) try to manage their limited resources and engage in simultaneous tasks without speaking up to rectify the issue. An ordinary seaman (R60) explained:

Bosun is the one getting jobs from chief officer and pass on to us. Bosun knows we cannot do all the work safely but he is dead scared of the chief mate and never speak-up to explain the situation and we have to manage somehow. And we somehow manage most of the time but not very safely doing many jobs together.

Safety concerns are communicated to the master of the ship at safety meetings held monthly. Only those safety concerns the master considers necessary are reported to the company for assessment. Seafarers believe that it is not their place to influence change onboard ships. This conviction is because seafarers work on ships on a contract basis, and most seafarers probably will never return to serve on a ship they have served on before. They are anxious that if they raise safety concerns, they will be labelled as 'trouble makers', affecting their future employment. This trend is a contradiction within the *subject* component in the seafarers' activity system. Concerning this issue, a shipping company's senior superintendent (S3) claimed:

The company has an 'employee hazard reporting' system where everyone (seafarers) are encouraged to report any type of hazards they experience or think that would have the potential to cause an accident. We are committed to addressing these issues as long as they are reasonable. Crew can do this anonymously as well so that we can take action from shore side. This system is one of our KPIs in the safety department. But it is so difficult to get them (seafarers) to fill out at least one card per month. We ask the masters to encourage this, every safety meeting, but the results are still very poor. People (seafarers) are very good in criticising the company but unless they speak up and report how do we know that we need to change things.

Senior seafarers and shore staff use their bureaucratic powers to get subordinates to help them do their jobs. Seafarers accommodate their superiors' requests while conducting other jobs to prevent tarnishing good relations with their supervisors. This submissive behaviour has resulted in seafarers taking on tasks to overwhelming levels without speaking up. For example, a senior officer requested a junior officer engaged in crude oil washing preparations to assist her job. Subsequently, this led the junior officer to forget to close two valves on deck, creating a dangerous situation. This task deviation was due to a contradiction between *subject* and *division of labour* in the seafarers' activity system.

Seafarers are also embarrassed to ask for assistance when they are in difficult situations, especially if they have made a mistake of some sort. On one occasion, a 2nd engineer, who forgot to transfer

bunkers at the correct time, attempted the operation while manoeuvring the vessel, resulting in an oil spill due to multitasking. This contradiction within the *subject* component in the seafarers' activity system leads to task deviation.

Research participants observed that accidents at sea could be avoided if seafarers who observed their colleagues engaged in dangerous simultaneous tasks spoke up to stop them from doing so. For example, a third officer who observed dangerous multitasking did not speak up to stop a second mate from engaging in paperwork while navigating the ship in congested waters, resulting in a collision. Seafarers are concerned that interrupting a colleague at work to point out a mistake may tarnish their relationship.

Answering telephone calls while conducting a task leads to task deviations resulting in discrepancies between WAD and WAI. The requirement to answer company telephone calls even while on a task contradicts the *subject* and the *community* components in the seafarers' activity system. A chief engineer (R6) explained his experience of being on the phone with the ship owner's office while bunkering operations leading to an overflow of a bunker tank. A second mate (R17) described his experience on the wheelhouse when the master was on the phone while on pilotage. The master could have told the caller to call later but decided to take on both tasks simultaneously. The attempted simultaneous work resulted in missing a telegraph order by the pilot, causing the vessel to collide with the wharf, severely damaging the vessel and wharf.

This research shows that the lack of speak-up culture onboard ships contributes to seafarers engaging in simultaneous tasks. Contradictions within the *subject* component and between the components of *subject* with *division of labour* and *community* in the seafarers' activity system have caused direct conflicts to the seafarers' activity system's objective of work-as-done (WAD) by seafarers aligned with work-as-imagined (WAI).

4.3. Insufficient crewing

Seafarers stated that ships are understaffed for conducting consistent safe ship operations. Remarkably, this understaffing is in compliance with the minimum safe crewing standards of the SOLAS and STCW conventions. Insufficient number of crew leads to multitasking at sea and prevent the *object* of conducting WAD by seafarers to be aligned with WAI by shipping companies. For example, as a chief engineer (R5) indicated:

Small crew sizes do jobs which needs more people to do them. We have the safe crewing certificate. It is ok for normal periods at sea when we are not too busy. But there are times, say at least three-four times a month when we can't handle the pressure so I have to rotate people, frequently from one job before completion to another for example to get things done in these situations. This is the way it's been for years.

Shipping companies restructure the already downsized crewing on ships which has resulted in the absence of highly technical positions such as Electrical Engineers and Radio Officers on ships. This crewing structure means that seafarers have more work over their regular duties. Stress from high workloads is evident in seafarers due to a lack of sufficient crew, resulting in simultaneous tasks. *Rules* contradict the *subject* in the seafarers' activity system. Seafarers suggest it is impossible to align WAD with WAI on ships today because of insufficient crewing. An experienced chief officer (R12) explained, for instance:

Unbelievable workloads for chief mates. Sometimes I have to keep awake for two three days continuously working. This job that job, take care of crew issues, cargo issues, stability issues, office issues, taking care of master's requests, safety issues and it is never ending. I know some people who've gone insane from burnout. I'm worn out

already. Nothing left in the tank but keep on pushing doing about five jobs at once. People interrupt me all the time with problems, not with solutions which adds to the pressure. This whole thing is a simple fix. Add another officer to the team and things will change, but will not happen because our crewing is more than that is required by the safe crewing certificate. But it is still not enough. Whoever designed the safe crewing certificate has no idea about actual ship's work.

When ships arrive at ports, seafarers (subject) must coordinate and manage various shore-based agencies and other visiting shore-based personnel (Community) for an effective port stay. Contemporary crewing onboard is insufficient to manage these uncoordinated parties without taking shortcuts and deviating from procedures. Further, lack of crewing results in inadequate guidance and supervision required by multitasking senior officers. A master (R40) explained his concerns:

Ships calling ports need an agent for everything. Agent for berthing, agent for pilots and tugs, agent for repairs, agent for bunkers (fuel), We need to handle agent for stevedores, agents for different cargoes, agents for taking sick crew to doctors, agent for freshwater, agent for customs and clearances, agent for bringing cash. And the list goes on. They don't talk to each other so we need to handle all of them. Just imaging sometimes we only stay in port for 6 h. We need to handle them even after leaving port. So I'm up in the bridge for sometime and hurry to my office leaving junior officers in charge where I need to be on bridge. It is honestly a non-conformity since it is a breach of SMS (Safety management system). Everyone does it. But we will have to stop the ship otherwise. This is the way of working on ships.

This study found that some shipping companies provide ships with more personnel than required by the ship's safety crewing certificate (rules) because the minimum safe crewing certificate did not stipulate sufficient human resources for ship operations. Multitasking is unavoidable with a crew complement exactly as per the safe crewing certificates. This situation aggravates when ships call at their home (mother) ports. It is the port where shipping companies supply replenishments of food and spares to the vessel at the cheapest cost. Therefore, seafarers manage machinery breakdowns and survive with minimum victualling until reaching the home port. A junior engineer (R26) explained the rush at the home port:

We try to manage several jobs at once in mother ports and that is one reason for many accidents at mother ports. We have requested office to spare us a couple of experienced people at least during the port call to help.

Crew sizes of ships have decreased over time, justified by increased automation (CFR, 2018). Further, changes in the ships' registry have facilitated reduced crewing and multitasking (Alderton & Winchester, 2002; Winchester & Alderton, 2003). As a master (R22) explained:

Concept of automation first and now second registry is worse than when open registry was introduced. There is not much increase in automation on board as announced on magazines always which help to reduce workload. 2nd register is a good excuse to bring less paid manpower & even less manpower from overseas. Powerful companies have influenced authorities in helpless times to reduce crewing giving excuses like automation. Frequency of huge accidents over time has reduced because of technology no doubt. But reduced crewing is the main cause for most accidents happening today. It is ok for companies as long as the costs of accidents are less than crewing. Even then they have insurance.

Crewing has recently reduced significantly (Ljung & Lützhöft, 2014). However, the paperwork associated with jobs has increased

considerably (Størkersen et al., 2017), which consumes a considerable amount of time to complete. Seafarers are also concerned about how accidents on other ships, sometimes not even in their own company, resulted in the introduction of more checklists, procedures and other paperwork. A senior officer (R59) pointed out:

Paperwork is ever increasing. Compare it to fifteen years ago when shipping had much less paperwork but still operated well. However, the number of the crew has reduced. In recent times, some of our huge container ships have gone down from 22 to only 8 people. The amount of paperwork remains the same as before though and other work as well. A single person operates the winch, handles the rope and act as the dogman (signal man) on some ships. One person has to be in 3 places at the same time. Sometimes we need the cook to help out with mooring which is insane. That is the level of safety on ships.

The research participants identified insufficient crewing as a factor leading to task deviation at sea because seafarers cannot follow procedures to achieve their objectives without reverting to multitasking.

5. Discussion and conclusion

Accident investigations and analysis reports show that simultaneously performing different tasks onboard ships has led to many accidents at sea. This research shows that the way tasks are expected by shipping companies to be carried out (WAI) at sea may differ from the actual way tasks are carried out when seafarers are under the influence of multitasking (WAD), which may lead to dangerous situations.

Upon investigating the findings from the analysis as to why seafarers engage in simultaneous tasks at sea, common themes arose. They are *administrative burden, lack of speak-up culture, and insufficient crew*. These themes highlight the significant impact of socio-cultural aspects of contemporary shipping on seafarers' work practices. The findings of this research project support the findings of the work done by Loukopoulos et al. (2009) in the aviation industry as well as Woods (2010) and Westbrook et al. (2018) in the medical industry. This study too observed that sociocultural elements in the workplace influence seafarers to deviate from their work tasks which may lead to accidents. Elements in the seafarers' activity system contradicted the object of aligned WAD with WAI causing task deviation in periods where seafarers engaged in simultaneous tasks. These findings raise safety-critical concerns to reflect on by the maritime industry, which could assist in mitigating dangerous situations at sea as follows.

- Shipping companies need to involve seafarers in the design process of procedures and checklists. This is to ensure WAI can safely be aligned to WAD.
- Shipping companies need to provide adequate resources for the safe execution of the revised procedures.
- STCW convention needs to be amended to include training for all seafarers on the severity of task deviation and the importance of 'one job at a time', to mitigate unsafe habits of multitasking on board ships.
- Shipping companies need to promote a culture where seafarers are rewarded for speaking up on safety issues and stopping jobs in unsafe situations.
- Shipping companies need to gain seafarers' trust and confidence by implementing changes requested by seafarers in the reported unsafe conditions.
- Shipping companies should re-assess safe crewing levels onboard their ships with feedback from their crew, taking into account unforeseen circumstances at sea that require more human resources to complete work tasks safely. Additionally, flag states

should take more responsibility in reviewing *safe crewing certificate* applications by shipping companies before approval.

- Shipping companies should provide additional experienced personnel to assist in busy periods, such as ships visiting their home (mother) ports.
- Shipping companies should also re-assess the planned maintenance systems to prevent abrupt high workloads.

This research recognises that aligning WAD and WAI in the maritime industry could be complex (Hollnagel et al., 2013). However, *administrative burden, lack of speak-up culture, and insufficient crew* could be some of the reasons why maritime accidents continue to occur where the human element is still the leading cause. Understanding these socio-cultural issues could help mitigate task deviation at sea, leading to dangerous situations influenced by multitasking.

Conflict of interest statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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