



CHALMERS

How digitalization is affecting maritime safety and the work environment of the crew

A study of technological advances and its effect on end-users onboard an LNG vessel

Bachelor thesis for Master Mariner Program

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DEPARTMENT OF MECHANICS AND MARITIME SCIENCES

CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2023

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PREFACE

This bachelor thesis is a mandatory part of the four-year Nautical Science program at Chalmers University of Technology and consists of 15 credit points.

I would like to thank my supervisor Dr. Monica Lundh for the guidance and support during the time of this study, the company where this study was conducted and all the crew onboard the vessel who volunteered to participate. I'm grateful to all! Your time and effort is very appreciated!

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SAMMANDRAG

Sjöfartsindustrin upplever en förändring med Shipping 4.0, som involverar integration av digital teknik. Medan dessa tekniker syftar till att öka effektiviteten och minska kostnaderna, så skapar de också nya utmaningar och stressfaktorer för anställda ombord på fartyget. Technostress är ett psykologiskt fenomen som uppstår av användningen av informations- och kommunikationsteknik (ICT), som är förknippad med negativa resultat som stress, utbrändhet, minskad arbetstillfredsställelse och minskad prestation. Dessutom kan tekno-invasion och tekno-överbelastning i sjöfartsindustrin leda till en förlust av kontroll, vilket ytterligare förstärker teknostressen.

Denna stress kan också förvärras av den sociala isoleringen och de långa arbetstimmar som sjöfarare upplever. En tematisk analys av intervjuer har genomförts ombord på ett LNG fartyg där en internationell besättning blev ombesatt att identifiera hur ICT påverkade deras arbete, stressnivå och arbetstillfredsställelse. Medan besättningen är positiv till digitaliseringen av branschen känner många en brist på delaktighet när nya system introduceras på fartyg, vilket gör att de känner sig osäkra och kan uppleva brist på kontroll när de använder dessa system. Kommunikationen mellan fartyg och land är både begränsad och repetitivt, vilket gör att besättningen upplever en tekno-överbelastning och en bristande karriärutveckling påverkar besättningens arbetstillfredsställelse som leder till en minskning av effektiviteten i arbetet. Därmed dras slutsatsen att om en webbsida finns på plats där både fartyg och land har åtkomst, kommer den att minska teknostressen ombord, samt att hårdvarusystem ska testas noggrant och läras ut till besättningen innan de implementeras på fartygen.

Nyckelord: teknostress, ICT, digitalisering, shipping 4.0, tekno-invasion, tekno-komplexitet, tekno-obestämdhet, tekno-osäkerhet, tekno-överbelastning, tankerfartyg.

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ABSTRACT

The shipping industry is experiencing a transformational shift towards Shipping 4.0, which involves the integration of digital technologies. While these technologies promise to increase efficiency and reduce costs, they also create new challenges and stressors for workers onboard tanker-vessels. Technostress is a psychological phenomenon that arises from the use of information and communication technologies (ICT), which is associated with negative outcomes such as burnout, decreased job satisfaction, and reduced performance. Furthermore, the techno-invasion and techno-overload in the maritime industry can lead to a loss of control further amplifying technostress.

This stress can be compounded by the physical isolation and long work hours experienced by seafarers. A thematic analysis of interviews has been carried out onboard an LNG vessel where an international crew were asked to identify how ICT affected their work, stress level and job satisfaction. While the crew are positive to the digitalization of their industry many feel that the un-involvement in the introduction of new systems on vessels causes them to feel insecure and in loss of control when operating said systems. The communication between ship and shore is both limited and repetitive causing the crew to experience a techno-overload, and the absence of career advancement affects the job satisfaction of the crew, minimizing the efficiency of the work. However, it is concluded that if a web-page is in place with both ship and shore accessing it, it will minimize the technostress experienced onboard as well as hardware systems being thoroughly tested and taught to the crew before implementation to the fleet.

Keywords: technostress, ICT, digitalization, shipping 4.0, techno-invasion, techno-complexity, techno-uncertainty, techno-insecurity, techno-overload, tanker-ships.

TABLE OF CONTENTS

1. Introduction	1
1.1 Background	1
1.2 Aim of the study	2
1.3 Research questions	2
1.4 Delimitations	2
2. Theory	3
2.1 ICT & Digitalization of the shipping industry	3
2.1.1 Shipping 4.0	3
2.1.2 Trust in digitalization	3
2.2 User centered design	4
2.3 The evolution of maritime Shipping	4
2.4 Stress in the workplace	5
2.5 Stress Theories	5
2.6 Stress among seafarers	6
2.7 Technostress	7
2.7.1 Consequences and health problems relating to stress	7
3. Methods	9
3.1 Procedure of data collection	9
3.2 Quantitative research	9
3.3 Qualitative research	9
3.4 Demography and selection	10
3.5 Analysis	10
3.6 Ethics	10
4. Results	11
4.1 How has digitalization and ICT affected the workplace onboard?	11
4.2 How has ICT affected the crew's experience of stress?	14
4.3 How has the job satisfaction of the crew onboard been affected?	19
5. Discussion	23
5.1 How has digitalization and ICT affected the workplace onboard?	23
5.2 How has ICT affected the crew's experience of stress?	23
5.2.1 Old ship= Old hardware	24
5.3 How has the job satisfaction of the crew onboard been affected?	24
5.3.1 Feeling replaceable	24
5.3.2 Getting rewarded	25
5.3.3 Ship-Shore communication	25
5.3.4 Company policy	25
6. Conclusion	27
6.1 Recommendations for further research	27

References	28
Appendix 1- Survey	32
Appendix 2- Consent form	32
Appendix 3- Interview questions.....	32

LIST OF FIGURES

- Figure 1 Maritime Development (Conceição et.al 2017)
- Figure 2 Techno-Overload
- Figure 3 Techno-Invasion
- Figure 4 Involvement facilitation
- Figure 5 Techno-Complexity Figure 6 Techno-Insecurity
- Figure 7 Techno-Uncertainty
- Figure 8 Literacy facilitation
- Figure 9 Technical support provision
- Figure 10 Job satisfaction
- Figure 11 Organizational commitment
- Figure 12 Continuance commitment

ACRONYMS AND TERMINOLOGY

AIS	Automatic Identification system
CCR	Cargo Control Room
C-ES	Cyber Enabled Ship
ECDIS	Electronic Chart and Display Information
Familiarization	Training onboard to familiarize new seafarers with the vessel.
ICT	Information and Communication Technology
LNG	Liquified Natural Gas
MSI	Maritime Safety Information
Navtex	Navigational Text Messages
SEC	Shore Enabled Ship
Shore leave	The opportunity to leave the ship and go on shore for a few hours

1. INTRODUCTION

The introduction of computers and digitalization has evolved during the past decades. This development has, among other things, changed the communication pattern and can be referred to as ICT, which stands for *information and communication technologies*. Definition of ICT as Berg-Beckhoff et.al (2017) describes it is a diverse set of technological tools and resources used to manage information for the consumer to work with. ICT has had a positive impact on our lives not only by making work more efficient, but also by making it easier to communicate with our families and friends. The use of ICT has increased dramatically, making the end-user dependent on technological devices, sometimes referred to as a so-called techno-addiction (Young 2017).

In order to create a safer, more reliable workplace and to keep up with the constant development of technology the maritime shipping industry has been introduced to digitalization (Bauk S et.al 2017). The transport business has been growing every year (Sanchez-Gonzalez P et.al 2019). and with the intention of keeping up with the client's demands companies have embraced new technologies. Use of technology exists in many different ways, for example a direct email to send to the company office instead of a physical meeting. Technology is also used in e-navigation, for example the use of electronic chart display and information system (ECDIS) has had a dramatic change in how seafarers operate on a global level (Bauk S et.al 2017) It has made it easier to navigate and get the latest navigational information. This development has been successful in providing information so that one person can navigate, instead of having a team of officers on the bridge.

Despite the positive impact there are also stress related issues concerning the digitalization of the work environment. (La Torre et.al 2018) Employees have to always change their work routine and adapt to new equipment, new procedures and new ways of approaching things. This can lead to a rather negative experience with the fast-paced digitalization such as anxiety, job dissatisfaction and stress. This phenomenon is also referred to as technostress (Clark and Kalin 1996, Weil and Rosen 1997, Brillhart 2004). The increase of usage of ICT and the limited time to learn how to operate new technology makes it difficult to perform the task. It creates a shift in the nature of the employee's workflow. This can lead to a difficulty to perform to the high standards a company requires and be fully satisfied with the job done. It can also require more time to learn how a new device works rather than actually spending that time on something else. (Ragu-Nathan et.al. 2008). In short, technostress is about (a) how end-users cope with the change of work environment, (b) how it increases the workload leading to employees having negative experience with ICT and (c) how it can lead to frustration and lack of motivation to perform tasks.

The focus of this study is the ICT effect, both positive and negative for the crew onboard an LNG vessel to help further understand technostress and its effects on the individual's work ethics and satisfaction within the work environment.

1.1 Background

Stress has been an accompanying side effect to maritime workers since the early oceanic navigation due to its unique nature of dangerous workspaces, from mooring risks to weather catastrophes. A new stress factor that has been studied in this industry has been stress due to the introduction of technology, a *technostress*. In order to minimize and hinder further stress to this industry, it is important to study ICT's pros and cons from the ship's side of view.

1.2 Aim of the study

The aim of this report is to study and analyse both the negative and the positive effects of ICT and the digitalization of systems onboard. As well as identifying factors leading to technostress and hopefully coming to a conclusion to minimize it.

1.3 Research questions

- How has digitalization and ICT affected the workplace onboard?
- How has ICT affected the crew's experience of stress?
- How has the job satisfaction of the crew onboard been affected?

1.4 Delimitations

In this report only one LNG vessel has been included in the collection of data. Other LNG vessels within the fleet have been asked to participate but no response was given.

2. THEORY

The maritime industry is undergoing a digital transformation with the implementation of ICT systems and tools introduced to improve the maritime operation efficiency and safety. However, the introduction of new systems can lead to unintended negative outcomes such as technostress.

Technostress is a psychological state caused by the use of technology that can impact the worker's job satisfaction and productivity (La torre et.al 2018). This theory seeks to explore the connection between ICT and technostress in the maritime industry, highlighting the unique difficulties seafarers face in their work. Thus, it is important to understand the factors that contribute to technostress and develop strategies to minimize them.

2.1 ICT & Digitalization of the shipping industry

ICT is an abbreviation for Information and Communication Technologies. Defined by Berg-Beckhoff et.al (2017) as technology that supplies the user with information using telecommunications such as, internet and electronic equipment, for instance mobile phones. This continued development has enabled maritime crew for a safer navigation and a collaborative environment with shore and terminal, allowing for easier access to communication (Ichimura et.al 2022). In order to advance in digitalization and keep up with customer demand companies have a developing plan to promote ICT in their vessels. This revolution in technology is referred to as Shipping 4.0 (Ichimura et.al 2022).

2.1.1 Shipping 4.0

Shipping 4.0 is the name given to identify a trend towards automation and data exchange developments in digitalization of shipping. It was given due to its similarities with the land-based digitalization called industry 4.0 (Schwab, 2017). The shipping industry is coming to an alignment with the industry 4.0 by introducing new advanced technology, For example, the emergence of crewless vessels. They are referred to as cyber enabled ships (C-ES) which means a vessel in a cyber system that is shore controlled (SEC). The SEC handles the communication between the vessel and other ships in the vicinity. SEC consists of both information and operational technology systems that are supposed to be crucial for the vessels secure and safe operations. (Cross & Meadow, 2017).

2.1.2 Trust in digitalization

The introduction of shipping 4.0 has changed how work is performed on board. It has improved safety and efficiency but also introduced new risks (Androjna & Perkovič, 2021). One of the new risks is cybersecurity; As the modern maritime industry is heavily dependent on technology it makes it important for the crew both onboard and on land to have these systems protected. Although many ships are not crewless, there is still an interest in C-ES which are ultimately prone to a high risk of cyber-attacks. (Tam & Jones. 2018).

This growing trend of digitalization presented to the crew onboard creates a safety issue, often seen as a human error, or human factor (Hollnagel & Leonhardt, 2014) in which the failure of systems is blamed on the individuals operating it rather than a manufacturer's error. This creates a skepticism between end-users and machinery, as there is little information given to them regarding how to solve the problems that occur in technological devices (Hollnagel & Leonhardt, 2014). In order to have less issues when operating systems, a user centered design is recommended.

2.2 User centered design

User-centered design is an approach to design that prioritizes the needs and preferences of the end-user throughout the design process. This approach involves understanding the user's goals, tasks, and behaviors and incorporating this understanding into the design of products, services, or systems. By putting the user at the center of the design process, designers can create products that are intuitive, usable, and meet the user's needs. User-centered design involves a collaborative process of design, testing, and refinement to ensure that the final product meets the user's expectations and provides a positive user experience. Ultimately, user-centered design can lead to increased customer satisfaction, loyalty, and product adoption (Abrams et al 2004).

But when it concerns the maritime industry, changes are made as a reaction to an incident rather than a regular modernization to the work, such as the implementation of high frequency radio (Dul & Neumann 2009) that is now seen as inefficient as it was installed without educating the end-users on how to use it.

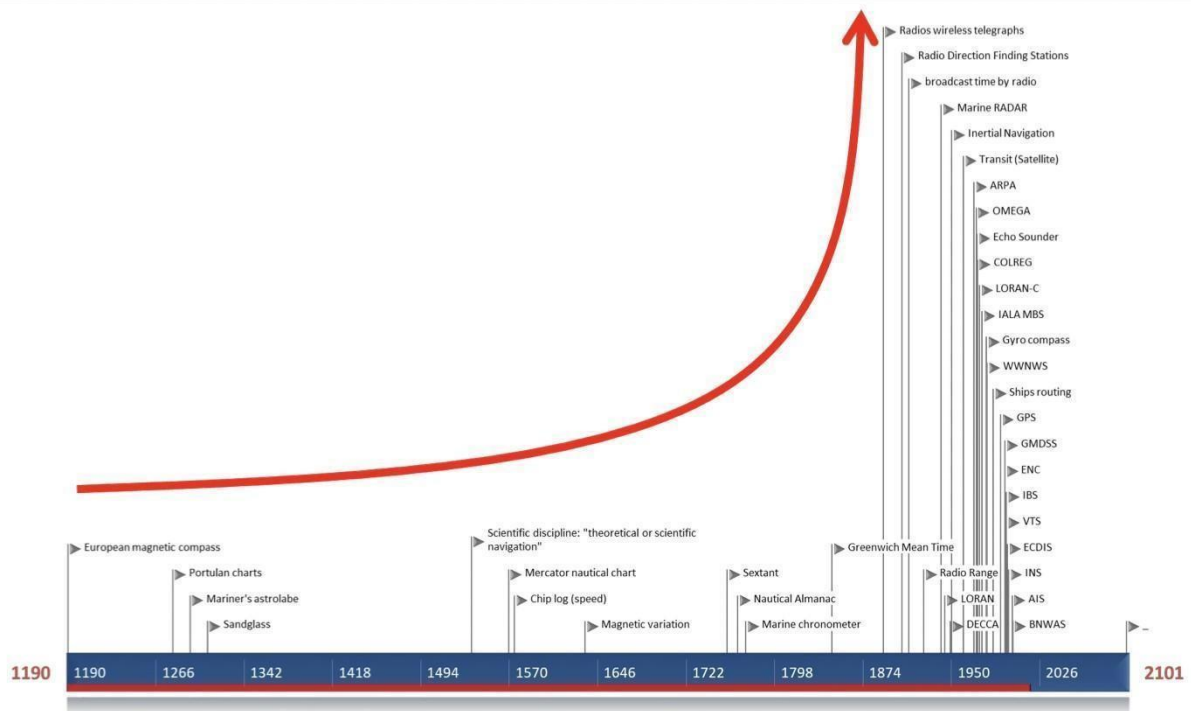
2.3 The evolution of maritime Shipping

In order to create a safer, more reliable workplace and to keep up with the constant development of technology the maritime shipping industry has been introduced to digitalization (Bauk S. et al 2017). The transport industry has been growing every year showing an increase of 40% in business between 2005 and 2015. This ultimately puts a pressure on the industry to develop rapidly (United Nations. 2018).

With the intention of keeping up with the client's demands companies have embraced new technologies, such as the usage of ECDIS. ECDIS has provided the navigator with the latest navigational information and thus has made navigating the vessel safer and more efficient (Bauk S et al 2017); Installment of stability computers in the Cargo Control Room (CCR) has also provided officers with easier access to calculations and techniques in loading/Discharging operations (Boulougouris et. al 2016)

Digitalization of the maritime industry started in the 1960s with the introduction of computers onboard (Nowaki H., 2010). This introduction has revolutionized the shipping industry on a global level and led to improvisation of the performance of computers onboard as well as electronic systems such as an alarm system with a text screen, anti-collision radar and a docking log (Johansson, 2019). There is a constant conversation of developing all communication means such as MSI (Maritime Safety Information), AIS (Automatic Identification system, Navtex (Navigational Text Messages) etc. (Bauk et al , 2017). A timeline of how navigational aids have been introduced onboard is shown in figure 1.

Figure 1
Maritime development



A graph taken from Conceição et.al (2017) with permission, shows the timeline different electronic systems were introduced to the maritime industry.

2.4 Stress in the workplace

Effects of stress have been documented since the 1700s as a hardship that causes the individual mental and physical strain. Nowadays stress is defined by Cooper et.al (1989) as a reaction to an individual's lack of capability to adapt to the environment. This stress can be caused by "Stressors". Stressors are situations that cause stress. (Ekman and Arnetz, 2005; Jones and Bright, 2001; Allvin et al, 2006; de Lange et al. 2003) A stressor would be an imbalance in the individual's personal and professional life. It is recorded that people in the beginning of their career have a bigger imbalance between work and family due to economic issues. Younger individuals want to better and upgrade their career as fast as possible, which can create less resting hours and an increasing workload (Cooper et.al. 1989).

2.5 Stress Theories

In order to understand exactly what stress is, it has to be explained. Some theories have come to study stress and discover how to reduce the impact of it for a couple of decades. According to Ragu-Nathan et. al (2008) being under stress is a situation where a person's knowledge and capabilities do not meet the requirements to perform a task. This can result in the individual not being rewarded for their efforts. (McGrath 1976, p. 1351). Stress is a psychological theory in which there is an imbalance between the individual's capabilities and the environment where the individual anticipates being able to perform to the standards of the environment (Cooper et al. 2001).

Many factors have been described as stressors, meaning situations that contribute to stress. There are six major factors contributing to stress according to Cooper (1983). First one is poor

physical working conditions. For example, how a workplace is designed might make it easier to perform tasks. (Otway & Misenta 1980). Second factor is shift work; For example, the hours in which an individual works and the rhythm of their work was observed in a study by Cobb and Rose (1973). The results indicated that this affects the blood, temperature, metabolic rate and blood sugar levels. This can result in stress related diseases. There is also a complaint about shiftwork, that the employee may feel excluded from society due to inconvenient work hours.

Third one is job overload. This is both quantitative (having too much work) and qualitative (being too complex) overload. A study by French & Caplan (1972) has shown that job overload is associated with lower self-esteem, low work motivation and even alcohol use. Job underload is the fourth factor and is associated with the same repetitive routine that under-stimulates the employee and results in boredom. This disinterest in the job risks reducing the employer's response to further emergency situations (Cox. 1980). Physical danger is the fifth stressor where the individual experiences a fear or uncertainty performing a job due to the possibility of a physical injury. There are certain jobs which have a high-risk rate, such as working aloft, working in a high voltage area, mooring etc.

Person-Environment fit in job satisfaction (P-E fit). Finally, is a measure between the person and the environment. According to McMichael (1978) this is an interaction between the individual characteristics and environmental work conditions. The score can be obtained by subtracting the amount of workload the person experiences that they have, from the actual amount of work load in the person's environment. (Frese & Zapf 1988). The hypothesis is that if there is a P-E misfit then the worker can feel anxiety, depression and job dissatisfaction.

2.6 Stress among seafarers

Separation from family and friends can be difficult to manage as it causes loneliness; That's why Wi-Fi is an important feature to have onboard as it allows seafarers to connect with their families. It could also affect the crew members negatively as they might feel that they are not involved and unable to help with disturbances at home. Cultural differences can also lead to loneliness as individuals might not understand each other's actions or choose to not speak a language that everybody understands; This can lead to an individual feeling left out and bullied (Thomas et.al. 2003).

Another stressor in seafarer's life is lack of shore leave. According to Dreele (2008) shore leave has been reported to be averaging at 20-25% per ship. This low number could be due to the work/rest schedule, need for a visa, terminal being far away from the city and poor transportation opportunities. This leaves the seafarers with limited social contact as they are restricted in their ability to "another life than onboard".

Long working hours and disturbed rest can also lead an individual to depression and stress. According to Allen et.al (2008) seafarers should have eight hours of undisturbed rest but due to economic issues there is a shortage of seafarers onboard, which can lead to an increased workload due to the crew being woken up to work, thus not having enough time to rest.

Entering piracy and war zones has also been a concern to seafarers, as frequent attacks on ships near the coast of Somalia has been recorded with 2011 being dubbed "Year of the pirate". 450 hostages were taken that year and 15 murdered (ICC International Maritime Bureau, 2012). Ships are kept for an average of 210 days before a ransom is paid or being released by naval forces.

Job security has also been a concern as many seafarers are employed by contracts. This means that a company doesn't have a legal obligation to keep the same seafarer when their contract expires. This leads many seafarers to worry if their contracts will be renewed. (International Committee on Seafarers' Welfare [ICSW], 2009)

An added stressor to the maritime crew is the dependence on integrated technological systems. In the maritime industry, where workers already face high levels of stress due to the dynamic and unpredictable nature of the work, the introduction of new technologies may contribute to this stress and impact worker well-being, job satisfaction, and productivity. This is referred to as technostress (Brod. 1984)

2.7 Technostress

Technostress is defined by Brod (1984) as an inability to adapt with new technology in a healthy manner. Later definition by La Torre et.al (2018) is that technostress is the long-term reaction resulting from usage of ICT. Brod (1984) further describes that there are two forms of technostress; First is the struggle to use newer technology, second one is the excessive usage of technology, where the individual slowly over time interacts less with others. This is later known as techno-addiction (Young. 2017). According to Turel et.al (2011) techno-addiction is described to have multiple symptoms such as a thrill or a relief when doing a task involving technology. Relief is characterized as a reward since it releases endorphins in the individual for successfully performing a task. This leads to an addiction to technology as they feel like they are rewarded (Turel et.al 2011). Another reward an individual strives after is a promotion. Companies have an appraisal system where they evaluate the worker after each contract and see if they have shown capability and determination to be promoted. This is described as "the reward theory" (Pearce et.al 1994) and it will conclude if they are worthy of a promotion or a renewal of a contract. These performance related awards can in the long run cause negative influence on the individual in the form of technostress, as they feel they can be replaced or miss out on a career advancement if they do not cope with technology.

In order to research technostress, it has to be dissected into multiple sections. Below are the descriptions of the factors in technostress used for the survey in accordance with Ragu-nathan (2008):

- Techno-invasion is where the boundary between the individual's free time and work is overstepped by being in contact with work in their free time.
- Techno-complexity is where the individual feels insufficient due to their inexperience with technology.
- Techno-insecurity is when the individual's fears a threat to their livelihood as a result of advancements in ICT.
- Techno-uncertainty is where the individual experiences an uncertainty or unsettlement due to the constant upgrades in ICT.
- Techno-overload is a situation where technology forces the individual to have an increased workload.

2.7.1 Consequences and health problems relating to stress

Although it was created as a means to increase productivity and minimize workload, it has led to the end-user's need for continued adaptation of newer technology and over-exposure of information. Adding to the phenomenon of techno-stress. The increase of usage of ICT and the limited time to learn how to operate new technology makes it difficult to perform efficiently. Consequences reported to have been caused by technostress are listed below:

1. Physical health problems: Technostress can manifest in physical health problems such as headaches, wrist strain, and neck pain. The prolonged use of technology can lead to musculoskeletal disorders, obesity, and other health issues. (Alotaibi. et.al 2020)
2. Mental health problems: Technostress can also lead to mental health problems such as anxiety, depression, and burnout. The constant pressure to be connected and productive can cause individuals to feel overwhelmed, leading to decreased job satisfaction and increased stress. (Bondanini et.al. 2020)
3. Decreased productivity: Technostress can negatively affect an individual's ability to focus and concentrate, leading to decreased productivity. This can have a significant impact on work performance and can even result in job loss. (Bondanini et.al. 2020)
4. Reduced job satisfaction: Technostress can also lead to reduced job satisfaction, particularly if an individual feel that they are constantly "on call" or that they cannot disconnect from work. This can lead to feelings of frustration, disillusionment, and a lack of engagement with work. (Adams. et.al. 1996)
5. Strained relationships: Technostress can also affect personal relationships, as individuals may feel compelled to be constantly connected to technology, even when spending time with family and friends. This can lead to feelings of isolation, disconnection, and even conflict in relationships. (Turel. et.al 2011)
6. Addiction: Technostress can also lead to addiction, as individuals may feel a compulsive need to check their devices or engage with technology, even when it interferes with other aspects of their lives. (Turel. et.al 2011)

In conclusion, technostress can have a range of negative consequences, both on an individual and organizational level. It is essential to manage and mitigate technostress to promote physical and mental well-being, increase productivity and job satisfaction, and maintain healthy relationships with technology.

According to a study by Oldenberg & Jensen (2019) 58 of the 67 nautical officers participating felt mentally stressed with 45 of them having sleep deficiency. According to Iversen (2012) a consequence of stress is suicide. This is resulted by disturbed resting hours, family conflict, physical health and level of control a seafarer has over her/his job. When under severe stress a seafarer might lose their ability to make decisions and lose productivity. This is a symptom of a "burnout". 5.9 % of all deaths reported onboard are of suicide.

3. METHODS

The method used in this study has a mixed-methods approach (Denscombe, 2008) consisting of semi-structured interviews and a survey. Semi-structured interviews are qualitative research (Kallio et.al., 2016) that have leading questions but allow for follow-up questions, creating a discussion between the interviewer and participant. The subjects of the interview were strategically chosen as they were officers and engineers, i.e., the crew who depend on technology to do their work.

The survey was written with inspiration from Ragu-Nathan et. al 2008. As well as: Ye, Q. 2018. It consisted of 42 "Agree/Disagree scale" questions, where the respondent could choose from five options; Strongly Agree-Agree-Undecided-Disagree-Strongly Disagree. There were also five follow-up questions where the respondent could write down the answers.

3.1 Procedure of data collection

To study technostress, qualitative research has been conducted where twelve officers and engineers onboard were strategically chosen based on rank, as well as 28 surveys were filled by all crewmembers onboard with a total of 47 questions covering their work experience, their use of technology and its various effects on stress and private life.

3.2 Quantitative research

The surveys were distributed to all the crew-members onboard the LNG vessel to include both deck and engine department. The survey was handed out during a weekly meeting where all the crew gather to discuss a safety topic given by the company office. Each member received a survey and an explanation of the project and its purpose was explained. 28 surveys in total were filled out with all the "Agree/Disagree" questions answered; The last five follow up questions involving personnel experience on how participants work with ICT, problems they face and how to solve them were filled out by 26 of the 28 crew members.

3.3 Qualitative research

The interviews were conducted in the timeline of a week where the twelve chosen crewmembers, regular end-users of ICT were informed of the interviews and a consent form was filled out. All the interviews were done anonymously with questions that can be found in appendix 3.

All interviews were led by the questions in appendix 3 except for the fourth questions being added on later; The first three crew members to be interviewed did not have this question but the other nine did.

The questions were written to highlight the technostress added to the individual's work as well as the technological advances needed to be introduced to LNG shipping vessels. The questions were partly inspired by reading articles about technostress such as Ragu-Nathan et. al 2008. As well as: Ye, Q. 2018. The theme of the questions was written as a direct way to find out how the crew felt about technology advances, but also as a way to let the participant feel comfortable to further explain their answers and improvise the interview with follow-up answers.

3.4 Demography and selection

Convenience sampling occurred when collecting data due to the participants being the only available pool of respondents. This was also done as time and budget were restricted in the time of this study. This section will provide information about the participants and their backgrounds.

The crew interviewed were all colleagues working onboard the same ship at the time of the research. They were a multinational group with Russian, Croatian, Danish, Indian and British backgrounds and had an age range between 22-69 years old with the average age being 37 years old. Experience between 0-27 years, with the average being 13 years.

Both Deck and engine crew were interviewed with ranks ranging from Cadet, 3rd Officer, 2nd Officer, Chief officer and Captain. Engine crew ranged from 4th Engineer, 3rd Engineer, Gas Engineer, 2nd Engineer and Chief engineer. All crewmembers were male.

The crew members who participated in the survey were all of the 28 crew onboard. The average sea time experience was also 13 years and the average age was 40 years old. 27 males and 1 female with Swedish, Danish, Russian, Croatian, British, Indian and Filipino backgrounds.

3.5 Analysis

The interviews were recorded with consent and later transcribed using www.otter.ai. Interview time ranged from 5 minutes to 40 minutes. The interviews were later analyzed by using a thematic analysis approach with identifying and interpreting a pattern within the data (Braun & Clarke, 2006). This was done using an Excel spreadsheet and lining up the crewmembers' answers to the same question and highlighting the information given within the answers.

Descriptive statistics are used to analyze the surveys and summarize the variables (Kaur. et al. 2018), graphs were created using an Excel spreadsheet and marking the scale options from 5 (Strongly Agree) to 1 (Strongly Disagree); The average of each question was later calculated and shown in the graphs; The average value is included in the results for analyzation of the crew's answers. For example, question 1 has an average value of 3,43 out of five, which falls under "Undecided" and "Agree".

3.6 Ethics

The company office was asked for permission to conduct the study on their fleet through emails. Permission was later granted through email. All interviewees were given a consent form to sign where a description of the study and contact information were prescribed. All interviews were recorded with consent by the participants. This form can be found in appendix 2.

The master of the ship was verbally asked for permission to conduct the weekly safety meeting about technostress, the crew were also verbally informed about the purpose of this study and volunteered to fill out the survey that was distributed to them.

4. RESULTS

This project aimed at answering how digitalization and ICT has affected the crew's workplace, stress and job satisfaction. These questions are also listed below and answered with the results from the interviews presented in text and results from the surveys presented in graphs. In the survey there were five follow up questions that the crew answered by writing down the response. The questions were about the usage of ICT, the problems and what they do to solve them. The results for these follow up questions are presented in text along with the interview results.

4.1 How has digitalization and ICT affected the workplace onboard?

The overall results of this project show that in general terms, the crew members think digitalization and ICT technology is good. However, they listed both positive and negative aspects. Some pros were that the majority thinks that equipment onboard have been improved. Physical labor, such as manually measuring oil in machines has been reduced and the digital equipment has become more user friendly. The development of the technology has made work onboard faster as well as it saves more time and the respondents argue it is easier to multi-task. A majority of the respondents felt that they did not have to sacrifice a lot of time to learn how a new instrument works, only at the beginning of a contract since they already have the training and knowledge to understand the system while four participants feel the opposite, that it takes too long to understand, and that sufficient user information is not provided by the manufacturers.

In the first survey follow-up question regarding how crew work with ICT, Majority answered that it is comfortable and easy to perform tasks such as ordering, planning routes and loading/discharging cargo.

Despite the basically positive attitude towards digitalization and ICT there are still some cons, such as the majority have experienced problems with the equipment failing and regularly albeit with different intervals. Attention was brought to situations with major updates and/or changes to systems, e.g. after ship yard visits, equipment not being suited for maritime conditions and problems with the quality of hardware equipment as problematic. This has created an increased workload together with added paperwork as a lot of digital information still needs to be logged in paper format.

Although some have answered that it gives them more paperwork since everything must be logged in paper format. According to some crew members, technology gives them more work since cyber systems fail. One crewmember has brought attention to the hardware creating more issues along the years as well as quality of material getting worse.

Ten out of twelve crew members have experienced systems failing. The two members that did not experience system failure have short experience at sea. According to the more experienced crew members, equipment is not built for the condition they are in, which makes them prone to fail. The crew need time and resources to fix it which they might not always have. Regarding the problems crew face when using ICT in the second follow-up question, 50% answered that it is not applicable to their position while the other half answered that they experience slow systems due to old equipment, no support and training and this affects their time off onboard as they have to work overtime.

Some crew members have responded that they face these problems regularly at every contract. Other members have answered that this happens rarely, usually after dry-docking. A few members are undecided while some have answered that they have never faced it due to their short time at sea. Conclusion is that almost everybody has faced these problems but at a different scale and pattern.

Figure 2:

Techno-Overload

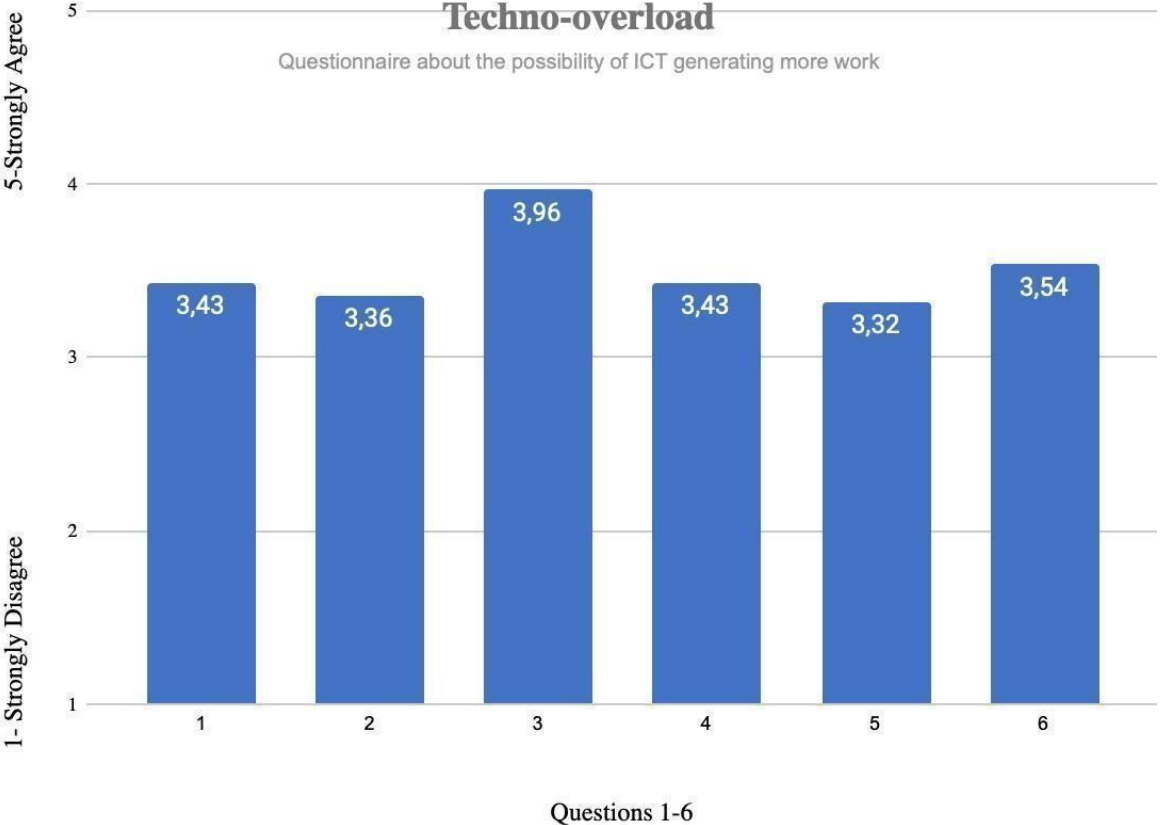


Figure 2 represents the data from the questionnaire about techno-overload. How technology creates more work for the crew onboard and if it takes more time.

Result shows that the average values of the bars fall between undecided and agree, meaning that the majority of the crew feel that technology has in some way created more workload.

Figure 3:
Techno-Invasion

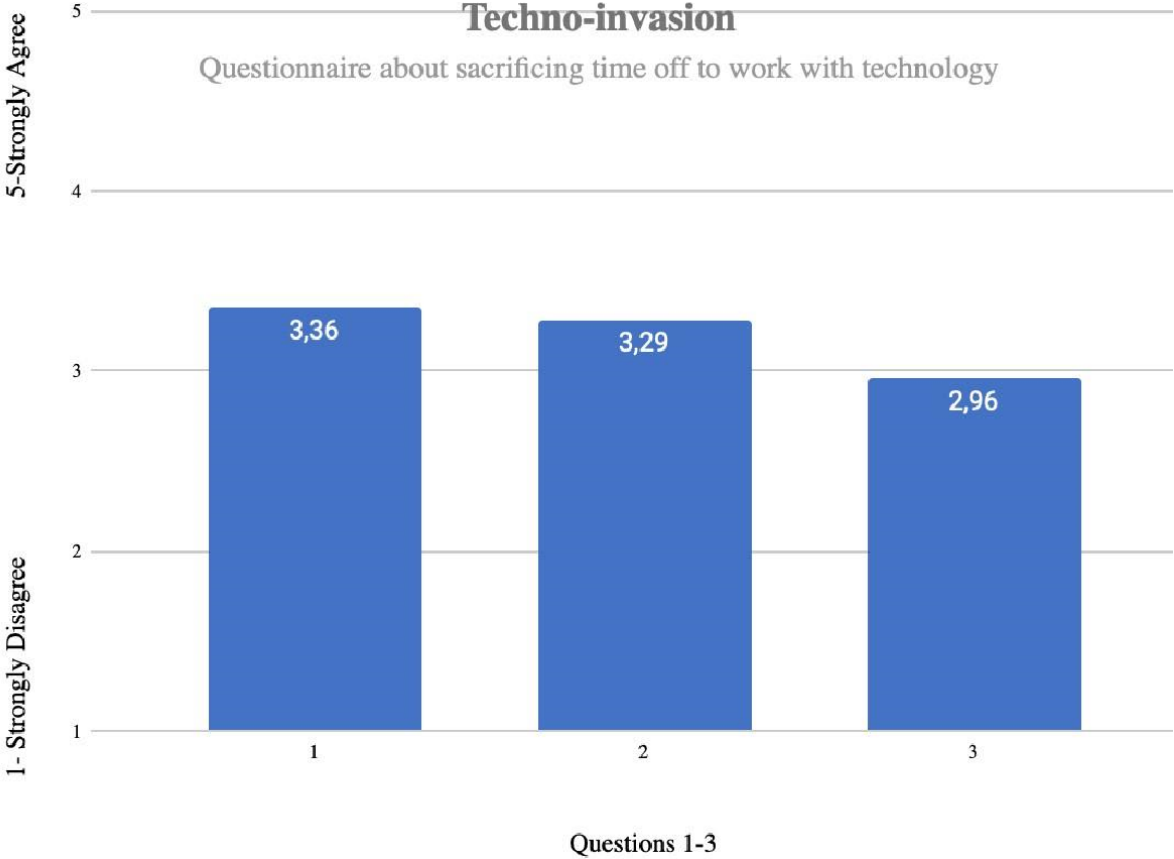


Figure 3 shows the results from a questionnaire about the invasion technology has on private life and time off work. The average values fall between a 3 (Undecided) and 4 (Agree) with the last bar (number 3) falling between a 3 and a 2 (Disagree). This means that the majority are indecisive if their private life is being invaded by ICT.

Figure 4:
Involvement facilitation

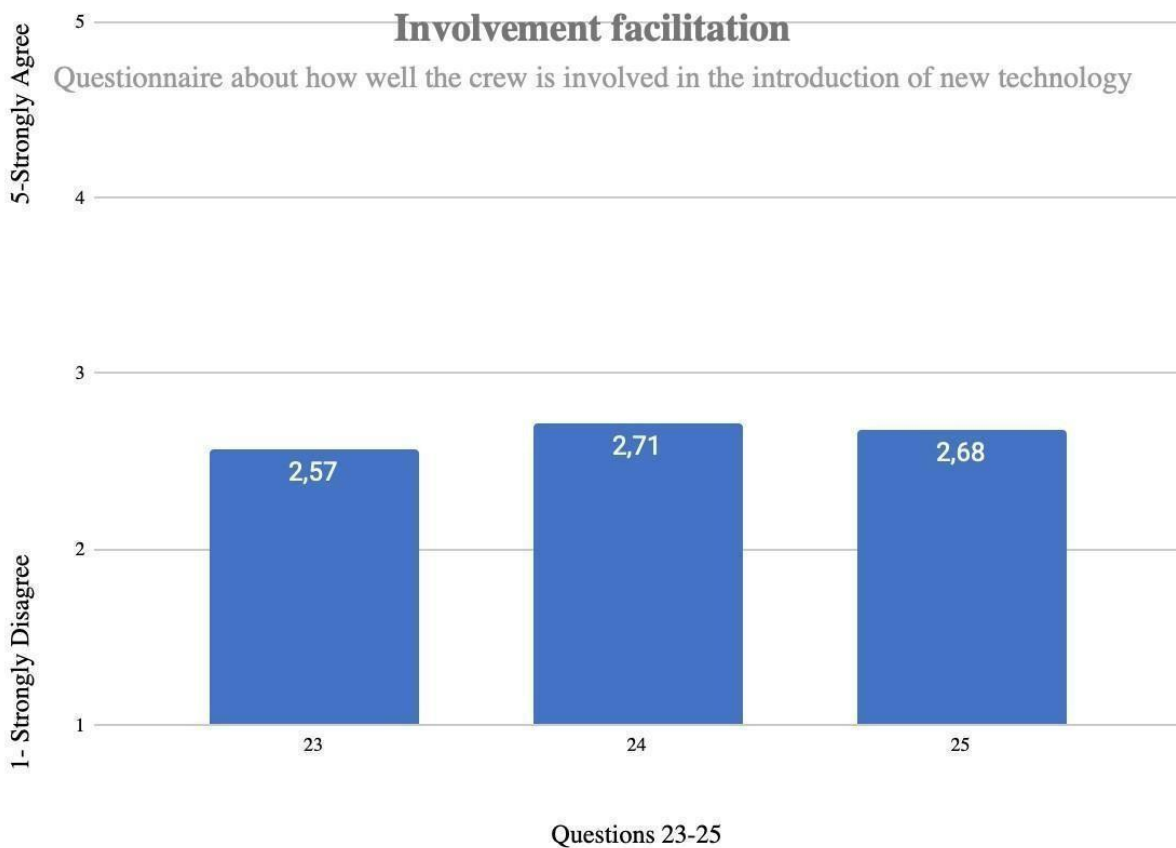


Figure 4 visualizes the results from a questionnaire about the involvement of end-users in the introduction and usage of new electronic equipment. The average falls between a 2 (Disagree) and 3 (Undecided) meaning that the crew do not feel involved or rewarded in the introduction of a new technology.

4.2 How has ICT affected the crew's experience of stress?

The frequency of crew facing problems relating to usage of ICT differs from rank to rank. According to the follow-up survey questions a third of the crewmembers who held the officer rank answered with daily/regular, another third of the crewmembers answered rarely and/or only when new equipment was introduced. The rest answered that it was not applicable to their job description. The fourth question in the survey relating to how the crew prevents ICT problems, 33% answered with not applicable. The ranks of this particular third vary from deck, galley and engine. The rest of the crew answered by seeking help from the IT-department and reading manuals; A few answered by sacrificing their own free time to solve work related problems.

According to the interviews, crewmembers read the manuals and learn how to fix the issues that technology causes by themselves before contacting IT help-desk. However, two crewmembers feel like there is nothing they can do and are left alone by the company.

Six out of twelve members interviewed think that the company provides help. Others do not since they feel like the help-desk is not user-friendly and takes too much time. According to the interviews half the crew feel that ICT is stressing them out due to increased workload and

systems failing. The remaining half have answered that they disassociate from ICT problems by reading a book or fish; If they cannot fix the problem then they wait for help when the vessel is at shore.

Although it is going forward, the workload has increased due to double logging of the information. Answers have showed that there are more improvements for the deck department but not for the engine department. Certain systems such as risk-based observation programs are implemented with the goal of minimizing injuries onboard, but it has taken the opposite effect and is seen by the crew as an added digital task that they need to fill. Figure 3 also shows the invasion crew members feel it has during their time off.

Figure 5:
Techno-Complexity

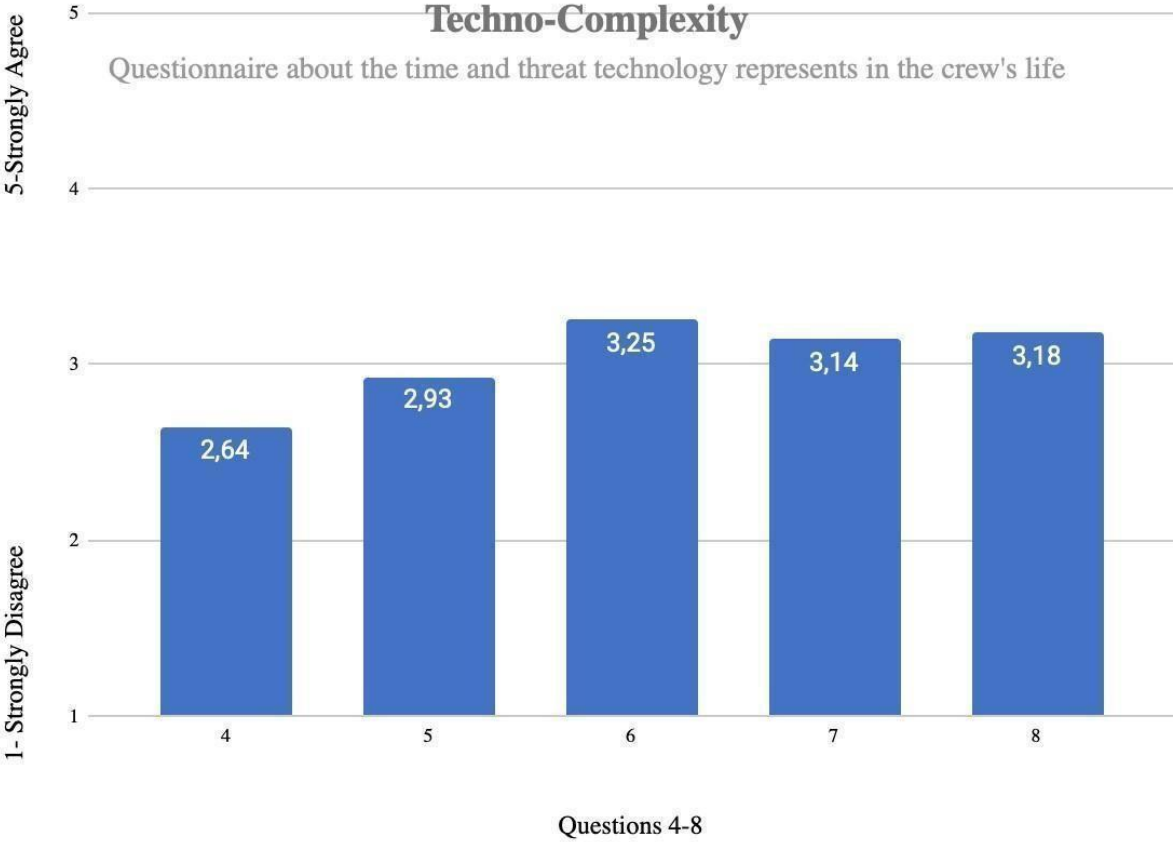


Figure 5 shows results from questions 4-8 about the end-user's experience in using ICT. Results show that the average in bar 4 is 2.64, meaning that the crew answered that they have enough skills to handle the new technology, but this is accomplished by sacrificing time off to learn according to bar 5. Bars 6-8 show that the crew are somewhat agreeing that they find technology too complex and that new recruits have better knowledge in ICT than them.

Figure 6:
Techno-Insecurity

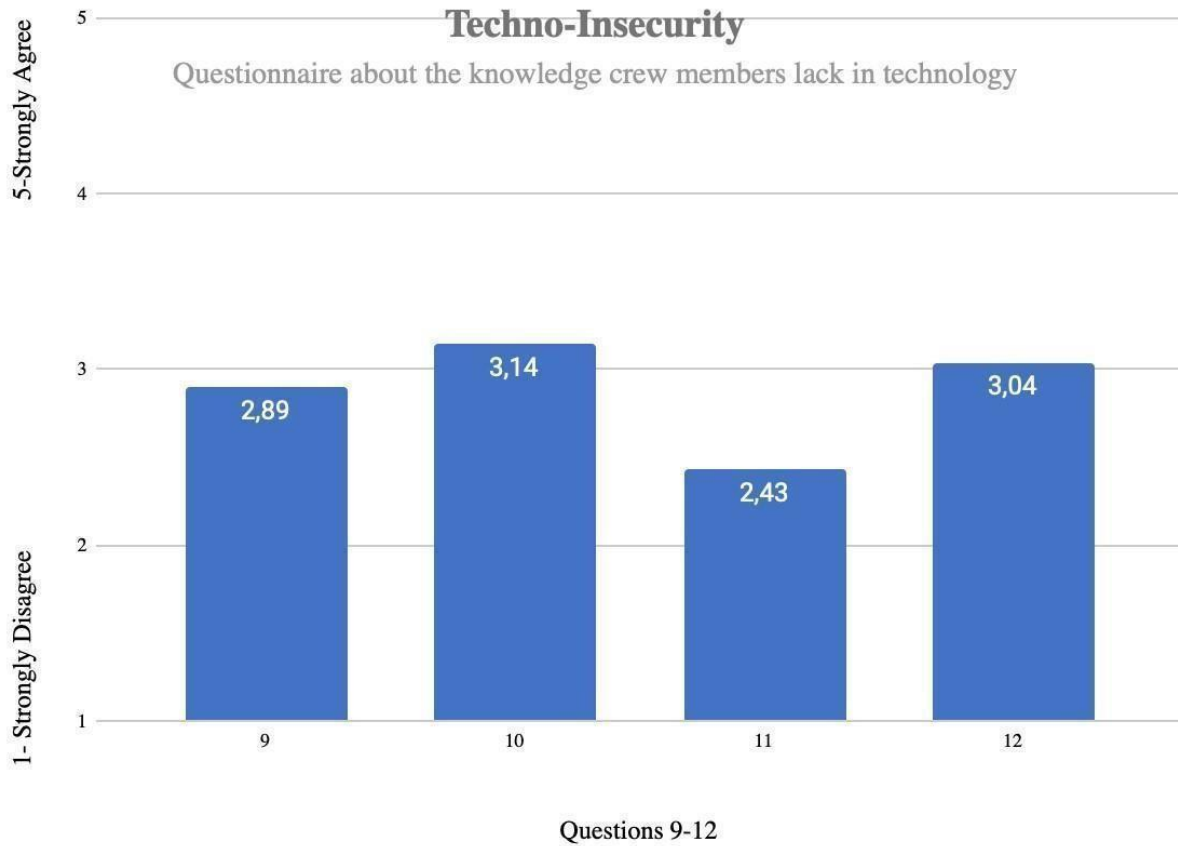


Figure 6 shows the answers of end-users concerning feeling a threat in being replaced due to inexperience in ICT. Results show that the majority of the crew are indecisive if they feel a threat of being replaced but do feel threatened by other colleagues' skills.

Figure 7:
Techno-Uncertainty

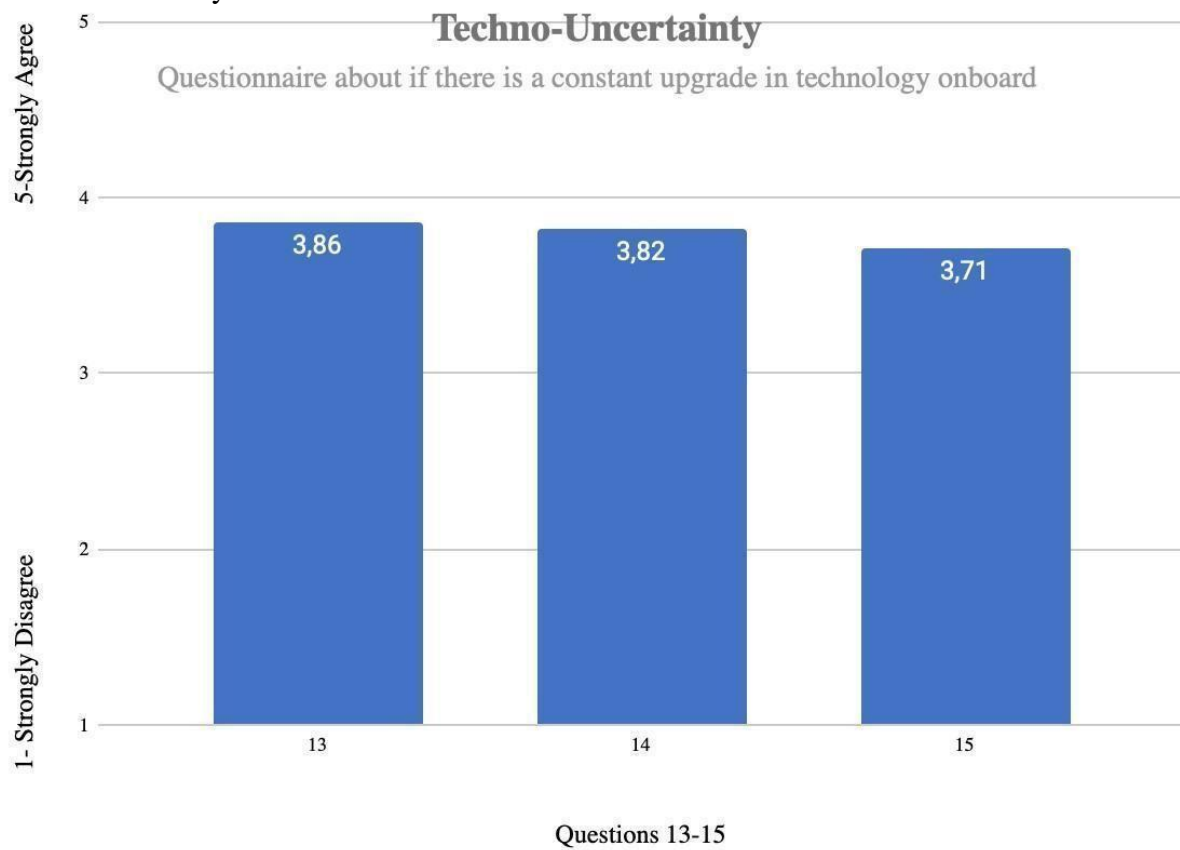


Figure 7 shows if end-users feel an uncertainty in the constant change and upgrades in their electronic equipment. Results show that the majority agree that there are constant changes and developments applied to the systems.

Figure 8:
Literacy facilitation

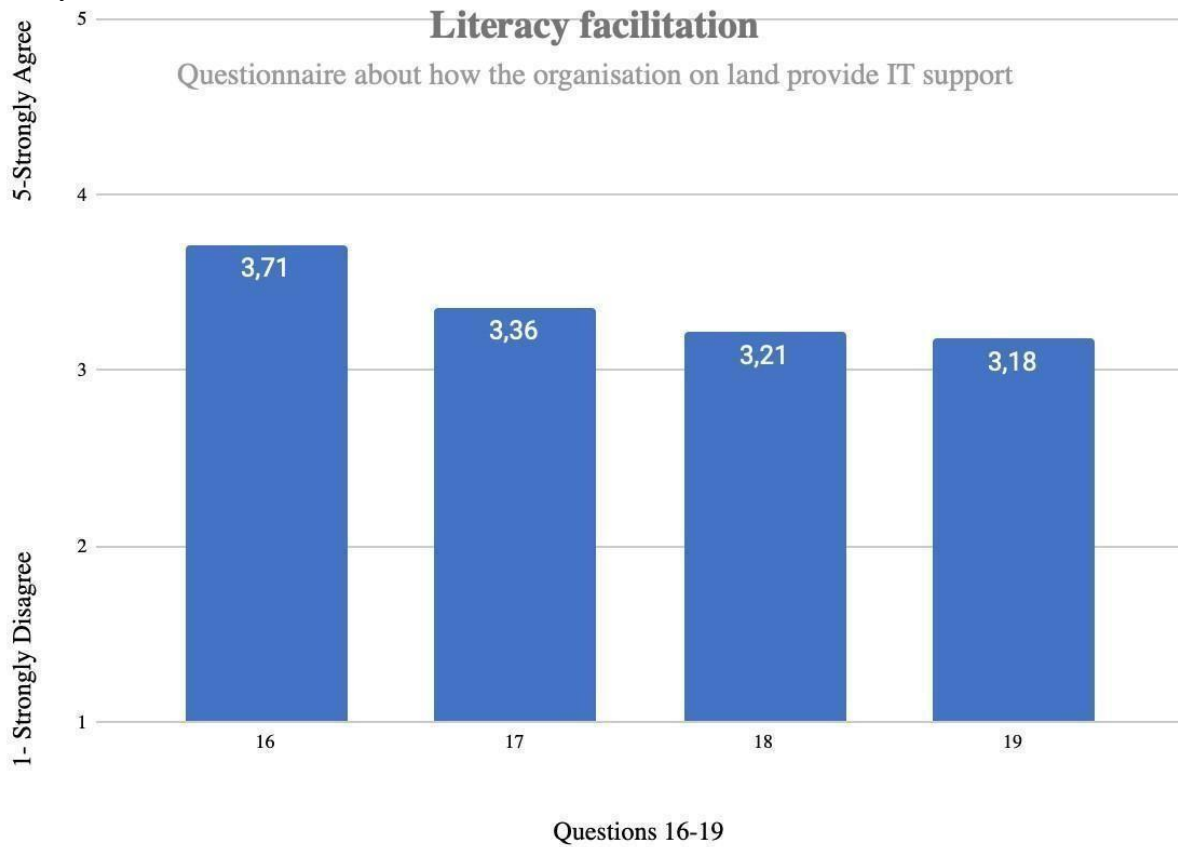


Figure 8 shows if end-users feel the company gives them support in dealing with new technology. According to the results above the crew are undecided if they receive training, IT help from the desk and clear documentation to deal with equipment.

Figure 9:
Technical support provision

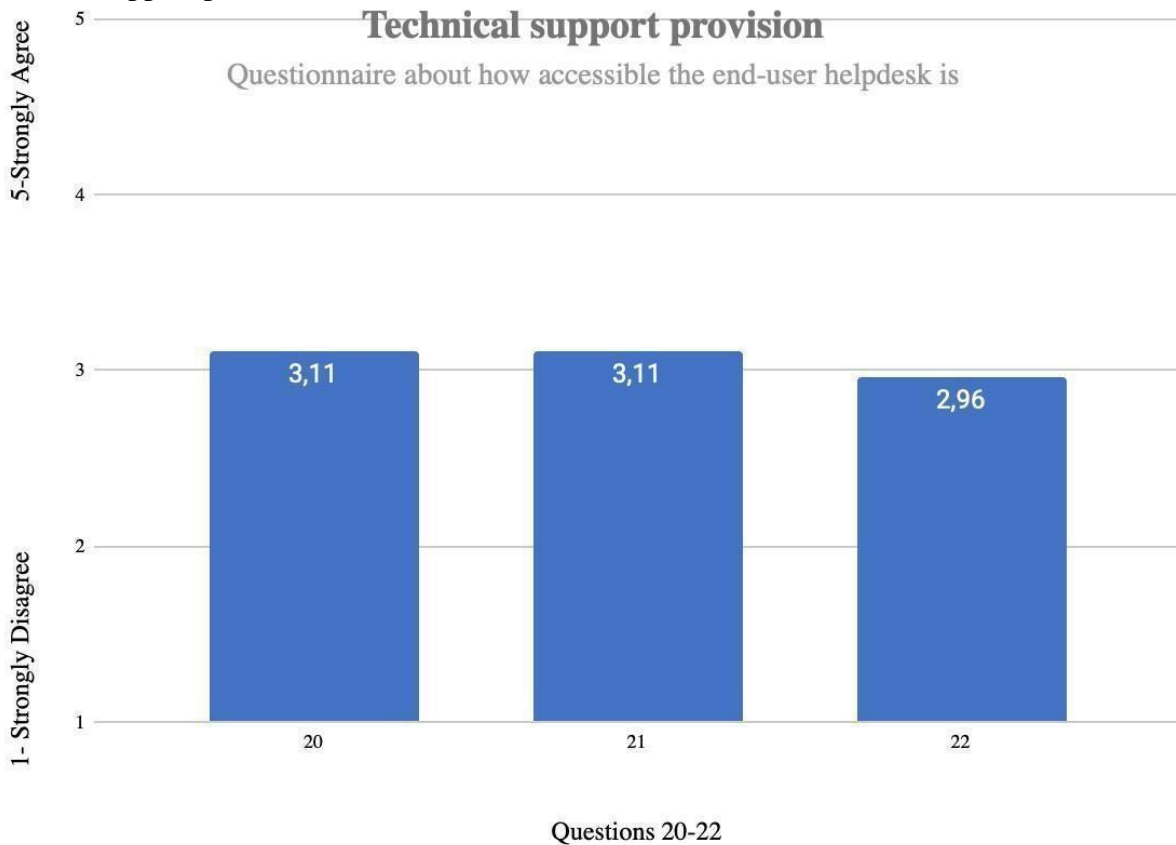


Figure 9 shows if end-users receive help from the company’s help-desk. Majority of the crew are undecided if the IT helpdesk provides help.

4.3 How has the job satisfaction of the crew onboard been affected?

According to the interviews, for the crew to be more satisfied at their workplace a login website has to be implemented so that the crew can see their personal data such as the next ship, seadays etc. A website between office and ship should exist to minimize emails facilitating better management and communication between the two. More learning tools and better familiarization to the newly joined crew. Handing over should be more specific, as well as reducing the programs on the computer to two or three and minimizing the doubling of information on paper format.

Most crewmembers do feel like onboard systems have been improvised. The last follow-up question of the survey relates to how systems can be changed in order to be prevented and easily operated, in order to increase job satisfaction. A third answered with not applicable. The rest answered that the company needs to invest in newer equipment and better internet communication, as well as involvement of end-users in system implementation and better support from the company.

Figure 10:
Job satisfaction

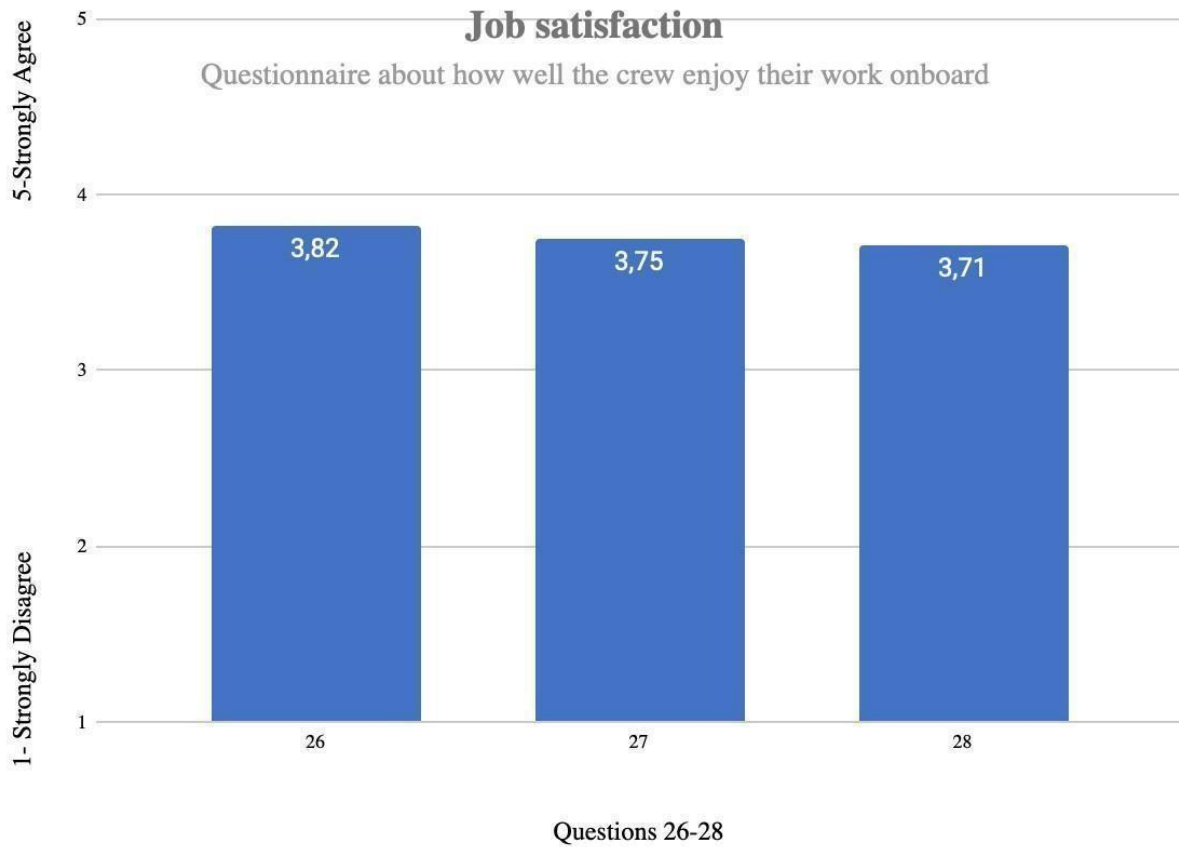


Figure 10 displays how satisfied the crew are in their work. Results show that the majority are satisfied with their work onboard as they also feel a sense of pride while performing it.

Figure 11:
Organizational commitment

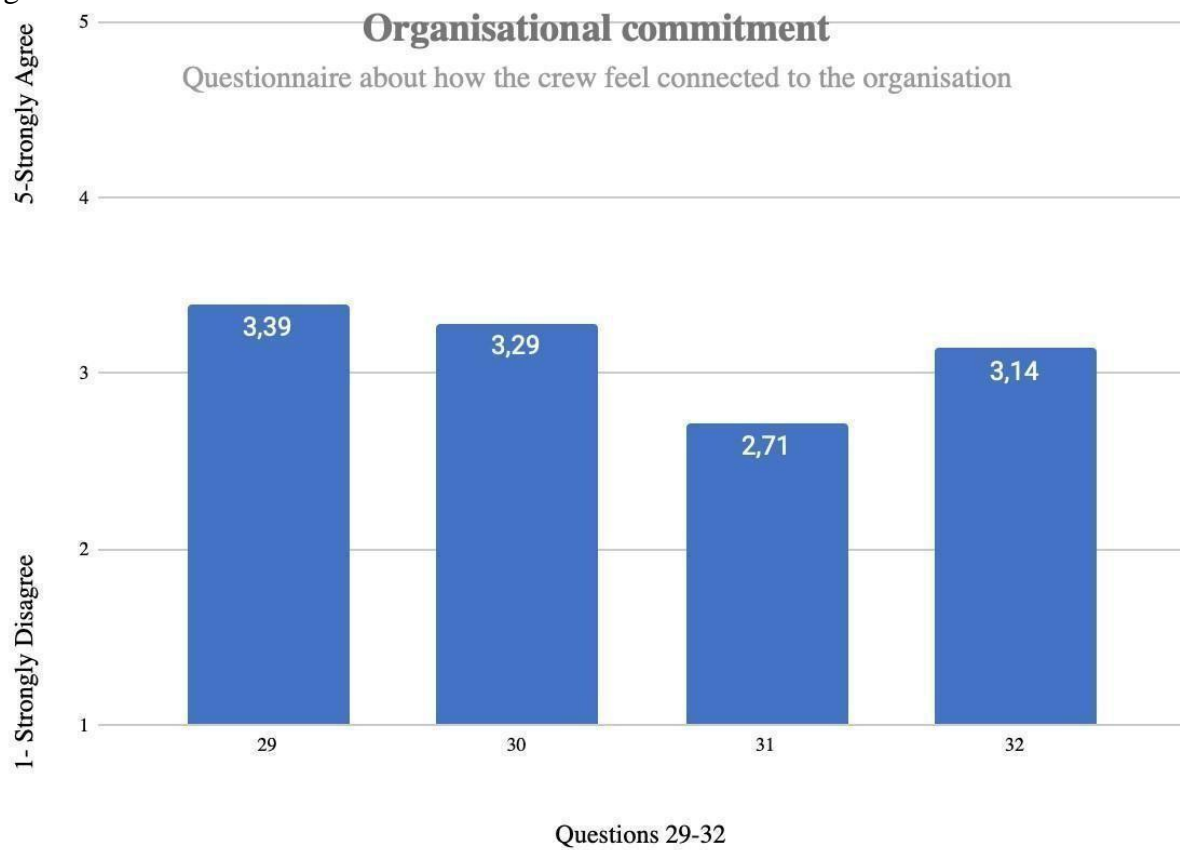


Figure 11 displays the commitment the crew feel to the company. Majority are indecisive if they feel a personal or professional commitment to the company as shown in bars 29, 30 and 32. Bar 32 shows that majority of the crew are disconnected to the company's problems.

Figure 12:
Continuance commitment

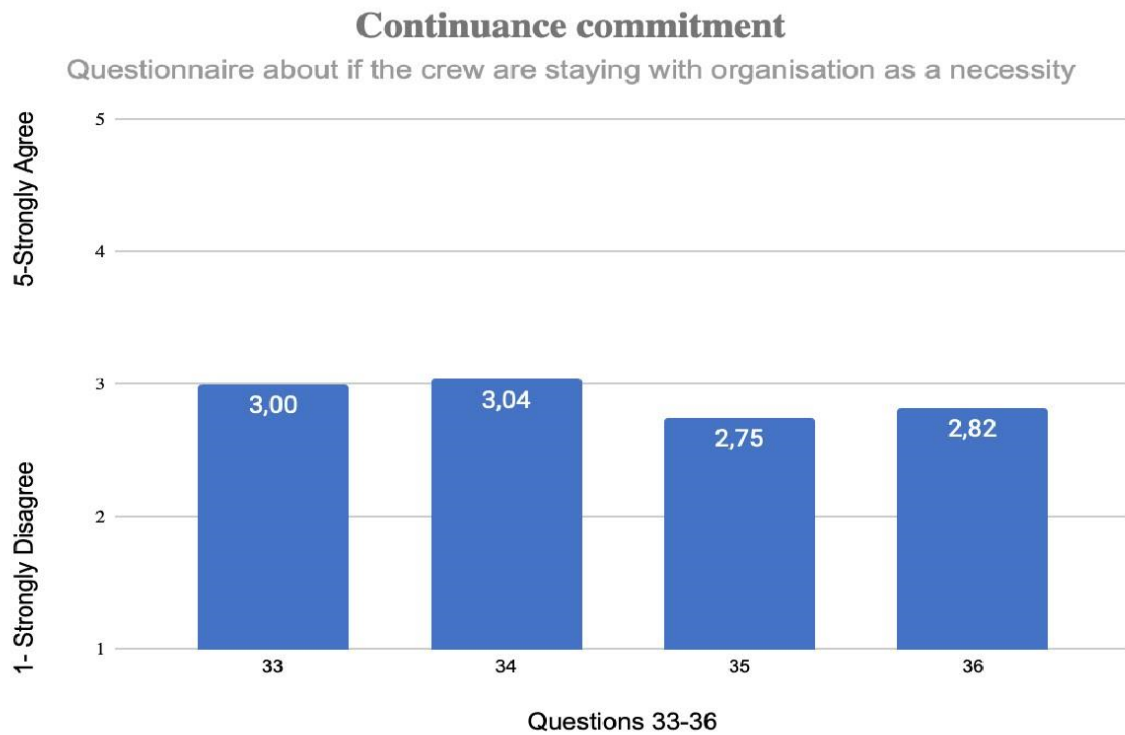


Figure 12 shows answers from the crew concerning if they stay in the company to not disrupt their private life. Results show that the majority of the crew fall between a 3 (Undecided) and a 2 (Disagree). This means that they are not sure if leaving the company would have a negative impact in their private lives, but at the same time do feel that they have other job options at other companies.

5. DISCUSSION

The purpose of this study was to identify factors to technostress and hopefully find solutions to minimize and hinder it, which is why participants were questioned if they feel that they have the knowledge to perform their tasks with the help of ICT or sacrifice free time due to the maritime industry being increasingly reliant on technology. These questions can be found in appendix 1 and 3. The questions this report aimed to answer are the titles underneath.

5.1 How has digitalization and ICT affected the workplace onboard?

The overall results of this study gave evidence that the crew members view of ICT onboard is positive. However, the crew members have listed suggestions on what needs to be improved. Among these answers they expressed a need for systems to be more user-friendly, that there should be better communication between shore and ship and better familiarization. Since the maritime industry desires to mirror the land industry they have taken on the trend of digitalization without consulting with the crew in how to work them. The maritime industry should focus on user centered designs since some of these digital equipment hardware are not made to be on ships since they are prone to breakdown when an increase in vibration occurs. As Dul & Neumann (2009) described in their article many changes in the maritime industry happen as a response to an incident rather than a response to a complaint by end-users. This ultimately sets back the upgrades and the modifications that might be essential for a better working environment.

The equipment also sometimes fails if the Wi-Fi is not working and oftentimes will not be working when the ship is miles away from land. It's not always easy for the crew to quickly fix the issues since some of these manuals are missing. According to figures 8 and 9(Literacy facilitation and Technical support provision) and two interviews conducted with higher ranked personnel, crewmembers feel that the IT-Helpdesk is not always helpful and thus leaves the crew to fend for themselves.

5.2 How has ICT affected the crew's experience of stress?

Some of these technological devices are presented as a way to make life easier onboard as well as a safety measure, but according to Hollnagel & Leonhardt (2014) the crew can feel that they are blamed for the system failures and other technological failures ICT contributes to. This leads to a discomfort and distrust for technology when operating technological devices. There's always a human error to hold responsible since the crew is easier to blame than the manufacturer. This creates the opposite effect of what this technology is designed for; However, it is shown in figures 4 & 5 about involvement facilitation and techno-complexity that the crew agree with the statement that technology is complex and that they have to sacrifice time off to learn how to use these systems. If the crew got involved in the introduction of new technology such as going on courses to learn how these systems work, it would save time onboard due to them having the knowledge to operate the equipment, thus not only feeling that they do not have to sacrifice time off but also feeling in control and secure in performing their tasks. As French & Caplan (1972) described as job overload this can lead the worker to be under stress and cause fatigue leading them to not perform their job well. In order for the individual to have efficient work there has to be a balance between private and professional life, when that line crosses for example a crew member sacrificing time off to learn new equipment, individuals will be under stress causing them to be dissatisfied with their job.

Another doubt the crew experience in ICT is the double logging of information. Officers onboard have to double log information both digitally and on paper as a requirement by the company office to have a backup in case the systems fail, which indirectly tells the crew that these systems cannot be trusted. If the company office does not trust the systems that they have implemented on their ships, then how can the crew onboard trust and believe that they will work every time. This leads some crewmembers to avoid putting a lot of effort in working with the systems since they feel that if there is a problem with the systems they will be blamed. As described by Hollnagel & Leonhardt (2014) it is efficient for the company office to recognize manufacturers' failure and educate the crew on how to solve these problems when they occur so that they feel confident and secure in working with ICT.

5.2.1 Old ship= Old hardware

Some of the equipment on board the vessel were old models. Old hardware that is not updated very often because it's expensive therefore the crew are told to push the hardware to the maximum, causing it to get overloaded. If the hardware was updated more often it will be easier from a troubleshooting perspective to fix the problems occurring. While the crew do have basic knowledge on the systems there are a lot of the advanced, manufacturer specific settings they are not aware of on how to operate. Therefore, they need to use help from the IT department with programs such as a TeamViewer, but that does need Wi-Fi in order for it to work and in some areas of the world Wi-Fi signal is very limited therefore this is not always an option, leaving the crew with inoperative systems. This can be shown in figure 2 about techno-overload where the crew are left to find solutions for the failing hardware.

5.3 How has the job satisfaction of the crew onboard been affected?

When it comes to the job satisfaction of the crew onboard (figure 10), majority falls between undecided and agree which means that they are for the most part satisfied with their jobs. According to figure 11 (organizational commitment) they are able to disconnect from the company's problems which can contribute to a positive attitude in the workplace. When asked if they are committed to stay in the company the average fall between undecided and disagree in figure 12 (Continuance commitment), this can be explained by Dreele (2008) and Allen et.al (2008) that many of the crewmembers are on board for long contracts sometimes extending to a whole year, and this is bad for their mental health since they do not have shore leave and Wi-Fi connect with family members is limited.

Every crew member reacts to stress differently. However, according to the interviews some crew members are able to disconnect from the problems during their free time and participate in other activities such as fishing, karaoke etc. These members had lower ranks than the ones not able to disconnect. The reason behind this could be that the higher the rank the more of the responsibility assigned to the rank. Thus, the company puts more pressure on the higher-ranking individuals to solve these problems, so these individuals feel they have to sacrifice free time in order to satisfy the company and to have a running ship.

5.3.1 Feeling replaceable

According to the surveys younger crew, especially younger officers ages 21-27 feel more stressed; This can be explained by Copper (1989) as young or newly graduated people have a difficulty creating barriers between professional and private life as they want to present themselves as hard-workers. As the crew are employed by contracts that get renewed every few

months, they have to put in more effort into learning new systems to not get replaced, as the company does not have an obligation to renew their contract.

5.3.2 Getting rewarded

McGrath (1976) reported that in order for the individual to feel satisfaction from stressful situations there has to be a reward. In this case the reward for many crewmembers is a promotion. While it was easy to promote to junior and third officers, it wasn't easy to promote to second, chief and captain. This is widely known in the shipping industry as "being stuck in the matrix" where the company wants experienced rank-holders leading them to not promote workers as this means that they can keep the long experience in their current rank, compared to being promoted and having short experience in their new higher rank. This creates a job underload (Cox. 1980) where the individual develops a disinterest in the job because they feel that they are not being rewarded with a promotion. This leads the crew to feel undervalued and insecure thus not putting in the effort into learning new systems, as according to them it will lead to nothing.

5.3.3 Ship-Shore communication

When interviewing the officers many agreed on the same idea of a webpage for seafarers in the company to easily communicate to shore. This to reduce emailing and asking for the same information again and again, for example a crew list has to be sent to the office every so often where the officers onboard have to write a completed list of vaccinations and passports for each crew member and email it to the office. This takes a lot of time from the officers when they have to focus on navigation. For that reason, the company should invest in a webpage where information can be updated there, and the office can access the same page and see the crew list. This is where the crew were very positive about the digitalization of their industry as the constant emailing of the same requirements create a job overload for the officers when they're on watch.

5.3.4 Company policy

Further stressor that can be experienced by the crew are the company policies, there are policies created for every event and bridge manning level on the vessel. These policies do not always correspond with reality, for instance when alarms are set to a very low value causing them to beep every few seconds, even though the vessel is navigating safely. This adds more stress as the alarms are indicating a danger that isn't there. Therefore, a crew member, oftentimes the officer overwatch has to stand next to the alarm panel and acknowledge the alarms for a period of time, limiting them from accessing other navigational areas of the bridge.

5.4 Methodological discussion

The method chosen for this research is a mixed methods approach as this allows for a larger collection of data. Since not all the crewmembers onboard work daily with technology it was decided that only the crew who work with ICT to be interviewed. This became the qualitative part of the study while surveys are used as an addition to the results, also known as the quantitative (Kallio et.al, 2016). Convenience sampling was used in this study as the maritime shipping industry is a unique field of business, thus there aren't many in the population who have knowledge or experience with it. While the reliability of the survey used for this study is high as it is validated, written with inspiration from articles by Ragu-Nathan et.al. (2008) and Ye, Q. (2018) an overall conclusion representing the shipping industry as a whole can't be

drawn, due to the data being collected from one vessel, compared to numerous vessels making the results more accurate.

A difficulty experienced using the semi-structured interview approach was writing the questions, as a question about job satisfaction was forgotten. While it was present in the survey it would have been interesting for the results to interview the crew and have them reflect on it.

6. CONCLUSION

The purpose of this study was to find out if seafarers experienced technostress due to the usage of ICT and if so, how this has affected their job performance and job satisfaction. The results show that while the overall view on ICT and digitalization onboard are met with positivity there are some cons as some tasks are doubled as the crew have to log everything both digitally and on paper. In order to minimize technostress, the maritime industry should focus more on user centered designs, thus including the crew on the systems of their vessel before its implementation. The crew has to feel a sense of control and confidence while performing their tasks and this is lost when workers are not educated or thoroughly taught in how to work those systems.

While the majority of the lower-ranking crew were satisfied with their job, the higher-ranking crew experienced difficulty separating themselves from ICT issues in their off time as they are the ones who have a responsibility over technological tasks. In order to increase job satisfaction a website should be designed for easier contact between ship and shore that shows crew list, sea time, wages etc. This way emails between office and bridge team would decline, and with it minimizing technostress brought on by ICT.

Another action that can be taken to increase job satisfaction and job performance is promoting the employees who have shown capability and determination. This shows the employees that they are valued and not easily replaceable, which creates a security and commitment to the company.

6.1 Recommendations for further research

When working on this report it was noticed that there weren't many studies conducted from the seafarer's point of view. It is seen as essential that maritime workers are interviewed and asked for participation in future research. By surveying maritime workers about their experiences with ICT, researchers and policymakers can identify the specific challenges and opportunities that come with technological advancements in the maritime industry. This knowledge can then be used to develop user-friendly programs, policies, and guidelines to support maritime workers and improve their working conditions.

REFERENCES

- Abras, Chadia & Maloney-Krichmar, Diane & Preece, Jennifer. (2004). User-centered design. *User-Centered Design*. 445-456.
- Adams, G. A., King, L. A., & King, D. W. (1996). Relationships of job and family involvement, family social support, and work–family conflict with job and life satisfaction. *Journal of Applied Psychology*, 81(4), 411-420. <https://doi.org/10.1037/0021-9010.81.4.411>
- Allen P. et al. Seafarers' fatigue: a review of the recent literature. *Int Marit Health* 2008; 59: 167–177.
- Allvin, Michael, Aronsson, Gunnar, Hagström, Tom, Johansson, Gunn & Lundberg, Ulf (2006) *Gränslöst arbete: socialpsykologiska perspektiv på det nya arbetslivet*. Malmö: Liber.
- Alotaibi, T., Almuhan, R., Alhassan, J., Alqadhib, E., Mortada, E., & Alwhaibi, R. (2020). The relationship between technology use and physical activity among typically-developing children. *Healthcare*, 8(4), 488. <https://doi.org/10.3390/healthcare8040488>
- Androjna, A., & Perkovič, M. (2021). Impact of spoofing of navigation systems on maritime situational awareness. *Transactions on Maritime Science*, 10(2), 361-373. <https://doi.org/10.7225/toms.v10.n02.w08>
- Bauk, S., Kapidani, N., & Schmeink, A. (2017). On intelligent use of ICT in some maritime business organizations. *Montenegrin Journal of Economics*, 13(2), 163-173. <https://doi.org/10.14254/1800-5845/2017.13-2.11>
- Berg-Beckhoff, G., Nielsen, G., & Ladekjær Larsen, E. (2017). Use of information communication technology and stress, burnout, and mental health in older, middle-aged, and younger workers – results from a systematic review. *International Journal of Occupational and Environmental Health*, 23(2), 160-171. <https://doi.org/10.1080/10773525.2018.1436015>
- Bondanini, G., Giorgi, G., Ariza-Montes, A., Vega-Muñoz, A., & Andreucci-Annunziata, P. (2020). Technostress dark side of technology in the workplace: A Scientometric analysis. *International Journal of Environmental Research and Public Health*, 17(21), 8013. <https://doi.org/10.3390/ijerph17218013>
- Boulougouris, E., Cichowicz, J., Jasionowski, A., & Konovessis, D. (2016). Improvement of ship stability and safety in damaged condition through operational measures: Challenges and opportunities. *Ocean Engineering*, 122, 311-316. <https://doi.org/10.1016/j.oceaneng.2016.06.010>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
- Brillhart, P.E. (2004) *Technostress in the Workplace: Managing Stress in the Electronic Workplace*. *Journal of American Academy of Business*, Cambridge, 5, 302-307.
- Brod, C. (1984). *Technostress: The human cost of the computer revolution*. Addison-Wesley.

Clark, K. and Kalin, S. (1996) Technostressed Out? How to Cope in the Digital Age. *Library Journal*, 121, 30-32.

Cobb, S., & Rose, R. M. (1973). Hypertension, peptic ulcer, and diabetes in air traffic controllers. *JAMA: The Journal of the American Medical Association*, 224(4), 489-492. <https://doi.org/10.1001/jama.1973.03220170019004>

Conceição, V., Carmo, M. B., Dahlman, J., & Ferreira, A. (2017). Visualization in maritime navigation: A critical review. *Advances in Intelligent Systems and Computing*, 199-212. https://doi.org/10.1007/978-3-319-60441-1_20

Cooper, C. L. (1983). Identifying stressors at work: Recent research developments. *Journal of Psychosomatic Research*, 27(5), 369-376. [https://doi.org/10.1016/0022-3999\(83\)90068-5](https://doi.org/10.1016/0022-3999(83)90068-5)

Cooper CL, Rout U, Faragher B. Mental health, job satisfaction, and job stress among general practitioners. *BMJ*. 1989 Feb 11;298(6670):366-70. doi: 10.1136/bmj.298.6670.366. PMID: 2493939; PMCID: PMC1835734.

Cooper, C. L., P. Dewe, M. P. O'Driscoll. 2001. *Organizational Stress: A Review and Critique of Theory, Research, and Applications*. Sage, Thousand Oaks, CA.

Cox I. (1980) Repetitive work. In *Current Concerns in Occupational Stress* (Edited by COOPER CL, PAYNE R). New York: John Wiley & Sons.

Cross & Meadow. (2017). Autonomous Ships 101. *Journal of Ocean Technology*, 12(3), 23-27.

De Lange, A. H., Taris, T. W., Kompier, M. A., Houtman, I. L., & Bongers, P. M. (2003). "The very best of the millennium": Longitudinal research and the demand-control-(support) model. *Journal of Occupational Health Psychology*, 8(4), 282-305. <https://doi.org/10.1037/1076-8998.8.4.282>

Denscombe, M. (2008). Communities of practice. *Journal of Mixed Methods Research*, 2(3), 270-283. <https://doi.org/10.1177/1558689808316807>

Dul, J., & Neumann, W. P. (2009). Ergonomics contributions to company strategies. *Applied Ergonomics*, 40(4), 745-752. <https://doi.org/10.1016/j.apergo.2008.07.001>

Ekman, R., & Arnetz, B. B. (2005). *Stress: Molekylerna, individen, organisationen, samhället*(2nd ed.). Liber.

French J, Caplan R. (1972) Organisational stress and individual strain. In *The Failure of Success* (Edited by MARROW AJ), pp. 31-66. New York: Amacon.

Frese, M., & Zapf, D. (1988). Methodological issues in the study of work stress. In C.L. Cooper, & R. Payne (Eds.), *Causes, coping and consequences of stress at work* (pp. 375-411). Chichester: Wiley.

Hollnagel, E. and J. Leonhardt (2014). *From Safety-I to Safety-II: A White Paper*. <https://doi.org/10.1109/CyberSecPODS.2018.8560690>

- ICC International Maritime Bureau. (2012). PIRACY AND ARMED ROBBERY AGAINST SHIPS REPORT FOR THE PERIOD 1 January - 31 December 2011. www.icc-ccs.org
- Ichimura, Y., Dalaklis, D., Kitada, M., & Christodoulou, A. (2022). Shipping in the era of digitalization: Mapping the future strategic plans of major maritime commercial actors. *Digital Business*, 2(1), 100022. <https://doi.org/10.1016/j.digbus.2022.100022>
- ICSW. Guidelines for mental care onboard merchant ships. International Committee on Seafarers' Welfare, Seafarers Health Information Program 2009: 12 p. (www.seafarershealth.org; e-mail: ship@icsw.org.uk).
- Iversen. (2012). The Mental Health of Seafarers. *Marit Health*, 63(2), 78-89. https://journals.viamedica.pl/international_maritime_health/article/view/26143
- Jensen, H., & Oldenburg, M. (2020). Training seafarers to deal with multicultural crew members and stress on board. *International Maritime Health*, 71(3), 174-180. <https://doi.org/10.5603/imh.2020.0031>
- Johansson. (2019, November 28). Fifty Years Since the First Computer at Sea. *The Maritime Executive*. <https://maritime-executive.com/editorials/fifty-years-since-the-first-computer-at-sea>
- Jones, F., & Bright, J. (Eds.). (2001). *Stress: Myth, theory and research*. Prentice Hall/Pearson Education.
- Kallio, H., Pietilä, A., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: Developing a framework for a qualitative semi-structured interview guide. *Journal of Advanced Nursing*, 72(12), 2954-2965. <https://doi.org/10.1111/jan.13031>
- Kaur, P., Stoltzfus, J., & Yellapu, V. (2018). Descriptive statistics. *International Journal of Academic Medicine*, 4(1), 60. https://doi.org/10.4103/ijam.ijam_7_18
- La Torre, G., Esposito, A., Sciarra, I., & Chiappetta, M. (2018). Definition, symptoms and risk of techno-stress: A systematic review. *International Archives of Occupational and Environmental Health*, 92(1), 13-35. <https://doi.org/10.1007/s00420-018-1352-1>
- McGrath, J. E. 1976. Stress and behavior in organizations. M. D. Dunnette, ed. *Handbook of Industrial and Organizational Psychology*. Rand-McNally, Chicago, 1351–1395.
- Mcmichael, A. J. (1978) Personality, behavioural, and situational modifiers of work stressors. In: Cooper, C.L.; Payne, R; , editor/s. *Stress at work*. New York: Wiley;. 127-147. <http://hdl.handle.net/102.100.100/299960?index=1>
- Nowacki, H. (2010). Five decades of computer-aided ship design. *Computer-Aided Design*, 42(11), 956-969. <https://doi.org/10.1016/j.cad.2009.07.006>
- Oldenburg, M., & Jensen, H. (2019). Stress and strain among seafarers related to the occupational groups. *International Journal of Environmental Research and Public Health*, 16(7), 1153. <https://doi.org/10.3390/ijerph16071153>

- Otway, H. J., & Misenta, R. (1980). Some human performance paradoxes of nuclear operations. *Futures*, 12(5), 340-357. [https://doi.org/10.1016/0016-3287\(80\)90089-0](https://doi.org/10.1016/0016-3287(80)90089-0)
- Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S., & Tu, Q. (2008). The consequences of Technostress for end users in organizations: Conceptual development and empirical validation. *Information Systems Research*, 19(4), 417-433. <https://doi.org/10.1287/isre.1070.0165>
- Pearce, J. L., Branyiczki, I., & Bakacsi, G. (1994). Person-based reward systems: A theory of organizational reward practices in reform-communist organizations. *Journal of Organizational Behavior*, 15(3), 261-282. <https://doi.org/10.1002/job.4030150307>
- Sanchez-Gonzalez, P., Díaz-Gutiérrez, D., Leo, T., & Núñez-Rivas, L. (2019). Toward digitalization of maritime transport? *Sensors*, 19(4), 926. <https://doi.org/10.3390/s19040926>
- Schwab, K. (2017). *The fourth Industrial Revolution*. Currency.
- Tam, K. and Jones, K. (2018) Cyber-Risk Assessment for Autonomous Ships. 2018 International Conference on Cyber Security and Protection of Digital Services (Cyber Security), Glasgow, 11-12 June 2018, 1-8.
- Thomas, M., Sampson, H., & Zhao, M. (2003). Finding a balance: Companies, seafarers and family life. *Maritime Policy & Management*, 30(1), 59-76. <https://doi.org/10.1080/0308883032000051630>
- Turel, O., Serenko, A., & Bontis, N. (2011). Family and work-related consequences of addiction to organizational pervasive technologies. *Information & Management*, 48(2-3), 88-95. <https://doi.org/10.1016/j.im.2011.01.004>
- United Nations (2018) Review of Maritime transport. (UNCTAD/RMT/2018). https://unctad.org/system/files/official-document/rmt2018_en.pdf
- Von Dreele JD. *The Human Elements in Shipping: A Maritime Chaplain's Perspective*. Proceedings of the American Petroleum Institute Conference, San Diego, California, June 24, 2008. 5 p.
- Weil, M. M., & Rosen, L. D. (1997). *TechnoStress: Coping with technology @Work @Home @Play*. John Wiley & Sons.
- Ye Qian. (2018). Extending research on technostress: exploring the moderating effects of techno-savvy and the proactive personality on the relationship between technostress and job satisfaction and stress [Master's thesis]. <https://ir.canterbury.ac.nz/handle/10092/15328>
- Young, K. (2017). The evolution of internet addiction disorder. *Internet Addiction*, 3-18. https://doi.org/10.1007/978-3-319-46276-9_1

APPENDIX 1- SURVEY

Underneath is a link to the survey given to the crew members onboard the LNG carrier.

<https://docs.google.com/document/d/1Wq1Bg7HT19-D-mfXuTDJTUXbNjwQZfk3zgMKgRtxbBw/edit?usp=sharing>

APPENDIX 2- CONSENT FORM

Informed consent for the participation in the interviews for the project.

<https://docs.google.com/document/d/1G8yXuiNkgDwgBsd77Lac3vOGQ7Kg0vPm/edit?usp=sharing&oid=10374450594577777588&rtpof=true&sd=true>

APPENDIX 3- INTERVIEW QUESTIONS

Below are the questions used for the semi-structured interviews:

- *How long have you been working in your current field?*
- *Do you feel that equipment onboard has been improved since you first started?*
- *How has technological advances improved your work environment?*
- *How has it affected it negatively? Do you have a personal experience with technology failing?*
- *How often do you face these problems?*
- *What do you do to solve them?*
- *Do you feel as if a major part of your day goes to learning how an instrument works rather than quickly understanding and finishing the job?*
- *Do you think the company gives you time and resources to learn how new equipment works or do you feel you have to figure it out by yourself?*
- *Does ICT make you more stressed in your free time? Wifi not working? Like checking your work email? Answering questions from your reliever?*
- *What is your overall view of technological advances onboard?*
- *What would you like to change? What measures need to be developed and implemented to improve your work onboard?*

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